INTEGRATED NUTRIENT MANAGEMENT IN AROMATIC RICE

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CERTIFICATE – I

This is to certify that the thesis entitled **"INTEGRATED NUTRIENT MANAGEMENT IN AROMATIC RICE"** submitted in partial fulfillment of the requirements for the award of the degree of **MASTER OF SCIENCE IN AGRICULTURE (AGRONOMY)** to the Orissa University of Agriculture and Technology, Bhubaneswar is an authentic record of *bona fide* research work carried out by **Harekrushna Chand Hansdah** under my guidance and supervision. No part of this thesis has been submitted for any other degree or diploma or published in any other form.

It is further certified that the assistance and help availed by him from various sources during the course of investigation have been duly acknowledged.

(Dr. B. K. Sahoo)
Chairman
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CERTIFICATE – II

This is to certify that the thesis entitled **"INTEGRATED NUTRIENT MANAGEMENT IN AROMATIC RICE"** submitted by **Harekrushna Chand Hansdah** to the Orissa University of Agriculture and Technology, Bhubaneswar in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE IN AGRICULTURE (AGRONOMY)** has been approved by the student's Advisory Committee and the External Examiner.

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ABSTRACT

A field experiment was conducted at central research station of Orissa University of Agriculture and Technology, Bhubaneswar during *kharif* 2010, to study the effect of integrated nutrient management through organic and inorganic sources of nutrient, in aromatic rice taking Thakursona as test variety. The experiment was laid out in randomized block design with nine treatments comprising of RDF (40:20:20 kg NPK/ha) replicated thrice.

The result of investigation revealed that among the treatments tried T_7 (75 % RDF + FYM 10 t/ha + BF) was found to produce highest yield of 27.13 q/ha and was closely followed by T_5 (75 % RDF + FYM 10 t/ha) with a grain yield of 26.30 q/ha. The high yield under T_7 was associated with highest number of panicle per m^2 (306), highest number of fertile grain (172.33) per panicle and also significantly increases hulling, milling, head rice recovery % and protein content. T_7 (75 % RDF + FYM 10 t/ha + BF) recorded highest net return and B:C ratio of Rs.13101 and 1.887 respectively.

Dedicated

to My

Beloved Parents

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INTRODUCTION

Rice is the major cereal crop playing significant role in diet, culture and economy of millions of people across the world. It is the leading food source in terms of calories being consumed for mankind and feeds about 60 % of the world's population. It is the primary staple food crop throughout Asia and other parts of the world. Today there is a great demand for both increase in productivity and quality of rice from the available marginal land. Japonica and Indica are two major subspecies grown in different regions of the world of which Indica is the most widely cultivated variety grown in wide area ranging from temperate to tropical regions occupying about 85-90 %of the total cultivable rice in the world (FAO 2007).

Among the rice growing countries, India ranks the top position with regards to area sown(44.6 million hectare), production(90 million tons) and productivity (2086 kg per ha), respectively. It is estimated that in India alone, the demand for rice in 2025 will be around 140 million tons (Murali 2005). Thus, there is a challenging need to improve rice yield to meet the growing demand. During last two decades, significant progress has been made in increasing the yield and quality.

The major portion of rice area is devoted to the course and medium slender rice. However, very less area, (less than 20 per cent) of the total rice area, has been diverted to the fine and scented rice. Every year 50- 70 percent basmati rice production in the country is exported. Among agricultural commodities their share in total foreign exchange through export is about 24 percent, whereas, the quality is only 18 percent of total exported agricultural products (Sinha *et al*., 2003).

Rice is one of the most important staple food crop of Odisha. It is grown in an area of 4.5million hectares, which constitutes 63% of the total area under food grains of the state. The total production of rice in the state is about 7.15million metric tones. Being the secondary centre of origin of cultivated rice; Odisha has the distinction of possessing about 10000 to 15000 traditional rice cultivars out of 45000 to 50000 found in the world(Ray,2007).Among these traditional rice varieties, land races of aromatic rice bears special significance because of their special flavor and economic value in the present globalised era (Chaudhury *et al*.,2003).In the recent past from a survey it was ascertained that more than one hundred land races of aromatic rice are found in the state (Khatana *et al*,2004, Das and Rout,2006).They are mostly short grained with pleasant aroma. Unlike Basmati rice, these varieties retain aroma when grown in prevailing sub tropical warm climate of the state.

The quality of rice is judged from the viewpoint of milling quality, grain size, shape, appearance and cooking characteristics. Consumer judges the quality of rice basing on its appearance, particularly the colour, size and shape and on its elongation during cooking. On the other hand, millers and traders prefer a rice capable giving high head rice recovery (Sharma, 2002). Besides this other aspects of quality like amylose content and gelatinization temperature are also important (Bhattacharya, 1989 and Jennings *et al*., 1979). Rice with soft gel consistency cook tender and remain soft to medium gel consistency, is preferred by most rice consumers (Sankar *et al*., 1994).

Scented rice occupies an important status in domestic as well as in International market due to its several outstanding qualities and therefore earns premium prices. Of late, the area under scented rice (*Oryza sativa* L.) has increased many folds owing to remunerative price in international market. The yields of scented rice are comparatively less than high yielding non scented rice. The farmers have switched over to high yielding coarse rice because of the higher yield from hybrid rice which compensates for the premium price of scented rice. It is therefore important to achieve high yield from scented rice, while, maintaining its quality too. This objective cannot be achieved by chemical or organic nutrients source alone. Chemical fertilizers are well known for their effects on the yield increment whereas; the aroma is improved by the use of organics nutrients (Prakash *et al*., 2002). An appropriate combination of inorganic and organic nutrient can help in achieving high yield of rice as well as quality.

Intensive cultivation of rice has caused considerable damage to the environment and natural resources including build up of salinity or alkalinity, water logging, water pollution, depletion of groundwater and health hazards due to excessive use of agro chemicals and pesticides and release of higher methane gas to the environment. This has forced the farmers, scientists and policy makers to look at the integrated approach of nutrient management to rice. Organic agriculture is one among the broad spectrum of production methods that are supportive of the environment. The demand for organic food is steadily increasing both in developed and developing countries with an annual growth rate of 20 – 25 per cent (Ramesh *et al.,* 2005). Organic cultivation which is responsible for material circulation in agricultural ecosystem and enhanced crop production with a minimal environmental load in keeping ecological balance contains the holistic approach for production and management system for enhancing health of agricultural ecosystem. Organic systems avoid the use of synthetic fertilizers, pesticides and growth regulators. Instead they rely on crop residues, animal manures, legumes, green manures, off – farm wastes, mechanical cultivation and biological pest control to maintain soil health, supply of plant nutrients and minimize insects, weeds and other inputs. Organic culture helps in improvement of crop quality and reduces environmental pollution. It brightens the prospects of export of organic food items. Now there are signs of change across the agriculture landscape of the country towards organic farming. Rice produced by organic farming had higher grain quality (Mendoza, 2004). Sustainability in crop yield and soil health could be achieved by the application of mineral fertilizers along with organic manures. Benefits of organic manures like farm yard manure, green manures, poultry manure and vermi-compost are well known but the availability is reducing day by day. These organic manures are not only good sources of nutrients but also improve the physical structure of the soil. Apart from containing NPK, these also contain small amounts of trace elements especially boron, copper, iron, sulphur, zinc and with fair quantity of growth promoting substances.

Integrated nutrient management (INM) involves maintenance of soil fertility, sustainable agricultural productivity and improvement in farmer‘s profitability through the combined use of chemical fertilizer, organic manures and biofertilizer etc. The nutrient use efficiency of applied mineral nutrients by the crop is markedly influenced by the presence of various organic manures. Using organic resources like, FYM, poultry manure, and green manure deserves priority for sustained production and better resource utilization in integrated nutrient management. In this system, the use of chemicals is kept at minimum i.e to the level of bare necessity. Compared to chemical farming this method was self sufficient, self dependant and release more biological inputs (Singh *et al*., 2001).The role of plant nutrient would be extremely important from sustainability point of view. Nitrogen is the key nutrient element limiting the yield of rice. Fertilizer N use efficiency varies from 18 to 40 percent in different rice soil, because applied inorganic N is rapidly lost from the soil by ammonia volatilization and denitrification. Urea blended with organic materials minimizes N loss and increase N use efficiency. With the increasing trend in price of fertilizers and the reduction in the use of chemical fertilizers it has become necessary to judiciously manage the inflow of organic sources of nutrients and their integration with fertilizers. Therefore, information needs to be generated with respect to proper dose of organic manures along with inorganic fertilizers for scented rice in general and aromatic rice in prticular. In the state of Odisha the local aromatic rice is mostly grown under low input management condition resulting in lower productivity. Hence there is need to develop the suitable nutrient management practices for obtaining higher productivity with better quality rice by integration of organic and inorganic sources of nutrients and proper blending of the same in order to increase the nutrient use efficiency.

Keeping these points in view a field experiment was conducted in the 'F' block of the central research station of the Orissa University of Agriculture &Technology, Bhubaneswar during *kharif* 2010-11, to study the "Integrated Nutrient Management in Aromatic Rice" with the following objectives:-

1. To find out the effect of recommended dose fertilizers on quality traits and yield of aromatic rice
2. To find out the effect of organic nutrients on quality traits and yield of aromatic rice
3. To find out the effect of Integrated Nutrient Management on yield and quality of aromatic rice.

REVIEW OF LITERATURE

Integrated nutrient management (INM) involves in maintaining soil fertility which in turn makes the agricultural productivity sustainable and improves the farmer's profitability through the combined use of chemical fertilizer, organic manures and biofertilizer etc. The nutrient use efficiency of applied mineral nutrients by the crop is markedly influenced by the presence of various organic manures. Compared to chemical farming this method is self sufficient, self dependant and relies more biological inputs (Singh *et al*., 2000).

In this chapter an attempt has been made to review the earlier findings relating to the nutrient management of aromatic rice including the integrated nutrient management on its yield attributes, yield, quality, economics and nutrient use efficiency.

2 EFFECT OF ORGANICS ON GROWTH, YIELD AND YIELD ATTRIBUTES

2.1 Green manuring

Green manuring crops act as field covers which suppress the weeds through smothering effect and conserve soil moisture by reducing evaporation from the soil. They promote biological transformation in soil leading to improved soil structure, fertility and increased crop yields. Use of legumes as green manures contribute to the fertility of soil by way of addition of roots, nodules, leaves, tops etc. Green manuring is a possibly practice in subtropical regions, where winter fallow is common, which found to substitute nearly 50 to 56 N over a period of time, improves soil fertility and there was considerable residual effect due to green manure addition (Palaniappan, 2000).

2.1.1 Yield and yield attributes

The highest rice grain yield (5.5 t/ha) was recorded with the combination of sunhemp as green manure (GM) + 120 kg N/ha, whereas highest husk (2.4 t/ha) and straw (8.0 t/ha) yields were recorded with dhanicha as GM + 120 kg N/ha. Application of GM, in general, increased the K uptake from 2.9 to 4.6 kg/ha in rice grain and from 2.4 to 33.9 kg/ha in straw. Application of N also increased the K uptake by rice grain, husk and straw from 4.6 to 8.9, 3.9 to 6.8 and from 62.8 to 98.2 kg/ha, respectively (Duhan *et al*., 2001).

Bandara *et al*. (2009) revealed that application of organic manure at 10 t ha^{-1} increased grain yield of rice by 25 % compared to the no organic manure control.

Among all organic sources, animal dung, crop residues, green manure, bio-fertilizers and bio-solids from agro-industries and food processing wastes are some of the potential sources of nutrients of organic nutrition. These manures have the capacity to fulfill the nutrient demand of crops adequately (Singh *et al.*, 2000).

Maintaining soil fertility in organic cultivation typically involves more combination of crop rotation with green manure/cover crops, applying rock minerals, animal manures and composts and other approved organic amendments (Sullivan, 2003).

Agriculture wastes such as manures, plant materials and other organic materials containing beneficial nutrients can be used to fertilize or condition the soil (Mishra, 2003).

