RESPONSE OF RAINFED RICE (*Oryza Sativa* L.) TO PLANTING DATES AND LIQUID ORGANIC FORMULATIONS IN THE CONTEXT OF CLIMATE CHANGE IN MANDLA DISTRICT OF MADHYA PRADESH

THESIS

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Allahabad **Chubaienla Jamir**
Date:

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LIST OF ABBREVIATION

%	:	Percentage
&	:	And
/	:	Per
@	:	At the rate of
^{0}C	:	Degree Centigrade or Celsius
ANOVA	:	Analysis of Variance
Avg.	:	Average
CD	:	Critical Difference at 5% level of Significance
CGR	:	Crop Growth Rate
cm	:	Centimetre (s)
DAS	:	Days after sowing
DAT	:	Days after transplanting
df	:	Degree of freedom
DPO	:	District Programme Officer
EC	:	Electrical conductivity
e.g.	:	Example
ESS	:	Error sum of squares
et al.	:	And others
Etc.	:	Etcetera
F (cal.)	:	Calculated value of ‘F’
F (tab.)	:	Table value of ‘F’
Fig.	:	Figure
FPDCS	:	Food Production, Distribution and Consumption System
FYM	:	Farm yard manure

g	:	Gram
Ha	:	Hectare
i.e.	:	That is
kg	:	Kilogram
kg ha^{-1}	:	Kilogram per hectare
l	:	Litre
m	:	Meter
Max.	:	Maximum
MESS	:	Error Mean Sum of Squares
Min.	:	Minimum
mm	:	Millimeter
MSS	:	Mean Sum of Square
No.	:	Number
NS	:	Non-significant
OFAR	:	On-farm Adaptive Research
pp	:	Pages
t ha^{-1}	:	Tonnes per hectare
r	:	Replication
RBD	:	Randomized block design
Ref	:	References
RGR	:	Relative Growth Rate
RH	:	Relative humidity
₹	:	Rupees
RSS	:	Replicate Sum of Squares
S	:	Significant

SHFC	:	Smallholder Farmers Collective
SV	:	Source of Variation
T	:	Treatment
Temp.	:	Temperature
TSS	:	Total Sum of Squares
viz.	:	Namely
VRA	:	Village Research Assistant

Chapter - I

Introduction

CHAPTER 1

INTRODUCTION

Cereals are the member of grasses, which belong to family *Gramineae* (*Poaceae*) cultivated for edible components of their grain composed of the endosperm, germ and bran. Cereal grains are grown in greater quantities and provide more food energy worldwide than any other type of crop. In their natural form, they are rich source of carbohydrates, protein, vitamins, minerals and fats. Rice alone accounts for 40% of the food grain production (Singh and Singh, 2011) in India. Rice continues to play vital role in national food grain supply. Predicted changes in global climate may affect the production of food crops like rice (*Oryza sativa* L.) which is the world's most important cereal crop and staple food for more than half of world's population.

In India, rice is grown in an area of 42.41 m ha with a production of 104.40 m tonnes (GOI, 2013). India shares the worlds 22.25% rice production. India holds 2nd and china 1st position in rice production in the world (GOI, 2011). Rice is staple food of more than 60% of Indian population. It accounts for about 43% of total food grain production and 46% of total cereal production in the country. In order to meet the domestic demand of the increasing population the present day production of 95.32 million tonnes (2010) of milled rice has to be increased to 130 million tonnes by the year 2025. In Madhya Pradesh, rice is grown in an area of 1.88 m ha with a production of 2.78 m tonnes and 1.48 kg ha^{-1} productivity (GOI, 2013).

World food security is a major issue with ever increasing population. The situation is worsened by variability in climate that has become predominant in recent years. Climate change will compound the existing food insecurities and vulnerability patterns. Climate and agriculture are interrelated and climate change over the next century may have significant effects on crop productivity and thus the availability of food. Climate change impacts on agriculture are being witnessed all over the world, but countries like India are more vulnerable in view of the high population depending on agriculture and excessive pressure on natural resources. If temperatures rise by 4℃ in India, grain yields (*i.e.*, rice, wheat, coarse grains, and protein feed) could collectively fall by 25-40% (Rosenzweig and Parry, 1994) with rice yields decreasing by 15-25% (Kumar and Parikh, 1998). There are already evidences of negative impacts on yield of paddy in parts of India due to increasing water stress and reduction in number of rainy days. Climate change impacts are likely to vary in different parts of the country. Parts of western Rajasthan, Southern Gujarat, Madhya Pradesh, Maharashtra, Northern Karnataka, Northern Andhra Pradesh, and Southern Bihar are likely to be more vulnerable in terms of extreme events (Mall *et al.*, 2006). For every one degree increase in temperature, rice yields may decline by 6%. Similarly, for every one degree increase in temperature yields of wheat, soybean, mustard, groundnut and potato are expected to decline by 3-7% (Agarwal, 2009 and Saseendran *et al*., 2000). Understanding the potential impact of climate change on rice-based production systems is important for the development of appropriate strategies to adopt to and mitigate the likely outcomes on long-term food security of interaction between rice production and climate change.

The present OFAR was conducted in 9 villages of Mandla district of Madhya Pradesh. Mandla is a tribal district of Madhya Pradesh. Mandla district is situated in the east central part of Madhya Pradesh. The Climate Vulnerability Index (CVI), calculated from social, economic, agriculture, water resource, forest and climate indices, suggests that Mandla is among those districts most vulnerable to climate change (Government of Madhya Pradesh, 2012). In Mandla, agriculture is the primary economic activity undertaken by the community on a large scale. Agricultural production in Mandla is strongly dependent upon the amount and distribution of rainfall in a year. The major crops grown are rice, wheat, maize, mustard, minor millets, linseed, rapeseed, lentil, chickpea, redgram, and blackgram. Irrigation coverage in the district is poor, and a vast majority of the agricultural area is rainfed. With about 90% of the region being rain-fed, erratic rainfalls in the last fifteen years have caused up to a 60% decrease in crop yields, directly impacting the food security of the region (Sushant, 2013). With only 8% of cultivation areas irrigated in Mandla, rainfall and temperature variations have a significant effect on agricultural productivity. Where agriculture is practiced using traditional (*i.e.*, non-mechanized) methods to meet subsistence needs, the role of rainfall patterns becomes more critical.

The present OFAR project is a part of SAF-BIN (Strengthening Adaptive Farming in Bangladesh, India and Nepal) programme funded by the European Union, under the project title ‘Building resilience to climate change through strengthening adaptive small scale farming system in rainfed areas in Bangladesh, India and Nepal’. SHIATS is an associate partner of this action research. This action research initiative seeks to contribute to local food and nutritional security in some of the impoverished regions of the world critically vulnerable to climate change. This action is primarily a civil society attempt to fill the gap in research and extension support to Smallholder farmers (SHF) and also to help in examination of their Food Production, Distribution and Consumption System (FPDCS) in the context of impact and adaptation to climate change and nutritional security potential. The present OFAR was conducted keeping in mind the farmers' points of view (including an understanding of farmers' conditions and problems, their priorities, and their criteria in adopting or rejecting new technologies) with respect to climate change and nutritional food security. The problems were discussed along with the smallholder farmers and solutions to alleviate identified farming constraints were brought about using the locally available inputs as well as improved agronomic practices. The research results are evaluated in terms of their suitability, production levels and economics. OFAR also provide feedback to research stations for further research required.

On-farm adaptive research (OFAR) is an important component of agricultural research that attempts to adapt technology to suit farmers' conditions. On-farm adaptive research is a bridge between technology and production, and thus encourages agricultural development. According to Abraham (2014), OFAR can be defined in its simplest term as research carried out in farmer's environment, by farmer's environment, in an area of farmer's preference, on farmer's land and environment. Further, unlike the conventional On-Farm Research (OFR), OFAR focuses on "Farmer Designed" and "Farmer Implemented" action research where farmers are the leaders and all other stakeholders have the limited role of "facilitation". OFAR includes identifying constraints and opportunities for improvement; choice of improved technologies that fit the local farming systems; their testing and evaluation under farmers' condition and dissemination of suitable technologies to farmers.

OFAR has to relate to farmers as active farmers' participation in OFAR is a necessity and it will provide an interactive mode so that both the researcher and farmer can decide on the conduct of trials, and technology to be tested. And it also improves the chances of its success. Farmers' participation in the OFAR also affords them the opportunities of identifying farming system constraints, problems and its priorities, managing experiment and evaluating results. Participation in this context means the active involvement of all the stakeholders in OFAR process of diagnostic survey, research, field test, and demonstration phases (Adeola *et al.*, 2014). It is often said, that seeing is believing. Results of OFAR have to be seen and approved by farmers and their families as the extent of acceptance/adoption of a product/technology is a measure of success.

Planting date can have a dramatic effect on crop development and yield. Transplanting rice in the optimum period of time is critical to obtain high grain yield. However, optimum rice planting dates are regional and vary with location and genotypes (Bruns and Abbas, 2006 and Sha and Linscombe, 2005). The intensity and distribution of rains during the crop growing period (June to October) play a pivotal role in determining the success of water-intensive crops like rice. Planting rice after the optimum dates can result in higher diseases and insect incidence, tropical storm related lodging, and possible cold damage during heading and the grain filling period resulting in low yields (Groth and Lee, 2003 and Thompson *et al*., 1994). Temperature cannot be manipulated easily under field conditions but seedling/ transplanting dates can be adjusted to meet specific requirements for physiological stages of crop growth cycle. As temperature varies from month to month, it is possible to select the right date for crop establishment in such a way that the reproductive and grain filling phases of rice falls into those months with a relatively low temperature. This would minimize the negative effect of temperature increase on rice yield as reported by Peng *et al*. (2004). Among the crop production tools, proper time of sowing is one of the prerequisites that allow the crop to complete its life phase timely and successfully under a specific agro-ecology (Baloch *et al.*, 2006). As an advantage to farmers, forecasting yield under climate change scenarios will simultaneously give favourable planting dates on which to plant in order to maximize yield.

Mandla district is one of the drought prone districts of Madhya Pradesh with extreme temperature variations and with most farmers facing poor economic condition (*www.safbin.org*). Hence, bringing down the cost of cultivation through use of safer and cheaper inputs has much relevance. Abraham and Lal, 2003, reported that the practice of using all the three forms, *viz.*, inorganic fertilizers, manurial forms and biofertilizer and/or organic spray, registered higher values of the yield parameters in legume-cereal based cropping system, which may be ascribed to the growth promoting properties due to the synergistic phenomenon. Further, this has been proved to create a balancing effect among the soil microflora, physical conditions and the chemical constituents. The scientific integration of various forms of nutrient sources, which not only act as suppliers of nutrients, but also as ammenders of soil physico-chemical and biological features has an amalgamative effect, and this approach is sustainable and profitable for building up production systems with least consequences of breakdown (Lal and Abraham, 2012). *Matka khad* is a cheap soil enrichment solution and also has pre-emergence disease control property. Scientific studies on role of *matka khad* in agriculture are limited (Chadha *et al.*, 2012).

High infestation of green semi-looper (Naranga aenescens Moore) due to dry spell and warm weather during node stage of rice crop was one of the most common and major problem faced by the smallholder farmers in Mandla district of Madhya Pradesh. Green semi-looper (*Naranga aenescens* Moore) is a common pest of rice. They are found in wetland environments. They are abundant during the rainy season. The insect pest is found during the seedling and tillering stages of the rice crop. It infests 30-40 days old upland crop and continues to damage the crop up to 65 days. The larvae feed mainly on leaves and defoliate them. Numerious plant species have been identified as possessing pesticidal properties and have shown potential as alternative to chemical pesticides (Singh, 2000). Plant community is the most efficient source for natural pesticide. It synthesizes numerous products, many of which have been shown to effect on insect and other harmful organism (Nathan, 2013). Neem (*Azadirachta indica*) has proved to be one of the most promising plant ingredient for integrated pest management at the present time. Only about 20-50g of the active ingredient (*Azadirachtin*) is sufficient to treat one hectare of area to achieve a satisfactory reduction in pest populations.

A large population in Mandla district are often characterized by large-scale poverty, and highly dependent on local natural resources, hence these communities are far more vulnerable to the impacts of climate change than urbanized parts of the country. This vast segment of farming community often find it difficult to purchase costly inputs (fertilizers and pesticides) and so, the present trial was carried out using eco-friendly, easily available and low cost practices to help improve the economic condition of the smallholder farmers.

In the light of the above background the present investigation entitled, "Response of rainfed rice (*Oryza sativa* L.) to planting dates and liquid organic formulations in the context of climate change in Mandla district of Madhya Pradesh", was carried out during the *Kharif* season of 2013, with the following objectives.

OBJECTIVES

1. To find the effect of transplanting dates and liquid organic formulations on growth and yield of rainfed rice.

2. To evaluate the efficacy of liquid organic formulations against semi-looper (*Naranga aenescens* Moore) in rainfed rice.

3. Economic analysis of the treatment combinations.

Chapter - II

Review of Literature

CHAPTER 2
REVIEW OF LITERATURE

Adaptive research is part of the research continuum of the development of appropriate agricultural technologies to alleviate identified farming constraints (Murithi, 2000). Tripp (1982) indicated that learning from farmers is a piecemeal, fragmented and interactive process requiring repeated interactive process requiring repeated interaction between researchers and farmers over an extended period of time.

In this chapter, attempt has been made to review the important and relevant research work related to the present thesis entitled, "Response of rainfed rice (Oryza sativa L.) to planting dates and liquid organic formulations in the context of climate change in Mandla district of Madhya Pradesh", which was conducted under the OFAR (On Farm Adaptive Research).

The salient features pertaining to the present investigation are presented under the following headings:

2.1 On Farm Adaptive Research (OFAR).

2.2 Impacts of climate change on rice production.

2.3 Effect of planting dates and liquid organic formulations on growth and yield of rice.

2.4 Effect of liquid organic formulations against semi-looper (Naranga aenescens Moore) in rice.

2.5 Economic analysis of planting dates and liquid organic formulations on rice.

2.1 On Farm Adaptive Research (OFAR)

On-farm adaptive research (OFAR) is a link between the laboratory or on-station research and the actual acceptance of proven technologies by farmers. Farmers' participation in OFAR will provide an interactive mode so that both the researcher and farmer can decide on the conduct of trials, and technology to be tested. Active participation of farmers in the conduct of OFAR improves the chances of its success (Nene, 1993).

Abraham (2014) stated that OFAR can be defined in its simplest term as research carried out in farmer's environment, by farmer's environment, in an area of farmer's preference, on farmer's land and environment. Further, unlike the conventional On-Farm Research (OFR), OFAR focuses on "Farmer Designed" and "Farmer Implemented" action research where farmers are the leaders and all other stakeholders have the limited role of "facilitation".

Subair (2002) reported that the concept of OFAR entails full participation of farmers', direct contact between researchers and farmers and concerted multi-disciplinary investigation of farmers' situations. Only when this is done that farmers will have the opportunity of *articulating their felt needs and the technologies fashioned around such needs become relevant, appropriate and adoptable.*

Knight (1974) remarked that On-farm Research (OFR) involves adaptation and/or adoption of technologies to suit the conditions in a given location with active participation from farmers. Farmers themselves experiment constantly using the resources available to them, borrowing ideas from neighbouring farmers and adopting those ideas, technologies, and cultivars.

Fujisaka (1989) stated that farmers have been increasingly recognised as sources of indigenous knowledge and technology. Since many farmers do experiment themselves, advantage should be taken of their technical knowledge and experimental abilities in planning OFR, evaluation of technical alternatives, and adaptation of technologies to local circumstances.

Adeola et al. (2014) stated that farmers' participation in the OFAR also affords them the opportunities of identifying farming system constraints, problems and its priorities, managing experiment and evaluating results. Participation in this context means the active involvement of all the stakeholders in OFAR process of diagnostic survey, research, field test, and demonstration phases.

