Response of local rice *(Oryza sativa* L.*)* cultivars to different levels of N, P and K under upland rainfed condition of Nagaland

Thesis

Submitted to

NAGALAND UNIVERSITY

In partial fulfilment for the Degree
of
DOCTOR OF PHILOSOPHY
in

Agronomy

By

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Admn. No. Ph-148/13 Regn. No. 654/2015

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2017

STUDENT'S DECLARATION

I, Miss Sentirenla Changkija, hereby declare that the subject matter of this Thesis is the record of work done by me, that the contents of this Thesis did not form the basis of the award of any previous Degree to me or to the best of my knowledge to anybody else, and that the Thesis has not been submitted by me for any research degree to any other Universities/Institute.

This is submitted to SASRD, Nagaland University for the Degree of Doctor of Philosophy in Agronomy.

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Supervisor

ACKNOWLEDGEMENT

All praises to the Almighty God for His manifold blessings bestowed upon me during the course of my study.

This manuscript could be collated to finality owing to valuable support and sacrifices of the following individuals, whose unflinching support is dearly and sincerely acknowledged.

My heartfelt gratitude goes to my supervisor Dr. T. Gohain, Associate Professor, Department of Agronomy, SASRD:NU, for his dynamic guidance, constructive criticisms, patience and father like guidance. Thank you sir, for being my teacher, guide and guardian throughout the entire course of my study.

I am thankful to the members of my advisory committee comprising of Dr. L.T Longkumer and Dr. P.L Singh, Associate Professor, Department of Agronomy and Dr. P.K Singh, Associate Professor, Department of Agricultural Chemistry and Soil Science for rendering necessary guidance and motivation in the course of my research.

My sincere thanks to all the teaching and non-teaching staff members, not forgetting the farm attendants of the Department of Agronomy, SASRD:NU, for providing me with all the necessary facilities and kind help during the course of my study.

To Dr. A.K Sahu, Assistant Proffessor, Department of Agricultural Economics for rendering his help for the statistical analysis of my research work and to Shri. Mhombemo Ngullie, Assistant Librarian and his staff members for enabling me to utilize the library facilities.

My profound gratitude to Mr. Temjenmenba, Audio Visual Specialist, Department of Agricultural Extension, for his enthusiastic help in photographing my research works and for the meticulous arrangement and layout of the thesis.

I am extremely thankful to my friends Meshenji, Apole, Atu and Nana for their joyful company and ever willing help and support in all ways.

Last but not the least, I express my genuine love and gratefulness to my loving parents, my siblings Moa and Tong, cousin Sunep and helper Athong, family friends and neighbors for their assistance, encouragement and unceasing prayers and resolute support during the entire course of my study.

My study and work would not have been a success without all of your support.

THANK YOU.

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Affectionately

dedicated

to

my Loving Family

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CERTIFICATE – I

This is to certify that the Thesis entitled "**Response of local rice *(Oryza sativa* L.*)* cultivars to different levels of N, P and K under upland rainfed condition of Nagaland**" Submitted to Nagaland University in partial fulfilment of the requirements for the degree of DOCTOR OF PHILOSOPHY in the discipline of Agronomy is a record of Research work carried out by Miss Sentirenla Changkija Registration No. 654/2015 under my personal supervision and guidance.

All help received by him/her have been duly acknowledged.

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CERTIFICATE – II

This is to certify that the Thesis entitled "**Response of local rice *(Oryza sativa* L.*)* cultivars to different levels of N, P and K under upland rainfed condition of Nagaland**" Submitted by Miss Sentirenla Changkija Registration No. 654/2014 to Nagaland University in partial fulfillment of the requirements for the degree of DOCTOR OF PHILOSOPHY in the discipline of **AGRONOMY** has been examined and approved by the Student Advisory Committee and External Examiner, after *viva voce*.

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LIST OF ABBREVIATIONS

%	: Percentage
/	: Per
@	: At the rate of
^0C	: Degree Centigrade
BCR	: Benefit cost ratio
Cm	: Centimetre
CD	: Critical Difference
cv.	: Cultivar
DAS	: Days After Sowing
E	: East
et al.	: And others
Fig.	: Figure
FYM	: Farm Yard Manure
g	: Gram
ha	: Hectare
HI	: Harvest Index
i.e.	: That is
INM	: Integrated Nutrient Management
K	: Potassium
kg	: Kilogram
kg ha^{-1}	: Kilogram per hectare
Max.	: Maximum
Min.	: Minimum
m	: Meter
m^2	: Meter square
ml	: Millilitre
mm	: Millimetre
MOP	: Muriate of potash
MT	: Metric tonnes
mt	: Million tonnes
N	: Nitrogen
No.	: Number
NPK	: Nitrogen, phosphorus and potassium
NS	: Non-significant
NU	: Nagaland University
P	: Phosphorus
pH	: negative logarithm of hydrogen ion activity of a soil
q	: Quintal
₹	: Rupees
RBD	: Randomized Block Design
RDF	: Recommended Dose of Fertilizer
SASRD	: School of Agricultural Sciences and Rural Development
SEm±	: Standard error mean
SOM	: Soil Organic Matter
SSP	: Single Super Phosphate
t	: tonnes
viz.	: Namely

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CHAPTER-I

INTRODUCTION

Among the cereals of great social and economic importance in the world, highlights the rice (*Oryza sativa* L.), which is an energy source for two-thirds of the world population, providing about 20% of energy and 15% of the protein that human needs. It has shaped the culture, diets and economy of thousands and millions of people. For more than half of the humanity "rice is life". Although, the national food security heavily depends on rice and wheat (78 per cent), rice alone contributes to 43 per cent of food grain production and 46 per cent of cereal production in the country (Raj *et al*., 2016). In the global context India stands first in area with 43.39 m ha, second in production with 108.86 million tonnes and an average productivity of 2.40 t ha^{-1} (Anonymous, 2016-17) accounting 21.49% of total rice production in the world (Anonymous, 2016_b). At the current rate of population growth (1.55%) in India, the rice requirements by 2020 would be around 120-150 million tonnes. Raising the rice production from present level to the anticipated 120-135 million tonnes is a herculean task especially in the backdrop of plateauing yield trend due to declining resource base in terms of land, water, labour and other inputs (Anup Das *et al*., 2012). By 2030, a projected demand of 121.6 million t for rice is expected to be fulfilled, if production rate will be at 1.34% per annum compared to the present growth rate at 1.14% (Anonymous, 2011).

In North Eastern Region of India, rice is the principal food crop occupying 3.52 million ha with a production of 6.57 million t and a productivity of 2.05 t ha^{-1} (Anonymous, 2015). While in Nagaland rice is grown in an area of about 1,95,240 ha with a production of 4,54,190 t and productivity of only 2.33 t ha^{-1} (Anonymous, 2016_a), which is below the average national productivity. The NE region is considered to be one of the hot pockets of rice genetic resources in the world and a potential rice-growing region with extremely diverse rice growing conditions as compared to other parts of the country. Rice is cultivated traditionally in the region, and has a rich diversity of native cultivars/land races distributed in various regions of the state. These land races are being maintained by the local farmers to meet their specific needs and are part and parcel of their traditional crop management system. It is worth to mention that the primitive rice cultivars including the wild species are the rich source of rice genetic material to be used by modern plant breeders which contributed to the development of present day high yielding varieties. The north eastern region is also home to a large number of aromatic and quality rice varieties. In fact, the whole region is considered as a veritable treasure trove of rice germplasm with wide genetic resource of rice. Traditional varieties though low in production, is still favoured by farmers in many regions of the world because they are better adapted to local field condition and they adapt to the changing environment and farming practices of the particular area (Singh *et al*., 2016).

Agriculture has traditionally been and continues to be the mainstay of Naga way of life. Seventy-three percent of the people in Nagaland are engaged in agriculture. And like most of the world's tribal population, the agriculture system has been proto- type, enabling close links between nature and people. These linkages and traditional practices have been formalized through experience yet have not been formally documented. In Nagaland, rice is taken up as- Shifting and Permanent cultivation. Rice grown under shifting cultivation is direct seeded and mainly on hill slopes and tilled land. Rainfed permanent areas are either terraced hills or bunded flat land and directly seeded. In Nagaland shifting cultivation is commonly called as 'Soka Kheti' and occupies about 94,380 ha area and produce about 1,82,640 t (Anonymous, 2016_a) which seems less notable at national level. Nagaland consists of various tribes who use different local rice cultivars or land races in their respective areas. However, the production is often low due to lack of knowledge about the management practices such as use of local varieties of low genetic potential, leaching loss of N, unfavourable growth conditions, low inputs and heavy infestation of weeds, insects and pests attack clubbed with inefficient resources management practices (Rathore, 2011). The state also lacks in availability of high yielding varieties and package of practices for cultivation of potential indigenous races, Since variety is an important parameter for yield exploitation and an adequate and balance supply of plant nutrients is a prerequisite to maximize crop production, these two factors assume great significant for crop production.

Rice needs adequate nutrition for growing well and producing high yield. As about 40 percent of yield increase is accounted against fertilizer use, the fertilizer recommendations should be matched to the basic soil fertility, season, target yield, climate etc. With the advent of modern production technology, the usage of higher doses of fertilizers in balanced manner is inevitable to exploit their full potential particularly under rain-fed conditions. Modern high yielding varieties producing around 5 t ha^{-1} of grain can remove about 110 kg N, 15 kg P, 129 kg K, 5 kg S, 2 kg Fe, 2 kg Mn, 200 g Zn and 150 g B per hectare from the soil. Emergence of widespread multi-nutrient deficiencies, depletion of native nutrient reserves, imbalanced fertilization are of utmost concern, causing serious stagnation in yields and declining productivity of various rice ecosystems (Mohanty *et al*., 2008). Excess use of fertilizer nutrients implies increase of cost and decrease of returns and risk of environmental pollution. On the other hand, under use of nutrients depress the scope for increasing the present level of nutrients to the economically optimum level to exploit production potential to a larger extent (Singh *et al*., 2012). Application of inadequate and unbalanced fertilization to crops not only results in low crop yields but also deteriorate the soil health (Sharma *et al*., 2015). The existing fertilizer recommendations for major nutrients in rice are proving to be sub-optimal for attaining higher productivity levels and need a fresh look to revise them to optimum and more balanced levels.

Generally the recommended dose of fertilizer under upland rice cultivation is done by applying 45-60 kg ha^{-1} N in three equal split doses. The first split dose of N (15-20 kg ha^{-1}) after final land preparation, second dose as top dressing after 40 days from germination and the final dose a week before panicle initiation. For short and medium rice varieties 2 split doses are recommended, while 3 split doses are recommended for long duration varieties. In rice a yield advantage of 3.7 q ha^{-1} in *kharif* and 4.8q ha^{-1} was obtained by 3 split applications as compared to a single application of N (Rao and Mahapatra, 1978). Phosphorus (30-35 kg ha^{-1} P_2O_5) and Potassium (20-30 kg ha^{-1} K_2O) fertilizers are applied on need basis as basal. It should be taken into consideration that the application of fertilizer should be varied during the different growth stages of a plant. Along with improved cultural management, the use of balanced fertilizer is one of the most important aspects for increased crop productivity.

In Nagaland, the farmers grow traditional rice varieties available (856 rice land races reported by the Directorate of Agriculture, Govt. of Nagaland) with them without application of fertilizers. The majority of these people belong to what governments usually call "ethnic minorities" or "tribal people". Today, however, many of these peoples prefer to be called indigenous peoples. It is a general fear of the farmers that the application of fertilizer will deteriorate the quality of the soil as well as the quality of the product will be inferior from the original product with fertilizer. The concrete manifestations about the use of fertilizers are as diverse as the people who practice it, and it is therefore a difficult concept to define. So, the productivity of rice in Nagaland is greatly hampered. It is proposed that the investigation will demonstrate the differences of their beliefs and will help the farming community to increase the productivity level of rice. Also the findings of the proposed work will provide a new vista in the breeders to utilize those fertilizer responsive local cultivars for further breeding works to develop cultivars suitable for Nagaland. With this background, it has been proposed to study **"Response of local rice *(Oryza sativa* L.*)* cultivars to different levels of N, P and K under upland rainfed condition of Nagaland"** with the following objectives-

1. To find out the fertilizer responsive local rice cultivars
2. To find out the suitable fertilizer doses for local rice cultivars
3. To find out the interaction effect of fertilizer doses and rice cultivars
4. To find out the economics of the performance of treatments

CHAPTER-II

LITERATURE REVIEW

Rice (*Oryza sativa* L.), one of the most important food crops in the world, forms the stable diet of 2.7 billion people. However, at the present scenario the production of rice is low which need to be increased to meet the need of the growing population. In Nagaland, most of the rice farmers grow local cultivars or landraces and are skeptic about modern technologies as a result the production is often low. Since rice productivity has a strong relationship with the extent of use of high yielding varieties and fertilizers application, proper interventions are needed in traditional varieties also in response to fertilizers. Therefore, in this chapter an attempt has been made to review the works carried out in this regard.

2.1 Effect of NPK fertilizers on growth and yield

Saud *et al*. (1999) studied on the response of summer rice (*Oryza sativa* L.) to varying levels of NPK fertilizers and reported that the application of 100:50:50 kg N: P_2O_5:K_2O produced a mean grain yield of 4.57 t ha^{-1} and the highest net return.

Murali, M. K. and Setty, R. A. (2000) conducted a field experiment on the effect of levels of NPK, vermicompost and growth regulator (triacontanol) on growth and yield of scented rice (*Oryza sativa* L.) and reported that application of 150:75:75 NPK kg ha^{-1} recorded significantly higher growth, yield attributes and yield (5261 kg ha^{-1}) compared to lower NPK rates.

Prasad K and Chauhan, RPS. (2000) carried out a field experiment on response of K in upland rice and found that the application of 50 kg K_2O ha^{-1} in two equal splits, ½ at basal and ½ at tillering produced significant higher grain and straw yield of rice.

Singh and Jain (2000) studied the growth and yield response of traditional and improved semi-tall rice cultivars to the application of moderate and high nitrogen, phosphorus and potassium and found that the traditional tall cultivars were superior to improved semi-tall in total biomass production, leaf area index, pre-anthesis dry matter production, biological productivity ha^{-1} day^{-1}, straw and biological yield. The improved semi-tall cultivars, however proved to be better than traditional tall in grains $panicle^{-1}$, foliage efficiency, harvest index, grain yield and post anthesis dry matter production. The traditional tall basmati cultivars proved to be promising in total biomass production m^{-2} in both moderate and high soil fertility levels, but manifested gave lower grain yield than semi-tall improved ones because of poor conversion efficiency of biomass into grain under severe lodging.

Tunga and Nayak (2000) reported the result of field trail conducted on 4 high yielding cultivars comprising 5 fertilizers treatment 4 N, P, K rate plus the highest N P K rate with Zn. Grain yield ranged from 3.99 ton ha^{-1} in cv. MW 10 to 5.48 t in MPH 504. Yield was 2.63 ton ha^{-1} without NPK and increased significantly up to 5.03 t with 9:45:45 kg NPK ha^{-1}.

Channabasavanna, A. S. and Biradar, D. P. (2001) carried out a field experiment on the response of rice cv. SIRI-429 to poultry manure and NPK under irrigated conditions and reported that increasing the fertilizer level from 75:35.5:37.5 to 150:75:75 kg NPK ha^{-1} significantly increased grain yield during both years. Agronomic efficiency of N (AEN) at 75% NPK (112.5:56.3:56.3 kg NPK ha^{-1}) was equivalent to 2 t poultry manure/ha.

Fageria and Baligar (2001) conducted a field experiment on the response of low land rice to nitrogen fertilization (0, 30, 60, 90, 120, 150, 180 and 210 kg N ha^{-1}) for three years (1996-98) and reported that nitrogen fertilization increased dry matter yield.

Ikrramulah and Ranjan (2001) also carried out a field experiment to compare the different level of N P K fertilizers. It was found out that the yield of rice significantly increased by N rate at the recommended rate of 120 kg N ha^{-1} There was a trend of increasing yield with higher P (0-45 kg P_2O_5 ha^{-1}) and K (0-30 Kg K_2O ha^{-1}) rate.

Singh *et al.* (2002) reported the result of field trail conducted in upland rice cv. Kalinga III in response to nitrogen fertilizer and found out that the grain and straw yield increased significantly to N fertilization up to 40 $kgha^{-1}$ N.

Subhendu and Swamy (2003) conducted a field experiment during the *kharif* season in Hyderabad and found out the effect of N application on rice cultivars (BIT-5204, MTU-1010 and IR-64). It was reported that application of N (120 kg ha^{-1}) as urea in equal splits during different stages resulted in highest number of panicle, number of filled grains per panicle, grain yield (5024 kg ha^{-1}), straw yield, harvest index (49.18%).

Choundhury A T M A and Khanif Y M. (2004) evaluate the effect of nitrogen in greenhouse using "N tracer technique". The treatment comprised N at 0, 60, 120 and 180 kg ha^{-1} along with Cu. Grain yield increased significantly due to N fertilizer application up to 120 kg N ha^{-1}. The estimated N rat for maximum yield was 158 kg ha^{-1}.

Mahavishnan *et al*. (2004) studied the effect of organic sources of plant nutrients in conjunction with chemical fertilizers on growth, yield and quality of rice and reported that the crop growth and yield were higher with 125% RDF (120:60:40 kg ha^{-1}) + poultry manure and 100% RDF + poultry manure compared to the other treatments.

Singh and Namdeo (2004) conducted a field experiment during the rainy season of 1999 and 2000, to find out the effect of fertility levels and herbicides on growth, yield and nutrient uptake of direct seeded rice. The fertility levels upto N45 P40 K30 and 25kg ZnSO4 + foliar spray of micronutrient mixture (thrice) proved the best, producing 6.34 q ha^{-1} extra yield. The seed protein and nutrient uptake were also increased significantly with increasing fertility levels.

Balasubramaniam *et al*. (2005) conducted a field experiment to calibrate the NPK requirements for lowland rice var. ADT-36 with and without green leaf manure and $ZnSO_4$ based on the soil fertility status and reported that the coefficient efficiency of soil was increased by the application of green leaf manure and $ZnSO_4$ with an increase of 61.6, 16.9 and 40.1% for soil N, P and K, respectively, further the fertilizer efficiency was also increased to 91, 264 and 163% for N, P and K, respectively.

Masthana *et al.* (2005) conducted a field experiment and reported that applicantion of NPK significantly improves the soil P and K status and increased the N content of the soil.

Niranjan, R. K. and Bharat Singh (2005) studied on the effect of organic and inorganic fertilizers on yield and uptake of rice and their residual response on wheat crop and found out that the application of various organic sources and inorganic fertilizers significantly increased the grain yield of rice and wheat and the yield of rice grain increased significantly with increasing level of fertilizer up to 100% NPK, followed by 50% NPK, 50% NP and 50% N (48.24, 40.31, 35.82 and 31.70 q ha^{-1}, respectively.

Choundhury A T M A and Khanif Y M. (2004) evaluate the effect of nitrogen in greenhouse using "N tracer technique". The treatment comprised N at 0, 60, 120 and 180 kg ha^{-1} along with Cu. Grain yield increased significantly due to N fertilizer application up to 120 kg N ha^{-1}. The estimated N rate for maximum yield was 158 kg ha^{-1}.

Barik *et al.* (2006) conducted a field experiment on kharif rice var. IR 36 to study the effect of organic and chemical sources of nutrients on productivity. It was found that the rice when applied with 50% of recommended N P K fertilizers (30:15:15) along with vermicompost @ 10 t ha^{-1} produced significantly higher number of effective tillers m^2 and higher number of filled grain $panicle^{-1}$ in comparison to 100% of recommended N P K fertilizers (60:30:30).

Saito *et al*. (2006) reported that three traditional (Vieng, Nok and Makhin Sung) and 3 improved cultivars (lR7152-19-1-1, IT55423-01, B6144-MR-6-0-0) were grown under 4 fertilizer treatment, IT55423-01 and B6144-MR-6-0-0 out yielded the traditional cultivars at all location and under all fertilizer treatment.

Singh *et al.* (2013) carried out an experiment to evaluate the effects of chemical fertilizer (urea), farmyard manure (FYM) and biofertilizer (*Azospirillum*) on the yield of rice and physicochemical properties of the soil and reported that the treatment comprising 80 kg N ha^{-1} + *Azospirillum* + 2.5 t FYM ha^{-1} was significantly superior over all the other treatments in terms of rice yield. Soil application of chemical fertilizer alone increased the bulk density and particle density but decreased the water holding capacity and organic carbon content of the soil.

Krishna *et al.* (2007) studied the response of long term use of NPK fertilizers and manure to P-fractions, soil properties and their relationship to yields of rice in rice-wheat-cowpea cropping system on a Mollisol of *Tarai* and reported that application of 100% recommended NPK fertilizers + FYM @ 15 t ha^{-1} produced maximum grain and straw (4.6 and 5.6 t ha^{-1}) and nutrients uptake by rice and it was followed by 100% NPK + Zn. Whereas, continuous use of optimal and super optimal dose of 100 and 150% NPK fertilizers without zinc gave 18.63 and 21.63% lower grain yield respectively as compared to 100% NPK+FYM. However, 100% phosphorus application with nitrogen and zinc shows superiority over optimal and super optimal doses of NPK fertilizers without zinc and alone nitrogen with zinc. Remarkable decrease in organic carbon from initial (1.48%) to control (0.57%) was observed up to 30th cycle of rice-wheat-cowpea and it was maintained with 100% NPK + FYM treatment (1.52%). This shows that organic manure application @ 15.0 t ha^{-1} in combination with optimal dose of NPK fertilizers retained initial soil fertility level and produced maximum yields.

Rao, B. R. B. (2007) studied on the response of rice varieties in alfisol and vertisol to different levels of fertility, soil test crop responses and site specific fertilizer recommendations for optimum production and profits and found out that the application of 120:0:50 kg NPK ha^{-1} in Jagtial and 60:60:50 kg NPK ha^{-1} in Warangal produced optimum yield.

Sharma *et al*. (2007) reported from his field experiment carried out during the rainy season at Sabour that the grain and straw yield of rice increased significantly with successive increase in nitrogen upto 120 kg ha^{-1}.

Singh *et al.* (2010) carried out an experiment to evaluate the effects of chemical fertilizer (urea), farmyard manure (FYM) and biofertilizer (*Azospirillum*) on the yield of rice and physicochemical properties of the soil and reported that the treatment comprising 80 kg N ha^{-1} + *Azospirillum* + 2.5 t FYM ha^{-1} was significantly superior over all the other treatments in terms of rice yield. Soil application of chemical fertilizer alone increased the bulk density and particle density but decreased the water holding capacity and organic carbon content of the soil.

Ravikant, A. (2009) reported from the experiment with 4 doses of N (0. 80, 120 and 160kg N ha^{-1}) that the grain yield increased with increasing levels of N from 80 to 160 kg ha^{-1}. Conjunctive application of FYM and urea increased the N uptake by 11.1 to 26.2%, recovery efficiency (11.1 to 46.7%) and agronomic efficiency (5.4 to 14.8%). Basal application of FYM @ 2.5t ha^{-1} and top-dressing 80kg N ha^{-1} through urea as ¼ N at 10 DAT + ½ N at PI stage recorded the highest recovery efficiency by 12.1 and 37.6% and agronomic efficiency by 9.9 and 15.8% over N_{120} with and without FYM.

Munda *et al*. (2008) conducted a field experiment during 2003-04 and 2004-05 at Umiam, Meghalaya to identify a suitable economically viable and feasible nutrient management practices for rice-toria cropping system. Application of FYM @ 2.5t ha^{-1} +Eupatorium 2.5t ha^{-1}, being on a par with Eupatorium 5t ha^{-1}, improved significantly the grain, straw and NPK uptake by rice, registering 11.5, 13.4 and 9.7% increased in grain yield over FYM 5 t ha^{-1} and FYM 2.5t ha^{-1} +Alnus 2.5t ha^{-1} respectively. Manuring of rice with FYM 2.5t ha^{-1} +Eupatorium 2.5 t ha^{-1} also significantly improved the mean rice-equivalent yield (REY) of the system (10.6-11.7%) compared with Alnus 5t ha^{-1} and FYM 2.5t ha^{-1} +Alnus 5t ha^{-1} and FYM 2.5t ha^{-1} + Alnus 2.5t ha^{-1} respectively, giving the highest net returns and benefit : cost ratio (1.93)

XianQuan *et al*. (2009) evaluate and found a yield of 640.3 kg 667m^{-2} under 23.5 kg urea 667 m^{-2}, 54.4 kg calcium phosphate 667 m^{-2} and 20.6 kg potassium chloride 667m^{-2}.

Urkurkar *et al*. (2010) also reported from their experiment conducted to compare organic, inorganic and chemical fertilizer nutrient inputs packages in scented rice (*Oryza sativa* L)-potato cropping system and found that total productivity in terms of rice equivalent yield of the system (13.36t ha^{-1}) and total net return (`92, 634 kg^{-1}) was highest with chemical fertilizer treatment closely followed by integrated inputs use. 100% N (1/3 each from cowdung manure, neem cake and composed crop residue) appreciably increased the organic carbon (6.3g kg^{-1}) over initial value (5.8g kg^{-1}). However, availability of P and K did not show any perceptible change after competition of five cropping cycles under organic as well as integrated nutrient approaches.

Dash *et al*. (2012) studied the effect of long term application of inorganic fertilizers and manure on yields, nutrients uptake and grain quality of wheat under rice-wheat cropping system on a Mollisol and reported that FYM application @ 15 t ha^{-1} along with 100% NPK fertilizers produced maximum yields, nutrients uptake along with improvement in soil properties. Balanced application of fertilizer nutrients and combined use of manure and inorganic fertilizers enhanced the grain quality of wheat over alone application of inorganic NPK fertilizers. Phosphorous application with N and Zn gave significant response over N + Zn treatment. 100% NPK + S + Zn resulted significantly higher yields, nutrients uptake and grain quality parameters when compared with 100% NPK + FYM, 100% NPK + Zn and 100% NP + Zn treatments showing the response of S application over S free fertilizer use continuously.

Bulbule, A. V. and Gajbhiye, P. N. (2013) conducted a field experiment on the response of upland rice (*Oryza sativa* L.) to briquettes containing NPK and reported that application of fertilizer briquettes @ 100% RD (100-50-50 kg NPK ha^{-1}) to rice crop increased the grain yield of rice by 24% (37.0 q ha^{-1}) over the RD (29.9 q ha^{-1}) applied through conventional fertilizers. Application of nitrogen as basal through briquettes to rice was more effective and recorded higher yield of rice when compared to the split application of nitrogen. Basal application of nitrogen @ 75 and 100% RD through briquettes produced 15 and 6% higher grain yields of rice (34.5 and 37.0 q ha^{-1}), respectively, as compared to application of nitrogen in two splits (25.6, 29.9 and 34.9 q ha^{-1}) through briquettes. The straw yield and nutrient uptake by the crop also revealed similar trend. Fertilization of rice crop through the briquettes recorded relatively higher values of nutrient uptake which were reflected in higher grain, straw yields and yield contributing parameters. The soil nutrient contents after harvest of the rice crop revealed slightly higher soil test values when the crop was fertilized through briquettes.

Dubey *et al*. (2014) reported that 100% inorganic nutrient management (120: 26.4: 33.3 kg N: P: K ha^{-1}) in rice-berseem cropping system improved rice equivalent yield of this cropping system with the maximum soil microbial growth. The maximum rice equivalent yield was observed in 100% inorganic nutrient management (68.23 q ha^{-1}), which was at par to integrated nutrient management (66.07 q ha^{-1}) and 100% organic nutrient management (60.18 q ha^{-1}).

Pramanik *et al.* (2013) through his experiment on the response of different sources of phosphate fertilizers and homo-brassinotide on total chlorophyll content, yield attributes and yield of hybrid rice under lateritic zone of West Bengal, India reported that application of 150:60:60 NPK kg ha^{-1} in PHB71 significantly resulted in higher total chlorophyll content, number of effective tillers $hill^{-1}$, panicle length, test weight, number of filled grains $panicle^{-1}$, fertility%, straw and grain yield $hill^{-1}$and harvest index as compared to rice hybrid 25P25 and Application of DAP significantly increased total chlorophyll content, number of tillers $hill^{-1}$, panicle length, test weight, number of filled grains $panicle^{-1}$, fertility(%), straw and grain yield $hill^{-1}$.

Yoseftabar (2013) reported from the study that panicle structure increased significantly with increasing rate of nitrogen fertilizer from 100, 200 to 300 kg N ha^{-1}. With increased nitrogen to 300 kg ha^{-1} observed high rate of this parameter viz. maximum total grain $panicle^{-1}$ (209.85), maximum panicle number (12.38), highest panicle length (28.64 cm) in harvesting stage, maximum panicle dry matter (954.93).The N content of rice at the panicle formation stage (about 10 - 15 days before flowering) had been shown to be an important determinant of sink size and eventual yields. Panicle structure such as number of panicles (heads), panicle length, panicle curvature and the number of grains $panicle^{-1}$ were determined by the nitrogen application.

Chavan *et al*. (2014) conducted a field experiment to study the direct and residual effects of different doses of fertilizers and biofertilizers on yield, nutrient uptake and economics of groundnut (Arachis hypogaea L.)-rice (Oryza sativa L.) cropping system and reported that Rice crop responded significantly to each higher level of fertilizer up to 125% RDF (direct) in terms of grain and straw yields as well as N, P and K uptake. Application of 125% RDF to rice recorded significantly higher total N, P and K uptake (447.1 kg ha-1), rice-grain equivalent yield (10.89 t ha-1), production efficiency (42.6 kg ha-1 day-1), net returns (`78300 ha-1) and benefit: cost ratio (2.17) in groundnut-rice cropping system.

Kanfany *et al.* (2014) reported that increasing fertilizer levels significantly improved growth, grain and straw yields of rice. Increasing fertilizer levels increased days to maturity, plant height, panicle m^{-2}, and grain yield except panicle length and 1000 grain weight. Interactions of hybrid varieties with different fertilizer levels were non-significant and grain quality traits did not follow any trend according to fertilizer levels.

Said *et al*. (2014) observed that adequate amount of nitrogen to rice increased the number of tillers $plant^{-1}$ irrespective of application time *viz*. split and basal. The tillers were more responsive to 120 kg N ha^{-1}, whether applied in split or as basal. Produced taller plant height in response to application of N fertilizers probably due to enhanced availability of adequate nitrogen (120 kg N ha^{-1}) and assimilates, which enhance plant growth. Panicles $plant^{-1}$ and panicle length were increased with adequate amount of fertilizer. Availability of nutrients and better plant growth might be the reason for heavier grain with 120 N kg ha^{-1} and increase in straw yield might be attributed to taller plants, greater tiller and panicle number.

Dekhane *et al*. (2014) conducted an experiment on different doses of fertilizers on growth and yield of paddy in North konkan coastel zone of Maharashtra, and reported that application of 125% of RDF significantly recorded higher panicle length (22.1 cm), grains $panicle^{-1}$ (128), 1000 grain weight (20.9 g) and grain yield (5.18 t ha^{-1}), straw yield (5.79 t ha^{-1}), tillers $plant^{-1}$ 9.7 and 11.7 at 45 DAT and harvest.

Dakshina *et al*. (2015) conducted an experiment on rice (Oryza sativa L.) on Godavari alluvials (Vertic chromusters) at Andhra Pradesh Rice Research Institute, Maruteru, with an objective to revise the existing fertilizer doses of major nutrients for rabi rice in Krishna Godavari delta regions of Andhra Pradesh. Through the experiment grain yield was increased by 11.5% and 6.3% due to increase in recommended dose of N from 100% (120 kg ha-1) to 125% and 150%. Increase in P & K doses from 100 to 125% (P from 60 to 75 and K from 40 to 50 kg ha-1) also improved grain yield significantly.

Longchar T S and Toshimenla (2015) conducted a field study during the *Kharif* 2010 at State Agricultural Research Station (SARS) Yisemyong, Nagaland and revealed the findings that cultivar Manen tsÜk (SARS-5) responded differently to the application of different rates of NPK fertilizers viz. T_1=0:0:0, T_2=30:20:10, T_3=40:30:20 T_4=50:30:40, T_5 =60:50:40, T_6=70:60:50 (kg ha^{-1}). The treatment of NPK 60:50:40 kg ha^{-1} recorded the tallest plant height at harvest (170 cm), longest panicle length (31 cm), highest 1000 grain weight (7.2 g) and maximum grain yield (44 q ha^{-1}).

2.2 Effect of Varieties

Baishya and Thakur (2000) reported that the possibility of increasing production of rainfed winter rice in Assam , India were explored through trials on farmer's field from 1991-1994 with newly evolved rice varieties, namely IET 8002, Pioli, IET 9188, Ranjit and TTB101-14 (Moni ram). The trials were conducted at 8 different locations. Mean values for different years revealed that the promising varieties out yielded the local varieties in different years. IET8002 yielded the highest (38.80q ha^{-1}) during 1991, IET-9188 (37.35 q ha^{-1}) during 1992 and TTB101-14 during 1993 and 1994 (33.91 and 32.93 q ha^{-1}) respectively. However, mean of different years showed that among the varieties IET-9188 had the highest yield (38.05 q ha^{-1}).

Bharat Bhushan *et al.* (2000) reported the results of field trial conducted with three rice varieties (Pusa Basmati 1, Kasturi and RNR 18833) which were direct sown from 15th July to 14th August at 15 days of interval. Variety RNR 18833 was reported to produce significant higher dry matter, heavier panicles and number of total grain and resulted in maximum grain yield of 3354 kg ha^{-1}, this accounted for additional grain yield over Pusa Basmati 1 by about 4%. The variety Kasturi yielded 2940 kg ha^{-1}. This was 12.3% less than the yield realised from the variety RNR 18833.

Lotha *et al.* (2005) reported the growth and yield of 7 direct sown upland rice cultivars (Leikhumo, Narendra, HUR-36, Chilarai, Luit, Saraju-52 and Pant-12) performed in the field experiment on Medziphema, Nagaland. Significantly the highest number of tillers/plant and shoot dry weight were recorded in Saraju-52, whereas the highest plant height was recorded in local cultivars Leikhumo. Sanju-52 also recorded significantly higher number of effective tillers, number of panicle m^{-2}, grain (40.03 q ha^{-1}) and straw (45.33q ha^{-1}) yields compared to other cultivars. Liekhumo recorded significantly highest number of filled grains per panicle as well as weight and length on panicle.

Yadav and Rao (2003) conducted field trial during *kharif* season in 1999 on rice cultivars IET-7564, IET-9219, IET-9614, IET-7613, IET-6155 and Poonima. IET-9219 was reported to have the highest number of panicle m^{-2} (179.4) and earlier to 50% flowering (75.6) and days to maturity (94). IET-7613 had the highest 100-seed weight (2.5 g), grain yield (30.62 q ha^{-1}) and grain yield per day (35.2 kg ha^{-1}).

Maiti *et al*. (2003) carried out a field experiment on different nitrogen fertilizer rate (0,120 and 140 kgha^{-1}) on the performance of 1 cultivar (IEY-4786) and 4 hybrid varieties and reported that the application of 140 kg ha^{-1} nitrogen resulted in the highest increase in grain yield (by 76.2%), number of panicle (by 109.00%), number of filled grains per panicle (by 26.2%) and 1000-grain weight (5.80) over the control.

Pramanik *et al*. (2003) reported the results of field trial conducted with medium duration high yielding rice cultivars (HYV: IET 6314, Ponni, Quing Livan No. 1 and Taichung Sen Yu). It was found that the high yielding rice cultivars were better than those farmers' cultivars. Ponni showed the highest number of panicle bearing tiller (13.4 tiller $hill^{-1}$) and longest panicle (24.2 cm). IET 6314 was the tallest

(115.3 cm). Taichung Sen Yu and Ponni showed the highest yield (5.5 t ha^{-1}) which was highest than that of the control (5.2 t ha^{-1}). The most preferred cultivar Quing Livan No 1, which was resistant to lodging and insect pest had better taste and bolder grain.

Subhendu and Swamy, S. N. (2003) studied the effects of poly rice (a commercial fertilizer containing N, P, K, Zn, Mn, Fe, B, and Mo) and N application on the performance of rice cultivars IR-64, BPT-5204 and MTU-1010 and reported that among the cultivars, MTU-1010 recorded the highest grain (5052 kg ha^{-1}) and straw (5322 kg ha^{-1}) yields, grain (1.49%) and straw (0.66%) N contents, total N uptake (105.36 kg ha^{-1}) and N recovery (29.98%), whereas BPT-5204 registered the highest gross returns (`35626 $ha^{-1}$), net returns (`25 183 ha^{-1}) and benefit cost ratio (2.39). Among the N treatments, N application during transplanting, tillering, panicle initiation and 50% flowering with poly rice resulted in the highest grain (5278 kg ha^{-1}) and straw (5310 kg ha^{-1}) yields, total N uptake (116.18 kg ha^{-1}), N recovery (35.89%), gross returns (`32320 $ha^{-1}$), net returns (`21420 ha^{-1}) and benefit cost ratio (1.96).

Mahajan *et al.* (2004) carried out field trial with rice cultivars PR 111, PR 113, PR 115, PR 116 and PR 64 which were directly sown or transplanted at 30 days old seedling during *kharif* season. Plant height, number of days to 50% flowering, panicle initiation and number of panicles were higher with direct sowing compared to transplanting. PR 111, PR 64, PR 113 and PR115 recorded to highest number of panicles, panicles length, number of grains $panicle^{-1}$ and1000-grain weight respectively. PR 115 recorded the highest yield (64.9 q ha^{-1} whereas PR 116 recorded the lowest (49.8 q ha^{-1}).

Paul and Rafeyn (2004) evaluated the performance of upland rice cultivars RR347-166, RR 347-167, RR 347-1, RR 267-1, RR 361-783, RR 361-1, CR 876-6, Vandana, Br. Gora and BAU 105. RR 347-166 gave the highest rice grain yield (19.51 qha^{-1}) while RR 347-1 gave the highest rice straw yield.

Hossain *et al.* (2005) recorded the performance of five local and three modern aromatic rice cultivars i.e., Kataribhog, Radhunipagal, Chinigura, Badshabhog, Kalizera, BRRI dhan 34, BRRI dhan 37 and BRRI dhan 38. The yield of modern cultivars i.e., BRRI dhan 34 recorded the highest grain yield.

Ghose *et al.* (2008) recorded the performance of indigineous local rice variety jotai in to N fertilizer application in which it was observed that 20 kg N ha^{-1} gave the highest yield of 5.5 t ha^{-1}.

Islama *et al*. (2009) carried out an experiment to assess the effect of four nitrogen levels *viz*. T_1 (full doze of urea i.e. 215 kg urea ha^{-1} at 15 DAT), T_2 (full doze of urea at two equal splits, 1/2 at 15 DAT+1/2 at 30 DAT), T_3 (full doze of urea at two equal splits, 1/2 at 15 DAT+1/2 at 55 DAT) and T_4 (full doze of urea at three equal splits, 1/3 at 15 DAT+1/3 at 30 DAT+1/3 at 55 DAT) on morpho-physiological attributes of Boro rice genotypes viz. V_1 (BINAdhan 5), V_2 (Tainan 3) and V_3 (BINAdhan 6), in which it was observed that V_3 (BINA dhan 6) produced the highest grain yield (40.26 g $hill^{-1}$) with the application of full doze of urea i.e. 215 kg urea ha^{-1} at 15, 30 and 45 DAT.

Mohanty *et al*. (2008) conducted an experiment on the response of rice (*Oryza sativa*) varieties *viz*., Vandana, ZHU-11-26, RR-361-1, Jaldi-6, RR-166-645, RR-348-6, Heera and Saria to varying fertilizer levels (60-30-30, 40-20-20, 20-10-10 kg N-P_2O_5-K_2O ha^{-1} and a control) under moist sub humid Alfisols and reported that Vandana was superior in control and 20-10-10 kg ha^{-1}, compared with the RR-348-6 in 40-20-20 kg ha^{-1} and RR-166-645 in 60-30-30 NPK kg ha^{-1}. Optimum NPK doses for attaining maximum yield were minimum for Saria and maximum for ZHU-11-26. For economic yield they were minimum for Saria while N was maximum for Vandana and K was maximum for ZHU-11-26. P was maximum for RR-166-645 at 750 and 1000 mm and ZHU-11-26 at 1 250 mm of rainfall. Optimum N ranged from 35 to 77 kg ha^{-1} while, P and K ranged from 16 to 67 kg ha^{-1} for maximum yield at a crop seasonal rainfall of 750 to 1250 mm. The optimum doses for economic yield ranged from 32 to 69 kg ha^{-1} for N, 15 to 56 kg ha^{-1} for P and 16 to 62 kg ha^{-1} for K in the study.

Patra and Bhattacharyya (2008) studied on the relative performance of 24 rice genotypes (*Oryza sativa* L.) under two levels of nitrogen supply in the rainfed medium low land ecosystem of Red and Laterite zone of West Bengal and reported that IET-8682 and UPR-103-80-1-2 had higher yields than IR-36, which was considered the most widely adopted cultivar in the zone. IET-8682, IR-36, IET-12703, Khitish, IET-10384 and UPR-103-80-1-2 also performed well in the absence of N fertilizer. The results indicated the superiority of CN-907-6-2 under both traditional (without N fertilizer application) and intensive methods of cultivation; thus, it may be recommended for cultivation under rainfed medium lowland ecosystem of the Red and Laterite zone of West Bengal, particularly in Jhargram.

Sarangi, S. K. (2008) studied on the effects of variety and integrated nutrient management practices on yield and productivity of rice (*Oryza sativa* L.)-rapeseed (*Brassica campestris* L.) cropping sequence and reported that both the varieties, Vandana and IR 6008-32 were at par with respect to grain and straw yields. The nutrient management practices had a significant effect on developmental phases of upland rice. The crop flowered and matured early due to application of recommended dose of fertilizer (RBD) + Single super phosphate incubated with FYM (1:2)+5 t FYM ha^{-1} with highest grain (2.60 t ha^{-1}) and straw (6.90 t ha^{-1}) yields.

Pal and Mahunta (2010) carried out a field experiment on the Growth of kharif rice (*Oryza sativa* L.) as influenced by age of seedlings and application of nitrogen fertilizer and farm yard manure with two cultivars (IET 4786 and IET 4094) and three fertility levels (40 kg N + 60 kg P_2O_5 + 40 kg K_2O ha^{-1}, 80 kg N + 60 kg P_2O_5 + 40 kg K_2O ha^{-1} and 15 t FYM + 60 kg P_2O_5 + 40 kg K_2O ha^{-1}) which revealed that for almost all the growth parameters, IET 4094 (Khitish) showed better performance over IET 4786 (Satabdi).

Singh *et al.* (2010) conducted a field experiment on the performance of hybrid rice (*Oryza sativa* L.) at different levels of phosphorus and zinc application and reported that Variety Proagro-6207 attained maximum plant height i.e. 120 and 126 cm followed by NDRH-2, Proagro-6444 and Sarju-52 at 80 days after transplanting. Maximum number of green leaves plant^{-1} (29.95 and 31.65) and leaf area index (6.97 and 7.18) were observed in variety Proagro-6444 followed by NDRH-2, Proagro-6207 and Sarju-52 in both the crop season. Grain yield and yield attributes significantly with increasing rates of phosphorus and zinc application. Effective tillers m^{-2} (323.11 and 329.11), length of panicle (33.48 cm and 34.32 cm), number of grains panicle^{-1} (120.60 and 125.50) and grain yield q ha^{-1} (72.75 and 76.43) were recorded in variety proagro-6444. In all the hybrids *viz.* Proagro-6207, NDRH-2 and Proagro-6444 recorded significantly higher grain yield.

Ranjitha *et al*. (2013) studied on the response of rice varieties to integrated nitrogen management practices in SRI method and reported that hybrid KRH-2 recorded significantly higher grain and straw yield than the other varieties. Among the different nitrogen management practices, application of 50% RDN (recommended dose of nitrogen) through urea and 50% through vermicompost resulted in significantly higher grain (5,520.8 kg ha^{-1}) and straw yield (6,264.9 kg ha^{-1}) followed by 100% RDN (through urea) application.

Jamkhogin *et al*. (2013) reported the results of field trial conducted with seven local *jhum*/upland rice genotypes from different regions of India namely. South India (Coimbatore localrice cultiva'Cv7'North India (HimachalPradesh local rice cultivar'Cv6'), and North-East India (Manipur local rice cultivar 'Cv1, Cv2, Cv3, Cv4 and Cv5', collected from the five hill districts of Manipur) respectively. It was observed that the local genotype from Manipur (Cv4), locally known as *Rasom* exhibited the highest yield and significantly better performances in yield a ttributes, harvest index, nutrient content and uptake than other cultivars.

Hussain *et al.* (2014) studied four varieties of rice for their growth and yield characteristics with 80-100-90 NPK Kg ha^{-1} and reported that Koshihikari variety was the tallest (117 cm). Plant length increased in all varieties with elongation of stem internodes till full heading stage. Japonica varieties produced higher number of tillers

m^{-2} due to their genetic variations; higher dry weight (t ha^{-1}), leaf area index, number of panicles m^{-2} due to more number of tillers production and lower nitrogen contents in panicle, stem and leaves. NERICA-4 gave higher number of spikelets $panicle^{-1}$ (106) and harvest index (0.47). The highest straw weight (11.53 t ha^{-1}) and paddy yields (6.79 t ha^{-1}) and lowest harvest index (0.37) were obtained from IR-28.

Okuno *et al.* (2014) reported that traditional varieties of rice grow excessively tall when fertilizer was abundant and become susceptible to lodging with significant yield loss. In contrast, varieties with short stature were resistant to lodging even when fertilized excessively and thus were capable of supporting their own body even if high grain yielding trait was introduced.

Soares *et al.* (2014) evaluated the performance of a hybrid cultivar of upland rice (Ecco) and 5 conventional cultivars in 2 environments. There was no cultivar-environment interaction for all traits and with 90-80-90 kg NPK ha^{-1} the cultivars performed similar in relation to the number of whole grains $panicle^{-1}$, sterile grain number $panicle^{-1}$, mass of grains $panicle^{-1}$ and 1000 grain weight. With respect to tillering and panicle number $area^{-1}$, Ecco hybrid was superior and the most productive among all tested cultivars. Among the characteristics evaluated**,** tillering influenced the productivity of upland rice.

Abdul Hamid *et al*. (2016) conducted on farm trials involving fifteen (15) farmers of five villages representing tidal flood plain. There was significant varietal difference in fertilizer response. Variety Sadamota gave higher yield (3.84 t per ha) than the other two varieties. This was attributed to more panicles per unit area and larger number of spikelets per panicle. Varieties, Moulata and Sadamota respectively produced 26 and 21% higher yield when grown with a moderate dose of 40 kg N, 15 kg P and 24 kg K per ha. Fertilizer induced higher yield in Sadamota was associated with greater number of filled spikelets per panicle and larger grain size.

Gupta *et al.* (2016) observed that number of grains $panicle^{-1}$ was significant among the rice cultivars but not with other yield contributing characters viz. panicle length, number of panicles m^{-2} and number of tillers m^{-2}. CR Dhan-40 (224 grains) gave the highest number of grains $panicle^{-1}$ followed by Sahbhagi Dhan (208 grains). Also, the highest grain yield and straw yield was significantly recorded with Rajendra Suwasini (42.4 q ha^{-1}) and Abhishek (60.3 q ha^{-1}) respectively.

2.3 Effect of NPK on the economics

Pattanayak *et al.* (2008) revealed that the cumulative two-season production cost of hybrid rice varied between ₹ 35,302 ha^{-1} to ₹ 67,676 ha^{-1}. Highest income (₹ 128,303 ha^{-1}) and profit (₹ 62,497 ha^{-1}) was obtained with full recommended dose of nutrient application (290 kg N, 170 kg P_2O_5, 180 kg K_2O, 1 kg B, 7 kg Zn, and 4 kg Cu ha^{-1} + 100% P dose). Application of 150% of the recommended rates of nutrients gave no extra economic advantage.

Dobermann (2012) reported that the shorter duration of Sahbhagi Dhan allowed farmers to use remaining moisture in the field to plant and grow subsequent summer season legume or pulse crops, thereby providing additional returns and better nutritional security to poor farmers of rainfed ecosystems.

Sharma *et al*. (2012) reported an increase in net return and benefit: cost ratio with increasing levels of NPK application in rice and gave the highest return under 100% NPK levels. Economics was governed mainly by grain yield. The highest net return and benefit to the cost ratio were maximum with 90 kg N, 45 kg P ha^{-1}, the increase was due to higher yields in those treatments that contributed more return over control.

Mondal *et al.* (2013) revealed that fertility levels exerted significant effect on economics of hybrid rice production. Results advocated that crop at medium plant density (33 hills m^{-2}) with medium fertility 125 kg N, 62.5 kg P_2O_5 and 62.5 kg K_2O ha^{-1} produced the highest grain yield (7039 kg ha^{-1}) and paid the highest gross (₹ 87,970 ha^{-1}) and net returns (₹ 59,695 ha^{-1}) during *kharif* season.

Malabayabas *et al*. (2014) reported that direct seeding and shorter duration rice varieties enabled farmers to obtain a higher yield and income, with early planting and harvest of boro crops and selling of their crops at a time when the supply in the market was low and prices were higher thus, ensured efficient use of limited resources for sustainable agricultural production.

Nayak *et al*. (2015) reported that the highest cost of cultivation (₹ 34,948 ha^{-1}) was recorded with the application of nitrogen at 80 kg ha^{-1} and the lowest (₹ 33,892 ha^{-1}) with control (no nitrogen). The maximum gross return (₹ 51,763 ha^{-1}), net return (₹ 16,815 ha^{-1}) and benefit: cost ratio (1.48) were obtained from the crop receiving 80 kg N ha^{-1} which might have produced higher grain yield with higher nitrogen levels.

Samant *et al*. (2015) analysis on economics revealed that Sahabhagi dhan recorded higher gross return of ₹ 50,365 ha^{-1} with a benefit-cost ratio of 1.38 and additional net return of ₹ 6,059 ha^{-1} as compared to farmers practice (Khandagiri-local check) which gave the net return ₹ 7,706 ha^{-1} and benefit-cost ratio 1.24.

Tiwari *et al.* (2015) revealed that higher net income resulted due to higher yields that fetched higher market price. Variety PS 3 proved its superiority to PS 5, IR 64, Danteshwari and Vandana varieties by giving highest net income up to ₹ 49778 ha^{-1} with B:C ratio 3.55.

Aruna *et al.* (2016) reported from the two years experiment on aerobic rice that net returns and benefit: cost ratio (B: C ratio) were influenced significantly with graded levels of nutrient. The nutrient level with 175% RDN- recommended dose of nutrients (140:70:70 kg N, P_2O_5, K_2O ha^{-1}) was superior to all other treatments (i.e. Net returns ₹ 36,634 $ha^{-1}$and B: C ratio 3.20). The treatment with 75% RDN (60:30:30 kg N, P_2O_5, K_2O ha^{-1}) was significantly recorded the lowest (i.e. Net returns ₹ 17,815 $ha^{-1}$and B: C ratio 2.20).

Borah *et al.* (2016) reported that nutrient management exerted significant effect on gross and net returns from rain fed upland rice. All the fertility treatments markedly increased the gross and net returns over those of the control plots that paid the lowest return during both the years under the study. Use of only chemical fertilizers (100% RDF: 40.0-8.9-16.7 kg NPK ha^{-1}) incurred quite low cost in comparison with other fertility treatments.

Raj *et al*. (2016) revealed that rice hybrids obtained maximum gross return(₹ 70,900 ha^{-1}), net return (₹ 40,500 ha^{-1}) and benefit: cost ratio (1.33) at 125% RDF (Recommended dose of fertilizers; 187.5:93.75:75:31.25 N, P_2O_5, K_2O, $ZnSO_4$ kg ha^{-1}) as compared to RDF (150:75:60:25 N, P_2O_5, K_2O, $ZnSO_4$ kg ha^{-1}) and farmer's dose (80:30:30 N, P_2O_5, K_2O, $ZnSO_4$ kg ha^{-1}).

2.4 Effect of NPK on nutrient uptake

Fageria (2001) reported that upland rice genotypes differed significantly with N, P, K utilization. Approximately 70 to 80% of the total K uptake was found to remain in the shoots of rice.

Sudha and Chandini (2002) observed higher uptake of N, P and K (161.38, 21.74, 149.64 kg NPK ha^{-1}) with the highest level of NPK addition (105, 52.5, 52.5 kg N, P_2O_5 and K_2O ha^{-1}) due to the increased availability of the nutrients.

Awan *et al.* (2003) found that nitrogen and phosphorus concentration in both paddy and straw increased with increasing rate of N and P application to soil. Maximum paddy contents of N (1.45%) and P (0.38%) were obtained with highest doses of 180 kg N ha^{-1} and 100 kg P ha^{-1} respectively. Also with the same dose, maximum straw contents of N (0.75%) and P (0.18%) were obtained. Addition of P and K to soil significantly increased the K contents in both paddy and straw. Maximum K contents in paddy (0.45%) and straw (1.89%) were obtained with the treatment 120-75-100 NPK kg ha^{-1}.

Panaullah *et al.* (2006) reported that majority of K uptake was in straw and the proportion in grain varied little across 3 experimental sites. The larger K uptake under soil test-based (STB) at all sites is attributable to greater N application, which promoted greater biomass concentration in rice.

Nachimuthu *et al*. (2007) revealed from the experiment that NPK uptake were highest during panicle initiation to first flowering stages for the tested variety CO 47. Increase in P and K uptake with increased dose of N had synergistic effect on the uptake of other nutrients besides N which was due to increase in biomass of the crop with increased N application.

Saha *et al*. (2007) reported higher nutrient uptake in those treatments that produced the higher biomass. And the nutrient concentration in straw at harvest during wet season were 0.44-0.95% N, 0.06-0.14% P, 0.90-1.20% K and in grain were 1.12-1.43% N, 0.26-0.30% P, 0.17-0.20% K.

Arif *et al.* (2010) reported that total K uptake increased gradually with an increase in K application up to certain extent but the uptake varied with genotypes. Further application of K @ 90 and 120 kg K ha^{-1} resulted in a sharp decrease in total K uptake in genotype 99509, while in Super basmati was insignificant. Lesser total K uptake had higher grain yield, resulted high KUE (potassium use efficiency) in terms of grain yield.

Fageria *et al.* (2010) reported higher nitrogen (N) concentration in grain compared to shoot. In grain, N concentration was not influenced either by N or by genotype treatments but N uptake was only influenced by N treatment. Uptake of N in shoot as well as in grain had a highly significant association with grain yield.

Sharma *et al*. (2012) observed through an experiment that Nitrogen content in grain was non-significant with NP levels .Phosphorus content in grain was maximum with 120 kg N, 45 kg P_2O_5 ha^{-1}. In straw, N and P content were also higher in 120 kg N, 45 kg P_2O_5 ha^{-1}. The combined application of NP was reported to increase availability of N and P in soil and also increased cation exchange capacity of roots that enhanced N and P absorption in plants. Thus, increased NP concentration in grain and straw. Semi-dwarf cultivar (Pusa Basmati-1121) showed maximum uptake than tall cultivars (CSR-30 and HKR03-408).

Crusciol *et al*. (2013) found that level of phosphorus affected nutrients contents in shoots and root system of upland rice cultivars. The increasing phosphorus fertilization increased the uptake of nutrients per meter of root.

Fageria and Knupp (2013) reported through a study that nitrogen and phosphorus accumulations were maximum in grain, whereas, potassium accumulations were maximum in shoot at harvest in upland rice cultivar Talento.

Yan-hong *et al*. (2014) through a five-year (2008-2012) experiment reported an increase in potassium uptake by rice plant, especially rice straw with the increasing amount of potassium application.

Zadeh (2014) observed that nitrogen uptake of straw was lower than grain uptakes. Distribution of N in the straw and grain varied with the genotypes. However, across the genotypes, N accumulation of 60% in the grain and 40% in the shoot were observed. The treatment with the highest nitrogen level (80 kg N ha^{-1}) produced the highest grain yield (3373 kg ha^{-1}) was recorded with the highest straw nitrogen uptake (42.9 kg ha^{-1}) and total nitrogen uptake (87.7 kg ha^{-1}).