From a study to find out the impact of green manures *viz*., *Sesbania rostrata*, *Crotolaria juncea* and sulphur application on the dynamics of soil enzymes, nutrient contents and grain yield of rice in rice soil,it was found that incorporation of green manures *Sesbania rostrata* and *Crotalaria juncea* enhanced soil enzyme activity by recording the highest activity on 30th day after incorporation. *Sesbania rostrata* with fertilizer nitrogen registered maximum grain yield of 4893.5 kg/ha (Ramalingam and Kannaiyan, 2006) as compared to other treatment combinations.

Application of green manure increased the grain yield of rice from 4.1 to 4.4 t/ha as compared to 2.5 t/ha in no green manure treatment. Highest grain yield and dry matter yield of rice (4.4 t/ha and 5.1 t/ha) was recorded in sunhemp, respectively (Duhan *et al.* , 2004).Insitu incorporation of *dhaincha* @ 12 tonnes/ha remarkably increased the grain (18%) and straw (16%) yields of rice (*Oryza sativa* L.) over no organic manure, owing to increase in growth and yield-attributing characters of rice(Hemalatha *et al*., 2000).

2.1.2 Quality

In aromatic rice, Hemalatha *et al*. (2000) revealed that incorporation of *dhaincha* increased the optimum cooking time, total amylase content, crude protein content and reduced the gruel loss (%) of grain. Organic manures significantly improved the soil fertility status and it was pronounced by the *dhaincha* incorporation by increasing organic carbon content, available soil N, P and K at post-harvest stage .

Dwivedi and Thakur (2000) revealed that green manuring with dhaincha @ 14 t/ha gave significantly higher yield (47.70 q/ha) followed by bio-gas-slurry (37.16 q/ha) @ 10 t/ha over no green manure (33.90 q/ha) and rice straw incorporation (34.74 q/ha). Significantly higher protein content was recorded in dhaincha and biogas-slurry while it was unaffected with inorganic fertilizer treatment.

Murali and Setty, (2001) concluded that incorporation of green manure, dhaincha increased the optimum cooking time, total amylase content, crude protein and reduced the gruel loss (per cent) of scented rice grain.

2.1.3 Nutrient uptake

Selvi and Kalpana (2009) concluded that green manuring of rice is a well established practice and saving of fertiliser N through green manuring ranged from 30 to 100 kg N/ha.

Application of green manure 9.0 t ha^{-1} and neem cake (12.50 kg/ha) recorded higher available N in rice cultivar white ponni. (Balasubramaniyan, 2003).

Gupta *et al*., (2000) revealed that combined application on of *Sesbania rostrata* + FYM resulted in larger amount of total N uptake than prilled urea.

Bhadoria and Prakash (2002) studied the effect of application of vermicompost in combination with different organic sources (FYM, city waste, oil cake) on growth and yield of rice.

2.2. FARM YARD MANURE

2.2.1 Growth Characteristics

Application of FYM @ 20 tha^{-1} to scented rice significantly increased the plant height, leaf area index (LAI) and DMP (Singh *et al*., 1996). Kandasamy and Ramasamy (1998) revealed that in rice , application of FYM (10 t ha^{-1}) increased the plant height, LAI, tiller production and DMP than other manures.

2.2.2 Yield attributes

Application of FYM @ 10 t ha^{-1} produced more number of panicles m^{-2}, panicle length and more number of grains $panicle^{-1}$ (Sharma *et al*., 1990). The number of panicles m^{-2} was significantly increased with FYM application (Soni and Sikarwar, 1991; Sharma and Sharma, 1994). FYM @ 7.5 t ha^{-1} recorded the highest grain yield (Singh *et al*., 1998). Reddy and Shivaraj (1999) reported that FYM (10 t ha^{-1}) recorded maximum grain and straw yield during *kharif* season.

Roy *et al*., (1995) revealed that application of 60 kg N ha^{-1} through FYM produced highest rice yield. The yield and yield attributes were lower when all 120 kg N ha^{-1} was applied through FYM only.

Application of FYM@ 10 t ha^{-1} in conjunction with different fertilizer levels exhibited a significant increase in effective tillers m^{-1} row, grain and straw yield of rice compared to fertilizer treatment alone (Azad and Lehria, 2001).

2.2.3 Yield

Among the organic manures, FYM is commonly used in rice and it proved its ability in enhancing various aspects of crop production. Application of FYM had beneficial effects on physico-chemical properties of soil and to sustain high levels of rice yield (Sharma and Yadav, 1995; Soni and Sikarwar, 1991) in addition to an efficient source of plant nutrients (Kumar and Yadav, 1995).

Application of 10 t FYM/ha resulted in either same or significantly higher grain yield than with 40 kg N/ha applied basally through urea fertilizer. Top dressing of 20-40 kg N/ha through urea super granule placement resulted in no additional advantage in the FYM-treated plots, suggesting continued N supply throughout the crop growth period with organic manuring. The yield potential of rice was realized with 10 t FYM/ha applied along with 20 kg N/ha at sowing under these drought-cum-flood prone lowland conditions (Sharma, 1999).

Dikshit and Khatik (2002) opined that application of 10 t FYM ha^{-1} gave significantly highest seed yield (14.30 q ha^{-1}) and straw yield (28.30 q ha^{-1}) compared to control (13.05 q ha^{-1} and 26.55 q ha^{-1}, respectively) in soybean.

2.2.4 Quality

Hemalatha *et al*. (2000) reported that application of FYM @ 12.5 t ha^{-1}, incorporated at the start of first puddling, improved the yield and quality of rice and soil fertility.

Application of 50 kg P_2O_5 ha^{-1} recorded numerically higher head rice recovery in aromatic rice. Similarly 30 kg K_2O ha^{-1} recorded higher values of head rice recovery, kernel length : breadth length, breadth ratio after cooking in comparison to 60 and 90 kg K_2O ha^{-1} (Singh *et al*.,2000).

Zhang and Shao (1999) observed that application of FYM promoted higher total head milled rice recovery as well as protein content in grain than in the treatment with commercial fertilizers which may be due to higher uptake of nutrient in FYM applied plots.

2.2.5 Nutrient uptake

Sharma and Mitra (1994) reported that NPK uptake was significantly higher with FYM application than control. With the application of FYM, concentration of Fe, Mn, Cu and Zn in paddy grain and straw also increased during wet season under 50 per cent as well as 100% recommended dose of fertilizer (RDF) application (Verma, 1991). In a field experiment conducted by Singh and Ghosh (1992) at Ranchi, 40:13:17 kg NPK uptake in upland rice was noticed with the application of 10 t FYM per hectare.

Bal *et al*. (1993) reported that application of FYM @ 5 t ha^{-1} alone gave rice seed yield of 2.36 t ha^{-1} compared to the control (1.49 t ha^{-1}), while, combined application of FYM and N fertilizer increased uptake.

Application of FYM improved the efficiency of applied P by 18.6% in terms of P utilization and 23.6% of applied P was recovered by the rice crop (Sharma and Tripathi, 1994).

2.3. EFFECT OF BIO- FERTILIZER ON GROWTH, YIELD AND YIELD ATTRIBUTES

2.3.1. Growth Characteristics

Peeran *et al*., (1995) observed that in a field experiment at TNAU increasing levels of N from 75 kg/ha to 100 kg/ha along with *Azospirillum* application to rice crop gave significantly taller plants than urea alone.

Experimental evidences indicated that application of 50% of N as inorganic fertilizer +25% N through *Ipomoea carnea* + *Azospirillum* as seed and soil application recorded maximum plant height of 96.4 cm (Balasubramanian and Veerabadran, 1997) as compared to complete fertilizer application.

2.3.2. Yield attributes

Peeran (1995) observed that application of *Azospirillum* along with 75 kg N /ha and green manure produced higher number of productive tillers per hill which was at par with application of 100 kg N/ha.

2.3.3. Yield

Balasubramanian *et al*., (1997) stated that application of 50% N as inorganic fertilizer + 25% of N as prilled urea in combination with *Sesbania* + *Azospirillum* as seed and soil application recorded higher grain yield of 58.7 q/ha in rice. Similarly in pearl millet dual inoculation of *Azotobacter* and *Azospirillum* + 50 kg N/ha produced highest grain yield of 1.49 t/ha which was at par with 1.31 t/ha obtained with dual inoculation +37.5 kg N/ha (Raghuwansi *et al*., 1998) .

2.3.4. Nutrient uptake

Yanni *et al*., (1999) reviewed that combined application of three N fixers *viz. Azotobacter, Azospirillum and Cynobacteria* along with one third of the chemical N to the rice variety Giza172 stimulated highest N-content in the plants.

2.4. EFFECT OF CHEMICAL FERTILIZER ON GROWTH, YIELD AND YIELD ATTRIBUTES

2.4.1. Growth Characteristics

Mahajan *et al*., (2010) revealed that N treatments had significant effect on plant height in aromatic rice.The maximum plant height of 104.6cm was recorded in treatments supplemented with 60 kg N ha^{-1}, which was at par with plant height at 40 kg N ha^{-1}. Minimum plant height (94.4cm) was observed in the unfertilized plots.

Kumar and Shivaya (2009) recorded that each successive increase in the level of N application increased the plant height significantly. The highest plant height was recorded with 150 kg Nha^{-1} and minimum with no N (control).Similar findings were also reported in aromatic rice by Gautam *et al*., (2008) .They had opined that application of nitrogen resulted in significant increase in plant height at all the growth stages ,the highest average plant height of 111.6 cm was recorded at harvest stage with the application of 160 kg N ha^{-1}.

2.4.2. Yield attributes

Murali and Setty (2001) showed that scented rice, Pusa Basmati-1, responded significantly to the application of N : P_2O_5 :K_2O @ 150 :75: 75 kg per ha with increased total dry matter production, number of panicles per sq.m, filled grains per panicle, grain yield and total N uptake.

Mandal *et al*., (2004) revealed that number of effective tillers m^{-2}, number of filled grains $panicle^{-1}$,grain and straw yield of scented rice varieties were found to increase with the higher level of fertility (60:30:30 kg NPK ha^{-1}).

Tariq Sultan *et al*., (2007) observed that in scented rice significantly higher values were obtained by application of chemical fertilizer as compared to that of organics.

2.4.3. Yield

Dahiphale and Khandagale (2007) revealed that recommended dose of fertilizer 80:50:50 kg NPK ha^{-1} has recorded 3.25 and 1.42 times more yield over control and organic nutrition, respectively.

Ganajaxi and Math (2008) found that inorganic fertilizers at 50 and 100 percent of the recommended doses were equally effective with regard to the enhancement of grain yield over the control.

The grain and straw yield of rice varieties increased gradually with increasing levels of N application @ 40 to 120 kg ha^{-1} and the responses were significant.

2.4.4. Quality

Srivastava *et al*. (2009) revealed that application of 45 kg of N in three equal splits, 30 kg P_2O_5 , 30 kg K_2O and 37.5 $ZnSO_4$ was found to the best to achieve higher grain yield of good quality Basmati rice with lower kernel degradation(Alkali score) and higher aroma score, the properties which are considered to be the most important for table purposes.

Chandrakar *et al*., (2004) revealed that among the three fertilizer doses application of 100:60:40 kg NPK ha^{-1}can be recorded as best for raw seed yield and seed recovery percentage of scented rice variety Indira Sugandhit Dhan-1.

Singh *et al*. (2000) revealed that 30 kg K_2O ha^{-1} recorded higher values of head rice recovery, kernel length, length: breadth ratio and kernel length after cooking in comparison to 60 and 90 kg K_2O/ha.

2.4.5. Nutrient uptake

Grain yield of rainy-season rice was higher under 100% recommended NPK fertilizer supplied through either inorganic source alone or 75% through inorganic and 25% through organic source. Application of NPK at suboptimal dose, i.e. 75% and 50% of recommended NPK dose, or following farmer's practice reduced the seed yield significantly. The total productivity in rice was higher when both rainy-season and winter season rice received 100 per cent recommended dose of NPK fertilizer. For the rainy-season rice, uptake of the nutrients NPK was more when 75 per cent of the fertilizer were applied as inorganic and 25 per cent as organic sources, whereas in winter season maximum uptake of the nutrients by rice was recorded when 100 per cent of NPK was supplied as inorganic source (Jana and Ghosh, 1996).