Okwu and Ejembi (2005) stressed the need for availability of necessary physical facilities and infrastructures (classrooms, demonstration plots, equipment, teaching aids) in enhancing adoption process of farmers.

2.2 Impacts of climate change on rice production

Yield is end result of interaction between genetic constitutions of a plant and environment under which it grows. Among environment factors, climate plays an important role in getting high yield (Akram et al., 2007).

Furuya and Koyama (2005) reported that high temperatures would cause a marked decrease in world rice production.

Horie et al. (1994) reported that total biomass production of rice is determined mainly by crop photosynthesis and respiration losses, both are which are sensitive to temperature.

Singh and Singh (2006) observed that the low temperature along with short periods of sunshine in late August particularly under late transplanting were responsible for the lower percentage of grain filling.

Ziska et al. (1996) reported that in rice the productive processes occurs within 1 hour after dehiscence of anthers, shedding of pollens, germination of pollen grains on stigma and *elongation of pollen tubes and is sensitive to night temperatures below 20 °C, which results in spikelet sterility with a subsequent reduction in seed set and grain yield.*

Nguyen (2005) opined that variability in the amount and distribution of rainfall is the most important factor limiting yield of rainfed rice. Variability in the onset of the rainy season leads to variation in the start of the planting season in rainfed rice. Moreover, in freely drained upland, moisture stress severely damages or even kills rice plant in an area that receives as much as 200 mm of precipitation in 1 day and then receives no rainfall for the next 20 days. Complete crop failure usually occurs when severe drought stress takes place during the reproductive stage.

Depledge (2002) reported that the changes in the pattern of rainfall distribution may lead to a more frequent occurrence of intense flood and drought in different parts of the world.

Varshneya (2007) observed that in general, the tropical regions appear to be more vulnerable to climate change than the temperate regions for several reasons. (i) On the bio-physical side, temperate C_3 crops are likely to be more responsive to increasing levels of CO_2; (ii) The tropical crops are closer to their high temperature optima and experience high temperature stress, despite lower projected amounts of warming; and (iii) insects and diseases, already much more prevalent in warmer and more humid regions may become even more widespread.

Sushant (2013) reported that with about 90% in Eastern Madhya Pradesh being rainfed, erratic rainfalls in the last fifteen years have caused up to a 60% decrease in crop yields, directly impacting the food security of the region.

2.3 Effect of planting dates and liquid organic formulations on growth and yield of rice

Planting date can have a dramatic effect on crop development and yield (Darko et al., 2013) as well as adopting organic fertilization (compost, animal, and green manure) is widely found to have positive effects on the yields (Branca et al., 2013). The duration of crop stand is important in terms of physiological activities. Longer the time taken for photosynthetic and respiration activities more is the output of plants in terms of growth and yield (Mahmood et al., 1995).

Ghosh and Singh (1998) suggested that for successful rice production, timely planting, appropriate control of vegetative growth throughout the duration of the crop, suitable transplanting densities for optimum tillering and control of leaf growth by controlling water, fertilizer and chemical inputs are essential for improving the growth variables responsible for high yield.

Harper (1983) reported that the optimum sowing time of any field crop depends on the environmental conditions required for good growth and development. Sowing dates can be *manipulated to avoid the periods of greatest risk from insect pests, weeds and diseases and hence improved yields of the crop.*

Akram et al. (2007) reported that yield and yield parameters like number of tillers, grains per panicle, plant height, 1000 grain weight and sterility of different rice varieties/lines were significantly affected by transplanting dates.

Groth and Lee (2003) observed that planting rice after the optimum dates can result in higher disease and insect pest incidence, tropical storm-related lodging and possible cold damage during heading and the grain filling period resulting in low yields.

Yoshida (1981) reported that rice plants require a particular temperature for its phonological affairs such as panicle initiation, flowering, panicle exertions from flag leaf sheath and maturity and these are very much influenced by planting dates during rainy season.

Peng et al. (2004) reported that as temperature varies from month to month, it is possible to select the right date for crop establishment in such a way that the reproductive and grain filling phases of rice fall into those months with a relatively low temperature. This would minimize the negative effect of temperature increase on rice yield.

Singh et al. (2005) reported that the decreasing trend in delayed planting might be associated with significantly lower number of panicles m^{-2} *and grains panicle*$^{-1}$ *along with non-significant decreasing trend in test weight. This may be attributed to the thermo sensitivity of the high yielding varieties of rice at flowering and grain filling stages.*

Sarkar et al. (2006) reported that date of flowering did not vary much when sown between 20 May and 20 July. However, the date of flowering altered when sowing was done on second to third week of August. The shifting in date of flowering was due to the prevalence of a pre-insensitive or basic vegetative phase followed by photoperiod sensitive phase observed in rice. Flowering of rainfed lowland rice occurs within the crop growing season if sown from May onwards up to the first week of August.

Nazir (1994) reported that sowing and transplanting at the optimum time is important for obtaining high paddy yield. Too early or too late transplanting causes yield reduction due to crop sterility and lower number of productive tillers, respectively.

Chandra and Manna (1989) while studying the influence of date of planting found that transplanting in mid-August or mid-September decreased paddy yield by 22 to 54% in 1983 and 22 and 44% in 1984, respectively, compared with transplanting in mid-July.

Bali and Uppal (1995) concluded that rice crop transplanted on 10 July gave 9.4 to 17.9% higher grain yield than 30 July transplanting due to higher root density and NPK uptake.

Nayak et al. (2003) observed that there was a progressive decline in all the growth and yield-attributing characters due to delayed planting on 31 July and 16 August. A fortnight delay in planting from 16 July reduced the grain yield by 7.6 and 3.3% during the first and second year respectively. One day delay in planting from 16 July reduced the grain yield by 24.3% and straw yield by 21.5%. Per day reduction in grain and straw yields was 38 and 45 kg ha^{-1} respectively.

Chaudhary et al. (2011) reported that there was significant reduction in yield attributes, yields and nutrient uptake due to delayed transplanting. Transplanting on 5 July recorded 13.6 and 25.3% higher grain yield than transplanting on 25 July and 4 August, respectively.

Abraham and Lal (2003) reported that in trials conducted using all the three forms, viz., inorganic fertilizers, manurial forms and biofertilizer and/or organic spray, the outcome registered higher values of the yield parameters, which may be ascribed to the growth promoting properties due to the synergistic phenomenon.

Chettri and Bandhopadhya (2005) reported that organic sources of plant nutrients offer the twin benefits of increase in organic matter content and improvement in physical, chemical and microbiological properties of soil while meeting a part of nutrients need of crops.

Miller (2007) reported that organic sources offer more balanced nutrition to the plants, especially micronutrients which positively affect number of tillers in plants and improve reproductive performance.

Lal and Bruce (1999) reported that judicious nutrient management is crucial to humification of carbon in the residues and to soil organic carbon sequestration. Soils under low input and subsistence agricultural practices have low soil organic content which can be improved using organic amendments and strengthening nutrient recycling mechanisms.

Chadha et al. (2012) reported that matka khad promotes the plant growth and that Microbial anylysis indicated higher count of microbial population including Actinomycetes, Azotobactor and Phosphate solublizers, which gave significant higher yield over control in different crops (knol-khol, onion, garden pea, French bean) and efficacy against different plant pathogens.

Shiva (2012) reported increased productivity of various crop, viz., paddy, maize, groundnut, soybean, sorghum, etc., with the application of matka khad.

2.4 Effect of liquid organic formulations against control of semi-looper (Naranga aenescens Moore) in rainfed rice

Effective crop protection is an integral component of efforts to increase and sustain rice (Oryza sativa) yields. Neem has been used for pest control since ancient times. Recent *scientific and commercial interest in neem has evolved in response to the need to find alternatives to costly and hazardous synthetic pesticides (Soon and Bottrell, 1994).*

Pathak and Dhaliwal (1995) reported that various biotic and abiotic constrains encountered the rice production and productivity, among them insects are major harmful biotic factor that caused 21 to 40 per cent losses in rice yield.

Panda and Rath (2003) reported the yield loss due to insect pests of rice ranges from 25 to 51%.

Prakash and Rao (2003) reported that paddy crop suffers maximum losses due to wide range of insects and non-insect-pests under different ecological condition. Insects alone cause about 30% yield losses in rice every year by attacking almost all the aerial parts of the crop plants as well as root system in soil.

Ascher (2000) reported that anti-feedant effects of neem extracts are well known. However, in most insect species IGR effects such as molting disturbance, prevention of pupation and of adult emergence or malformation- production of abnormal pupae and adults, and sterility effects induced by neem treatment in the seemingly normal surviving adults are much more conspicuous and, in fact, important.

Saxena (1982) reported that neem seed derivatives have been found to be promising against sucking insects: the green leafhopper, the brown plant hopper, white backed plant hopper, and foliage feeders such as rice leaf folders, ear cutting caterpillar, and the rice armyworm. Insects fed far less, grew poorly and laid fewer eggs on rice plants.

2.5 Economic analysis of planting dates and liquid organic formulations in rice

Kumar et al. (2013) reported that among the dates of transplanting, 16 July produced maximum net returns than other transplanting dates. Benefit cost ratio was also recorded maximum in 16 July transplanting. The higher returns in 16 July transplanting was due to significantly higher grain yield (3.91 t ha^{-1}) which was 3.99% higher as compared to 26 July transplanting grain yield (3.76 t ha^{-1}).

Chapter – III

Materials and Methods

CHAPTER 3

MATERIALS AND METHODS

Understanding the potential impact of climate change on rice-based production systems is important for the development of appropriate strategies to adapt to and mitigate the likely outcomes on long-term food security of interaction between rice production and climate change (Nguyen, 2005).

The present OFAR was conducted during *Kharif* season of 2013 in 9 villages of Mandla district of Madhya Pradesh under the SAF-BIN programme of Caritas India. During this OFAR project the problems were discussed along with the smallholder farmers and solutions to alleviate identified farming constraints were brought about using the locally available inputs as well as improved agronomic practices. The concept of OFAR entails full participation of farmers, direct contact between researchers and farmers and concerted multi-disciplinary investigation of farmers' situations. Only when this is done that farmers will have the opportunity of articulating their felt needs and the technologies fashioned around such needs become relevant, appropriate and adoptable (Subair, 2002).

The materials, methodology and techniques adopted during the course of the investigation entitled, "Response of rainfed rice (*Oryza sativa* L.) to planting dates and liquid organic formulations in the context of climate change in Mandla district of Madhya Pradesh", which was conducted under the OFAR are described in this chapter under the following heads:

3.1 Experimental site

The experiment was carried out during *Kharif* season of 2013 in the 18 participating farmers' field of Mawai block. Mandla District is one among 50 districts of Madhya Pradesh state, India. It is Located 364 km west towards state capital Bhopal. Mandla is a tribal district of Madhya Pradesh. The district lies almost entirely in the catchment of river Narmada and its tributaries. In Mandla, agriculture is the primary economic activity undertaken by the community on a large scale. Agricultural production in Mandla is strongly dependent upon the amount and distribution of rainfall in a year.

Mandla district is situated in the east central part of Madhya Pradesh and is located between the latitude 22^0 2' and 23^0 22' north and longitude 80^0 18' and 81^0 50' east.

3.2 Soil of the experimental field

The experimental field was divided into two clusters. The 1st cluster comprised of 5 villages, *viz.*, Ghota, Bhadvar, Katigahan, Begakeda and Jaitpuri, and the 2nd cluster comprised of 4 villages, *viz.*, Bijatola, Tikariya, Kheri and Kurela. The soil samples were collected randomly from 3 spots of each field of the two cluster at a depth of 0 to 15cm just before layout of experiment. A representative homogenous composite sample of the cluster was drawn by mixing all these soil samples together, which was analysed to determine the physio-chemical properties of the soil. The result of analysis along with the methods used for determination is presented under the following heads:

3.2.1 Mechanical analysis of the soil

The mechanical analysis of soil (0 to 15 cm depth) is presented in Table 3.1.1 and Table 3.1.2

Table 3.1.1 Mechanical analysis of the soil of farmers' field of 1st cluster (Vertisols)

Mineral fraction	Value (unit)	Method (references)
Sand	28.16 (%)	
Silt	33.41 (%)	Bouyoucos hydrometer method
Clay	37.43 (%)	(Bouyoucos, 1927)
Textural class	Clay loam	

Table 3.1.2 Mechanical analysis of the soil of farmers' field of 2st cluster (Alfisols)

Mineral fraction	Value (unit)	Method (references)
Sand	21.60 (%)	
Silt	47.00 (%)	Bouyoucos hydrometer method
Clay	31.40 (%)	(Bouyoucos, 1927)
Textural class	Silty clay loam	

3.2.2 Chemical analysis of soil

Chemical analysis of the soil (0 to 15 cm depth) is presented in Table 3.2.1 and Table 3.2.2

Table 3.2.1 Chemical analysis of soil at pre-experiment stage of 1st cluster (Vertisols)

Parameter	Value (unit)	Method (references)
Available nitrogen	192.00kg ha^{-1}	Alkaline permanggnate method (Subbiah and Asija, 1956)
Available phosphorus	12.79 kg ha^{-1}	Olsen's colorimetric method (Olsen *et al.*, 1954)
Available potassium	297.00 kg ha^{-1}	Flame Photometer method (Toth and Prince, 1949)
Organic carbon	0.42%	Walkley and Black method (Jackson, 1973)
pH	7.6	Glass electrode pH meter (Jackson, 1973)
EC	0.16dS m^{-1}	Method No.4 USDA Hand Book No.16 (Richards, 1954)

Table 3.2.2 Chemical analysis of soil at pre-experiment stage of 2nd cluster (Alfisols)

Parameter	Value (unit)	Method (references)
Available nitrogen	195.50 kg ha^{-1}	Alkaline permanggnate method (Subbiah and Asija, 1956)
Available phosphorus	13.15 kg ha^{-1}	Olsen's colorimetric method (Olsen *et al.*, 1954)
Available potassium	310.00 kg ha^{-1}	Flame Photometer method (Toth and Prince, 1949)
Organic carbon	0.38 (%)	Walkley and Black method (Jackson, 1973)
pH	7.7	Glass electrode pH meter (Jackson, 1973)
EC	0.18 dS m^{-1}	Method No.4 USDA Hand Book No.16 (Richards, 1954)

3.3 Cropping history

Different crops grown in successive years and seasons in all the 18 farmers' of the 9 villages were recorded for the last 5 years to get an idea about the different species grown. The land was left fallow during the *rabi* and *zaid* cropping season in both the clusters mostly due to scarcity of water/rainfall. Cropping history of the experimental field for the last five years is presented in Table 3.3.

Table 3.3 Cropping history of the experimental field of the two clusters

Years	**Cropping Season**		
	Kharif	***Rabi***	***Zaid***
2008-09	Rice	Fallow	Fallow
2009-10	Rice	Fallow	Fallow
2010-11	Rice	Fallow	Fallow
2011-12	Rice	Fallow	Fallow
2012-13	Rice	Fallow	Fallow
2013-14	Rice (experimental crop)	Fallow	Fallow

3.4Climate and Weather condition

Mandladistrict of Madhya Pradesh has hot moist sub humid climate. It is one of the drought prone districts of Madhya Pradesh with scanty rainfall and extreme temperature variations with erratic pattern.Mandla district extends over the highest plateaus of the Satpura ranging from 500 metres above mean sea level. Thus, the climate of Mandla district is characterised by hot summer season and general dryness except in the southwest monsoon season. The highest temperature, relative humidity and rainfall during the *kharif* trial 2013 was recorded during September II week (34.72 °C), August IV week (117.75%) and August III week (370.20 mm) respectively. The total number of rainy days during the cropping season (*Kharif*, 2013) was 66 days, with a total rainfall of 1527.40 mm.