Nayak *et al.* (2015) reported a significant increase in uptake of N, P and K by grain and straw with successive increase in nitrogen levels up to 80 kg ha^{-1}. This was due to cumulative effect of increase in straw yield as well as increased nutrient content in straw.

Aruna *et al.* (2016) reported that nutrient uptake of aerobic rice was significantly influenced and increased progressively with graded nutrient levels. The highest NPK uptake 98.3, 24.8, 126.6 kg NPK ha^{-1} was recorded with 175% RDN (140:70:70 kg N, P_2O_5, K_2O ha^{-1}) which was at par with 150% RDN (120:60:60 kg N, P_2O_5, K_2O ha^{-1}). Higher level of nutrient supply was found to be conducive for extensive root proliferation to absorb larger quantities of nutrients that often correlated positively with dry matter production and concentration of nutrients in the plant.

Hashem *et al.* (2016) revealed that NPK uptake by rice grain (kg ha^{-1}) increased significantly with nitrogen application up to 165 kg N ha^{-1}. Application of 165 kg N ha^{-1} with K_2O (2% through potassium sulfate) produced the highest values of NPK uptake by rice grain (kg ha^{-1}).

CHAPTER-III

MATERIALS AND METHODS

The present investigation entitled "Response of local rice (*Oryza sativa* L.) Cultivars to different levels of N, P and K under upland rainfed condition of Nagaland" was carried out in the experimental research farm of School of Agricultural Sciences and Rural Development (SASRD), Nagaland University campus, Medziphema during the *kharif* seasons of 2015-16. The details of materials used and the research methodology followed during the investigation for recording various observations and analysis are described below.

3.1 General information

3.1.1. Site of experiment

The experimental farm is located in the foot hill of Nagaland at an altitude of 310 metres above mean sea level with the geographical location at 25^{o} $45^{/}$ $43^{//}$North latitude and 95^{o} $53^{/}04^{//}$ East longitude. Previously, the selected crop field was under rice -rice cropping sequence since 2013-2014.

3.1.2. Climatic condition

The climatic condition of the experimental site is sub-tropical with high humidity and moderate temperature, having medium to high rainfall. The mean temperature ranges between 21^{o} C to 32^{o} C during summer and rarely goes below 8^{o}C in winter due to high atmospheric humidity. The annual rainfall ranges from 2000-2500 mm, spread over six months *i.e.*, from April to September, while the remaining period from October to March is virtually dry. More precise information on meteorological data during the investigation is presented in Table 1(a) and 1(b) and illustrated in Fig. 1(a) and 1(b).

The data are presented on a weekly basis, starting from June to harvest of crop during 2015 and 2016.

Table 1 (a) Meteorological data during the period of investigation (2015)

Week no.	Temperature		Relative humidity (%)		Total rainfall (mm)	Bright Sunshine Hours	Number of Rainy Days
	Max. (°C)	Min. (°C)	Max. (%)	Min. (%)			
22	30.7	23.5	80	54	8.4	44.2	1
23	32.2	23.9	82	53	10.2	3.3	2
24	29.9	24.2	85	61	112.3	1.7	5
25	31.7	25.2	81	65	19.3	4.5	3
26	32.4	25.3	81	58	47.0	4.8	4
27	32.3	25.4	84	57	47.4	2.8	2
28	32.4	25.2	87	59	81.1	3.6	4
29	29.9	24.6	85	66	127.9	1.6	5
30	32.7	24.3	83	53	53.8	6.2	4
31	30.8	24.3	82	63	32.3	1.8	3
32	32.1	25.0	85	65	47.1	4.7	3
33	33.1	25.8	82	56	15.9	4.0	2
34	30.8	24.8	84	64	60.4	2.3	4
35	30.8	24.9	81	62	81.4	1.6	3
36	32.0	24.6	82	58	86.2	4.8	2
37	32.6	24.6	86	59	64.1	6.4	2
38	31.8	24.2	85	59	30.1	4.7	3
39	31.4	23.7	86	58	5.2	6.6	1
40	34.0	24.4	88	64	19.7	6.1	2
41	31.0	22.0	94	69	41.1	1.7	2
42	30.8	20.6	91	63	0.3	8.6	0
43	31.2	17.6	93	54	0.1	8.8	0
44	29.2	18.6	93	66	19.8	5.5	2
45	28.4	16.2	93	61	0.9	7.1	0

46	28.5	15.4	94	60	0.0	7.0	0
47	28.3	12.8	93	53	0.0	7.9	0
48	27.9	12.7	91	54	0.0	7.3	0

Source: ICAR Research Complex for NEH Region, Nagaland centre Jharpani.

Table 1(b) Meteorological data during the period of investigation (2016)

Week no.	Temperature		Relative humidity (%)		Total rainfall (mm)	Bright Sunshine Hours	Number of Rainy Days
	Max. (°C)	Min. (°C)	Max. (%)	Min. (%)			
22	31.9	23.1	92	70	42.6	5.1	4
23	34.7	24.0	87	63	3.9	6.9	0
24	32.9	25.8	90	72	71.3	3.3	4
25	32.9	24.5	90	71	85.5	3.0	3
26	33.6	25.3	89	68	30.2	3.8	3
27	33.3	24.8	92	70	133.2	3.4	6
28	33.4	25.3	91	79	28.1	4.0	5
29	32.0	24.8	91	67	57.1	0.5	2
30	30.6	23.9	93	73	36.6	1.2	2
31	34.2	24.8	92	65	9.6	5.3	1
32	32.6	24.1	94	72	110.9	3.5	6
33	34.6	24.6	91	69	126.4	3.9	3
34	33.7	24.4	91	68	15.2	4.5	2
35	33.9	23.9	94	71	149.9	3.9	6
36	32.9	24.6	93	70	53.6	4.4	3
37	32.4	23.7	94	74	94.1	3.4	5
38	32.7	23.6	94	74	69.9	5.1	5
39	32.2	23.9	95	74	60.0	5.3	5
40	33.9	23.4	94	66	2.8	8.2	0

41	31.9	22.9	93	79	18.3	3.8	2
42	31.7	21.7	94	66	1.8	7.8	0
43	31.1	20.3	94	67	1.5	6.2	0
44	29.2	20.4	94	68	11.4	6.9	2
45	26.6	18.5	94	80	130.1	2.7	3
46	29.1	16.9	95	62	0.0	7.9	0
47	28.0	11.8	95	54	0.0	8.2	0
48	26.5	13.7	95	58	0.6	5.4	0

Source: ICAR Research Complex for NEH Region, Nagaland centre Jharpani.

3.1.3 Soil condition

In general, the soil type of the experimental site was categorised sandy loam in texture and well drained. The texture and fertility of the soil was ascertained by taking representative soil samples randomly from each experimental plot taken at a depth of 0-15 cm with the help of a screw auger, which was processed and analysed by methods of mechanical and chemical analysis. The results thus obtained are presented in Table 2.

Table 2(a). Initial soil fertility status of the experimental field

Characteristics	Method followed	2015		2016	
		Content	Inference	Content	Inference
pH	Digital pH meter (Single electrode meter)	4.75	Acidic	4.60	Acidic
Organic carbon (%)	Walkley and Black Method, (Piper, 1966)	1.72	High	1.66	High

Available N (kg ha^{-1})	The alkaline – potassium permanganate method (Subbiah and Asija, 1956)	210	Medium	204.21	Medium
Available P_2O_5 (kg ha^{-1})	Bray and Kurtz method, 1945	19.42	Medium	19.11	Medium
Available K_2O (kg ha^{-1})	Flame photometer (Hanway and Heidal, 1952)	198.21	Medium	223.42	Medium

3.2. Experimental details

3.2.1 Seed material

Seeds of different local rice cultivars: Gwabilo ssu, Hoikha, Ronga shea and Semvu shea were collected from different districts of Nagaland preferably those practicing jhum cultivation to analyse their response under different fertilizer doses. These local varieties were selected because it was found to be popularly grown in their respective areas. Also a hybrid dwarf variety Sahbhagi was collected from Hazaribagh (ICAR-NRRI, Regional centre) to act as a check variety to the mentioned cultivars.

3.2.2 Experimental design

The experimental design that was conducted in the experiment field was Randomized Block Design (RBD) with three replications and it has factorial concept. The whole experimental field was divided into 3 equal blocks with each block sub-divided into 20 plots, in total consisting of 60 plots. Placement of each treatment was done in randomized manner into the plots of each block. The details of the plan and layout of the experimental field are given in Fig. 2.

3.2.3 Details of the experiment

Rice cultivars	**: 4- different local rice cultivars and 1 check variety**	
		V_1- Gwabilo ssu
		V_2- Hoikha
		V_3- Ronga shea
		V_4-Semvu shea
		V_5- Sahbhagi dhan (Check variety)
Fertilizer dose	**: 4- different NPK doses**	
		F_0- 0:0:0NPK kg ha^{-1}
		F_1-30:15:15 NPK kg ha^{-1}
		F_2-60:30:30 NPK kg ha^{-1}
		F_3-90:45:45 NPK kg ha^{-1}

Experimental design	:	FRBD
Replication	:	3
Total number of plots	:	60
Plot size	:	4m x 3m
Block border	:	1.5m
Plot border	:	0.5m
Seed rate	:	80 kg ha^{-1} (Direct seeded)
Method of sowing	:	Line sowing at 20cm row spacing

3.2.4 Treatment details

The experiment was carried out with the following treatments

Treatment combinations	**Symbol**
Cultivar Gwabilo ssu + control	T_1 (V_1F_0)
Cultivar Gwabilo ssu + 30:15:15 NPK kg ha^{-1}	T_2 (V_1 F_1)
Cultivar Gwabilo ssu + 60:30:30 NPK kg ha^{-1}	T_3 (V_1 F_2)
Cultivar Gwabilo ssu + 90:45:45 NPK kg ha^{-1}	T_4 (V_1 F_3)
Cultivar Hoikha + control	T_5 (V_2 F_0)
Cultivar Hoikha + 30:15:15 NPK kg ha^{-1}	T_6 (V_2 F_1)
Cultivar Hoikha + 60:30:30 NPK kg ha^{-1}	T_7 (V_2 F_2)

Cultivar Hoikha + 90:45:45 NPK kg ha^{-1}	T_8 (V_2 F_3)
Cultivar Ronga shea + control	T_9 (V_3 F_0)
Cultivar Ronga shea + 30:15:15 NPK kg ha^{-1}	T_{10} (V_3 F_1)
Cultivar Ronga shea + 60:30:30 NPK kg ha^{-1}	T_{11} (V_3 F_2)
Cultivar Ronga shea + 90:45:45 NPK kg ha^{-1}	T_{12} (V_3 F_3)
Cultivar Semvu shea + control	T_{13} (V_4 F_0)
Cultivar Semvu shea + 30:15:15 NPK kg ha^{-1}	T_{14} (V_4 F_1)
Cultivar Semvu shea + 60:30:30 NPK kg ha^{-1}	T_{15} (V_4 F_2)
Cultivar Semvu shea + 90:45:45 NPK kg ha^{-1}	T_{16} (V_4 F_3)
Variety Sahbhagi dhan + control	T_{17} (V_5 F_0)
Variety Sahbhagi dhan + 30:15:15 NPK kg ha^{-1}	T_{18} (V_5 F_1)
Variety Sahbhagi dhan + 60:30:30 NPK kg ha^{-1}	T_{19} (V_5 F_2)
Variety Sahbhagi dhan + 90:45:45 NPK kg ha^{-1}	T_{20} (V_5 F_3)

3.2.5 Characteristic of rice varieties

1) **Gwabilo ssu:** Gwabilo ssu is a local cultivar collected from northern part of Kohima district where jhum cultivation is a major practice. The seeds are light brown in colour and slender in shape. The crop has duration of 125-130 days and a yield potential of 1500 kg ha^{-1}.

2) **Hoikha:** This cultivar was collected from Zuneboto district. The seeds are awned in nature and light brown in colour with a slender shape. The crop has duration of 125-130 days and a yield potential of 1800 kg ha^{-1}.

3) **Ronga shea:** This cultivar was collected from Phek district. The seeds are light brown in colour having a slender shape and comparatively smaller in size with the husk tightly intact. The crop has duration of 130-135 days and a yield potential of 1400 kg ha^{-1}.

4) **Semvu shea:** This cultivar was also collected from Phek district. It is a highly favoured cultivar in the area because of its high yielding and resistant properties.The seeds are dark brown in colour with a bold shape and slightly

awned. The crop has a duration of 130-135 days and a yield potential of 2000 kg ha^{-1}.

5) **Sahbhagi dhan:** Sahbhagi Dhan (IR74371-70- 1-1) is a drought-tolerant rice variety that was released in India in 2010—and subsequently in Nepal as 'Sukha Dhan 3' and in Bangladesh as 'BRRI Dhan 56'—and has performed well in rainfed farmers' fields. The seeds are golden brown in colour with a slender shape and have duration of 125-130 days and a yield potential of 2500 kg ha^{-1}.

3.3 Agronomic practices

Table 2(b): Calendar of agronomic management practices

Sl.no	Operations	Date	
		2015	2016
1.	First ploughing	15.05.15	12.05.16
2.	FYM application	19.05.15	19.05.16
3.	Second ploughing	10.06.15	08.06.16
4.	Layout	14.06.15	09.06.16
5.	First split of N	16.06.15	11.06.16
6.	Sowing	16.06.15	11.06.16
7.	Thinning	18.07.15	13.07.16
8.	First weeding	22.07.15	19.07.16
9.	Second weeding	24.08.15	21.08.16
10.	Second split of N	21.09.15	17.09.16
11.	Harvesting		
12.	a. First	06.11.15	04.11.16
13.	b. Second	11.11.15	10.11.16
14.	c. Third	18.11.15	16.11.16

	Threshing	26.11.15	28.11.16

3.3.1. Selection and preparation of field

A suitable site was selected to carry out the research in the experimental field in Agronomy block at SASRD farm, Medziphema. The experimental field was ploughed with tractor drawn disc plough in second week of May followed by second ploughing in first week of June. Final ploughing and breaking of clods were done with the help of a rotovator during the second week of June. Then finally the field was laid out according to the plan and design of the experimental field.

3.3.2. Manures and fertilizers

Well decomposed farm yard manures (FYM) @ 15 tonnes ha^{-1} was uniformly broadcasted and thoroughly incorporated over the experimental plot during the final land preparation.

The recommended level of nitrogen, phosphorus and potassium were applied in the form of urea, single super phosphate (SSP) and murate of potash (MOP), respectively as per the given treatment details. NPK was applied in 3 different doses, *i.e.*, the first dose include 30 kg N ha^{-1}, 15 kg P_2O_5 ha^{-1} and 15kg K_2O ha^{-1}. Nitrogen was applied in 2 split doses. First split dose of 15 kg N ha^{-1} and full dose of phosphorus (15kg P_2O_5 ha^{-1}) and potassium (15 kg K_2O ha^{-1}) was applied as basal application before sowing followed by second split dose of 15 kg N ha^{-1} at panicle initiation stage. The second fertilizer dose includes 60 kg N ha^{-1}, 30 kg P_2O_5 ha^{-1} and 30 kg K_2O ha^{-1} and the third dose includes 90 kg N ha^{-1}, 45 kg P_2O_5 ha^{-1} and 45 kg K_2O ha^{-1}. Similar method of application was followed.

3.3.3 Seed and sowing

First healthy and clean seeds were selected and treated with fungicide Bavistin against seed borne diseases.

For sowing, furrows were made in lines with spacing of 20 cm apart. Which was followed by spreading of malathion dust over the furrows and then slightly covering with soil to control ants and termites. After which line sowing of the seeds were done maintaining a depth of about 3-5 cm. The sowing was done on 16^{th} june. While during the second year sowing was done a few days ahead i.e., 11^{th} of june owing to variation in climatic condition.

3.3.4 Thinning and gap filling

The thinning operation was carried out after about one month of sowing to maintain an optimum plant population by removing excess germinated seedlings and at the same time gap filling was done in required plots.

3.3.5. Weed control

Hand weeding was done twice with the help of khurpi and local hoe at 30 days interval from the date of sowing. This cultural operation was carried out because during the seedling stage the crop-weed competition is very high specially for direct seeded rice.

3.3.6. Insect pest and disease management

After sowing, soil drenching of bunds around the plots were done with Chloropyriphos 20 EC @ 2 ml $litre^{-1}$ of water to control termites, since the experimental plot has a history of heavy termite infestation.

Phorate 10% (granules) @ 1 kg a.i. ha^{-1} and Chloropyriphos 20 EC @ 2.5 ml $litre^{-1}$ of water was applied to control stem borer. Gundhi bug and plant hoppers were found to be prevalent during flowering and milking stage of the crop. Dusting of malathion 5% dust @ 25 kg ha^{-1} was done to control the same.

Since the area was blast prone, infestation was observed during the vegetative stage but it was found to be below the economic threshold level, however contaf hexadeconale 0.5 EC @ 1ml per litre of water was applied to control further spreading.

Besides the insect pest infestation, severe bird attack during the maturity stage was a serious matter of concern causing much loss of crop yield. Though several cultural as well as technical methods were applied to manage the problem, desired result couldn't be achieved.

3.3.5 Harvesting and threshing

Since there are five different varieties, harvesting and threshing were done at different dates. Harvesting was done with the help of sickle by cutting the plant close to the ground. The plants were then made into bundles which were labeled according to treatment and replication number and the bundle were sun dried and threshed with the help of mechanical thresher. After threshing, winnowing was done; thereafter grains were dried in the sun.

3.4 Experimental observations to be recorded

3.4.1. Meteorological observations

Meteorological observations on rainfall (mm), relative humidity (%), temperature (maximum and minimum in ◦C), bright sunshine hours and number of rainy days (mm) were recorded for the research period during both the years.

3.4.2. Growth attributes

Five plants were randomly selected in each plot and tagged. Their growth attributes were recorded.

3.4.2.1.Plant height (cm)

Five plants in each plot were tagged for recording the plant height. The plant height was measured in centimetres from the ground level to the tip of the upper most leaf of the plant at 30, 60, 90 DAS and at harvest. The average plant height was calculated for each treatment respectively.

3.4.2.2.Plant population m^{-2}

Plant population was calculated by counting the number of plants per running metre in a randomly selected row multiplied by the number of rows m^{-1} and thereby converted into plant population m^{-2}.

3.4.2.3.Number of tillers m^{-2} at 90 DAS

The number of tillers m^{-2} was also calculated by counting the number of tillers per running metre in a randomly selected row multiplied by the number of rows m^{-1} and thereby converted into number of tillers m^{-2}.

3.4.2.4.Number of leaves $plant^{-1}$

The numbers of green leaves were counted from the tagged plants in each plot and the average was recorded for 30, 60 and 90 DAS.

3.4.2.5.Crop growth rate (CGR)

The crop growth rate was calculated by taking the dry weight of the tagged plants at 30 and 60 DAS and expressed as g m^{-2} day^{-2}.

$$\mathrm{CGR} = \frac{\mathrm{W2} - \mathrm{W1}}{(t2 - t1)S}$$

Where,

W_1 and W_2 are plant dry weight (g) at time t_1 and t_2, respectively

S is the land area (m^2) over which dry matter was recorded.

3.4.2.6.Relative growth rate (RGR)

The relative growth rate was calculated from the obtained crop growth rate values and expressed as g of dry matter produced by a g of existing dry matter in a day.

$$RGR = \frac{\log eW2 - \log eW1}{T2 - T1}$$

Where,

W_1 and W_2 are plant dry weight (g) at time T_1 and T_2, respectively

3.4.2.7.Leaf area index (LAI)

Five leaves were collected from each tagged plant and run through LAI meter and calculated. However the formula applied for LAI is given as-

$$LAI = \frac{\text{Leaf area}}{\text{Ground area}}$$

3.4.3 Yield and yield attributes

3.4.3.1. Number of panicles m^{-2}

The number of panicles m^{-2} was calculated by counting the number of panicles per running metre in a randomly selected row and the data thus obtained was converted into number of panicles $m\text{-}^{2}$.

3.4.3.2. Length of panicle (cm)

Five panicles were selected at random from each plot and the length of each panicle was measured from base to the tip of the last grain and average length was expressed and recorded in centimetre (cm).

3.4.3.3. Weight of panicle (g)

From the collected samples of randomly selected panicles, the weight of five panicles was recorded and the mean was calculated.

3.4.3.4. Number of filled and unfilled grains panicle^{-1}

From the collected samples of randomly selected panicles, number of fertile grains panicle^{-1} was counted and the average was recorded thereafter.

3.4.3.5. Filled grain percent (%)

Five panicles were randomly selected and the number of fertile and unfertile grains per panicle was counted and thereafter calculated using the given formula. The average was then recorded.

$$\text{Filled grain percent (\%)} = \frac{\text{Number of filled grains per panicle}}{\text{Total number of grains per panicle}} \text{X } 100$$

3.4.3.6. Test weight (g)

From the grain yield of individual plot, test weight was taken randomly by counting thousand grains.

3.4.3.7 Grain yield (kg ha^{-1})

The obtained grains from each plot after threshing were thoroughly sun dried and then weighed to determine the grain yield in terms of kg ha^{-1}. The grain yield obtained from each plot was recorded and later converted into kg ha^{-1} using the formula:

$$\text{Grain yield (kg ha}^{-1}) = \frac{\text{weight of the grain per plot(kg)}}{\text{size of the plot(m2)}} \times 10000$$

3.4.3.8 Straw yield (kg ha^{-1})

The straw bundles collected from each plot after threshing were allowed to dry in the sun for some days and then weight was taken separately to determine the straw yield in terms of kg ha^{-1}. The grain yield obtained from each plot was recorded and later converted into kg ha^{-1} using the formula:

$$\text{Straw yield (kg ha}^{-1}) = \frac{\text{weight of the straw per plot(kg)}}{\text{size of the plot(m2)}} \times 10000$$

3.4.3.8. Harvest index (%)

Harvest index was calculated by dividing the grain yield of the crop by its biological yield multiplied by 100. The formula applied is shown as

$$\mathrm{HI}(\%) = \frac{\text{Grain yield}}{\textit{Biological yield}} \text{ x } 100$$

3.4.3.9. Production Efficiency (kg kg^{-1})

Production efficiency of the crop was worked out by calculating the difference in yield over various levels of additional nutrient applied. It is expressed in kg kg^{-1}.

$$\mathrm{PE}\ (\mathrm{kg\ kg} - 1) = \frac{\mathrm{GYn} - \mathrm{GYn} - 1}{\mathrm{Nn} - \mathrm{Nn} - 1}$$

Where,

GY_n = Grain yield or economic yield with N_n amount of nutrient.

GY_{n-1} = Grain yield or economic yield with N_{n-1} amount of nutrient.

3.4.4 Phenological observations

3.4.4.1. Days to 50 % flowering

Days to 50 % flowering of the crop were observed for individual treatment plot and recorded.

3.4.4.2. Days to maturity

The days to maturity were recorded for individual treatment plot and it was worked out from the date of sowing to the date of harvesting.

3.4.5 Nutrient status of the soil and plant after harvest

To determine the nutrient status of the experimental field, soil samples were collected from each plot at a depth of 15 cm with the help of screw type auger. The collected soil samples were dried under shade ground and sieved for determination of following nutrient status.

3.4.5.1 Soil pH

The pH of the soil was determined in 1:2 soil water suspensions using Digital pH metre.

3.4.5.2 Soil organic carbon

The organic carbon of the soil was determined by Walkley and Black titration method (Piper, 1966). The result was expressed in terms of percentage.

3.4.5.3 Available nitrogen

The available soil nitrogen (N) was determined by Alkaline Potassium Permanganate Method as suggested by Subbiah and Asija (1956) and the data was calculated in terms of kg ha^{-1}.

3.4.5.4 Available phosphorus

The available soil phosphorus (P_2O_5) was determined by Bray's method (Bray and Kurts, 1945). The results were expressed in kg ha^{-1}.

3.4.5.5 Available potassium

The available potassium (K_2O) in soil was determined by Neutral Normal Ammonium Acetate Method (Hanway and Heidal, 1952) and the result obtained was expressed in kg ha^{-1}.

3.4.5.6 Nutrient balance sheet of soil

After the harvest of crop the nutrient balance sheet of the research plot was worked out and accordingly nutrient status was evaluated.

3.4.6 Plant sample for NPK uptake

The rice plant after threshing was dried in the oven and grinded and then sieved for determination of NPK uptake.

3.4.6.1 Nitrogen uptake

The nitrogen content in the digested rice sample was determined by kjeldahl distillation method (Jackson, 1973), and the uptake was calculated by multiplying with grain and straw yield.

3.4.6.2 Phosphorus uptake

The phosphorus content in the digested rice sample was determined by vanado molybdophoshoric acid yellow colour method using spectrophotometer at 660 nm (Jackson, 1973).

3.4.6.3 Potassium uptake

The potassium content in the digested rice sample was determined using flame photometer after making proper dilution (Jackson, 1973).

3.5 Statistical analysis

The experiment data recorded during the course of investigation from each parameter were analysed statistically by applying the techniques of Factorial RDB as described by Panse and Sukhatme (1985). Significance and non-significance of variance due to treatment was determined by calculating respective 'F' values.

The standard error of difference (SEd ±) was calculated by using the following formulae. The significance was tested by calculating the CD at 5% level of significance wherever 'F' test was found significant. The CD was calculated to find out the significance or non-significance of mean different amongst treatment by using the following formula-

$$SEd\ (\pm) = \sqrt{\frac{2\ x\ error\ mean\ sqaure}{n}}$$

CD = SEm$\pm$ x 't' (Fisher)

Where, t = tabulated value of 't' at 5% probability level for error degree of freedom (D.F).

CHAPTER-IV
RESULTS AND DISCUSSION

With the advent of modern production technology, the usage of higher doses of fertilizers in balanced manner is inevitable to exploit their full potential particularly under rainfed conditions. As about 40 percent of yield increase is accounted against fertilizer use, the fertilizer recommendations should be matched to the basic soil fertility, season, target yield, climate etc. Modern high yielding varieties producing around 5 t ha^{-1} of grain can remove about 110 kg N, 15 kg P, 129 kg K, 5 kg S, 2 kg Fe, 2 kg Mn, 200 g Zn and 150 g B per hectare from the soil. Emergence of widespread multi-nutrient deficiencies, depletion of native nutrient reserves, imbalanced fertilization are of utmost concern, causing serious stagnation in yields and declining productivity of various rice ecosystems (Murthy *et al*. 2011). Excess use of fertilizer nutrients implies increase of cost and decrease of returns and risk of environmental pollution. On the other hand, under use of nutrients depress the scope for increasing the present level of nutrients to the economically optimum level to exploit production potential to a larger extent (Singh.B and Singh. R.V. 2008). Application of inadequate and unbalanced fertilization to crops not only results in low crop yields but also deteriorate the soil health (Sharma *et al*. 2014). The existing fertilizer recommendations for major nutrients in rice are proving to be sub-optimal for attaining higher productivity levels and need a fresh look to revise them to optimum and more balanced levels.

The present investigation entitled, "Response of local rice *(Oryza sativa* L.*)* cultivars to different levels of N, P and K under upland rainfed condition of Nagaland" (June to November) was conducted during the year 2015 and 2016. It is well known fact that the selection of rice varieties is of outmost significant in crop production in increasing the production and maximizing the economic return per unit land area, since different varieties perform different under such situation. The grain yield of a crop is the result of combined effect of genetic traits which it inherits and the environment to which it exposed. Therefore a proper integration is necessary for increase in yield.

In this chapter, the response obtained due to different varieties and fertilizer doses during the course of experiment has been critically examined and statistically analysed and the records of different field observations as well as laboratory analysis are presented in this chapter, and the results obtained have been duly supported by tables and figures.

Also an attempt has been made to explain and discuss the possible reason of variation exhibited by statistically proved significant responses of varieties and fertilizer doses. For convenience the chapter has been classified to discuss the variation conclusively for varieties, fertilizer doses and its interaction effects on growth and yield attributes separately supporting the findings and possible cause, relevant references have been cited as per the need.

4.1. Growth attributes

4.1.1. Plant height (cm)

A perusal of the results presented in Table 3(a) showed the effects of cultivars and fertilizers and Table 3(b) along with depicted Fig 4 to Fig 15 showed its interaction effects on plant height (cm) at 30, 60, 90 DAS and at harvest.

4.1.1.1. Plant height at 30 DAS

Cultivars

The variations on plant height due to different cultivars were found to be significant during both the year of experiment. The highest plant height (54.41 cm) was recorded in cultivar V_4 (Semvu shea) and the lowest (43.29 cm) was recorded in variety V_5 (Sahbhagi dhan). Similar trend of finding was also recorded during 2016, with the highest plant height (55.35 cm) by cultivar V_4 (Semvu shea) and the lowest (42.89 cm) was recorded in variety V_5 (Sahbhagi dhan). The cultivars Gwabilo ssu, Hoikha and Ronga shea were found to be at par.

The pooled data also revealed a significant difference with highest plant height (54.10 cm) recorded in cultivar V_4 (Semvu shea) and the lowest (43.09) was in variety V_5 (Sahbhagi dhan).

Fertilizer doses

The result pertaining to plant height due to different doses of fertilizer showed significant variation. The highest plant height (55.47 cm) was recorded during the first year with fertilizer dose F_3 (90:45:45 NPK kg ha^{-1}) and the lowest (47.21 cm) was recorded in control. During the second year also recorded similar result with the highest plant height (53.32 cm) in F_3 (90:45:45 NPK kg ha^{-1}) and the lowest (45.49 cm) was in control. While fertilizer doses F_0, F_1 and F_2 were found to be statistically at par, which may be owing to less responsiveness of the crop at initial growth phase. Pooled data also showed a significant variation with the highest plant height (54.46 cm) recorded from fertilizer dose F_3 (90:45:45 NPK kg ha^{-1}) and the lowest (46.99 cm) was in control. While fertilizer doses F_0, F_1 and F_2 were found to be statistically at par.

Interaction effects

The interaction effects between different doses of fertilizers and cultivars on plant height presented in (Table 3 (b)) was found to be significant at 30DAS. The highest plant height (64.57cm) during the first year was associated with interactionV_4F_3 (cultivar, Semvu shea + 90:45:45 NPK kg ha^{-1}) while the lowest (31.56 cm) was associated with V_5F_0 (variety, Sahbhagi dhan + control). During the second year result also revealed the highest plant height (68.66 cm) from interaction V_4F_3 (cultivar, Semvu shea + 90:45:45 NPK kg ha^{-1}) while the lowest (33.04 cm) was recorded for V_5F_0 (variety, Sahbhagi dhan + control).

The pooled result of both the years also showed significantly higher plant height (66.61 cm) with interaction V_4F_2 (cultivar, Semvu shea + recommended dose of fertilizers) and the lowest (32.30 cm) with V_5F_0 (variety, Sehawagi dhan + control). However, the interactions V_5F_1,V_4F_3 and V_3F_2 were found to be statistically at par.

Table 3 (a) Effect of cultivars and fertilizer doses on plant height (cm) at different growth stages of rice

Treatments	Plant height (cm) at different growth stages of rice											
	30 DAS			60 DAS			90 DAS			Harvest		
	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
Cultivars (V)												
V_1- Gwabilo ssu	51.09	47.95	49.61	97.02	96.32	96.66	120.31	129.19	124.75	151.74	149.13	150.41
V_2- Hoikha	52.85	48.28	50.28	96.35	94.66	95.51	126.35	120.69	123.52	148.53	146.30	140.15
V_3- Ronga shea	50.42	47.81	49.12	93.60	95.75	94.67	135.11	136.65	134.39	156.00	152.79	154.39
V_4- Semvu shea	54.41	55.35	54.10	99.72	102.30	101.01	144.11	140.67	142.39	156.97	155.42	156.19
V_5- Sahbhagi dhan	43.29	42.89	43.09	79.39	77.30	78.35	114.19	116.03	115.11	136.84	135.62	136.22
SEm±	1.40	0.94	1.37	4.42	2.84	2.63	2.33	2.74	1.80	4.68	4.55	3.26
CD (P=0.05)	4.01	2.71	4.44	12.65	8.13	8.49	6.67	7.86	5.82	13.42	13.01	10.56
F_0- Control	48.49	45.49	46.99	86.57	88.65	87.61	127.88	114.45	121.16	133.91	132.19	133.05
F_1- 30:15:15	47.21	48.28	47.78	89.59	91.54	90.56	125.98	120.07	123.03	148.45	145.46	141.09
F_2- 60:30:30	50.49	46.74	48.50	94.15	96.42	95.28	126.19	129.45	127.81	153.04	152.05	152.54
F_3- 90:45:45	55.47	53.32	54.46	102.54	104.85	103.69	132.00	144.79	138.39	164.65	161.69	163.20
SEm±	1.25	0.84	1.23	3.95	2.54	2.35	2.08	2.45	1.61	4.19	4.07	2.92
CD (P=0.05)	3.58	2.42	3.97	11.32	NS	7.59	NS	7.03	5.21	11.99	11.64	9.44

Table 3 (b) Interaction effects of cultivars and fertilizer doses on plant height (cm) at different growth stages of rice

Treatments	Plant height (cm) at different growth stages of rice											
	30 DAS			60 DAS			90 DAS			Harvest		
	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
V×F												
T_1 (V_1F_0)	45.28	50.02	47.65	77.32	101.07	89.19	119.61	124.21	121.91	142.27	137.66	139.96
T_2 (V_1F_1)	55.92	50.21	53.06	99.67	100.33	100.00	116.33	127.37	121.85	155.72	154.04	154.88
T_3 (V_1F_2)	46.72	42.35	44.87	101.70	103.33	102.51	124.18	128.35	126.26	155.45	155.06	155.26
T_4 (V_1F_3)	56.46	49.24	52.85	109.37	107.53	108.45	122.77	126.85	124.81	179.28	178.51	178.89
T_5 (V_2F_0)	49.09	45.92	47.50	95.34	114.13	104.72	130.15	134.66	132.41	174.43	174.91	174.67
T_6 (V_2F_1)	31.64	41.76	36.70	112.38	126.29	119.30	123.18	116.68	119.93	99.26	99.39	99.33
T_7 (V_2F_2)	54.27	44.69	49.48	101.38	117.47	109.43	128.39	132.88	130.64	167.94	165.25	166.59
T_8 (V_2F_3)	38.29	39.21	38.75	67.79	98.27	83.03	128.39	119.56	123.97	100.86	99.31	100.08
T_9 (V_3F_0)	59.81	36.26	56.20	95.83	101.93	78.88	123.18	88.30	105.74	156.88	152.65	154.77
T_{10}(V_3F_1)	50.10	43.27	46.71	103.91	118.67	111.29	133.70	122.94	128.32	157.77	155.64	156.64
T_{11}(V_3F_2)	59.00	56.13	57.57	109.22	135.53	122.37	151.87	137.98	144.93	181.90	178.87	180.71
T_{12}(V_3F_3)	55.05	46.28	50.66	101.73	114.80	108.27	131.67	120.17	125.92	160.20	158.35	159.27
T_{13}(V_4F_0)	56.32	62.25	59.28	107.10	129.27	119.85	142.28	121.96	132.12	169.6	166.15	167.88
T_{14}(V_4F_1)	40.08	44.86	42.47	101.15	119.81	93.10	137.17	112.95	125.06	108.48	105.63	107.06
T_{15}(V_4F_2)	56.00	58.18	57.09	107.49	113.27	110.38	136.28	129.14	132.71	163.52	157.45	160.48
T_{16}(V_4F_3)	64.57	68.66	66.61	112.92	135.60	124.26	160.74	142.02	154.22	182.40	181.92	182.16
T_{17}(V_5F_0)	31.56	33.04	32.30	53.05	76.33	64.69	98.07	85.50	91.78	94.23	92.35	93.29
T_{18}(V_5F_1)	58.42	61.31	59.98	75.07	85.13	110.48	124.29	120.69	122.49	148.33	146.27	147.34
T_{19}(V_5F_2)	52.78	54.75	53.77	89.22	96.59	97.91	116.33	108.76	112.55	154.42	151.81	152.98
T_{20}(V_5F_3)	46.64	40.81	43.16	82.64	95.96	94.27	116.45	107.99	112.22	147.32	145.77	146.54
SEm±	5.16	1.88	2.75	8.84	5.68	5.25	4.66	5.48	3.60	9.37	9.09	6.53
CD (P=0.05)	14.77	5.40	8.88	25.31	16.26	16.98	13.35	15.72	11.64	26.83	26.03	21.11

4.1.1.2. Plant height at 60 DAS

Cultivars

The variation in plant height due to cultivars during the year 2015 was found to be significant, with the highest plant height (99.72 cm) observed in cultivar V_4 (Semvu shea) and the lowest (79.39 cm) in variety V_5 (Sahbhagi dhan). During the second year 2016 significant result was recorded, with cultivar V_4 (Semvu shea) giving the maximum height (102.30 cm) and the least value (77.30 cm) recorded from variety V_5 (Sahbhagi dhan). The cultivars Gwabilo ssu, Hoikha and Ronga shea were found to be at par.

Pooled data also recorded the maximum height (101.01cm) from cultivar V_4 (Semvu shea) and the least value recorded from V_5 (Sahbhagi dhan). These results were purely based on the physical characters of the crop, Sahbhagi dhan being a dwarf variety by nature.

Fertilizer doses

The result pertaining to plant height due to different does of fertilizer during the year 2015 was found to be significant. However, the results obtained during 2016 was found to be non significant. The highest plant height (102.54cm) during the year 2015 was recorded with fertilizer dose F_3 (90:45:45 NPK kg ha^{-1}) which was followed by fertilizer dose F_2 (94.15 cm) and the lowest (86.57cm) was recorded in control. While the fertilizer doses F_0 and F_1 were found to be statistically at par. Pooled data also showed a significant variation with fertilizer dose F_3 (90:45:45 NPK kg ha^{-1}) giving the highest value for plant height (103.69 cm) which was at par with fertilizer dose F_2. While fertilizer doses F_0 and F_1 were found to be statistically at par.

Interaction effects

The interaction effects between fertilizers and cultivars on plant height presented in (Table 3 (a)) was found significant on both the years of experimentation at 60DAS. The highest plant height (112.92 cm) during 2015 was associated with interactionV_4F_3 (cultivar Semvu shea + 90:45:45 NPK kg ha^{-1}) which was statistically at par with interactionV_4F_2 (cultivar Semvu shea + 60:30:30 NPK kg ha^{-1}), while the lowest (53.05 cm) was recorded from interactionV_5F_0 (variety Sahbhagi dhan + control). Similarly, in 2016 the highest plant height (115.60 cm) was obtained with interaction V_4F_3 (cultivar Semvu shea + 90:45:45 NPK kg ha^{-1}) and the lowest (76.33 cm) was recorded for interaction V_5F_0 (variety Sahbhagi dhan + control).

The pooled results showed similar trend of findings, the highest plant height (124.26 cm) being recorded with interactionV_4F_3 (cultivar Semvu shea + 90:45:45 kg ha^{-1} NPK) which was statistically at par with interactionV_4F_2 (cultivar Semvu shea + 60:30:30 NPK kg ha^{-1}) and the lowest (64.69 cm) recorded for V_5F_0 (variety Sehawagi dhan + control).

4.1.1.2. Plant height at 90 DAS

Cultivars

The variation in plant height due to cultivars at 90 DAS were found to be significant during both the years of experiment. Result obtained during 2015 revealed the highest height (144.11cm) in cultivar V_4 (Semvu shea) which was followed by cultivar V_3 (Ronga shea) (135.11 cm). While cultivars V_1 and V_2 were found to be statistically at par. The lowest plant height (114.19 cm) was however recorded from variety V_5 (Sahbhagi dhan). Also during 2016 the highest plant height (140.67 cm) was obtained from cultivar V_4 (Semvu shea) and the lowest (116.03 cm) from variety V_5 (Sahbhagi dhan). Pooled data also complied with the findings of both the years experiment with the highest plant height (142.39 cm) obtained from cultivar V_4 (Semvu shea) which was followed by cultivar V_3 (Ronga shea) (134.39 cm), while the lowest value (115.11 cm) was obtained from variety V_5 (Sahbhagi dhan).

Fertilizer doses

During the first year of experiment 2015, fertilizer doses failed to show any significant variation on plant height. While, during 2016 significant variation was recorded with the highest plant height (144.79 cm) obtained from fertilizer dose F_3 (90:45:45 NPK kg ha^{-1}) and the lowest (114.45cm) was recorded in control. Pooled data also gave a significant variation with the highest plant height (138.39cm) obtained from fertilizer dose F_3 (90:45:45 NPK kg ha^{-1}) and the lowest (121.16cm) was recorded in control. Fertilizer doses F_0 and F_1 were found to be statistically at par.

Interaction effects

The interaction effects between cultivars and fertilizer doses on plant height presented in (Table 3(b)) was found significant on both the years at 90DAS. The highest plant height (160.74 cm) during 2015 was associated with interaction V_4F_3 (cultivar Semvu shea + 90:45:45 NPK kg ha^{-1}) which was at par with interaction V_3F_2 (cultivar Ronga shea + 60:30:30 NPK kg $ha^{-}1$) while the lowest (98.07 cm) was recorded for interaction V_5F_0 (variety Sahbhagi dhan + control). Similarly, in 2016 the highest plant height (152.02 cm) was obtained with interactionV_4F_3 (cultivar Semvu shea + 90:45:45 NPK kg ha^{-1}) and the lowest (85.50 cm) was recorded for interaction V_5F_0 (variety Sahbhagi dhan + control). Pooled data followed the similar trend of findings with the highest plant height (154.22 cm) obtained from interactionV_4F_3 (cultivar Semvu shea + 90:45:45 NPK kg ha^{-1}) which was statistically at par with interaction V_4F_2 (cultivar Semvu shea + 60:30:30 NPK kg ha^{-1}), while the lowest (91.78 cm) was recorded for interaction V_5F_0 (variety Sahbhagi dhan + control).

4.1.1.2. Plant height at maturity

Cultivars

Plant height at maturity also showed variation among the cultivars during both the year of experimentation.

During 2015, the highest plant height (156.97 cm) was obtained from cultivar V_4 (Semvu shea) which was at par with cultivar V_3 (Ronga shea) and V_1 (Gwabilo ssu) and the lowest (136.84 cm) from variety V_5 (Sahbhagi dhan). Similar result was also obtained during 2016, with cultivar V_4 (Semvu shea) giving the highest plant height (155.42cm) which was at par with cultivar V_3 (Ronga shea) and V_1 (Gwabilo ssu) and the lowest (135.62 cm) from variety V_5 (Sahbhagi dhan). Pooled result thus obtained complied with the findings of both the years experiment, with cultivar V_4 (Semvu shea) showing the highest value (156.19 cm) which was statistically at par with cultivar V_3 (Ronga shea) and V_1 (Gwabilo ssu). While, variety V_5 (Sehawagi dhan) recorded the lowest plant height (136.22 cm).

Fertilizer doses

The variation in plant height due to fertilizers also showed significant results during both the years of experiment. The highest plant height (164.65cm) was recorded from fertilizer dose F_3 (90:45:45 NPK kg ha^{-1}) during 2015, which was statistically at par with fertilizer dose F_2 (60:30:30 NPK kg ha^{-1}) and the lowest (133.91cm) was recorded in control. During 2016 also, the highest plant height (161.69 cm) was recorded in fertilizer dose F_3 (90:45:45 NPK kg ha^{-1}) which was statistically at par with fertilizer dose F_2 (60:30:30 NPK kg ha^{-1}) and the lowest (132.19 cm) was from control. Pooled data of both the year followed the similar trend of findings with the highest plant height (163.20 cm) in fertilizer dose F_3 (90:45:45 NPK kg ha^{-1}) which was statistically at par with fertilizer dose F_2 (60:30:30 NPK kg ha^{-1}) and the lowest (133.05 cm) was from control.

Interaction effects

The interaction effects between cultivars and different doses of fertilizers on plant height are presented in Table 3 (b) showed significant result on both the years at the time of harvest. The highest plant height (182.40 cm) during 2015 was associated with interactionV_4F_3 (cultivar Semvu shea + 90:45:45 kg ha^{-1} NPK) which was statistically at par with V_4F_2 (cultivar Semvu shea + 60:30:30 NPK kg $ha^{-}1$), V_3F_2 (60:30:30 NPK kg $ha^{-}1$) and V_1F_3 (cultivar Gwabilo ssu +60:30:30 NPK kg $ha^{-}1$), while the lowest (94.23 cm) was recorded for V_5F_0 (Variety Sahbhagi dhan + control). Similarly, in 2016 the highest plant height (181.92cm) was obtained with interactionV_4F_3 (cultivar Semvu shea + 90:45:45 NPK kg ha^{-1}), which was also found to be statistically at par with V_3F_2 (cultivar Ronga shea +60:30:30 NPK kg $ha^{-}1$) and V_1F_3 (Gwabilo ssu + 60:30:30 NPK kg $ha^{-}1$). The lowest (92.35 cm) was recorded in V_5F_0 (variety Sahbhagi dhan + control). Pooled data also showed the similar trend of results. The highest plant height (182.16cm) being recorded with interaction V_4F_3 (cultivar Semvu shea + 90:45:45 kg ha^{-1} NPK) which was also found to be statistically at par with V_3F_2 (cultivar Ronga shea +60:30:30 NPK kg $ha^{-}1$) and V_1F_3

(Gwabilo ssu + 60:30:30 NPK kg ha-1), while the lowest (93.29 cm) was recorded for V_5F_0 (variety Sehawagi dhan + control).

4.1.2. Plant population m^{-2} at 30 DAS and 60 DAS

The data on plant population due to various treatments on cultivars and fertilizer doses are presented in Table 4(a) and Table 4(b) showed its interaction effects on plant population m^{-2} at 30 DAS and 60 DAS.

Cultivars

The variation in plant population due to cultivars were found to be non significant during both the year of experiment at both the growth stages, However pooled result recorded the highest plant population in variety V_5 (Sahbhagi dhan) and the lowest recorded in cultivar V_3 (Ronga shea).

Fertilizer doses

The effect of fertilizer doses to plant population was also found non-significant during both the year, however pooled data of both the year revealed the highest plant population with fertilizer dose F_3 (90:45:45 NPK kg ha-1) and the lowest (96.39) was in F_0 (Control).

Interaction effects

The interaction effects between cultivars and fertilizer doses on plant population also failed to show any significant variation. However pooled data showed the highest plant population (143.33) with interaction V_5F_3 (variety Sahbhagi dhan + 90:45:45 NPK kg ha^{-1}), while the lowest (50.67) with interaction V_1F_0 (cultivar Gwabilo ssu + control).

4.1.3. Number of leaves plant^{-1} at 30, 60 and 90 DAS

Table 5(a) showed the effects of cultivars and fertilizer doses and Table 5(b) showed its interaction on number of leaves per plant at 30, 60 and 90 DAS.

The variations on number of green leaves plant^{-1} among the cultivars, fertilizers as well as their interactions were found non-significant at all growth stages during both the year of experiment.

4.1.4 Number of tillers m^{-2} at 90 DAS

The data on number of tillers due to various treatments on cultivars and fertilizer doses are presented in Table 6(a) with Fig 16 and Fig 17 and Table 6(b) along with depicted Fig 18 showed its interaction effects on number of tillers m^{-2} at 60 DAS.

Cultivars

The variations in number of tillers due to cultivars were found to be significant during both the years of experiment. During the year 2015 the highest tiller number (157m^{-2}) was recorded with variety V_5 (Sahbhagi dhan), while the rest of the cultivars were found to be statistically at par. Similar trend of result was also recorded during 2016 with variety V_5 (Sahbhagi dhan) showing the highest tiller number (156m^{-2}) which was followed by cultivar V_4 (Semvu shea) giving a tiller count of (144 m^{-2}). Cultivars V_1 (Gwabilo ssu), V_2 (Hoikha) and V_3 (Ronga shea) were found to be at par. Pooled data of both the year also showed a significant variation with variety V_5 (Sahbhagi dhan) showing the highest tiller count m^{-2} (156.46) which was followed by cultivar V_4 (Semvu shea) giving a tiller count of (142.63 m^{-2}). While Cultivars V_1 (Gwabilo ssu), V_2 (Hoikha) and V_3 (Ronga shea) were found to be statistically at par.

Fertilizer doses

The effects of fertilizers on number of tillers m^{-2} were found to be significant during both the years of experiment. The highest tiller number (144 m^{-2}) during the year 2015 was recorded with F_3 (90:45:45 NPK kg ha^{-1}) which was statistically at par with F_2 (60:30:30) and the lowest (141m^{-2}) was recorded in F_0 (Control). The result obtained during 2016 complied with the findings of the year 2015 with fertilizer dose F_3 (90:45:45 NPK kg ha^{-1}) showing the highest value (143 m^{-2}) and the lowest (139 m^{-2}) recorded in F_0 (Control). Pooled result also showed significant variation with the

Table 4 (a) Effect of cultivars and fertilizer doses on plant population (m^{-2}) at different growth stages of rice

Treatments	Plant population (m^{-2})					
	30 DAS			60 DAS		
	2015	2016	Pooled	2015	2016	Pooled
Cultivars (V)						
V_1- Gwabilo ssu	103.00	103.25	103.12	72.00	68.59	70.25
V_2- Hoikha	103.33	99.92	101.63	68.33	73.99	71.42
V_3- Ronga shea	101.83	95.00	93.17	74.00	83.67	78.84
V_4- Semvu shea	117.00	111.08	114.04	78.33	73.00	86.00
V_5- Sahbhagi dhan	114.67	117.67	116.17	87.67	84.33	82.38
SEm±	7.91	6.73	4.44	7.85	5.09	4.51
CD (P=0.05)	NS	NS	NS	NS	NS	NS
Fertilizer doses (NPK kg ha^{-1})						
F_0- Control	99.73	96.39	98.06	73.87	71.47	72.63
F_1- 30:15:15	106.27	97.00	101.63	75.73	72.60	76.40
F_2- 60:30:30	104.80	106.53	105.66	79.20	81.27	80.23
F_3- 90:45:45	112.07	113.60	117.35	79.47	81.53	78.74
SEm±	7.07	6.02	3.98	7.02	4.52	4.03
CD (P=0.05)	NS	NS	NS	NS	NS	NS

Table 4 (b) Interaction effects of cultivars and fertilizer doses on plant population (m^{-2}) at different growth stages of rice

Treatments	Plant population (m^{-2})					
	30 DAS			60 DAS		
	2015	2016	Pooled	2015	2016	Pooled
V×F						
T_1 (V_1F_0)	74.67	78.67	76.50	64.00	63.00	63.50
T_2 (V_1F_1)	106.67	102.33	104.50	76.00	74.00	75.00
T_3 (V_1F_2)	118.67	119.67	124.17	64.00	70.67	67.33
T_4 (V_1F_3)	112.00	120.00	116.00	85.33	95.00	90.17
T_5 (V_2F_0)	92.00	93.33	92.67	62.67	67.33	65.00
T_6 (V_2F_1)	103.33	94.33	86.83	97.33	96.00	96.67
T_7 (V_2F_2)	104.00	96.00	93.00	65.33	73.33	69.17
T_8 (V_2F_3)	89.33	102.33	95.83	60.00	67.00	64.67
T_9 (V_3F_0)	128.00	117.67	122.83	85.33	88.33	86.83
T_{10}(V_3F_1)	128.00	114.67	111.33	68.00	79.00	73.50
T_{11}(V_3F_2)	105.33	95.00	95.17	60.00	73.00	66.50
T_{12}(V_3F_3)	106.67	115.67	111.17	70.67	86.67	78.67
T_{13}(V_4F_0)	101.33	84.00	92.67	76.00	77.33	76.67
T_{14}(V_4F_1)	98.67	84.00	91.33	66.67	50.67	58.50
T_{15}(V_4F_2)	128.00	122.00	125.00	105.33	100.33	102.83
T_{16}(V_4F_3)	104.00	99.67	101.83	81.33	75.67	78.50
T_{17}(V_5F_0)	102.67	111.33	107.00	69.33	53.67	61.33
T_{18}(V_5F_1)	112.00	130.33	121.17	82.67	71.00	88.17
T_{19}(V_5F_2)	100.00	99.33	99.67	80.00	83.33	81.67
T_{20}(V_5F_3)	144.00	143.33	143.66	81.33	84.00	98.33
SEm±	15.82	13.47	8.89	15.70	10.11	9.02
CD (P=0.05)	NS	NS	NS	NS	NS	NS

Table 5 (a) Effect of cultivars and fertilizer doses on number of green leaves plant^{-1} at different growth stages of rice

Treatments	Number of green leaves plant^{-1}								
	30 DAS			60 DAS			90 DAS		
	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
Cultivars (V)									
V_1- Gwabilo ssu	4.36	4.38	4.37	5.36	5.34	5.35	6.65	6.26	6.51
V_2- Hoikha	4.46	4.48	4.61	5.38	5.35	5.37	6.66	6.36	6.58
V_3- Ronga shea	4.78	4.76	4.93	5.37	5.39	5.38	6.90	6.54	6.68
V_4- Semvu shea	5.18	5.20	5.19	5.33	5.30	5.32	6.92	6.76	6.72
V_5- Sahbhagi dhan	5.12	5.13	5.12	5.21	5.22	5.21	6.80	6.36	6.76
SEm±	0.192	0.22	0.77	0.18	0.13	0.11	0.12	0.13	0.08
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Fertilizer doses (NPK kg ha^{-1})									
F_0- Control	4.45	4.42	4.70	5.13	5.13	5.13	6.78	6.43	6.58
F_1- 30:15:15	4.55	4.76	4.63	5.42	5.26	5.31	6.79	6.43	6.67
F_2- 60:30:30	4.78	4.70	4.74	5.51	5.29	5.39	6.80	6.44	6.66
F_3- 90:45:45	4.93	5.02	4.99	5.57	5.37	5.48	6.82	6.53	6.69
SEm±	0.17	0.13	0.11	0.16	0.117	0.09	0.11	0.11	0.07
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 5 (b) Interaction effects of cultivars and fertilizer doses on number of green leaves plant^{-1} at different growth stages of rice

Treatments	Number of green leaves plant^{-1}								
	30 DAS			60 DAS			90 DAS		
	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
V×F									
T_1 (V_1F_0)	4.78	4.70	4.74	5.22	5.00	5.11	6.67	6.20	6.55
T_2 (V_1F_1)	4.88	5.00	4.94	5.22	5.00	5.11	6.33	6.20	6.27
T_3 (V_1F_2)	4.66	4.70	4.68	4.78	4.67	4.72	6.63	6.60	6.61
T_4 (V_1F_3)	4.11	4.15	4.13	5.22	5.00	5.11	7.00	6.07	6.54
T_5 (V_2F_0)	4.78	4.50	4.67	5.22	5.55	5.39	6.73	6.36	6.56
T_6 (V_2F_1)	5.01	4.80	4.95	5.55	5.33	5.44	6.80	6.40	6.66
T_7 (V_2F_2)	4.56	4.50	4.34	5.10	5.11	5.11	6.56	6.20	6.38
T_8 (V_2F_3)	3.67	3.70	3.68	5.22	5.55	5.05	6.53	6.50	6.51
T_9 (V_3F_0)	4.00	4.00	5.00	5.44	5.33	5.38	6.93	6.36	6.68
T_{10}(V_3F_1)	4.22	4.26	4.61	5.77	5.11	5.45	7.30	6.40	6.85
T_{11}(V_3F_2)	5.33	5.40	5.38	5.65	5.64	5.65	6.90	6.43	6.69
T_{12}(V_3F_3)	4.56	4.90	4.73	5.22	5.00	5.11	6.63	6.26	6.48
T_{13}(V_4F_0)	4.55	4.90	4.72	5.33	5.00	5.16	6.67	6.50	6.57
T_{14}(V_4F_1)	4.33	4.30	4.32	5.33	5.33	5.33	6.73	6.46	6.59
T_{15}(V_4F_2)	4.00	4.12	4.06	5.78	5.33	5.55	7.00	6.70	6.85
T_{16}(V_4F_3)	5.47	5.50	5.49	5.77	5.55	5.66	7.20	6.50	6.83
T_{17}(V_5F_0)	5.00	5.20	5.11	5.89	5.44	5.50	7.00	6.76	6.87
T_{18}(V_5F_1)	4.33	4.70	4.50	5.67	5.44	5.55	6.80	6.73	6.82
T_{19}(V_5F_2)	5.11	5.10	5.11	5.56	5.44	5.50	6.80	6.73	6.77
T_{20}(V_5F_3)	5.33	5.30	5.31	5.22	5.44	5.33	6.76	6.83	6.78
SEm±	0.38	0.44	0.24	0.358	0.26	0.22	0.23	0.25	0.17
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 6 (a) Effect of cultivars and fertilizer doses on number of tillers (m^{-2}) at 90 DAS

Treatments	Number of tillers (m^{-2})		
	90 DAS		
	2015	2016	Pooled
Cultivars (V)			
V_1- Gwabilo ssu	138.58	133.67	136.54
V_2- Hoikha	138.42	136.00	137.54
V_3- Ronga shea	138.26	135.58	137.21
V_4- Semvu shea	139.61	140.16	142.63
V_5- Sahbhagi dhan	157.10	155.83	156.46
SEm±	0.58	0.81	0.49
CD (P=0.05)	1.66	2.30	1.60
Fertilizer doses (NPK kg ha^{-1})			
F_0- Control	141.07	139.53	141.30
F_1- 30:15:15	141.73	140.80	141.03
F_2- 60:30:30	143.60	141.27	142.63
F_3- 90:45:45	143.65	142.60	143.33
SEm±	0.52	0.72	0.44
CD (P=0.05)	1.48	2.06	1.43

Table 6 (b) Interaction effects of cultivars and fertilizer doses on number of tillers (m^{-2}) at 90 DAS

Treatments	Number of tillers (m^{-2})		
	90 DAS		
	2015	2016	Pooled
V×F			
T_1 (V_1F_0)	139.33	139.00	139.17
T_2 (V_1F_1)	137.00	131.67	134.33
T_3 (V_1F_2)	140.33	138.66	139.49
T_4 (V_1F_3)	137.67	135.33	136.44
T_5 (V_2F_0)	139.00	137.00	138.00
T_6 (V_2F_1)	136.67	137.00	136.87
T_7 (V_2F_2)	137.67	132.67	135.33
T_8 (V_2F_3)	140.33	137.33	138.71
T_9 (V_3F_0)	137.67	139.00	138.42
T_{10}(V_3F_1)	138.00	129.33	135.21
T_{11}(V_3F_2)	140.67	138.67	139.55
T_{12}(V_3F_3)	136.67	135.33	136.21
T_{13}(V_4F_0)	137.33	140.00	138.66
T_{14}(V_4F_1)	140.33	145.33	143.65
T_{15}(V_4F_2)	139.67	149.33	145.78
T_{16}(V_4F_3)	141.00	142.00	141.45
T_{17}(V_5F_0)	152.00	149.00	151.50
T_{18}(V_5F_1)	156.67	154.33	155.23
T_{19}(V_5F_2)	159.66	157.00	158.31
T_{20}(V_5F_3)	160.00	163.00	162.00
SEm±	1.16	1.61	0.99
CD (P=0.05)	3.32	4.60	3.20

highest tiller number (143 m^{-2}) recorded with fertilizer dose F_3 (90:45:45 NPK kg ha^{-1}) which was statistically at par with F_2 (60:30:30) and the lowest (141) recorded in F_0 (Control).