2.5 COMBINED EFFECT OF ORGANIC AND INORGANICS ON YIELD ATTRIBUTES AND YIELD.

2.5.1 Yield attributes

Mishra *et al*., (2003) concluded that in hybrid rice the yield attributes viz. number of effective tillers hill^{-1}, panicle weight, number of spikelets and fertile spikelets panicle^{-1} were appreciably higher under supply of N through integrated approach of 75% recommended N blended with cow dung or cow urine . Integrated approach of N being at par with that of application of 100% recommended N through chemical fertilizer resulted higher yield of hybrid rice and the maximum (85.2 q/ha) was realized with application of 75% recommended N blended with cow dung and urine.

Manish Kumar *et al*., (2003) observed that application of wheat straw @ 5 or 10 tonnes per ha resulted in higher values of yield attributes (panicle length, filled spikelets/panicle and 1,000 seed weight) and seed and straw yields of rice compared to the control. Increasing dose of nitrogen increased yield attributes and seed yield of rice significantly, where in, application of 100% recommended dose of N recorded more panicle length, filled spikelets per panicle and 1,000 seed weight and consequently seed yield and NPK uptake. FYM @ 20 tonnes per ha also resulted significantly higher values of yield attributes, seed yield and nutrient uptake of rice over the control and wheat straw applied @ 5 or 10 tonnes per ha as well as 50% N used alone, integrated use of wheat straw @ 10 tonnes per ha+ 100% recommended dose of N resulted in maximum values of yield attributes, seed yield as well as NPK uptake by rice. Use of organic sources helps in maintaining soil fertility, whereas with chemical fertilizers a significantly decline.

2.5.2 Yield

Subbaiah *et al.* (2000) obtained the higher grain yields with FYM + NPK than with GM (green manure) + NPK in *kharif* and the residual effect of these organic manure was also had significant effect on *rabi* crop.

Application of inorganic fertilizer @ 60 : 40 : 30 kg NPK/ha in combination with 5t/ha of FYM or inorganic fertilizer of 30 kg N/ha applied along with 2t/ha of poultry manure were found equally effective for higher grain yield(Santosh Kumar *et al*., 2004). The earlier treatment produced 70 per cent more grain yield than that of the control. These treatments were closely followed by application of inorganic fertilizer 30:20:15 kg NPK/ha supplemented with 1.5 t/ha of cow dung urine (CDU) and 5 t/ha green manure. However, inorganic fertilizer of 50:40:30 kg NPK /ha supplemented with 3 t/ha of cow dung urine mixture produced significantly higher grain yield when compared with application of inorganic fertilizer alone. It is well known fact that blending of N with cow dung urine mixture helps in continuous supply of the nutrients, reduced the nutrient loss and enhanced the nutrient use efficiency and grain yield over higher doses of inorganic fertilizer applied alone.

Panda and Sing (1996) reported a saving up to 20- 25percent of inorganic nitrogen with application of FYM. Several workers have also reported significant increase in grain yield due to conjunctive use of FYM and fertilizer over the use of NPK fertilizers alone.

2.5.3 Nutrient uptake

Mondal *et al*., (2003) revealed that application of FYM @ 10 tonnes per ha with and 100 per cent NPK could increase the available N status of soil and plant.

Under low land situations, Singh *et al.* (2001) studied the effect of different nutrient management practices on yield and quality of rice. They opined that the uptake of NPK and soil fertility could be enhanced by combined application of 50 per cent dose of recommended NPK + FYM (10 t/ha). Available N, P and organic C contents of the soil in all the situation were increased significantly due to application of FYM, either alone or in combination with NPK fertilizer.

2.6. EFFECT OF INM ON GROWTH, YIELD AND YIELD ATTRIBUTES

2.6.1. Growth character

Solunke and Giri (2010) revealed that combined application of FYM (5t/ha) and + 100 % RDF (75:37.5:37.5 kg NPK ha^{-1})has positive effect on all growth characters as compared to that of sole application of recommended dose of fertilizer.

Application of 100% recommended dose of nitrogen blended with FYM has significant effect on growth parameters(plant height, dry matter accumulation, root mass density) as well as physiological parameters (leaf area index, leaf area duration, light interception) as reported by Roul *et al*., (2007) .

Chinnusamy *et al*., (2006) reported that the combination BGA+PSB+ VAM + Azospirillum was best for improvement in growth and yield traits and nutritional status of rice.

In scented rice, integrated application of organics and inorganics significantly increased plant height, effective tillers per hill, seed and straw yield compared to their sole application (Pandey *et al*., 1999) .

2.6.2. Yield attributes

Application of NPK @ 56:37:37 kg ha^{-1}+ FYM 4 t ha^{-1} + biofertilizers (Azotobacter and PSB) recorded the highest number of panicles, panicle length, grain $panicle^{-1}$, panicle weight, percentage of filled grain, grain and straw yield of scented rice (Dahiphale *et al*., 2004)**.**

Paraye *et al*., (2006) revealed that application of 50% RDF (40: 25:15 kg NPK ha^{-1} for Madhuri and Kasturi and 30:20:10 kg NPK ha^{-1} for Dubraj) in conjunction with 5 t FYM ha^{-1} recorded higher yield attributes (number of grains $panicle^{-1}$ and test weight of seeds), yield (grain + straw) of rice is compared to that of 100% RDF alone. They also revealed that application of FYM @10 t ha^{-1} recorded significantly lowest grain and straw yield of aromatic rice.

Netam *et al*., (2008) concluded that integrated nutrient management improves the growth and yield of scented rice. The application of 5 t GM + 30:30:30 kg NPK ha^{-1} produced significantly higher panicle length, panicle weight, grain yield and net returns followed by 5 t FYM + 5 t GM + 20:20:30 kg NPK ha^{-1}.

Sarawgi and Sarawgi (2004_b) revealed that higher level of nutrients (i.e. 60:50:40 kg NPK ha^{-1} + N blended with FYM) recorded significantly higher number of tiller $panicle^{-1}$ at maximum tillering stage, plant height, panicle $plant^{-1}$, panicle length, panicle weight, test weight, filled grain as well as total number of grain $panicle^{-1}$, grain and straw yield of semi tall and short to medium slender scented rice varieties followed by same level of nutrients blending and lower level of nutrients (40:40:30 kg NPK ha^{-1}) with or without blending . Further, it was observed that there was no significant differences in between lower level of nutrients blended with FYM (40:40:30 kg NPK ha^{-1}+ N blended with FYM) and higher level of nutrients without blending (60:50:40 kg NPK ha^{-1}) for plant height, panicle length, test weight, number of filled grains as well as total number of grains $panicle^{-1}$ and straw yield. It was also found that application of 10 t FYM ha^{-1} (45:20:40 kg NPK ha^{-1}) proved as good as higher level of nutrient (60:50:40 kg NPK ha^{-1}) without blending.

Mandal and Adhikary (2005) concluded that the plant height, effective tillers per hill, number of grains per panicle, 1000 grain weight and grain yield were significantly higher with the treatment receiving 50 per cent N through chemical fertilizer and 50 per cent N through FYM followed by the treatment receiving 75 per cent N through chemical fertilizer and 25 percent N through through FYM. However, highest straw yield wad recorded with treatment receiving 75% N through chemical fertilizer and 25 per cent N through FYM. Highest harvest index was obtained with treatment receiving 50 per cent N through chemical fertilizer and 50 per cent N through FYM.

2.6.3 Yield

Virdia and Mehta (2010) revealed that the rice grain and straw yield was significantly higher with integrated nutrient application (press mud @ 20 t/ha +RDF), which remained at par with press mud @15 t/ha + RDF or FYM @10 t/ha+ RDF.

Application of chemical fertilizers @ 120:60:30 kg NPK ha^{-1} could achieve significantly higher grain yield in scented rice , however, the response of FYM alone was at par with all the chemical fertilizers(Pandey and Nandeha ,2004).

Jha *et al*., (2006) recorded equally effective grain yield by application of inorganic fertilizer of 60:40:30 kg NPK ha^{-1} combined with 5 t FYM ha^{-1} or inorganic fertilizer of 30 kg N ha^{-1} applied along with poultry manure 2 t ha^{-1} to scented rice variety Pusa Basmati-1. The earlier treatments produced 70% more grain yield than that of control.

Sarawgi *et al*., (2006) revealed that grain yield of scented rice varied significantly due to nutrient management. Higher level of nutrients (i.e. 60:50:40 kg N: P_2O_5:K_2O ha^{-1} + Nitrogen blended with FYM) recorded significantly higher grain of scented rice than rest of the nutrient management practices.

Pushpanathan *et al*.(2004) revealed that integrated use of organic and inorganic nitrogen is the best combination of available nitrogen management techniques, which would facilitate achieving the required productivity and sustainability by efficient use of soil and applied nitrogen.

Integrated use of organic manures and inorganic chemical fertilizers produced higher and sustainable crop yields and maintained the soil fertility and productivity (Laxminarayana *et al*., 2006) .They opined that organics and inorganics are not only complementary but also synergistic since organic inputs had beneficial effects beyond their nutritional components and enhanced the efficiency of the applied mineral fertilizers.

2.6.4 Quality

Acharya and Mondal (2010) concluded that the higher productivity and quality of the crops in sequence and rice equivalent yield (32.4 ton ha^{-1}) was observed with application of 75 % recommended dose of fertilizers (RDF) along with 25 % N through Neematex.

Better quality parameters of rice like head rice recovery, volume expansion ratio etc was recorded by the application of 50% organics and 50% inorganics and it was at par with 100% recommended dose of N through organic source (Mrudula *et al*., 2004) .

Loganadhan and Rajeswari (2005) revealed that application of inorganic fertilizers recorded higher seed yield (4.27 t/ha) and harvest index (0.43) compared to organic manuring in Pusa Basmati. The quality parameters *viz.,* amylose content (21.69%) and gel consistency (72.0 mm) were higher in organic manure applied pots. Comparatively the kernel length, kernel breadth and its ratio were lower in organic manured pots recording 6.35 mm, 1.86 mm and 3.41 mm compared to 6.60 mm, 1.70 mm and 3.80 mm indicating the superiority of organic manured pots which is seen in the quality parameters after cooking. The marketing oriented parameters like hulling (77%), milling (68.1%) and head rice recovery (35.9%) were higher in organic manured pots compared to 76.5%, 67.5% and 32.6% respectively in inorganic fertilizer applied pots.

Singh *et al*., (2000) concluded that application of organic combination of nutrients increased the rice grain quality (Nakagawa *et al*., 2000). Application of compost @ 10 t ha^{-1} recorded higher values of milling and kernel length after cooking in Pusa basmati rice.

Hemalatha *et al*. (2000) revealed application of vermicompost numerically increased the values of all quality parameters like hulling per cent, head rice recovery compared to no vermicompost application.

Saha *et al*. (2007) revealed that application of 75 % RDF (80:40:40 kg NPK ha^{-1}) in conjunction with 25 % N through pelleted form of organic manure or neem seed powder or FYM improve the productivity, quality of aromatic rice and fertility build up of soil.

Pandey *et al*. (1999) revealed that response of farmyard manure and chemical N fertilizer on seed yield, N uptake and quality traits of scented rice (*Oryza sativa* L.) 'Madhuri 11' and 'Pusa Basmati-1' during wet season of 1996-97. Application of farmyard manure (10 tonnes/ha), chemical fertilizer (80 kg N/ha) and combination of farmyard manure (5 tonnes/ha) and chemical fertilizer (40 kg N/ha) were found equally effective as that of 120 kg N per ha applied through chemical fertilizer for seed yield and N uptake. The head rice recovery and alkali value were also higher with the application of 10 tonnes of farmyard manure or 80 or 120 kg N per ha than that of the other treatments during both the years. Application of N fertilizer had positive influence on kernel length and length: breadth ratio after cooking and elongation ratio and the values remained higher in fertilized plots than those of control. Among the varieties, 'Madhuri 11' recorded higher seed yield, N uptake than 'Pusa Basmati 1', whereas 'Pusa Basmati 1' was found to be better than 'Madhuri 11' in kernel length and length : breadth ratio, after cooking, elongation ratio and alkali value.