Table 3.4 Mean weekly weather parameters and total rainfall during the cropping *kharif* season, 2013

Months	Week	Temperature (°C)		Relative humidity (%)		No. of rainy days	Total rainfall (mm)
		Max.	Min.	Max.	Min.		
June	IV	28.41	20.56	91.86	70.50	6	104.80
July	I	28.33	20.27	91.63	86.20	4	82.60
	II	29.44	21.24	92.13	89.25	7	247.20
	III	31.55	21.50	93.13	92.50	7	143.40
	IV	27.36	20.29	94.14	85.50	7	161.40
August	I	30.40	20.76	92.50	83.67	6	52.80
	II	29.53	20.68	92.25	*	5	147.20
	III	28.31	19.26	97.88	90.50	8	370.20
	IV	27.82	25.48	117.75	85.40	3	52.00
September	I	32.54	20.23	88.67	65.33	0	0
	II	34.72	20.23	113.00	67.80	0	0
	III	32.47	19.48	88.65	85.17	4	32.40
	IV	31.60	13.50	77.60	75.00	0	0
October	I	29.97	23.10	92.83	83.17	7	115.40
	II	31.04	*	89.00	69.40	2	7.00
	III	32.19	20.00	94.00	69.57	0	0
	IV	30.46	*	66.00	98.40	0	11.00
November	I	30.90	13.50	85.00	66.80	0	0
	II	28.74	10.60	85.13	54.43	0	0
	III	29.70	15.30	88.50	57.50	0	0
					Grand total	**66**	**1527.40**

*Data not available

Source: India Meteorological Department (IMD), Pune, 2013

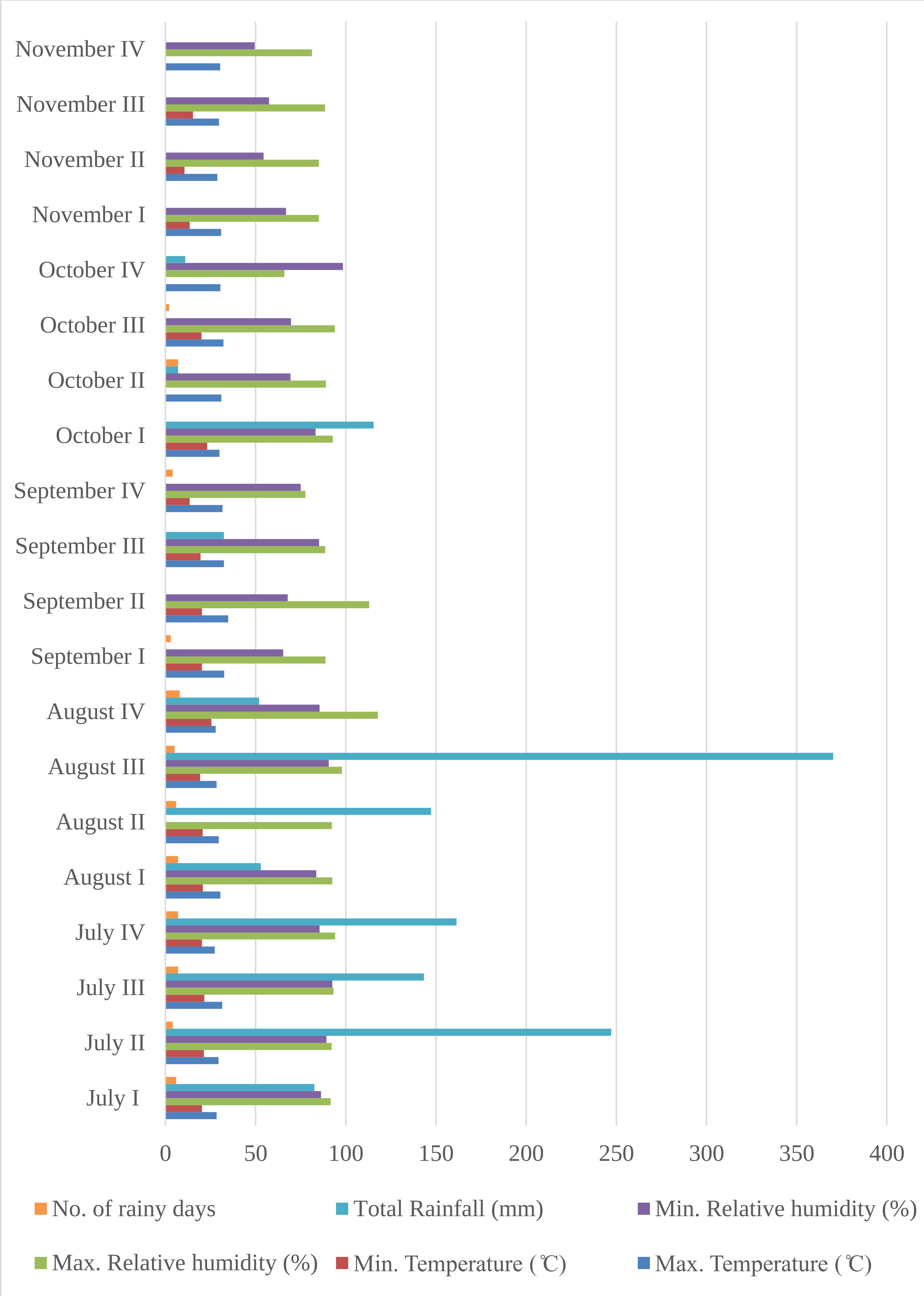

Fig. 3.1 Meteorological observations and total rainfall (weekly) during the experimental period (*Kharif*, 2013)

3.5 Experimental details of OFAR (On-farm Adaptive Research)

The experimental details are given below under different headings:

3.5.1 Experimental design

The experiment was conducted in randomized block design consisting of 2 treatment combinations with 9 replications each and was laid out with the different treatments allocated randomly in each replication spread out into 18 locations.

3.5.2 Details of layout

Experimental Design	:	RBD
Number of treatments	:	2
Number of replications	:	9
Total number of plots	:	18
Net plot size	:	10 m × 10 m (100 m^2)
Width of bunds	:	0.3 m
Length of the field	:	20.9 m
Width of the field	:	93.3 m
Net cultivated area	:	1800 m^2
Gross cultivated area	:	1949.97 m^2

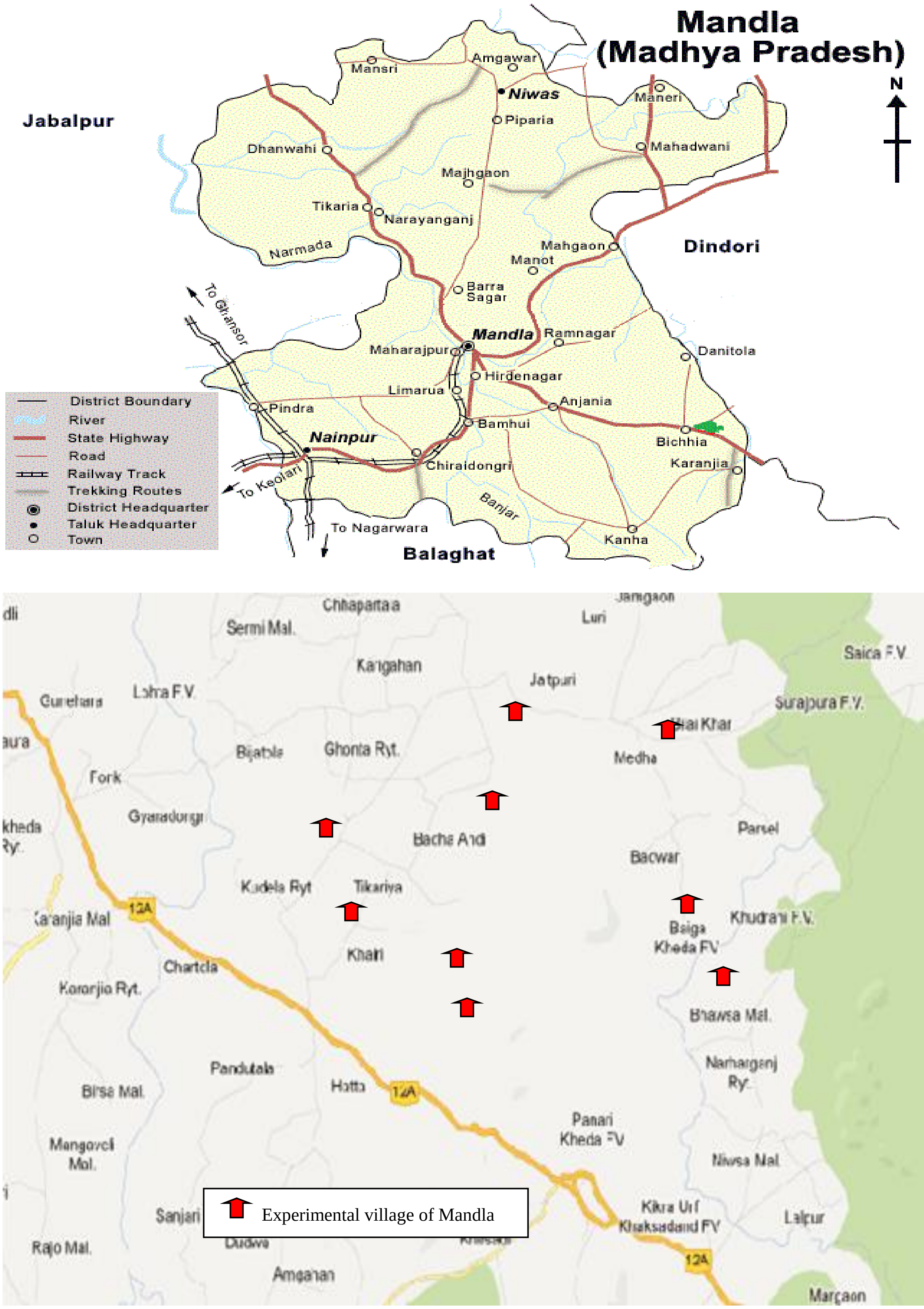

Fig 3.2 Map of Mandla district (M.P.) depicting the 9 villages where th erainfed rice experimental trials were conducted

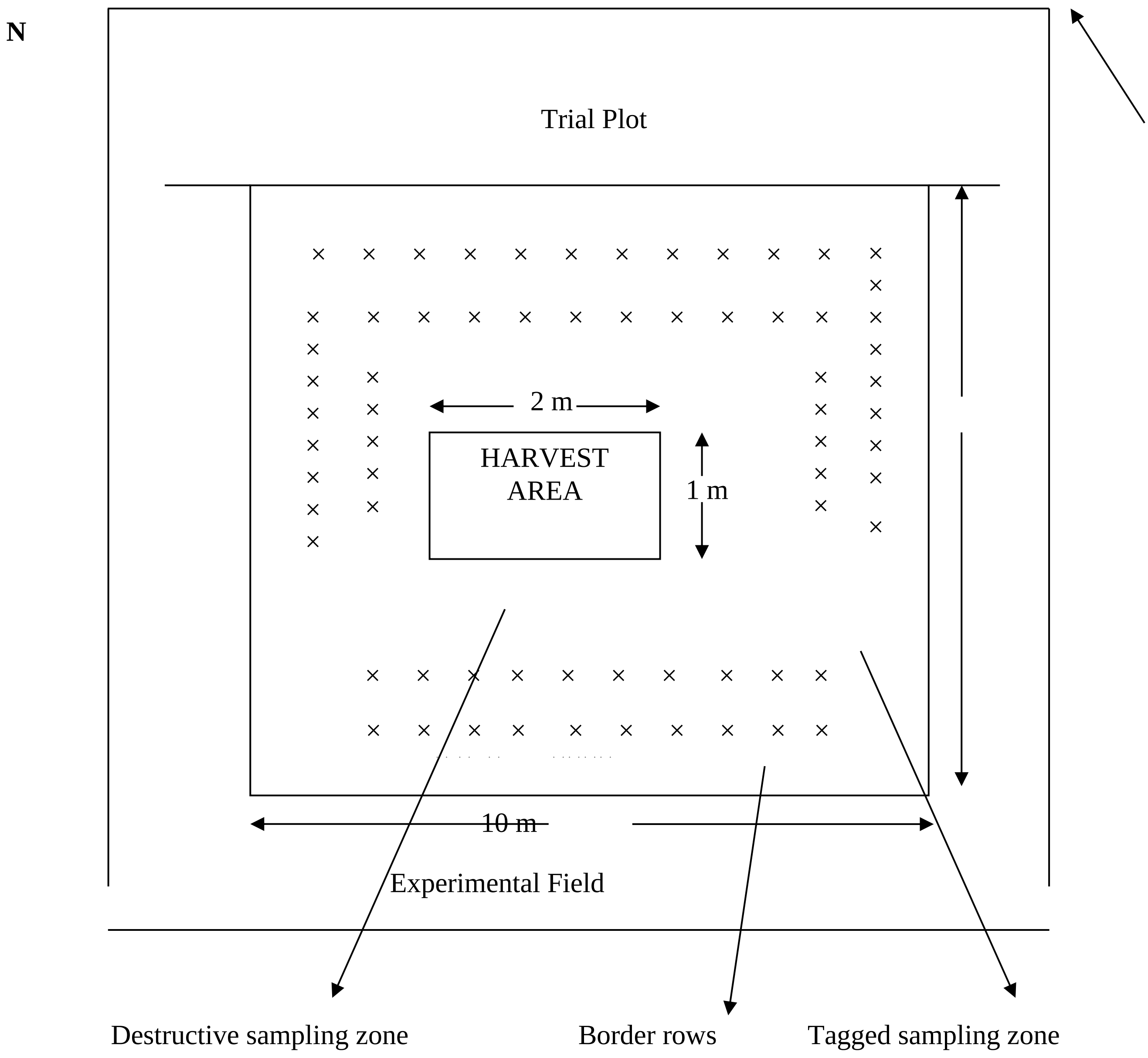

Fig 3.3 Layout of one plot (representative layout) in farmer's field which included total of 18 plots in 9 villages in Mandla district

3.5.3 Details of crop cultivation

Crop : Rice

Variety : MTU1010

Spacing : 20 x 20 cm

Duration : 120 days

3.5.4 Factor for Treatments

Factor I : Date of Planting

i. Modified Transplanting date (July 17 to 19)

ii. Traditional Transplanting date (July 25 to 27)

Factor II : Liquid organic formulation

i. *Matka khad* (2 litre cow urine + 2 kg cow dung + 250 g jaggery + 3 litre water)

ii. Fermented plant juice [*Azadirachta indica* (2 kg leaves)+ *Ipomoea carnea* (2 kg leaves) + *Calotropis procera* (2kg leaves)]

3.5.5 Treatment Combinations*

T_1: Modified transplanting date + 3% of *matka khad*

T_2: Traditional transplanting date + 5% of fermented plant juice

*Under the On Farm Adaptive Research (OFAR), based on the two factors, the two treatment combination was worked out and replicated 9 times.

3.6 Details of raising the test crop

The schedule of different pre and post planting operations carried out in the plot where experiment was conducted in farmers' field has been presented in Table 3.5.