Interaction effects

The interaction effects between cultivars and fertilizers on number of tillers m^{-2} presented in Table 6(b) was found significant during both the years of experiment. Result obtained during the year 2015 revealed the highest number of tillers (160m^{-2}) with interaction V_5F_3 (variety Sahbhagi dhan + 90:45:45 NPK kg ha^{-1}) which was statistically at par with V_5F_2 (variety Sahbhagi dhan + 60:30:30 NPK kg ha^{-1}) while the lowest (137m^{-2}) was recorded for V_2F_1 (cultivar Hoikha + 30:15:15 NPK kg ha^{-1}). Also during 2016 similar result was obtained. The highest number of tillers (163m^{-2}) with interaction V_5F_3 (variety Sahbhagi dhan + 90:45:45 NPK kg ha^{-1}) and the lowest with V_1F_2 (cultivar Gwabilo ssu + 60:30:30 NPK kg ha^{-1}). Pooled result thus obtained also showed a significant variation with the highest number of tillers m-^{2} (162.00) obtained from interaction V_5F_3 (variety Sahbhagi dhan + 90:45:45 NPK kg ha^{-1}) which was statistically at par with V_5F_2 (variety Sahbhagi dhan + 60:30:30 NPK kg ha^{-1}) while the lowest (134m^{-2}) was recorded for V_1F_1 (cultivar Gwabilo ssu + 30:15:15 NPK kg ha^{-1}).

4.1.5 Crop growth rate (CGR) at 30 and 60 DAS

The data on crop growth rate due to various treatments on cultivars and fertilizer doses are presented in Table 7(a) and Table 7(b) showed its interaction effects on plant growth rate.

4.1.5.1 Crop growth rate (CGR) at 30 DAS

The variations on crop growth rate among the cultivars, fertilizer doses as well as their interaction failed to show any significant variations during both the year.

Table 7 (a) Effect of cultivars and fertilizer doses on Crop Growth Rate (g m^{-2} day^{-1})

Treatments	Crop Growth Rate (g m^{-2} day^{-1})					
	30 DAS			60 DAS		
	2015	2016	Pooled	2015	2016	Pooled
Cultivars (V)						
V_1- Gwabilo ssu	1.43	1.32	1.37	7.82	7.57	7.68
V_2- Hoikha	1.41	1.41	1.41	11.22	11.20	11.21
V_3- Ronga shea	1.36	1.20	1.28	15.13	14.92	15.03
V_4- Semvu shea	1.49	1.46	1.47	15.20	15.06	15.13
V_5- Sahbhagi dhan	1.24	1.25	1.25	14.11	14.10	14.11
SEm±	0.08	0.11	0.06	0.51	0.69	0.43
CD (P=0.05)	NS	NS	NS	1.48	1.99	1.40
Fertilizer doses (NPK kg ha^{-1})						
F_0- Control	1.23	1.12	1.18	13.07	10.24	11.66
F_1- 30:15:15	1.36	1.17	1.27	14.04	11.09	12.56
F_2- 60:30:30	1.29	1.35	1.32	14.07	11.11	12.59
F_3- 90:45:45	1.57	1.35	1.48	15.64	12.63	14.21
SEm±	0.07	0.09	0.05	0.46	0.62	0.38
CD (P=0.05)	NS	NS	NS	1.32	1.78	1.25

Table 7 (b) Interaction effects of cultivars and fertilizer doses on Crop Growth Rate (g m^{-2} day^{-1})

Treatments	Crop Growth Rate (g m^{-2} day^{-1})					
	30 DAS			60 DAS		
	2015	2016	Pooled	2015	2016	Pooled
V×F						
T_1 (V_1F_0)	1.28	1.24	1.26	6.80	6.31	6.56
T_2 (V_1F_1)	1.39	1.52	1.47	7.28	7.33	7.31
T_3 (V_1F_2)	1.15	1.15	1.15	8.12	8.17	8.15
T_4 (V_1F_3)	1.38	1.45	1.42	8.09	8.75	8.42
T_5 (V_2F_0)	1.24	1.21	1.23	9.38	9.22	9.31
T_6 (V_2F_1)	1.26	1.15	1.19	12.82	12.03	12.43
T_7 (V_2F_2)	1.27	1.39	1.32	8.58	8.17	8.38
T_8 (V_2F_3)	1.33	1.57	1.46	7.08	6.92	7.01
T_9 (V_3F_0)	1.53	1.01	1.27	10.01	9.92	9.97
T_{10}(V_3F_1)	1.45	1.15	1.27	10.25	10.33	10.28
T_{11}(V_3F_2)	1.34	0.74	1.04	11.98	11.84	11.92
T_{12}(V_3F_3)	1.24	1.51	1.37	11.24	11.87	11.62
T_{13}(V_4F_0)	1.51	1.40	1.35	12.69	12.96	12.84
T_{14}(V_4F_1)	1.17	1.52	1.38	14.74	14.65	14.69
T_{15}(V_4F_2)	1.53	1.56	1.54	14.46	14.18	14.28
T_{16}(V_4F_3)	1.54	1.57	1.56	19.13	19.18	19.15
T_{17}(V_5F_0)	1.12	1.27	1.21	10.82	10.78	10.80
T_{18}(V_5F_1)	1.27	1.07	1.18	12.57	12.83	12.67
T_{19}(V_5F_2)	1.15	1.17	1.16	12.54	12.99	12.76
T_{20}(V_5F_3)	1.19	1.18	1.19	14.49	14.82	14.67
SEm±	0.17	0.21	0.12	1.04	1.39	0.86
CD (P=0.05)	NS	NS	NS	2.96	3.98	2.81

4.1.5.2Crop growth rate (CGR) at 60 DAS

Cultivars

The variations on crop growth rate among different cultivars were found to be significant during both the years of experiment. During the first year 2015 cultivar V_4 (Semvu shea) showed the highest growth rate (15.20 g m^{-2} day^{-1}) which was statistically at par with cultivar V_3 Ronga shea and variety V_5 (Sahbhagi dhan). Similar result was also recorded during the second year 2016 with highest crop growth rate (15.06 g m^{-2} day^{-1}) in cultivar V_4 (Semvu shea) which was at par with variety V_5 (Sahbhagi dhan) and cultivar V_3 Ronga shea. Pooled result thus obtained showed a significant variation with the highest growth rate (15.13 g m^{-2} day^{-1}) obtained from cultivar V_4 (Semvu shea) which was statistically at par with cultivar V_3 Ronga shea and variety V_5 (Sahbhagi dhan). While the lowest was obtained from cultivar V_1 Gwabilo ssu.

Fertilizer doses

The effects of fertilizer doses on crop growth rate were found to be significant during the both years of experiment. The highest crop growth rate (15.64 g m^{-2} day^{-1}) during 2015 was recorded with F_3 (90:45:45 NPK kg ha^{-1}) which was statistically at par with F_2 (60:30:30 NPK kg ha^{-1}) and F_1 (30:15:15 NPK kg ha^{-1}), while the lowest (13.07 g m^{-2} day^{-1}) recorded in F_0 (Control). The result obtained during 2016 complied with the findings of the year 2015 with fertilizer dose F_3 (90:45:45 NPK kg ha^{-1}) showing the highest value (12.63 g m^{-2} day^{-1}) and the lowest recorded in F_0 (Control). Pooled data also followed the same trend of findings, with the highest crop growth rate (14.21 g m^{-2} day^{-1}) recorded with F_3 (90:45:45 NPK kg ha^{-1}) and the lowest recorded in F_0 (Control).

Interaction effects

The interaction effect between cultivars and fertilizers on crop growth rate was found significant during both the experiment year. Result obtained during 2015 revealed the highest crop growth rate (19.13 g m^{-2} day^{-1}) with interaction V_4F_3 (cultivar Semvu shea + 90:45:45 NPK kg ha^{-1}), while the lowest (6.80 g m^{-2} day^{-1})

was recorded for V_1F_0 (cultivar Gwabilo ssu + control). Also during 2016 similar result was obtained. The highest crop growth rate (19.18 NPK kg ha^{-1}) and the lowest still recorded with treatment V_1F_0 (cultivar Gwabilo ssu + control). Pooled data thus obtained also showed a significant variation with the highest crop growth rate (19.15 g m^{-2} day^{-1}) recorded with interaction V_4F_3 (cultivar Semvu shea + 90:45:45 NPK kg ha^{-1}), while the lowest (6.80 g m^{-2} day^{-1}) was recorded for V_1F_0 (cultivar Gwabilo ssu + control). Treatment interactions V_4F_2 (cultivar Semvu shea + 60:30:30 NPK kg ha^{-1}), V_4F_1 (cultivar Semvu shea + 30:15:15 NPK kg ha^{-1}) and V_5F_3 (variety Sahbhagi dhan + 90:45:45 NPK kg ha^{-1}) were found to be statistically at par.

4.1.6 Relative growth rate (RGR) at 30 and 60 DAS

The result presented in Table 8(a) with Fig 19, 20, 22 and 23 showed the effects of cultivars and fertilizers and Table 8(b) with Fig 21 and 24 showed its interaction on relative growth rate at 30 and 60 DAS.

4.1.6.1 Relative growth rate (RGR) at 30 DAS

The variations on relative growth rate among the cultivars, fertilizer doses as well as their interaction were found to be non-significant during both the year of experiment.

4.1.6.2 Relative growth rate (RGR) at 60 DAS

Cultivars

The variations on relative growth rate among different cultivars were found to be significant during both the year of experiment. In 2015 cultivar V_4 (Semvu shea) showed the highest relative growth rate (0.052 g g^{-1} day^{-1}) which was statistically at par with cultivars V_2 Hoikha and variety V_5 (Sahbhagi dhan). Also during 2016 the highest relative growth rate (0.050 g g^{-1} day^{-1}) was recorded with cultivar V_4 (Semvu shea) which was also at par with variety V_5 (Sahbhagi dhan). Pooled data also complied with the finding of both the years experiment. The highest relative growth rate (0.051 g g^{-1} day^{-1}) was obtained from cultivar V_4 (Semvu shea) which was

Table 8 (a) Effect of cultivars and fertilizer doses on Relative Growth Rate (g g^{-1} day^{-1})

Treatments	Relative Growth Rate (g g^{-1} day^{-1})					
	30 DAS			60 DAS		
	2015	2016	Pooled	2015	2016	Pooled
Cultivars (V)						
V_1- Gwabilo ssu	0.033	0.035	0.034	0.047	0.043	0.045
V_2- Hoikha	0.035	0.036	0.036	0.051	0.046	0.049
V_3- Ronga shea	0.043	0.034	0.039	0.046	0.043	0.045
V_4- Semvu shea	0.043	0.036	0.040	0.052	0.050	0.051
V_5- Sahbhagi dhan	0.040	0.036	0.038	0.051	0.049	0.050
SEm±	0.004	0.003	0.002	0.002	0.002	0.001
CD (P=0.05)	NS	NS	NS	0.005	0.006	0.003
Fertilizer doses (NPK kg ha^{-1})						
F_0- Control	0.035	0.033	0.034	0.045	0.045	0.045
F_1- 30:15:15	0.038	0.031	0.035	0.046	0.045	0.045
F_2- 60:30:30	0.039	0.030	0.036	0.049	0.047	0.048
F_3- 90:45:45	0.043	0.033	0.039	0.050	0.048	0.049
SEm±	0.004	0.003	0.001	0.002	0.002	0.001
CD (P=0.05)	NS	NS	NS	0.005	0.006	0.004

Table 8 (b) Interaction effects of cultivars and fertilizer doses on Relative Growth Rate (g g^{-1} day^{-1})

Treatments	Relative Growth Rate (g g^{-1} day^{-1})					
	30 DAS			60 DAS		
	2015	2016	Pooled	2015	2016	Pooled
V×F						
T_1 (V_1F_0)	0.034	0.036	0.035	0.063	0.055	0.059
T_2 (V_1F_1)	0.022	0.024	0.023	0.046	0.028	0.038
T_3 (V_1F_2)	0.041	0.038	0.040	0.042	0.037	0.040
T_4 (V_1F_3)	0.033	0.031	0.032	0.052	0.047	0.050
T_5 (V_2F_0)	0.031	0.028	0.030	0.049	0.031	0.039
T_6 (V_2F_1)	0.046	0.047	0.047	0.054	0.066	0.061
T_7 (V_2F_2)	0.029	0.024	0.026	0.050	0.052	0.051
T_8 (V_2F_3)	0.034	0.032	0.033	0.054	0.048	0.052
T_9 (V_3F_0)	0.044	0.037	0.041	0.048	0.037	0.045
T_{10}(V_3F_1)	0.045	0.036	0.041	0.051	0.041	0.046
T_{11}(V_3F_2)	0.038	0.035	0.037	0.043	0.040	0.042
T_{12}(V_3F_3)	0.040	0.038	0.039	0.043	0.055	0.048
T_{13}(V_4F_0)	0.036	0.032	0.034	0.044	0.048	0.045
T_{14}(V_4F_1)	0.032	0.030	0.031	0.042	0.052	0.047
T_{15}(V_4F_2)	0.051	0.048	0.050	0.041	0.045	0.043
T_{16}(V_4F_3)	0.062	0.061	0.062	0.063	0.061	0.062
T_{17}(V_5F_0)	0.035	0.023	0.029	0.044	0.059	0.052
T_{18}(V_5F_1)	0.046	0.024	0.034	0.050	0.034	0.047
T_{19}(V_5F_2)	0.030	0.036	0.033	0.045	0.049	0.047
T_{20}(V_5F_3)	0.035	0.033	0.034	0.056	0.054	0.055
SEm±	0.008	0.007	0.003	0.004	0.004	0.003
CD (P=0.05)	NS	NS	NS	0.010	0.017	0.009

statistically at par with variety V_5 (Sahbhagi dhan) and cultivar V_2 (Hoikha), while the lowest was obtained from cultivars V_1 (Gwabilo ssu) and V_3 (Ronga shea).

Fertilizer doses

The effects of fertilizers on crop growth rate were found to be significant during both the year of experiment. The highest crop growth rate (0.050 g m^{-2} day^{-1}) during 2015 was recorded with F_3 (90:45:45 NPK kg ha^{-1}) which was statistically at par with F_2 (60:30:30 NPK kg ha^{-1}) and F_1 (30:15:15 NPK kg ha^{-1}), while the lowest was recorded in F_0 (Control). The result obtained during 2016 complied with the findings of the year 2015 with fertilizer dose F_3 (90:45:45 NPK kg ha^{-1}) showing the highest value (0.048 g m^{-2} day^{-1}) and the lowest recorded in F_0 (Control). Pooled data also showed a significant variation with fertilizer dose F_3 (90:45:45 NPK kg ha^{-1}) recorded to give the highest crop growth rate (0.049 g m^{-2} day^{-1}) which was followed by fertilizer dose F_2 (60:30:30 NPK kg ha^{-1}), while fertilizer doses F_0 and F_1 were found to be statistically at par.

Interaction effects

The interaction effects between cultivars and fertilizers on crop growth rate presented was found significant during both the experiment year. Result obtained during 2015 revealed the highest relative growth rate (0.063 g m^{-2} day^{-1}) with interaction V_4F_3 (cultivar Semvu shea + 90:45:45 NPK kg ha^{-1}). Also during 2016 similar result was obtained. The highest relative growth rate (0.061 g m^{-2} day^{-1}) was recorded with the same treatment interaction V_4F_3 (cultivar Semvu shea + 90:45:45 NPK kg ha^{-1}). Pooled data also showed a significant variation with the highest relative growth rate (0.063 g m^{-2} day^{-1}) obtained from interaction V_4F_3 (cultivar Semvu shea + 90:45:45 NPK kg ha^{-1}) which was found to be statistically at par with interaction V_2F_1 (cultivar Hoikha + 30:15:15 NPK kg ha^{-1}). And the lowest was recorded with interaction V_2F_0 (cultivar Hoikha + control).

4.1.7 Leaf Area Index (LAI) at 30 DAS and 60 DAS

The result presented in Table 9(a) showed the effects of cultivars and fertilizers and Table 9(b) showed its interaction on leaf area index at 30 and 60 DAS.

4.1.7.1 Leaf Area Index (LAI) at 30 DAS

Cultivars

The variations on leaf area index due to cultivars were found to be significant during both the years of experiment. In the first year the highest leaf area index (1.15) was recorded in cultivar V_4 (Semvu shea) which was at par with cultivars V_1 (Gwabilo ssu) and V_2 (Hoikha) and the lowest (1.07) was recorded in variety V_5 (Sahbhagi dhan). Also during 2016 the highest leaf area index (1.14) was recorded in cultivar V_4 (Semvu shea) which was also at par with cultivars V_1 (Gwabilo ssu) and V_2 (Hoikha), while the lowest (1.08) was recorded in variety V_5 (Sahbhagi dhan). Pooled data also recorded similar trend of finding. The highest leaf area index (1.15) was recorded in cultivar V_4 (Semvu shea) which was statistically at par with cultivars V_1 (Gwabilo ssu) and V_2 (Hoikha) and the lowest (1.08) was recorded in variety V_5 (Sahbhagi dhan).

Fertilizer doses

However the differences in leaf area index due to fertilizers recorded non-significant during both the year.

Interaction effects

The interaction effects between cultivars and fertilizers on leaf area index at 30 DAS were found to be significant. The highest leaf area index (1.20) was recorded for V_4F_2 (cultivar Semvu shea + 60:30:30 kg ha^{-1} NPK) which was at par with V_4F_3 (cultivar Semvu shea + 90:45:45 NPK kg ha^{-1}) and the lowest (1.02) was in V_5F_0 (Sahbhagi dhan + control) and V_5F_1 (Sahbhagi dhan + 30:15:15 NPK kg ha^{-1}). During 2016 the highest value (1.19) was recorded with V_4F_2 (cultivar Semvu shea + 60:30:30 kg ha^{-1} NPK) which was at par with V_4F_3 (cultivar Semvu shea + 90:45:45 NPK kg ha^{-1}) and the lowest (1.03) was in V_4F_0 (variety Sahbhagi dhan + control). Pooled result thus obtained complied with the findings of both the years experiment. The highest leaf area index (1.20) was recorded for V_4F_2 (cultivar Semvu shea + 60:30:30 kg ha^{-1} NPK) which was at par with V_4F_3 (cultivar Semvu shea + 90:45:45 NPK kg ha^{-1}) and V_2F_3 (cultivar Hoikha+ 90:45:45 NPK kg ha^{-1}) while the lowest

Table 9 (a) Effect of cultivars and fertilizer doses on Leaf Area Index (LAI) at different stages of crop growth

Treatments	Leaf Area Index (LAI)					
	30 DAS			60 DAS		
	2015	2016	Pooled	2015	2016	Pooled
Cultivars (V)						
V_1- Gwabilo ssu	1.12	1.13	1.13	1.26	1.27	1.27
V_2- Hoikha	1.12	1.13	1.13	1.31	1.29	1.30
V_3- Ronga shea	1.08	1.09	1.09	1.30	1.28	1.29
V_4- Semvu shea	1.15	1.14	1.15	1.35	1.33	1.34
V_5- Sahbhagi dhan	1.07	1.08	1.08	1.25	1.24	1.25
SEm±	0.01	0.02	0.01	0.007	0.007	0.004
CD (P=0.05)	0.04	0.06	0.04	0.021	0.021	0.012
Fertilizer doses (NPK kg ha^{-1})						
F_0- Control	1.09	1.08	1.09	1.28	1.27	1.28
F_1- 30:15:15	1.10	1.12	1.11	1.30	1.29	1.30
F_2- 60:30:30	1.11	1.12	1.12	1.29	1.27	1.28
F_3- 90:45:45	1.08	1.14	1.11	1.30	1.29	1.30
SEm±	0.01	0.02	0.01	0.006	0.006	0.004
CD (P=0.05)	NS	NS	NS	NS	NS	NS

Table 9 (b) Interaction effects of cultivars and fertilizer doses on Leaf Area Index (LAI) at different stages of crop growth

Treatments	Leaf Area Index (LAI)					
	30 DAS			60 DAS		
	2015	2016	Pooled	2015	2016	Pooled
V×F						
T_1 (V_1F_0)	1.12	1.11	1.12	1.28	1.29	1.29
T_2 (V_1F_1)	1.19	1.14	1.17	1.29	1.33	1.31
T_3 (V_1F_2)	1.14	1.12	1.13	1.25	1.24	1.25
T_4 (V_1F_3)	1.14	1.16	1.15	1.23	1.22	1.23
T_5 (V_2F_0)	1.05	1.05	1.05	1.28	1.29	1.29
T_6 (V_2F_1)	1.11	1.09	1.10	1.25	1.23	1.24
T_7 (V_2F_2)	1.03	1.05	1.04	1.24	1.26	1.25
T_8 (V_2F_3)	1.18	1.17	1.18	1.29	1.28	1.29
T_9 (V_3F_0)	1.08	1.09	1.08	1.31	1.27	1.29
T_{10}(V_3F_1)	1.13	1.16	1.15	1.29	1.30	1.30
T_{11}(V_3F_2)	1.04	1.05	1.05	1.30	1.28	1.29
T_{12}(V_3F_3)	1.09	1.08	1.09	1.29	1.28	1.29
T_{13}(V_4F_0)	1.05	1.04	1.05	1.33	1.31	1.32
T_{14}(V_4F_1)	1.15	1.13	1.14	1.33	1.30	1.32
T_{15}(V_4F_2)	1.20	1.19	1.20	1.31	1.29	1.30
T_{16}(V_4F_3)	1.16	1.16	1.16	1.41	1.40	1.41
T_{17}(V_5F_0)	1.02	1.03	1.03	1.23	1.20	1.22
T_{18}(V_5F_1)	1.02	1.06	1.04	1.32	1.30	1.31
T_{19}(V_5F_2)	1.05	1.07	1.06	1.31	1.28	1.29
T_{20}(V_5F_3)	1.06	1.08	1.07	1.31	1.29	1.30
SEm±	0.03	0.02	0.02	0.02	0.01	0.009
CD (P=0.05)	0.08	0.06	0.07	0.04	0.04	0.020

value was recorded with V_5F_0 (Sahbhagi dhan + control) and V_5F_1 (Sahbhagi dhan + 30:15:15 NPK kg ha^{-1}).

4.1.7.2 Leaf Area Index (LAI) at 60 DAS

Cultivars

The variations on leaf area index due to cultivars were found to be significant during both the year of experiment. The highest leaf area index (1.35) during 2015 was recorded in cultivar V_4 (Semvu shea) and the lowest (1.25) was observed in V_5 (Sahbhagi dhan). Also during 2016 the highest leaf area index (1.33) was recorded in cultivar V_4 (Semvu shea) and the lowest (1.24) was observed in V_5 (Sahbhagi dhan). Pooled data also followed the similar trend of finding. The highest leaf area index (1.34) was recorded in cultivar V_4 (Semvu shea) which was statistically at par with cultivars V_1 (Gwabilo ssu) and V_2 (Hoikha) and the lowest (1.25) was recorded in variety V_5 (Sahbhagi dhan).

Fertilizer doses

Different fertilizer doses failed to show any significant variation on leaf area index of the crop at 60 DAS.

Interaction effects

The interaction effects between cultivars and fertilizer doses on leaf area index at 60 DAS were found to be significant during both the years of experiment. During the year 2015 the highest leaf area index (1.41) was recorded for V_4F_3 (cultivar Semvu shea + 90:45:45 NPK kg ha^{-1}) and the lowest (1.23) was in V_5F_0 (Sahbhagi dhan + control). During 2016 the highest value (1.40) was recorded with V_4F_3 (cultivar Semvu shea + 90:45:45 NPK kg ha^{-1}) and the lowest (1.20) was in V_5F_0 (Sahbhagi dhan + control). Pooled result also showed a significant variation with the highest leaf area index (1.41) recorded in interaction V_4F_3 (cultivar Semvu shea + 90:45:45 NPK kg ha^{-1}) and the lowest (1.22) in V_5F_0 (Sahbhagi dhan + control).

It is evident from the present investigation that different cultivars and fertilizer doses *viz*., F_0- 0:0:0NPK kg ha^{-1}, F_1-30:15:15 NPK kg ha^{-1}, F_2-60:30:30

NPK kg ha^{-1}(RDF) and F_3-90:45:45 NPK kg ha^{-1} and their interactions have differential effects on the growth attributes such as Plant height, number of green leaves, number of tillers, crop growth rate, relative growth rate and leaf area index of the crop. These growth parameters are influenced by a number of intrinsic and extrinsic environmental factors apart from management practices. The application of fertilizer dose F_2-60:30:30 NPK kg ha^{-1} (upland rice) has been found to influence morphological characters of the local cultivars better as unlike the highest dose F_3-90:45:45 NPK kg ha^{-1} of fertilizer under experiment to which the check improved variety performed better.

Experimental findings revealed that height of the plant, being a varietal character, was found to differ among the cultivars, also increase in plant height could be attributed to the role of nitrogen in the stimulation of cell division, inter node elongation and gibberellin activity. The maximum plant height (Table 3(a)) was obtained from V_4 (cultivar Semvu shea) at all the stages, while among the fertilizer doses F_3 (90:45:45 NPK kg ha^{-1}) gave the best result with the interaction V_4F_3 showing the best interaction effect at all growth stages except at 30 DAS (Table 3 (b)). This findings were in conformity with Pal and Mahunta (2010) who ascribed that growth of *kharif* rice (*Oryza sativa* L.) as influenced by three fertility levels (40 kg N + 60 kg P_2O_5 + 40 kg K_2O ha^{-1}, 60 kg N + 30 kg P_2O_5 + 30 kg K_2O ha^{-1} and 15 t FYM + 60 kg P_2O_5 + 40 kg K_2O ha^{-1}) which revealed that for almost all the fertility levels 60 kg N + 30 kg P_2O_5 + 30 kg K_2O ha^{-1} revealed higher plant growth attributes such as plant height and number of green leaves. Also these findings are in close agreement with those reported by Metwally (2015).

The number of green leaves as well as plant population m^{-2} were found to be non significant during both the year of experiment.

While in case of number of tillers m^{-2} variety V_5 (Sahbhagi dhan) recorded the highest value (Table 6(a)) during both the years, with fertilizer dose F_3 (90:45:45 kg ha^{-1} NPK) and treatment interaction T_{20} (Sahbhagi dhan + 90:45:45 NPK kg ha^{-1}) giving the highest value (Table 6 (b)) for both the years. This may be attributed to the genetic makeup of the variety having a potential to produce more tillers even under drought conditions which proved instrumental in showing effective variation. These results are in agreement with Sarkar *et al* . (2013) and Mondal *et al*.(2005) who also reported that higher tillers plant^{-1} (19.3), effective tillers plant^{-1} (13.2), 1000 grain weight (22.3 g) were recorded in Sahbhagi dhan whereas lower effectivity of tillers (7.4 %) was observed in local check Khandagiri attributing to their genetic variability, varietal difference and environmental adaptability.

In case of crop growth rate at 30 DAS no significant variation was recorded, while at 60 DAS cultivar significant variation was recorded with cultivar V_4 (Semvu shea) giving the highest value (Table 7 (a)) with the fertilizer dose F_3 (90:45:45 NPK kg ha^{-1}) (Table 7 (b)) during both the years of experiment. Concerning the interaction effect among different nutrient (NPK) the highest values of dry matter accumulation were observed when 90 kg N ha^{-1} was combined with 45 kg P ha^{-1} and 45 kg k ha^{-1}. On the other hand, the lowest value of dry matter accumulation was recorded in control. This could be attributed to the increase in vegetative growth owing to higher dose of nitrogen application which activates the growth hormones resulting in formation of more vegetative parts of the plant. This finding were in conformity with Gosh (2015) who revealed that crop receiving 75 % RDF and vermicompost 25 % produced higher CGR than that of other treatments throughout the growth periods except tillering to PI, when it produced comparable CGR to that of 50 % RDF through FYM or vermicompost 50 %. While also in case of relative growth rate similar trend of finding was recorded at 30 DAS no significant variation was recorded, while at 60 DAS cultivar significant variation was recorded with cultivar V_4 (Semvu shea) giving the highest value (Table 8 (a)) with the fertilizer dose F_3 (90:45:45 NPK kg ha^{-1}) (Table 8 (b)) during both the experiment year.

Leaf area index (LAI) was found to be significantly higher with V_4 (Semvu shea) with a fertilizer dose of F_3 (90:45:45 NPK kg ha^{-1}) (Table 9 (a)). This is mainly due to the fact that nitrogen is the major factor influencing leaf growth as it affects average leaf size, number of leaves per tiller and number of tillers per hill. These findings are similar to those of Metwally (2015) who reported that nitrogen application at 90 kg N ha^{-1} in combination with cycocel revealed the highest values of leaf area index. This increase in leaf area index may be due to the increase in the plant canopy. Hashem *et al*.,(2016) also reported that application of nitrogen in the form of urea (46.5%N) @ 90 kg N ha-1 and K @ 40 kg ha-^{1} revealed higher value of leaf area index in comparison to nitrogen levels 0, 110 and 165 kg N ha^{-1}.

4.2 Yield attributes

All the cultivars under experiment showed variations in yield attributes and yield in response to different doses of fertilizer, this could be because of the genetic variations among the different cultivars as genetic variations play a key role in yield and yield components which was also supported by Singh *et al*. 2010, Ranjitha *et al*. 2013 and Jamkhogin *et al*. 2013.

The data on yield attributes, Number of panicles m^{-2}, Length of panicle (cm), weight of panicle (g) and number of grains per panicle due to the effects of cultivars and fertilizer doses are given in Table 10(a), and their interaction effects are given in Table 10(b) , while Filled grain percentage (%) and Test weight (g)) due to the effects of cultivars and fertilizer doses are given in Table 11(a) with Fig 28, 29, 31 and 32 while their interaction effects are given in Table 11(b) with Fig 30 and 33. Finally grain yield (kg ha^{-1}), straw yield (kg ha^{-1}) and harvest index (%) due to the effects of cultivars and fertilizer doses are given in Table 12(a) with Fig 34, 35, 37 and 38 while their interaction effects are given in Table 12(b) with Fig 36 and 39.

4.2.1 Number of panicles m^{-2}

The variations on number of panicles due to cultivars and fertilizers were found to be non-significant during both the years of experiment. The pooled result thus obtained also could not show significant variation among the treatments. Treatment interactions also could not record any significant variation.

4.2.2 Length of panicle (cm)

Cultivars

Variation on length of panicle due to cultivars was found to be significant during both the years of experiment. The longest panicle during 2015 was recorded with the cultivar V_4 (Semvu shea) (28.51cm). Cultivars V_1 (Gwabilo ssu), V_2 (Hoikha) and V_3 (Ronga shea) were found to be at par, while the shortest panicle (27.22 cm) was recorded with V_5 (Sahbhagi dhan). During the second year 2016 the longest panicle length (28.55 cm) was recorded by the same cultivar V_4 (Semvu shea) and the shortest recorded with V_5 (Sahbhagi dhan). Pooled result thus obtained also recorded the longest panicle length with cultivar V_4 (Semvu shea) (28.53cm) while cultivars V_1 (Gwabilo ssu), V_2 (Hoikha) and V_3 (Ronga shea) were statistically at par.

Fertilizer doses

The differences in length of panicle (cm) due to fertilizer doses were however found to be non-significant during both the years of experiment. Pooled data complied with the findings of both the years.

Interaction effects

The treatment interaction on length of panicle was found to be significant during both the years. The interaction V_4F_2 (cultivar Semvu shea + 60:30:30 NPK kg ha^{-1}) gave the highest (29.88 cm) panicle length during 2015, which was statistically at par with V_4F_3 (cultivar Semvu shea + 90:45:45 NPK kg ha^{-1}) and V_2F_2 (cultivar Hoikha + 60:30:30 NPK kg ha^{-1}). During the year 2016 also the treatment interaction V_4F_2 (cultivar Semvu shea + 60:30:30 NPK kg ha^{-1}) gave the highest panicle length (29.90 cm) which was statistically at par with V_4F_3 (cultivar Semvu shea + 90:45:45 NPK kg ha^{-1}). While the pooled data also followed the same trend of finding with the treatment interaction V_4F_2 (cultivar Semvu shea + 60:30:30 NPK kg ha^{-1}) giving the highest panicle length (29.53 cm) which was again statistically at par with V_4F_3 (cultivar Semvu shea + 90:45:45 NPK kg ha^{-1}). Thus from the observation recorded it can be assumed that genetic trait of the crop has more influence on the development of the yield attributing characters.

Table 10 (a) Effect of cultivars and fertilizer doses on yield attributes of rice

Treatments	Yield attributes											
	Number of panicles m^{-2}			Length of panicle (cm)			Weight of panicle (g)			Number of grains $panicle^{-1}$		
	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
Cultivars (V)												
V_1- Gwabilo ssu	111.00	111.33	111.16	27.65	27.77	27.71	4.49	4.47	4.48	184.42	177.07	180.75
V_2- Hoikha	111.67	111.99	111.83	27.46	27.59	27.52	4.80	5.00	4.89	203.59	197.97	200.78
V_3- Ronga shea	113.00	112.34	112.67	27.48	27.46	27.47	4.74	4.75	4.74	223.31	200.57	211.95
V_4- Semvu shea	115.33	114.34	114.33	28.51	28.55	28.53	5.25	5.36	5.31	233.21	218.98	226.09
V_5- Sahbhagi dhan	117.34	116.99	117.16	27.22	27.26	27.24	5.00	5.33	5.17	227.17	212.07	219.61
SEm±	2.66	1.53	1.53	0.49	0.50	0.38	0.20	0.15	0.19	6.81	7.18	4.95
CD (P=0.05)	NS	NS	NS	1.40	1.41	1.24	0.58	0.44	0.56	19.49	20.54	15.99
Fertilizer doses (NPK kg ha^{-1})												
F_0- Control	111.93	110.46	111.19	25.76	26.60	26.18	3.62	3.26	3.44	199.77	184.73	192.25
F_1- 30:15:15	110.07	109.87	109.97	27.40	26.36	26.86	4.61	4.91	4.76	216.11	197.15	206.62
F_2- 60:30:30	113.00	107.47	110.23	28.00	27.60	27.80	5.22	5.55	5.38	223.33	212.65	217.99
F_3- 90:45:45	112.47	110.67	111.57	27.83	26.18	27.00	4.85	4.94	4.89	218.16	209.39	213.49
SEm±	2.38	1.36	1.37	0.44	0.50	0.34	0.18	0.14	0.17	6.09	6.42	4.42
CD (P=0.05)	NS	NS	NS	NS	NS	NS	0.52	0.39	0.54	NS	NS	NS

Table 10 (b) Interaction effects of cultivars and fertilizer doses on yield attributes of rice

Treatments	Yield attributes											
	Number of panicles m^{-2}			Length of panicle (cm)			Weight of panicle (g)			Number of grains $panicle^{-1}$		
	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
V×F												
T_1 (V_1F_0)	105.33	109.33	107.33	27.93	27.50	27.72	6.09	5.83	5.97	132.02	135.77	133.89
T_2 (V_1F_1)	113.33	104.00	108.67	26.12	25.71	25.87	4.64	4.33	4.48	202.27	196.40	199.32
T_3 (V_1F_2)	110.67	108.00	109.33	27.80	25.85	26.33	4.69	4.95	4.82	162.67	163.68	163.18
T_4 (V_1F_3)	114.67	108.00	111.33	28.75	25.94	27.30	5.52	5.69	5.61	240.80	212.42	226.61
T_5 (V_2F_0)	108.00	102.66	105.33	26.04	24.91	25.43	4.08	4.06	4.07	238.67	199.40	219.05
T_6 (V_2F_1)	114.67	109.33	112.00	28.79	28.31	28.55	4.29	4.26	4.27	161.87	199.25	180.56
T_7 (V_2F_2)	126.67	113.33	120.00	29.42	28.71	27.50	5.64	5.66	5.65	232.50	162.33	197.42
T_8 (V_2F_3)	110.67	118.66	114.66	26.04	27.65	26.84	3.98	4.90	3.93	181.33	230.92	206.13
T_9 (V_3F_0)	113.33	105.33	109.33	25.07	26.22	25.63	3.82	3.57	3.69	219.30	168.07	193.70
T_{10}(V_3F_1)	125.33	105.33	115.33	27.42	27.46	27.43	4.65	4.77	4.71	214.47	188.40	201.45
T_{11}(V_3F_2)	126.67	106.67	116.67	28.29	28.79	28.54	5.78	5.99	5.88	249.13	242.43	245.78
T_{12}(V_3F_3)	110.67	108.00	109.34	28.99	27.19	28.09	4.50	4.53	4.52	216.60	183.12	199.86
T_{13}(V_4F_0)	105.33	108.00	106.67	22.73	24.57	26.76	4.43	4.32	4.37	229.50	211.00	210.27
T_{14}(V_4F_1)	112.00	114.67	113.33	26.23	26.10	26.16	3.86	4.62	4.24	206.93	195.22	201.08
T_{15}(V_4F_2)	114.67	125.33	120.00	29.88	29.90	29.53	7.96	8.11	8.04	271.33	262.73	267.03
T_{16}(V_4F_3)	116.00	108.00	112.00	29.19	29.58	29.38	6.88	6.85	6.86	223.13	219.61	221.31
T_{17}(V_5F_0)	113.33	106.67	110.00	26.10	24.31	25.20	5.19	4.03	4.61	218.67	139.68	179.18
T_{18}(V_5F_1)	114.67	104.00	109.37	28.83	24.44	26.63	4.65	4.51	4.58	213.33	184.36	198.85
T_{19}(V_5F_2)	112.00	108.00	110.00	27.17	27.86	27.51	4.50	4.37	4.44	159.50	157.16	158.33
T_{20}(V_5F_3)	129.33	118.67	124.00	27.91	27.44	27.67	5.64	5.23	5.44	252.87	262.67	252.78
SEm±	5.32	3.06	3.07	0.98	0.97	0.78	0.41	0.30	0.38	13.62	14.35	9.89
CD (P=0.05)	NS	NS	9.92	2.81	2.79	2.48	1.16	0.87	1.21	38.98	41.09	31.99

4.2.3 Weight of panicle (g)

Cultivars

The variations on weight of panicle due to cultivars were found significant during both the years of experiment, since weight of grain is a genetic trait it varies with the type and size of the grain. The first year result recorded highest panicle weight (5.25g) in cultivar V_4 (Semvu shea) which was at par with cultivar V_5 (Sahbhagi dhan) with panicle weight (5.00g) and the lowest (4.49g) with cultivar V_1 (Gwabilo ssu). Similar finding was recorded in the following year with cultivar V_4 (Semvu shea) giving the highest panicle weight (5.36g) which was at par with cultivar V_5 (Sahbhagi dhan) with panicle weight (5.33g) and the lowest (4.47g) with cultivar V_1 (Gwabilo ssu). Pooled data thus obtained also complied with the findings of both the year. Cultivar V_4 (Semvu shea) recorded the highest panicle weight (5.31 g) which was statistically at par with variety V_5 (Sahbhagi dhan) with panicle weight (5.17g) and the lowest (4.48g) with cultivar V_1 (Gwabilo ssu).

Fertilizer doses

Fertilizer doses also recorded significant variation on weight of panicle (g). During 2015 the highest panicle weight (5.22 g) was recorded for F_2 (60:30:30 NPK kg ha^{-1}). Similar result was obtained during 2016 with the highest panicle weight (5.55 g) recorded with fertilizer dose F_2 (60:30:30 NPK kg ha^{-1}) while the lowest was recorded in control during both the year. Pooled data also followed the same trend of finding. Fertilizer dose F_2 (60:30:30 NPK kg ha^{-1}) recorded the highest panicle weight (5.38 g) while the lowest was recorded in control.

Interaction effects

The interaction effect between cultivars and fertilizer on weight of panicle also recorded to be significant. The treatment interaction V_4F_2 (cultivar Semvu shea + 60:30:30 NPK kg ha^{-1}) gave the highest panicle weight during both the year (7.96 g and 8.11g respectively), while the lowest was recorded in V_3F_0 (cultivar Ronga shea + control). Pooled result thus obtained also recorded the highest panicle weight (8.04g) with treatment interaction V_4F_2 (cultivar Semvu shea + 60:30:30 NPK kg ha^{-1}, while the lowest was recorded with interaction V_3F_0 (cultivar Ronga shea + control).

4.2.4 Number of grains panicle^{-1}

Cultivars

The variations on number of grains panicle^{-1} due to cultivars showed significant variation. The highest number of grains panicle^{-1} (233.21) during 2015 was recorded with cultivar V_4 (Semvu shea) which was statistically at par with V_5 (variety Sahbhagi dhan), During the year 2016, the highest number of grains panicle^{-1} (218.98) was recorded with the same cultivar V_4 (Semvu shea), which was again statistically at par with V_5 (variety Sahbhagi dhan), while cultivar V_1 (Gwabilo ssu) recorded the lowest number of grains panicle^{-1} during both the year. Pooled result thus obtained complied with the findings of both the year. The highest number of grains panicle^{-1} (226.09) was recorded with the cultivar V_4 (Semvu shea) which was statistically at par with V_5 (variety Sahbhagi dhan), while the lowest was recorded with cultivar V_1 (Gwabilo ssu).

Fertilizer doses

The variation in number of grains panicle^{-1} due to fertilizers was however found to be non- significant.

Interaction effects

The interaction effect between cultivars and fertilizer doses on number of grains panicle^{-1} was found to be significant. During the year 2015, the treatment interaction V_4F_2 (cultivar Semvu shea + 60:30:30 NPK kg ha^{-1}) gave the highest number of grains panicle^{-1} (271.33). The interactions V_5F_3 (variety Sahbhagi dhan + 90:45:45 NPK kg ha^{-1}) and V_1F_3 (cultivar Gwabilo ssu + 60:30:30 NPK kg ha^{-1}) were found to be at par. Similar findings were observed during the year 2016. The interaction V_4F_2 (cultivar Semvu shea + 60:30:30 NPK kg ha^{-1}) gave the highest number of grains panicle^{-1}(262.73), while the interactions V_5F_3 (variety Sahbhagi dhan + 90:45:45 NPK kg ha^{-1}) and V_3F_2 (cultivar Ronga shea + 60:30:30 NPK kg ha^{-1}) were found to be at par. Pooled result of both the year also followed the similar finding with the interaction V_4F_2 (cultivar Semvu shea + 60:30:30 NPK kg ha^{-1}) giving the highest number of grains panicle^{-1}(267.03), which was statistically at par with the interactions V_5F_3 (variety Sahbhagi dhan + 90:45:45 NPK kg ha^{-1}) and V_3F_2 (cultivar Ronga shea + 60:30:30 NPK kg ha^{-1}).

4.2.5 Filled grains percent (%)

Cultivars

The variation on filled grain percentage due to cultivars was found to be significant. During the first year 2015, variety V_5 (Sahbhagi dhan) significantly recorded the highest filled grain percentage (85.14 %). Cultivars V_4 (Semvu shea), V_3 (Ronga shea) and V_1 (Gwabilo ssu) were found to be statistically at par. While during the second year 2016, the highest filled grain percentage (85.66 %) was recorded with variety V_5 (Sahbhagi dhan) . Pooled data of both the year followed the same trend of finding with variety V_5 (Sahbhagi dhan) significantly giving the highest filled grain percentage (85.42 %) which was statistically at par with cultivar V_4 (Semvu shea). While cultivar V_1 (Gwabilo ssu) recorded the lowest value which also recorded the lowest number of grains panicle^{-1}.

Fertilizer doses

The variation in filled grain percentage due to fertilizers doses also recorded significant variation. During the year 2015 the fertilizer dose F_3 (90:45:45 NPK kg ha^{-1}) recorded significantly highest filled grain percentage (87.55 %) which was statistically at par with fertilizer dose F_2 (60:30:30 NPK kg ha^{-1}) while control showed the lowest filled grain percentage. During the year 2016 fertilizer dose F_3 (90:45:45 NPK kg ha^{-1}) significantly recorded the highest filled grains percentage (83.14 %). Pooled data thus obtained complied with the finding of the two year experiment where fertilizer dose F_3 (90:45:45 NPK kg ha^{-1}) significantly recorded the highest filled grains percentage (83.84 %), which was followed by fertilizer dose F_2

Table 11 (a) Effect of cultivars and fertilizer doses on yield attributes of rice

Treatments	Yield attributes					
	Filled grain percent (%)			Test weight (g)		
	2015	2016	Pooled	2015	2016	Pooled
Cultivars (V)						
V_1- Gwabilo ssu	80.59	80.08	80.33	20.18	20.23	20.21
V_2- Hoikha	83.00	82.59	82.30	21.13	20.29	20.68
V_3- Ronga shea	82.62	82.05	82.34	20.36	20.25	20.32
V_4- Semvu shea	83.81	84.65	84.23	21.16	21.41	21.28
V_5- Sahbhagi dhan	85.14	85.66	85.42	21.23	21.47	21.35
SEm±	0.84	1.32	0.78	0.24	0.21	0.16
CD (P=0.05)	2.52	3.85	2.35	0.69	0.62	0.52
Fertilizer doses (NPK kg ha^{-1})						
F_0- Control	81.39	81.23	81.27	20.19	20.05	20.12
F_1- 30:15:15	82.15	82.58	82.37	20.43	20.28	20.35
F_2- 60:30:30	84.25	82.05	83.32	20.61	20.82	20.71
F_3- 90:45:45	84.55	83.14	83.84	20.63	20.86	20.75
SEm±	0.75	1.18	0.69	0.21	0.19	0.14
CD (P=0.05)	2.13	3.62	2.25	0.61	0.55	0.47

Table 11 (b) Interaction effects of cultivars and fertilizer doses on yield attributes of rice

Treatments	Yield attributes					
	Filled grain percent (%)			Test weight (g)		
	2015	2016	Pooled	2015	2016	Pooled
V×F						
T_1 (V_1F_0)	76.76	78.30	77.53	19.98	19.85	19.94
T_2 (V_1F_1)	85.58	85.05	85.32	21.75	21.29	21.53
T_3 (V_1F_2)	83.94	78.63	81.28	19.01	19.80	19.41
T_4 (V_1F_3)	88.72	84.16	86.44	21.83	20.99	21.41
T_5 (V_2F_0)	80.57	78.63	79.60	19.80	20.65	20.22
T_6 (V_2F_1)	79.31	78.86	79.08	20.59	20.38	20.48
T_7 (V_2F_2)	86.66	86.46	86.57	21.03	19.31	22.54
T_8 (V_2F_3)	81.09	79.75	80.43	19.77	19.10	19.44
T_9 (V_3F_0)	84.76	86.48	85.62	18.84	18.70	18.77
T_{10}(V_3F_1)	87.29	88.25	87.85	20.84	19.28	20.06
T_{11}(V_3F_2)	90.79	88.13	89.46	21.99	19.96	20.98
T_{12}(V_3F_3)	83.74	78.10	80.92	20.56	20.87	20.71
T_{13}(V_4F_0)	80.78	81.54	81.16	21.24	20.79	21.02
T_{14}(V_4F_1)	84.30	82.56	83.43	19.68	20.55	20.12
T_{15}(V_4F_2)	91.45	88.42	89.85	22.65	22.48	22.57
T_{16}(V_4F_3)	80.04	81.82	80.93	20.52	22.14	21.33
T_{17}(V_5F_0)	80.16	78.53	79.35	19.02	18.72	18.87
T_{18}(V_5F_1)	83.93	84.22	84.07	20.20	19.94	20.07
T_{19}(V_5F_2)	88.37	84.38	86.38	22.67	22.41	22.54
T_{20}(V_5F_3)	91.49	91.74	91.62	23.42	23.03	23.22
SEm±	1.67	2.64	1.56	0.48	0.43	0.32
CD (P=0.05)	5.01	7.55	4.78	1.38	1.24	1.05

(60:30:30 NPK kg ha^{-1}) and F_1 (30:15:15 NPK kg ha^{-1}) while control recorded the lowest filled grain percentage.

Interaction effects

The interaction effect between cultivars and fertilizer doses on filled grain percentage recorded significant variation. During the year 2015, the treatment interaction V_5F_3 (variety Sahbhagi dhan + 90:45:45 NPK kg ha^{-1}) gave the highest filled grain percentage (91.49 %) which was statistically at par with interaction V_4F_2 (cultivar Semvu shea + 60:30:30 NPK kg ha^{-1}), V_5F_2 (variety Sahbhagi dhan + 60:30:30 NPK kg ha^{-1}) and V_1F_3 (cultivar Gwabilo ssu + 90:45:45 NPK kg ha^{-1}). During the year 2016 the treatment interaction V_5F_3 (variety Sahbhagi dhan + 90:45:45 NPK kg ha^{-1}) maintained the highest filled grain percentage (91.74 %) which was statistically at par with interaction V_4F_2 (cultivar Semvu shea + 60:30:30 NPK kg ha^{-1}), V_3F_1 (cultivar Ronga shea + 30:15:15 NPK kg ha^{-1}) and V_3F_2 (cultivar Ronga shea + 60:30:30 NPK kg ha^{-1}). The pooled data thus obtained followed similar trend of finding with treatment interaction V_5F_3 (variety Sahbhagi dhan + 90:45:45 NPK kg ha^{-1}) giving the highest filled grain percentage (91.62 %) which was statistically at par with interaction V_4F_2 (cultivar Semvu shea + 60:30:30 NPK kg ha^{-1}) and V_3F_2 (cultivar Ronga shea + 60:30:30 NPK kg ha^{-1}). While the lowest was recorded in interaction V_1F_0 (cultivar Gwabilo ssu + control) during both the years of experiment.

4.2.6 Test weight (g)

Cultivars

The variations on test weight due to cultivars were found to be significant. During the first year 2015 the highest value for test weight (21.23 g) was recorded with V_5 (variety Sahbhagi dhan) which was statistically at par with cultivar V_4 (Semvu shea), While the lowest (20.18 g) was recorded in V_1 (cultivar Gwabilo ssu). During the year 2016, similar results were recorded. The highest value for test weight (21.47 g) was recorded with V_5 (variety Sahbhagi dhan) which was statistically at par with cultivar V_4 (Semvu shea), while the lowest (20.23 g) was recorded in V_1 (cultivar Gwabilo ssu). Pooled data also recorded the same trend of finding with the highest value for test weight (21.35 g) recorded in V_5 (variety Sahbhagi dhan) which was statistically at par with cultivar V_4 (Semvu shea), While the lowest (20.21 g) was recorded in V_1 (cultivar Gwabilo ssu). This result depicting that genetic character has a vital role in the development of a seed thereby maintaining a constant weight of the grain.

Fertilizer doses

The differences in test weight due to fertilizer doses were also found to be significant. The fertilizer dose F_3 (90:45:45 NPK kg ha^{-1}) recorded the highest (20.63 g) test weight during the year 2015 which was found to be statistically at par with F_2 (60:30:30 NPK kg ha^{-1}) and F_1 (30:15:15 NPK kg ha^{-1}). During 2016, the same trend of finding followed with fertilizer dose F_3 (90:45:45 NPK kg ha^{-1}) giving the highest test weight (20.86 g). While fertilizer doses F_2 (60:30:30 NPK kg ha^{-1}) and F_1 (30:15:15 NPK kg ha^{-1}) were found to be statistically at par. Also the pooled data thus obtained complied with the findings of both the year. The fertilizer dose F_3 (90:45:45 NPK kg ha^{-1}) recorded the highest (20.75 g) test weight which was found to be statistically at par with F_2 (60:30:30 NPK kg ha^{-1}) and F_1 (30:15:15 NPK kg ha^{-1}).

Interaction effects

The interaction effects of treatments on test weight recorded significant variation. During the year 2015, the highest value (23.42 g) was recorded with interaction V_5F_3 (variety Sahbhagi dhan + 90:45:45 NPK kg ha^{-1}). The interactions V_4F_2 (cultivar Semvu shea + 60:30:30 NPK kg ha^{-1}) and V_5F_2 (variety Sahbhagi dhan + 60:30:30 NPK kg ha^{-1}) were found to be at par. Similar finding was recorded during 2016 with interaction V_5F_3 (variety Sahbhagi dhan + 90:45:45 NPK kg ha^{-1}) giving the highest value (23.03 g) of test weight. While interactions V_4F_2 (cultivar Semvu shea + 60:30:30 NPK kg ha-^{1}) and V_5F_2 (variety Sahbhagi dhan + 60:30:30 NPK kg ha^{-1}) still recorded to be at par during the following year of experiment. Pooled data also showed a similar result with interaction V_5F_3 (variety Sahbhagi dhan + 90:45:45 NPK kg ha^{-1}) maintaining the highest value of test weight (23.22 g) which was at par with interactions V_4F_2 (cultivar Semvu shea + 60:30:30 NPK kg ha^{-1}) and V_5F_2 (variety Sahbhagi dhan + 60:30:30 NPK kg ha^{-1}). While the lowest value of test weight was recorded with interaction V_3F_0 (cultivar Ronga shea + control).