Raikar *et al*., (2008) revealed that application of 50 percent N through FYM and 50 percent through inorganic along with recommended P_2O_5 and K_2O (50 kg/ha each) produced significantly higher seed yield (3775 kg/ha) and quality over organics (3356kg/ha) and farmers practice (3422kg/ha).

Jeong *et al*. (1996) reported that amylase content of grain was lower in plants given straw, compost or compost + pig manure compared with 100 percent NPK treatment. In general organic fertilizer did not improve rice cooking quality and taste.

Prakash *et al*., (2002) concluded that the application of FYM gave higher total and head milled rice recovery, longer kernel expansion and higher protein content. The crop was nourished with different organic nutrient sources *viz.,* vermicompost, neem cake, FYM, glyricidia leaf green manuring and biofertilizer (*Azotobacter* + PSB) in comparison with recommended dose of fertilizer (80: 50:50 NPK kg ha^{-1}) and control.

2.6.5 Nutrient uptake

Singh *et al*. (2005) studied the effect of INM practices in transplanted rice on yield, nutrient uptake and soil fertility status. Results revealed an increase in crop yield, nutrient uptake and improvement in soil fertility status due to selected INM package. Application of soil test based N, P and K in conjunction with FYM/green manuring resulted in additional rice seed yield by 22.6 q per ha over farmers practice (20.3 q ha^{-1}). INM practices in farmers field soils resulted in an increase in the crop removable of N, P and K and also improved the available nutrient status of soil.

Gupta *et al.,* (2000) showed the effect of conjunction use of organic manures and chemical fertilizer on lowland rice. Two species of dhaincha *viz*. *Sesbania aculeate* (Poir) and *S. rostrata* (Brem.) were grown before wet season rice. Azolla, Farm yard manure with *S. rostrata* green manure and FYM with prilled urea (PU) were integrated and compared vis-à-vis PU 120 (the recommended practice of applying N @ 120 kg ha^{-1}). PU 180 and USG, had significant effect on yield, N content and N uptake of rice crop. Integrated use of purely organic sources *S. rostrata* green manure with FYM (SR + FYM) excelled the recommended practice of applying nitrogen (120 kg N ha^{-1} as prilled urea).

2.7 ECONOMICS

Kumari *et al*., (2009) revealed that scented rice (Birsamati) receiving *Dhaincha* green manure @ 5 t/ ha+ FYM @ 10 t/ha was found to be most appropriate organic nutrient management system for higher productivity as well as profitability.

Singh *et al*., (2006) revealed the effect of integrated nutrient supply on yield, yield attributes, nutrient uptake and economics of rice (*Oryza sativa* L.). Application of 25% recommended dose of N (RDN) through pressmud and the rest 75% NPK through inorganic fertilizers increased the seed yield of rice by 51.1 per cent over no NPK treatment. Addition of zinc with 100% of recommended NPK through inorganic fertilizers gave higher seed and straw yield of rice over 100% of recommended NPK alone. The net income and benefit : cost ratios were also highest with 25% of recommended N through pressmud and the rest 75% NPK through inorganic fertilizer. The study was aimed to find out the effect of organic sources of nitrogen integrated with chemical sources on rice at the Raipur Inceptisol. Over the 12 years of study period, highest rice yield was obtained when 50% of nitrogen was supplied through green manuring (GM). When 50% N was supplied through farmyard manure (FYM), it produced rice yield at par with the treatment where, 100% NPK had been applied through chemical fertilizers. It showed that wherever, nitrogen was substituted through GM, FYM or crop residue (rice straw) in rice, bulk density was significantly lowered as compared to the initial status and control plot. Corresponding decrease in bulk density favorably enhanced the infiltration rate and it was found to be highest in the green-manured plot and lowest in control.

Bajpai *et al*., (2006) concluded that sustainability is possible either by providing 50% of recommended N through GM to rice and 50% through chemical fertilizers or even with 100% of recommended NPK through chemical fertilizers to rice.).

Raghuwanshi, *et al*., (2003) revealed that in scented rice (CV.JR 503-7), application of 80 kg N ha^{-1} registered maximum values of all the yield attributes, which ultimately produced highest grain yield during both the years. The highest gross monetary return, net monetary and benefit : cost ratio was achieved with 80 kg N ha^{-1}.

MATERIALS AND METHODS

A field experiment entitled “Integrated nutrient management in aromatic rice (*Oryza sativa L.*) was conducted using the material and following the methods as described in this chapter.

3.1 EXPERIMENTAL SITE

The experiment was conducted in the ‘F’ block of the Central Research Station of the Orissa University of Agriculture and Technology, Bhubaneswar during *kharif* 2010. The Research Station is situated at 20º15′ North latitude and $85^{0}52'$ East longitude and about 65 Km away from Bay of Bengal at an elevation of 25.9 m above the mean sea level (MSL).

3.2. SOIL CHARACTERISTICS

Soil samples were collected randomly from 0 to 15 cm depth of the experimental site thoroughly mixed together and composite sample was drawn for physical, mechanical and chemical analysis.

The soil of the experimental site was sandy loam and slightly acidic in reaction (P^{H}-5.5), low in available N (225 Kg per ha) and medium in available P (32 Kg per ha) and K (156 Kg per ha). The result of the analysis are presented in Table 1 a and b.

Table-1a Mechanical composition of soil (0-15cm depth)

Mechanical constituents	Percentage composition (air dry basis)	Method employed
Sand	74.6	Bouyoucos hydrometer method(Piper,1950)
Silt	12.7	
Clay	11.4	
Textural Class	Sandy loam	
Soil Type	Red Soil(*Haplustalf*)	

Table 1b Chemical composition of the soil

Parameter	Value	Method employed
pH	5.5	Glass electrode Beckman's pH meter(Jackson,1973)
EC(dSm^{-1})	0.25	Conductivity bridge method (Jackson,1973)
Organic carbon (%)	0.34	Walkley and Black method (Jackson,1973)
Available nutrients(Kg/ha)		
Nitrogen	225	Modified Kjeldahl method (Jackson,1973)
Phosphorous	32	Bray's-1 'P' method (Jackson, 1973)
Potassium	156	Flame photometer method (Jackson,1973)

3.3 Cropping history of the Experimental Site

The crops grown in the experimental plot during the last three years prior to commencement of the experiment are presented in Table 2.

Table 2 Cropping history of the experimental plot

Year	Kharif	Rabi
2007	Rice	Fallow
2008	Rice	Fallow
2009	Rice	Fallow

3.4 Climate and Weather condition

Bhubaneswar is experiencing a warm and moist climate characterized by humid summer and mild winter. Broadly the climate falls in moist and hot group (Lenka 1976). Agro-climatically the area comes under East and South-East Coastal plain zone. Generally monsoon commences here in the second week of June (Table 3 and 4).

Table 3 Mean weather data (2000-2009) at Bhubaneswar

Month	Rainfall (mm)	Rainy days (No.)	Evaporation (mm/d)	Atmospheric Temperature		Relative humidity		BSH (d^{-1})
				Max. (°C)	Min. (°C)	FN (%)	AN (%)	
January	9.5	1	3.9	29.2	14.7	91	43	8.1
February	15.2	2	4.6	31.9	18.3	93	44	8.4
March	18.7	2	6.0	34.9	22.2	93	47	8.3
April	30.1	3	7.5	36.4	25.3	90	53	8.6
May	82.3	6	8.4	38.0	26.4	88	53	8.7
June	234.2	13	8.9	35.4	26.3	90	66	5.3
July	369.5	21	3.8	32.3	25.7	93	77	3.6
August	363.4	21	3.8	31.8	25.5	94	78	4.1
September	306.1	17	3.6	32.2	25.2	93	77	5.6
October	162.0	10	3.4	32.0	23.5	93	65	7.1
November	22.2	3	3.5	30.9	18.6	91	50	7.9
December	2.2	0.3	3.5	29.1	14.7	90	40	8.0
Total	1615.4	104	20.0	-	-	-	-	-

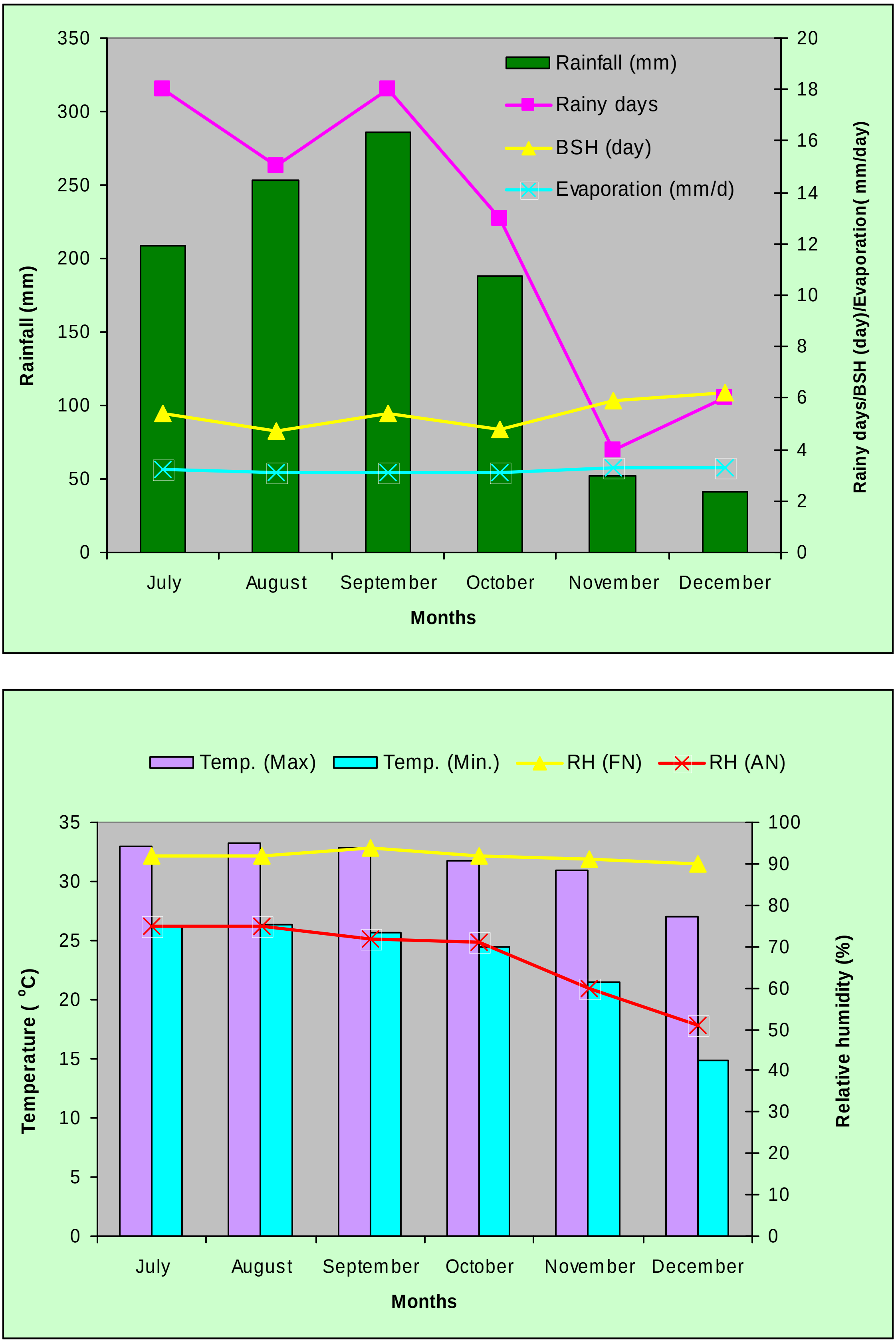


Fig. 1 Monthly meteorological parameters during crop growth period (2010)