Table 3.5 Chronological record of agro-techniques (Calendar of operations) during experiment

S.No.	Operations	Date		DAT	
1	2	3		4	
		Modified transplanting date	Traditional transplanting date	Modified transplanting date	Traditional transplanting date
1	Seed bed preparation & seed sowing	29.06.2013 to 01.07.2013	05.07.2013 to 07.07.2013		
2	Field preparation (Ploughing + Harrowing + Planking)	07.07.2013 to 09.07.2013	14.07.2013 to 16.07.2013		

3	Basal application of organic manuring (FYM @ 10 t ha^{-1})	10.07.2013 to 13.07.2013	17.07.2013 to 20.07.2013		
4	Transplanting	17.07.2013 to 19.07.2013	25.07.2013 to 27.07.2013	19 to 21	21 to 23
5	Intercultural Operations				
	Gap filling	24.07.2013 to 26.07.2013	24.08.2013 to	7	7
	Two weeding's (Hand weeding)	16.08.2013 to 18.08.2013	01.08.2013 to 03.08.2013	30	30
		30.08.2013 to 01.09.2013	15.08.2013 to 17.08.2013	45	45
6	Organic liquid formulationapplication of*matkakhad* and fermented plant juice(foliar spraying).				
	1st application	01.08.2013 to 03.08.2013	09.08.2013 to 11.08.2013	15	15
	2nd application	16.08.2013 to 18.08.2013	24.08.2013 to 26.08.2013	30	30
	3rd application	31.08.2013 to 02.09.2013	10.08.2013 to 12.08.2013	45	45
7	Harvesting	12.11.2013 to 14.11.2013	18.11.2013 to 20.11.2013	117 to 120	117 to 120
8	Threshing	14.11.2013 to 16.11.2013	21.11.2013 to 23.11.2013		

3.6.1 Land preparation

The farmers' field (experimental field) in all the 9 villages was ploughed with the help of bullock drawn desiplough followed by two harrowing and planking. Thereafterflooding and puddling operations were done manually in all the18 plots. The layout of the field was prepared manually with the help of wooden pegs, rope,measuring tape,*etc*.

3.6.2 Transplanting

The transplanting of 19 to 21 and 21 to 23 days old rice seedling was done manually in all the 18 plots of the farmers' field (experimental field) from 17 to 19 July and 25 to 27 July respectively.

3.6.3 FYM application

FYM was applied at the rate of 10 tonnes ha^{-1} 7 days before transplanting.

3.6.4 Intercultural operations

3.6.4.1 Gap filling

Gaps caused by mortality were filled by re-transplanting after 7 days of transplanting. This operation was done for maintaining a proper hill to hill distance and standard plant population.

3.6.4.2 Weeding

Two hand weeding was done at 30 DAT and 45 DAT by two labourers manually.

3.6.5 Preparation of liquid organic formulations

During the process of finalizing the experiment details the organic liquid formulations which are inherently ITKs, with some refinement were included. *Matka khad* a cheap soil enrichment solution and fermented plant juice which has an anti-feedant effect on pest was a new practice for some of the 18 participating farmers. These organic formulations are eco-friendly, cheap, and made from locally available raw materials, and were included in the treatment considering the preferences of the SHFC members.

The methods for preparation of different liquid organic formulations are given below.

3.6.5.1 *Matkakhad*

The treatment *matkakhad* was prepared with 1 litre cow urine + 2 kg cow dung + 250 g jaggery + 3 litre water. Firstly, the required amount of cow dung and cow urine was mixed together. Then, jaggery was added to the mixture of cow dung and urine, after which the whole mixture was stirred thoroughly. The mouth of the container (plastic drum or mud pot)wascovered withmuslin cloth and kept under shade. The mixture was stirred at an interval of 2 to 3 days. After 15 to 20 days the above mixture was ready for use. *Matka khad* 3% was prepared by adding 300 ml prepared and filtered solution in 10 litres of water, and applied as foliar spray 3 times at fortnightly intervals.

3.6.5.2Fermented plant juice

The leaves and young twigs of *Azadirachta indica* (2 kg leaves)+ *Ipomoea carnea* (2 kg leaves) + *Calotropis procera* (2kg leaves) was used in the preparation of fermented plant juice.The leaves and young twigs were chopped andgrounded,and the mixture was stirred thoroughly in 8 litresof water. The mouth of the container (plastic drum or mud pot)was covered tight withmuslin cloth and kept under shade. The mixture was stirred at an interval of 2 to 3 days. After 15 to 20 days the above mixture was ready for use. Fermented plant juice can be applied to the crop by either spraying through a wide mouth nozzle sprayer or by sprinkling with a broom. Fermented plant juice 5% was prepared by adding 500 ml prepared and filtered solution in 10 litres of water, and applied as foliar spray 3 timesat fortnightly intervals.

3.6.6 Harvesting

The crop was harvested separately from each plot taking 2.0 m^2 area excluding the border rows and sampling rows. The harvesting was done with the help of sickle.The produce from net plot was tied in bundles separately and were allowed for curing (sun drying) in the field for 3 days and thereafterthe weight of bundles was recorded for obtaining biological yield.

3.6.7 Threshing

Threshing of rice was done manually by beating panicles on the sheaf with wooden baton and then seeds were separated by winnowing. This was done on temporary (*kachha*) threshing floor, which was well maintained.

Observations recorded

The observations were recorded with the cooperation of VRAs as per the schedule proposed in the synopsis.The non-destructive samples were recorded from the tagged plants. The other field samples (plants and soil) were brought to the department laboratory (Department of Agronomy), SHIATS, Allahabad, U.P., for necessary analysis.Crop management aspects of the experimental plots in the respective villages were managed by the participating farmers of SHFC, especially the plot owning farmer.

3.7 Growth parameters

The growth parameters are important in determining the ultimate yield potential of the crop. There was some flexibility in dates while taking the observations, due to the distance, logistics, *etc*.

3.7.1 Plant height (cm)

Four hills were selected randomly from each plot and tagged. The heights of these plants were measured from the ground level up to the collar joint of rice. Plant height was recorded at 15, 30, 45, 60, 75 and 90 DAT.

3.7.2 Number of tillers hill^{-1}

Number of tillers hill^{-1}was recorded at 15, 30, 45, 60, 75 and 90 DAT. These were counted from four tagged hills in each plot.

3.7.3 Plant dry weight (g)

Three plants were randomly uprooted without damaging the root from the destructive sampling zone of each plot at 15, 30, 45, 60, 75 and 90 DAT. The samples were air dried and then kept in oven for 72 hours at 70°C after removing the root portion, thereafter dry weight was determined and the average dry weight $hill^{-1}$ was calculated.

3.7.4 Crop growth rate (CGR)

It represents dry weight gained by a unit area of crop in a unit time expressed as g m^{-2} day^{-1} (Fisher, 1921). The values of plant dry weight at 0 to15, 15to30, 30to45, 45 to60, 60 to 75 and 75to90 DAT intervalswere used for calculating the CGR. The value of CGR is expressed ing m^{-2} day^{-1}.

$$\text{Crop growth Rate} = \frac{W_2 - W_1}{t_2 - t_1}$$

Where,

W_1 = Initial dry weight of plant (g)

W_2 = Final dry weight of plant (g)

t_1 = Initial time period

t_2 = Final time period

3.7.5 Relative growth rate (RGR)

It indicates the increase in dry weight per unit dry matter over any specific time interval and it was calculated by the following equation:

$$\text{Relative growth rate (RGR)} = \frac{\text{In}W_2 - \text{In}W_1}{t_2 - t_1}$$

Where,

In = Natural logarithm

W_1 = Initial dry weight of plant (g)

W_2 = Final dry weight of plant (g)

t_1 = Initial time period

t_2 = Final time period

It is also called efficiency index (y) and is expressed in g g^{-1} day^{-1} (Fisher, 1921).

This parameter was calculated for the time intervals, *i.e.*, 15 to 30, 30 to 45, 45 to 60, 60 to 75 and 75 to 90 DAT intervals using the data obtained from dry weight of plants.

3.8 Yield and Yield attributes

3.8.1 Panicle length (cm)

Panicle length (cm) was observed at the time of harvest from the fourrandomly tagged hills and their averages were recorded.

3.8.2 Number of grains panicle^{-1}

Grains from the four panicles were counted separately which were obtained randomly from the harvest zone (net plot) and their averages were recorded.

3.8.3 Test weight (g)

One thousand grains were randomly counted from the threshed, cleaned and dried grains obtained from each plot and weighed and recorded as test weight (g) at 14% moisture approximately. The moisture of the grains was tested by biting the grains before taking the test weight which was done 4 weeks after harvesting of the crop.

3.8.4 Grain yield (t ha^{-1})

Grains from the harvest area (2.0 m^2) were dried in sun, cleaned and weighed separately from each plot for calculating the grain yield in tonnes hectare^{-1}.

3.8.5 Straw yield (t ha^{-1})

Straw from the harvest area (2.0 m^2) was dried in sun, bundled, tagged and weighed separately from each plot for calculating the straw yield in tonnes hectare^{-1}.

3.8.6 Harvest index (%)

Harvest index was obtained by dividing the economic yield (grain) by the biological yield (grain + straw). It was calculated for each of the plots and was represented in percentage. The following formula was used (Donald, 1962).

$$\text{Harvest index (\%)} = \frac{\text{Economic yield (t ha}^{-1}\text{)}}{\text{Biological yield (t ha}^{-1}\text{)}} \times 100$$

3.9 Post-harvest qualitative studies

Approximately 100 g seed samples were collected at the time of threshing from each plot after dehusking and thereafter, ground into powder with the help of pestle and mortar. The qualitative parameters, *viz*., protein (%) and carbohydrate (%) in grains was evaluated. The methodology that was adopted is described below.

3.9.1 Protein (%) in grain

It is calculated by the formula, Protein (%) = N (%) × 6.25. The nitrogen content of grains was analyzed by Micro-Kjeldahl’s method (AOAC, 1965).

The Micro-Kjeldahl’s methodfor total nitrogen content (%) essentially involves digestion of the sample to convert N compounds in the sample to NH_4 form. The grain sample was digested with sulphuric acidand catalyst mixture (K_2SO_4 + $CuSO_4$) was added to each digestion tube to raise the temperature of digestion and thereafter, cooled to room temperature. The digest was transferred to distillation flask with granulated zinc added to it (which act as anti-bumping agent). Thirty to 50 ml NaOH was poured into the distillation flask where NH_4 was captured in the flask containing boric acid and the ethylene blue indicator was mixed in receiving flask. Titration of the sample was done by using 0.05N HCl. Similar procedure for blank sample was followed. The N (%) content was calculated using the formula:

$$\text{Nitrogen (\%)} = \frac{\text{(Sample titre – Blank titre)} \times 0.05\text{N HCl} \times 14 \times 100}{\text{Weight of sample (g)} \times 1000}$$

3.9.2 Carbohydrate (%) in grain

The following formula was used for calculation (Ranganna, 2003).

Carbohydrate (%) = 100 – [Moisture (%) + Fat (%) + Ash (%) + Protein (%)]

3.9.3 Fat (%) in grain

The extractor and extract flask were cleanedand dried. The extract flask was weighed on chemical balance up to 2 decimal. Two grams of prepared sample was placed on whatman paper number 42, which was folded in to a shape as thimble and it was placed inside the extractor. Two hundred fifty ml of ether solvent was added in the extractor flask and to avoid overheating, the intensity of heat from electric coil was lowered with the help of regulator and 1000 ml of ether solvent were used in four cycles of siphoning, which was needed for complete removal of fat of grain sample.

The solvent was kept in flask and only the fat content was heated gently till the smell of ether was not there. It was taken out and kept for cooling and the weight was taken. It was represented in percentage. The following formula was used for calculation (Ranganna, 2003).

$$\text{Fat percentage} = \frac{(X - Y)}{\text{Weight of sample}} \times 100$$

Where,

X is initial weight of flask (g)

Y is final weight of flask (g)

3.9.4Moisture (%) in the rice grain

This method consists in measuring the weight lost by prepared sample. The moisture content was determined by the air oven method and the methodology was used as follows. The temperature of the oven was set at 80 °C and samples were placed inside the oven and the final weight of samples were measured after 8 hours (Ranganna, 2003).

$$\text{Moisturepercentage} = \frac{(X - Y)}{X} \times 100$$

Where,

X = initial weight of grain sample (g)

Y = final weight of grain sample (g)

3.9.5 Ash (%) in the rice grain

The ash content in rice was determined by the Bunsen burner and muffle furnace. The methodology was used as follows. Two g sample was prepared and put in the crucible and the initial weight was taken. The sample was kept over the Bunsen burner for 5 to 6 minutes. Samples were put inside the muffle furnace at 525 °C for 4 hours and thereafter it was cooledwith the aid ofdessicator and the final weight was recorded. The difference in weights gave the total ash content and was expressed as percent (Ranganna, 2003).

$$\text{Ashpercentage} = \frac{(X - Y)}{X} \times 100$$

Where,

X = initial weight of grain sample (g)

Y = final weight of grain sample (g)

3.10 Economic analysis

Cost of cultivation, gross return, net return and benefit cost ratio was worked out to evaluate the economics of each treatment, based on the existing market prices of inputs and outputs.

Cost of Cultivation(₹ ha^{-1})

The cost of cultivation for each treatment was worked out separately, taking into consideration all the cultural practices followed in the cultivation.

Gross return (₹ ha^{-1})

The gross return from each treatment was calculated.

Gross return(₹ ha^{-1}) = Income from grain + Income from straw

Net return(₹ ha^{-1})

The net profit from each treatment was calculated separately, by using the following formula.

Net return (₹ ha^{-1}) = Gross return – cost of cultivation

Benefit cost ratio

The benefit cost ratio was calculated using the following formula

$$\text{Benefit cost ratio} = \frac{\text{Gross return (₹ ha}^{-1}\text{)}}{\text{Cost of cultivation (₹ ha}^{-1}\text{)}}$$

3.11 Statistical analysis

Data recorded on different aspects of crop, *viz*., growth, yield attributes and yield were tabulated and subjected to statistical analysis as per Gomez and Gomez, 1976. Significance of difference between treatment means was tested through 'F' test and the critical difference (CD) was worked out wherever 'F' value was found to be significant for treatment effect. The analysis of variance for the data has been given in appendix at the end of this thesis. Table 3.6 depicts the skeleton of ANOVA.

Table 3.6 Skelton of ANOVA

Sources of variation	df	SS	MSS	F Cal
Replication	r-1	RSS	RMSS	RMSS/EMSS
Treatment	t-1	TSS	TMSS	TMSS/EMSS

Error	(r-1) (t-1)	ESS	EMSS	-
Total	rt-1	Total SS	-	-

The significant difference between the means was tested against the critical difference at 5% level of significance.

$$SEd = \sqrt{\frac{2 \times MSSE}{r \times s}}$$

CD (P=0.05) = S. Ed. (±) x t error degrees of freedom at 5%

$$CV = \frac{\sqrt{EMSS}}{Mean} \times 100$$

Where,

CD	=	Critical difference
CV	=	Coefficient variance
d.f.	=	Degrees of freedom
EMSS	=	Error mean sum of squares
ESS	=	Error sum of squares
MSS	=	Mean sum of squares
r	=	Replication
RMSS	=	Replication mean sum of squares
RSS	=	Replication sum of squares
SS	=	Sum of squares
t	=	Treatment

TMSS	=	Treatment mean sum of squares
TSS	=	Treatment sum of squares

Chapter - IV

Results

and

Discussion

CHAPTER 4

RESULTS AND DISCUSSION

The findings of the present experiment entitled, "Response of rainfed rice (*Oryza sativa* L.) to planting dates and liquid organic formulations in the context of climate change in Mandla district of Madhya Pradesh", which was conducted under theOn Farm Adaptive Research (OFAR), are being presented and discussed in the following pages under appropriate headings. Data on pre-harvest and post-harvest observations were analyzed and discussion on experimental findings in the light of scientific reasoning has been attempted to arrive upon logical reasons.

The OFAR is a part of SAF-BIN (Strengthening Adaptive Farming in Bangladesh, India and Nepal) programme funded by European Union, under the project title 'Building resilience to climate change through strengthening adaptive small scale farming system in rainfed areas in Bangladesh, India and Nepal', with the primary objectives of developing the FPDCS and SHFC. SHIATS is an associate partner of this action research. The adaptive research activities are conducted on-farm, with varying degrees of researcher and farmer involvement in the design and management of on-farm trials. OFAR aims at the development of appropriate agricultural technologies to alleviate identified farming constraints, especially better agronomic practices, insect-pest management,*etc*.