4.2.7 Grain yield (kg ha^{-1})

Cultivars

Different cultivars recorded significant variation in grain yield during both the years of experiment. During the year 2015, the highest grain yield (2790.74 kg ha^{-1}) was recorded with V_5 (variety Sahbhagi dhan), which was statistically at par with the cultivar V_4 (Semvu shea). While the lowest (1405.01 kg ha^{-1}) was recorded in cultivar V_1 (Gwabilo ssu) which was at par with cultivar V_2 (Hoikha). During the year 2016 also the highest grain yield (2789.81 kg ha^{-1}) was recorded in V_5 (variety Sahbhagi dhan) which was statistically at par with cultivar V_4 (Semvu shea) and the lowest was in cultivar V_1 (Gwabilo ssu).

Fertilizer doses

The variation in grain yield due to fertilizer doses were found to be significant. Fertilizer dose F_3 (90:45:45 NPK kg ha^{-1}) recorded the highest grain yield (2299.63 kg $ha^{-1}$and 2218.52 kg ha^{-1} respectively) during both the years of experiment, which was statistically at par with fertilizer dose F_2 (60:30:30 NPK kg ha^{-1}) while the lowest was recorded in control. Similar findings were recorded during the experiment in 2016. Pooled data also recorded the highest grain yield (2259.07 kg ha^{-1}) with fertilizer dose F_3 (90:45:45 NPK kg ha^{-1}) which was at par with fertilizer dose F_2 (60:30:30 NPK kg ha^{-1}) and the lowest value recorded with control.

Interaction effects

The treatment interaction on grain yield also produced significant variation. The highest grain yield (3600.00 kg ha^{-1}) during 2015 was associated with interaction V_5F_3 (variety Sahbhagi dhan + 90:45:45 NPK kg ha^{-1}) which was followed by V_4F_2 (cultivar Semvu shea + 60:30:30 NPK kg $ha-^{1}$) and V_5F_2 (variety Sahbhagi dhan +

Table 12 (a) Effect of cultivars and fertilizer doses on yield of rice

Treatments	Yield								
	Grain yield (kg ha^{-1})			Straw yield (kg ha^{-1})			Harvest index (%)		
	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
Cultivars (V)									
V_1- Gwabilo ssu	1405.01	1438.66	1421.84	3768.52	4512.50	4140.51	27.16	24.17	25.69
V_2- Hoikha	1516.66	1565.05	1540.86	4111.11	4506.25	4368.53	27.52	27.86	27.45
V_3- Ronga shea	1601.43	1684.72	1634.74	4218.48	4361.11	4286.66	26.94	25.78	26.17
V_4- Semvu shea	2668.52	2607.87	2638.19	4930.59	4806.48	4868.54	35.12	35.17	35.15
V_5- Sahbhagi dhan	2790.74	2789.81	2790.27	4185.18	4247.92	4208.68	37.83	38.02	37.76
SEm±	48.48	33.21	29.38	283.08	300.22	233.42	0.36	0.22	0.21
CD (P=0.05)	138.79	95.07	95.02	810.44	NS	754.85	1.02	0.64	0.68
Fertilizer doses (NPK kg ha^{-1})									
F_0- Control	1362.92	1532.15	1440.87	3503.70	4927.78	4260.18	28.01	28.52	28.28
F_1- 30:15:15	2058.51	2203.15	2130.83	4125.92	3885.18	4594.44	32.02	29.89	32.91
F_2- 60:30:30	2264.81	2101.75	2189.95	4037.03	3838.89	4766.66	33.28	36.18	34.73
F_3- 90:45:45	2299.63	2218.52	2259.07	4881.48	4055.55	4937.96	35.93	35.36	35.69
SEm±	43.36	29.70	26.28	253.19	257.97	208.77	0.32	0.20	0.18
CD (P=0.05)	124.15	85.04	84.98	NS	NS	NS	0.92	0.57	0.61

Table 12 (b) Interaction effects of cultivars and fertilizer doses on yield of rice

Treatments	Yield								
	Grain yield (kg ha^{-1})			Straw yield (kg ha^{-1})			Harvest index (%)		
	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
V×F									
T_1 (V_1F_0)	1016.33	986.67	1001.50	3237.04	3688.89	3462.96	26.64	22.64	24.64
T_2 (V_1F_1)	1633.33	1650.00	1641.67	5185.18	4570.37	4877.77	26.84	23.51	25.17
T_3 (V_1F_2)	1525.92	1625.92	1575.92	5459.25	6411.11	5935.18	27.65	24.91	26.28
T_4 (V_1F_3)	1444.44	1492.07	1468.25	4774.07	5055.55	4914.81	27.78	25.59	26.68
T_5 (V_2F_0)	1037.04	1218.52	1127.77	3518.52	4694.44	4106.48	24.36	24.85	24.61
T_6 (V_2F_1)	1740.74	1825.00	1782.86	4444.44	3722.22	4083.33	26.34	24.45	25.39
T_7 (V_2F_2)	1488.88	1616.67	1552.77	3370.37	5972.22	4671.95	27.96	24.66	26.31
T_8 (V_2F_3)	1800.00	1600.00	1700.00	3740.74	6861.11	5300.93	28.67	28.12	28.39
T_9 (V_3F_0)	1057.57	1316.67	1153.78	3370.37	6111.11	4740.74	26.02	21.85	23.93
T_{10}(V_3F_1)	1614.81	1755.55	1685.18	3888.88	6527.77	5208.33	29.45	28.85	29.15
T_{11}(V_3F_2)	1883.33	1850.00	1866.67	4148.15	5625.00	4886.57	27.45	29.19	28.32
T_{12}(V_3F_3)	1850.00	1816.67	1833.33	5037.04	4861.11	4949.07	26.78	29.98	28.38
T_{13}(V_4F_0)	1148.15	2064.81	1606.48	3025.92	4055.56	3540.74	32.97	37.89	35.42
T_{14}(V_4F_1)	2896.29	2933.33	2914.81	3925.93	6511.11	5218.52	33.66	38.97	36.32
T_{15}(V_4F_2)	3200.00	3233.33	3250.00	4444.44	5458.33	4951.38	40.67	37.20	38.53
T_{16}(V_4F_3)	3029.63	2366.67	2698.15	4444.44	6166.67	5305.55	36.65	34.63	35.64
T_{17}(V_5F_0)	2555.56	2074.07	2314.82	3888.88	4250.00	5069.44	39.42	34.77	37.09
T_{18}(V_5F_1)	2407.40	2851.84	2629.62	4185.18	4694.44	4439.81	33.67	38.81	36.24
T_{19}(V_5F_2)	3000.00	2933.33	2966.67	3185.18	4611.11	3898.15	35.98	37.47	36.73
T_{20}(V_5F_3)	3600.00	3066.67	3333.33	4666.66	4888.89	4777.77	41.86	41.33	41.56
SEm±	96.96	66.42	58.76	502.28	800.45	466.84	0.72	0.44	0.42
CD (P=0.05)	277.00	190.15	1190.03	NS	NS	NS	2.04	1.28	1.36

60:30:30 NPK kg ha^{-1}) while the lowest (1016.33 kg ha^{-1}) was recorded with interaction V_1F_0 (cultivar Gwabilo ssu + control). However during the following year the highest grain yield (3066.67 kg ha^{-1}) was associated with interaction V_4F_2 (cultivar Semvu shea + 60:30:30 NPK kg ha^{-1}) which was found to be statistically at par with interactions V_5F_3 (variety Sahbhagi dhan + 90:45:45 NPK kg ha^{-1}) which was followed by interactions V_4F_2 (cultivar Semvu shea + 60:30:30 NPK kg ha-^{1}). The pooled data thus obtained complied with the finding of the first year experiment, with interaction V_5F_3 (variety Sahbhagi dhan + 90:45:45 NPK kg ha^{-1}) giving the highest value (3333.33 kg ha^{-1}) which was found to be statistically at par with interaction V_4F_2 (cultivar Semvu shea + 60:30:30 NPK kg ha-^{1}) while the lowest grain yield (1001.50 kg ha^{-1}) was recorded with interaction V_1F_0 (cultivar Gwabilo ssu + control).

4.2.8 Straw yield (kg ha^{-1})

Cultivars

The variations on straw yield due to cultivars were found significant during 2015, while results proved to be non significant during the following year of experiment. However, the highest (4185.18 kg ha^{-1}) straw yield during first year of experiment was recorded with V_4 (cultivar Semvu shea), while the lowest was recorded in cultivar V_1 (Gwabilo ssu). Pooled data thus obtained showed a significant variation with V_4 (cultivar Semvu shea) giving the highest value for straw yield (4868.54 kg ha^{-1}) which was followed by cultivar V_2 (Hoikha), while the lowest was recorded in cultivar V_1 (Gwabilo ssu).

The interaction of different treatments could not produced significant result on straw yield during both the years.

4.2.9 Harvest index (%)

Cultivars

Harvest index showed significant variation among the different cultivars under observation. During the year 2015, the highest value for harvest index (37.83 %) was recorded with V_5 (variety Sahbhagi dhan) and the lowest (26.94 %) was in cultivar V_3 (Ronga shea). During the second year of experiment V_5 (variety Sahbhagi dhan) gave the highest value (38.02 %) of harvest index which was followed by V_4 (cultivar Semvu shea) during both the year of experiment. While V_3 (Ronga shea) still recorded the lowest value (28.61 %) of harvest index.

Fertilizer doses

The variations in harvest index due to different fertilizer doses were found to be significant. 2015 result recorded that fertilizer dose F_3 (90:45:45 NPK kg ha^{-1}) gave the highest value (35.93 %) of harvest index and the lowest (28.01 %) was in control, while in the following year fertilizer dose F_3 (90:45:45 NPK kg ha^{-1}), which was followed by fertilizer dose F_2 (60:30:30 NPK kg ha^{-1}), F_1 (30:15:15 NPK kg ha^{-1}) and the lowest was in control (28.52 %). Pooled data followed the similar trend of finding with the highest value (35.69 %) recorded in fertilizer dose F_3 (90:45:45 NPK kg ha^{-1}) followed by fertilizer dose F_2 (60:30:30 NPK kg ha^{-1}), F_1 (30:15:15 NPK kg ha^{-1}) and the lowest was in control (28.28 %).

Interaction effects

The interaction effects of different treatments on harvest index were found to be significant. The highest value of harvest index (41.86 %) during the first year of experiment was recorded with treatment interaction V_5F_3 (variety Sahbhagi dhan + 90:45:45 NPK kg ha^{-1}) which also recorded the highest value in terms of cultivars and fertilizer doses under experiment. The interactions V_4F_2 (cultivar semvu shea + 60:30:30 NPK kg ha^{-1}) and V_3F_2 (cultivar Ronga shea + 60:30:30 NPK kg ha^{-1}) were statistically at par. While, during the year 2016 the highest (41.33 %) value of harvest index was also recorded with treatment interaction V_5F_3 (variety Sahbhagi dhan + 90:45:45 NPK kg ha^{-1}) while treatment interaction V_3F_0 (cultivar Ronga shea + control) recorded the lowest harvest index value during both the year of experiment. Pooled data revealed similar finding with treatment interaction V_5F_3 (variety Sahbhagi dhan + 90:45:45 NPK kg ha^{-1}) giving the highest value for harvest index (41.56 %) while treatment interaction V_3F_0 (cultivar Ronga shea + control) recorded the lowest harvest index value.

Crop yield is mainly dependant on the interplay of various biochemical functions of the plant in addition to the impact of growing environment. The cause and effect relationship is difficult to understand mainly because of complexity in understanding the interplay of several processes and functions which ultimately lead to changes not only in growth, development and physiology but also on yield, which is the most complex character.

The findings of the experiment indicated beneficial effects of using the correct dose of fertilizer for obtaining higher yield and yield attributing characters of rice crop.

The variations on number of panicles due to cultivars and fertilizers were found to be non-significant. Interaction effects between the cultivars and fertilizers also could not record any significant difference during both the years of experiment. However the highest number of panicles m^{-2} (117.16) was recorded with V_5 (Sahbhagi dhan). This could be attributed mainly to the stimulation effect of nitrogen on effective tillers formation. These findings are consistent with those reported by Metwally (2015). While the longest panicle length (28.53cm), panicle weight (5.31 cm) and number of grains per panicle (226.09) was recorded in cultivar V_4 (Semvu shea) with a fertilizer dose of F_2 (60:30:30 NPK kg ha^{-1}). This could be because of the genetic variations among the different cultivars as genetic variations play a key role in development of yield attributing components. This finding is in conformity with Sarawate *et al*. (2007) who carried out an experiment to study the comparative performance of rice cultivars Phule Radha, a short slender, medium duration rice cultivar with KJT-4 and Zinia 63 under various nutrients sources and reported that that Phule Radha was superior in terms of yield contributing characters such as panicle length, number of spikelets $panicle^{-1}$ resulting in significantly higher grain yield than KJT-4 and Zinia 63. However, amongst the different sources of nutrients under study, the application of fertilizer in form of briquettes (56:30 N: P kg ha^{-1}) and combination of 50% of briquettes (28:15 kg N:P ha^{-1}) + green leaf manuring (Gliricidia at 5 t ha^{-1}) being at par, have shown significantly higher grain yield over the other treatments. This result was also in conformity with Ikramullah and Mahunta 2001, who reported that application of different graded level of fertilizers had significant impact on yield and yield components. Rice crop fertilized with 180:60:40NPK kg ha^{-1} produced highest number and length of panicle, grains per panicle as well as grain and straw production whereas crop without fertilizer recorded the lowest values. While, the other yield attributing components such as grain filled percent (85.42 %) and test weight (21.35 g) were recorded to be highest with the improved check variety Sahbhagi dhan. This could be due to higher spikelet fertility owing to reduced no of unfilled spikelet than the local check. This finding is in corroboration with the findings of C.R.R.I (2014). Dekhane *et al*. (2014) also reported that application of 125% of RDF significantly recorded higher panicle length (22.1 cm), grains panicle^{-1} (128), 1000 grain weight (20.9 g) and grain yield (5.18 t ha^{-1}), straw yield (5.79 t ha^{-1}), tillers plant^{-1} 9.7 and 11.7 at 45 DAT and harvest. The number of grains per panicle was also found to be significantly highest (233.21) in the check variety Sahbhagi dhan. Also Samant *et al*.(2015) reported that Sahbhagi dhan showed higher germination(48.4 %), effective tillers plant^{-1}(13.2), length of panicle(22.6 cm), filled grains panicle^{-1}(125.3) with spikelet fertility(93.65 %) and 1000 grain weight(22.3 g) than Khandagiri.

Highest grain yield (2790.27 kg ha^{-1}) was obtained from the check variety Sahbhagi dhan under fertilizer dose F_3 (90:45:45 NPK kg ha^{-1}) (table 12 (a)). The treatment interaction also showed highest value (3600 kg ha^{-1}) for V_5F_3 (variety Sahbhagi dhan + 90:45:45 NPK kg ha^{-1}) (Table 12 (b)). This could be owing to higher production of tillers, spikelet fertility and filled grain percent as compared to the other local cultivars. Also due to its dwarf stature it could resist lodging even under development of heavy yield attributing characters during reproductive stage and management practices could be more effectively carried out in case of this variety. This finding was in conformity with Raman *et al*. (2012) who reported a high ranking for Sahbhagi Dhan and also a consistently higher yield than IR64 and MTU1010 (popular high-yielding but drought-susceptible varieties) across irrigated and drought-stress environments. Verulkar *et al*. (2010) also reported average yields of Sahbhagi Dhan that were consistently higher than those of standard checks in irrigated, moderate drought, and severe drought conditions. Based on genotype plus geno- type environment plots, Kumar *et al*. (2012) also reported that Sahbhagi Dhan was the most stable yielding out of about 40 entries across 16 rain-fed stresses and irrigated environments at three locations in eastern India in wet-season trials. Straw yield was found to be non-significant. However, highest (4868.54 kg ha^{-1}) value was recorded in V_4 (cultivar Semvu shea). This was owing to higher vegetative growth as a result of higher dose of fertilizer application.

Owing to its advantage of higher grain yield and low dry matter content, harvest index was also found to be highest for the check variety Sahbhagi dhan. The grain yield was significantly and positively correlated with Harvest index, number of tillers and test weight, however grain yield was significantly and negatively correlated with straw yield. Similar finding was supported by Girish *et al*. (2006) who reported a better grain yield (4.51 kg ha^{-1}), number of tillers (350), test weight (25.2 g), sterility percent (36.7 %) and harvest index 39.6 %) from Sahbhagi dhan under aerobic conditions in eastern India. Anantha *et al.* (2016) also reported Sahbhagi dhan to record higher germination (13.2 %), effective tillers $plant^{-1}$(48.4 m^{-2}), length of panicle (22.6 cm), filled grains $panicle^{-1}$ (125.3) with spikelet fertility(93.65 %) and 1000 grain weight (22.3 g) than Khandagiri. The same variety also produced grain yield 35.5 q ha^{-1} which was 28.6 % higher yield than Khandagiri with harvest index (47.9 %) and water productivity (3.17 kg mm^{-1}).

4.2.10 Production efficiency (kg kg^{-1})

Cultivars

Production efficiency showed significant variation among the different cultivars under observation. During the year 2015, the highest production efficiency in terms of all the three nutrients *viz*., nitrogen, phosphorus and potassium (59.56, 119.13 and 119.13 kg kg^{-1} respectively) was recorded with cultivar V_4 (Semvu shea) while the lowest (44.09, 78.20 and 78.20 kg kg^{-1} respectively) was recorded in cultivar V_1 (Gwabilo ssu). During the second year of experimentation cultivar V_4 (Semvu shea) gave the highest value (56.47, 112.38 and 112.38 kg kg^{-1} respectively) for N, P and K, while cultivar V_1 (Gwabilo ssu) recorded the lowest value. Pooled data also revealed the similar finding with cultivar V_4 (Semvu shea) showing the

Table 13 (a) Effect of cultivars and fertilizer doses on production efficiency of rice

Treatments	Production efficiency (kg kg^{-1})								
	NUE			PUE			KUE		
	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
Cultivars (V)									
V_1- Gwabilo ssu	44.09	38.12	41.08	78.20	75.09	76.61	78.20	75.09	76.61
V_2- Hoikha	45.09	43.54	44.21	90.19	80.30	85.21	90.19	80.30	85.21
V_3- Ronga shea	48.45	45.14	46.72	97.33	92.96	95.12	97.33	92.96	95.11
V_4- Semvu shea	59.56	56.47	58.06	119.13	112.38	115.71	119.13	112.38	115.69
V_5- Sahbhagi dhan	48.66	45.46	47.02	101.38	97.97	99.61	101.38	97.97	99.61
SEm±	0.56	0.50	0.37	0.57	0.48	0.37	0.57	0.48	0.37
CD (P=0.05)	1.60	1.43	1.21	1.63	1.39	1.21	1.63	1.39	1.21
Fertilizer doses (NPK kg ha^{-1})									
F_0- Control	35.31	33.81	34.51	74.19	67.63	70.86	74.19	67.63	70.86
F_1- 30:15:15	42.64	41.28	41.95	101.23	82.57	91.90	101.23	82.57	91.87
F_2- 60:30:30	54.81	52.96	53.81	111.94	117.24	114.51	111.94	117.24	114.51
F_3- 90:45:45	50.61	51.76	51.18	109.63	85.93	97.71	109.63	85.93	97.71
SEm±	0.50	0.44	0.34	0.51	0.43	0.33	0.51	0.43	0.33
CD (P=0.05)	1.43	1.28	1.08	1.46	1.24	1.08	1.46	1.24	1.08

Table 13 (b) Interaction effects of cultivars and fertilizer doses on production efficiency of rice

Treatments	Production efficiency (kg kg^{-1})								
	NUE			PUE			KUE		
	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
V×F									
T_1 (V_1F_0)	31.40	36.22	33.54	62.80	72.44	67.23	62.80	72.44	67.23
T_2 (V_1F_1)	51.31	49.26	50.32	96.63	94.53	95.45	96.63	94.53	95.45
T_3 (V_1F_2)	59.95	58.35	59.03	101.91	100.70	101.05	101.91	100.70	101.05
T_4 (V_1F_3)	37.73	36.74	37.20	55.47	53.48	54.43	55.47	53.48	54.43
T_5 (V_2F_0)	34.56	33.51	34.02	87.03	87.03	87.03	87.03	87.03	87.03
T_6 (V_2F_1)	30.49	29.81	30.15	46.98	47.63	47.17	46.98	47.63	47.17
T_7 (V_2F_2)	40.74	39.01	40.35	58.48	58.02	58.38	58.48	58.02	58.38
T_8 (V_2F_3)	25.92	22.37	23.74	106.04	107.71	106.87	106.04	107.71	106.87
T_9 (V_3F_0)	40.19	40.27	40.23	80.38	80.55	80.44	80.38	80.55	80.44
T_{10}(V_3F_1)	53.63	42.43	48.03	87.27	84.87	86.27	87.27	84.87	86.27
T_{11}(V_3F_2)	40.05	36.01	38.78	80.11	80.55	80.33	80.11	80.55	80.33
T_{12}(V_3F_3)	42.52	31.79	37.13	65.05	63.58	64.21	85.05	63.58	64.21
T_{13}(V_4F_0)	33.33	36.60	34.96	66.67	65.21	66.17	66.67	65.21	66.17
T_{14}(V_4F_1)	62.95	52.16	57.55	105.91	104.32	105.12	105.91	104.32	105.12
T_{15}(V_4F_2)	88.88	85.06	86.97	167.77	165.12	166.56	167.77	165.12	166.56
T_{16}(V_4F_3)	58.02	53.85	55.32	43.84	44.75	44.35	43.84	44.75	44.35
T_{17}(V_5F_0)	37.04	39.81	38.22	78.07	79.62	79.35	78.07	79.62	79.35
T_{18}(V_5F_1)	45.67	42.39	43.78	87.35	86.79	86.98	87.35	86.79	86.98
T_{19}(V_5F_2)	66.67	62.65	64.32	124.93	121.60	123.41	124.93	121.60	123.41
T_{20}(V_5F_3)	72.46	68.80	70.61	126.33	125.31	125.82	126.33	125.31	125.82
SEm±	1.12	1.00	0.75	1.14	0.97	0.75	1.14	0.97	0.75
CD (P=0.05)	3.21	2.87	2.44	3.27	2.78	2.43	3.27	2.78	2.43

highest production efficiency (46.72, 99.61 and 99.61 kg kg^{-1} respectively) in terms of all the three nutrients under observation.

Fertilizer doses

Different fertilizer doses showed significant variation during both the experiment years. During the year 2015 fertilizer dose F_2 (60:30:30 NPK kg ha^{-1}) recorded the highest value in terms of production efficiency (54.81, 111.94 and 111.94 kg kg^{-1} respectively) for all the three nutrients and the lowest was recorded in control, while in the following year again, fertilizer dose F_3 (90:45:45 NPK kg ha^{-1}) recorded the highest value (52.96, 117.24and 117.24 kg kg^{-1} respectively) and the lowest in control. Pooled data also followed the similar trend of finding with fertilizer dose F_2 (60:30:30 NPK kg ha^{-1}) revealing the highest value in terms of production efficiency (51.18, 85.93 and 85.93 kg kg^{-1} respectively) for all the three nutrients and the lowest was recorded in control.

Interaction effects

Interaction effects of different treatments recorded significant variation on production efficiency. The highest efficiency value (88.88, 167.77 and 167.77 kg kg^{-1} N, P and K respectively) was recorded during first year of experiment with the treatment interaction V_4F_2 (cultivar Semvu shea + 60:30:30 NPK kg ha^{-1}), during the second year 2016 also highest value (85.06, 165.12 and 165.12 kg kg^{-1} respectively for N P and K) was recorded with the same treatment combination V_4F_2 (cultivar Semvu shea + 60:30:30 NPK kg ha^{-1}). Pooled data complied with the finding of the two years experiment. The highest efficiency value (55.32, 123.41 and 123.41 kg kg^{-1} N P and K respectively) was recorded with the same treatment combination V_4F_2 (cultivar Semvu shea + 60:30:30 NPK kg ha^{-1}) which was followed by treatment combination V_5F_3 (variety Sahbhagi dhan + 90:45:45 NPK kg ha^{-1}).

Production efficiency in terms of nitrogen phosphorus and potassium response was recorded to be highest in cultivar V_4 Semvu shea (Table 13 (a)) during both the year with fertilizer dose F_2 (60:30:30 NPK kg ha^{-1}) (Table 13 (a)) while the treatment interaction V_4F_2 (cultivar Semvu shea + 60:30:30 NPK kg ha^{-1}) (Table 13 (b)) recorded the highest production efficiency, which was followed by variety Sahbhagi dhan under fertilizer dose F_3 (90:45:45 NPK kg ha^{-1}). The higher value for production efficiency could be a result of positive response of the rice cultivar to the particular fertilizer dose resulting in higher yield. Thus clearly indicating that higher dose of fertilizer is not directly proportional to the use efficiency by the crop but the fine tuning of the right crop variety and adequate dose as per the crop requirement that influences the crop yield. Similar results were observed by Reddy and Kumar (2010) at Warangal (A.P.) and Sree Rekha and Pradeep (2012) at Adilabad (A.P.) in rice. Khiriya (2001) also reported a decrease in agronomic efficiency and P recovery with increasing levels of P application in fenugreek.

4.3. Phenological observations

4.3.1. Days to 50 % flowering

Cultivars

The variations in days to 50% flowering due to cultivars was found to be non-significant during the year 2015 but was significant during the second year of experiment. Pooled data also showed a significant variation on days to 50% flowering. The cultivar V_4 (Semvu shea) recorded the highest number of days to 50% flowering (84.25) which was statistically at par with V_3 (cultivar Ronga shea). While V_5 (variety Sahbhagi dhan) recorded the lowest (83.01) number of days to 50% flowering. Cultivars V_1, V_2 and V_3 were statistically at par.

Fertilizer doses

The effect of fertilizer doses to 50% flowering was found to be non-significant during the year 2015 but was recorded significant during the following year of experiment. Pooled data also showed a significant variation with fertilizer dose F_3 (90:45:45 NPK kg ha^{-1}) which was recorded the highest number of days to 50% flowering (84.17) and it was statistically at par with fertilizer dose F_2 (60:30:30 NPK kg ha^{-1}) while the lowest was recorded with control.

Table 14 (a) Effect of cultivars and fertilizer doses on phonological attributes of rice

Treatments	Phenological attributes of rice					
	Days to 50% flowering			Days to maturity		
	2015	2016	Pooled	2015	2016	Pooled
Cultivars (V)						
V_1- Gwabilo ssu	83.08	83.67	83.25	117.50	116.67	117.08
V_2- Hoikha	84.09	83.67	83.67	117.92	116.33	117.13
V_3- Ronga shea	83.83	84.17	83.13	117.08	116.84	116.96
V_4- Semvu shea	83.34	85.17	84.25	118.00	117.42	117.74
V_5- Sahbhagi dhan	82.67	83.34	83.01	116.58	117.08	116.78
SEm±	0.43	0.43	0.31	0.26	0.31	0.20
CD (P=0.05)	NS	1.23	0.99	0.74	NS	0.65
Fertilizer doses (NPK kg ha^{-1})						
F_0- Control	82.80	83.20	83.00	117.33	116.20	116.77
F_1- 30:15:15	83.80	83.67	83.57	117.67	116.40	116.93
F_2- 60:30:30	83.73	84.06	83.90	117.20	117.40	117.30
F_3- 90:45:45	83.27	85.07	84.17	117.47	117.47	117.47
SEm±	0.38	0.38	0.27	0.23	0.27	0.18
CD (P=0.05)	NS	1.11	0.88	NS	0.79	0.58

Table 14 (b) Interaction effects of cultivars and fertilizer doses on phenological attributes of rice

Treatments	Phenological attributes of rice					
	Days to 50% flowering			Days to maturity		
	2015	2016	Pooled	2015	2016	Pooled
V×F						
T_1 (V_1F_0)	85.67	82.00	83.83	118.00	116.33	117.17
T_2 (V_1F_1)	83.00	84.00	83.50	118.00	116.00	117.00
T_3 (V_1F_2)	83.67	85.67	84.50	116.67	117.00	116.83
T_4 (V_1F_3)	84.00	81.67	82.83	119.00	116.00	117.50
T_5 (V_2F_0)	81.67	83.00	82.33	116.33	117.33	116.83
T_6 (V_2F_1)	81.67	82.33	82.00	117.67	116.00	116.83
T_7 (V_2F_2)	83.67	86.33	85.00	116.00	119.00	117.50
T_8 (V_2F_3)	86.33	85.00	85.67	119.00	116.67	117.83
T_9 (V_3F_0)	81.33	84.00	83.67	118.00	118.00	117.50
T_{10}(V_3F_1)	84.00	86.33	85.67	117.00	116.67	116.83
T_{11}(V_3F_2)	85.67	86.33	85.00	118.33	117.00	117.67
T_{12}(V_3F_3)	81.67	83.00	82.17	116.00	116.80	116.40
T_{13}(V_4F_0)	84.00	84.00	84.00	116.67	117.00	116.83
T_{14}(V_4F_1)	83.00	82.33	82.00	116.67	116.33	116.50
T_{15}(V_4F_2)	85.67	86.33	86.00	118.33	117.33	117.83
T_{16}(V_4F_3)	86.33	86.33	86.33	119.00	119.00	119.00
T_{17}(V_5F_0)	81.33	83.00	82.33	117.33	116.67	117.50
T_{18}(V_5F_1)	81.00	84.00	82.50	117.00	117.00	116.50
T_{19}(V_5F_2)	81.00	81.33	81.16	116.33	116.00	116.16
T_{20}(V_5F_3)	82.33	83.00	82.66	117.00	117.00	117.00
SEm±	0.86	0.86	0.61	0.52	0.62	0.41
CD (P=0.05)	2.47	2.47	1.98	1.48	NS	1.31

The interaction effects between cultivars and fertilizer doses on days to 50% flowering were found to be significant during both the years of experiment. Pooled data complied with the findings of both the years. The highest value (86.33) during 2015 was recorded for interactions V_4F_3 (cultivar Semvu shea + 90:45:45 NPK kg ha^{-1}) and V_2F_3 (cultivar Hoikha + 90:45:45 NPK kg ha^{-1}) which was found to be statistically at par with interaction V_4F_2 (cultivar Semvu shea + 60:30:30 NPK kg ha^{-1}) and V_3F_2 (cultivar Ronga shea + 60:30:30 NPK kg ha^{-1}). During the year 2016, the highest value (86.33) was recorded for interactions V_4F_3 (cultivar Semvu shea + 90 :45:45 NPK kg ha^{-1}), V_4F_2 (cultivar Semvu shea + 60:30:30 NPK kg ha^{-1}), V_3F_2 (cultivar Ronga shea + 60:30:30 NPK kg ha^{-1}) and V_3F_2 (cultivar Ronga shea + 60:30:30 NPK kg ha^{-1}). However pooled data of both the years revealed that interaction V_4F_3 (cultivar Semvu shea + 90:45:45 NPK kg ha^{-1}) took the highest number of days (86.33) to attain 50% flowering.

4.3.2 Days to maturity

Cultivars

The variations in days to maturity due to cultivars were found to be significant during the year 2015. The cultivar V_4 (Semvu shea) recorded the highest (118) number of days to maturity which was statistically at par with V_2 (cultivar Hoikha) while V_5 (variety Sahbhagi dhan) recorded the lowest (116) number of days to maturity. During the second year of experiment it was found to be non-significant. However, pooled data recorded significant variation with cultivar V_4 (Semvu shea) recorded the highest (118) number of days to maturity which was statistically at par with V_1 (cultivar Gwabilo ssu) and V_2 (cultivar Hoikha), while V_5 (variety Sahbhagi dhan) recorded the lowest (117) number of days to maturity.

Fertilizer doses

The effect of fertilizer doses to 50% flowering was found to be non-significant during the year 2015 however, during the second year it recorded significant effects. Fertilizer dose F_3 (90:45:45 NPK kg ha^{-1}) recorded the highest number of days to attain maturity (117) which was statistically at par with F_2 (60:30:30 NPK kg ha^{-1}) while the lowest was recorded with control. Pooled data revealed a significant variation with fertilizer dose F_3 (90:45:45 NPK kg ha^{-1}) showing the highest number of days to attain maturity (117) which was statistically at par with F_2 (60:30:30 NPK kg ha^{-1}) while the lowest was recorded with control. This could be due to the slow early growth of the crop owing to low nutrition and ultimately late development and maturity.

Interaction effects

The interaction effects between cultivars and fertilizer doses on days to maturity were found to be significant during the year 2015. The highest value (119 days) was recorded for interactions V_4F_3 (cultivar Semvu shea + 90:45:45 NPK kg ha^{-1}) while V_3F_2 (cultivar Ronga shea + 60:30:30 NPK kg ha^{-1}) and V_4F_3 (cultivar were statistically at par. However during the year 2016 no significant variations were recorded. Pooled data obtained showed a significant variation on days to maturity. Treatment interaction V_4F_3 (cultivar Semvu shea + 90:45:45 NPK kg ha^{-1}) recorded the highest days to maturity (119) while the shortest was recorded with V_5F_2 (variety Sahbhagi dhan + 60:30:30 NPK kg ha^{-1}) which was at par with V_5F_1 (variety Sahbhagi dhan + 30:15:15 NPK kg ha^{-1}).

In the present investigation, observations on days to 50 percent flowering and days to maturity showed significant differences in the crop among the various cultivars and fertilizer doses. This type of variability may be attributed to genetically make up of individual cultivars, their response to fertilizer doses and also the genotype-environment interaction.

4.4. Soil chemical and nutrient status of the soil after harvest

The data on soil nutrient status due to the various treatments between fertilizer doses and rice cultivars and there interaction effects are presented in Table 15(a) and Table 15(b).

4.4.1 Soil pH

Cultivars

The variations on soil pH due to cultivars were found significant for both the years of experiment. During the year 2015, maximum soil pH (4.79) was recorded in cultivar V_3 (Ronga shea) and the lowest (4.39) was in V_2(Hoikha). During the second year also similar result was found. The highest soil pH (4.94) was recorded in cultivar V_3 (Ronga shea) and the lowest (4.64) was in V_2(Hoikha). Pooled data obtained complied with the findings of both the years experiment. The highest soil pH (4.87) was recorded in cultivar V_3 (Ronga shea) which was followed by cultivar V_4 (Semvu shea) and V_5 (variety Sahbhagi dhan) while the lowest (4.51) in V_2 (Hoikha).

Fertilizer doses

The differences in soil pH due to fertilizer doses were found to be significant only during year 2015, the highest soil pH (4.59) was recorded for F_2 (60:30:30 NPK kg ha^{-1}) and the lowest was in control while, during the second year it was found non-significant. Pooled data however recorded significant variation with the highest value (4.69) was for F_2 (60:30:30 NPK kg ha^{-1}) and the lowest was in control.

Interaction effects

The interaction effects on soil pH due to cultivars and fertilizer doses were found to be significant. Results obtained during the year 2015 revealed that treatment interaction V_3F_2 (cultivar Ronga shea + 60:30:30 NPK kg ha^{-1}) gave the highest value (4.94) of soil pH. Treatment interactions V_4F_2 (cultivar Semvu shea + 60:30:30 NPK kg ha^{-1}) and V_5F_2 (variety Sahbhagi dhan + 60:30:30 NPK kg ha^{-1}) were statistically at par. During the year 2016, the treatment interaction V_3F_2 (cultivar Ronga shea + 60:30:30 NPK kg ha^{-1}) recorded the highest soil pH (5.04), which was at par with interaction V_4F_2 (cultivar Semvu shea + 60:30:30 NPK kg ha^{-1}). Pooled data thus obtained revealed similar result with treatment interaction V_3F_2 (cultivar Ronga shea + 60:30:30 NPK kg ha^{-1}) showing the highest value (4.99) of pH which was closely followed by interaction V_3F_1 (cultivar Ronga shea + 30:15:15 NPK kg ha^{-1}) while the lowest was recorded with V_5F_0 (variety Sahbhagi dhan + control).

Table 15 (a) Effect of cultivars and fertilizer doses on soil nutrient status after harvest

Treatments	Soil nutrient status after harvest														
	Soil pH			Soil Organic Carbon (%)			Available nitrogen (kg ha^{-1})			Available phosphorus (kg ha^{-1})			Available potassium (kg ha^{-1})		
	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
Cultivars (V)															
V_1- Gwabilo ssu	4.52	4.68	4.60	1.07	1.57	1.28	178.68	167.48	173.08	16.11	15.81	15.96	275.29	288.57	281.93
V_2- Hoikha	4.39	4.64	4.51	1.14	1.42	1.28	178.39	181.74	180.07	20.86	20.39	20.63	285.70	282.41	282.63
V_3- Ronga shea	4.79	4.94	4.87	1.52	1.50	1.51	182.77	174.77	178.78	17.14	21.91	19.53	280.05	317.74	298.89
V_4- Semvu shea	4.53	4.71	4.63	1.59	1.64	1.72	180.27	184.35	182.32	20.61	23.01	22.70	308.39	315.41	311.50
V_5- Sahbhagi dhan	4.56	4.70	4.63	1.54	1.47	1.50	186.24	184.96	185.60	22.40	25.20	23.04	352.21	339.84	345.50
SEm±	0.01	0.04	0.02	0.02	0.04	0.02	1.06	4.21	5.28	0.30	0.67	0.37	1.04	7.01	6.22
CD (P=0.05)	0.03	0.11	0.06	0.05	0.11	0.07	3.05	12.05	17.10	0.86	1.94	1.15	2.98	20.07	20.10
Fertilizer doses (NPK kg ha^{-1})															
F_0- Control	4.54	4.71	4.63	1.33	1.44	1.38	171.78	170.99	171.42	18.54	18.80	18.77	292.40	305.69	299.35
F_1- 30:15:15	4.58	4.71	4.65	1.44	1.35	1.39	174.20	177.80	176.00	19.09	22.04	20.57	314.72	283.04	298.88
F_2- 60:30:30	4.59	4.78	4.69	1.40	1.48	1.44	187.47	182.16	184.82	19.41	21.78	20.92	293.62	299.82	296.77
F_3- 90:45:45	4.53	4.73	4.64	1.48	1.52	1.50	191.63	183.69	188.66	20.65	22.43	21.22	349.73	321.45	335.39
SEm±	0.01	0.04	0.02	0.02	0.04	0.02	0.95	3.76	4.73	0.27	0.61	0.33	0.93	6.27	5.56
CD (P=0.05)	0.03	NS	NS	0.04	0.10	0.06	2.73	NS	NS	0.77	NS	NS	2.66	17.95	17.98

Table 15 (b) Interaction effects of cultivars and fertilizer doses on soil nutrient status after harvest

Treatments	Soil nutrient status after harvest														
	Soil pH			Soil Organic Carbon (%)			Available nitrogen (kg ha^{-1})			Available phosphorus (kg ha^{-1})			Available potassium (kg ha^{-1})		
	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
V×F															
T_1 (V_1F_0)	4.62	4.65	4.64	1.20	1.38	1.55	137.38	159.65	148.52	10.83	14.31	12.58	218.86	272.36	245.62
T_2 (V_1F_1)	4.48	4.25	4.37	0.76	1.61	1.19	174.50	179.20	176.85	14.73	14.93	14.83	283.27	317.28	294.55
T_3 (V_1F_2)	4.56	4.89	4.73	1.33	1.62	1.31	215.96	156.13	186.05	19.60	16.91	18.26	387.07	309.03	348.05
T_4 (V_1F_3)	4.42	4.76	4.59	0.97	1.14	1.06	186.88	174.95	180.91	19.26	17.10	18.18	253.61	230.96	242.28
T_5 (V_2F_0)	4.25	4.49	4.37	0.71	1.25	1.12	167.37	168.68	168.03	20.39	22.05	21.23	266.61	308.75	287.69
T_6 (V_2F_1)	4.53	4.93	4.74	1.23	1.62	1.43	202.60	173.87	188.24	22.56	16.80	19.68	324.30	288.89	306.59
T_7 (V_2F_2)	4.28	4.51	4.40	1.29	1.67	1.48	176.75	170.58	173.67	19.27	17.28	18.27	330.65	280.81	305.73
T_8 (V_2F_3)	4.51	4.79	4.66	1.34	1.13	1.24	224.88	168.63	196.75	22.63	24.77	23.70	179.61	275.81	227.71
T_9 (V_3F_0)	4.64	4.94	4.79	1.46	1.47	1.47	160.78	164.93	162.86	21.20	25.44	23.32	274.95	282.96	278.96
T_{10}(V_3F_1)	4.82	4.99	4.91	1.64	1.39	1.52	157.76	173.10	165.57	16.48	24.26	20.88	139.72	309.38	224.56
T_{11}(V_3F_2)	4.94	5.04	4.99	1.22	1.60	1.41	158.02	172.86	165.45	22.08	23.04	22.56	369.73	327.11	348.42
T_{12}(V_3F_3)	4.75	4.79	4.77	1.76	1.55	1.66	184.68	187.29	185.99	19.64	21.97	20.81	348.25	309.39	328.82
T_{13}(V_4F_0)	4.23	4.46	4.35	1.24	1.37	1.30	168.09	204.14	186.12	17.52	21.39	19.46	280.81	294.04	288.93
T_{14}(V_4F_1)	4.42	4.63	4.53	1.83	1.47	1.65	163.54	186.26	174.91	15.39	19.42	17.41	349.59	328.44	339.02
T_{15}(V_4F_2)	4.92	5.01	4.96	1.54	1.46	1.50	184.37	185.95	185.16	13.58	23.77	18.68	359.23	312.03	335.63
T_{16}(V_4F_3)	4.52	4.74	4.64	2.16	2.11	2.13	241.74	214.51	228.12	24.06	27.68	25.87	371.22	363.25	367.23
T_{17}(V_5F_0)	4.19	4.46	4.33	1.54	1.56	1.56	157.04	167.93	162.49	21.05	21.36	21.21	422.40	271.93	347.17
T_{18}(V_5F_1)	4.64	4.76	4.69	1.45	1.61	1.53	160.51	142.54	151.53	23.55	18.59	21.07	357.26	369.22	363.24
T_{19}(V_5F_2)	4.90	5.02	4.96	1.81	1.27	1.54	155.59	173.09	164.35	20.92	24.41	22.66	314.43	228.03	271.22
T_{20}(V_5F_3)	4.46	4.57	4.52	1.92	1.90	2.02	246.96	248.89	233.13	25.70	29.79	27.75	422.78	370.34	396.57
SEm±	0.03	0.08	0.04	0.03	0.08	0.04	2.14	8.42	10.57	0.60	1.35	0.74	2.08	14.02	12.43
CD (P=0.05)	0.08	0.22	0.13	0.09	0.22	0.14	6.11	24.10	34.21	1.72	3.88	2.27	5.96	40.14	40.21

4.4.2 Organic carbon (%)

Cultivars

The variations on soil organic carbon percent due to cultivars were found to be significant. During the year 2015, the highest organic carbon (1.59 %) was recorded with cultivar V_4 (Semvu shea). Variety V_5 (Sahbhagi dhan) and V_3 (Ronga shea) were statistically at par. During the year 2016, the highest organic carbon (1.64 %) was recorded with cultivar V_4 (Semvu shea), however the organic carbon content was slightly increased from previous year which may be a result of the crop residue decomposition in the soil from the previous year's experiment and thereby more availability.

Fertilizer doses

The differences in soil organic carbon per cent due to fertilizer doses were found to be significant. The highest value (1.48 %) of organic carbon recorded during the year 2015 for F_3 (90:45:45 NPK kg ha^{-1}). Fertilizer doses F_2 (60:30:30 NPK kg ha^{-1}) and F_3 (90:45:45 NPK kg ha^{-1}) were statistically found to be at par, while the lowest was recorded in control. During the year 2016, the highest value (1.52 %) of organic carbon was also recorded for the same fertilizer dose F_3 (90:45:45 NPK kg ha^{-1}) which was found to be statistically at par with fertilizer dose F_2 (60:30:30 NPK kg ha^{-1}). Pooled data also recorded similar results. Fertilizer dose F_3 (90:45:45 NPK kg ha^{-1}) still recorded the highest value (1.50 %) of organic carbon content which was also at par with fertilizer dose F_2 (60:30:30 NPK kg ha^{-1}), while the lowest was recorded in control.

Interaction effects

The effects of treatment interaction on soil organic carbon content were found to be significant in both the experimental years. Pooled result also showed significant variations. Results obtained during the year 2015 revealed that treatment interaction V_4F_3 (cultivar Semvu shea + 90:45:45 NPK kg ha^{-1}) gave the highest value (2.16 %) of organic carbon, while the lowest was recorded with interaction V_2F_0 (cultivar Hoikha + control). During the second year also treatment interaction V_4F_3 (cultivar

Semvu shea + 90:45:45 NPK kg ha^{-1}) recorded the highest value of organic carbon percent (2.11 %). Pooled data obtained also revealed the highest value of organic carbon (2.13 %) from treatment interaction V_4F_3 (cultivar Semvu shea + 90:45:45 NPK kg ha^{-1}) which was at par with interaction V_5F_1 (variety Sahbhagi dhan + 30:15:15 NPK kg ha^{-1}), while the lowest was recorded with treatment interaction V_2F_0 (cultivar Hoikha + control).

4.4.3 Available nitrogen after harvest (kg ha^{-1})

Cultivars

The variations on nitrogen availability in soil due to cultivars were found to be significant during both the years of experiment. Soil under variety V_5 (Sahbhagi dhan) recorded the highest value (186.24 kg N ha^{-1}) during the year 2015. While cultivars V_3 (Ronga shea) and V_4 (Semvu shea) were statistically found to be at par. Similar trend of result was recorded in the following year of experiment. The highest value (184.96 kg N ha^{-1}) was recorded for variety V_5 (Sahbhagi dhan) while cultivar V_2 (Hoikha), V_3 (Ronga shea) and V_4 (Semvu shea) were statistically at par. Pooled data thus obtained also revealed similar finding. The highest value (185.60 kg ha^{-1}) was recorded for variety V_5 (Sahbhagi dhan) while, the lowest was recorded with cultivar V_1 (Gwabilo ssu).

Fertilizer doses

The differences in nitrogen availability in soil due to fertilizers were found to be significant only during the first year of experiment. The highest available nitrogen (191.63 kg ha^{-1}) was recorded for F_3 (90:45:45 NPK kg ha^{-1}) and the lowest in control. Pooled data also failed to show any significant variation.

Interaction effects

The interaction effects between cultivars and fertilizer doses on soil available nitrogen were found to be significant during both the years of experiment. The highest available nitrogen (246.96 kg ha^{-1}) was recorded during the year 2015 for interaction V_5F_3 (variety Sahbhagi dhan + 90:45:45 NPK kg ha^{-1}). The interaction effects of V_3F_3 (Ronga shea + 90:45:45 NPK kg ha^{-1}) and V_4F_2 (Semvu shea + 60:30:30 NPK kg ha^{-1}) were found to be at par. During the year 2016 also highest available nitrogen (248.89 kg ha^{-1}) was recorded for interaction V_5F_3 (variety Sahbhagi dhan + 90:45:45 NPK kg ha^{-1}), while interaction effects of V_4F_1 (Semvu shea + 30:15:15 NPK kg ha^{-1}) and V_4F_2 (Semvu shea + 60:30:30 NPK kg ha^{-1}) were found to be at par. Pooled data also complied with the findings of both the years experiment with the highest available nitrogen (233.13 kg ha^{-1}) still recorded with interaction V_5F_3 (variety Sahbhagi dhan + 90:45:45 NPK kg ha^{-1}) which was at par with V_4F_3 (Semvu shea + 90:45:45 NPK kg ha^{-1}) while the lowest was recorded with treatment interaction V_1F_0 (cultivar Gwabilo ssu + control).

4.4.4 Available phosphorus after harvest (kg ha^{-1})

Cultivars

The differences on phosphorus availability in soil were found to be significant under different cultivars on both the years of experiment. The highest value (22.40 kg ha^{-1}) during the year 2015 was recorded for variety V_5 (Sahbhagi dhan) and the lowest was recorded with V_1 (Gwabilo ssu) which was found statistically at par with V_3 (Ronga shea). During the following year of experiment highest value of phosphorus availability was recorded with variety V_5 (Sahbhagi dhan) which was statistically at par with cultivar V_4 (Semvu shea). The lowest value was recorded for cultivar V_1 (Gwabilo ssu) during both the year of experiment. The pooled data followed the same trend of finding with variety V_5 (Sahbhagi dhan) giving the highest value for available phosphorus (23.04 kg ha^{-1}) which was statistically at par with cultivar V_4 (Semvu shea), while cultivar V_1 (Gwabilo ssu) recorded the lowest available phosphorus after harvest.

Fertilizer doses

The variation in phosphorus availability in soil due to fertilizer doses was found to be significant during the first year of experiment with the highest available phosphorus (20.65 kg ha^{-1}) recorded for fertilizer dose F_3 (90:45:45 kg NPK ha^{-1}) and the lowest was in control. However, during the following year of experiment fertilizer doses could not show any significant variation. Pooled data could not show any significant variation.

Interaction effects

The interaction effects between cultivars and fertilizer doses on soil available phosphorus were found to be significant during both the years of experiment. The highest available phosphorus (25.70 kg ha^{-1}) was recorded during the year 2015 for interaction V_5F_3 (variety Sabhagi dhan + 90:45:45 kg NPK ha^{-1}). The interaction effects of V_5F_1 (variety Sahbhagi dhan + 30:15:15 NPK kg ha^{-1}) and V_4F_3 (cultivar Semvu shea + 90:45:45 NPK kg ha^{-1}) were found to be at par. During the year 2016, the highest available phosphorus (29.79 kg ha^{-1}) was recorded for interaction V_5F_3 (variety Sahbhagi dhan + 90:45:45 kg NPK ha^{-1}), while interaction effects of V_5F_2 (variety Sahbhagi dhan + 60:30:30 NPK kg ha^{-1}) and V_4F_3 (cultivar Semvu shea + 90:45:45 NPK kg ha^{-1}) were found to be at par. Pooled data showed available phosphorus to be highest (27.75 kg ha^{-1}) for interaction V_5F_3 (variety Sabhagi dhan + 90:45:45 kg NPK ha^{-1}) which was statistically at par with interaction V_4F_3 (cultivar Semvu shea + 90:45:45 NPK kg ha^{-1}) while the lowest was recorded with treatment interaction V_1F_0 (cultivar Gwabilo ssu + control) as in case of available nitrogen.

4.4.5 Available potassium after harvest (kg ha^{-1})

Cultivars

The differences on potassium availability in soil due to cultivars were found to be significant during both the year of experiment. The highest value of available potassium during the first year (352.21 kg K ha^{-1}) was recorded from variety Sahbhagi dhan which was also at par with cultivar V_4 (Semvu shea), while the lowest was recorded with cultivar V_2 (Hoikha). Variety Sahbhagi dhan also recorded the highest potassium availability in soil (315.41 kg ha^{-1}) during the following year of experiment which was statistically at par with cultivars V_4 (Semvu shea) and V_3 (Ronga shea). Pooled data also followed the similar trend of finding with the highest value of available potassium (345.50 kg ha^{-1}) was recorded from variety Sahbhagi dhan which was also at par with cultivar V_4 (Semvu shea), while the lowest was recorded with cultivar V_1 (Gwabilo ssu) which also recorded the lowest available nitrogen and phosphorus in the soil after harvest.

Fertilizer doses

The variation in potassium availability in soil due to fertilizer doses was found to be significant during both the years of experiment. The highest available potassium (349.73 kg ha^{-1}) was recorded for fertilizer dose F_3 (90:45:45 NPK kg ha^{-1}) and the lowest in control. Same trend of findings followed during the second year of experiment with fertilizer dose F_3 (90:45:45 NPK kg ha^{-1}) giving the highest value for potassium availability (321.45 kg ha^{-1}). Pooled data complied with the findings of both the year and it was found that fertilizer dose F_3 (90:45:45 NPK kg ha^{-1}) recorded the highest value for potassium availability (335.39 kg ha^{-1}) which was followed by fertilizer dose F_2 (60:30:30 NPK kg ha^{-1}) while the lowest was recorded in control.

Interaction effects

The interaction effects between cultivars and fertilizer doses on soil available potassium also showed significant variation during both the years of experiment. The highest available potassium (422.78 kg ha^{-1}) was recorded during the year 2015 for interaction V_5F_3 (variety Sahbhagi dhan + 90:45:45 NPK kg ha^{-1}). The interaction effects of V_4F_2 (cultivar Semvu shea + 60:30:30 NPK kg ha^{-1}) and V_5F_1 (variety Sahbhagi dhan + 30:15:15 NPK kg ha^{-1}) were found to be at par. During the year 2016 the highest available potassium (370.34 kg ha^{-1}) was also recorded for interaction V_5F_3 (variety Sahbhagi dhan + 90:45:45 NPK kg ha^{-1}) which was statistically at par with V_4F_3 (cultivar Semvu shea + 90:45:45 NPK kg ha^{-1}). Pooled data obtained also revealed similar finding with the highest available potassium (396.57 kg ha^{-1}) recorded for interaction V_5F_3 (variety Sahbhagi dhan + 90:45:45 NPK kg ha^{-1}) which was followed by V_4F_3 (cultivar Semvu shea + 90:45:45 NPK kg ha^{-1}) and V_5F_1 (variety Sahbhagi dhan + 30:15:15 NPK kg ha^{-1}) while the lowest was recorded in V_3F_1 (Cultivar Ronga shea + 30:15:15 NPK kg ha^{-1}).

The status of availability of major nutrients, organic carbon and pH after harvest as per findings revealed significant differences due to fertilizer application, cultivars and their interactions affecting the nutrient release efficiency in different magnitudes.

Maximum organic carbon after harvest during both the year as well as the pooled data was recorded with cultivar V_4 (Semvu shea) under fertilizer dose F_3 (90:45:45 kg ha^{-1}) (Table 15 (a)) and interaction V_4F_3 (cultivar Semvu shea + 90:45:45 NPK kg ha^{-1}) (Table 15 (b)) while soil pH was recorded highest for cultivar V_3 (Ronga shea) under fertilizer dose F_2 (60:30:30 kg ha^{-1}) (Table 15 (a)) and interaction V_4F_2 (cultivar Semvu shea + 60:30:30 NPK kg ha^{-1}) (Table 15 (b)). This finding was in accordance with that of Virema *et al.* (2012) who reported that the status of available NPK and organic carbon in soil after harvest were significantly influenced by application of 100% NPK fertilizers, organic manures and biofertilizers alone or in combination. He also reported that application of 50% FYM + biofertilizers resulted in highest availability of phosphorus and organic carbon under Nagaland conditions.

From the experimental data analysis, the total nitrogen availability during both the year as well as the pooled data showed significant under different cultivars while in case of fertilizer dose, significant variation was recorded only during the first year of experiment. The highest value was obtained from variety V_5 (Sahbhagi dhan) (Table 15 (a)) under fertilizer dose F_3 (90:45:45 kg ha^{-1}) (Table 15 (a)) and interaction V_5 F_3 (Table15 (b)). The probable cause of high available nitrogen could be due to less utilisation during the crop growth stages, poor soil physical structure, lack of organic manures and microbial activities in the soil. The present findings was in agreement with Masthana *et al.* (2005), who reported the application of 100 percent NPK significantly improved the soil available N. Therefore, application of 100 % NPK result in increased in available NPK in soil as compared to control.

The maximum available P_2O_5 and K_2O after harvest during both the year as well as their pooled result was recorded with variety V_5 (Sahbhagi dhan) under fertilizer dose F_3 (90:45:45 kg ha^{-1}) (Table 15 (a)) and interaction V_5F_3 (variety Sahbhagi dhan + 90:45:45 NPK kg ha^{-1}) (Table 15 (b)). Although the soil was acidic in reaction, even then it showed an increase in available P over initial value, indicating that the increase in dose of fertilizers not only substantiates crop requirement but also enhances residual P and K (Zango *et al*., 2009).

4.5 Plant analysis: NPK uptake by the crop (kg ha^{-1})

4.5.1 Nitrogen uptake (kg ha^{-1})

Cultivars

The variations on nitrogen uptake among the cultivars were found to be non-significant during the first year of experiment. However, significant variation was recorded during the following year as well as for the pooled data of both the year. The highest value (46.49 kg ha^{-1}) was recorded for cultivar V_4 (Semvu shea) which was at par with cultivar V_3 (Ronga shea) and variety V_5 (Sahbhagi dhan) while, the lowest was recorded with cultivar V_1 (Gwabilo ssu).