Table 4 Weekly meteorological parameters during the cropping period

Meteorological Week		Temperature (°C)		Rainfall (mm)	Rainy days (No)	Relative humidity (%)			Sunshine Record (hours)	Wind velocity (Km/hr)	Pan Evaporation (mm)
Week No	Period	Max.	Min.			M	AN	AV			
22	28-3 June 2010	37.0	27.7	11.2	1	88	66	77	8.1	-	7.9
23	4-10	39.4	28.0	1.8	1	90	53	72	8.2	-	7.2
24	11-17	34.0	25.9	122.6	5	91	78	85	5.2	-	4.3
25	18-24	35.2	26.5	3.7	1	90	72	81	7.4	-	6.0
26	25-1 July 2010	33.5	25.8	67.9	3	93	78	86	3.3	-	3.3
27	2-8	33.1	25.4	65.1	6	94	78	86	5.9	5.7	3.2
28	9-15	34.0	26.7	11.7	2	90	72	81	5.6	5.2	3.6
29	16-22	34.0	27.1	3.3	2	89	68	79	8.8	5.3	3.4
30	23-29	30.9	25.7	95.7	6	94	81	88	2.0	3.6	2.6
31	30-5 August 2010	32.6	26.1	149.9	6	94	86	90	2.9	2.9	2.6
32	6-12	33.3	26.6	81.6	2	91	66	79	5.7	3.9	3.1
33	13-19	33.8	27.1	16.2	2	93	72	83	5.2	3.8	3.4
34	20-26	34.2	26.4	1.4	3	89	70	80	6.9	3.3	3.7
35	27-2 Sept 2010	31.8	25.9	43.6	6	93	83	88	2.9	2.4	3.0
36	3-9	33.3	26.5	41.3	5	92	73	83	7.4	3.6	3.4
37	10-16	32.5	25.4	86.0	4	95	73	84	3.9	2.7	2.7
38	17-23	31.1	25.3	130.8	6	97	77	87	2.7	3.1	2.6
39	24-30	34.6	25.3	22.3	1	92	77	85	7.2	2.4	3.5
40	1-7 Oct 2010	32.2	24.8	58.5	5	92	60	76	5.6	4.0	3.1
41	8-14	30.9	25.0	44.2	1	92	78	85	3.8	3.7	3.0
42	15-21	31.6	24.5	68.1	4	95	70	83	5.5	5.1	2.8
43	22-28	32.9	24.2	16.5	2	91	73	82	5.3	1.8	3.4
44	29-4 Nov 2010	28.5	22.3	13.5	3	86	61	74	3.7	4.6	3.1
45	5-11	30.5	21.8	70.1	2	90	70	80	5.3	4.3	2.8
46	12-18	31.9	21.6	0.0	0	97	62	80	7.4	2.3	3.7
47	19-25	32.1	20.9	0.0	0	89	57	73	7.5	1.9	3.5
48	26-2 Dec 2010	31.2	20.9	0.0	0	89	62	76	4.5	1.7	3.5
49	3-9	25.3	17.0	35.6	4	89	79	84	3.9	5.9	2.9
50	10-16	27.1	17.5	5.9	2	92	54	73	4.2	4.0	2.8
51	17-23	26.4	10.9	0.0	0	90	32	61	8.5	2.6	3.5
52	24-31 Dec 2010	28.2	13.0	0.0	0	93	38	66	7.6	1.4	3.7

M- Morning AN – Afternoon AV- Average

3.4.1 Rainfall

The total rainfall received during the cropping season (July-December) was 1129.2 mm. The maximum rainfall was 286.2 mm in September and minimum rainfall 41.5 mm in December which coincides with the planting and panicle development stages, respectively. The total number of rainy days was 56 in the cropping season. (Fig.1)

3.4.2 Air Temperature

It was revealed from the data that, the maximum and minimum temperature during cropping season were 32.22º C and 24.50º C, respectively which coincide with maturity stage and growth respectively .

3.4.3 Relative Humidity

The mean relative humidity during cropping season was 92.25% in the morning and 67.50% in the afternoon hours.

3.4.4 Bright Sunshine Hours (BSH)

During the crop growth period, the crop received maximum bright sunshine hours per day in December with 6.2 hours while the minimum was in with 4.7 hours.

The weekly meteorological data during cropping season i.e. from June, 2010 to December, 2010 as recorded in the meteorological observatory, Department of Agronomy, College of Agriculture, OUAT, Bhubaneswar is presented in table 3.4.

3.5 EXPERIMENTAL DETAILS

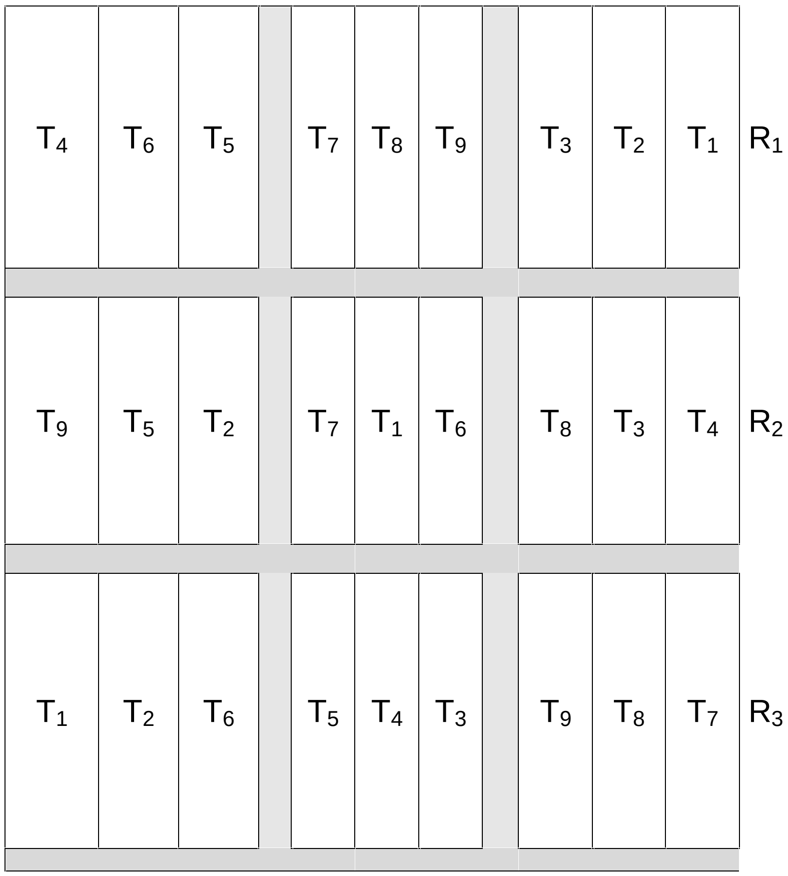
3.5.1 Design and layout

The experiment was laidout in a Randomized Block Design (RBD) with nine treatments and three replications. The treatments were allocated to different plots randomly following the random number table of Fisher and Yates (1957). The plans of the field layout along with details of treatments are presented in Fig. 2.

3.5.2 Particulars of field layout

Design	:	Randomized Block Design
Number of treatments	:	9
Number of replication	:	3
Total number of plots	:	27
Gross plot size	:	5 x 4 = 20 m^2
Net plot size	:	4.7 x 3.8 = 17.86 m^2
Variety	:	Thakursona
Spacing	:	15 cm x 10 cm

Fig. 2 Plan of layout of the experimental site



Treatments

The details of the treatment are given below. The treatments were allocated randomly to different plots.

T_1 - RDF @40:20:20 kg NPK per ha

T_2 - RDF (40:20:20) +FYM@ 5 tonnes per ha

T_3 - 50% RDF (20:10:10) + FYM@ 10 tonnes per ha

T_4 - RDF (40:20:20) per ha + BF (*Azospirillum* &PSM)

T_5 - RDF (40:20:20) +FYM@ 5 tonnes + BF (*Azospirillum* &PSM)

T_6 - 75% RDF (30:15:15) + FYM@ 10 tonnes per ha

T_7 - 75% RDF (30 :15 :15) + FYM@ 10 tonnes per ha + BF(*Azospirillum* &PSM)

T_8 - FYM@ 10 tonnes per ha + BF (*Azospirillum* &PSM)

T_9 - Green manure(Sesbania) +FYM @ 10 tonnes per ha + BF (*Azospirillum* &PSM)

N.B: RDF=Recommended dose of fertilizer FYM=Farm yard manure
BF=Biofertilizer GM= Green manure

3.5.3 Description of crop variety

The local aromatic rice variety Thakursona is grown in the coastal alluvial plain of Odisha. It is a tall variety, photosensitive with straw colored short slender grain and white colored rice. The mean days to 50% flowering is 103days with mean plant height of 138cm,panicle length 23cm,no.of panicles per plant is 6.The mean no. of fertile grains per plant is 148 having fertility of 87%.The mean test wt. of the variety is 12.50gm with mean harvest index of 37. The average grain yield is 21.19q/ha.

3.6 DETAILS OF FIELD OPERATION

3.6.1 Raising of seedlings

Seedlings were raised in wet nursery beds. The required quantity seeds (50kg per ha) were soaked for 24 hours in water to induce sprouting during incubation. After draining out water, seeds were treated with Thiram @

2.5g/kg of seed and incubated for sprouting for 48 hours. The sprouted seeds were sown on 03.07.2010 on wet beds of the size 10 m x 1.5 m with a channel of 30 cm width between two beds for drainage purpose. The seedling were fertilized with 100 kg well decomposed FYM, 500 g Urea, 300 g SSP and 90 g potash per bed of 15 m^2 . After 4 days of sowing, a thin film of 1-2 cm standing water was maintained to keep down weeds and to keep nursery moist. Seedlings were ready for transplanting after 21days of sowing in nursery bed and attained 4-5 leaves.

3.6.2 Field Preparation and lay out

The drainage channels were prepared manually to facilitate drainage of excess water. The Primary tillage operation like opening of soil was done by tractor drawn mould board plough twice to break the clods followed by ploughing by cultivator. Proper levelling and pulverization was achieved by laddering. Cleaning of weeds and stubbles were done manually. After thorough land preparation, the experimental field was laid out into small plots for different treatment. The sub plots were puddled with power tiller.

3.6.3 Manuring and fertilizer application

The manures and fertilizers were applied as per treatments.

3.6.4 Transplanting

Transplanting was done on dt.29.07.11 with 21 days old seedling with a spacing of 15 cm between row and 10 cm between plants in a row. The number of seedlings per hill at planting was 2. Planting was taken up in North-South direction.

3.6.5 Intercultural operation

To reduce the crop weed competition and to provide better crop growth one hand weeding was done at 21 days after transplanting in all the treatments. Plant protection measure was done by spraying endosulphan @ 2 ml per litre + Saaf @ 2 gm per litre of water.

3.6.6 Harvesting and threshing

The crop was ready for harvest when 80% of the panicles became straw-colored and the grains in the lower portions of the panicle were in the hard-dough stage. The harvesting was done by cutting the plants manually with sickle. Harvesting of each net plot was done separately leaving the borders. The harvested produce of each plots was tied into bundles separately and tagged. Then it was transported to the threshing floor. The harvested crop of each plot was allowed to sun drying. Threshing was done on cemented floor separately by thresher. Grains were separated after proper cleaning and the weight of seed and straw were taken independently.