OBSERVATIONS RECORDED

A. Pre-harvest observations (at 15, 30, 45, 60, 75 and 90 DAS/DAT)

4.1 Plant height (cm)

4.2 Plant dry weight (g)

4.3 CGR (g m^{-2} day^{-1}) at 0 to 15, 15 to 30, 30 to 45, 45 to 60, 60 to 75 and 75 to 90 DAT intervals

4.4 RGR (g g^{-1} day^{-1})at 15 to 30, 30 to 45, 45 to 60, 60 to 75 and 75 to 90 DAT intervals

4.5 Number of tillers $hill^{-1}$

B. Post-harvestobservations

4.6 Panicle length (cm)

4.6Number of grains panicle^{-1}

4.6Test weight (g)

4.6Grain yield (t ha^{-1})

4.6Straw yield (t ha^{-1})

4.6Harvest Index (%)

C. Damage (%) of rainfed rice by semi-looper(*Narangaaenescens* Moore)as perceived by the farmers

D. Quality parameter

4.8Carbohydrate content in grain (%)

4.8Protein content in grain (%)

E. Economics

4.9 Cost of cultivation (₹ ha^{-1})

4.9 Gross return (₹ ha^{-1})

4.9Net return (₹ ha^{-1})

4.9Benefit cost ratio

F. Nutrient and chemical properties of soil

4.10Available Organic carbon (%)

4.10Available N(kg ha^{-1})

4.10 Available P (kg ha^{-1})

4.10Available K (kg ha^{-1})

4.10pH

4.10EC (dSm^{-1})

GROWTH PARAMETERS OF RICE

A. Pre-harvest findings

4.1 Plant height (cm)

Observations regarding the plant height are given in table 4.1.

The data showed that there was an increase in plant height at successive growth stages. At 15, 45, 60, 75 and 90 DATplant height was found to be non-significant, except at 30 DAT. At 30DAT significant and highest plant height (31.16 cm) was observed in treatment T_1(Modified transplanting date + *matka khad*)than treatment T_2 (Traditional transplanting date + fermented plant juice). Also, at 15,45,60,75 and 90 DAT highest plant height(19.68, 48.72, 66.09, 79.81 and 85.88 cm respectively) was observed intreatment T_1(Modified transplanting date + *matka khad*) though non-significant.

Plant height did not differ significantly in reference totransplanting date. Increased plant height in earlier transplanting dates was due to availability of prolonged period for vegetative growth (Safdar*et al*., 2008). Thedecrease in plant height under late sowing may be due to shorter growing period. The result confirm the finding of Mukherjee (2012) on wheat.

4.2 Plant dry weight (g hill^{-1})

Observations regarding the plant dry weight are given in table 4.2.

The data showed that there was anincrease in plant dry weightfrom 15 to 90 DAT. At 15, 30, 45 and 60 DAT, plant dry weight was significant. At all the successive stages 15, 30, 45, 60, 75 and 90 DAT highest plant dry weight (0.87, 2.47, 7.90, 15.83, 21.83 and 23.32 g hill^{-1} respectively) was observed in treatment T_1 (Modified transplanting date + *matka khad*) as compared to treatment T_2 (Traditional transplanting date + fermented plant juice).

Vandana*et al*. (1994) reported that dry matter accumulation in leaves decreased in test cultivars with later transplanting dates. The amount of plant dry matter accumulation was appropriate in early transplanting in the current experiment, because of sufficient planting and plant growth period with environmental conditions. Further, it may be also because thecrop could cover entire surface of ground more properly and use environmental factors more pleasantly, and finally more total dry weight has been produced as compared to late transplanting. This corroborates the findings of Moradpour*et al*. (2013).

Table 4.1 Effect of planting dates and liquid organic formulations on plant height (cm) of rice at different intervals

Treatments	Plant height (cm)					
	15DAT	**30DAT**	**45DAT**	**60DAT**	**75DAT**	**90DAT**
T_1 Modified transplanting date + *matka khad*	19.68	31.16	48.72	66.09	79.81	85.88
T_2 Traditional transplanting date + fermented plant juice	17.42	27.12	44.48	62.04	75.51	81.25
SEd (±)	1.26	1.59	2.02	0.26	4.39	4.27
CD (P=0.05)	NS	3.67	NS	NS	NS	NS
CV (%)	14.42	11.58	9.19	12.19	12.00	10.84

Traditional transplanting date: July 25 to 27
Modified transplanting date : July 17 to 19

Table 4.2 Effect of planting dates and liquid organic formulations on plant dry weight ($g\ hill^{-1}$) of rice at different intervals

Treatments	**Dry weight ($g\ hill^{-1}$)**					
	15 DAT	**30 DAT**	**45 DAT**	**60 DAT**	**75 DAT**	**90 DAT**
T_1 Modified transplantingdate + *matka khad*	0.87	2.47	7.90	15.83	21.83	23.32
T_2 Traditional transplantingdate + fermented plant juice	0.71	1.94	7.17	14.42	20.56	21.69
SEd (±)	0.04	0.13	0.26	0.59	0.55	0.87
CD (P=0.05)	0.10	0.31	0.59	1.37	NS	NS
CV (%)	11.87	12.80	7.32	8.3	7.76	8.17

Traditional transplanting date: July 25 to 27
Modified transplanting date : July 17 to 19

4.3 Crop Growth Rate (g $m^{-2}day^{-1}$)

Observations regarding the CGR are given in the table 4.3 and fig. 4.1.

The data showed that at 0 to 15, 15 to 30 and 75 to 90 DAT intervals, significant difference with regard to crop growth rate was evident, whereas at 30 to 45, 45 to 60 and 60 to 75 DAT intervals non-significant difference was observed. The highest crop growth rate was observed at 45 to 60 DAT interval. At 0 to 15, 15 to 30, 30 to 45, 45 to 60 and 75 to 90 DAT intervals, highest crop growth rate (1.44, 2.67, 8.98, 13.29 and 2.48g $m^{-2}day^{-1}$ respectively) was observed in treatment T_1 (Modified transplanting date + *matka khad*) as compared to treatment T_2 (Traditional transplanting date + fermented plant juice). However, at 60 to 75 DAT interval highest crop growth rate (10.22 g $m^{-2}day^{-1}$) was observed in treatment T_2 (Traditional transplanting date + fermented plant juice).

Crop growth rateis an index of total dry matter per ground area per time(Moradpour*et al*., 2013). Since the rate of plant dry matter accumulation was appropriate in early transplanting date in the current experiment, crop growth rate was also found to be higher,which may be due to the appropriate environmental conditions. The use of different local formulation proved beneficial and produced better growth of the plant (Chadha *et al*., 2012).

Table 4.3 Effect of planting dates and liquid organic formulations on crop growth rate ($g\ m^{-2}\ day^{-1}$) of rice at different intervals

Treatments	Crop growth rate ($g\ m^{-2}\ day^{-1}$)					
	0 to15 DAT	15 to 30 DAT	30 to 45 DAT	45 to 60 DAT	60 to 75 DAT	75 to 90 DAT
T_1 Modified transplanting date + *matka khad*	1.44	2.67	8.98	13.29	10.00	2.48
T_2 Traditional transplanting date + fermented plant juice	1. 18	2.05	8.70	12.09	10.22	1.89
SEd (±)	0.08	0.07	0.28	0.69	0.53	0.25
CD (P=0.05)	0.19	0.15	NS	NS	NS	0.58
CV (%)	22.34	18.94	6.56	11.45	11.18	24.2

Traditional transplanting date: July 25 to 27
Modified transplanting date : July 17 to 19

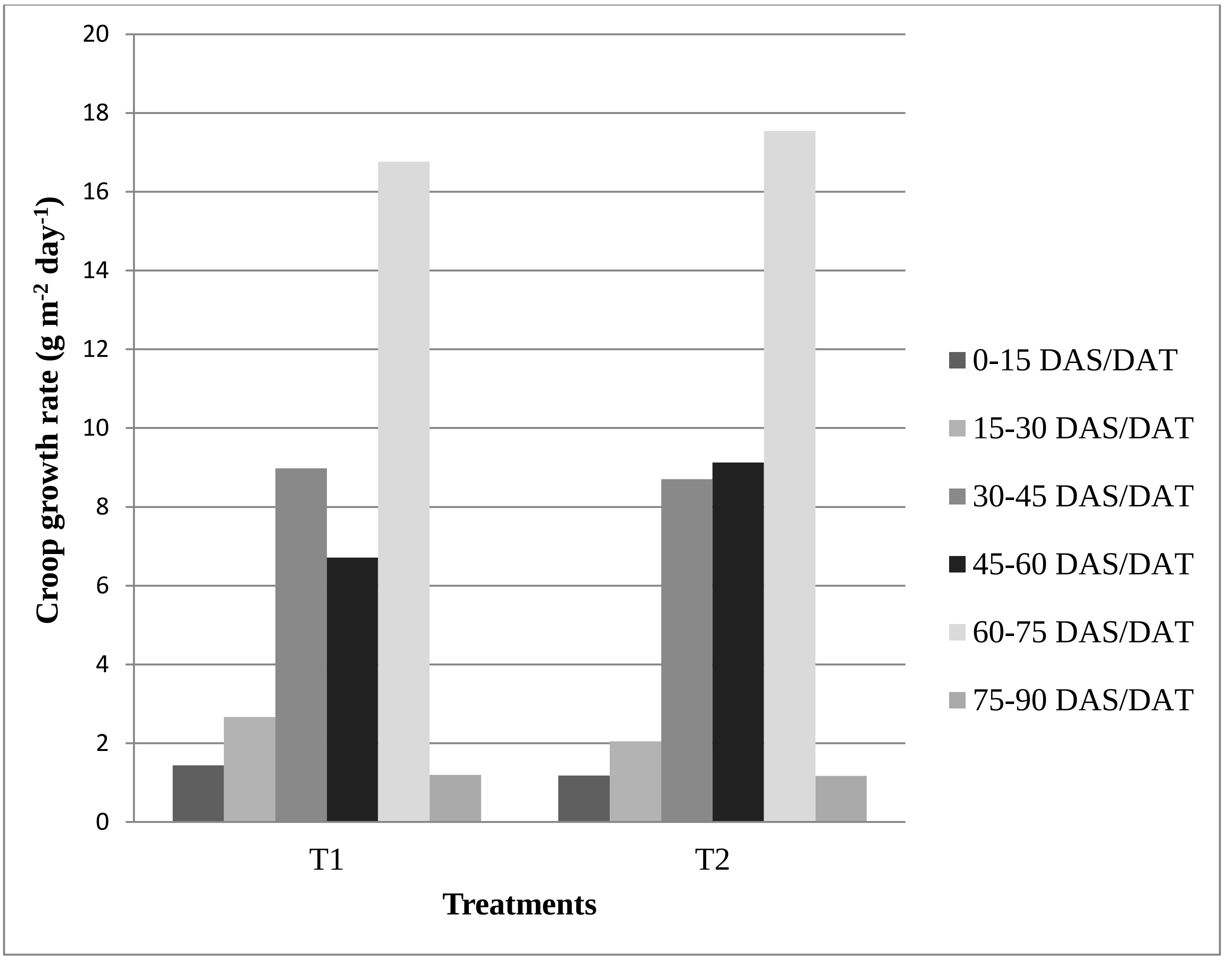

Fig 4.1Crop growth rate (g m^{-2} day^{-1}) ofrainfed rice at different intervals as effectedby planting dates and liquid organic formulations

4.4 Relative Growth Rate (g g^{-1} day^{-1})

Observations regarding the RGR are given in table4.4 and fig. 4.2.

The relative growth rate increased at initial stage and peaked at 30 to 45 DAT interval. Thereafter, there was a decreasing trend till maturity stage. At 30 to 45 and 75 to 90 DAT intervals significant difference with regard to relative growth ratewasobserved, however at 15 to 30,45 to 60 and 60 to 75 DAT intervals relative growth rate was observed to be non-significant. At 15 to 30, 30 to 45 and 60 to 75 DAT intervals, highest relative growth rate (0.081, 0.085 and 0.024 g g^{-1} day^{-1}respectively) was observed in treatment T_2 (Traditional transplanting date + fermented plant juice). Whereas, at 45 to 60 and 75 to 90 DAT intervals highest relative growth rate (0.048 and 0.005 g g^{-1} day^{-1}respectively) was observed in treatment T_1 (Modified transplanting date + *matka khad*).

In both the treatments T_1 (Modified transplanting date + *matka khad*) and T_2 (Traditional transplanting date + fermented plant juice) the highestrelative growth rate (0.078 and 0.086g g^{-1} day^{-1}respectively) was observed at 30 to 45 DAT interval, which was 93.59% and 96.5% respectively higher than the lowest relative growth rate (0.005 and 0.003g g^{-1} day^{-1}respectively) observed at 75 to 90 DAT interval.

4.5 Number of tillers $hill^{-1}$

Observations regarding the number of tillers $hill^{-1}$ are given in table 4.5.

The data showed that there was an increase in number of tillers $hill^{-1}$at all the successive stages. At all the growth stages non-significant difference with regard to number of tillers $hill^{-1}$wasobserved, except at 15 DAT. At 15 DATnumber of tillers $hill^{-1}$(5.00) was significantly higher in treatment T_1 (Modified transplanting date + *matka khad*) than treatment T_2 (Traditional transplanting date + fermented plant juice). At 30, 45, 60, 75 and 90 DAT,highest number of tillers $hill^{-1}$ (7.42, 10.03, 12.17, 13.94 and 14.22 respectively) was observed in treatment T_1 (Modified transplanting date + *matka khad*) though non-significant.

Kumar *et al*. (2013) reported that, varying the date of transplanting of rice was found to influence the number of tillers $hill^{-1}$.