Fertilizer doses

The effect of fertilizer doses on phosphorus uptake by the plant also showed a varied result during both the year of experiment. While pooled data thus obtained showed a non-significant variation among the different fertilizer doses applied.

Interaction effects

The interaction effects between cultivars and fertilizer doses on plant nitrogen uptake was found to be non-significant during the first year of experiment. However, showed a significant variation during the following year. Pooled data thus obtained also showed a significant variation. The highest uptake (48.49 kg ha^{-1}) was recorded for interaction V_4F_3 (cultivar semvu shea + 90:45:45 NPK kg ha^{-1}). The interaction effects of V_2F_3 (Cultivar hoikha + 90:45:45 NPK kg ha^{-1}), V_3F_1 (Semvu shea + 30:15:15 NPK kg ha^{-1}) and V_5F_2 (variety Sahbhagi dhan + 60:30:30 kg ha^{-1}) and V_5F_3 (variety Sahbhagi dhan + 90:45:45 kg ha^{-1}) were found to be at par.

Table 16 (a) Effect of cultivars and fertilizer doses on plant nutrient uptake

Treatments	Nitrogen uptake (kg ha^{-1})								
	2015			2016			Pooled		
	Grain (kg ha^{-1})	Straw (kg ha^{-1})	Total	Grain (kg ha^{-1})	Straw (kg ha^{-1})	Total	Grain (kg ha^{-1})	Straw (kg ha^{-1})	Total
Cultivars (V)									
V_1- Gwabilo ssu	28.59	14.81	43.45	27.71	14.49	42.23	28.15	14.54	42.63
V_2- Hoikha	29.22	14.46	43.68	29.09	14.65	43.97	29.15	14.51	43.82
V_3- Ronga shea	30.03	15.44	45.47	30.11	14.80	44.81	30.06	15.19	44.72
V_4- Semvu shea	30.08	16.75	46.81	30.16	16.12	46.17	30.09	16.45	46.49
V_5- Sahbhagi dhan	30.66	15.15	44.73	30.78	14.48	45.26	30.71	14.83	44.99
SEm±	0.65	0.24	0.99	0.39	0.27	0.87	0.37	0.19	0.66
CD (P=0.05)	1.85	NS	NS	1.12	0.77	2.51	NS	NS	2.14
Fertilizer doses (NPK kg ha^{-1})									
F_0- Control	28.77	15.02	43.69	28.24	14.79	43.03	28.54	14.91	43.36
F_1- 30:15:15	29.91	15.22	45.14	29.63	14.81	44.44	29.77	15.03	44.79
F_2- 60:30:30	29.94	15.25	45.18	30.17	14.89	45.06	30.01	15.09	45.12
F_3- 90:45:45	30.04	15.27	45.31	30.25	14.92	45.17	30.15	15.11	45.25
SEm±	0.57	0.24	0.89	0.35	0.24	0.87	0.34	0.17	0.59
CD (P=0.05)	NS	NS	NS	1.00	NS	0.78	NS	NS	NS

Table 16 (b) Interaction effects of cultivars and fertilizer doses on plant nutrient uptake

Treatments	Nitrogen uptake (kg ha^{-1})								
	2015			2016			Pooled		
	Grain (kg ha^{-1})	Straw (kg ha^{-1})	Total	Grain (kg ha^{-1})	Straw (kg ha^{-1})	Total	Grain (kg ha^{-1})	Straw (kg ha^{-1})	Total
V×F									
T_1 (V_1F_0)	28.90	14.45	43.35	28.95	14.47	43.42	28.92	14.46	43.37
T_2 (V_1F_1)	28.80	15.18	45.55	30.78	15.41	46.23	29.76	15.31	45.89
T_3 (V_1F_2)	29.60	14.85	44.56	30.13	15.05	45.19	29.85	14.95	44.87
T_4 (V_1F_3)	30.03	15.15	45.47	30.79	15.39	46.19	30.39	15.25	45.83
T_5 (V_2F_0)	28.06	15.70	47.12	29.19	14.59	43.78	28.61	15.14	45.45
T_6 (V_2F_1)	29.71	14.94	44.83	28.44	14.19	42.56	29.06	14.56	43.69
T_7 (V_2F_2)	28.25	13.75	41.24	30.34	15.17	45.53	29.27	14.46	43.38
T_8 (V_2F_3)	30.86	13.84	41.52	32.45	15.79	47.37	31.61	14.81	44.43
T_9 (V_3F_0)	28.52	14.15	42.45	24.20	12.68	38.05	26.31	13.41	40.25
T_{10}(V_3F_1)	29.71	15.75	47.26	30.85	15.44	46.34	30.18	15.65	46.80
T_{11}(V_3F_2)	30.93	15.77	45.75	26.66	16.23	45.64	28.71	16.02	45.71
T_{12}(V_3F_3)	30.96	14.94	44.83	27.81	14.25	42.78	29.31	14.59	43.55
T_{13}(V_4F_0)	30.07	15.18	45.55	26.17	13.10	42.65	28.09	14.14	44.23
T_{14}(V_4F_1)	30.17	14.33	43.00	30.94	15.11	45.33	30.47	14.72	44.23
T_{15}(V_4F_2)	31.25	14.79	44.38	27.07	13.64	40.93	29.10	14.21	42.72
T_{16}(V_4F_3)	31.33	16.85	48.18	32.92	16.02	48.69	32.10	16.43	48.49
T_{17}(V_5F_0)	25.90	13.62	40.87	32.68	13.33	39.99	29.12	13.47	40.15
T_{18}(V_5F_1)	29.92	15.08	45.24	30.26	15.13	45.39	30.01	15.10	45.31
T_{19}(V_5F_2)	31.25	15.96	47.33	29.76	14.87	44.63	30.45	15.41	46.23
T_{20}(V_5F_3)	30.17	15.25	48.07	30.43	15.21	47.03	30.25	15.23	47.65
SEm±	0.65	0.54	1.98	0.78	0.54	1.75	0.75	0.39	1.32
CD (P=0.05)	1.85	NS	NS	2.24	1.54	5.02	NS	NS	3.95

4.5.2 Phosphorus uptake (kg ha^{-1})

Cultivars

The variations on phosphorus uptake among the cultivars were found to be significant during both the year of experiment. Pooled data showed significant variation in phosphorous uptake. From the experiment, highest value for pooled data (9.38 kg ha^{-1}) was recorded for cultivar V_4 (Semvu shea) which was followed by variety V_5 (Sahbhagi dhan) though statistically not at par and the lowest was recorded with cultivar V_1 (Gwabilo ssu).

Fertilizer doses

The effect of fertilizer doses on phosphorus uptake by the crop was found to be significant during both the year of experiment. The highest phosphorus uptake (9.32 kg ha^{-1}) was recorded during the year 2015 for fertilizer dose F_3 (90:45:45 NPK kg ha^{-1}) and the lowest was in control. Similar trend of result was recorded during the following year of experiment. The highest phosphorus uptake (8.55 kg ha^{-1}) was recorded for fertilizer dose F_3 (90:45:45 NPK kg ha^{-1}) and the lowest was in control. Pooled data complied for both the years and found the highest phosphorus uptake (8.94 kg ha^{-1}) for fertilizer dose F_3 (90:45:45 NPK kg ha^{-1}) which was statistically at par with fertilizer dose F_2 (60:30:30 NPK kg ha^{-1}) while the lowest was recorded with control.

Interaction effects

The interaction effects between cultivars and fertilizers on plant phosphorus uptake were found to be significant during both the year of experiment. The highest uptake (10.98 kg ha^{-1}) was recorded during the year 2015 for interaction V_4F_3 (cultivar Semvu shea + 90:45:45 NPK kg ha^{-1}), which was found to be statistically at par with interaction V_5F_3 (variety Sahbhagi dhan + 90:45:45 NPK kg ha^{-1}). During the following year the highest uptake (10.84 kg ha^{-1}) was recorded for interaction V_4F_3 (cultivar Semvu shea + 90:45:45 NPK kg ha^{-1}) which was also at par with interaction V_5F_3 (variety Sahbhagi dhan + 90:45:45 NPK kg ha^{-1}). Pooled data also revealed similar findings with the highest uptake (10.92 kg ha^{-1}) recorded for interaction V_4F_3

Table 17 (a) Effect of cultivars and fertilizer doses on plant nutrient uptake

Treatments	Phosphorus uptake (kg ha^{-1})								
	2015			2016			Pooled		
	Grain (kg ha^{-1})	Straw (kg ha^{-1})	Total	Grain (kg ha^{-1})	Straw (kg ha^{-1})	Total	Grain (kg ha^{-1})	Straw (kg ha^{-1})	Total
Cultivars (V)									
V_1- Gwabilo ssu	4.94	1.76	6.74	4.89	2.36	7.37	4.91	2.05	7.06
V_2- Hoikha	5.52	2.75	8.29	5.19	5.19	7.79	5.35	3.97	8.04
V_3- Ronga shea	5.63	2.76	8.27	5.24	2.62	7.86	5.43	2.66	8.06
V_4- Semvu shea	6.35	3.20	9.71	5.66	3.40	9.05	6.01	3.35	9.38
V_5- Sahbhagi dhan	6.05	3.10	9.10	6.04	2.56	8.50	6.05	2.83	8.80
SEm±	0.11	0.05	0.17	0.08	0.06	0.16	0.07	0.04	0.12
CD (P=0.05)	0.31	0.16	0.49	0.25	0.16	0.46	0.23	0.12	0.36
Fertilizer doses (NPK kg ha^{-1})									
F_0- Control	5.02	2.38	7.14	5.16	2.58	7.73	5.08	2.48	7.43
F_1- 30:15:15	5.61	2.77	8.31	5.22	2.61	7.84	5.41	2.71	8.07
F_2- 60:30:30	5.99	2.97	8.92	5.56	2.77	8.34	5.77	2.87	8.63
F_3- 90:45:45	6.17	3.11	9.32	5.68	2.85	8.55	5.93	2.98	8.94
SEm±	0.09	0.05	0.15	0.07	0.05	0.15	0.06	0.04	0.11
CD (P=0.05)	0.28	0.15	0.44	0.22	0.15	0.42	0.20	0.12	0.34

Table 17 (b) Interaction effects of cultivars and fertilizer doses on plant nutrient uptake

Treatments	Phosphorus uptake (kg ha^{-1})								
	2015			2016			Pooled		
	Grain (kg ha^{-1})	Straw (kg ha^{-1})	Total	Grain (kg ha^{-1})	Straw (kg ha^{-1})	Total	Grain (kg ha^{-1})	Straw (kg ha^{-1})	Total
V×F									
T_1 (V_1F_0)	3.81	1.91	5.72	4.12	2.06	6.17	3.96	1.98	5.95
T_2 (V_1F_1)	5.11	2.55	7.66	4.76	2.38	7.15	4.93	2.48	7.41
T_3 (V_1F_2)	4.68	2.12	6.36	5.76	2.87	8.64	5.22	2.49	7.50
T_4 (V_1F_3)	6.36	3.20	9.60	6.13	3.07	9.20	6.26	3.14	9.40
T_5 (V_2F_0)	6.33	3.22	9.66	6.26	3.12	9.38	6.29	3.18	9.48
T_6 (V_2F_1)	5.93	2.95	8.86	5.34	2.67	8.01	5.53	2.87	8.54
T_7 (V_2F_2)	5.45	2.64	7.91	5.22	2.61	7.83	5.34	2.63	7.87
T_8 (V_2F_3)	6.48	3.32	9.97	5.85	2.92	8.77	6.16	3.12	9.37
T_9 (V_3F_0)	4.45	1.75	5.24	3.83	1.91	5.74	4.14	1.87	5.24
T_{10}(V_3F_1)	4.60	2.07	6.21	4.49	2.25	6.75	4.55	2.16	6.54
T_{11}(V_3F_2)	6.04	3.03	9.16	5.78	2.89	8.67	6.54	3.22	9.71
T_{12}(V_3F_3)	6.78	3.39	10.18	4.42	2.25	6.74	5.60	2.82	8.46
T_{13}(V_4F_0)	4.60	2.07	6.21	4.36	2.18	6.54	4.44	2.14	6.34
T_{14}(V_4F_1)	5.40	2.60	7.81	5.74	2.87	8.61	5.55	2.74	8.21
T_{15}(V_4F_2)	5.63	2.75	8.26	5.79	2.89	9.35	5.71	2.81	8.81
T_{16}(V_4F_3)	6.99	3.66	10.98	6.24	3.11	10.84	6.66	3.44	10.92
T_{17}(V_5F_0)	6.44	3.29	9.88	7.23	3.61	8.68	6.83	3.51	9.28
T_{18}(V_5F_1)	5.92	2.95	8.85	4.63	2.32	6.95	5.27	2.64	7.90
T_{19}(V_5F_2)	6.05	3.04	9.11	5.34	2.67	8.00	5.69	2.85	8.55
T_{20}(V_5F_3)	6.90	3.60	10.80	6.84	3.42	10.26	6.34	3.25	9.74
SEm±	0.22	0.12	0.34	0.17	0.12	0.33	0.14	0.07	0.24
CD (P=0.05)	0.63	0.33	0.99	0.49	0.33	0.93	0.45	0.26	0.72

(cultivar Semvu shea + 90:45:45 NPK kg ha^{-1}) which was at par with interaction V_5F_3 (variety Sahbhagi dhan + 90:45:45 NPK kg ha^{-1}) while the lowest was recorded with interaction V_3F_0 (cultivar Ronga shea + control).

4.5.3 Potassium uptake (kg ha^{-1})

Cultivars

The variations on potassium uptake among the cultivars were found to be significant during both the years of experiment. During the first year highest value (30.11 kg ha^{-1}) was recorded for cultivar V_4 (Semvu shea) and the lowest was recorded with cultivar V_1 (Gwabilo ssu). The following year of experiment recorded similar trend of result with the highest value (26.99 kg ha^{-1}) recorded for variety V_4 (Semvu shea) and the lowest was recorded in cultivar V_2 (Hoikha). Cultivars V_1 (Gwabilo ssu) V_2 (Hoikha) and V_3 (Ronga shea) were found to be statistically at par. Pooled data also showed a significant variation with cultivar V_4 (Semvu shea) giving the highest value (28.55 kg ha^{-1}) which was followed by variety V_5 (Sahbhagi dhan) while the rest of the cultivars were found to be at par.

Fertilizer doses

The effect of fertilizer doses on potassium uptake by the crop was found to be non-significant during both the year of experiment.

Interaction effects

The interaction effects between cultivars and fertilizer doses on plant nitrogen uptake were found to be significant during both the year of experiment. The highest uptake (30.29 kg ha^{-1}) was recorded during the year 2015 for interaction V_4F_3 (cultivar Semvu shea + 90:45:45 NPK kg ha^{-1}), which was found to be statistically at par with interaction V_4F_2 (cultivar Semvu shea + 60:30:30 NPK kg ha^{-1}). During the year 2016, the highest uptake (30.34 kg ha^{-1}) was recorded for interaction V_4F_3 (cultivar Semvu shea + 90:45:45 NPK kg ha^{-1}), which was found to be statistically at par with interaction V_4F_2 (cultivar Semvu shea + 60:30:30 NPK kg ha^{-1}). Pooled data

Table 18 (a) Effect of cultivars and fertilizer doses on plant nutrient uptake

Treatments	Potassium uptake (kg ha^{-1})								
	2015			2016			Pooled		
	Grain (kg ha^{-1})	Straw (kg ha^{-1})	Total	Grain (kg ha^{-1})	Straw (kg ha^{-1})	Total	Grain (kg ha^{-1})	Straw (kg ha^{-1})	Total
Cultivars (V)									
V_1- Gwabilo ssu	11.86	5.93	20.14	14.54	7.27	21.99	13.20	6.60	21.06
V_2- Hoikha	12.32	6.45	20.47	14.57	7.28	21.81	13.44	6.86	21.14
V_3- Ronga shea	12.93	6.57	20.42	15.27	7.33	21.86	14.10	6.95	21.14
V_4- Semvu shea	14.19	9.53	30.11	17.16	8.99	26.99	15.67	9.26	28.55
V_5- Sahbhagi dhan	14.07	8.41	22.48	17.93	7.78	25.75	16.00	8.09	24.11
SEm±	0.62	0.27	0.80	0.53	0.27	0.84	0.41	0.19	0.58
CD (P=0.05)	1.77	0.76	2.29	1.53	0.76	2.41	1.32	0.63	1.88
Fertilizer doses (NPK kg ha^{-1})									
F_0- Control	13.94	6.96	20.58	18.24	7.37	24.22	16.09	7.16	22.40
F_1- 30:15:15	14.92	7.21	20.30	19.63	8.01	22.16	17.27	7.61	21.22
F_2- 60:30:30	14.97	7.24	20.51	20.17	8.07	24.04	17.57	7.66	22.27
F_3- 90:45:45	15.27	7.64	20.58	20.25	8.09	24.30	17.76	7.86	22.44
SEm±	0.56	0.24	0.71	0.35	0.24	0.75	0.36	0.17	0.52
CD (P=0.05)	NS	NS	NS	1.00	NS	NS	NS	NS	NS

Table 18 (b) Interaction effects of cultivars and fertilizer doses on plant nutrient uptake

Treatments	Potassium uptake (kg ha^{-1})								
	2015			2016			Pooled		
	Grain (kg ha^{-1})	Straw (kg ha^{-1})	Total	Grain (kg ha^{-1})	Straw (kg ha^{-1})	Total	Grain (kg ha^{-1})	Straw (kg ha^{-1})	Total
V×F									
T_1 (V_1F_0)	13.44	6.72	20.16	13.51	6.76	20.27	13.47	6.74	20.22
T_2 (V_1F_1)	20.14	10.06	30.20	19.68	9.84	29.52	19.91	9.94	29.86
T_3 (V_1F_2)	20.13	10.06	30.17	20.17	10.08	29.68	20.15	10.07	29.92
T_4 (V_1F_3)	13.46	6.73	20.19	15.30	7.65	22.95	14.26	7.19	21.57
T_5 (V_2F_0)	16.00	8.00	30.00	17.60	8.79	26.39	16.80	8.39	28.19
T_6 (V_2F_1)	11.36	5.68	20.05	13.45	6.73	20.18	12.35	6.21	20.11
T_7 (V_2F_2)	7.40	3.59	10.78	6.86	3.43	10.29	7.13	3.51	10.52
T_8 (V_2F_3)	18.03	9.02	30.05	20.25	10.13	30.38	19.23	9.58	30.22
T_9 (V_3F_0)	13.56	6.78	20.34	15.26	7.63	22.88	14.56	7.18	21.54
T_{10}(V_3F_1)	6.77	3.38	10.15	9.31	4.65	13.96	8.04	4.02	12.56
T_{11}(V_3F_2)	13.70	6.85	20.55	20.21	10.10	30.31	17.45	8.75	25.43
T_{12}(V_3F_3)	13.42	6.71	20.13	13.52	6.76	20.28	13.48	6.74	20.23
T_{13}(V_4F_0)	16.04	9.02	30.07	18.01	7.01	21.02	17.45	8.06	26.21
T_{14}(V_4F_1)	18.01	9.01	30.02	17.95	8.97	26.93	17.97	8.99	28.72
T_{15}(V_4F_2)	20.11	10.05	30.19	20.23	10.11	30.26	20.19	10.08	30.22
T_{16}(V_4F_3)	20.24	10.11	30.32	20.64	9.89	30.34	20.44	10.01	30.33
T_{17}(V_5F_0)	13.57	6.77	20.03	19.53	10.18	16.89	16.53	8.47	18.46
T_{18}(V_5F_1)	13.40	6.69	20.10	15.65	6.74	20.22	14.55	6.72	20.16
T_{19}(V_5F_2)	13.40	6.69	20.09	13.53	6.76	20.28	13.47	6.73	20.17
T_{20}(V_5F_3)	11.36	5.67	20.34	11.26	5.63	30.16	11.31	5.65	25.25
SEm±	1.24	0.53	1.60	1.06	0.53	1.68	0.82	0.38	1.16
CD (P=0.05)	3.55	1.53	4.59	3.05	1.53	4.82	2.65	1.25	3.76

obtained showed significant variation with interaction V_4F_3 (cultivar Semvu shea + 90:45:45 NPK kg ha^{-1}) showing the highest uptake which was found to be statistically at par with interaction V_4F_2 (cultivar Semvu shea + 60:30:30 NPK kg ha^{-1}) and interaction V_2F_3 (cultivar Hoikha + 90:45:45 NPK kg ha^{-1}).

The findings of the experiment indicated that different cultivars, fertilizer doses and its various interactions significantly influenced the nutrient uptake by the plant. The uptake of N, P and K increased with increasing level of fertilizer application. The steady increase in N uptake during rice growing season indicated a rapid absorption of N by the crop.

The highest nitrogen, phosphorus and potassium uptake during both the year of experiment was recorded with cultivar V_4 (Semvu shea) (Table 16 (a), 17 (a) and 18 (a) respectively). Different fertilizer doses could not show any significant difference in its uptake. Fertilizer dose F_3 (90:45:45 NPK kg ha^{-1}) however gave the highest uptake (Table 16 (a), 17 (a) and 18 (a) respectively)) for the entire three nutrient element. In case of interaction effect V_4F_3 (cultivar Semvu shea + 90:45:45 NPK kg ha^{-1}) gave the highest value Table 16 (b), 17 (b) and 18 (b) respectively)) over all the other treatments under experiment. The rice crop absorbs N continuously up to maturity and the delayed N application at flowering stage expectedly results in relatively higher N accumulation in foliage including lower leaves, contributing to higher growth leading to larger cytokynine production. Cytokynine in turn release senescence of the whole plant causing more dry matter production to adequately meet the needs arising on account of larger sink in the crop.

The total P uptake increased with increase NPK levels up to 90:45:45 NPK kg ha^{-1}. When more water soluble P was applied, the available P content in the soil increased. Surekha *et al.* (1999) found out that anion nutrients like H_2PO_4 are co-transported with NH_4^+ cations during nutrient absorption process. When NH_4^+ is absorbed by the rice roots, counter release of protons (H^+) takes place to balance the charge. This decreases the pH in turn releases the dissolution of insoluble P compounds in oxidised rhizosphere, which helps absorb more P by rice. F_3 (90:45:45

NPK kg ha^{-1}) had also registered the highest K content in grain (Table 18 (a)) in rice crop.

4.6 Apparent nutrient balance sheet of the soil

4.6.1. Nitrogen status

During the first year of experiment the highest actual balance of nitrogen in the soil after harvest (246.96 kg ha^{-1}) was recorded in treatment V_5F_3 (variety Sabhagi dhan + 90:45:45 NPK kg ha^{-1}), which also recorded the highest nitrogen build up after harvest (36.96 kg ha^{-1}), while the highest nitrogen depletion (-72.62 kg ha^{-1}) was recorded in V_1F_0 (cultivar Gwabilo ssu + control).

Similar finding was recorded in the following year. The highest actual balance of nitrogen in the soil after harvest (248.89 kg ha^{-1}) was recorded in treatment V_5F_3 (variety Sabhagi dhan + 90:45:45 NPK kg ha^{-1}), which also recorded the highest nitrogen build up after harvest (44.68 kg ha^{-1}), while the highest nitrogen depletion (-61.67 kg ha^{-1}) was recorded in V_5F_1 (variety Sabhagi dhan + 30:15:15 NPK kg ha^{-1}).

4.6.2 Phosphorus status

Highest value (24.06 kg ha^{-1}) of available soil phosphorus was recorded in treatment V_5F_3 (variety Sahbhagi dhan + 90:45:45 NPK kg ha^{-1}) after harvest during the first year, which also recorded the highest build-up (4.64 kg ha^{-1}), while the highest depletion (-8.59 kg ha^{-1}) was recorded with V_1F_0 (cultivar Gwabilo ssu + control) as in case of nitrogen.

Similar trend of finding was recorded in the following year with treatment V_5F_3 (variety Sahbhagi dhan + 90:45:45 NPK kg ha^{-1}) giving the highest available phosphorus after harvest (29.79 kg ha^{-1}), which also recorded the highest build-up (10.68 kg ha^{-1}), while the highest phosphorus depletion (-4.80 kg ha^{-1}) was recorded with V_1F_0 (cultivar Gwabilo ssu + control).

Table 19. Nutrients balance sheet of soil (2015)

A. NITROGEN

Treatment	Initial N (kg ha^{-1}) (a)	N added through fertilizer (kg ha^{-1}) (b)	Total initial (kg ha^{-1}) (c=a+b)	Crop removed N (kg ha^{-1}) (d)	Apparent N balance (kg ha^{-1}) (e=c-d)	Actual balance N (kg ha^{-1}) (f) after harvest	N gain through N fixation (g=f-e)	Depletion (-) /build up (+) of N (h=f-a)
T_1 (V_1F_0)	210	0	210	43.35	166.65	137.38	-29.28	-72.62
T_2(V_1F_1)	210	30	250	45.55	204.45	174.50	-29.95	-35.50
T_3(V_1F_2)	210	60	280	44.56	235.44	215.96	-19.48	5.96
T_4(V_1F_3)	210	90	310	45.47	264.53	186.88	-77.65	-23.12
T_5(V_2F_0)	210	0	210	47.12	162.88	167.37	4.49	-42.63
T_6(V_2F_1)	210	30	250	44.83	205.17	202.60	-2.57	-7.40
T_7(V_2F_2)	210	60	280	41.24	238.76	176.75	-62.01	-33.25
T_8(V_2F_3)	210	90	310	41.52	268.48	224.88	-84.11	14.88
T_9(V_3F_0)	210	0	210	42.45	167.55	160.78	-6.77	-49.22
T_{10}(V_3F_1)	210	30	250	47.26	202.74	157.76	-44.98	-52.24
T_{11}(V_3F_2)	210	60	280	45.75	232.67	158.02	9.07	-51.98
T_{12}(V_3F_3)	210	90	310	44.83	265.17	184.68	-80.49	-25.32
T_{13}(V_4F_0)	210	0	210	45.55	169.13	168.09	15.24	-25.63
T_{14}(V_4F_1)	210	30	250	43.00	207.00	163.54	-43.46	-46.46
T_{15}(V_4F_2)	210	60	280	44.38	235.62	184.37	-67.53	-41.91
T_{16}(V_4F_3)	210	90	310	48.18	261.82	241.74	-20.19	31.74
T_{17}(V_5F_0)	210	0	210	40.87	169.13	157.04	-7.21	-52.96
T_{18}(V_5F_1)	210	30	250	45.24	204.76	160.51	-44.25	-49.49
T_{19}(V_5F_2)	210	60	280	47.33	231.82	155.59	-76.23	-54.41
T_{20}(V_5F_3)	210	90	310	48.07	261.93	246.96	-17.49	36.96

B. PHOSPHORUS

Treatment	Initial P (kg ha^{-1}) (a)	P added through fertilizer (kg ha^{-1}) (b)	Total initial (kg ha^{-1}) (c=a+b)	Crop removed P (kg ha^{-1}) (d)	Apparent P balance (kg ha^{-1}) (e=c-d)	Actual balance P (kg ha^{-1}) (f) after harvest	P gain through P fixation (g=f-e)	Depletion (-) /build up (+) of P (h=f-a)
T_1 (V_1F_0)	19.42	0	19.42	5.72	13.70	10.83	-3.32	-8.59
T_2(V_1F_1)	19.42	15	34.42	7.66	26.76	14.73	-12.03	-4.69
T_3(V_1F_2)	19.42	30	49.42	10.18	39.24	19.60	-19.64	0.18
T_4(V_1F_3)	19.42	45	64.42	9.60	54.82	19.26	-35.56	-0.16
T_5(V_2F_0)	19.42	0	19.42	9.66	9.76	20.39	10.63	0.97
T_6(V_2F_1)	19.42	15	34.42	8.86	25.56	22.56	-3.00	3.14
T_7(V_2F_2)	19.42	30	49.42	7.91	41.51	19.27	-22.24	-0.15
T_8(V_2F_3)	19.42	45	64.42	9.97	54.45	22.63	-33.25	1.78
T_9(V_3F_0)	19.42	0	19.42	5.24	14.18	21.20	8.45	3.21
T_{10}(V_3F_1)	19.42	15	34.42	6.21	28.21	16.48	-11.73	-2.94
T_{11}(V_3F_2)	19.42	30	49.42	9.16	40.26	22.08	-16.56	4.28
T_{12}(V_3F_3)	19.42	45	64.42	6.36	58.06	19.64	-38.42	0.22
T_{13}(V_4F_0)	19.42	0	19.42	6.21	13.21	17.52	4.31	-1.90
T_{14}(V_4F_1)	19.42	15	34.42	7.81	26.61	15.39	-11.22	-4.03
T_{15}(V_4F_2)	19.42	30	49.42	8.26	41.16	13.58	-27.58	-5.84
T_{16}(V_4F_3)	19.42	45	64.42	10.98	53.44	23.70	-31.54	2.66
T_{17}(V_5F_0)	19.42	0	19.42	8.85	10.57	21.05	10.48	1.63
T_{18}(V_5F_1)	19.42	15	34.42	10.80	23.44	23.55	0.11	4.13
T_{19}(V_5F_2)	19.42	30	49.42	9.11	40.31	20.92	-19.39	1.50
T_{20}(V_5F_3)	19.42	45	64.42	9.88	54.54	24.06	-30.48	4.64

C. POTASSIUM

Treatment	Initial K (kg ha^{-1}) (a)	K added through fertilizer (kg ha^{-1}) (b)	Total initial (kg ha^{-1}) (c=a+b)	Crop removed K (kg ha^{-1}) (d)	Apparent K balance (kg ha^{-1}) (e=c-d)	Actual balance K (kg ha^{-1}) (f) after harvest	K gain through K fixation (g=f-e)	Depletion (-) /build up (+) of K (h=f-a)
$T_1 (V_1F_0)$	198.21	0	198.21	20.16	178.05	218.86	40.81	20.65
$T_2(V_1F_1)$	198.21	15	213.21	30.20	183.01	283.27	100.26	85.06
$T_3(V_1F_2)$	198.21	30	228.21	30.17	198.04	387.07	189.03	188.86
$T_4(V_1F_3)$	198.21	45	243.21	20.19	223.02	253.61	30.59	55.40
$T_5(V_2F_0)$	198.21	0	198.21	30.00	168.21	266.61	98.40	68.40
$T_6(V_2F_1)$	198.21	15	213.21	20.05	193.16	324.30	131.14	126.09
$T_7(V_2F_2)$	198.21	30	228.21	10.78	217.43	330.65	113.22	132.44
$T_8(V_2F_3)$	198.21	45	243.21	30.05	213.16	179.61	-33.55	-18.60
$T_9(V_3F_0)$	198.21	0	198.21	20.34	177.87	274.95	97.08	76.74
$T_{10}(V_3F_1)$	198.21	15	213.21	10.15	203.06	139.72	-63.34	-58.49
$T_{11}(V_3F_2)$	198.21	30	228.21	20.55	207.66	369.73	162.07	171.52
$T_{12}(V_3F_3)$	198.21	45	243.21	20.13	223.08	348.25	125.17	150.04
$T_{13}(V_4F_0)$	198.21	0	198.21	30.07	168.14	280.81	112.67	82.60
$T_{14}(V_4F_1)$	198.21	15	213.21	30.02	183.19	349.59	166.40	151.38
$T_{15}(V_4F_2)$	198.21	30	228.21	30.19	198.02	359.23	161.21	161.02
$T_{16}(V_4F_3)$	198.21	45	243.21	30.32	212.89	371.22	207.89	173.01
$T_{17}(V_5F_0)$	198.21	0	198.21	20.03	177.87	422.40	244.53	46.32
$T_{18}(V_5F_1)$	198.21	15	213.21	20.10	193.11	357.26	164.15	159.05
$T_{19}(V_5F_2)$	198.21	30	228.21	20.09	208.12	314.43	106.31	116.22
$T_{20}(V_5F_3)$	198.21	45	243.21	20.34	223.18	422.78	148.04	224.57

4.6.3 Potassium status

Even in case of potassium, V_5F_3 (variety Sahbhagi dhan + 90:45:45 NPK kg ha^{-1}) recorded the highest available potassium in soil after harvest (422.40 kg ha^{-1}) during the first year, and the lowest (139.72 kg ha^{-1}) was recorded in V_3F_1 (cultivar Ronga shea + 30:15:15 NPK kg ha^{-1}). Also, the highest build-up (224.57 kg ha^{-1}) was recorded in V_5F_3 (variety Sahbhagi dhan + 90:45:45 NPK kg ha^{-1}) while the highest depletion (-58.49 kg ha^{-1}) of potassium was recorded in V_5F_3 (cultivar Ronga shea + 30:15:15 NPK kg ha^{-1}).

Similar trend of finding was followed during the second year with highest value of available potassium in soil (370.34 kg ha^{-1}) with V_5F_3 (variety Sahbhagi dhan + 90:45:45 NPK kg ha^{-1}) and the lowest (228.03 kg ha^{-1}) was however recorded with V_5F_2 (variety Sahbhagi dhan + 60:30:30 NPK kg ha^{-1}), while the highest build-up (146.92 kg ha^{-1}) was recorded in V_5F_3 (variety Sahbhagi dhan + 90:45:45 NPK kg ha^{-1}) and the lowest (7.54 kg ha^{-1}) recorded in V_1F_3 (cultivar Gwabilo ssu + 90:45:45 NPK kg ha^{-1}).

In case of nutrient balance in the soil after harvest during the year 2015, treatment V_1F_0 (cultivar Gwabilo ssu + control) showed the highest nitrogen as well as phosphorus depletion (Table 19 (a)) and (Table 19 (b)). While during 2016 highest nitrogen depletion was recorded with V_1F_2 (cultivar Gwabilo ssu + 60:30:30 NPK kg ha^{-1}) and for phosphorus treatment V_1F_0 (cultivar Gwabilo ssu + control) recorded the highest depletion (Table 20 (a)) and (Table 20 (b)). The declined in available P even after its application maybe due to high P-fixation capacity of acidic soils containing large amounts of soluble aluminium and iron, while in case of potassium, treatment V_3F_1 (cultivar Ronga shea + 30:15:15 NPK kg ha^{-1}) showed the highest depletion during 2015 (Table 19 (b)) while in the following year of experiment potassium potassium depletion was not recorded. As in case of the first year of experiment the depletion in potassium content might be due to the reason that K application was much below its removal by the crop, the decline in K status was quiet expected and the K release from the minerals was probably not adequate to maintain the initial K level. Interestingly the highest build up (Table 19 (a, b and c)) and (Table 20 (a, b and c)) of all the three nutrient in the soil was recorded with V_5F_3 (variety Sahbhagi dhan + 90:45:45 NPK kg ha^{-1}) which also recorded the highest grain yield (Table 12 (b)). This could be due to high responsiveness of the improved variety where the nutrient intake was higher as compared to nutrient spent during its growth and development, also recycling of more organic matter from stubbles left in the fields, which upon decomposition released nutrient in the soil. Hedge

Table 20. Nutrients balance sheet of soil (2016)

A. NITROGEN

Treatment	Initial N (kg ha^{-1}) (a)	N added through fertilizer (kg ha^{-1}) (b)	Total initial (kg ha^{-1}) (c=a+b)	Crop removed N (kg ha^{-1}) (d)	Apparent N balance (kg ha^{-1}) (e=c-d)	Actual balance N (kg ha^{-1}) (f) after harvest	N gain through N fixation (g=f-e)	Depletion (-) /build up (+) of N (h=f-a)
T_1 (V_1F_0)	204.21	0	204.21	43.42	160.79	159.65	-1.14	-44.56
T_2(V_1F_1)	204.21	30	234.21	46.23	187.98	179.20	-8.78	-25.01
T_3(V_1F_2)	204.21	60	264.21	45.19	219.02	156.13	-62.89	-48.08
T_4(V_1F_3)	204.21	90	294.21	46.19	248.02	174.95	-73.07	-29.26
T_5(V_2F_0)	204.21	0	204.21	43.78	160.43	168.68	8.25	-35.53
T_6(V_2F_1)	204.21	30	234.21	42.56	191.65	173.87	-17.78	-30.34
T_7(V_2F_2)	204.21	60	264.21	45.53	218.68	170.58	-48.10	-33.63
T_8(V_2F_3)	204.21	90	294.21	47.37	246.84	168.63	-78.21	-35.58
T_9(V_3F_0)	204.21	0	204.21	38.05	166.16	164.93	-1.23	-39.28
T_{10}(V_3F_1)	204.21	30	234.21	46.34	187.87	173.10	-14.77	-31.11
T_{11}(V_3F_2)	204.21	60	264.21	45.64	215.52	172.86	-42.66	-31.35
T_{12}(V_3F_3)	204.21	90	294.21	42.78	251.43	187.29	-64.14	-16.92
T_{13}(V_4F_0)	204.21	0	204.21	42.65	161.56	204.14	24.39	-18.26
T_{14}(V_4F_1)	204.21	30	234.21	45.33	188.88	186.26	-2.62	-17.95
T_{15}(V_4F_2)	204.21	60	264.21	40.93	223.28	185.95	-19.14	-0.07
T_{16}(V_4F_3)	204.21	90	294.21	48.69	254.52	214.51	-5.33	10.30
T_{17}(V_5F_0)	204.21	0	204.21	39.99	155.18	167.93	12.75	-36.28
T_{18}(V_5F_1)	204.21	30	234.21	45.39	188.82	142.54	-46.28	-61.67
T_{19}(V_5F_2)	204.21	60	264.21	44.63	219.58	173.09	-46.49	-31.12
T_{20}(V_5F_3)	204.21	90	294.21	47.03	248.57	248.89	-34.06	44.68

B. **PHOSPHORUS**

Treatment	Initial P (kg ha^{-1}) (a)	P added through fertilizer (kg ha^{-1}) (b)	Total initial (kg ha^{-1}) (c=a+b)	Crop removed P (kg ha^{-1}) (d)	Apparent P balance (kg ha^{-1}) (e=c-d)	Actual balance P (kg ha^{-1}) (f) after harvest	P gain through P fixation (g=f-e)	Depletion (-) /build up (+) of P (h=f-a)
T_1 (V_1F_0)	19.11	0	19.11	6.17	12.94	14.31	1.37	-4.80
T_2(V_1F_1)	19.11	15	34.11	7.15	26.96	14.93	-12.03	-4.18
T_3(V_1F_2)	19.11	30	49.11	8.64	40.47	16.91	-23.56	-2.20
T_4(V_1F_3)	19.11	45	64.11	9.20	54.91	17.10	-37.81	-2.01
T_5(V_2F_0)	19.11	0	19.11	9.38	9.73	22.05	12.32	2.94
T_6(V_2F_1)	19.11	15	34.11	8.01	26.10	16.80	-9.30	-2.31
T_7(V_2F_2)	19.11	30	49.11	7.83	41.28	17.28	-24.00	-1.83
T_8(V_2F_3)	19.11	45	64.11	8.77	55.34	24.77	-30.57	5.66
T_9(V_3F_0)	19.11	0	19.11	5.74	13.37	25.44	12.07	6.33
T_{10}(V_3F_1)	19.11	15	34.11	6.75	27.36	24.26	-3.10	5.15
T_{11}(V_3F_2)	19.11	30	49.11	10.26	38.85	23.04	-15.81	3.93
T_{12}(V_3F_3)	19.11	45	64.11	6.74	57.37	21.97	-35.40	2.86
T_{13}(V_4F_0)	19.11	0	19.11	6.54	12.57	21.39	8.82	2.28
T_{14}(V_4F_1)	19.11	15	34.11	8.61	25.50	19.42	-6.08	0.31
T_{15}(V_4F_2)	19.11	30	49.11	6.95	42.16	23.77	-18.39	4.66
T_{16}(V_4F_3)	19.11	45	64.11	10.84	53.11	27.68	-24.97	8.57
T_{17}(V_5F_0)	19.11	0	19.11	8.68	8.27	21.36	13.09	2.25
T_{18}(V_5F_1)	19.11	15	34.11	9.35	25.43	18.59	-6.84	-0.52
T_{19}(V_5F_2)	19.11	30	49.11	8.00	41.11	24.41	-16.70	5.30
T_{20}(V_5F_3)	19.11	45	64.11	8.67	55.44	29.79	-27.76	10.68

C. POTASSIUM

Treatment	Initial K (kg ha^{-1}) (a)	K added through fertilizer (kg ha^{-1}) (b)	Total initial (kg ha^{-1}) (c=a+b)	Crop removed K (kg ha^{-1}) (d)	Apparent K balance (kg ha^{-1}) (e=c-d)	Actual balance K (kg ha^{-1}) (f) after harvest	K gain through K fixation (g=f-e)	Depletion (-) /build up (+) of K (h=f-a)
T_1 (V_1F_0)	223.42	0	223.42	20.27	203.15	272.36	69.21	48.94
T_2(V_1F_1)	223.42	15	238.42	29.52	208.90	317.28	108.38	93.86
T_3(V_1F_2)	223.42	30	193.42	29.68	163.74	309.03	145.29	85.61
T_4(V_1F_3)	223.42	45	178.42	22.95	155.47	230.96	75.49	7.54
T_5(V_2F_0)	223.42	0	223.42	26.39	197.03	308.75	111.72	85.33
T_6(V_2F_1)	223.42	15	238.42	20.18	218.24	288.89	70.65	65.47
T_7(V_2F_2)	223.42	30	193.42	10.29	183.13	280.81	97.68	57.39
T_8(V_2F_3)	223.42	45	178.42	30.38	148.04	275.81	127.77	52.39
T_9(V_3F_0)	223.42	0	223.42	22.88	200.54	282.96	82.42	59.54
T_{10}(V_3F_1)	223.42	15	238.42	13.96	224.46	309.38	84.92	85.96
T_{11}(V_3F_2)	223.42	30	193.42	30.31	163.11	327.11	164.00	103.69
T_{12}(V_3F_3)	223.42	45	178.42	20.28	158.14	309.39	151.25	85.97
T_{13}(V_4F_0)	223.42	0	223.42	21.02	202.40	294.04	91.64	70.62
T_{14}(V_4F_1)	223.42	15	238.42	26.93	211.49	328.44	116.95	105.02
T_{15}(V_4F_2)	223.42	30	193.42	30.26	163.16	312.03	148.95	88.61
T_{16}(V_4F_3)	223.42	45	178.42	30.34	148.08	363.25	222.18	139.83
T_{17}(V_5F_0)	223.42	0	223.42	16.89	192.26	271.93	79.07	48.51
T_{18}(V_5F_1)	223.42	15	238.42	20.22	218.20	369.22	151.02	145.80
T_{19}(V_5F_2)	223.42	30	193.42	20.28	173.14	228.03	54.89	4.61
T_{20}(V_5F_3)	223.42	45	178.42	30.16	161.53	370.34	201.72	146.92

(1996), Dixit and Gupta (2000) also observed that application of FYM with 90:40:40 NPK kg ha^{-1} significantly increased the N, P and K status of soil.

The nutrient balance worked out for several treatments indicated that the highest N balance in the soil after harvest during both the year was recorded with fertilizer dose F_{3}- 90:45:45 kg NPK ha^{-1} in combination with the improved variety Sahbhagi dhan , while the same dose resulted in excess vegetative growth of the local cultivars resulting in soil nutrient depletion as well as reduction in yield.

4.7 Production economics

Production economics particularly cost of cultivation, gross return, net return, benefit cost ratio and production efficiency were calculated on the basis of prevailing market price.

4.7.1 Cost of cultivation

The data presented in (Table 21) revealed that the cost of cultivation differs with the treatments. There is a common cost of cultivation for all the control treatments where no fertilizer doses applied. In all other remaining treatments cost of cultivation is slightly varied because of the differences in fertilizer doses applied. Cost of fertilizer and labour cost involved for carrying and application make differences in cost of cultivation.

4.7.2 Gross return (₹ ha^{-1})

The perusal of mean data presented in Table 21 indicated that the maximum gross return of ₹ 77,020.6 was recorded during the year 2015 with the variety 'Sahbhagi dhan' under fertilizer dose of 90:45:45 kg ha-1, which was followed by cultivar 'Semvu shea'with a return of ₹ 49,444.30 for fertilizer dose of 60:30:30 kg ha-1, while the lowest return of ₹ 8,034.15 was recorded for cultivar 'Gwabilo ssu' under control. During the second year 2016 also higher gross return of ₹ 68,226 was recorded with variety 'Sahbhagi dhan' and fertilizer dose of 90:45:45 kg ha-1 followed by cultivar 'Semvu shea'with a return of ₹ 50,916.30 under fertilizer dose of 60:30:30 kg ha-1 and the least return of ₹17,655.60 was recorded for cultivar 'Gwabilo ssu' under control.

Table 21: Effect of varieties and treatments interaction on cost of cultivation and Gross return (₹ ha^{-1})

Interactions	Cost of cultivation (₹ ha^{-1})	Gross income (₹ ha^{-1})		Net income (₹ ha^{-1})		Benefit cost ratio	
		2015	2016	2015	2016	2015	2016
T_1 (V_1F_0)	21,700	8,034.15	17,655.60	-13665.85	-4044.40	-0.62	-0.18
T_2(V_1F_1)	25,100	38,496.30	24,317.15	13396.30	-782.85	0.53	-0.03
T_3(V_1F_2)	26,000	42,414.20	26,402.40	16414.20	402.40	0.63	0.02
T_4(V_1F_3)	26,900	32,340.65	30,354.20	5440.65	3454.20	0.20	0.13
T_5(V_2F_0)	21,700	16,962.40	20,960.20	-4737.60	-739.80	-0.22	-0.03
T_6(V_2F_1)	25,100	44,554.70	31,790.30	19454.70	6690.30	0.78	0.27
T_7(V_2F_2)	26,000	35,237.66	35,027.30	9237.66	9027.30	0.36	0.35
T_8(V_2F_3)	26,900	43,161.80	31,563.90	16261.80	4663.90	0.60	0.17
T_9(V_3F_0)	21,700	19,433.70	27,268.90	-2266.30	5568.90	-0.10	0.26
T_{10}(V_3F_1)	25,100	43,777.50	32,332.11	18677.50	7232.11	0.74	0.29
T_{11}(V_3F_2)	26,000	37,770.26	30,582.00	11770.26	4582.00	0.45	0.18
T_{12}(V_3F_3)	26,900	39,235.82	41,875.00	12335.82	14975.00	0.45	0.56
T_{13}(V_4F_0)	21,700	16,572.05	22,193.70	-5127.95	493.70	-0.24	0.02
T_{14}(V_4F_1)	25,100	44,902.40	31,887.90	19802.40	6787.90	0.78	0.27
T_{15}(V_4F_2)	26,000	49,444.30	50,916.30	24777.70	24916.30	0.90	0.96
T_{16}(V_4F_3)	26,900	47,889.20	48,578.10	20989.20	21678.10	0.78	0.81
T_{17}(V_5F_0)	21940	23,777.80	27,381.30	1837.80	5441.30	0.08	0.25
T_{18}(V_5F_1)	25340	30,799.00	26,765.70	5459.00	1425.70	0.22	0.06
T_{19}(V_5F_2)	26240	36,828.07	43,632.40	10588.07	17392.40	0.40	0.66
T_{20}(V_5F_3)	27140	77,020.6	68,226.00	39126.60	41086.00	1.44	1.51

4.7.3 Net return (₹ ha^{-1})

During the year 2015, the maximum net return of ₹ 39126.60 was recorded with variety 'Sahbhagi dhan' under fertilizer dose of 90:45:45 kg ha-1, which was followed by cultivar 'Semvu shea'with a return of ₹ 24,777.30 under fertilizer dose of 60:30:30 kg ha-1 while, the highest deficit of ₹ -13665.85 were recorded for cultivar 'Gwabilo ssu' under control. During the year 2016 also, maximum net return of ₹ 41,086 was recorded with variety 'Sahbhagi dhan' under fertilizer dose of 90:45:45 kg ha-1 followed by cultivar 'Semvu shea'with a return of ₹ 24916.30 under fertilizer dose of 60:30:30 kg ha-1, while a deficit of ₹ -4044.40 was recorded for cultivar 'Gwabilo ssu' under control.

4.7.4 Benefit cost ratio

In case of benefit cost ratio, during the year 2015 the highest ratio 1.44 was recorded with variety 'Sahbhagi dhan' under fertilizer dose of 90:45:45 kg ha^{-1}, which was followed by cultivar 'Semvu shea'with a ratio of 0.90 under fertilizer dose of 60:30:30 kg ha^{-1}. During the year 2016 also the highest benefit cost ratio 1.51 was recorded with variety 'Sahbhagi dhan' and fertilizer dose of 90:45:45 kg ha^{-1}, which was followed by cultivar 'Semvu shea'with a ratio of 0.96 under fertilizer dose 60:30:30 kg ha^{-1}. While the lowest ratio (-0.62 and -0.18 respectively for both the experiment) was recorded for cultivar 'Gwabilo ssu' for control during the two years of experiment.

Economics of the rice crop was significantly influenced by different treatments (Table 21). Cost of cultivation of test cultivars were exactly same, however varied slightly for the released check variety and also nutrient management levels incurred. Maximum cost involved in V_5 F_3 (variety Sahbhagi dhan + 90:45:45 NPK kg ha^{-1}) and minimum was at control. Gross income was significantly maximum in V_5 F_3 (variety Sahbhagi dhan + 90:45:45 NPK kg ha^{-1}) (table 21) followed by V_4 F_2 (cultivar Semvu shea + 60:30:30 NPK kg ha^{-1}) (Table 21). Increasing levels of nutrient management increased income significantly.

Net return was also influenced significantly by both the treatment factors. Variety Sahbhagi dhan earned maximum net returns followed by cultivar Semvu shea (table 21).While a depletion in net return was recorded from cultivars Gwabilo ssu and Hoikha (table 21). In case of nutrient management level, F_3 (90:45:45 NPK kg ha^{-1}) earned significantly highest profit (table 21) followed by F_2 (90:45:45 NPK kg ha^{-1}). It is obvious from table that check variety Sahbhagi dhan attained significantly highest benefit: cost ratio followed by cultivar Semvu shea while significantly lowest was attained by cultivars Gwabilo ssu and Hoikha (table 21) The benefit: cost ratio showed significant improvement with each increasing level of nutrient management.

Effect of nutrient management levels was more pronounced on benefit: cost ratio than hybrids. Gross returns of rice cultivars were attributed mainly to grain yield. These results may be similar to the findings of Bhowmick and Nayak (2000) and Singh and Singh (2008). Net returns and benefit: cost ratio was also worked out significantly highest at F_3 (90:45:45 NPK kg ha^{-1}) attributed mainly due to higher gross return under this treatment. Though cost of cultivation was also highest at F_3 (90:45:45 NPK kg ha^{-1}) than lower nutrient management levels, while margin of difference was found much higher in case of gross return which could not only compensated the higher cost but increased the net returns and benefit: cost ratio at higher nutrient management levels. Yadav *et al*. (2007) as well as Kumar and Yadav (2008) reported from Kanpur that increases in fertilizer level increase the economic parameters significantly in rice.

CHAPTER-V

SUMMARY AND CONCLUSION

The present investigation entitled "Response of local rice (*Oryza sativa* L.) cultivars to different levels of N, P and K under upland rainfed condition of Nagaland" was carried out in the experimental farm of the School of Agricultural Sciences and Rural Development, Medziphema, Nagaland University, during the period of 2015 and 2016. The investigation was carried out with the following objectives –

1. To find out the fertilizer responsive local rice cultivars
2. To find out the suitable fertilizer doses for local rice cultivars
3. To find out the interaction effect of fertilizer doses and rice cultivars
4. To find out the economics of the performance of treatment

The response of rice crop to the various treatments was measured in terms of quantitative expressions. The quantitative indices included observations of plant height, number of tillers per plant, number of green leaves per plant, plant population, crop growth rate, relative growth rate, leaf area index, number of panicles per metre square, length of panicle, weight of panicle, filled grains percent per panicle, test weight, grain yield, straw yield and harvest index. Observation on days to 50% flowering, observation on days to maturity and available nutrients status in soil after harvest were also recorded.

The salient findings thus obtained from the study were summarized below:

6.1. Growth characters

The growth characters were measured in term of plant height, number of tillers per plant, number of green leaves per plant and plant population at 30 days interval up to 90 days and maturity stage respectively.

Experimental findings revealed that the plant height being a varietal character was found to differ among the varieties. Significantly highest plant height (156.19 cm), plant population (86.00), crop growth rate and relative growth rate (15.13 0.051 g g^{-1} day^{-1} respectively) and also highest value (1.34) for leaf area index (LAI)during both the year was recorded with T_{16} (cultivar Semvu shea with a fertilizer dose of 90:45:45 NPK kg ha^{-1}).

However plants showed excessive vegetative growth and subsequent lodging and reduction in crop yield under this fertilizer dose. While in case of number of tillers count V_5 F_3 (variety Sahbhagi dhan with a fertilizer dose of 90:45:45 NPK kg ha^{-1}) recorded the highest value (156.46 m^{-2}) which is attributed to the genetic makeup of the variety having a potential to produce more tillers even under drought conditions which proved instrumental in showing effective variation.

6.2. Yield and yield attributing characters

The result of the findings indicated that V_4 F_2 (cultivar semvu shea +60:30:30 NPK kg ha^{-1}) recorded maximum result in yield attributing characters such as length of panicle and weight of panicle (29.53 cm and 8.04 g respectively). However treatment V_5 F_3 (variety Sahbhagi dhan + 90:45:45 NPK kg ha^{-1}) recorded maximum number of panicles per metre square (124), filled grains percent per panicle (91.62 %), test weight (23.22 g), grain yield (3333.33 kg ha^{-1}) and harvest index (41.56 %) thereby out-yielded V_4 F_2 proving its superiority over the treatment.

The fertilizer doses had significant influence on yield attributes. The highest values on number of panicle per metre square, filled grain percentage, test weight, grain yield and harvest index (111.57 m^{-2}, 83.84 %, 20.75 g, 2259.07 kg ha^{-1} and 35.69 % respectively) were recorded with fertilizer dose F_3 (90:45:45 NPK kg ha^{-1}), while for length of panicle and weight of panicle (27.80 cm and 5.38 g respectively) the highest value was recorded with fertilizer dose F_2 (60:30:30 NPK kg ha^{-1}).

The highest yield during both the year was associated with variety 'Sahbhagi dhan' which also recorded the highest number of panicles per metre square, test weight and filled grain percent (Table 10 (a) and 11 (a) respectively) while cultivar Semvu shea was associated with highest length of panicle and weight of the panicle (table 10 (a)). Harvest index (Table 12 (a)) was also observed highest in variety Sahbhagi dhan.

4.5. Crop phenology

4.5.1. Days to 50 % flowering and days to maturity

Days to 50% flowering and maturity were found to differ significantly due to fertilizer doses, cultivars and its interactions. Cultivar 'Semvu shea ' showed the longest duration (84.25) to days to 50% flowering. Variety 'Sahbhagi dhan' showed the shortest duration

(83.01) to days to 50% maturity. Also for days to maturity, Cultivar 'Semvu shea 'showed the longest duration (117.74), while variety 'Sahbhagi dhan' showed the shortest duration (116.78) also for days to maturity. While in case of fertilizer dose F_3 (90:45:45 NPK kg ha^{-1}) recorded the longest duration while control recorded the shortest (table 14 (a)).

6.4. Fertility status after harvest

The maximum available nitrogen after harvest was obtained by cultivar V_4 (Semvu shea) (185.60 kg ha-1) under fertilizer dose F_3 (90:45:45 kg ha^{-1}) (188.66 kg ha^{-1}) and interaction V_4 F_3 (233.13 kg ha^{-1}), while maximum available P_2O_5 and K_2O (23.04 kg $ha^{-1}$and 345.50 kg ha^{-1} respectively) after harvest during both the year was recorded with variety V_5 (Sahbhagi dhan) under fertilizer dose F_3 (90:45:45 kg ha^{-1}) (table 14 (a)) and interaction V_5F_3 (variety Sahbhagi dhan + 90:45:45 NPK kg ha^{-1}) (21.22 kg ha^{-1} and 335.39 kg ha^{-1}). Maximum organic carbon after harvest during both the year was recorded with cultivar V_4 (Semvu shea) under fertilizer dose F_3 (90:45:45 kg ha^{-1}) (1.72 % and 1.50 % respectively) and interaction V_4F_3 (cultivar Semvu shea + 90:45:45 NPK kg ha^{-1}) (2.13 kg ha^{-1}) while soil pH was recorded highest for cultivar V_3 (Ronga shea) under fertilizer dose F_2 (60:30:30 kg ha^{-1}) (4.87 and 4.69 respectively) and interaction V_4F_2 (cultivar Semvu shea + 60:30:30 NPK kg ha^{-1}) (4.99).