3.7 Calendar of field operation undertaken

Calendar of field operations

Sl. No.	Cultural operations	Implements/ Methods use	Date
1	Nursery raising	Manual	03.07.10
2	Cultivation	Tractor drawn cultivator	23.07.10
3	Puddling	Power tiller	26.07.10
4	Levelling	Planker	26.07.10
5	Layout and field channel preparation	Steel tape and Manual	26.07.10
6	Soil sampling	Soil auger	26.07.10
7	Transplanting and treatment application	Manual	29.07.10
8	Weeding	Manual	20.08.10
9	Harvesting	Manual	18.11.10
10	Threshing	Thresher	24.11.10
11	Winnowing and sun drying	Manual	24.11.10

3.8 BIOMETRIC OBSERVATIONS

Biometric observations of different growth parameters were taken at 30 days interval from planting to harvest.

Randomly sampling technique was adopted to select number of plant per sq. meter area of each plot were selected for the periodic observation of different growth parameter such as plant height, number of tillers etc. Observation on leaf area, root length and weight, stem weight and total dry matter accumulation was recorded. Border rows are avoided to counteract the border effect.

3.8 PRE HARVEST STUDIES

3.8.1 Plant height

The height of five randomly selected plants from each subplot was recorded at 30 days interval. The heights of these plants were measured from ground level to the tip of the main shoot with the help of a meter scale. Then the heights of the plants were average out to get the mean plant height.

3.8.1.2 Number of tillers

The numbers of tillers per sq. m. were counted at 30, 60, 90 DAT and at harvest each plot using one meter square quadrant from two different places and then number of tiller per sq.m. was worked out.

3.8.1.3 Leaf area index (LAI)

The leaf area index is the total leaf area per unit ground area which was calculated by using the following formula.

$$\text{LAI} = \frac{\text{Total leaf area in m}^2}{\text{Total land area in m}^2}$$

Total leaf area was found out by multiplying actual leaf area per plant with number of plants per m^2.

3.8.1.4 Dry matter production

The above ground portions of the plants from each plot were collected for dry matter study. The collected samples were air dried for a period of two days and then oven dried at 80ºC till the constant weight was obtained. The total dry matter accumulation per plant was estimated by adding leaf and stem weight of the plant of the corresponding treatment.

3.8.1.5 Shoot: root ratio

The shoot to root ratio was calculated by dividing the dry weight of shoots by their respective root dry weight. The shoot weight was estimated by adding these stem and leaf weight of corresponding plant

3.8.1.6 Crop growth analysis

Growth analysis parameters like Crop growth rate (CGR), Relative growth rate(RGR) in rice were calculated on the basis of above ground dry matter accumulation using the formulae suggested by Radford (1967).

$$\text{CGR} = \frac{W_2 - W_1}{t_2 - t_1} \ (\text{g/day/m}^2)$$

$$\text{RGR} = \frac{\ln W_2 - \ln W_1}{t_2 - t_1} \ (\text{g/g/day})$$

3.8.2 POST HARVEST OBSERVATIONS

3.8.2.1 Panicle length

Total panicles from the sampled plants were collected, counted and their average was taken as the number of panicle per plant for each treatment.

3.8.2.2 Number of spikelets per panicle

Five panicles were taken from the sampled plant from each treatment and threshed. The total spikelets were counted and averaged out to expressed the number of spikelet per panicle.

3.8.2.3 Number of fertile and sterile grain per panicle

The panicle taken for measuring length were threshed separately and the number of filled grains and chaffs were counted, totaled and averaged out. The total numbers of spikelets were also determined by adding both sterile and fertile.

3.8.2.4 Test weight

One thousand filled grains were collected at random from threshing of sample panicles from each plot and weight recorded with electrical balance to find out the test weight.

3.8.2.5 Grain and Straw yield

The crop harvested from each net plot was threshed by pedal thresher. The grains were cleaned and sundried for 2-3 days to bring down the moisture content to about 14% and weighed. The weight of straw and chaffs were also recorded after thorough sun drying. The net plot grain and straw yield were converted to quintals per hectare..

3.9 QUALITY CHARACTER

3.9.1 Kernel length and breadth (mm)

Ten milled kernels from each plot were taken at randomand measured on graph paper for their length breadth using a “Photo Enlarger” with a magnification of 3 *. The mean length and breadth were expressed in mm.

3.9.2 Hulling (%)

Well dried rough rice sample from each plot weighing 100 g were hulled in a mini "Satake Rice Medium" and the weight of brown rice was recorded. Hulling percentage was worked out as:

$$\text{Hulling (\%)} = \frac{\text{Weight of brown rice (g)}}{\text{Weight of rough rice (g)}} \times 100$$

3.9.3 Milling (%)

The hulled brown rice samples were milled in a "Satake Rice Whitenning and Caking Machine" for 5 minute. The polished rice was weighed and milling percentage was calculated as:

$$\text{Milling (\%)} = \frac{\text{Weight of milled rice (g)}}{\text{Weight of rough rice (g)}} \times 100$$

3.9.4 Head rice recovery (%)

The head rice yield was determined by separating whole grains and ¾ grains manually percentage was expressed as:

$$\text{Head rice recovery (\%)} = \frac{\text{Weight of whole milled rice (g)}}{\text{Weight of rough rice (g)}} \times 100$$

3.9.5 Alkali value

It was measured in terms of alkali disintegration using 7 point numerical spreading scale as suggested by Little et al. (1958). Six milled rice kernel were evenly placed in petriplates containing 1.7 percent KOH solution at 30 ± 1^0c for 23 hours and the spreading scale was recorded in following manner (Table 5 and 6)

Table 5 Alkali spreading scale

Scale	Spreading
1	Grain and affected
2	Grain swollen
3	Grain swollen,coller incomplete or narrow
4	Grain swollen, coller complete and wide
5	Grain split or segmented, coller complete and wide
6	Grain dis appearing, merging with coller
7	Grain with completely disappear, intermingled

Table 6 Alkali spreading value

Classification	Alkali spreading value	Gelatinization temperature (GT)
1-2	Low	High (>74 ^{o}C)
3	Low-intermediate	High, intermediate
4-5	Intermediate	Intermediate (70- 74 ^{o}C)
6-7	High	Low (55-96 ^{o}C)

3.9.6 Harvest index (HI)

The per hectare economic yield expressed as a percentage of its harvested biomass yield was calculated for determining the harvest index as per the below formula.

$$HI = \frac{\text{Economic yield}}{\text{Biological yield}} \times 100$$

3.10. CHEMICAL ANALYSIS

3.10.1 Plant Analysis

Plant samples were collected from each treatment at the time of harvest to study the uptake of different nutrients (N, P and K). A composition sample of grain and straw of each treatment from three replications were taken for this purpose. The samples were oven dried, finely ground and passed through 2mm sieve. The samples were then analyzed to determine N, P and K content by the following methods (Table 7).

Table 7 Method employed for plant analysis

Sl.No	Nutrient	Method employed
1	Total Nitrogen	Modified, Kjeldahl's method
2	Total phosphorus	Di- acid digestion method and colorimetric estimation(Piper, 1970)
3	Total potassium	Flame photometer method (Jackson, 1967)

3.11 STATISTICAL ANALYSIS

The data collected from field observation and that recorded in laboratory were subjected to statistical analysis by standard analysis of variance technique as described in "Statistical procedure for Agricultural Research" by Gomez and Gomez (1984). For significant treatment effects, standard error of means (SEm$\pm$) and critical differences were calculated at 5 percent level of significance.

3.12 ECONOMICS

Cost of production for all treatments was worked out on the basis of the prevailing input and market price of the produce. The net return per hectare was calculated by deducting the cost of production per ha from the gross return ha^{-1}. Ultimately, net return per rupees (cost: benefit ratio) invested was calculated treatment were to assess the economic impact of the treatments by the net return ha^{-1} by the cost of production.

EXPERIMENTAL FINDINGS

The experimental findings of the present investigation entitled "Integrated Nutrient Management in Aromatic Rice" have been presented in the chapter IV. Observation on different growth parameters, yield and yield attributes, uptake of NPK, their residual status after crop harvest and economics of production were recorded during the course of investigation . The results have been presented hereunder.

4.1 PREHARVEST STUDIES

4.1.1 Plant height

The data on mean plant height recorded during successive stage of growth at 30 days interval commencing from 30 DAT till 90 DAT and thereafter at harvest are presented in Table- 8 and illustrated in Fig- 3. In all the observations taken it would be evident that plant height increased progressively with time irrespective of treatments and reached maximum at harvest.

The heights of plants differed significantly among treatments at all the observations recorded. The rate of increase in height was maximum between 60 to 90 DAT and thereafter plant height increased progressively with time up to harvest but at a diminishing rate. The rate of increase height spectacularly slowed down after 90 DAT (i.e. after flowering stage). For example the rate of increase in height in plant height between 30 to 60 DAT was 108 % whereas the rate of increase was 5.2% and 0.8% respectively between 60 to 90 DAT and 90 DAT to harvest.

The maximum growth occurred during the period 30 to 90 DAT, coinciding with active tillering to start of flowering and can be considered as ground period of growth. Thereafter, there was very slight increase in height of plants. Among the treatments, maximum plant height was registered in T_7 (75% RDF +FYM 10 t ha^{-1} +BF) at all the growth stages followed by T_5 (RDF +FYM 5 t ha^{-1} +BF).

Table 8 Effect of integrated nutrient management on Plant height (cm)

Treatments	Days after Planting			
	30	**60**	**90**	**Harvest**
RDF	48.00	100.00	105.22	106.12
RDF +FYM 5 t ha^{-1}	48.67	103.33	112.56	113.33
50% RDF + FYM 10 t ha^{-1}	48.33	102.67	110.33	110.83
RDF + BF	48.67	103.00	103.33	103.73
RDF+FYM 5 t ha^{-1} + BF	51.00	104.67	124.67	125.27
75% RDF + FYM 10 t ha^{-1}	49.00	103.67	121.00	121.50
75% RDF + FYM 10 t ha^{-1}+ BF	52.00	107.00	131.44	131.97
FYM 10 t ha^{-1}+ BF	40.00	97.67	103.33	103.50
GM + FYM 10 t ha^{-1}+ BF	42.00	97.67	106.22	107.12
SEm($\pm$)	**0.62**	**3.49**	**1.29**	**2.31**
CD(0.05)	**1.87**	**10.46**	**5.87**	**6.85**

At harvest, also T_7 had the tallest plants (131.97 cm) and was at par with T5 and significantly superior to rest of the treatments. The (T_8) had the shortest plants (103.50 cm) at harvest. T_6 (75% RDF + FYM 10 t ha^{-1}), T_2 (RDF + FYM 5 t ha^{-1}) and T_3 (50%RDF +FYM 10 t ha^{-1}) with plant height of 121.50, 113.33 and 110.83 cm at harvest had 3nd, 4rd and 5th position respectively.

4.1.2 Number of tillers per m^2

Data pertaining to number of tillers m^{-2} are presented in Table-9 and Fig. 4. In general tillers m^{-2} increased with increasing the crop as up to 60 DAT, but the number of tillers at maturity was slightly reduced.

Among different integrated nutrient management treatments, application of 75% RDF +FYM 10 t ha^{-1} +BF (T_7) produced significantly higher number of tillers m^{-2} at all the stages of crop growth, which was found to be at par with the treatments of T_5 and T_6 at 30 DAT, while at 60 DAT, it was at par with T_5, Where as , at 90DAT all the integrated nutrient management treatments, except treatment T_1, T_9 and T_8 were at par to treatment T_7. However at harvest, tillers no. did not influence significantly due to integrated nutrient management treatments.

Between the organic treatments, the application of GM + FYM 10 tons per hectare + BF (T_9) produced relatively higher number of tillers per m^2 over the other organics treatment i.e. T_8 at all the growth stages.