Table 4.4 Effect of planting dates and liquid organic formulations on relative growth rate (g g^{-1} day^{-1}) of rice at different intervals

Treatments	Relative growth rate (g g^{-1} day^{-1})				
	15 to 30 DAT	30 to 45 DAT	45 to 60 DAT	60 to 75 DAT	75 to 90 DAT
T_1 Modified transplanting date + *Matka khad*	0.075	0.078	0.048	0.022	0.005
T_2 Traditional transplanting date + fermented plant juice	0.081	0.086	0.047	0.024	0.003
SEd (±)	0.004	0.003	0.002	0.001	0.0004
CD (P=0.05)	NS	0.006	NS	NS	0.001
CV (%)	11.08	6.71	7.03	8.55	23.45

Traditional transplanting date: July 25 to 27
Modified transplanting date : July 17 to 19

Table 4.5 Effect of planting dates and liquid organic formulations on number of tillers hill^{-1} of rice at different intervals

Treatments	Numbers of tillers hill^{-1}					
	15 DAT	**30 DAT**	**45 DAT**	**60 DAT**	**75 DAT**	**90 DAT**
T_1 Modified transplanting date + *matka khad*	5.00	7.42	10.03	12.17	13.94	14.22
T_2 Traditional transplanting date + fermented plant juice	3.97	6.47	9.56	11.78	13.36	13.75
SEd (±)	0.42	0.53	0.98	1.54	2.17	3.34
CD (P=0.05)	0.94	NS	NS	NS	NS	NS
CV (%)	19.29	16.17	21.14	27.23	33.78	50.66

Traditional transplanting date: July 25 to 27
Modified transplanting date : July 17 to 19

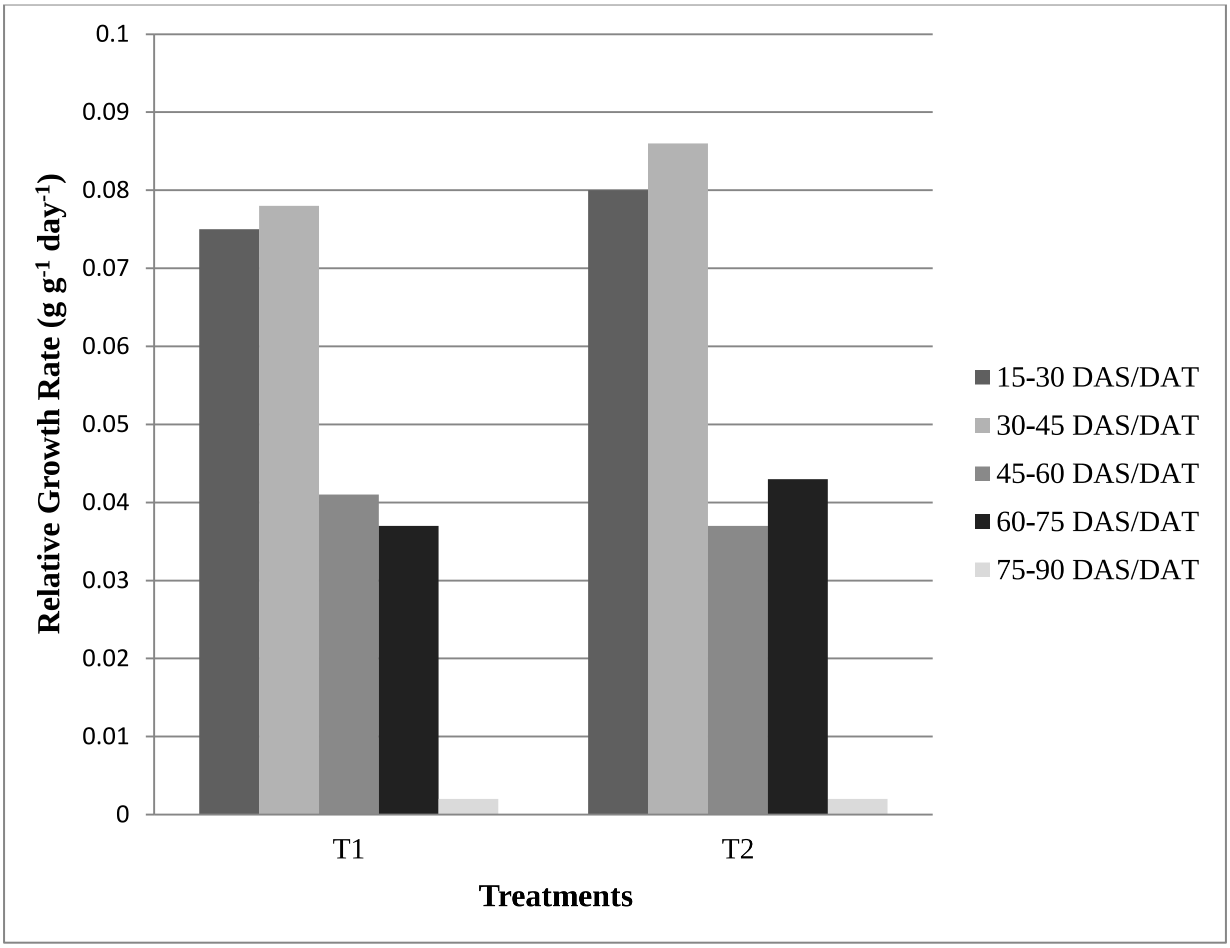

Fig 4.2Relative growth rate (g g^{-1} day^{-1}) of rainfed rice at different intervals as effected by planting dates and liquid organic formulations

B. Post-harvest findings

4.6 Panicle length (cm)

Observations regarding the panicle length (cm) are given in table 4.6 and fig 4.3.

Significant effect of transplanting date was observed on panicle length. Highest panicle length (21.01 cm) was observed in treatment T_1 (Modified transplanting date + *matka khad*) which was 16.46% higher as compared to treatment T_2 (Traditional transplanting date + fermented plant juice).

The combined effect of transplanting date and liquid organic formulation was apparently evident, and may be attributed as a positive interaction between the two factors.

4.6Number of grains panicle^{-1}

Observations regarding the number of grains panicle^{-1} are given in table 4.6.

The data showed that there was no significant effect of dates of transplanting on number of grains panicle^{-1}. However, treatment T_1 (Modified transplanting date + *matka khad*) produced comparatively higher number of grains panicle^{-1}(158.06) which was 4.98% higher than treatment T_2 (Traditional transplanting date + fermented plant juice).

Chaudhary *et al*.(2011), Kumar *et al*. (2013) and Mukesh*et al*.(2013) reported that number of grains panicle^{-1}did not differ significantly due to time of transplanting but early transplanting recorded comparatively higher number of grains panicle^{-1}. Less number of grains panicle^{-1} in late sowing may be due to less production of photosynthates due to shorter growing period. This result is in line with that of Shahzad*et al*. (2002). Planting rice after the optimum dates can result in higher disease and insect pest incidence, tropical storm-related lodging and possible cold damage during heading and the grain filling period resulting in low yields (Groth*and* Lee, 2003).

4.6 Test weight (g)

Observations regarding the test weight are given in table 4.6.

The analysis of test weightvalue was not found to be significant. However the highest test weight (26.00 g) was observed in treatment T_1 (Modified transplanting date + *matka khad*) as compared to treatment T_2 (Traditional transplanting date + fermented plant juice),which was higher by 2.08%.

Test weight remained unaffected. There was no significant effect of date of transplanting on test weight. Similar findings were reported by Chaudhary *et al*.(2011), Mukesh*et al*.(2013) and Kumar *et al*.(2013). The reduction in test weight due to delay in sowing was mainly due to reduction in growth period (Mukherjee, 2012).

4.6 Grain yield (t ha^{-1})

Observations regarding the grain yield are given in table 4.6 and fig 4.4.

The statistical analysis pertaining to grain yield showed no significant difference. The highest grain yield (5.77 t ha^{-1}) was recorded in treatment T_1 (Modified transplanting date + *matka khad*).The grain yield of treatment T_1 (Modified transplanting date + *matka khad*) was higher by 23.56% than treatment T_2 (Traditional transplanting date + fermented plant juice).

Noorbakhshian (2003) and Mukesh*et al*. (2013) reported that the delay in transplanting resulted in reduced grain yield. It is a natural process that the crop which had taken more number of days from seeding to maturity might have a more vigorous and extensive root system, increased growth rate during vegetative growth, more efficient sink formation and greater sink size, greater carbohydrate translocation from vegetative plant parts to the spikelets and longer leaf area index during grain filling period (Diouf*et al*., 2000). Hence, this might be the possible reason to have high yields in earlier transplanting (Shah and Yadav, 2001). The decreasing yield trend in delayed planting mightalso be associated with lower number of panicles and grains panicle^{-1} due torelatively more adverse condition.

The use of different local formulation proved beneficial and produced better growth of the crop and ultimately the final end of the product, *i.e.*, yield of the crop. The better performance of the crop may be due to the presence of better microbial population in the different formulations (Chadha *et al*., 2012).

4.6 Straw yield (t ha^{-1})

Observations regarding the straw yield are given in table 4.6.

The analyzed data of straw yield showed non-significant result. However,treatment T_1 (Modified transplanting date + *matka khad*) recorded the maximum straw yield (15.85 t ha^{-1}) which was 3.33% higher than Treatment T_2 (Traditional transplanting date + fermented plant juice).

Nayak*et al*.(2003) and Kumar *et al*. (2013) reported that straw yield was not influenced by date of transplanting, though early transplanting recorded the maximum straw yield.Mukesh*et al*. (2013) also similarly observed that straw yield decreased due to delayed transplanting.

4.6 Harvest index (%)

Observations regarding the harvest index are given in the table 4.6 and fig 4.5.

The statistical data of harvest index showed non-significant difference. The highest harvest index (35.71%) was recorded in treatment T_1 (Modified transplanting date + *matka khad*) as compared to treatment T_2 (Traditional transplanting date + fermented plant juice). The harvest index of treatment T_1 (Modified transplanting date + *matka khad)* was 15.49% higher than treatment T_2 (Traditional transplanting date + fermented plant juice).

Singh *et al*. (2012) reported that the negative effects of late transplanting on grain yield was greater than on biomass yield leading to drastic reduction in harvest index. Due to late transplanting, harvest index was decreased. Yang *et al*. (2006) also reported that, harvest index is highly correlated with grain yield, and thus late transplanted crop had low harvest index.

Table 4.6 Effect of planting dates and liquid organic formulations on yield attributes of rice at different intervals

Treatments	Yield attributes					
	Panicle Length (cm)	**Number of grains panicle^{-1}**	**Test weight (g)**	**Grain Yield (t ha^{-1})**	**Straw yield (t ha^{-1})**	**Harvest index (%)**
T_1 Modified transplanting date + *matka khad*	21.01	158.06	26.00	5.77	15.85	35.71
T_2Traditional transplanting date + fermented plant juice	18.04	150.56	25.47	4.67	15.34	30.92
SEd (±)	1.01	19.34	0.27	0.66	1.06	3.65
CD (P=0.05)	2.43	NS	NS	NS	NS	NS
CV (%)	11.47	26.59	2.23	26.89	14.46	8.42

Traditional transplanting date: July 25 to 27
Modified transplanting date : July 17 to 19

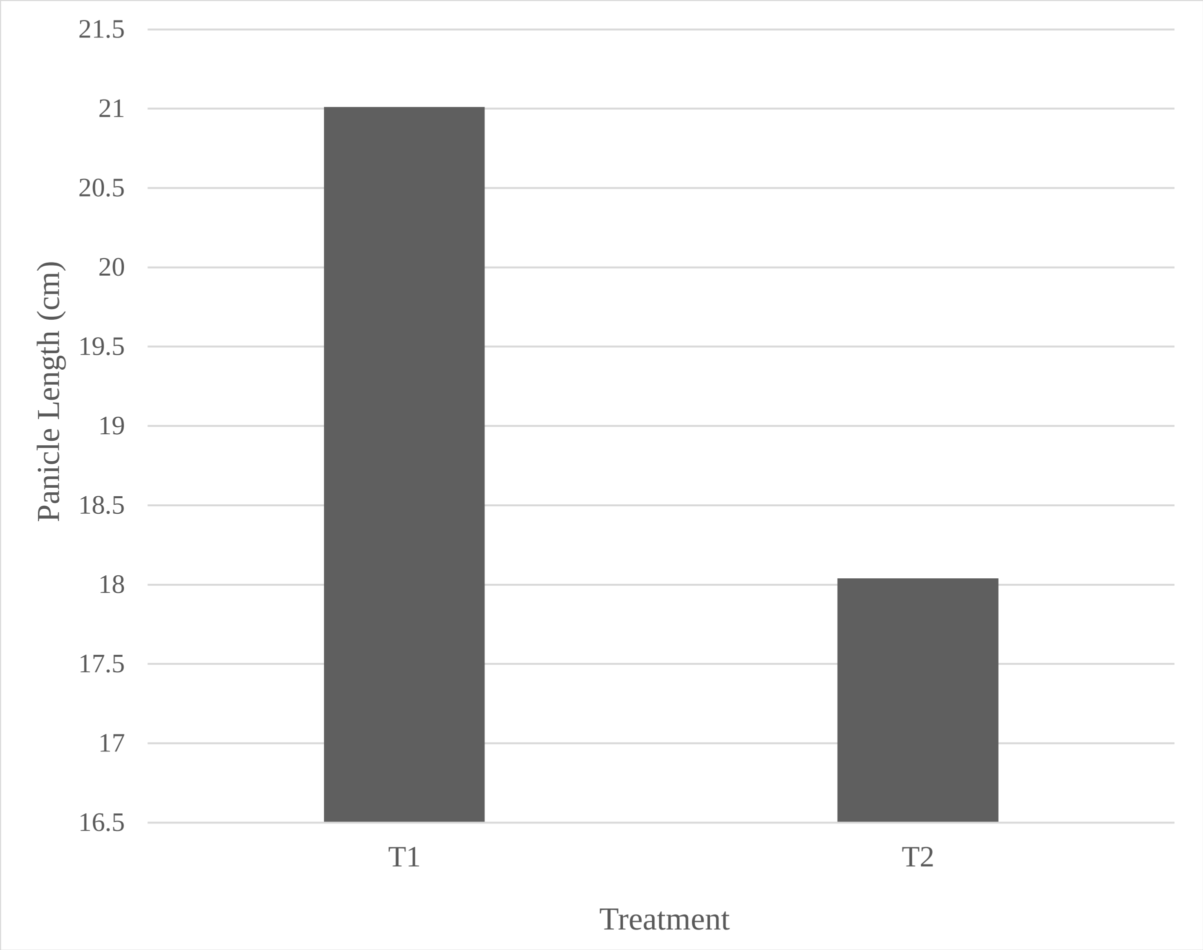

Fig 4.3Panicle length (cm) of rainfed riceas effected by planting dates and liquid organic formulation

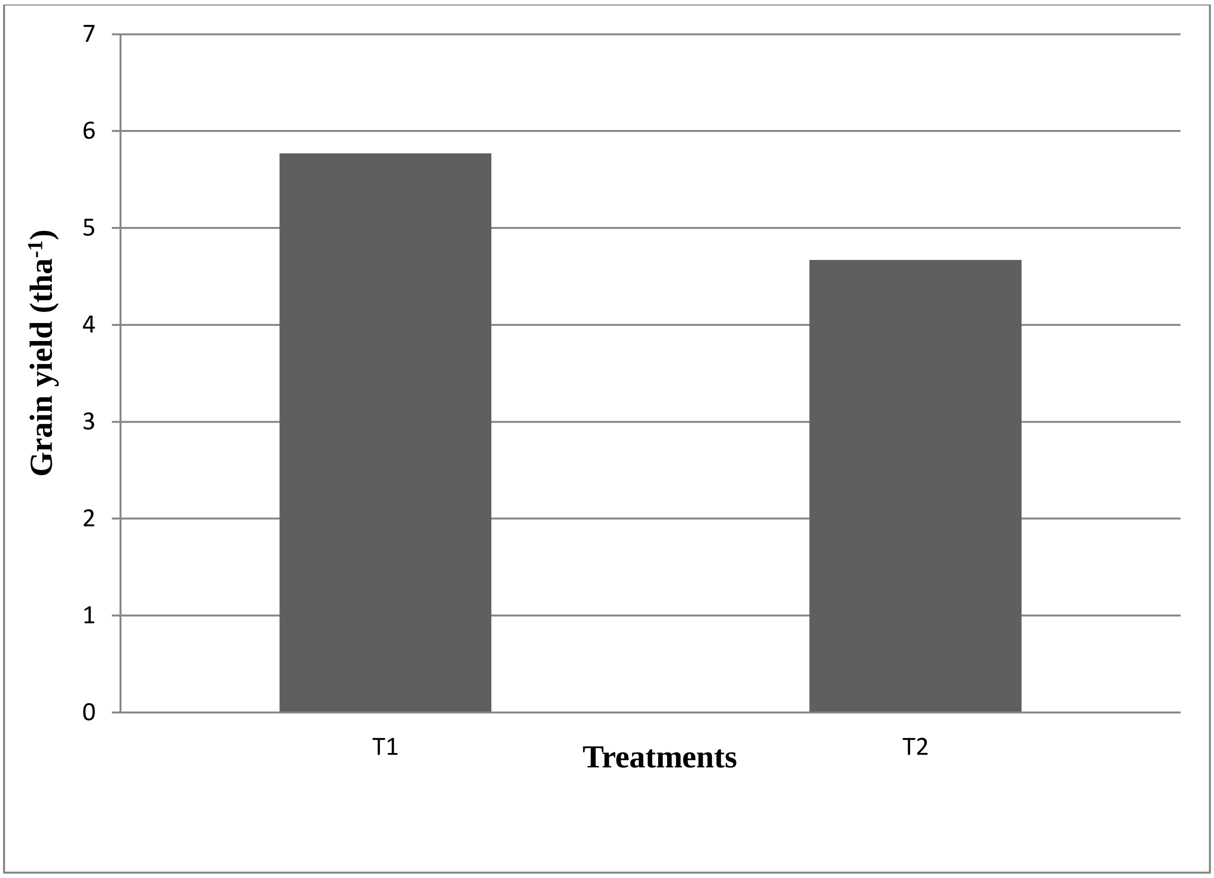

Fig 4.4Grain yield (t ha^{-1}) of rainfed rice as effected by planting dates and liquid organic formulations