6.5. Nutrient uptake by plants

The highest nitrogen, phosphorus and potassium uptake (46.49 kg ha^{-1}, 9.38 kg ha^{-1} and 28.55 kg ha^{-1} respectively) during the experiment was recorded with cultivar V_4 (Semvu shea). Though fertilizer doses did not show any significant difference in its uptake, fertilizer dose F_3 (90:45:45 NPK kg ha^{-1}) however gave the highest uptake for the entire three nutrient element. In case of interaction effect V_4F_3 (cultivar Semvu shea + 90:45:45 NPK kg ha^{-1}) gave the highest value (48.49 kg ha^{-1}, 10.92 kg $ha^{-1}$and 30.33 kg ha^{-1} respectively) over all the other nutrients under experiment.

4.5. Apparent nutrient balance sheet of the soil

The nutrient balance worked out for several treatments indicated that the highest N balance was recorded with fertilizer dose F_3- 90:45:45 NPK kg ha^{-1} though this same dose resulted in lodging of the local cultivar, this could be due to recycling of more organic matter from stubbles left in the fields, which upon decomposition released more nutrient in the soil.

Nitrogen uptake was also maximum with the same dose. The highest balance was observed with variety Sahbhagi dhan and a fertilizer dose of 90:45:45 NPK kg ha^{-1}.

6.6. Economics of the treatments

The economics of different treatments were calculated and highest net income (`9126.60 and `41086.00 respectively) for 2015 and 2016 as well as highest benefit cost ratio of 1.44 and 1.51 respectively for two years were obtained from V_5F_3 (variety Sahbhagi dhan + 90:45:45 NPK kg ha^{-1}).

From the findings of the present investigation, the following evidences and conclusions may be drawn.

CONCLUSION

a) From the experiment conducted, it can be concluded that cultivar Semvu shea is comparatively more fertilizer responsive giving the highest production efficiency and also producing yield which was significantly at par with the improved check variety, thus proving its superiority over the other cultivars under trail.

b) Application of fertilizer dose @ 60:30:30 NPK kg ha^{-1} resulted in a better performance of the local cultivars suiting the genetic make-up of the crop and the agroclimatic condition of the region.

c) Among the treatment interaction, cultivar Semvu shea with fertilizer dose @ 60:30:30 NPK kg ha^{-1} recorded the highest yield as well as benefit cost ratio, which was followed by cultivar Semvu shea @ 60:30:30 NPK kg ha^{-1} and cultivar Hoikha @ 30:15:15 NPK kg ha^{-1}.

d) Highest benefit cost ratio of 1.44 and 1.51 respectively for two years were obtained from treatment interaction V_5F_3 (variety Sahbhagi dhan + 90:45:45 NPK kg ha^{-1}) which was followed by interaction V_4F_2 (cultivar Semvu shea + 60:30:30 NPK kg ha^{-1}) for both the experiment year.

Recommendations:

Based on the results obtained in the present study, some recommendations can be drawn on the following aspects for increasing production and productivity of rice crop in the region.

1. To get a higher yield from the local cultivars in the region fertilizer dose @ 60:30:30 NPK kg ha^{-1} maybe recommended as it has been found to be more crop responsive and resulted in higher production.

2. Despite lodging susceptibility nature the local cultivar Semvu shea (V_4) recorded comparable grain yield with that of the check variety Sahbhagi dhan (V_5) @ 30:15:15 NPK kg ha^{-1}

Future research needs:

1. Long term fertilizer trial on local rice cultivars are needed for final recommendation to the farmers.
2. On farm trials on response of local rice cultivars to NPK fertilizers are needed.

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APPENDIX-A

ANOVA 1. Analysis of variance as influenced by cultivars, fertilizer doses and their interaction effects on plant height (cm) during 2015

ANALYSIS OF VARIANCE TABLE

(A) 30 DAS

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Sum of Squares	F. ratio	F. table 5%
Replication	2	213.90	106.9	4.53	3.24
Cultivar	4	714.36	178.59	7.57	2.62
Fertilizer doses	3	230.45	76.82	3.25	2.85
Cultivar X Fertilizer	12	4150.93	345.91	14.67	2.02
Error	38	895.62	23.56	-	-

(B) 60 DAS

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Sum of Squares	F. ratio	F. table 5%
Replication	2	1828.21	914.11	3.89	3.24
Cultivar	4	3110.06	777.52	3.13	2.61
Fertilizer doses	3	2130.87	710.28	3.03	2.85
Cultivar X Fertilizer	12	14185.39	1182.12	5.04	2.01
Error	38	8917.87	234.68	-	-

(C) 90 DAS

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Sum of Squares	F. ratio	F. table 5%
Replication	2	2.07	1.03	0.01	3.24
Cultivar	4	1480.74	370.18	4.09	2.61
Fertilizer doses	3	1719.38	573.13	6.34	2.85
Cultivar X Fertilizer	12	9578.53	798.21	8.83	2.02
Error	38	3434.78	90.38	-	-

(D) At Maturity

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Sum of Squares	F. ratio	F. table 5%
Replication	2	947.85	473.92	1.80	3.24
Cultivar	4	4585.89	1146.47	4.36	2.61
Fertilizer doses	3	6741.19	2247.06	8.55	2.85
Cultivar X Fertilizer	12	32467.9	2705.67	10.30	2.01
Error	38	9980.23	262.63	-	-

ANOVA 2. Analysis of variance as influenced by cultivars, fertilizer doses and their interaction effects on plant population (m^{-2}) during 2015.

ANALYSIS OF VARIANCE TABLE

(A) 30 DAS

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Sum of Squares	F. ratio	F. table 5%
Replication	2	1914.13	957.06	1.29	3.24
Cultivar	4	2643.73	660.93	0.89	2.61
Fertilizer doses	3	226.93	75.64	0.10	2.85
Cultivar X Fertilizer	12	10617.06	884.75	1.19	2.02
Error	38	43503.73	739.52	-	-

(B) 60 DAS

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Sum of Squares	F. ratio	F. table 5%
Replication	2	2451.73	1225.86	1.63	3.24
Cultivar	4	2598.93	649.73	0.86	2.61
Fertilizer doses	3	3806.93	1268.97	1.69	2.85
Cultivar X Fertilizer	12	7598.40	633.20	0.84	2.01
Error	38	28534.93	750.91	-	-

ANOVA 3. Analysis of variance as influenced by cultivars, fertilizer doses and their interaction effects on number of leaves plant^{-1} during 2015.

ANALYSIS OF VARIANCE TABLE

(A) 30 DAS

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Sum of Squares	F. ratio	F. table 5%
Replication	2	3.42	1.71	2.53	3.24
Cultivar	4	3.72	0.93	1.37	2.61
Fertilizer doses	3	0.75	0.25	0.37	2.85
Cultivar X Fertilizer	12	10.03	0.84	1.24	2.01
Error	38	25.72	0.67	-	-

(B) 60 DAS

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Sum of Squares	F. ratio	F. table 5%
Replication	2	1.74	0.87	2.29	3.24
Cultivar	4	0.65	0.16	0.42	2.61
Fertilizer doses	3	1.90	0.63	1.66	2.85
Cultivar X Fertilizer	12	2.33	0.19	0.51	2.01
Error	38	14.48	0.38	-	-

(C) 90 DAS

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Sum of Squares	F. ratio	F. table 5%
Replication	2	0.64	0.32	1.99	3.24
Cultivar	4	0.84	0.21	1.31	2.61
Fertilizer doses	3	0.06	0.02	0.13	2.85
Cultivar X Fertilizer	12	2.01	0.16	1.04	2.01
Error	38	6.12	0.16	-	-

ANOVA 4. Analysis of variance as influenced by cultivars, fertilizer doses and their interaction effects on number of tillers (m^{-2}) at 90 DAS during 2015.

ANALYSIS OF VARIANCE TABLE

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Sum of Squares	F. ratio	F. table 5%
Replication	2	25.2	12.60	3.13	3.24
Cultivar	4	2970.06	742.51	184.65	2.61
Fertilizer doses	3	56.33	18.77	4.67	2.85
Cultivar X Fertilizer	12	111.00	9.25	2.30	2.01
Error	38	152.800	4.02	-	-

ANOVA 5. Analysis of variance as influenced by cultivars, fertilizer doses and their interaction effects on Crop Growth Rate (g m^{-2} day^{-1}) during 2015.

ANALYSIS OF VARIANCE TABLE

(A) 30 DAS

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Sum of Squares	F. ratio	F. table 5%
Replication	2	0.22	0.11	1.22	3.24
Cultivar	4	0.73	0.18	2.01	2.61
Fertilizer doses	3	0.67	0.22	2.45	2.85
Cultivar X Fertilizer	12	1.45	0.12	1.33	2.01
Error	38	3.47	0.09	-	-

(B) 60 DAS

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Sum of Squares	F. ratio	F. table 5%
Replication	2	18.18	9.09	2.82	3.24
Cultivar	4	334.77	83.69	25.96	2.61
Fertilizer doses	3	54.48	18.16	5.63	2.85
Cultivar X Fertilizer	12	533.46	44.45	13.78	2.01
Error	38	122.50	3.22	-	-

ANOVA 6. Analysis of variance as influenced by cultivars, fertilizer doses and their interaction effects on Relative Growth Rate (g g^{-1} day^{-1}) during 2015.

ANALYSIS OF VARIANCE TABLE

(A) 30 DAS

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Sum of Squares	F. ratio	F. table 5%
Replication	2	0.00	0.00	0.64	3.24
Cultivar	4	0.00	0.00	1.30	2.61
Fertilizer doses	3	0.00	0.00	2.71	2.85
Cultivar X Fertilizer	12	0.00	0.00	1.85	2.01
Error	38	0.00	0.00	-	-

(B) 60 DAS

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Sum of Squares	F. ratio	F. table 5%
Replication	2	0.00	0.00	0.41	3.24
Cultivar	4	0.00	0.00	11.57	2.61
Fertilizer doses	3	0.00	0.00	2.91	2.85
Cultivar X Fertilizer	12	0.00	0.00	11.35	2.01
Error	38	0.00	0.00	-	-

ANOVA 7. Analysis of variance as influenced by cultivars, fertilizer doses and their interaction effects on Leaf Area Index (%) during 2015.

ANALYSIS OF VARIANCE TABLE

(A) 30 DAS

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Sum of Squares	F. ratio	F. table 5%
Replication	2	0.00	0.00	0.48	3.24
Cultivar	4	0.07	0.01	6.36	2.61
Fertilizer doses	3	0.05	0.02	6.05	2.85
Cultivar X Fertilizer	12	0.16	0.01	4.46	2.01
Error	38	0.11	0.00	-	-

(B) 60 DAS

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Sum of Squares	F. ratio	F. table 5%
Replication	2	0.00	0.001	2.09	3.24
Cultivar	4	0.04	0.009	15.45	2.61
Fertilizer doses	3	0.00	0.001	0.88	2.85
Cultivar X Fertilizer	12	0.05	0.00	6.75	2.01
Error	38	0.02	0.00	-	-

ANOVA 8. Analysis of variance as influenced by cultivars, fertilizer doses and their interaction effects on yield attributes of rice during 2015

(A) Number of panicles m^{-2}

ANALYSIS OF VARIANCE TABLE

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Sum of Squares	F. ratio	F. table 5%
Replication	2	4.38	2.19	0.38	3.24
Cultivar	4	51.71	12.92	2.28	2.61
Fertilizer doses	3	23.87	7.95	1.40	2.85
Cultivar X Fertilizer	12	115.84	9.65	1.70	2.01
Error	38	215.19	5.66	-	-

(B) Length of panicle (cm)

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Sum of Squares	F. ratio	F. table 5%
Replication	2	24.35	12.17	4.20	3.24
Cultivar	4	79.42	19.85	6.85	2.61
Fertilizer doses	3	24.32	8.10	2.79	2.85
Cultivar X Fertilizer	12	72.05	6.01	2.07	2.01
Error	38	110.09	2.89	-	-

(C) Weight of panicle (g)

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Sum of Squares	F. ratio	F. table 5%
Replication	2	0.58	0.29	0.58	3.24
Cultivar	4	6.31	1.57	3.18	2.61
Fertilizer doses	3	19.77	6.59	13.28	2.85
Cultivar X Fertilizer	12	41.92	3.49	7.04	2.01
Error	38	18.85	0.49	-	-

(D) Number of grains $panicle^{-1}$

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Sum of Squares	F. ratio	F. table 5%
Replication	2	759.47	379.73	0.84	3.24
Cultivar	4	3137.15	784.29	1.74	2.61
Fertilizer doses	3	2804.91	934.97	2.07	2.85
Cultivar X Fertilizer	12	42289.13	3524.09	7.82	2.01
Error	38	17124.12	450.63	-	-

(E) Filled grain percent (%)

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Sum of Squares	F. ratio	F. table 5%
Replication	2	45.11	22.55	2.66	3.24
Cultivar	4	108.23	27.05	3.19	2.61
Fertilizer doses	3	267.05	89.02	10.52	2.85
Cultivar X Fertilizer	12	1229.29	102.44	12.11	2.01
Error	38	312.54	8.46	-	-

(F) Test weight (g)

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Sum of Squares	F. ratio	F. table 5%
Replication	2	0.71	0.35	0.44	3.24
Cultivar	4	17.54	4.38	5.40	2.61
Fertilizer doses	3	12.83	4.27	5.26	2.85
Cultivar X Fertilizer	12	42.32	3.52	4.34	2.01
Error	38	30.85	0.81	-	-

ANOVA 9. Analysis of variance as influenced by cultivars, fertilizer doses and their interaction effects on yield of rice (kg ha^{-1}).

ANALYSIS OF VARIANCE TABLE

(A) Grain yield (kg ha^{-1})

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Sum of Squares	F. ratio	F. table 5%
Replication	2	78666.41	39333.2	1.39	3.24
Cultivar	4	21823316.1	5455829.1	193.43	2.61
Fertilizer doses	3	8537050.8	2845683.6	100.89	2.85
Cultivar X Fertilizer	12	584156.2	486804.7	17.25	2.01
Error	38	171815.1	28205.7	-	-

(B) Straw yield (kg ha^{-1})

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Sum of Squares	F. ratio	F. table 5%
Replication	2	14220828.8	7110414.4	7.39	3.24
Cultivar	4	29773722.2	7443430.5	7.74	2.61
Fertilizer doses	3	6509769.5	2169923.2	2.25	2.85
Cultivar X Fertilizer	12	22384568.2	1865380.7	1.94	2.01
Error	38	36541754.7	961625.1	-	-

(C) Harvest Index (%)

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Sum of Squares	F. ratio	F. table 5%
Replication	2	5.17	2.58	1.68	3.24
Cultivar	4	1223.15	305.78	199.41	2.61
Fertilizer doses	3	50.44	16.81	10.96	2.85
Cultivar X Fertilizer	12	133.73	11.14	7.26	2.01
Error	38	58.27	1.53	-	-

ANOVA 10. Analysis of variance as influenced by cultivars, fertilizer doses and their interaction effects on production efficiency of rice during 2015.

ANALYSIS OF VARIANCE TABLE

(A) Nitrogen use efficiency

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Sum of Squares	F. ratio	F. table 5%
Replication	2	11.13	5.56	1.47	3.24
Cultivar	4	1813.75	453.43	120.15	2.61
Fertilizer doses	3	453.43	1362.32	361.00	2.85
Cultivar X Fertilizer	12	1362.32	721.48	191.18	2.01
Error	38	721.48	3.77	-	-

(B) Phosphorus use efficiency

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Sum of Squares	F. ratio	F. table 5%
Replication	2	4.56	2.28	0.58	3.24
Cultivar	4	7289.08	1822.27	465.24	2.61
Fertilizer doses	3	13514.13	4504.71	1150.09	2.85
Cultivar X Fertilizer	12	35206.86	2933.91	749.05	2.01
Error	38	148.83	3.91	-	-

(C) Potassium use efficiency

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Sum of Squares	F. ratio	F. table 5%
Replication	2	4.56	2.28	0.58	3.24
Cultivar	4	7289.08	1822.27	465.24	2.61
Fertilizer doses	3	13514.13	4504.71	1150.09	2.85
Cultivar X Fertilizer	12	35206.86	2933.91	749.05	2.01
Error	38	148.83	3.91	-	-

ANOVA 11. Analysis of variance as influenced by cultivars, fertilizer doses and their interaction effects on phenological attributes of rice

ANALYSIS OF VARIANCE TABLE

(A) Days to 50% flowering

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Sum of Squares	F. ratio	F. table 5%
Replication	2	5.20	2.60	1.15	3.24
Cultivar	4	15.56	3.89	1.73	2.61
Fertilizer doses	3	9.73	3.24	1.44	2.85
Cultivar X Fertilizer	12	156.43	13.03	5.79	2.01
Error	38	85.46	2.24	-	-

(B) Days to maturity

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Sum of Squares	F. ratio	F. table 5%
Replication	2	21.23	1.61	13.11	3.24
Cultivar	4	16.83	4.21	5.19	2.61
Fertilizer doses	3	1.78	0.59	0.73	2.85
Cultivar X Fertilizer	12	37.96	3.16	3.91	2.01
Error	38	30.76	0.81	-	-

ANOVA 12. Analysis of variance as influenced by cultivars, fertilizer doses and their interaction effects on soil nutrient status after harvest

ANALYSIS OF VARIANCE TABLE

(A)Soil pH

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Sum of Squares	F. ratio	F. table 5%
Replication	2	0.001	0.00	0.15	3.24
Cultivar	4	0.97	0.24	115.16	2.61
Fertilizer doses	3	0.03	0.01	5.43	2.85
Cultivar X Fertilizer	12	2.12	0.17	83.90	2.01
Error	38	0.08	0.002	-	-

(B) Soil Organic Carbon (%)

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Sum of Squares	F. ratio	F. table 5%
Replication	2	0.004	0.002	0.63	3.24
Cultivar	4	4.76	1.19	356.88	2.61
Fertilizer doses	3	0.49	0.16	49.06	2.85
Cultivar X Fertilizer	12	2.62	0.22	65.49	2.01
Error	38	0.13	0.003	-	-

(C) Available nitrogen (kg ha^{-1})

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Sum of Squares	F. ratio	F. table 5%
Replication	2	22.02	11.01	0.81	3.24
Cultivar	4	18354.93	4588.73	335.69	2.61
Fertilizer doses	3	3570.65	1190.21	87.07	2.85
Cultivar X Fertilizer	12	30380.22	2531.68	185.21	2.01
Error	38	519.42	13.67	-	-

(D) Available phosphorus(kg ha^{-1})

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Sum of Squares	F. ratio	F. table 5%
Replication	2	2.43	1.21	1.11	3.24
Cultivar	4	357.34	89.31	81.69	2.61
Fertilizer doses	3	63.71	21.23	19.42	2.85
Cultivar X Fertilizer	12	333.72	27.81	25.43	2.01
Error	38	41.54	1.09	-	-

(E) Available potassium (kg ha^{-1})

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Sum of Squares	F. ratio	F. table 5%
Replication	2	4.02	2.01	0.15	3.24
Cultivar	4	94566.72	23641.68	1816.42	2.61
Fertilizer doses	3	38933.57	12977.85	997.11	2.85
Cultivar X Fertilizer	12	192134.36	16011.19	1230.16	2.01
Error	38	494.58	13.01	-	-

ANOVA 13. Analysis of variance as influenced by cultivars, fertilizer doses and their interaction effects on plant nutrient uptake

ANALYSIS OF VARIANCE TABLE

(A) Nitrogen uptake (kg ha^{-1})

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Sum of Squares	F. ratio	F. table 5%
Replication	2	138.63	69.31	5.83	3.24
Cultivar	4	87.62	21.91	1.84	2.61
Fertilizer doses	3	25.83	8.61	0.73	2.85
Cultivar X Fertilizer	12	158.81	13.23	1.12	2.01
Error	38	451.10	11.87	-	-

(B) Phosphorus uptake (kg ha^{-1})

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Sum of Squares	F. ratio	F. table 5%
Replication	2	0.50	0.25	0.69	3.24
Cultivar	4	60.42	15.11	41.60	2.61
Fertilizer doses	3	40.68	13.56	37.34	2.85
Cultivar X Fertilizer	12	69.07	5.75	15.85	2.01
Error	38	13.79	0.36	-	-

(C) Potassium uptake (kg ha^{-1})

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Sum of Squares	F. ratio	F. table 5%
Replication	2	42.06	21.03	2.73	3.24
Cultivar	4	1003.54	250.88	32.53	2.61
Fertilizer doses	3	33.65	11.22	1.45	2.85
Cultivar X Fertilizer	12	1034.43	86.20	11.17	2.01
Error	38	293.04	7.71	-	-

ANOVA 14. Analysis of variance as influenced by cultivars, fertilizer doses and their interaction effects on plant height (cm) during 2016

ANALYSIS OF VARIANCE TABLE

(A) 30 DAS

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Sum of Squares	F. ratio	F. table 5%
Replication	2	1479.18	739.59	8.56	3.24
Cultivar	4	796.58	199.14	2.31	2.61
Fertilizer doses	3	556.35	185.45	2.15	2.85
Cultivar X Fertilizer	12	3151.41	262.61	3.04	2.01
Error	38	3280.25	86.32	-	-

(B) 60 DAS

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Sum of Squares	F. ratio	F. table 5%
Replication	2	582.54	291.27	1.97	3.24
Cultivar	4	1982.24	495.56	3.36	2.61
Fertilizer doses	3	2235.75	745.25	5.05	2.85
Cultivar X Fertilizer	12	15119.25	1259.93	8.54	2.01
Error	38	5603.22	147.45	-	-

(C) 90 DAS

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Sum of Squares	F. ratio	F. table 5%
Replication	2	483.80	241.90	3.70	3.24
Cultivar	4	6852.90	1713.23	26.24	2.61
Fertilizer doses	3	205.83	68.61	1.05	2.85
Cultivar X Fertilizer	12	3837.91	319.82	4.89	2.01
Error	38	2480.88	65.28	-	-

(D) At Maturity

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Sum of Squares	F. ratio	F. table 5%
Replication	2	1284.25	642.12	2.59	3.24
Cultivar	4	2823.87	705.96	2.84	2.61
Fertilizer doses	3	6898.67	2299.55	9.27	2.85
Cultivar X Fertilizer	12	33784.87	2815.41	11.35	2.01
Error	38	9422.98	247.97	-	-

ANOVA 15. Analysis of variance as influenced by cultivars, fertilizer doses and their interaction effects on plant population (m^{-2}) during 2016.

ANALYSIS OF VARIANCE TABLE

(C) 30 DAS

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Sum of Squares	F. ratio	F. table 5%
Replication	2	1958.63	979.31	1.79	3.24
Cultivar	4	537.90	134.47	0.25	2.61
Fertilizer doses	3	981.38	327.12	0.60	2.85
Cultivar X Fertilizer	12	13028.36	1085.69	1.99	2.01
Error	38	20694.70	544.59	-	-

(D) 60 DAS

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Sum of Squares	F. ratio	F. table 5%
Replication	2	141.03	70.51	0.23	3.24
Cultivar	4	1768.43	442.11	1.43	2.61
Fertilizer doses	3	1078.26	359.42	1.17	2.85
Cultivar X Fertilizer	12	6734.90	561.24	1.82	2.01
Error	38	11672.30	307.16	-	-

ANOVA 16. Analysis of variance as influenced by cultivars, fertilizer doses and their interaction effects on number of leaves plant^{-1} during 2016.

ANALYSIS OF VARIANCE TABLE

(D) 30 DAS

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Sum of Squares	F. ratio	F. table 5%
Replication	2	0.11	0.06	0.09	3.24
Cultivar	4	4.44	1.11	1.87	2.61
Fertilizer doses	3	1.25	0.42	0.71	2.85
Cultivar X Fertilizer	12	14.29	1.19	2.01	2.01
Error	38	22.54	0.59	-	-

(E) 60 DAS

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Sum of Squares	F. ratio	F. table 5%
Replication	2	0.42	0.21	1.02	3.24
Cultivar	4	0.44	0.21	0.54	2.61
Fertilizer doses	3	0.44	0.54	0.72	2.85
Cultivar X Fertilizer	12	3.01	0.72	1.22	2.01
Error	38	7.84	1.22	-	-

(F) 90 DAS

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Sum of Squares	F. ratio	F. table 5%
Replication	2	0.69	0.35	1.73	3.24
Cultivar	4	1.19	0.29	1.49	2.61
Fertilizer doses	3	0.12	0.04	0.19	2.85
Cultivar X Fertilizer	12	2.45	0.20	1.02	2.01
Error	38	7.63	0.20	-	-

ANOVA 17. Analysis of variance as influenced by cultivars, fertilizer doses and their interaction effects on number of tillers (m^{-2}) at 90 DAS during 2016.

ANALYSIS OF VARIANCE TABLE

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Sum of Squares	F. ratio	F. table 5%
Replication	2	10.03	5.02	0.65	3.24
Cultivar	4	4047.90	1011.97	130.52	2.61
Fertilizer doses	3	83.06	27.68	3.57	2.85
Cultivar X Fertilizer	12	828.10	69.01	8.90	2.01
Error	38	294.63	7.75	-	-

ANOVA 18. Analysis of variance as influenced by cultivars, fertilizer doses and their interaction effects on Crop Growth Rate (g m^{-2} day^{-1}) during 2016.

ANALYSIS OF VARIANCE TABLE

(C) 30 DAS

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Sum of Squares	F. ratio	F. table 5%
Replication	2	16.07	8.04	1.38	3.24
Cultivar	4	291.34	72.83	12.53	2.61
Fertilizer doses	3	68.31	22.77	3.92	2.85
Cultivar X Fertilizer	12	145.92	12.16	2.09	2.01
Error	38	220.84	5.81	-	-

(D) 60 DAS

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Sum of Squares	F. ratio	F. table 5%
Replication	2	0.41	0.20	1.55	3.24
Cultivar	4	0.75	0.18	1.43	2.61
Fertilizer doses	3	1.03	0.34	2.62	2.85
Cultivar X Fertilizer	12	3.62	0.30	2.31	2.01
Error	38	4.97	0.13	-	-

ANOVA 19. Analysis of variance as influenced by cultivars, fertilizer doses and their interaction effects on Relative Growth Rate (g g^{-1} day^{-1}) during 2016.

ANALYSIS OF VARIANCE TABLE

(C) 30 DAS

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Sum of Squares	F. ratio	F. table 5%
Replication	2	0.00	0.00	0.41	3.24
Cultivar	4	0.00	0.00	8.43	2.61
Fertilizer doses	3	0.00	0.00	10.98	2.85
Cultivar X Fertilizer	12	0.00	0.00	3.43	2.01
Error	38	0.00	0.00	-	-

(D) 60 DAS

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Sum of Squares	F. ratio	F. table 5%
Replication	2	0.00	0.00	0.71	3.24
Cultivar	4	0.00	0.00	3.81	2.61
Fertilizer doses	3	0.00	0.00	1.03	2.85
Cultivar X Fertilizer	12	0.00	0.00	8.19	2.01
Error	38	0.00	0.00	-	-

ANOVA 20. Analysis of variance as influenced by cultivars, fertilizer doses and their interaction effects on Leaf Area Index (%) during 2016.

ANALYSIS OF VARIANCE TABLE

(C) 30 DAS

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Sum of Squares	F. ratio	F. table 5%
Replication	2	0.002	0.00	1.11	3.24
Cultivar	4	0.13	0.00	4.40	2.61
Fertilizer doses	3	0.00	0.00	0.49	2.85
Cultivar X Fertilizer	12	0.11	0.01	12.15	2.01
Error	38	0.03	0.001	-	-

(D) 60 DAS

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Sum of Squares	F. ratio	F. table 5%
Replication	2	0.00	0.00	0.45	3.24
Cultivar	4	0.09	0.02	42.75	2.61
Fertilizer doses	3	0.00	0.00	2.34	2.85
Cultivar X Fertilizer	12	0.02	0.00	3.62	2.01
Error	38	0.02	0.001	-	-

ANOVA 21. Analysis of variance as influenced by cultivars, fertilizer doses and their interaction effects on yield attributes of rice during 2016

(G) Number of panicles m^{-2}

ANALYSIS OF VARIANCE TABLE

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Sum of Squares	F. ratio	F. table 5%
Replication	2	22.08	12.54	5.97	3.24
Cultivar	4	17.75	4.44	2.11	2.61
Fertilizer doses	3	6.36	2.12	1.01	2.85
Cultivar X Fertilizer	12	130.77	10.89	5.19	2.01
Error	38	79.75	2.09	-	-

(H) Length of panicle (cm)

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Sum of Squares	F. ratio	F. table 5%
Replication	2	7.70	3.85	1.02	3.24
Cultivar	4	20.84	5.21	1.38	2.61
Fertilizer doses	3	31.06	10.35	2.74	2.85
Cultivar X Fertilizer	12	216.10	18.01	4.77	2.01
Error	38	143.37	3.77	-	-

(I) Weight of panicle (g)

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Sum of Squares	F. ratio	F. table 5%
Replication	2	0.46	0.23	0.83	3.24
Cultivar	4	16.77	4.19	15.07	2.61
Fertilizer doses	3	22.18	7.39	26.59	2.85
Cultivar X Fertilizer	12	72.59	6.04	21.75	2.01
Error	38	10.56	0.27	-	-

(J) Number of grains $panicle^{-1}$

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Sum of Squares	F. ratio	F. table 5%
Replication	2	1077.17	538.58	0.87	3.24
Cultivar	4	8802.45	2200.61	3.56	2.61
Fertilizer doses	3	2043.69	681.23	1.10	2.85
Cultivar X Fertilizer	12	58426.54	4868.87	7.87	2.01
Error	38	23491.64	618.20	-	-

(K) Filled grain percent (%)

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Sum of Squares	F. ratio	F. table 5%
Replication	2	40.87	20.44	0.97	3.24
Cultivar	4	135.14	33.78	1.62	2.61
Fertilizer doses	3	28.94	9.64	0.46	2.85
Cultivar X Fertilizer	12	967.23	80.60	3.85	2.01
Error	38	793.67	20.88	-	-

(L) Test weight (g)

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Sum of Squares	F. ratio	F. table 5%
Replication	2	1.39	0.70	1.23	3.24
Cultivar	4	14.38	3.59	6.35	2.61
Fertilizer doses	3	7.17	2.39	4.22	2.85
Cultivar X Fertilizer	12	68.21	5.68	10.04	2.01
Error	38	21.51	0.56	-	-

ANOVA 22. Analysis of variance as influenced by cultivars, fertilizer doses and their interaction effects on yield of rice (kg ha^{-1}).

ANALYSIS OF VARIANCE TABLE

(D) Grain yield (kg ha^{-1})

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Sum of Squares	F. ratio	F. table 5%
Replication	2	871969.5	435984.7	2.15	3.24
Cultivar	4	6737359.9	1684339.9	8.32	2.61
Fertilizer doses	3	5933265.2	1977755.1	9.76	2.85
Cultivar X Fertilizer	12	14065913.9	1172159.5	5.78	2.01
Error	38	7695070.4	202501.8	-	-

(E) Straw yield (kg ha^{-1})

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Sum of Squares	F. ratio	F. table 5%
Replication	2	467303.4	233651.7	0.12	3.24
Cultivar	4	2915429.7	728857.4	0.37	2.61
Fertilizer doses	3	9616982.1	3205660.7	1.66	2.85
Cultivar X Fertilizer	12	30276806.3	2523067.2	1.31	2.01
Error	38	73043240.8	1922190.5	-	-

(F) Harvest Index (%)

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Sum of Squares	F. ratio	F. table 5%
Replication	2	61.15	30.57	1.28	3.24
Cultivar	4	455.85	113.96	4.78	2.61
Fertilizer doses	3	126.52	42.17	1.77	2.85
Cultivar X Fertilizer	12	1794.88	149.57	6.28	2.01
Error	38	904.28	23.79	-	-

ANOVA 23. Analysis of variance as influenced by cultivars, fertilizer doses and their interaction effects on production efficiency of rice during 2016.

ANALYSIS OF VARIANCE TABLE

(A) Nitrogen use efficiency

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Sum of Squares	F. ratio	F. table 5%
Replication	2	0.34	0.17	0.06	3.24
Cultivar	4	2107.07	526.76	173.84	2.61
Fertilizer doses	3	777.06	259.02	85.48	2.85
Cultivar X Fertilizer	12	16791.01	1399.25	461.77	2.01
Error	38	115.14	3.03	-	-

(B) Phosphorus use efficiency

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Sum of Squares	F. ratio	F. table 5%
Replication	2	0.16	0.08	0.02	3.24
Cultivar	4	5587.99	1397.00	492.01	2.61
Fertilizer doses	3	19547.86	6515.95	2294.90	2.85
Cultivar X Fertilizer	12	65862.95	5488.58	1933.00	2.01
Error	38	17.89	2.84	-	-

(C) Potassium use efficiency

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Sum of Squares	F. ratio	F. table 5%
Replication	2	0.16	0.08	0.02	3.24
Cultivar	4	5587.99	1397.00	492.01	2.61
Fertilizer doses	3	19547.86	6515.95	2294.90	2.85
Cultivar X Fertilizer	12	65862.95	5488.58	1933.00	2.01
Error	38	107.89	2.84	-	-

ANOVA 24. Analysis of variance as influenced by cultivars, fertilizer doses and their interaction effects on phenological attributes of rice

ANALYSIS OF VARIANCE TABLE

(D) Days to 50% flowering

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Sum of Squares	F. ratio	F. table 5%
Replication	2	1.20	0.60	0.26	3.24
Cultivar	4	24.67	6.16	2.74	2.61
Fertilizer doses	3	28.40	9.46	4.21	2.85
Cultivar X Fertilizer	12	118.26	9.85	4.38	2.01
Error	38	85.46	2.24	-	-

(E) Days to maturity

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Sum of Squares	F. ratio	F. table 5%
Replication	2	0.23	0.12	0.10	3.24
Cultivar	4	8.10	2.02	1.73	2.61
Fertilizer doses	3	19.60	6.53	5.58	2.85
Cultivar X Fertilizer	12	18.56	1.55	1.32	2.01
Error	38	44.43	1.16	-	-

ANOVA 25. Analysis of variance as influenced by cultivars, fertilizer doses and their interaction effects on soil nutrient status after harvest

ANALYSIS OF VARIANCE TABLE

(A)Soil pH

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Sum of Squares	F. ratio	F. table 5%
Replication	2	0.15	0.07	4.21	3.24
Cultivar	4	0.66	0.16	9.07	2.61
Fertilizer doses	3	0.05	0.02	0.93	2.85
Cultivar X Fertilizer	12	2.19	0.18	10.07	2.01
Error	38	0.69	0.02	-	-

(B) Soil Organic Carbon (%)

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Sum of Squares	F. ratio	F. table 5%
Replication	2	0.03	0.01	0.77	3.24
Cultivar	4	0.25	0.06	3.32	2.61
Fertilizer doses	3	0.56	0.18	10.19	2.85
Cultivar X Fertilizer	12	2.36	0.19	10.61	2.01
Error	38	0.70	0.02	-	-

(F) Available nitrogen (kg ha^{-1})

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Sum of Squares	F. ratio	F. table 5%
Replication	2	256.57	128.28	0.60	3.24
Cultivar	4	2658.89	664.72	3.12	2.61
Fertilizer doses	3	1455.80	485.26	2.28	2.85
Cultivar X Fertilizer	12	25671.22	2139.26	10.05	2.01
Error	38	8081.25	212.66	-	-

(D) Available phosphorus(kg ha^{-1})

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Sum of Squares	F. ratio	F. table 5%
Replication	2	4.17	2.08	0.37	3.24
Cultivar	4	592.55	148.13	26.86	2.61
Fertilizer doses	3	124.59	41.53	7.53	2.85
Cultivar X Fertilizer	12	314.87	26.23	4.75	2.01
Error	38	209.52	5.514	-	-

(E) Available potassium (kg ha^{-1})

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Sum of Squares	F. ratio	F. table 5%
Replication	2	3396.99	1698.49	2.88	3.24
Cultivar	4	37954.34	9488.58	16.08	2.61
Fertilizer doses	3	17023.96	5674.65	9.62	2.85
Cultivar X Fertilizer	12	35364.75	2974.06	4.99	2.01
Error	38	22413.28	589.82	-	-

ANOVA 26. Analysis of variance as influenced by cultivars, fertilizer doses and their interaction effects on plant nutrient uptake

ANALYSIS OF VARIANCE TABLE

(D) Nitrogen uptake (kg ha^{-1})

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Sum of Squares	F. ratio	F. table 5%
Replication	2	11.77	5.88	0.63	3.24
Cultivar	4	159.37	39.76	4.30	2.61
Fertilizer doses	3	56.31	18.77	2.03	2.85
Cultivar X Fertilizer	12	292.00	24.33	2.63	2.01
Error	38	351.23	9.24	-	-

(B) Phosphorus uptake (kg ha^{-1})

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Sum of Squares	F. ratio	F. table 5%
Replication	2	1.51	0.75	2.36	3.24
Cultivar	4	2.91	5.22	16.35	2.61
Fertilizer doses	3	6.83	2.27	7.12	2.85
Cultivar X Fertilizer	12	80.08	6.67	20.87	2.01
Error	38	12.15	0.32	-	-

(F) Potassium uptake (kg ha^{-1})

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Sum of Squares	F. ratio	F. table 5%
Replication	2	12.86	6.43	0.75	3.24
Cultivar	4	298.97	74.74	8.76	2.61
Fertilizer doses	3	46.72	15.57	1.82	2.85
Cultivar X Fertilizer	12	1750.32	145.86	17.09	2.01
Error	38	324.19	8.53	-	-

ANOVA 27. Pooled analysis of variance as influenced by cultivars, fertilizer doses and their interaction effects on plant height (cm).

ANALYSIS OF VARIANCE TABLE

(A) 30 DAS

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Sum of Squares	F. ratio	F. table 5%
Replication	4	1390.15	347.53	7.67	2.49
Cultivar	4	1828.20	457.05	10.08	2.49
Fertilizer doses	3	865.23	288.40	6.36	2.72
Cultivar X Fertilizer	12	5721.17	476.76	10.52	1.88
Error	76	3442.906	45.30	-	-

(B) 60 DAS

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Sum of Squares	F. ratio	F. table 5%
Replication	4	3098.21	774.55	17.09	2.49
Cultivar	4	4809.62	1202.40	26.54	2.49
Fertilizer doses	3	887.36	295.78	6.52	2.72
Cultivar X Fertilizer	12	17048.77	1420.73	31.36	1.88
Error	76	12574.98	165.46	-	-

(C) 90 DAS

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Sum of Squares	F. ratio	F. table 5%
Replication	4	485.87	121.46	2.68	2.49
Cultivar	4	3628.75	907.18	20.02	2.49
Fertilizer doses	3	975.36	325.12	7.17	2.72
Cultivar X Fertilizer	12	10336.54	861.37	9.01	1.88
Error	76	5915.67	77.83	-	-

(D) At Maturity

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Sum of Squares	F. ratio	F. table 5%
Replication	4	2234.57	558.64	12.33	2.49
Cultivar	4	5960.49	1490.12	32.89	2.49
Fertilizer doses	3	14208.37	4736.12	104.54	2.72
Cultivar X Fertilizer	12	67183.38	5598.61	123.58	1.88
Error	76	19436.23	255.774	-	-

ANOVA 28. Pooled analysis of variance as influenced by cultivars, fertilizer doses and their interaction effects on plant population (m^{-2}).

ANALYSIS OF VARIANCE TABLE

(A) 30 DAS

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Sum of Squares	F. ratio	F. table 5%
Replication	4	3245.76	811.44	1.66	2.49
Cultivar	4	3919.63	979.90	2.00	2.49
Fertilizer doses	3	1140.89	380.29	0.77	2.72
Cultivar X Fertilizer	12	16188.56	1349.04	2.76	1.88
Error	76	37089.56	488.02	-	-

(B) 60 DAS

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Sum of Squares	F. ratio	F. table 5%
Replication	4	11912.96	2978.24	6.10	2.49
Cultivar	4	7310.25	1827.56	3.74	2.49
Fertilizer doses	3	4574.09	1524.69	3.12	2.72
Cultivar X Fertilizer	12	17223.61	1435.30	2.94	1.88
Error	76	36079.03	474.72	-	-

ANOVA 29. Pooled analysis of variance as influenced by cultivars, fertilizer doses and their interaction effects on number of leaves plant^{-1}.

ANALYSIS OF VARIANCE TABLE

(A) 30 DAS

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Sum of Squares	F. ratio	F. table 5%
Replication	4	4.79	1.19	3.38	2.49
Cultivar	4	7.19	1.79	5.08	2.49
Fertilizer doses	3	2.29	0.76	2.16	2.72
Cultivar X Fertilizer	12	15.54	1.29	3.66	1.88
Error	76	26.88	0.35	-	-

(B) 60 DAS

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Sum of Squares	F. ratio	F. table 5%
Replication	4	1.44	0.36	1.02	2.49
Cultivar	4	0.38	0.09	0.27	2.49
Fertilizer doses	3	1.94	0.64	1.83	2.72
Cultivar X Fertilizer	12	3.97	0.33	0.93	1.88
Error	76	22.45	0.29	-	-

(C) 90 DAS

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Sum of Squares	F. ratio	F. table 5%
Replication	4	1.33	0.33	0.94	2.49
Cultivar	4	1.08	0.27	0.76	2.49
Fertilizer doses	3	0.17	0.06	0.16	2.72
Cultivar X Fertilizer	12	1.90	0.16	0.44	1.88
Error	76	13.74	0.18	-	-

ANOVA 30. Pooled analysis of variance as influenced by cultivars, fertilizer doses and their interaction effects on number of tillers (m^{-2}) at 90 DAS.

ANALYSIS OF VARIANCE TABLE

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Sum of Squares	F. ratio	F. table 5%
Replication	4	35.23	8.08	0.01	2.49
Cultivar	4	6759.83	1689.95	3.46	2.49
Fertilizer doses	3	121.43	40.47	0.08	2.72
Cultivar X Fertilizer	12	595.23	49.60	0.10	1.88
Error	76	447.43	5.88	-	-

ANOVA 31. Pooled analysis of variance as influenced by cultivars, fertilizer doses and their interaction effects on Crop Growth Rate (g m^{-2} day^{-1}).

ANALYSIS OF VARIANCE TABLE

(A) 30 DAS

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Sum of Squares	F. ratio	F. table 5%
Replication	4	0.41	0.10	0.02	2.49
Cultivar	4	0.66	0.16	0.03	2.49
Fertilizer doses	3	1.34	0.44	0.09	2.72
Cultivar X Fertilizer	12	2.07	0.17	0.04	1.88
Error	76	6.42	0.08	-	-

(B) 60 DAS

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Sum of Squares	F. ratio	F. table 5%
Replication	4	34.26	8.56	1.89	2.49
Cultivar	4	543.62	135.90	30.08	2.49
Fertilizer doses	3	65.93	21.98	4.86	2.72
Cultivar X Fertilizer	12	467.66	38.97	8.62	1.88
Error	76	343.35	4.51	-	-

ANOVA 32. Pooled analysis of variance as influenced by cultivars, fertilizer doses and their interaction effects on Relative Growth Rate (g g^{-1} day^{-1}).

ANALYSIS OF VARIANCE TABLE

(A) 30 DAS

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Sum of Squares	F. ratio	F. table 5%
Replication	4	0.00	0.00	0.00	2.49
Cultivar	4	0.00	0.00	0.00	2.49
Fertilizer doses	3	0.00	0.00	0.00	2.72
Cultivar X Fertilizer	12	0.00	0.00	0.00	1.88
Error	76	0.00	0.00	-	-

(B) 60 DAS

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Sum of Squares	F. ratio	F. table 5%
Replication	4	0.00	0.00	0.00	2.49
Cultivar	4	0.00	0.00	0.00	2.49
Fertilizer doses	3	0.00	0.00	0.00	2.72
Cultivar X Fertilizer	12	0.00	0.00	0.00	1.88
Error	76	0.00	0.00	-	-

ANOVA 33. Pooled analysis of variance as influenced by cultivars, fertilizer doses and their interaction effects on Leaf Area Index (%).

ANALYSIS OF VARIANCE TABLE

(A) 30 DAS

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Sum of Squares	F. ratio	F. table 5%
Replication	4	0.03	0.01	0.00	2.49
Cultivar	4	0.07	0.02	0.00	2.49
Fertilizer doses	3	0.02	0.01	0.00	2.72
Cultivar X Fertilizer	12	0.13	0.01	0.00	1.88
Error	76	0.24	0.01	-	-

(B) 60 DAS

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Sum of Squares	F. ratio	F. table 5%
Replication	4	0.00	0.00	0.00	2.49
Cultivar	4	0.15	0.04	0.01	2.49
Fertilizer doses	3	0.01	0.00	0.00	2.72
Cultivar X Fertilizer	12	0.06	0.00	0.00	1.88
Error	76	0.03	0.00	-	-

ANOVA 34. Pooled analysis of variance as influenced by cultivars, fertilizer doses and their interaction effects on yield attributes of rice during 2015

ANALYSIS OF VARIANCE TABLE

(A) Number of panicles m^{-2}

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Sum of Squares	F. ratio	F. table 5%
Replication	4	27.31	6.83	1.81	2.49
Cultivar	4	61.30	15.32	4.06	2.49
Fertilizer doses	3	6.73	2.24	0.59	2.72
Cultivar X Fertilizer	12	159.49	13.28	3.52	1.88
Error	76	286.22	3.76	-	-

(B) Length of panicle (cm)

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Sum of Squares	F. ratio	F. table 5%
Replication	4	49.33	12.33	3.27	2.49
Cultivar	4	51.35	12.83	3.40	2.49
Fertilizer doses	3	41.82	13.94	3.70	2.72
Cultivar X Fertilizer	12	152.25	12.68	3.36	1.88
Error	76	267.07	3.51	-	-

(C) Weight of panicle (g)

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Sum of Squares	F. ratio	F. table 5%
Replication	4	5.34	1.33	0.35	2.49
Cultivar	4	9.59	2.39	0.63	2.49
Fertilizer doses	3	53.24	17.74	4.71	2.72
Cultivar X Fertilizer	12	110.35	9.19	2.44	1.88
Error	76	64.30	0.84	-	-

(D) Number of grains $panicle^{-1}$

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Sum of Squares	F. ratio	F. table 5%
Replication	4	1135.63	283.90	0.48	2.49
Cultivar	4	21290.55	5322.63	9.06	2.49
Fertilizer doses	3	6263.61	2087.87	3.55	2.72
Cultivar X Fertilizer	12	65121.48	5426.79	9.24	1.88
Error	76	44628.08	587.21	-	-

(E) Filled grain percent (%)

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Sum of Squares	F. ratio	F. table 5%
Replication	4	97.79	24.45	1.67	2.49
Cultivar	4	333.31	83.32	5.69	2.49
Fertilizer doses	3	264.74	88.24	6.03	2.72
Cultivar X Fertilizer	12	1507.35	125.61	8.58	1.88
Error	76	1111.51	14.62	-	-

(F) Test weight (g)

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Sum of Squares	F. ratio	F. table 5%
Replication	4	1.59	0.39	0.62	2.49
Cultivar	4	17.03	4.25	6.71	2.49
Fertilizer doses	3	12.99	4.33	6.83	2.72
Cultivar X Fertilizer	12	135.35	11.27	2.93	1.88
Error	76	48.20	0.63	-	-

ANOVA 35. Pooled analysis of variance as influenced by cultivars, fertilizer doses and their interaction effects on yield of rice (kg ha^{-1}).

ANALYSIS OF VARIANCE TABLE

(A) Grain yield (kg ha^{-1})

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Sum of Squares	F. ratio	F. table 5%
Replication	4	161945.99	40486.49	1.95	2.49
Cultivar	4	41044664.98	10261166.24	495.23	2.49
Fertilizer doses	3	12984973.41	4328324.47	208.89	2.72
Cultivar X Fertilizer	12	4743616.81	395301.40	19.07	1.88
Error	76	1574697.80	2719.71	-	-

(B) Straw yield (kg ha^{-1})

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Sum of Squares	F. ratio	F. table 5%
Replication	4	1200114.2	2550028.53	1.95	2.49
Cultivar	4	16844977.4	4211244.35	3.22	2.49
Fertilizer doses	3	10083114.5	3361038.15	2.57	2.72
Cultivar X Fertilizer	12	15339899.5	1278324.96	0.97	1.88
Error	76	99381674.85	1307653.62	-	-

(C) Harvest Index (%)

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Sum of Squares	F. ratio	F. table 5%
Replication	4	6.50	1.62	1.52	2.49
Cultivar	4	3077.09	769.27	720.84	2.49
Fertilizer doses	3	125.14	41.71	39.08	2.72
Cultivar X Fertilizer	12	138.54	11.54	14.73	1.88
Error	76	81.10	1.06	-	-

ANOVA 36. Pooled analysis of variance as influenced by cultivars, fertilizer doses and their interaction effects on production efficiency of rice during 2015 and 2016.

ANALYSIS OF VARIANCE TABLE

(A) Nitrogen use efficiency

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Sum of Squares	F. ratio	F. table 5%
Replication	4	5.69	1.42	0.00	2.49
Cultivar	4	2081.11	520.27	0.77	2.49
Fertilizer doses	3	2653.08	884.36	1.31	2.72
Cultivar X Fertilizer	12	21822.35	1818.52	2.70	1.88
Error	76	268.23	3.52	-	-

(B) Phosphorus use efficiency

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Sum of Squares	F. ratio	F. table 5%
Replication	4	4.72	1.18	0.00	2.49
Cultivar	4	6152.74	1538.18	2.29	2.49
Fertilizer doses	3	20910.18	6970.06	10.38	2.72
Cultivar X Fertilizer	12	82439.24	6869.93	10.23	1.88
Error	76	256.73	3.37	-	-

(C) Potassium use efficiency

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Sum of Squares	F. ratio	F. table 5%
Replication	4	4.72	1.18	0.00	2.49
Cultivar	4	6152.74	1538.18	2.29	2.49
Fertilizer doses	3	20910.18	6970.06	10.38	2.72
Cultivar X Fertilizer	12	82439.24	6869.93	10.23	1.88
Error	76	256.73	3.37	-	-

ANOVA 37. Pooled analysis of variance as influenced by cultivars, fertilizer doses and their interaction effects on phenological attributes of rice during 2015 and 2016.