Table 9 Effect of integrated nutrient management on number of tillers(m^{-2})

Treatments	Days after Planting			
	30	60	90	Harvest
RDF	230.33	295.00	290.67	290.00
RDF +FYM 5 t ha^{-1}	238.67	307.33	305.00	304.00
50% RDF + FYM 10 t ha^{-1}	236.00	301.00	300.00	299.33
RDF + BF	236.67	304.67	304.00	301.33
RDF+FYM 5 t ha^{-1} + BF	244.33	311.33	310.67	307.00
75% RDF + FYM 10 t ha^{-1}	240.67	310.00	309.67	305.00
75% RDF + FYM 10 t ha^{-1}+ BF	247.33	318.00	312.67	308.67
FYM 10 t ha^{-1}+ BF	215.67	281.00	280.67	274.33
GM + FYM 10 t ha^{-1}+ BF	226.00	289.33	288.67	286.00
SEm(±)	2.66	2.26	5.07	3.83
CD(0.05)	7.99	6.77	15.21	11.50

Besides, among the integration of organic and inorganic treatments the application of (T_7) 75% RDF + FYM 10 tons per hectare + BF recorded relatively higher number of tillers per $m^{2,}$ over the rest of the other combination of organic and inorganic source of nutrients treatments i.e. T_2, T_3,T_4 and T_6. The lowest tillers per m^2 was recorded T_8 (FYM 10t ha^{-1} + BF) at all the stages of crop growth.

4.1.3 Leaf area index

The data on mean LAI at different stages of growth (30, 60, 90 DAT and at harvest). As influenced by different doses and sources of nutrients application are presented in Table 10 and illustrated in Figure 5.

Table 10 Effect of integrated nutrient management on LAI

Treatment	Days after transplanting			
	30 DAS	60 DAS	90 DAS	HARVEST
RDF	2.43	4.57	3.28	2.36
RDF +FYM 5 tonns per ha	3.30	5.90	3.50	2.25
50% RDF + FYM 10 tonns per ha	2.67	5.10	3.30	2.14
RDF + BF	3.70	5.00	3.39	2.41
RDF+FYM 5 tonns + BF	3.40	6.03	4.18	3.00
75% RDF + FYM 10 tonns per ha	3.37	5.23	4.17	3.05
75% RDF + FYM 10 tonns per ha + BF	3.40	6.10	4.20	3.25
FYM 10 tonns per ha + BF	2.47	4.93	3.10	2.40
GM + FYM 10 tonns per ha + BF	2.91	5.01	3.41	2.60
SEm(±)	0.056	0.290	0.185	0.143
CD(0.05)	0.147	0.872	0.398	0.292

From the data it could be evident that LAI continues to increase up to 60 DAT, there after it declined. The rate of increase was however maximum between 30-60 DAT. The highest LAI was recorded at 60 DAT in all the treatments. The differences in LAI among the treatments were observed to be significant at all stages of growth. T_7 (75% RDF + FYM 10t ha^{-1} + BF) recorded highest LAI (6.10) at 60 DAT and was followed by T_5 (RDF + FYM 10t ha^{-1} + BF), T_6 (75%RDF+ FYM 10 ha^{-1}), T_2 (RDF +FYM 5 t ha^{-1}) and T_3 (50%RDF + FYM 10 t ha^{-1}) in descending order of merit. Leaf are index under T_7 at 90 DAT was significantly superior to other treatments, except T_5 and T_6 which were at par with T_7. At harvest also T_7, maintained superiority with LAI of 3.25 cm^2. Least LAI was recorded under T_8 (FYM 10 t ha + BF) both at 90 DAT and at harvest (Table 10).

4.1.4 Dry matter production

Data on dry matter production are influenced by different treatments consisting of different doses and sources of nutrients were recorded at 30 days interval, starting from 30 DAT up to 90 DAT and at harvest. The statistically analysed data are presented in Table- 11. And illustrated in Fig- 6. It would be seen from the data (Table-11.) that the production of dry matter increased progressively at the successive stages of growth and reached its maximum at harvest. The treatment differences with respect to dry matter production were significant at all the stages of growth. T_7 (75%RDF + FYM 10 t ha^{-1} + BF) recorded highest amount of dry matter at all growth stages, but was at par with T_5 (RDF + FYM 5 t ha^{-1}+ BF) and T_6 (75% RDF + FYM 10 t ha^{-1}). At harvest T7 (12.92 g) also gave maximum dry matter and was followed by T_5 (11.99 g) and T_6 (11.96 g) in descending order.T_8 (FYM 10 t ha^{-1}+ BF) produced the least amount of dry matter at all growth stages and at harvest (9.62 g).

Table 11 Effect of integrated nutrient management on Dry matter accumulation (g hill^{-1})

Treatment	Days after Planting			
	30 DAS	**60 DAS**	**90 DAS**	Harvest
RDF	4.65	7.74	9.40	9.60
RDF +FYM 5 t ha^{-1}	5.28	8.12	10.25	11.50
50% RDF + FYM 10 t ha^{-1}	5.01	7.89	9.98	10.98
RDF + BF	5.25	8.01	10.10	11.41
RDF+FYM 5 t ha^{-1} + BF	5.36	8.57	10.96	11.96
75% RDF + FYM 10 t ha^{-1}	5.32	8.17	10.94	11.99
75% RDF + FYM 10 t ha^{-1}+ BF	5.73	9.63	11.84	12.92
FYM 10 t ha^{-1}+ BF	4.16	6.80	8.53	9.62
GM + FYM 10 t ha^{-1}+ BF	4.59	7.34	9.22	10.32
SEm($\pm$)	0.25	0.59	0.85	0.05
CD(0.05)	0.73	1.76	2.55	0.15

4.1.5 Crop Growth Rate (CGR)

The data on crop growth rate was calculated by taking the rate of change in dry matter production per m^2 between 30-60, 60-90 and from 90 DAT till harvest and are presented in Table-12 and Fig.7.

It would be evident from the data presented in Table- 12 that the CGR increased progressively up to 90DAT and declined thereafter. The rate of increase was higher between 30-60 DAT. In all the treatments, the CGR was least between 90 DAT till harvest. Among the treatments T_7 (75%RDF +FYM 10 t ha^{-1}+ BF) produced highest CGR (4.33 g/day/m^2) followed by T_5 (RDF +FYM 5 t ha^{-1} + BF) with 3.56 g/day/m^2 between 30-60 DAT. T_8 (FYM 10 t ha^{-1}+ BF) recorded the minimum CGR of 2.93 g/day/m^2 between 30-60 DAT(Fig.6).

Table 12 Effect of integrated nutrient management on crop growth rate

Treatment	CGR (g/day/m2)		
	30 -40 DAT	60 - 90 DAT	90DAT – HARVEST
RDF	3.13	1.84	1.33
RDF +FYM 5 tonns per ha	3.15	2.36	1.24
50% RDF + FYM 10 tonns per ha	3.19	2.32	1.11
RDF + BF	3.06	2.32	1.45
RDF+FYM 5 tonns + BF	3.56	2.65	1.11
75% RDF + FYM 10 tonns per ha	3.16	3.07	1.14
75% RDF + FYM 10 tonns per ha + BF	4.33	3.48	1.19
FYM 10 tonns per ha + BF	2.93	1.92	1.21
GM + FYM 10 tonns per ha + BF	3.05	2.45	1.22

4.1.6 Relative Growth Rate (RGR)

Data on the relative growth rate as influenced by different integrated nutrient management treatments on different growth stages have been presented in the Table- 13 and illustrated in Fig-.8.

Table 13 Effect of integrated nutrient management on relative growth rate

Treatments	RGR (g $g^{-1}day^{-1}$)	
	30 – 60 DAS	60 - 90 DAS
RDF	0.017	0.065
RDF +FYM 5 tonns per ha	0.014	0.077
50% RDF + FYM 10 tonnes per ha	0.015	0.079
RDF + BF	0.014	0.073
RDF+FYM 5 tonns + BF	0.015	0.082
75% RDF + FYM 10 tonns per ha	0.014	0.097
75% RDF + FYM 10 tonns per ha + BF	0.017	0.069
FYM 10 tonns per ha + BF	0.016	0.076
GM + FYM 10 tonns per ha + BF	0.015	0.076

Among the treatments T_7 (75% RDF +FYM 10 t ha^{-1} + BF) recorded the highest RGR (0.017g/g/day) during the 30- 60 DAT, which was superior to other treatments but at par with T_1 (RDF).

4.1.7 Shoot: Root ratio

Data on shoot: root ratio was also influenced by different treatments consisting of different doses and sources of nutrients were recorded 30 days interval, starting from 30 DAT up to 90 DAT and at harvest. The statistically analysed data are presented in Table-14. It was evident from the data that the shoot : root ratio increased progressively at the successive stages of growth and reached its maximum at harvest. The treatment differences with respect to shoot: root ratio was significant at all the stages of growth. T_6 (75% RDF + FYM 10 t ha^{-1}) recorded highest shoot: root ratio at all the stages, but was at par with T_5 (RDF + FYM 5 t ha^{-1} + BF), T_6 (75% RDF + FYM 10t ha^{-1}). T8 (FYM 10 t ha^{-1} + BF) recorded the lowest shoot: root ratio.

Table 14 Effect of integrated nutrient management on Shoot: Root ratio

Treatment	Days after transplanting			
	30 DAS	60 DAS	90 DAS	Harvest
RDF	2.04	2.84	2.92	3.53
RDF +FYM 5 t ha^{-1}	2.15	2.90	3.26	3.77
50% RDF + FYM 10 t ha^{-1}	2.19	2.85	3.00	3.72
RDF + BF	2.27	2.89	3.14	3.73
RDF+FYM 5 t ha^{-1} + BF	2.35	3.04	3.38	4.15
75% RDF + FYM 10 t ha^{-1}	2.23	2.91	3.26	4.14
75% RDF + FYM 10 t ha^{-1}+ BF	2.54	3.15	4.50	4.52
FYM 10 t ha^{-1}+ BF	2.13	2.58	2.80	3.11
GM + FYM 10 t ha^{-1}+ BF	2.16	2.75	2.92	3.34
SEm(±)	0.04	0.15	0.24	0.16
CD(0.05)	0.12	0.45	0.73	0.47

4.2 YIELD ATTRIBUTING CHARACTERS

4.2.1 Number of Panicles per m^2

The data on different yield attributes are presented in Table – 15 and illustrated in Fig- 9.It was be evident from the data that, there was significant difference among different treatments with respect to number of ear bearing panicles per sq. meter. Among the treatments, T_7 (75%RDF + FYM 10 t ha^{-1} + BF) produced maximum number of effective panicles per m^2 (306), closely followed by T_6 (75% RDF + FYM 10 t ha^{-1}), T_5, and T_4, which were at par. Significant differences were also found among application of RDF and its combination with organics.. The minimum number of effective panicles per m^2 was recorded in T_8 (FYM 10 t ha^{-1} +BF).

4.2.2 Length of panicle

The data on length of the panicles (cm) is presented in Table –15. Length of panicle was at par among different treatments. However the treatment T_7 (75%RDF + FYM 10 t ha^{-1} + BF) recorded the longest panicles (23.03 cm) and was followed by T_5 (RDF + FYM 5 t ha^{-1} + BF) .The differences in panicle length between the organic sources were also not statistically significant. T_8 (FYM 10 t ha^{-1} +BF) recorded the shortest panicle length of 20.47 cm. T_6 and T_2 with the panicle length of 22.70 and 22.30 cm occupied 3rd and 4th position respectively.

4.2.3 Number of fertile grains per panicle

The data on mean number of filled grains per panicle are presented in Table- 15 and illustrated in Fig.9.

It would be evident from the data that the number of filled grains per panicle differed significantly among the treatments. T_7 (75%RDF + FYM 10 t ha^{-1} + BF) recorded the highest number of filled grains per panicle followed by T_5 (RDF + FYM 5 t ha^{-1} + BF). T_8 (FYM 10 t ha^{-1} +BF) recorded the least number of filled grains per panicle (96.67). The number of filled grains per panicle was also significantly influenced by the fertilizer doses.

4.2.4 Number of sterile grains per panicle

Data on the number of sterile grains per panicle are presented in Table 15. The result revealed that application of T_7 (75%RDF + FYM 10 t ha^{-1} + BF) recorded the lowest number of sterile grains per panicle (17.33) which was significantly lesser than other treatments. T_8 (FYM 10 t ha^{-1} +BF) recorded the highest number of sterile grains per panicle.