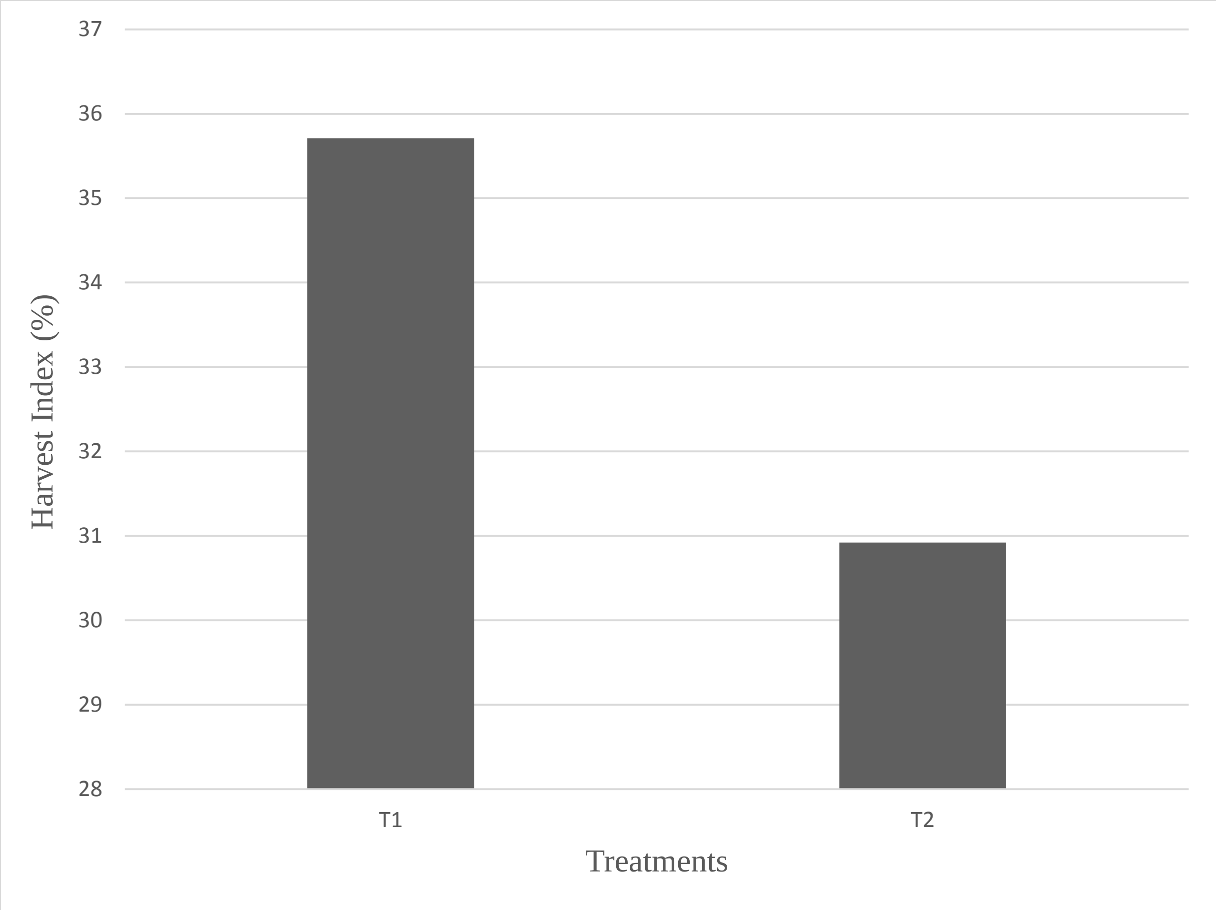

Fig4.5 Harvest index (%) of rainfed rice as effected by planting dates and liquid organic formulations

C. Damage (%) of rainfed rice by semi-looper(*Narangaaenescens* Moore)as perceived by the farmers

Observation regarding the damage (%) of rainfed rice bysemi-looper(*Narangaaenescens* Moore) as perceived by the participating farmers of SHFC under the OFAR is given in the table 4.7.

It was observed that in both the 1st cluster and 2nd cluster less damage (6.50% and 7.00% respectively) was recorded in treatment T_1 (Modified transplanting date + *matka khad*) as compared to treatmentT_2(Traditional transplanting date + fermented plant juice). The damage in treatment T_1 (Modified transplanting date + *matka khad*) as perceived by the farmers was lesser by 23.08% and 21.43% respectively as compared to treatmentT_2(Traditional transplanting date + fermented plant juice).

The application of both the liquid organic formulations, *viz*., *matka khad* and fermented plant juice was found to be effective in the control of semi-looper (*Narangaaenescens* Moore). Scientific studies on incidence of semi-looper(*Narangaaenescens* Moore) are limited as it is considered as a minor pest of rice. As per the farmers' perspective more damage due to semi-looper (*Narangaaenescens* Moore) during the previous years was observed when late transplanting was done. Hence, modified transplanting date and fermented plant juice was included as a preventive measure during the present *kharif* trial. Additionally, *matka khad* has pre-emergence disease control property. Scientific studies on role of *matka khad* in agriculture are limited (Chadha *et al*., 2012).Arivudainambi and Nachiappan (1993) observedthat extracts of *Ipomoea* have shown antifeedant property against the semilooper, *Achaea janata*Linn.Besides, the well-known anti-feedant activity, *azadirachtin*an active ingredient of neem(*Azadirachtaindica*) also showed strong insect growth regulating activity against many insects (Schmutterer, 1990; Mordue and Blackwell, 1993). Most of the *Meliaceae* botanical extracts proved to be strong growth inhibitors, acutely toxic and active feeding deterrents against lepidopteran species (Akhtar *et al*., 2008). These phenomenon may have played a vital role in reducing the biotic stress in the current OFAR experiment.

Table 4.7.Damage (%) of rainfed rice by semi-looper (*Narangaaenescens* Moore) as perceived by farmers*

Treatment	1st Cluster	2nd Cluster
T_1(Modified transplanting date + *matka khad*)	6.50%	7.00%
T_2(Traditional transplanting date + fermented plant juice)	8.00%	8.50%

*Data was not subjected to statistical analysis

D. Quality parameters

4.8 Protein content (%)

Observation regarding the quality parameter, *i.e.*,protein content (%) in grain is given in the table 4.8.

Protein content in grain of rice was observed to be statistically non-significant. Treatment T_1 (Modified transplanting date + *matka khad*) recorded the maximum protein content in grain (8.98%) as compared to treatment T_2 (Traditional transplanting date + fermented plant juice) which was higher by 2.98%.

4.8 Carbohydrate content (%)

Observation regarding the quality parameter, *i.e.*, carbohydrate content (%) in grain is given in the table 4.8.

The highest carbohydrate content of 73.51% was observed in treatment T_2 (Traditional transplanting date + fermented plant juice), which was 1.32% higher compared to treatment T_1 (Modified transplanting date + *matka khad*).However, the analyzed data of carbohydrate content was not found to be significant.

Table 4.8 Effect of planting dates and liquid organic formulations on quality parameter of rice at different intervals

Treatments	Protein content (%)	Carbohydrate content(%)
T_1 Modified transplanting date + *matka khad*	8.98	72.55
T_2Traditional transplanting date + fermented plant juice	8.72	73.51
SEd (±)	0.14	1.46
CD (P=0.05)	NS	NS
CV (%)	3.39	4.25

Traditional transplanting date: July 25 to 27
Modified transplanting date : July 17 to 19

D. Economics

Observation regarding the economics is given in table 4.9.

The highest gross return, net return and benefit cost ratio was found in treatment T_1 (Modified transplanting date + *matka khad*) as compared to treatment T_2 (Traditional transplanting date + fermented plant juice). The gross return, net return and B:C ratio oftreatment T_1 (Modified transplanting date + *matka khad*) was ₹ 85090ha^{-1}, ₹ 64498ha^{-1} and 4.13 respectively.

It was observed that organic application of both *matka khad* and fermented plant juice to rice was economically viable.The higher return in modified transplanting may be due to the higher grain yield compared to traditional transplanting date (Kumar *et al*., 2013) as well as in the reduce cost of organic input, *i.e*., *matka khad*. This finding is in line with. The higher returns under organic practices may be accrued to better soil health which resulted in better plant growth, yield componentsand yield (Yadav*et al.,* 2009).

E. Nutrient status of soil

Nutrient status of soil influenced by planting dates and liquid organic formulations is given in table 4.10.

In both, the 1st cluster and 2nd cluster, higher available N (213 and 218 kg ha^{-1}respectively) andavailable P (13.10 and 13.68 kg ha^{-1}respectively) was recordedwith application of liquid organic formulations (*matka khad* and fermented plant juice) as compared to pre experimental stage. Similarly, in both the clusters, desirable decrease in pH by 5.56% and 8.45% respectively and in EC by 3.60% and 2.75%respectively were recorded. However, in both the clusters non-desirable decrease in available K (271 and 282 kg ha^{-1}respectively), was observed.

It was also observed that between the two post-harvest soil samples of 1st and 2nd clusters, higheravailable N (218 kg ha^{-1}),available P (13.68 kg ha^{-1}),available K (282 kg ha^{-1}) andorganic carbon (0.40%) was registered in 2nd cluster.Similarly desirable lower pH (7.1) and EC (1.11 dS m^{-1}) was recorded in 2nd cluster.

The use of organic manures enhances the soil organic carbon pool more than application of the same amount of nutrients as inorganic fertilizers (Leiva*et al*., 1997).

Table 4.9.Economic analysis ofrainfed rice as influenced by planting dates and liquid organic formulations*

Treatment	**Gross return(** ₹ ha^{-1})	**Net return**(₹ ha^{-1})	**Cost of cultivation**(₹ ha^{-1})	**B:C ratio**
T_1Modified transplanting date + *matka khad*	85090.00	64498.00	20592.00	4.13
T_2Traditional transplanting date + fermented plant juice	71380.00	49588.00	21792.00	3.28

50 g N: 10 t FYM

Sale price of grain ₹ 12000 t^{-1}, sale price of straw ₹ 1000 t^{-1}

*Data was not subjected to statistical analysis

Table 4.10. Nutrients and chemical status of pre harvest and post-harvest soil*

Parameter (unit)	1st Cluster		2nd Cluster	
	Pre harvest	**Post-harvest**	**Pre harvest**	**Post-harvest**
Available nitrogen (%)	192.00	213.00	195.50	218.00
Available phosphorus (kg ha^{-1})	12.79	13.10	13.15	13.68
Available Potassium (kg ha^{-1})	297.00	271.00	310.00	282.00
Organic carbon (%)	0.36	0.32	0.42	0.40
pH	7.6	7.2	7.7	7.1
EC (dS m^{-1})	1.15	1.11	1.12	1.09

Post application: FYM,*matka khad*and fermented plant juice

*Data was not subjected to statisticalanalysis.

Chapter - V

Summary

and

Conclusion

CHAPTER 5
SUMMARY AND CONCLUSION

The present investigation entitled, "Response of rainfed rice (*Oryza sativa* L.) to planting dates and liquid organic formulations in the context of climate change in Mandla district of Madhya Pradesh", was conducted during *kharif*season of 2013,under the OFAR in 9 villages of Mandla district. The experiment was conducted in randomized block design consisting of 2 treatment combinations with 9 replications each. This OFAR was conducted under the *aegis* of an International project, *i.e*., SAF-BIN (Strengthening Adaptive Farming in Bangladesh, India and Nepal), with the active participation of 18 farmers, 10 Village Research Assistants, 1 District Programme Officer and other stakeholders, particularly the P.G. student researcher, Ms. Chubaienla Jamir (the author of the current thesis).

The results of the investigation based on the objectives are summarized below.

5.1 To find the effect of transplanting dates and liquid organic formulations on growth and yield of rice

Higher and significantplant height at 30 DAT (31.16 cm), number of tillers hill^{-1}at15 DAT (5.00), plant dry weightat15, 30, 45 and 60 DAT (0.87 g hill^{-1}, 2.47g hill^{-1}, 7.90g hill^{-1}, and 15.83g hill^{-1}respectively), crop growth rateat 0 to 15, 15 to 30 and 75 to 90 DAT intervals (1.44g m^{-2} day^{-1},2.67g m^{-2} day^{-1}and 2.48g m^{-2} day^{-1}respectively), and relative growth rate at 75 to 90 DAT interval (0.005 g g^{-1} day^{-1}) was observed in treatment T_1 (Modified transplanting date + *matka khad*). However, significant and higher relative growth rate at 30 to 45 DAT interval (0.086g g^{-1} day^{-1}) was observed in treatment T_2(Traditional transplanting date + fermented plant juice). Further, higher but non-significant plant heightat 90 DAT (85.88 cm) andnumber of tillers hill^{-1} at 90 DAT (14.22)was observed in treatment T_1 (Modified transplanting date + *matka khad*).

Higher and significant panicle length (21.01 cm) was observed in treatment T_1 (Modified transplanting date + *matka khad*). Further,higher but non-significant number of grains panicle^{-1}(158.06), test weight (26.00 g), grain yield (5.77 t ha^{-1}), straw yield (15.85 t ha^{-1}) and harvest index (35.71%) was observed in treatment T_1 (Modified transplanting date + *matka khad*).

Treatment T_1 (Modified transplanting date + *matka khad*) recorded higher proteincontent (8.98%) andcarbohydrate content (73.51%) in grain as compared to treatment T_2 (Traditional transplanting date + fermented plant juice) which was higher by 2.98% and 1.32% respectively.

5.2To evaluate the efficacy of liquid organic formulations against semi-looper (*Naranga aenescens* Moore) inrainfedrice

In both the 1st cluster and 2nd cluster of SHFC members experimental plot, lesser damage (6.50% and 7.00% respectively) by semi-looper (*Naranga aenescens* Moore) was recorded in treatment T_1 (Modified transplanting date + *matka khad*) as compared to treatment T_2(Traditional transplanting date + fermented plant juice).

5.3 Economic analysis of the treatment combinations

The highest gross return (₹ 85090 ha^{-1}), net return (₹ 64498 ha^{-1}) and benefit cost ratio (4.13) was found in treatment T_1 (Modified transplanting date + *matka khad*) as compared to treatment T_2(Traditional transplanting date +fermented plant juice).

A brief review on the current OFAR trial

The on-farm adaptive trials laid out in the villages in farmers' field caught the attention of other farmers and they too decided to put it into practice. The success in on-farm adaptive research is mainly dependent on farmers' active participation. The participating SHFC members also are in agreement with the findings of the trial.

Under the OFAR, both the treatments were worked out in view of the major problems faced by the farmers and proved to be successful. The significant effect between the planting dates on the yield and yield attributes could be efficiently analyzed. However, in the treatmentswith liquid organic formulations, the effect could not be compared between the formulations as fermented plant juice was applied only under traditional transplanting date in which the farmers faced losses due to semi-looper (*Naranga aenescens* Moore). Fermented plant juice was successful in some replications as no report of damage by the pest was reported. Similarly, *matkakhad*added extra benefit in combination with modified transplanting date, which is a simple and cheap soil enrichment solution. Hence, for improving the growth and yield of rainfedrice both the treatments proved to be fairly successful.

CONCLUSION

It may be concluded that between the planting dates, modified transplanting date (15 to 17 July)in combination with*matkakhad*was found to be the best for obtaining highest growth, grain yield, benefit cost ratio and net return in rainfedrice as compared to traditional transplanting date (25 to 27 July)in combination withfermented plant juice.