ANALYSIS OF VARIANCE TABLE

(A) Days to 50% flowering

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Sum of Squares	F. ratio	F. table 5%
Replication	4	6.40	1.60	0.71	2.49
Cultivar	4	24.78	6.19	2.75	2.49
Fertilizer doses	3	22.46	7.48	3.32	2.72
Cultivar X Fertilizer	12	221.61	18.46	8.21	1.88
Error	76	170.93	2.24	-	-

(B) Days to maturity

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Sum of Squares	F. ratio	F. table 5%
Replication	4	21.46	5.36	5.42	2.49
Cultivar	4	10.88	2.72	2.74	2.49
Fertilizer doses	3	8.49	2.83	2.86	2.72
Cultivar X Fertilizer	12	31.38	2.61	2.64	1.88
Error	76	75.20	2.11	-	-

ANOVA 38. Pooled analysis of variance as influenced by cultivars, fertilizer doses and their interaction effects on soil nutrient status after harvest during 2015 and 2016

ANALYSIS OF VARIANCE TABLE

(A)Soil pH

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Sum of Squares	F. ratio	F. table 5%
Replication	4	0.15	0.03	3.78	2.49
Cultivar	4	1.52	0.38	37.61	2.49
Fertilizer doses	3	0.06	0.02	2.13	2.72
Cultivar X Fertilizer	12	3.86	0.32	31.71	1.88
Error	76	0.77	0.01	-	-

(B) Soil Organic Carbon (%)

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Sum of Squares	F. ratio	F. table 5%
Replication	4	0.03	0.01	0.81	2.49
Cultivar	4	2.92	0.73	72.12	2.49
Fertilizer doses	3	0.01	0.01	0.44	2.72
Cultivar X Fertilizer	12	3.42	0.28	28.11	1.88
Error	76	0.83	0.01	-	-

(C) Available nitrogen (kg ha^{-1})

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Sum of Squares	F. ratio	F. table 5%
Replication	4	4202.64	1050.66	1.56	2.49
Cultivar	4	8664.37	2166.09	3.22	2.49
Fertilizer doses	3	4753.78	1584.59	2.36	2.72
Cultivar X Fertilizer	12	66829.39	5569.12	2.10	1.88
Error	76	51028.52	671.42	-	-

(D) Available phosphorus(kg ha^{-1})

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Sum of Squares	F. ratio	F. table 5%
Replication	4	6.60	1.65	0.00	2.49
Cultivar	4	770.57	192.51	0.28	2.49
Fertilizer doses	3	118.07	39.35	0.05	2.72
Cultivar X Fertilizer	12	437.09	36.42	0.05	1.88
Error	76	251.06	3.30	-	-

(E) Available potassium (kg ha^{-1})

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Sum of Squares	F. ratio	F. table 5%
Replication	4	27911.89	6977.97	1.39	2.49
Cultivar	4	76691.52	19172.88	28.55	2.49
Fertilizer doses	3	13209.80	4403.26	6.55	2.72
Cultivar X Fertilizer	12	185681.29	15473.44	23.04	1.88
Error	76	704.99	927.62	-	-

ANOVA 39. Pooled analysis of variance as influenced by cultivars, fertilizer doses and their interaction effects on plant nutrient uptake during 2015 and 2016

ANALYSIS OF VARIANCE TABLE

(A) Nitrogen uptake (kg ha^{-1})

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Sum of Squares	F. ratio	F. table 5%
Replication	4	150.41	37.60	3.56	2.49
Cultivar	4	203.70	50.92	4.82	2.49
Fertilizer doses	3	35.23	11.74	1.11	2.72
Cultivar X Fertilizer	12	300.23	25.02	2.37	1.88
Error	76	802.33	10.55	-	-

(B) Phosphorus uptake (kg ha^{-1})

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Sum of Squares	F. ratio	F. table 5%
Replication	4	2.01	0.50	0.04	2.49
Cultivar	4	74.33	18.58	1.76	2.49
Fertilizer doses	3	39.00	13.00	1.23	2.72
Cultivar X Fertilizer	12	131.70	10.97	1.03	1.88
Error	76	25.95	0.34	-	-

(C)Potassium uptake (kg ha^{-1})

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Sum of Squares	F. ratio	F. table 5%
Replication	4	54.93	13.73	2.49	2.49
Cultivar	4	1189.78	297.44	2.49	2.49
Fertilizer doses	3	76.75	25.58	2.72	2.72
Cultivar X Fertilizer	12	2532.93	211.07	19.99	1.88
Error	76	617.23	8.12	-	-

APPENDIX – I

Cost of cultivation (₹ ha^{-1})

(A) Common cost of cultivation				
Sl. no	**Items**	**No. of units**	**Rate (₹ ha^{-1})**	**Total (₹ ha^{-1})**
1.	Field preparation			
	Summer ploughing twice by tractor	2	1500	3000
	Levelling seed bed preparation	5	200	1000
2.	Seeds			
	a. Local cultivars	80	15	1200
	b. Improved variety	80	18	1440
3.	Furrow opening and sowing	30	200	6000
4.	Application of manures and fertilizers	10	200	2000
5.	Thinning and weeding	15	200	3000
6.	Plant protection	-	-	1000
7.	Chemical application	5	200	1000
8.	Harvesting, threshing and winnowing	10	200	2000
9.	Drying	5	200	1000
10.	Miscellaneous	-	-	500
TOTAL				23140

(B) Cost of variable inputs				
Sl. no	**Inputs**	**Quantity ha^{-1}**	**Rate (₹ ha^{-1})**	**Total (₹ ha^{-1})**
F_1	a) Urea	30 kg ha^{-1}	10	300
	b) SSP	15 kg ha^{-1}	15	225
	c) MOP	15 kg ha^{-1}	25	375
	d) FYM	10 t ha^{-1}	500	5000
TOTAL				5900
F_1	e) Urea	60 kg ha^{-1}	10	600
	f) SSP	30 kg ha^{-1}	15	450
	g) MOP	30 kg ha^{-1}	25	750
	h) FYM	10 t ha^{-1}	500	5000
TOTAL				6800
F_1	i) Urea	90 kg ha^{-1}	10	900
	j) SSP	45 kg ha^{-1}	15	675
	k) MOP	45 kg ha^{-1}	25	1125
	l) FYM	10 t ha^{-1}	500	5000
TOTAL				7700

APPENDIX – II

Cost of cultivation (₹ ha^{-1})

(A) Common cost of cultivation				
Sl. no	**Items**	**No. of units**	**Rate (₹ ha^{-1})**	**Total (₹ ha^{-1})**
1.	Field preparation			
	Summer ploughing twice by tractor	2	1500	3000
	Levelling seed bed preparation	5	200	1000
2.	Seeds			
	a. Local cultivars	80	15	1200
	b. Improved variety	80	18	1440
3.	Furrow opening and sowing	30	200	6000
4.	Application of manures and fertilizers	10	200	2000
5.	Thinning and weeding	15	200	3000
6.	Plant protection	-	-	1000
7.	Chemical application	5	200	1000
8.	Harvesting, threshing and winnowing	10	200	2000
9.	Drying	5	200	1000
10.	Miscellaneous	-	-	500
TOTAL				23140

(B) Cost of variable inputs				
Sl. no	**Inputs**	**Quantity ha^{-1} (kg ha^{-1})**	**Rate (₹ ha^{-1})**	**Total (₹ ha^{-1})**
F_1	a) Urea	30	10	300
	b) SSP	15	15	225
	c) MOP	15	25	375
	d) FYM	10	500	5000
TOTAL				5900
F_1	e) Urea	60	10	600
	f) SSP	30	15	450
	g) MOP	30	25	750
	h) FYM	10	500	5000
TOTAL				6800
F_1	i) Urea	90	10	900
	j) SSP	45	15	675
	k) MOP	45	25	1125
	l) FYM	10	500	5000
TOTAL				7700

(C) **Common cost of cultivation**	
Cost of local seed, 80 kg @ ₹ 15 kg^{-1}	₹ 1200
Cost of improved dwarf seed, 80 kg @ ₹ 20 kg^{-1}	₹ 6000
Cost of land preparation by 15 man days @ ₹200 man^{-1}	₹ 3000
Cost of sowing by 10 men @ ₹200 man^{-1}	₹ 2000
Intercultural operation, 3 times by 10 men @ ₹ 200 man^{-1}	₹ 6000
Cost of plant protection measures	₹ 2000
Cost of harvesting by 10 men @ ₹ 200 man^{-1}	₹ 2000
Miscellaneous	₹ 2000
Total	₹ 24,200

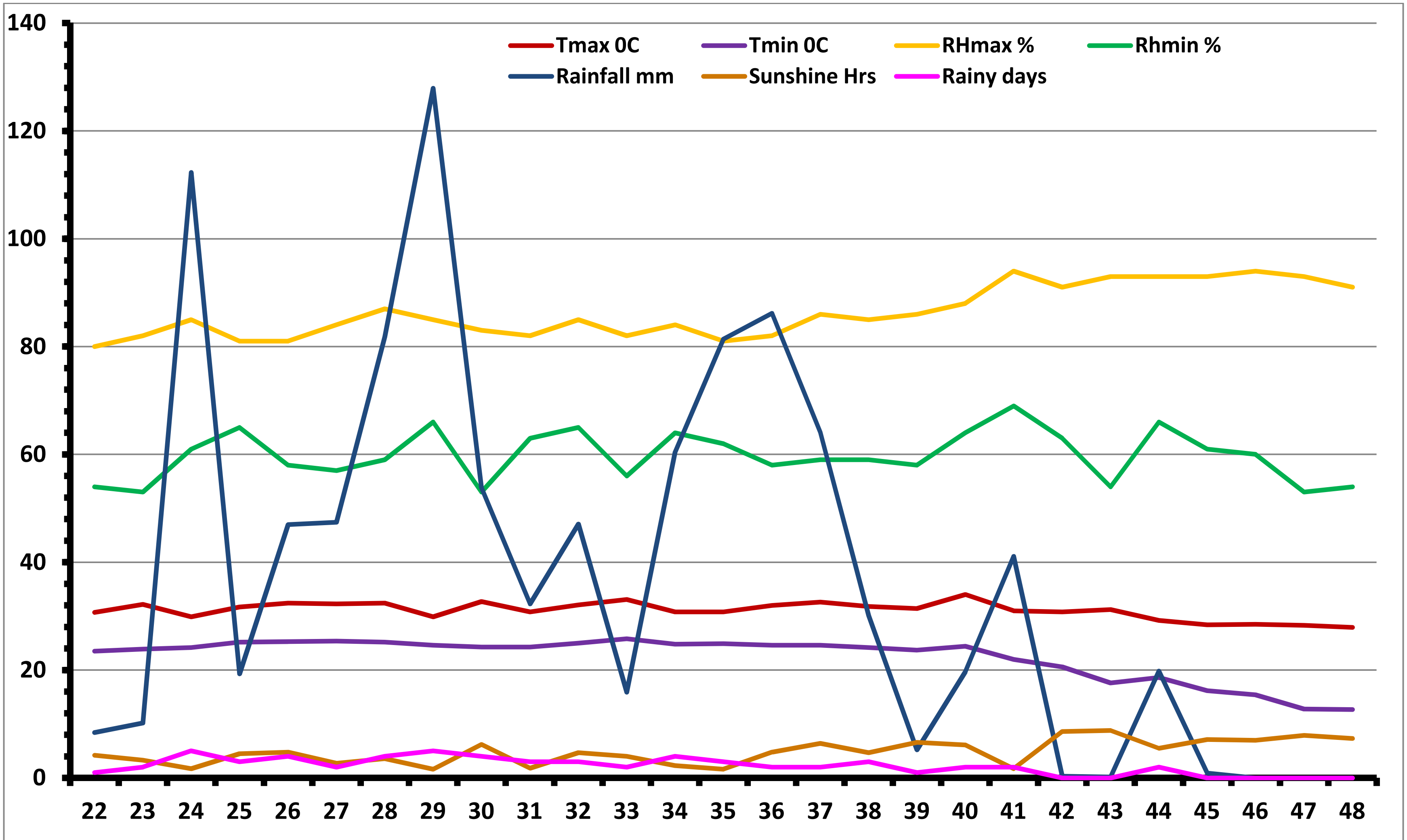


Fig 1. Meteorological data during the period of investigation (2015)

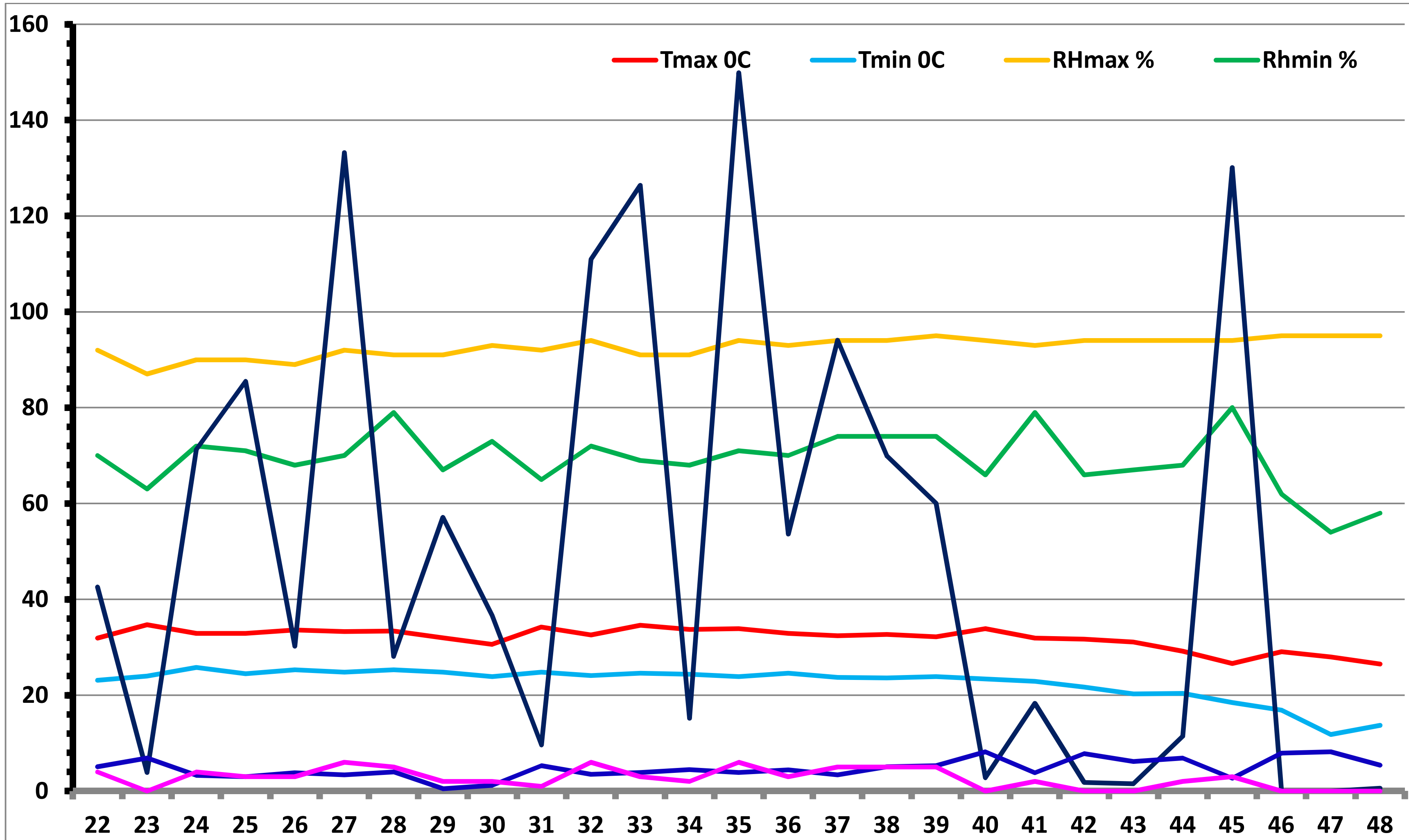
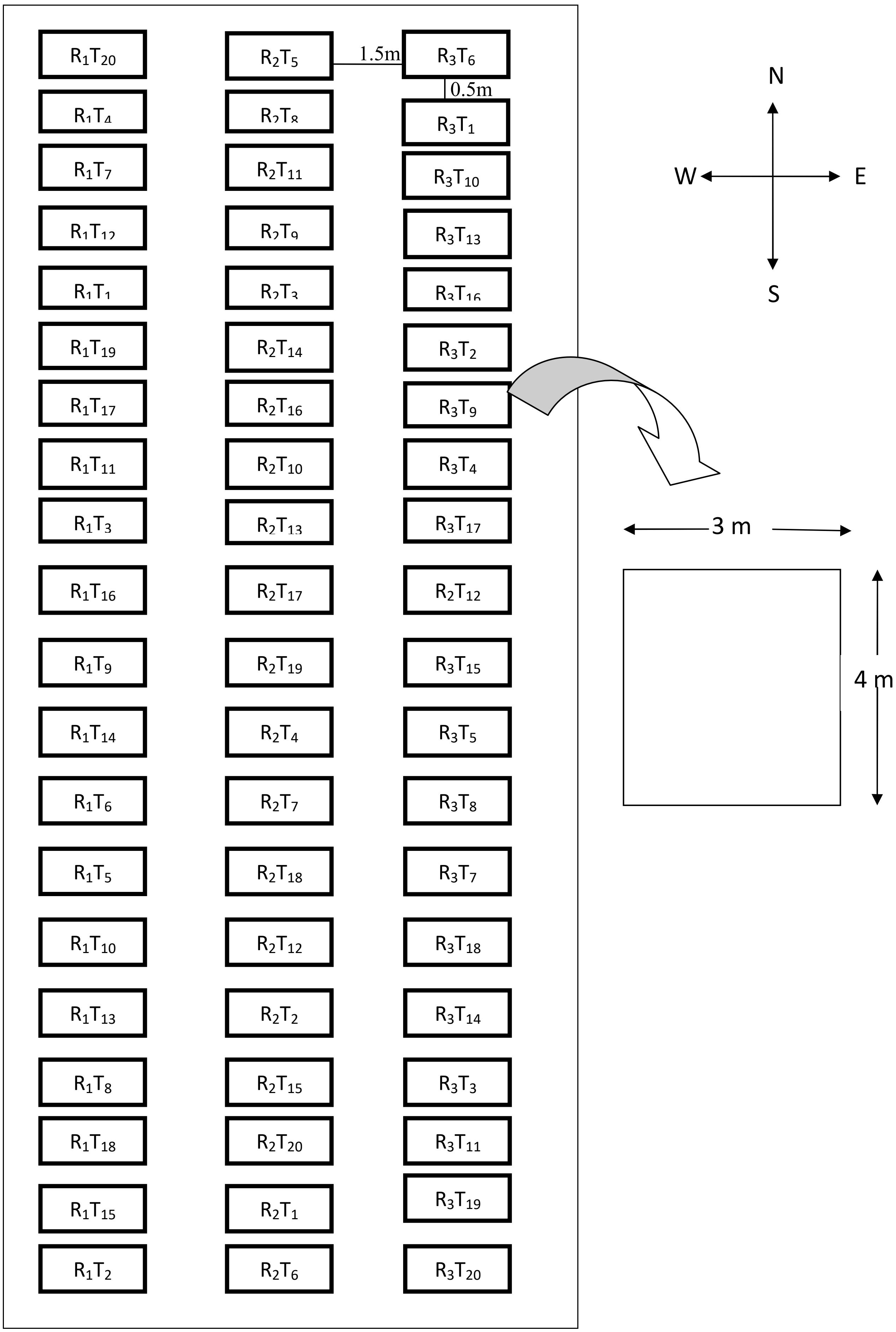


Fig 2. Meteorological data during the period of investigation (2016)

Fig. 3: Farm layout of the experiment in Randomized Block Design



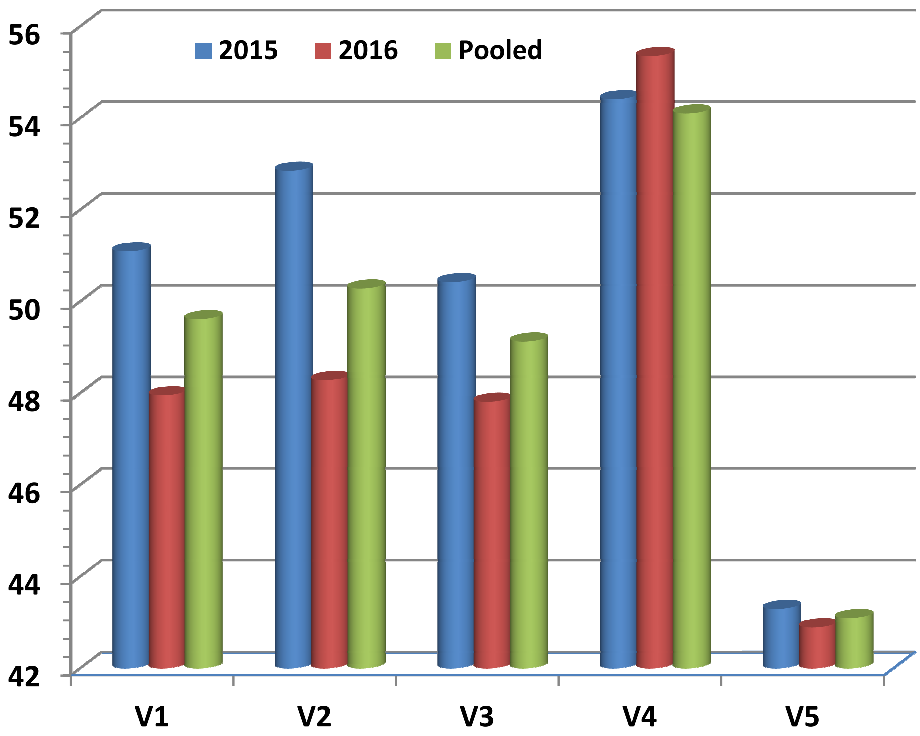


Fig.4 Effect of cultivarson plant height (cm) at 30 DAS

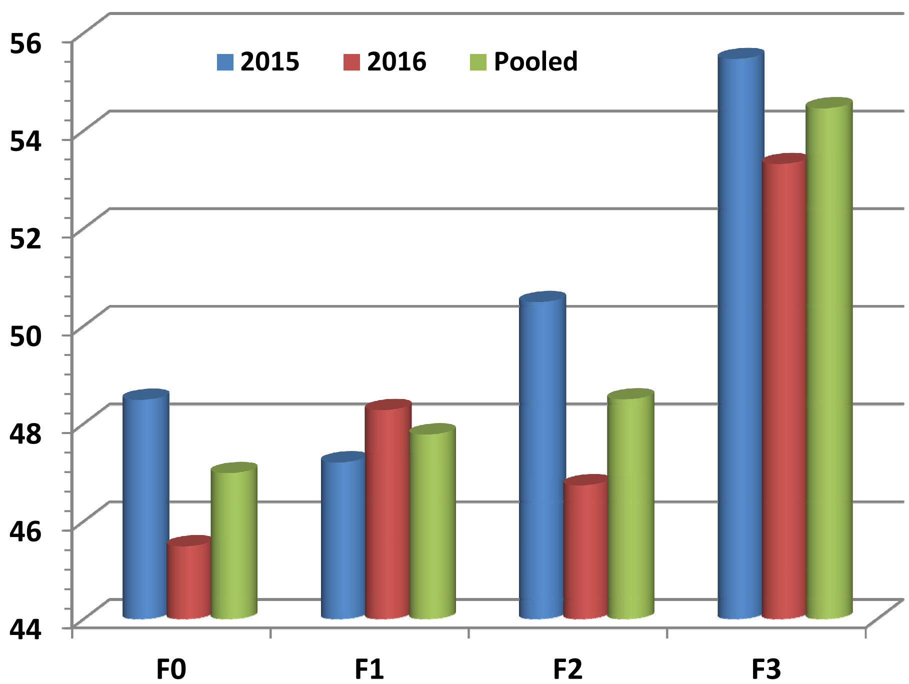


Fig. 5 Effect of fertilizer doses (kg ha^{-1}) on plant heightat 30

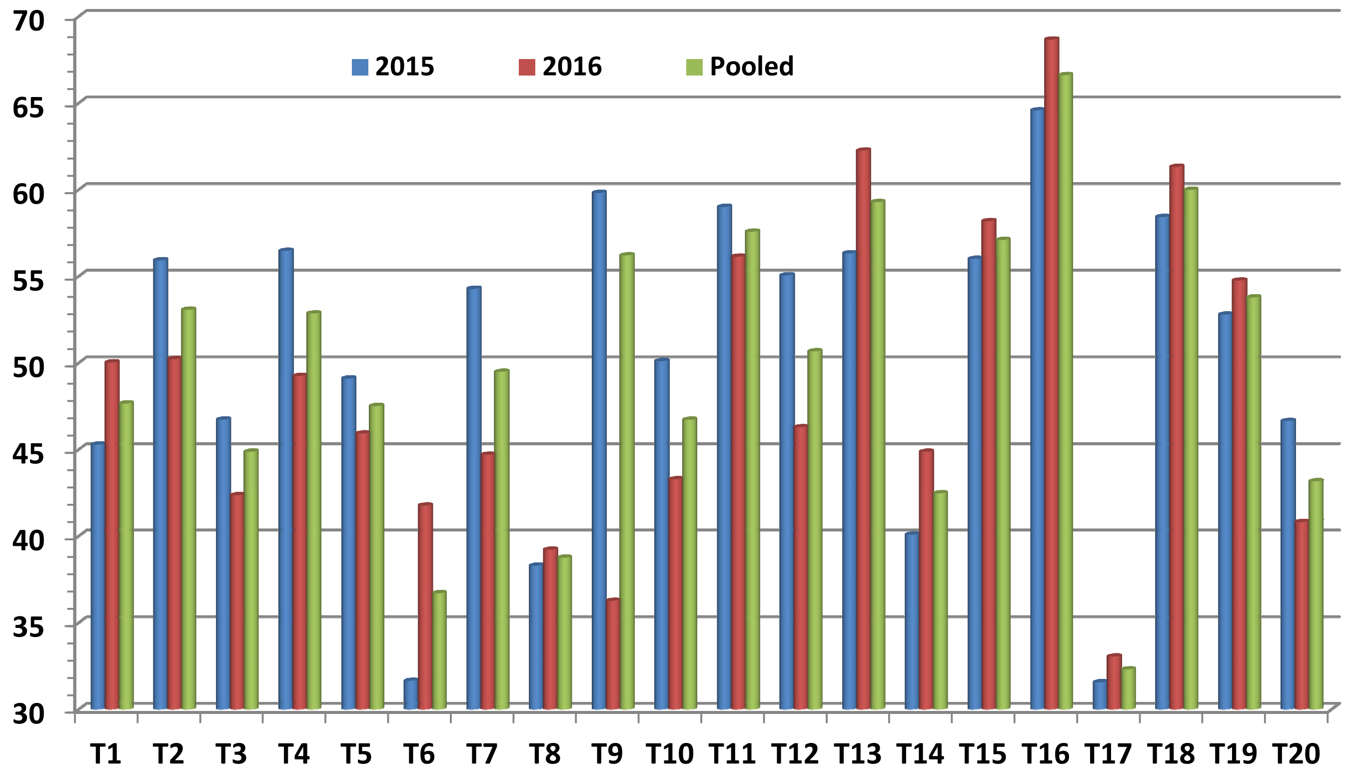


Fig. 6 Effect of treatment interaction on plant height (cm) at 30 DAS

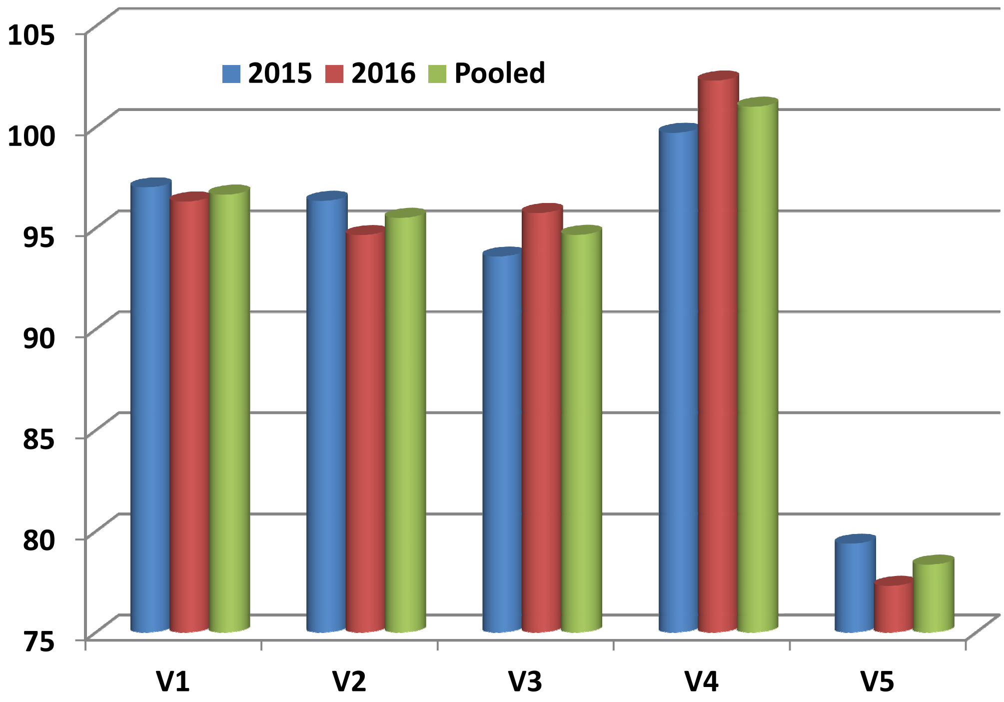


Fig. 7 Effect of cultivars on Plant height (cm) at 60 DAS

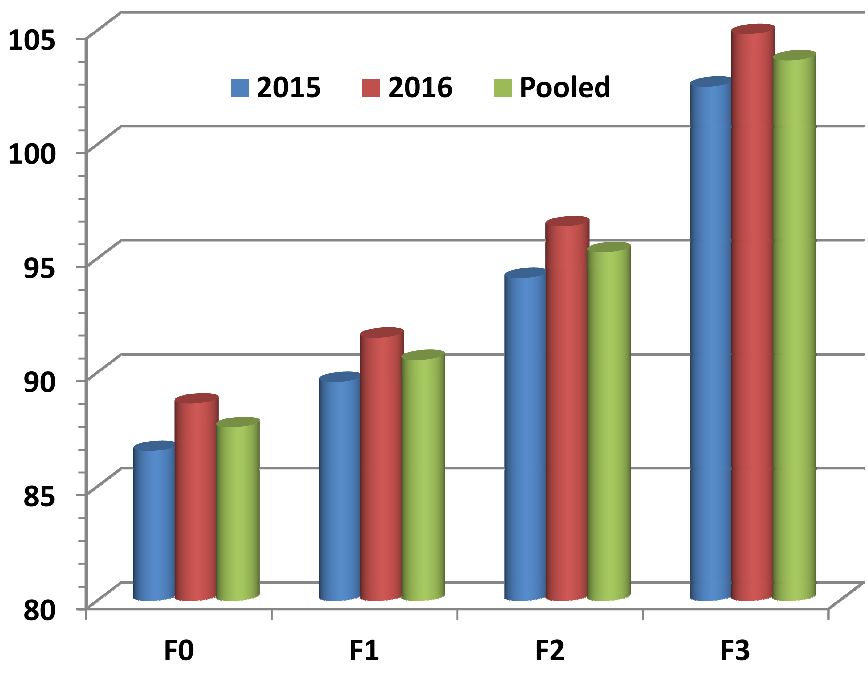


Fig. 8 Effect of fertilizer doses on Plant height (cm) at 60 DAS

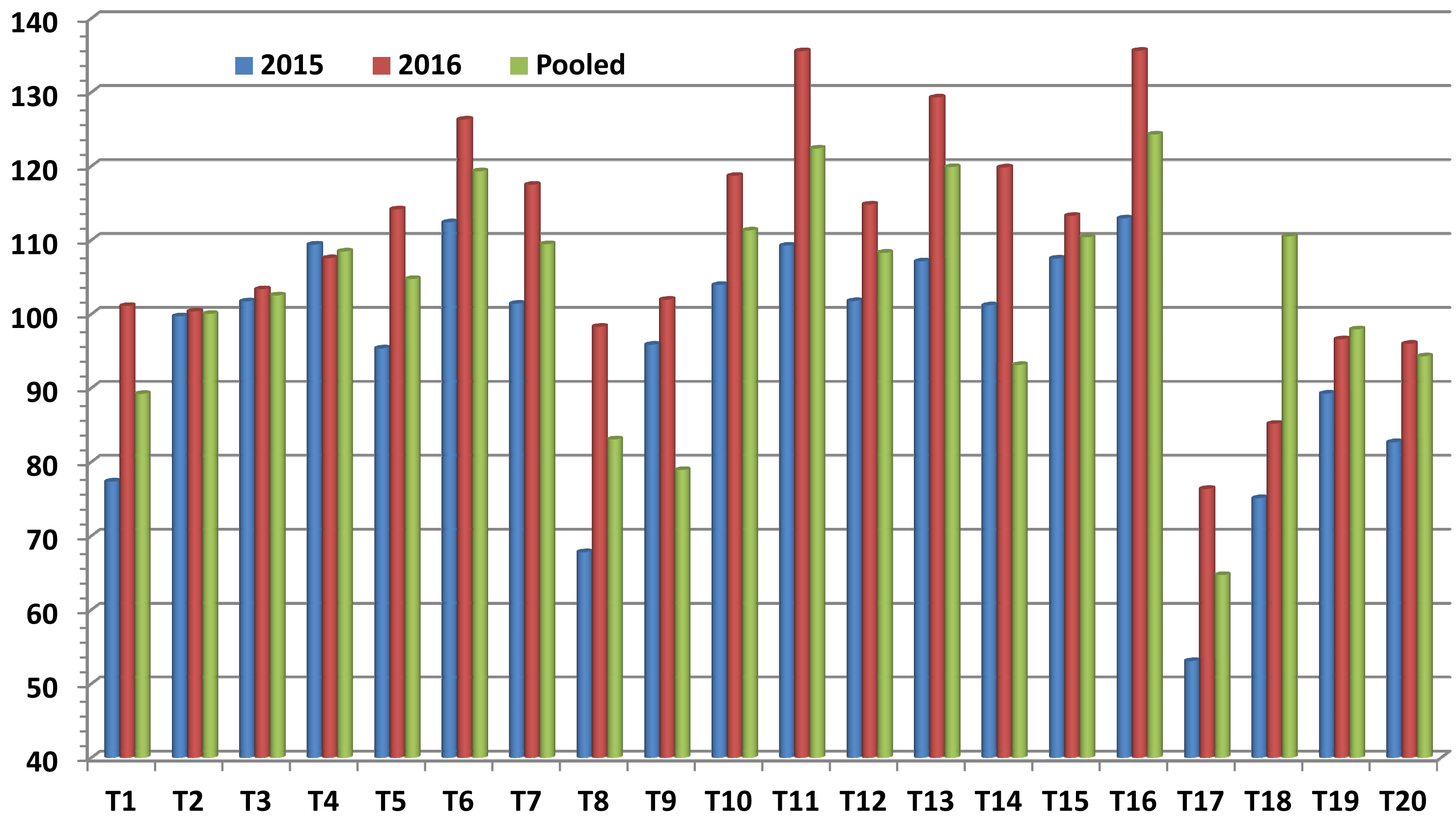


Fig. 9 Effect of treatment interaction on plant height (cm) at 60 DAS

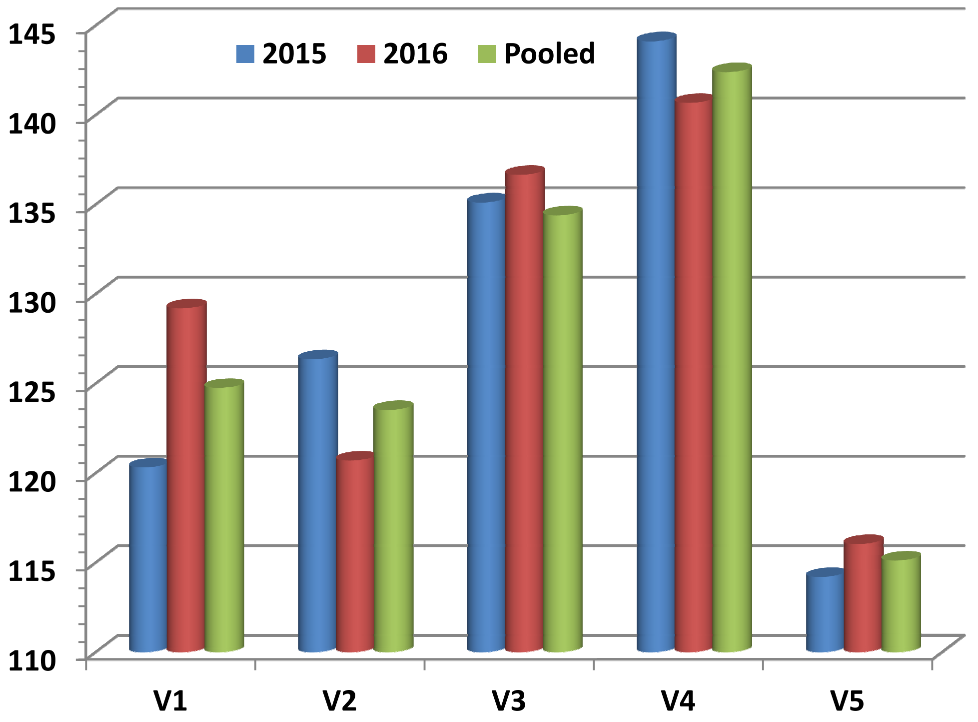


Fig. 10 Effect of cultivars on plant height (cm) at 90 DAS

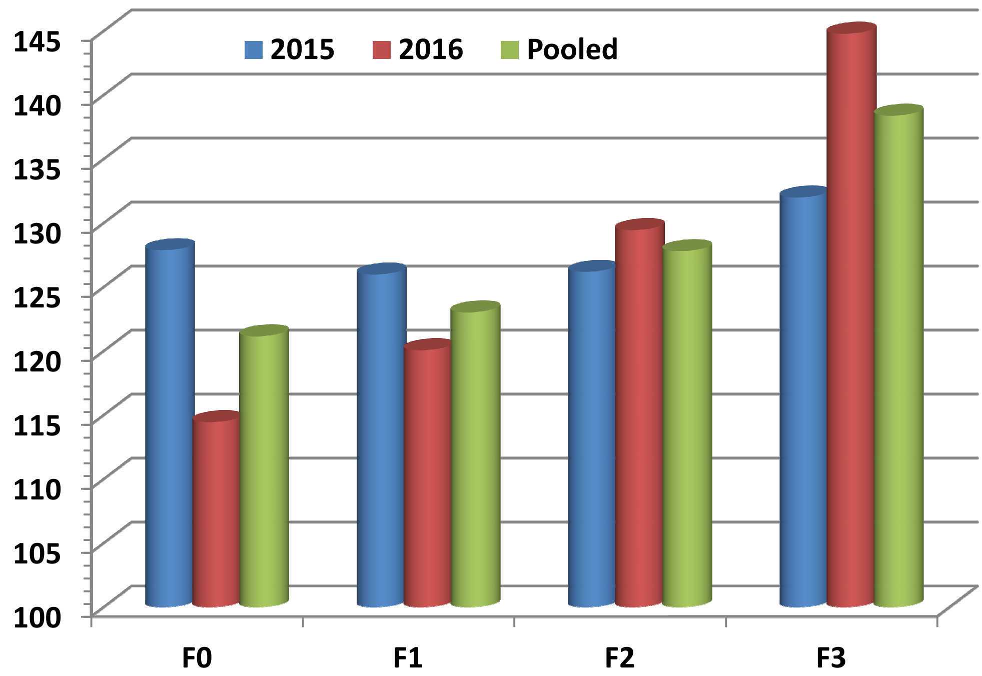


Fig. 11 Effect of fertilizer doses (kg ha^{-1}) on plant height at 90 DAS

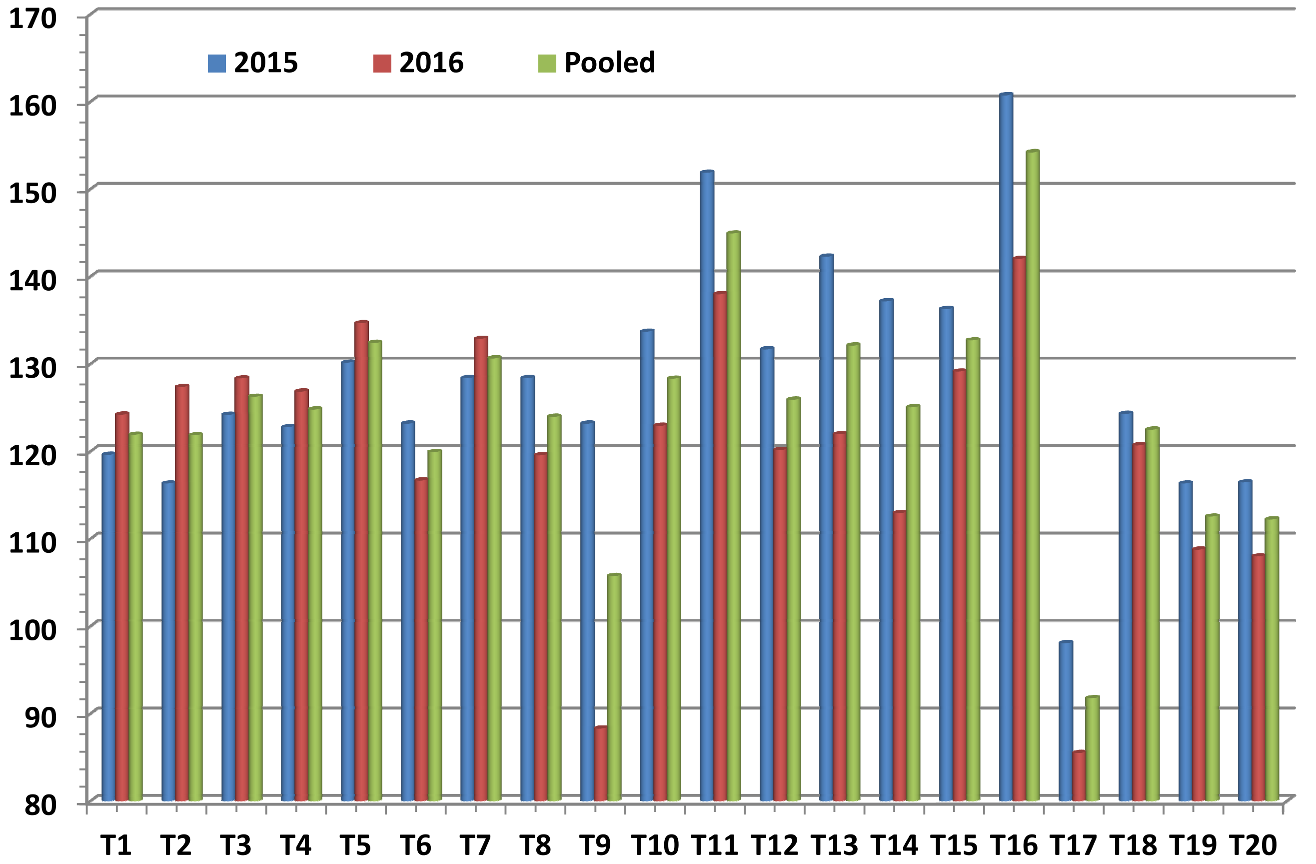


Fig. 12 Effect of treatment interaction on plant height (cm) at 90 DAS

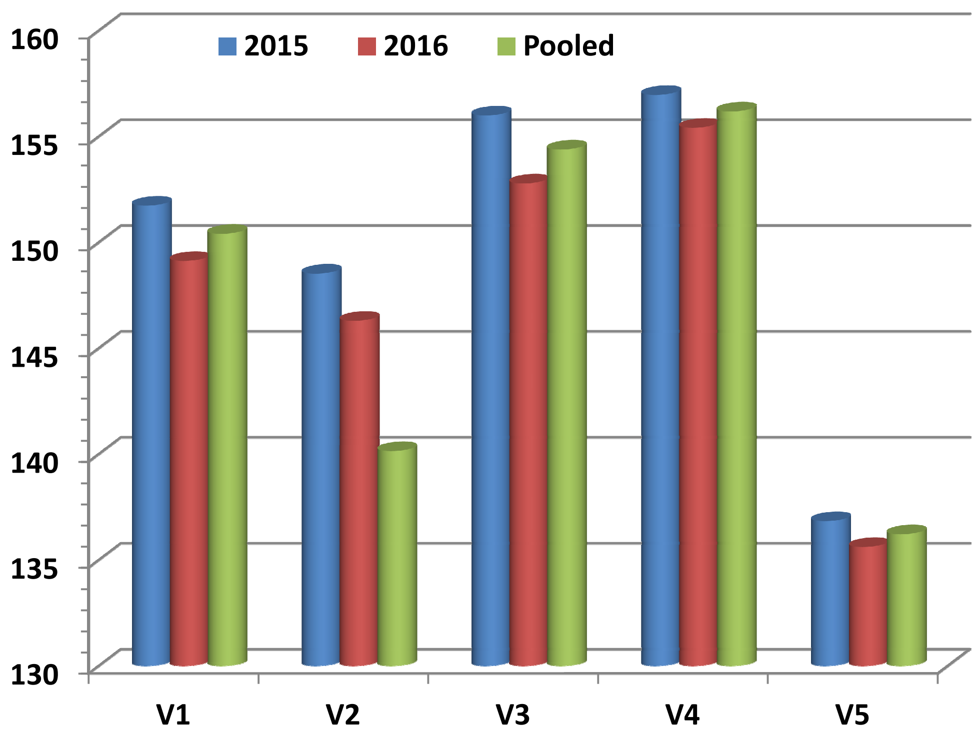


Fig. 13 Effect of cultivars on plant height (cm) at harvest

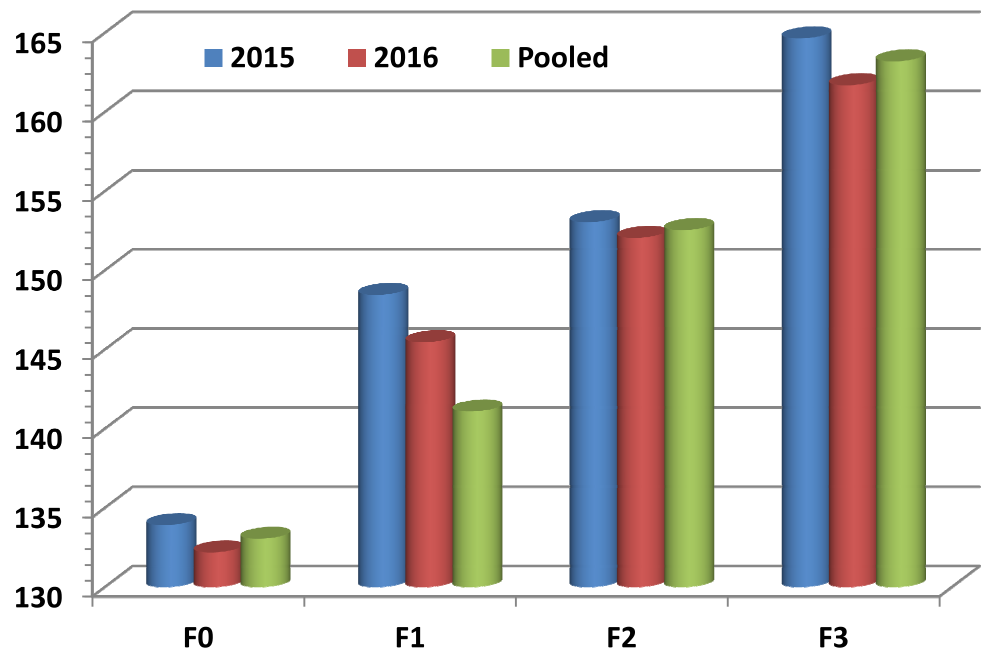


Fig. 14 Effect of fertilizer doses (kg ha $^{-1}$) on plant height at harvest

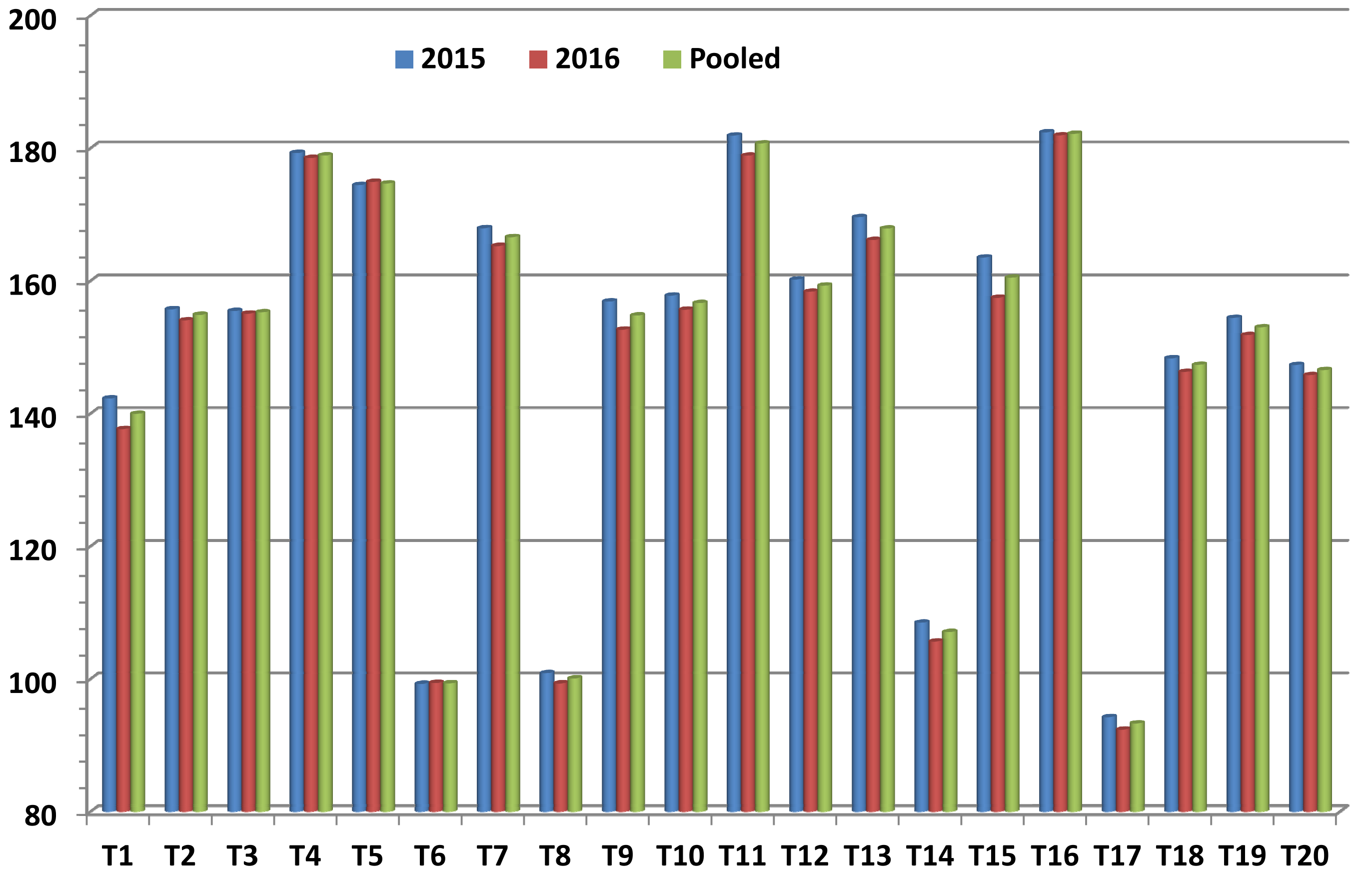


Fig. 15 Effect of treatment interaction on plant height (cm) at harvest

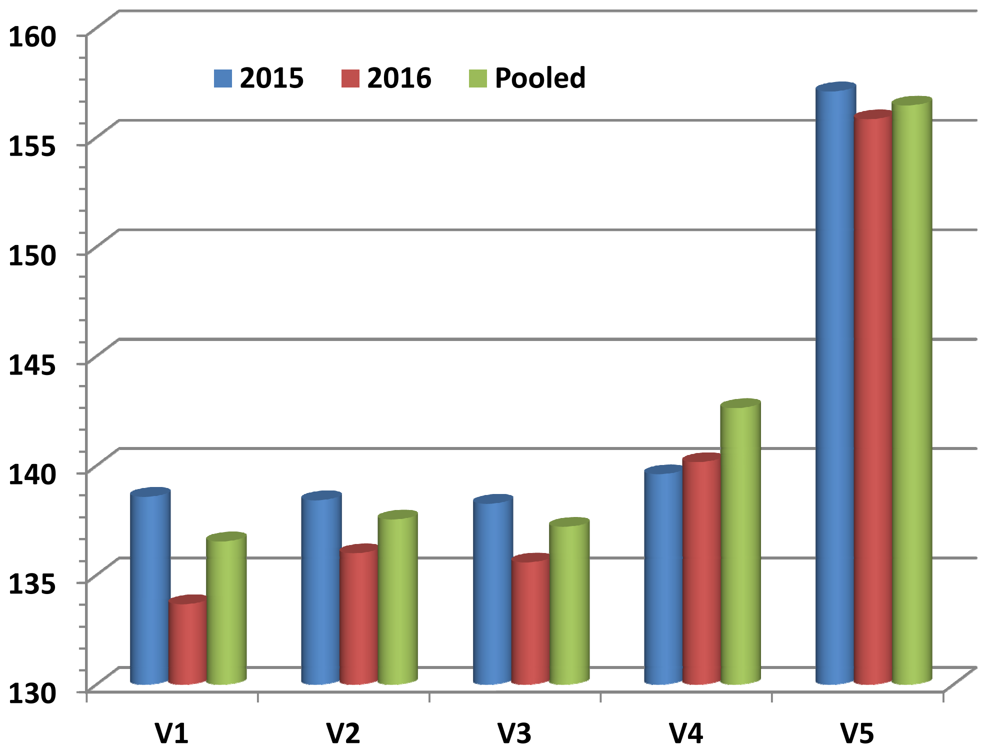


Fig. 16 Effect of cultivars on number of tillers at 90 DAS

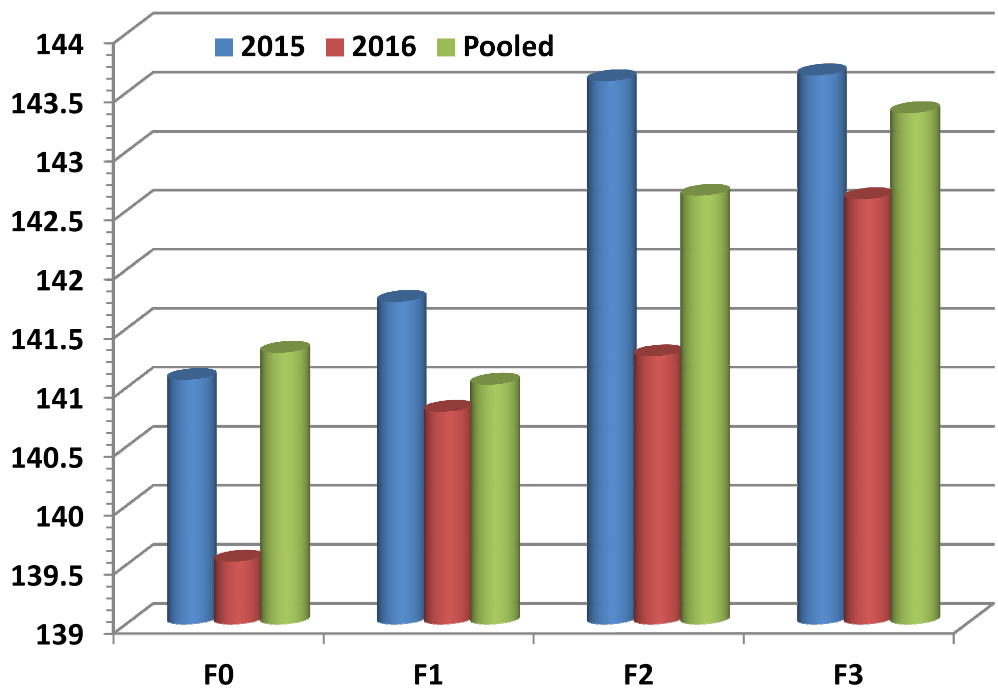


Fig. 17 Effect of fertilizer doses (kg ha^{-1}) on number of tillers at 90 DAS

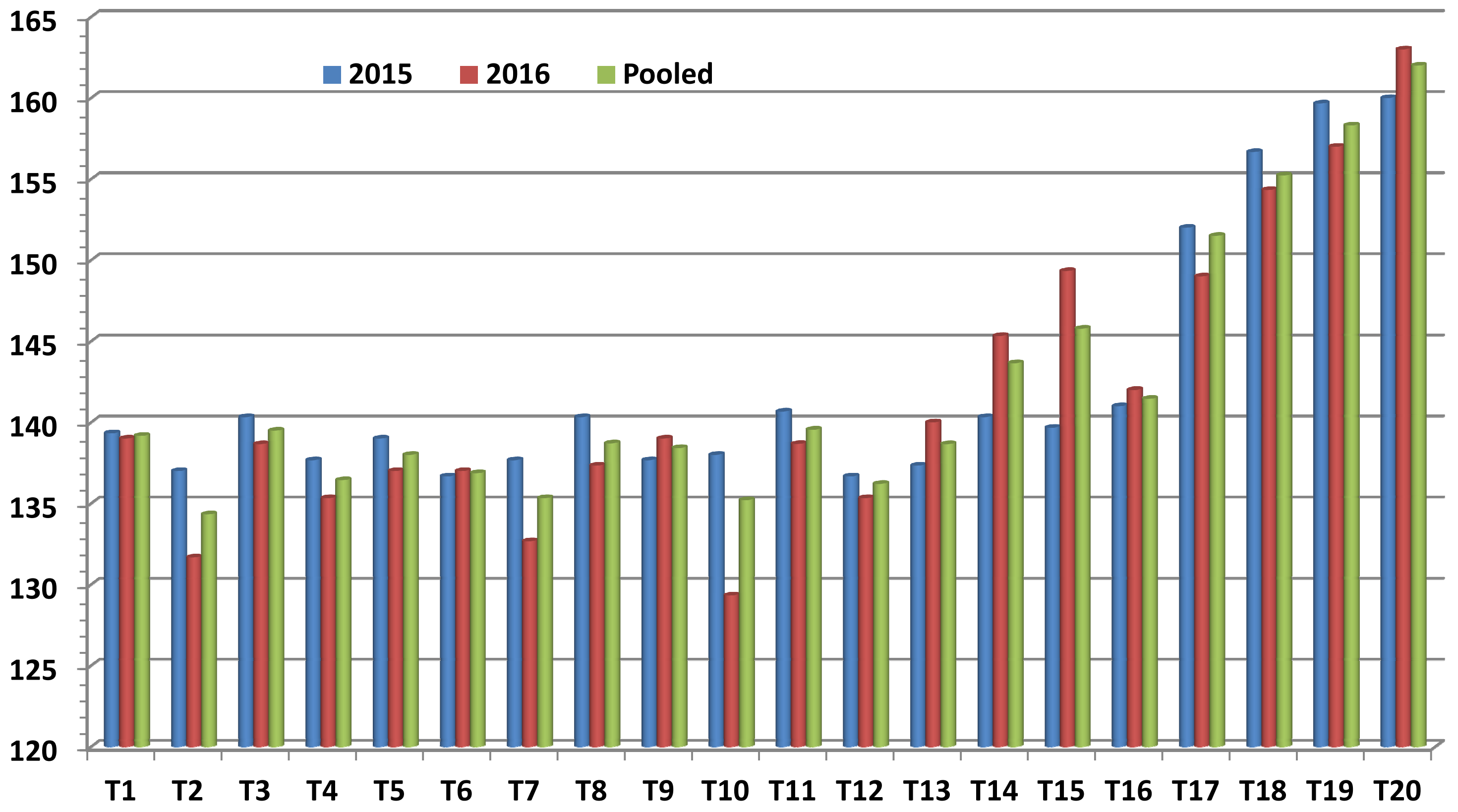


Fig. 18 Effect of treatment interaction on number of tillers at 90 DAS

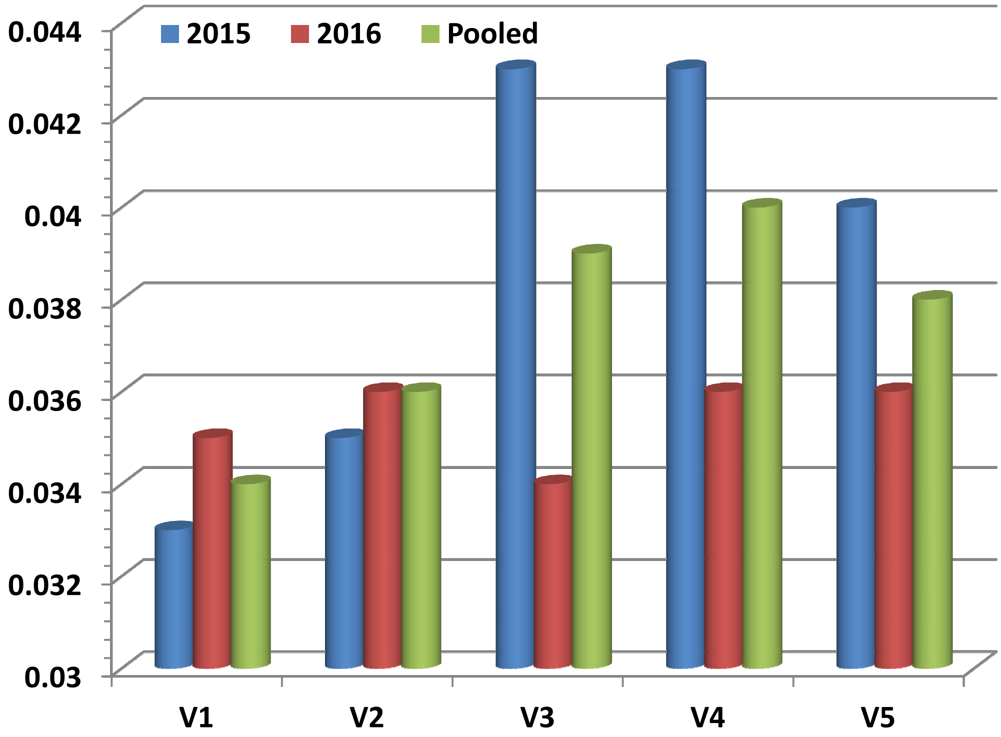


Fig. 19 Effect of cultivars on RGR (g g^{-1} day^{-1}) at 30 DAS

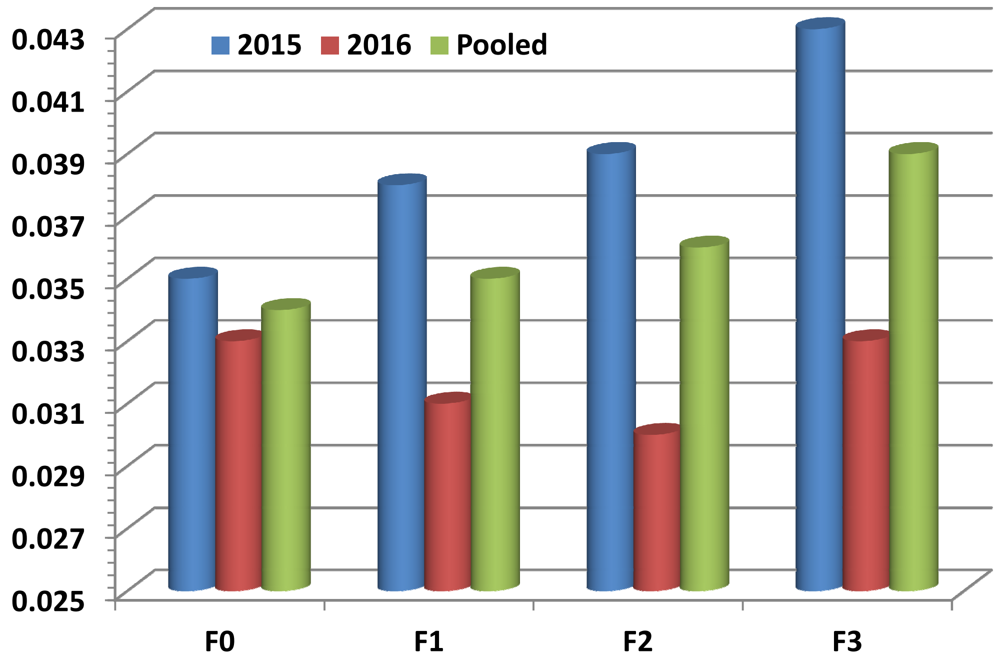


Fig. 20 Effect of fertilizer doses (kg ha^{-1}) on RGR (g g^{-1} day^{-1}) at 30 DAS