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Appendices

APPENDIX I

1 (a) **1 (b)**

Plate 1 (a) Nursery bed of rice in Jaitpuri village
(b) Farmers uprooting the rice seedlings from the nursery bed for transplanting in the experimental field

Plate 2 Ploughing of the field with bullock drawn desi plough in Kurela village

3 (a) **3 (b)**

Plate 3 (a) Student researcher, VRA and SHFC members transplanting the rice seedlings at Jaitpuri village

(b) VRA and the participating SHFC members transplanting the rice seedlings at Bhadvar village

Plate 4 Student researcher recording the agronomic parameters of rainfed rice in the experimental field at Ghota village

Plate 5 DPO, student researcher and SHFC member harvesting the rainfed rice (2 m × 1 m) at Begakeda village

Plate 6 DPO, VRA and SHFC members recording the post-harvest observations

APPENDIX II

ANOVA TABLE: 01 Plant height (cm) of rice at 15 DAT

Source of Variance	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	8	600.87	75.11	10.49	3.44	S

Treatment	1	22.98	22.98	3.21	5.32	NS
Error	8	57.28	7.16	-	-	-
Total	17	681.13	-	-	-	-

ANOVA TABLE: 02 Plant height (cm) of rice at 30 DAT

Source of Variance	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	8	866.83	108.35	9.52	3.44	S
Treatment	1	73.24	73.24	6.44	5.32	S
Error	8	91.04	11.38	-	-	-
Total	17	1031.11	-	-	-	-

ANOVA TABLE: 03 Plant height (cm) of rice at 45 DAT

Source of Variance	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	8	2829.38	353.67	19.32	3.44	S
Treatment	1	81.19	81.18	4.43	5.32	NS
Error	8	146.48	18.31	-	-	-
Total	17	3057.05	-	-	-	-

ANOVA TABLE: 04 Plant height (cm) of rice at 60 DAT

Source of Variance	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	8	3529.66	441.21	6.46	3.44	S
Treatment	1	73.73	73.73	1.08	5.32	NS
Error	8	546.80	68.35	-	-	-

Total	17	3658.13	-	-	-	-

ANOVA TABLE: 05 Plant height (cm) of rice at 75 DAT

Source of Variance	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	8	3633.27	4554.16	5.23	3.44	S
Treatment	1	83.38	83.38	0.96	5.32	NS
Error	8	694.41	86.80	-	-	-
Total	17	4411.06	-	-	-	-

ANOVA TABLE: 06 Plant height (cm) of rice at 90 DAT

Source of Variance	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	8	3712.65	464.08	5.56	3.44	S
Treatment	1	96.28	96.28	1.17	5.32	NS
Error	8	656.87	82.11	-	-	-
Total	17	4465.80	-	-	-	-

ANOVA TABLE: 07 Number of tillers hill^{-1} of rice at 15 DAT

Source of Variance	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	8	80.15	10.02	13.36	3.44	S
Treatment	1	4.76	4.76	6.35	5.32	S
Error	8	6.01	0.75	-	-	-
Total	17	90.92	-	-	-	-

ANOVA TABLE: 08 Number of tillers hill^{-1} of rice at 30 DAT

Source of Variance	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	8	126.31	15.79	12.53	3.44	S
Treatment	1	4.01	4.01	3.18	5.32	NS
Error	8	10.10	1.26	-	-	-
Total	17	140.40	-	-	-	-

ANOVA TABLE: 09 Number of tillers hill^{-1} of rice at 45 DAT

Source of Variance	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	8	285.43	35. 68	8.32	3.44	S
Treatment	1	1.00	1.00	0.23	5.32	NS
Error	8	34.33	4.29	-	-	-
Total	17	320.76	-	-	-	-

ANOVA TABLE: 10 Number of tillers hill^{-1} of rice at 60 DAT

Source of Variance	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	8	388.49	48.56	4.570	3.44	S
Treatment	1	0.68	0.68	0.064	5.32	NS
Error	8	84.93	10.62	-	-	-
Total	17	474.10	-	-	-	-

ANOVA TABLE: 11 Number of tillers hill^{-1} of rice at 75 DAT

Source of Variance	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	8	535.67	66.96	3.15	3.44	NS

Treatment	1	3.53	3.53	0.17	5.32	NS
Error	8	170.05	21.26	-	-	-
Total	17	709.25	-	-	-	-

ANOVA TABLE: 12 Number of tillers hill^{-1} of rice at 90 DAT

Source of Variance	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	8	381.34	47.67	0.95	3.44	NS
Treatment	1	1.01	1.01	0.02	5.32	NS
Error	8	401.81	50.23	-	-	-
Total	17	784.16	-	-	-	-

ANOVA TABLE: 13 Plant dry weight (g) of rice at 15 DAT

Source of Variance	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	8	4.02	0.50	56.82	3.44	S
Treatment	1	0.11	0.11	12.50	5.32	S
Error	8	0.07	0.0088	-	-	-
Total	17	4.20	-	-	-	-

ANOVA TABLE: 14 Plant dry weight (g) of rice at 30 DAT

Source of Variance	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	8	7.73	0.97	12.13	3.44	S
Treatment	1	1.23	1.23	15.38	5.32	S
Error	8	0.63	0.08	-	-	-

Total	17	9.59	-	-	-	-

ANOVA TABLE: 15 Plant dry weight (g) of rice at 45 DAT

Source of Variance	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	8	146.10	18.26	60.87	3.44	S
Treatment	1	2.14	2.14	7.13	5.32	S
Error	8	2.38	0.30	-	-	-
Total	17	150.62	-	-	-	-

ANOVA TABLE: 16 Plant dry weight (g) of rice at 60 DAT

Source of Variance	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	8	426.40	53.30	33.73	3.44	S
Treatment	1	8.96	8.96	5.67	5.32	S
Error	8	12.64	1.58	-	-	-
Total	17	448.00	-	-	-	-

ANOVA TABLE: 17 Plant dry weight (g) of rice at 75 DAT

Source of Variance	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	8	633.53	79.19	29.22	3.44	S
Treatment	1	7.35	7.35	2.71	5.32	NS
Error	8	21.67	2.71	-	-	-
Total	17	662.55	-	-	-	-

ANOVA TABLE: 18 Plant dry weight (g) of rice at 90 DAT

Source of Variance	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	8	660.95	83.62	24.52	3.44	S
Treatment	1	12.00	13.18	3.56	5.32	NS
Error	8	26.96	3.37	-	-	-
Total	17	710.04	-	-	-	-

ANOVA Table: 19 Crop growth rate (g m^{-2} day^{-1}) of rice at 0 to 15 DAT interval

Source of Variance	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	8	11.16	1.40	46.67	3.44	S
Treatment	1	0.31	0.31	10.33	5.32	S
Error	8	0.20	0.03	-	-	-
Total	17	11.67	-	-	-	-

ANOVA Table: 20 Crop growth rate (g m^{-2} day^{-1}) of rice at 15 to 30 DAT interval

Source of Variance	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	8	8.65	1.08	5.40	3.44	S
Treatment	1	1.69	1.69	8.45	5.32	S
Error	8	1.61	0.20	-	-	-
Total	17	11.95	-	-	-	-

ANOVA Table: 21 Crop growth rate (g m^{-2} day^{-1}) of rice at 30 to 45 DAT interval

Source of Variance	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	8	283.84	35.48	105.91	3.44	S

Treatment	1	0.35	0.35	1.04	5.32	NS
Error	8	2.68	0.34	-	-	-
Total	17	286.87	-	-	-	-

ANOVA Table: 22 Crop growth rate (g m^{-2} day^{-1}) of rice at 45 to 60 DAT interval

Source of Variance	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	8	229.24	28.66	13.58	3.44	S
Treatment	1	6.49	6.49	3.08	5.32	NS
Error	8	16.91	2.11	-	-	-
Total	17	252.64	-	-	-	-

ANOVA Table: 23 Crop growth rate (g m^{-2} day^{-1}) of rice at 60 to 75 DAT interval

Source of Variance	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	8	88.62	11.08	8.66	3.44	S
Treatment	1	0.22	0.22	0.17	5.32	NS
Error	8	10.20	1.28	-	-	-
Total	17	99.04	-	-	-	-

ANOVA Table: 24 Crop growth rate (g m^{-2} day^{-1}) of rice at 75 to 90 DAT interval

Source of Variance	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	8	1.69	0.21	0.75	3.44	NS
Treatment	1	1.57	1.57	5.61	5.32	S
Error	8	2.20	0.28	-	-	-

Total	17	5.46	-	-	-	-

ANOVA Table: 25 Relative growth rate (g g $^{-1}$ day^{-1}) of rice at 15 to 30 DAT interval

Source of Variance	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	8	0.0159905	0.001998813	27.28	3.44	S
Treatment	1	0.0001668	0.000166800	2.28	5.32	NS
Error	8	0.0005862	0.000073275	-	-	-
Total	17	0.0167435	-	-	-	-

ANOVA Table: 26 Relative growth rate (g g $^{-1}$ day^{-1}) of rice at 30 to 45 DAT interval

Source of Variance	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	8	0.0054775	0.0006846875	30.431	3.44	S
Treatment	1	0.0002960	0.0002960000	13.156	5.32	S
Error	8	0.0001800	0.0000225000	-	-	-
Total	17	0.0059535	-	-	-	-

ANOVA Table: 27 Relative growth rate (g g $^{-1}$ day^{-1}) of rice at 45 to 60 DAT interval

Source of Variance	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	8	0.0007530	0.000094125	1.96401	3.44	NS
Treatment	1	0.0000681	0.000068100	1.42097	5.32	NS
Error	8	0.0003834	0.000047925	-	-	-
Total	17	1.20445	-	-	-	-

ANOVA Table: 28 Relative growth rate (g g $^{-1}$ day^{-1}) of rice at 60 to 75 DAT interval

Source of Variance	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	8	0.0012009	0.0001501125	2.562	3.44	NS
Treatment	1	0.0001656	0.0001656000	2.826	5.32	NS
Error	8	0.0004688	0.0000586025	-	-	-
Total	17	0.0018353	-	-	-	-

ANOVA Table: 29 Relative growth rate (g g $^{-1}$ day^{-1}) of rice at 75 to 90 DAT interval

Source of Variance	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	8	0.00000309	0.00000038625	0.7783	3.44	NS
Treatment	1	0.00000002	0.00000002000	0.0403	5.32	NS
Error	8	0.00000397	0.00000049625	-	-	-
Total	17	0.00000708	-	-	-	-

ANOVA Table: 30 Panicle length (cm) of rice

Source of Variance	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	8	339.83	42.48	8.50	3.44	S
Treatment	1	39.72	39.72	7.90	5.32	S
Error	8	40.05	5.00	-	-	-
Total	17	419.60	-	-	-	-

ANOVA Table: 31 Number of grains panicle^{-1} of rice

Source of Variance	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	8	123216.25	15402.03	9.13	3.44	NS

Treatment	1	253.13	253.13	0.15	5.32	NS
Error	8	13470.41	1683.80	-	-	-
Total	17	136939.79	-	-	-	-

ANOVA Table: 32 Test weight (g) of rice

Source of Variance	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	8	26.00	3.25	9.85	3.44	S
Treatment	1	1.28	1.28	3.88	5.32	NS
Error	8	2.64	0.33	-	-	-
Total	17	29.92	-	-	-	-

ANOVA Table: 33 Grain yield (t ha^{-1}) of rice

Source of Variance	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	8	50.62	6.33	3.21	3.44	NS
Treatment	1	5.46	5.46	2.77	5.32	NS
Error	8	15.74	1.97	-	-	-
Total	17	71.82	-	-	-	-

ANOVA Table: 34 Straw yield (t ha^{-1}) of rice

Source of Variance	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	8	241.39	30.17	5.96	3.44	S
Treatment	1	1.17	1.17	0.23	5.32	NS

Error	8	40.50	5.06	-	-	-
Total	17	283.06	-	-	-	-

ANOVA Table: 35 Harvest index (%) of rice

Source of Variance	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	8	639.47	79.93	1.34	3.44	NS
Treatment	1	103.35	103.35	1.73	5.32	NS
Error	8	478.13	59.77	-	-	-
Total	17	1220.95	-	-	-	-

ANOVA Table: 36 Protein content (%) of rice

Source of Variance	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	8	2.44	0.305	3.44	3.44	S
Treatment	1	0.31	0.310	3.44	5.32	NS
Error	8	0.72	0.09	-	-	-
Total	17	3.47	-	-	-	-

ANOVA Table: 37 Carbohydrate content (%) of rice

Source of Variance	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	8	39.42	4.93	0.51	3.44	NS
Treatment	1	4.16	4.16	0.43	5.32	NS
Error	8	76.71	9.59	-	-	-
Total	17	120.29	-	-	-	-

APPENDIX III

Table I. Cost of cultivation of different forms of organic manure and cultural practices for rainfed rice (cost for all treatments)

S. No.		Particulars	Unit	Qty.	Rate unit^{-1} (₹)	Cost (₹ ha^{-1})
A		Land preparation				
	1	Ploughing and puddling	Bullocks	8	300.00	2400.00
	2	Layout	Labour	10	100.00	1000.00
B		Seed	kg	100	25.00	2500.00
C		Transplanting	Labour	10	132.00	1320.00
D		Nutrient application				
		FYM	Tonne	10	1000.00	10000.00
E		Interculture operation				
	1	Gap filling	Labour	2	132.00	264.00
	2	Two hand weeding	Labour	2	132.00	528.00
F		Harvesting and threshing	Labour	15	132.00	1980.00
						Total=19992.00

Table II. Variable cost for the treatments

Treatment	***Matka khad*** **3 % @ ₹ 2 l^{-1} total 300 l (3 times)**	**Fermented plant juice 5 % @ ₹ 20 l^{-1} total 90 l (3 times)**	**Total cost**
T_1	600.00	-	600.00
T_2	-	1800.00	1800.00

Matka khad @ ₹ 2 kg^{-1}

Fermented plant juice @ ₹ 20 kg^{-1}

APPENDIX IV
ANECDOTE

During the OFAR, a lot was learned and experienced. This project focused mainly on the current issues of climate change and its impact on agriculture as climate change amplifies the environmental and socio-economic dimensions leading to food insecurity. This OFAR project was a challenge as the main focus of the project are the farmers, and it requires a strong determination to convince the farmers to put the various agricultural practices into action.

The farmers engaged with the project in Mandla district of Madhya Pradesh, are small holder farmers and agriculture is their major source of income. They are largely dependent on rainfall as most of them have no other source of irrigation and hence the project title "Building Resilience to Climate Change through Strengthening Adaptive Small Scale farming system in Rainfed Areas in Bangladesh, India and Nepal" directly addresses the climate change and food security challenges of the farmers.

It was observed that most of the farmers preferred not to maintain proper spacing while sowing as they believe that lesser the spacing the more will be the yield. However, after implementing the trials the farmers have started to adopted and maintain spacing as they have seen the growth and yield benefit that can be obtained through proper spacing. It was also observed that women's participation in SAF-BIN project work is very low. **Sohdra Marwi**, one of the women farmer of Zaidpuri village of Mandla district of Madhya Pradesh, who is engaged as a VRA with the project said that she was happy and content to work in the project as it supports her financially and that the other members treat her as a friend and also that many other women have expressed their desire to work in the project if given the chance.

While discussing with the farmers about the benefits and drawbacks of the project, the farmers expressed nothing but their appreciation and gratitude for the project. After the trial was over all the farmers were happy with what they had harvested. **Sukhwati Tekam**, a woman farmer of Badwar village of Mandla district of Madhya Pradesh, said that she will continue to put into practice all that she had learned through this trial as the sources were locally available and cheap. In the end the trial was a success as all the farmers were happy with what they have harvested and appreciated the financial gains apart from putting into practice that is scientific yet economical.

Note: This anecdote has been compiled with active cooperation of DPO, VRAs and SHFC members during the conduct of the *kharif* trial.