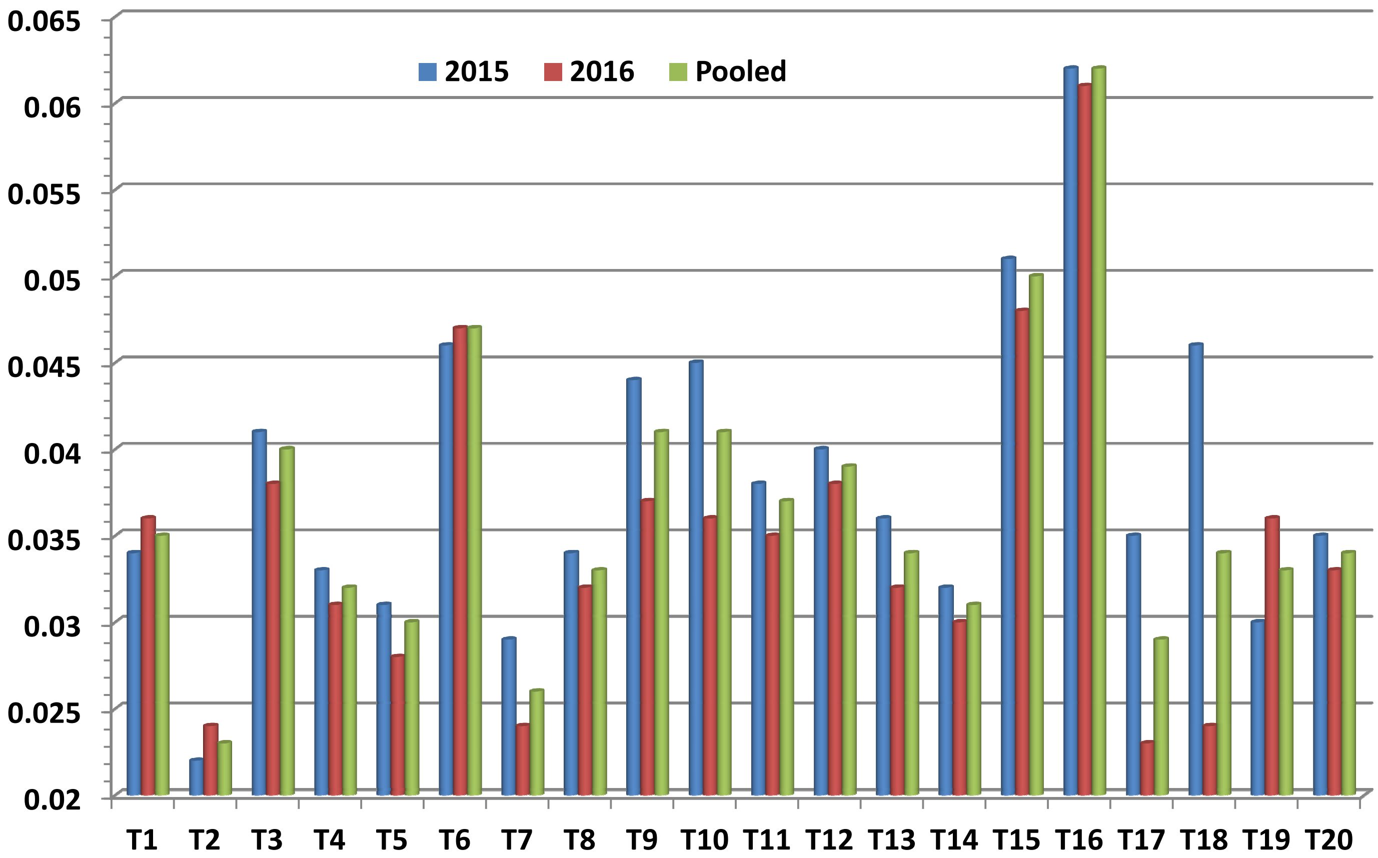


Fig. 21 Effect of treatment interaction on RGR (g g^{-1} day^{-1}) at 30 DAS

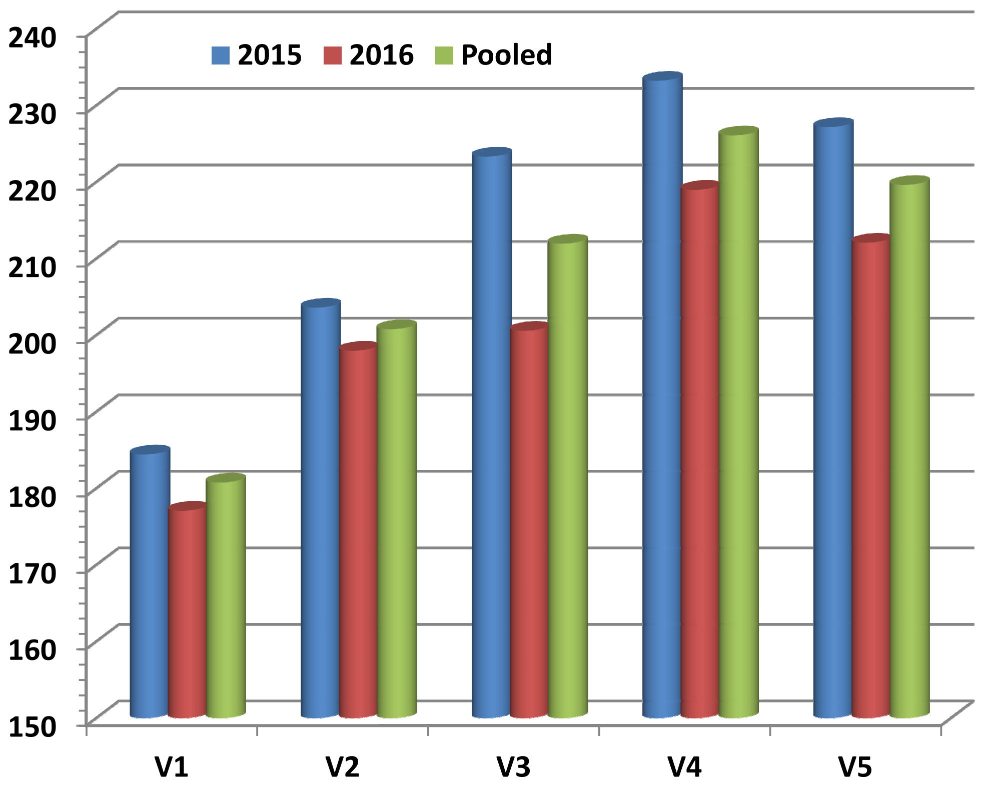


Fig. 22 Effect of cultivars on RGR (g g^{-1} day^{-1}) at 60 DAS

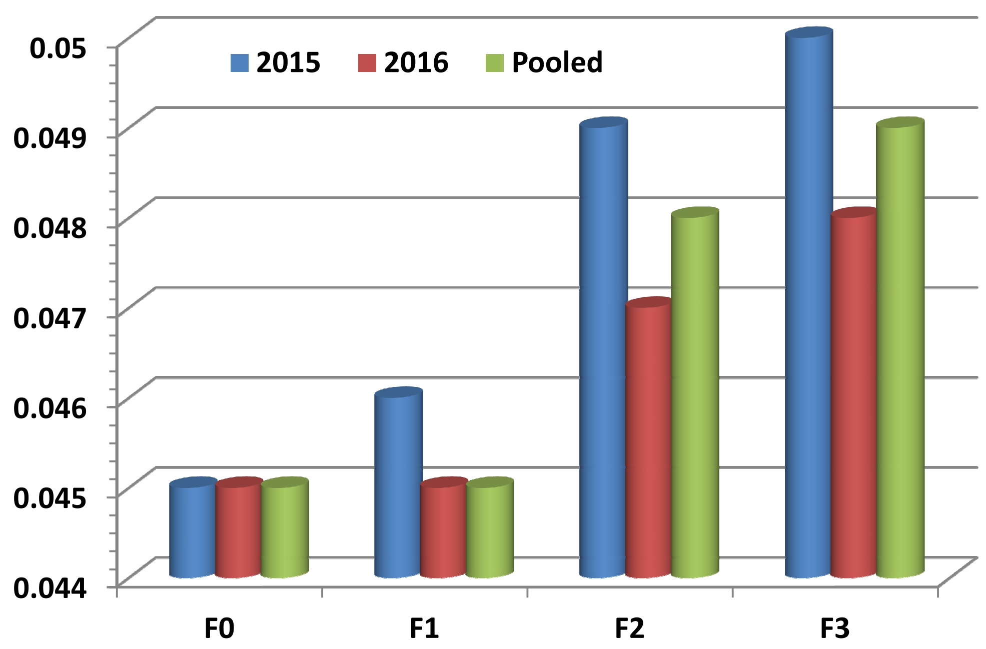


Fig. 23 Effect of fertilizer doses (kg ha^{-1}) on RGR (g g^{-1} day^{-1}) at 60 DAS

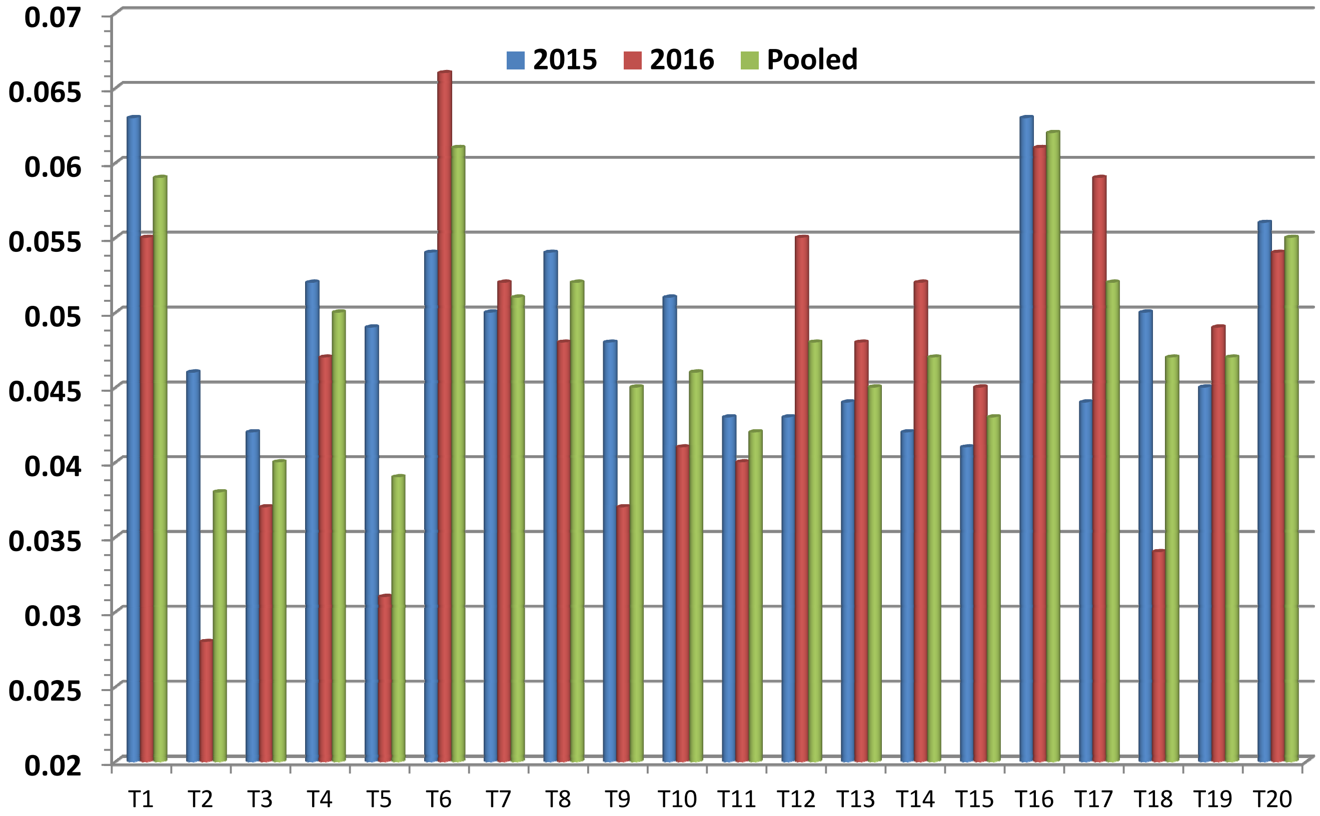


Fig. 24 Effect of treatment interaction on RGR (g g^{-1} day^{-1}) at 60 DAS

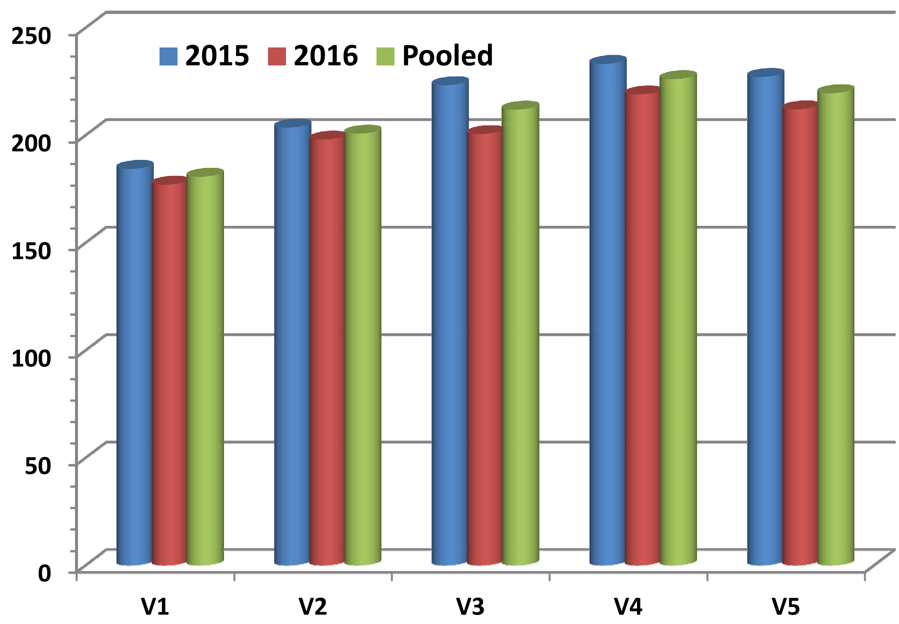


Fig. 25 Effect of cultivars on number of grains panicle^{-1}

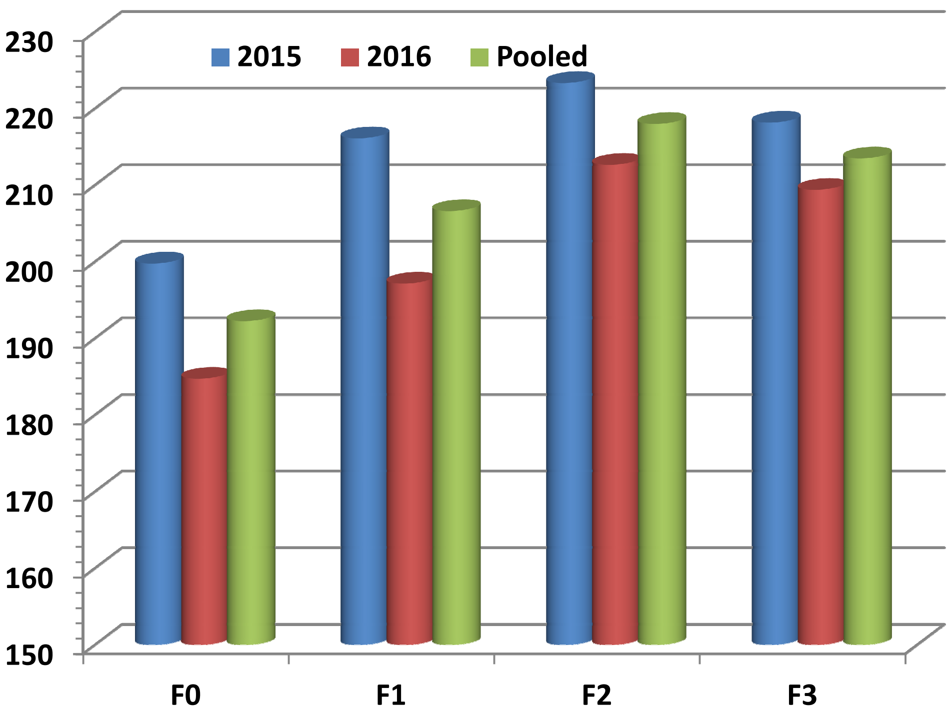


Fig. 26 Effect of fertilizer doses (kg ha^{-1}) on number of grains panicle^{-1}

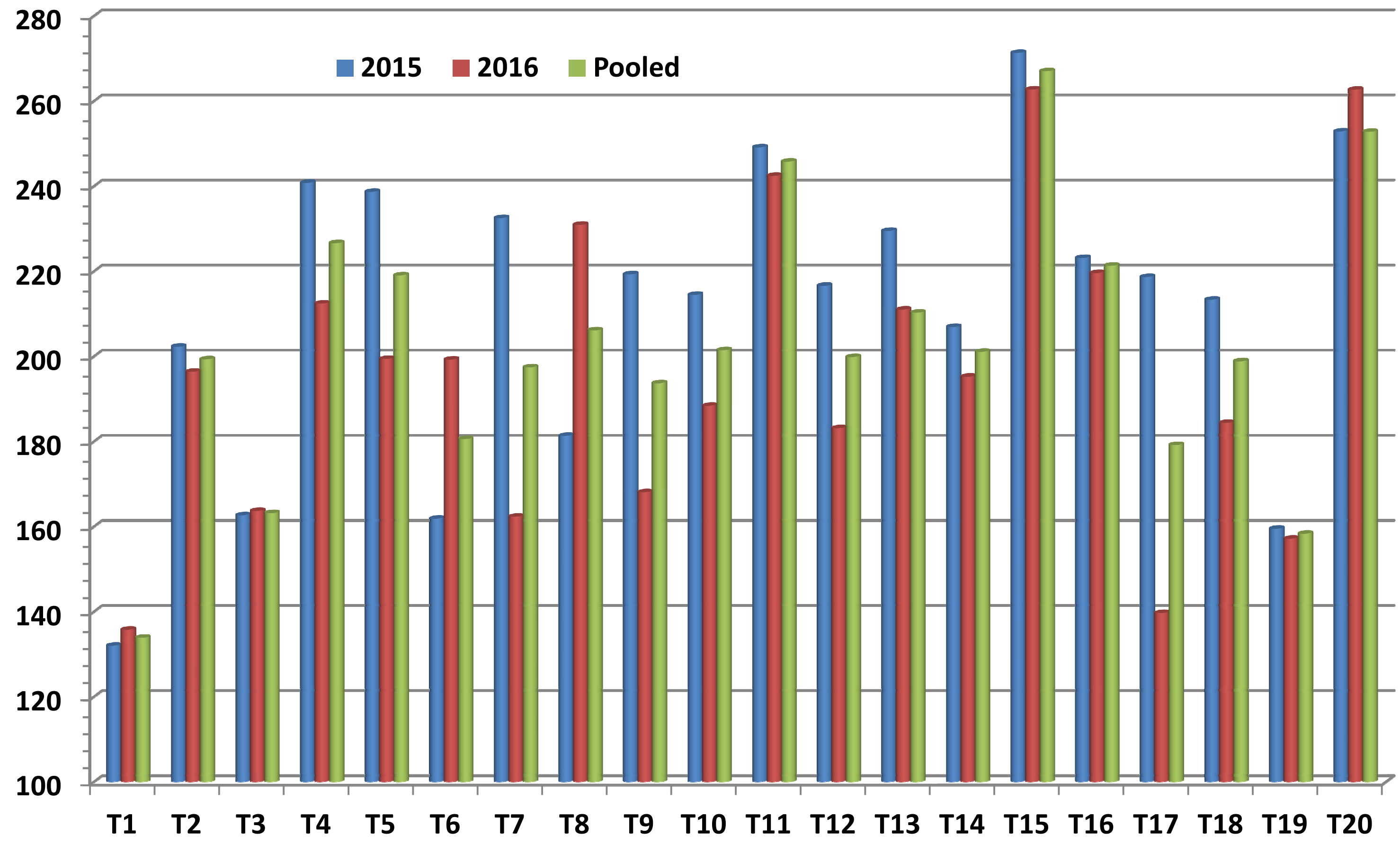


Fig. 27 Effect of treatment interaction on number of grains panicle^{-1}

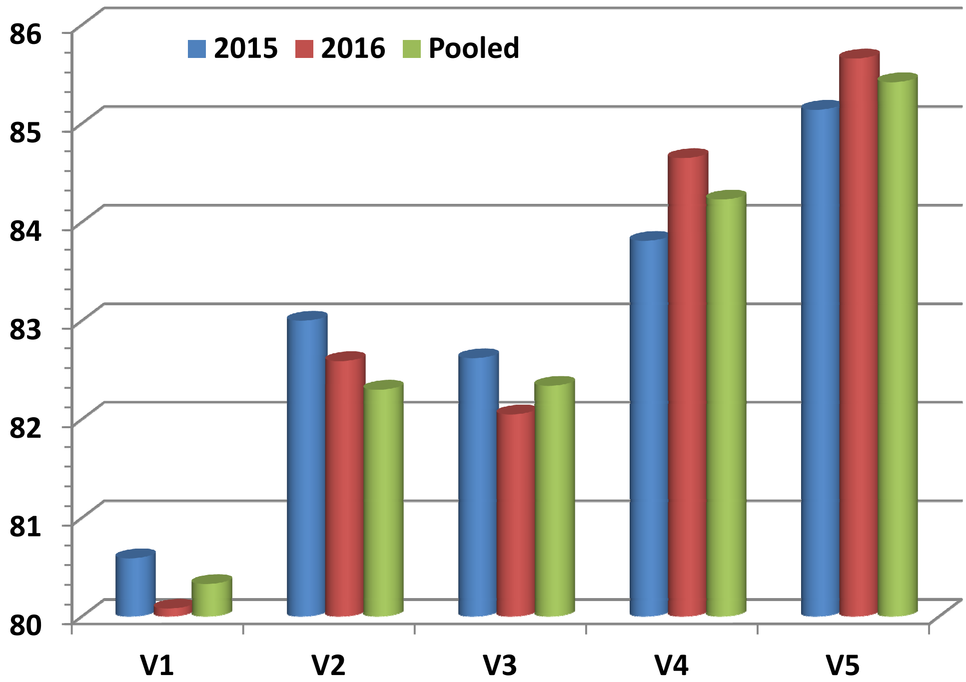


Fig. 28 Effect of cultivars on filled grain percent (%)

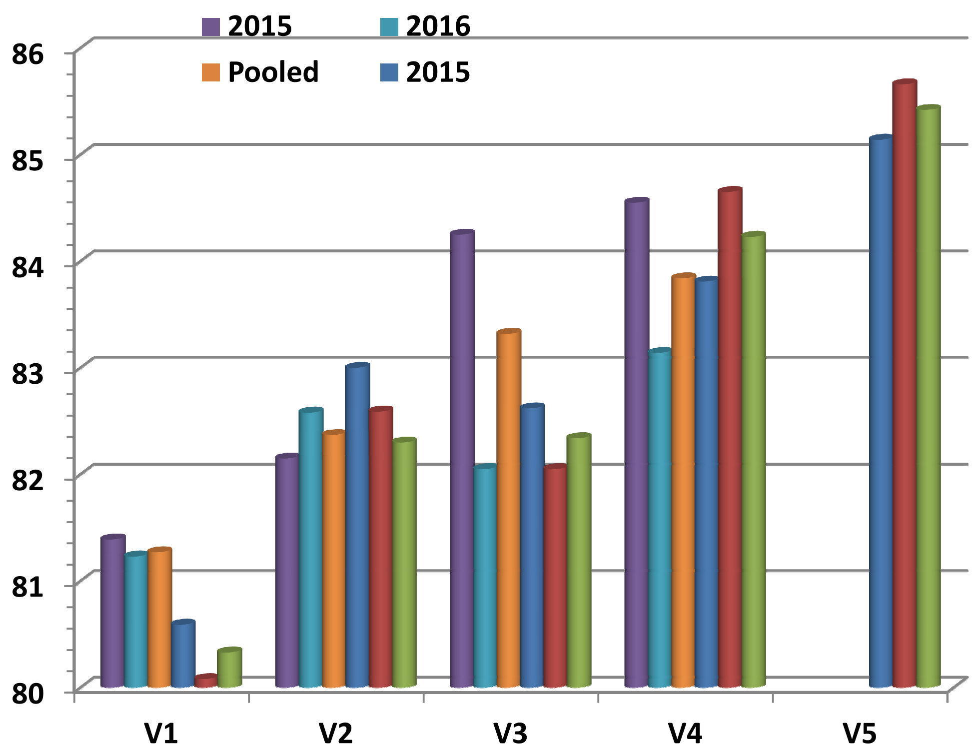


Fig. 29 Effect of fertilizer doses (kg ha^{-1}) on filled grain percent (%)

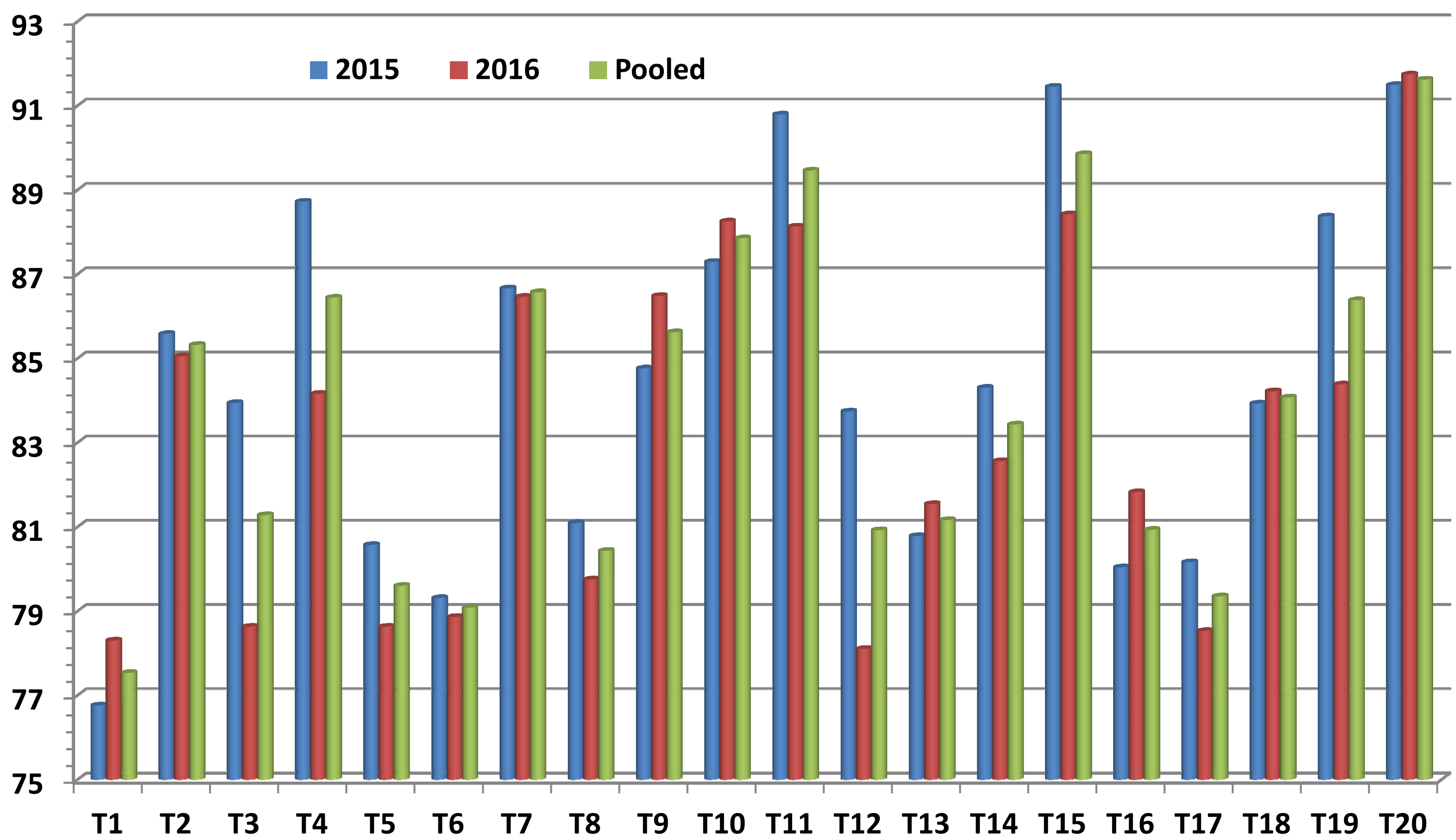


Fig. 30 Effect of treatment interaction on filled grain percent (%)

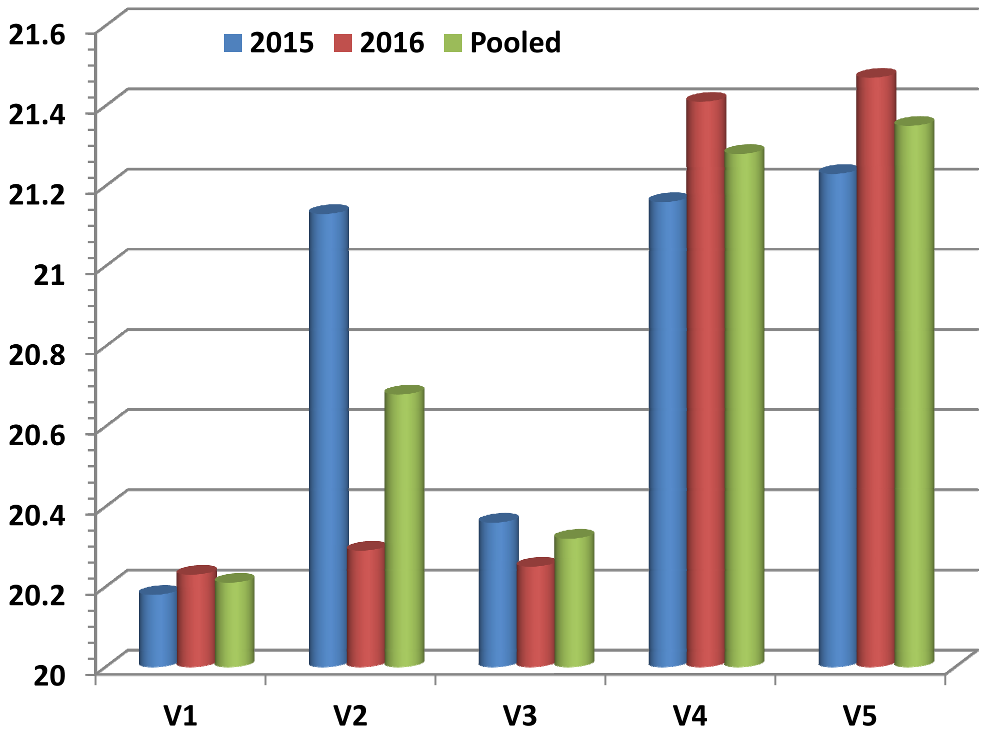


Fig. 31 Effect of cultivars on test weight (g)

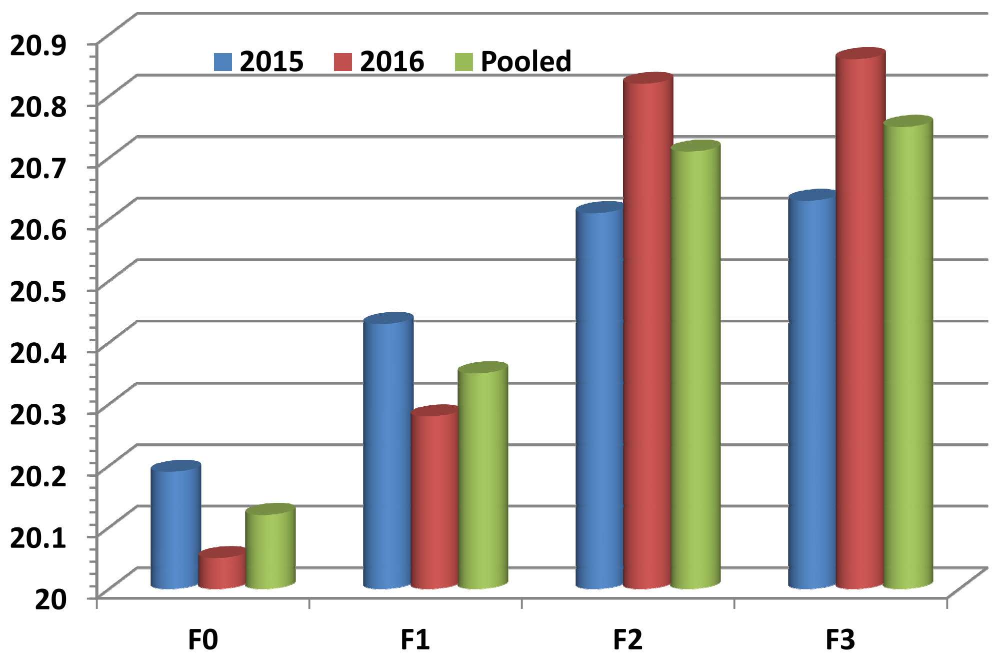


Fig. 32 Effect of fertilizer doses (kg ha^{-1}) on test weight (g)

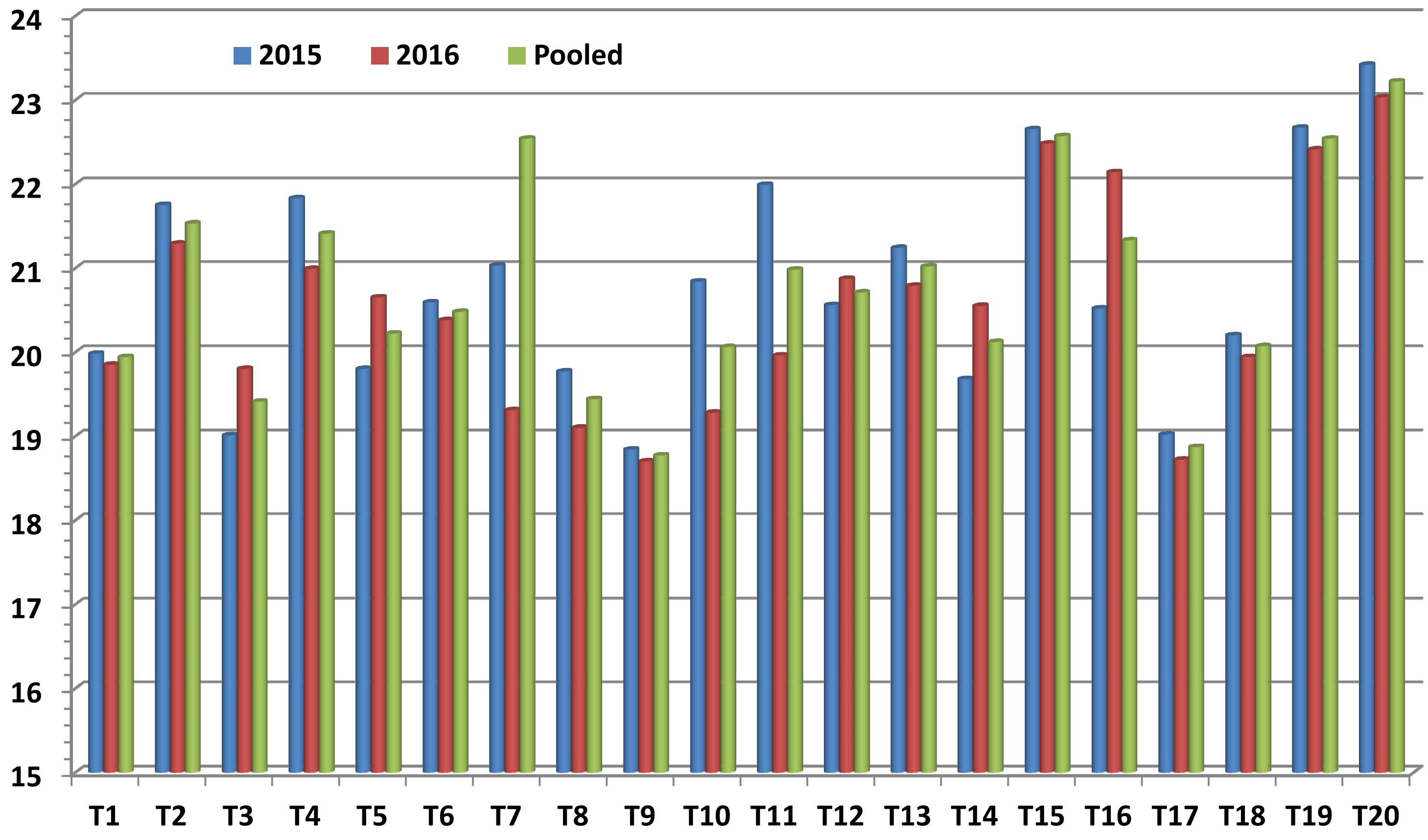


Fig. 33 Effect of treatment interaction on test weight (g)

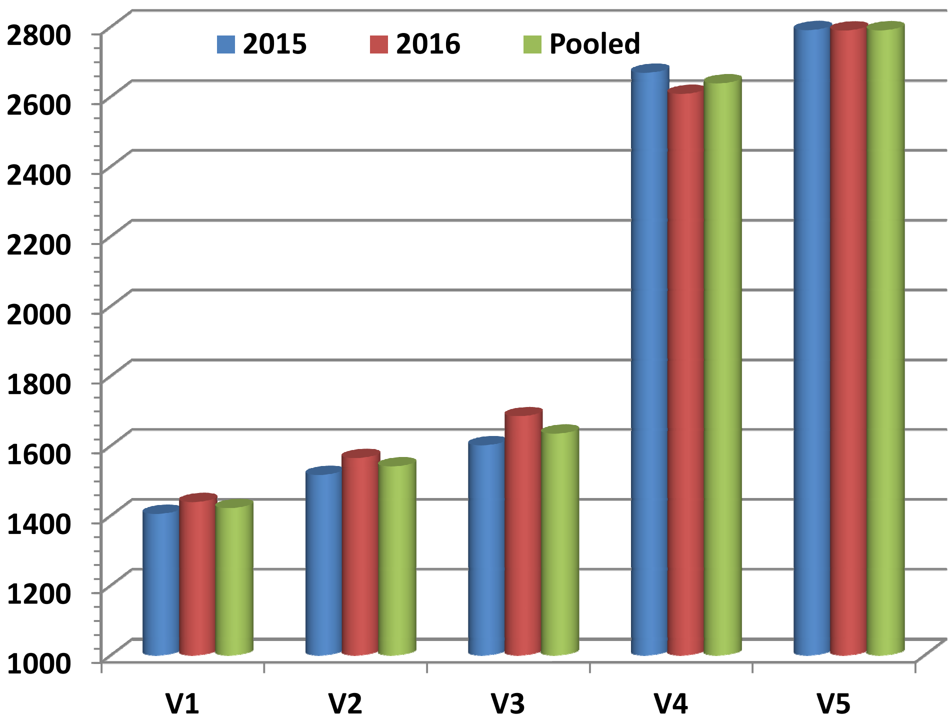


Fig. 34 Effect of cultivars on grain yield (kg ha^{-1})

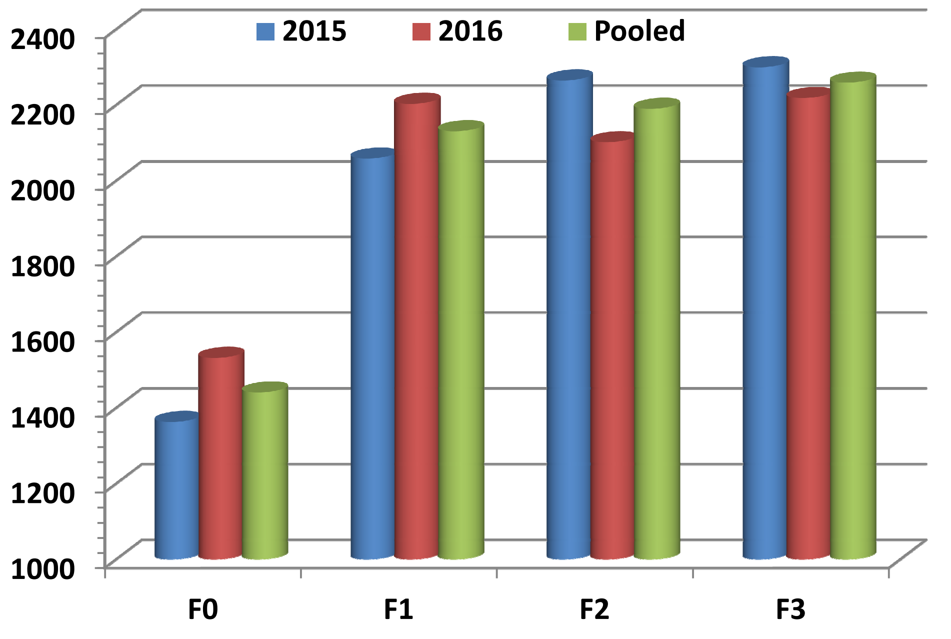


Fig. 35 Effect of fertilizer doses (kg ha^{-1}) on grain yield (kg ha^{-1})

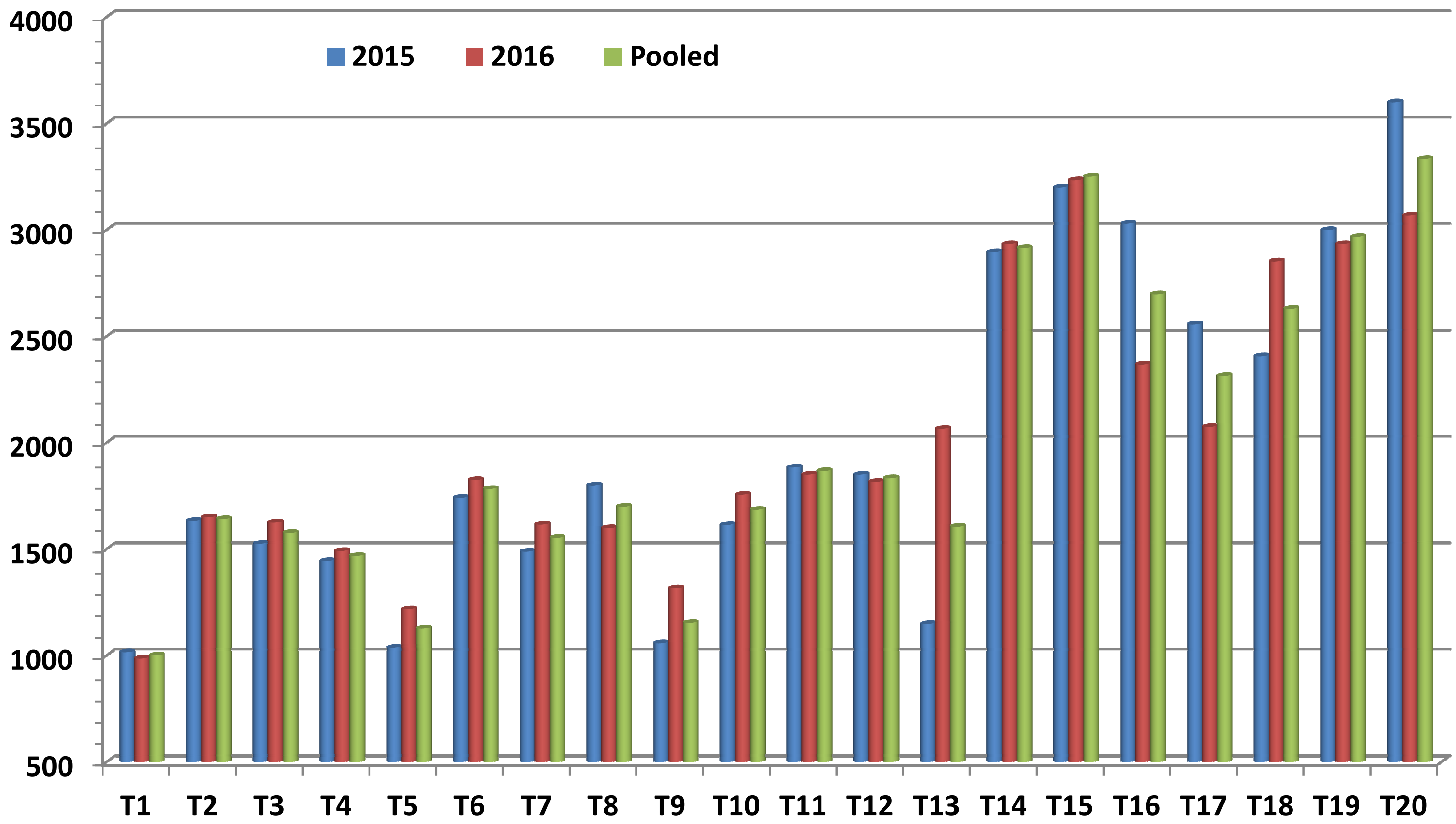


Fig. 36 Effect of treatment interaction on grain yield (kg ha^{-1})

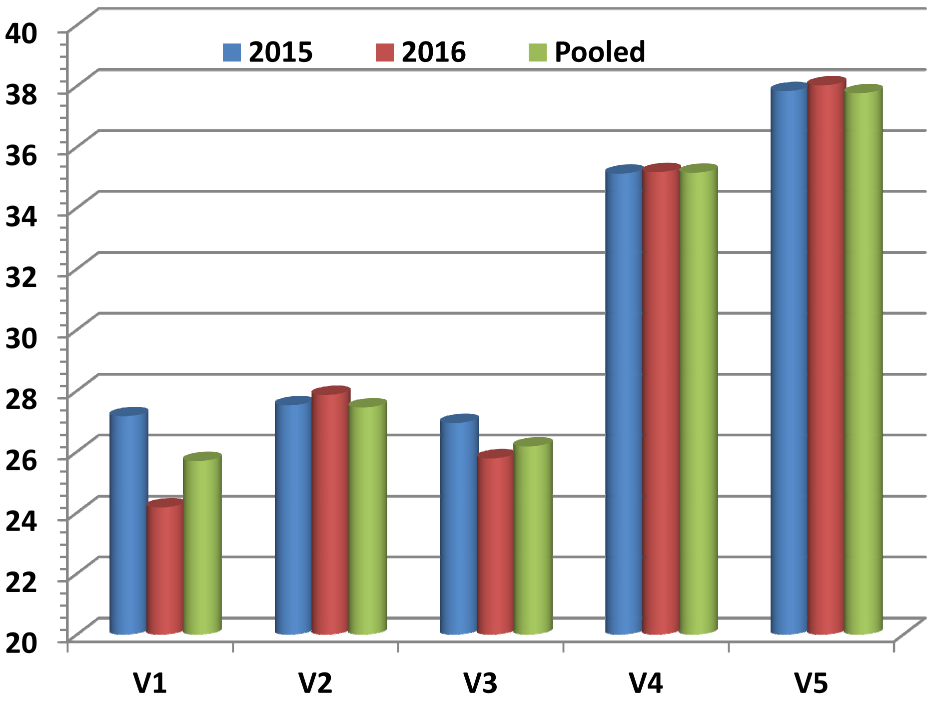


Fig. 37 Effect of cultivars on harvest index (%)

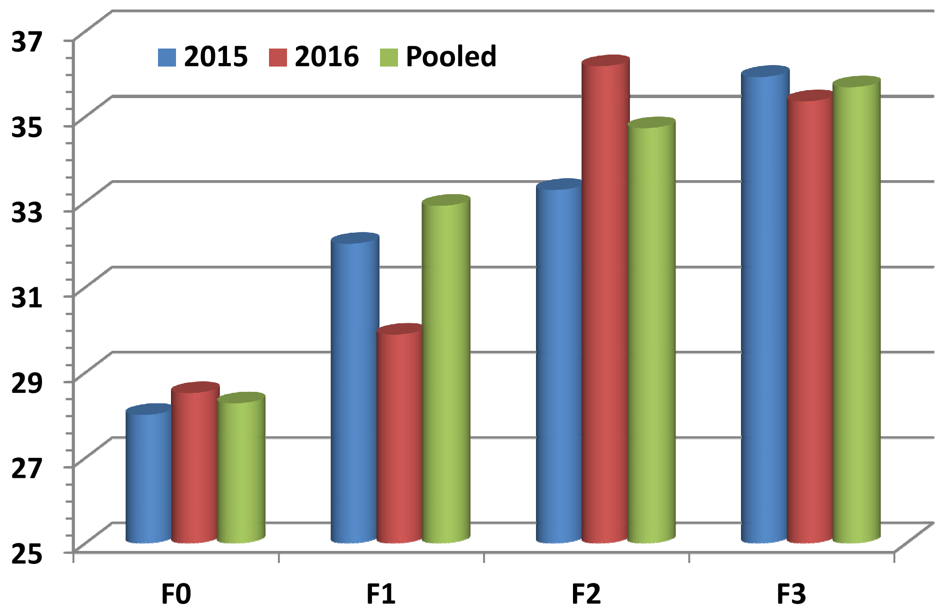


Fig. 38 Effect of fertilizer doses (kg ha^{-1}) on harvest index (%)

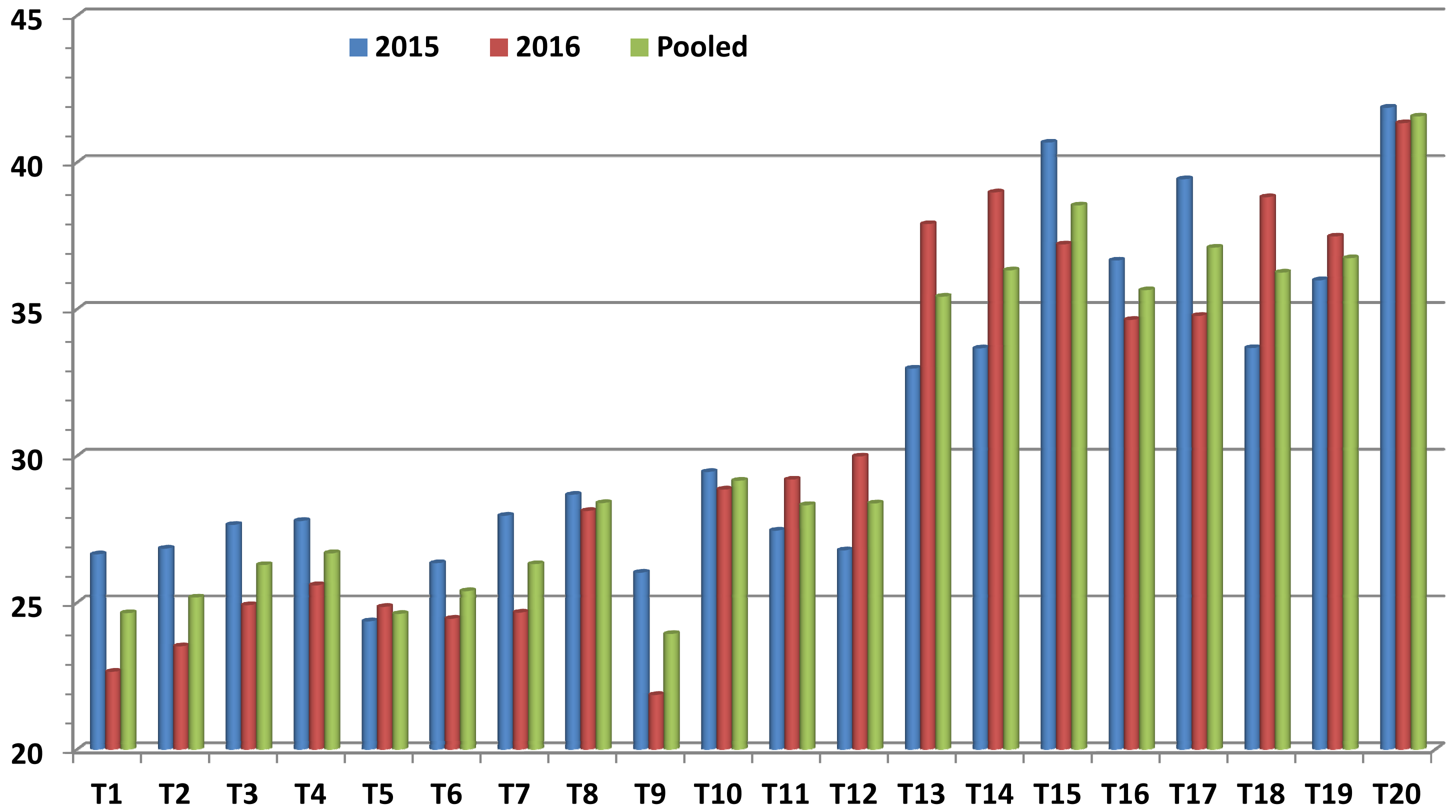


Fig. 39 Effect of treatment interaction on harvest index (%)