4.2.5 Test weight

The data on 1000 grain weight as influenced by different treatments are presented in Table-15 and illustrated in Fig-9 . The test weight differed significantly among the different treatments. T_7 **(**75%RDF + FYM 10 t ha^{-1} + BF) recorded the highest weight of 15.89 g, followed by T_5 **(**RDF + FYM 5 t ha^{-1} + BF**)-** 15.87 g, but are statistically at par, T_8 **(**FYM 10 t ha^{-1} +BF**)** recorded the minimum test weight of 14.50 g and was at par with T_1(RDF) and T_3 **(**50%RDF + FYM 10 t ha^{-1}**).**

4.2.6 Sterility percentage

Sterility percentage was calculated from total number of grains per panicles, analysed statistically and are presented in Table 15. The treatments differed significantly with respect to sterility percentage. The minimum sterility percentage (9.30%) was recorded under T_7 (75%RDF + FYM 10 t ha^{-1} + BF) was closely followed by T_5 (RDF + FYM 5 t ha^{-1} + BF) --%. T9 (GM + FYM 10 t ha^{-1} + BF) and T8 (FYM 10 t ha^{-1} + BF) recorded 19.60 and 21.60 percent respectively and were found to be at par with each other.

Table 15 Effect of integrated nutrient management of yield attributing characters

Treatment	No. of panicles/m^2	Length of panicle (cm)	No. of fertile grains/panicle	No. of sterile grains/panicle	Sterility percentage (%)	Test weight (g)
RDF	230	21.33	114.67	25.00	17.89	14.65
RDF +FYM 5 t ha^{-1}	285	22.30	139.33	20.67	12.90	15.32
50% RDF + FYM 10 t ha^{-1}	280	22.03	120.00	24.00	16.60	14.61
RDF + BF	290	22.27	123.67	23.33	15.80	15.60
RDF+FYM 5 t ha^{-1} + BF	300	22.90	166.00	19.60	10.50	15.87
75% RDF + FYM 10 t ha^{-1}	302	22.70	162.00	19.67	10.80	14.23
75% RDF + FYM 10 t ha^{-1}+ BF	306	23.03	172.33	17.33	9.30	15.89
FYM 10 t ha^{-1}+ BF	210	20.47	96.67	26.67	21.60	14.50
GM + FYM 10 t ha^{-1}+ BF	222	20.50	106.00	26.00	19.60	15.50
SEm(±)	11.33	0.93	10.37	1.84	0.700	0.102
CD (0.05)	32.95	NS	31.08	5.51	2.03	0.279

4.2.7 Grain yield

The data on grain yield as influenced by different treatments is presented in Table –16 and illustrated in Fig-10. It would be evident from the data that the grain yield significantly differed between the treatments both organic,inorganic and their combinations.

Among the treatments T_7 (75%RDF + FYM 10 t ha^{-1} + BF) recorded significantly higher grain yield (27.13 kg/ha) than the rest of the treatments except T_5 (RDF + FYM 5 t ha^{-1}) which was at par with the former. T_8 (FYM 10 t ha^{-1} +BF) gave the minimum yield of 15.88 q/ha.

Between the organic treatments, the application of GM + FYM 10 t ha^{-1} + BF recorded significantly higher grain yield over the other organic treatments. i.e. T_8 (FYM 10 t ha^{-1} +BF).

4.2.8 Straw yield

The straw yield unlike grain yield was also influenced by different treatments and presented in Table – 16 and illustrated in Fig- 10.

Among the treatments T_7 (75%RDF + FYM 10 t ha^{-1} + BF), recorded highest straw yield (52.58q/ha) which was significantly superior to rest of the treatments except T_5 (RDF + FYM 5 t ha^{-1} + BF) ie.51.62 q/ha , which was at par with each other. The treatment T_8 (FYM 10 t ha^{-1} +BF) recorded the lowest (30.63 q/ha) straw yield.

4.2.9 Straw: grain ratio

The data on straw: grain ratio are presented in Table-16.The ratio was significantly influenced by different treatments .

Among the treatments, T_4 (RDF + BF) gave the highest ratio of 1.99 which was closely was followed by T_2 (RDF + FYM 5 t ha^{-1}) with ratio of 1.96 and were at par with T_9(GM + FYM 10 t ha^{-1}+ BF) and T_7 (75% RDF + FYM

10 t ha^{-1}+ BF),respectively. The treatment T_8 (FYM 10 t ha^{-1}+ BF) recorded the minimum straw: grain ratio of 1.86.

4.2.10 Harvest index (HI)

The harvest index of different treatments is presented in Table -16. Among the treatments, integrated application of organic and inorganic sources T_7(75% RDF + FYM 10 t ha^{-1}+ BF), T_3 (50% RDF + FYM 10 t ha^{-1}) and T_6(75% RDF + FYM 10 t ha^{-1}) recorded higher harvest index of 34.03,34.28 and 34.83 whereas T_4(RDF + BF) recorded the least harvest index (33.17).

Table 16 Effect of integrated nutrient management Grain and Straw Yield

Treatment	Grain Yield (qha^{-1})	Straw Yield (qha^{-1})	Straw: grain ratio	Harvest Index (%)
RDF	18.81	35.61	1.89	34.56
RDF +FYM 5 t ha^{-1}	23.05	45.31	1.96	33.71
50% RDF + FYM 10 t ha^{-1}	20.94	40.13	1.91	34.28
RDF + BF	21.15	42.26	1.99	33.17
RDF+FYM 5 t ha^{-1} + BF	26.70	51.62	1.93	34.09
75% RDF + FYM 10 t ha^{-1}	24.95	46.67	1.87	34.83
75% RDF + FYM 10 t ha^{-1}+ BF	27.13	52.58	1.92	34.03
FYM 10 t ha^{-1}+ BF	15.88	30.63	1.86	34.14
GM + FYM 10 t ha^{-1}+ BF	17.04	33.54	1.96	33.68
SEm(±)	0.15	0.29	0.032	
CD(0.05)	0.44	0.87	0.071	

4.3. QUALITY

4.3.1 Kernel length

Data pertaining to kernel length is presented in Table-17. The date revealed that kernel length was highest (5.32mm) in T_7 (75%RDF+FYM 10t $^{-1}$ha+BF) which was significantly superior to rest of the treatments.

4.3.2 Kernel breadth

Date pertaining to kernel breadth is presented in Table 17. The Data revealed that the integrated nutrient management was unable to produce significant variation for kernel breadth. The highest kernel breadth of 1.89 was recorded in the treatment T7(75%RDF+FYM 10t $^{-1}$ha+BF) closely followed by T6(75%RDF+FYM 10t $^{-1}$ha).

4.3.3 Hulling and Milling percentage

Date pertaining to hulling and milling are presented in Table-17. The data revealed that integrated nutrient management influenced the hulling and milling percentage.The treatment T_7 (75%RDF+FYM10t ha^{-1}+BF) gave the highest hulling and milling percentage (72.67 and 68.15%), respectively closely followed by T6(71.11 and 67.14%),respectively..

4.3.4 Head rice recovery, amylase and protein content

Date pertaining to head rice recovery, amylase content and protein content were influenced by integrated nutrient management practices (Table-17). The results revealed that the treatment T_7 (75%RDF+FYM10tha^{-1}+BF) had the highest head rice recovery(60.40%), amylase(19.03%) and protein content(68.84mgg^{-1}).

4.3.5 Alkali spreading value

Alkali spreading values of the aromatic rice have been evaluated and the data is presented in Table17. It was found that the integrated nutrient management treatments were unable to bring significant variation for alkali spreading value. However the treatment T_3 (50 % RDF+FYM10t ha^{-1}) had the highest alkali spreading value of 4.20.

Table 17 Effect of integrated nutrient management Quality of aromatic rice

Treatment	Kernel length (mm)	Kernel breadth (mm)	Hulling (%)	Milling (%)	Head rice recovery (%)	Amylase content (%)	Protein content (mgg^{-1})	Alkali Value
RDF	4.41	1.56	64.80	60.40	52.93	17.00	66.03	2.65
RDF +FYM 5 t ha^{-1}	4.80	1.78	65.47	66.40	54.47	18.14	67.53	3.30
50% RDF + FYM 10 t ha^{-1}	4.20	1.66	67.47	65.60	55.80	18.20	68.10	4.20
RDF + BF	4.69	1.61	63.74	62.20	55.03	17.40	67.27	3.29
RDF+FYM 5 t ha^{-1} + BF	5.00	1.72	68.40	65.90	56.10	17.39	67.97	3.85
75% RDF + FYM 10 t ha^{-1}	5.12	1.87	71.11	67.14	59.64	18.73	68.47	4.07
75% RDF + FYM 10 t ha^{-1}+ BF	5.37	1.89	72.67	68.15	60.40	19.03	68.84	4.17
FYM 10 t ha^{-1}+ BF	3.79	1.62	61.60	62.31	55.10	16.40	66.53	3.97
GM + FYM 10 t ha^{-1}+ BF	4.20	1.49	64.00	63.27	54.26	16.87	66.67	3.10
SEm($\pm$)	0.05	0.02	0.97	1.15	1.00	0.16	0.17	0.01
CD(0.05)	NS	NS	2.92	3.46	3.00	0.47	0.51	NS

4.4 NUTRIENT UPTAKE

The nutrient concentration (%) and total uptake by plants presented in Table-18 and illustrated in figure 11.

4.4.1 Uptake of N

The data presented in Table-18 indicated that uptake of N was highest (63.13 kg/ha) in T_7 (75%RDF+FYM10 t/ha+BF) and was followed by T_6 (75%RDF+FYM10 t/ha). In contrast T_8 (FYM 10 t/ha + BF) registered the lowest N uptake followed by T_5 (RDF + FYM 5t/ha+BF),T_2 (RDF + FYM 5t/ha) and T_4 (RDF+BF), respectively . But in contrast, concentrations of N (%) in plant decreased with increase in levels of fertility (N).

4.4.2 Uptake of P

The data revealed that at harvest, the uptake of P was influenced by the doses and sources of fertilizer application. The P uptake was maximum (12.51kg/ha) with T_7 (75%RDF+FYM 10t/ha+BF) and was least under T_8 (FYM10t/ha + BF) .T_1 (RDF), T_3 (50%RDF+FYM10t/ha) and T_4 (RDF+BF) registered the lower uptake position, respectively.

4.4.3 Uptake of K

It would be seen from the data in Table -18 ,that the uptake of K was markedly influenced by different doses and sources of nutrient application .The uptake of K was highest in T_7 (85.92kg/ha) where as it was minimum in T_8 (54.92) .In line with N &P, concentration of K in plant decreased with increasing levels of fertility (K).

Table 18 Effect of integrated nutrient management nutrient content and uptake

Treatment	Nutrient concentration (%)			Nutrient uptake (kg/ha)		
	N	**P**	**K**	**N**	**P**	**K**
RDF	0.846	0.173	1.202	45.87	9.41	65.41
RDF +FYM 5 t ha^{-1}	0.815	0.163	1.105	55.71	11.14	75.53
50% RDF + FYM 10 t ha^{-1}	0.821	0.160	1.168	50.13	9.77	72.32
RDF + BF	0.843	0.172	1.125	53.45	10.90	71.33
RDF+FYM 5 t ha^{-1} + BF	0.808	0.161	1.138	59.29	11.81	83.51
75% RDF + FYM 10 t ha^{-1}	0.852	0.172	1.106	61.02	12.31	79.21
75% RDF + FYM 10 t ha^{-1}+ BF	0.792	0.157	1.078	63.13	12.51	85.92
FYM 10 t ha^{-1}+ BF	0.809	0.161	1.181	37.62	7.48	54.92
GM + FYM 10 t ha^{-1}+ BF	0.816	0.162	1.173	41.27	8.19	59.33

4.5 ECONOMICS OF PRODUCTION

Higher yield due to particular treatment may not result in higher net profit due to increased expenditure involved. Therefore, it was necessary to determine the ultimate net profit from each treatment. Keeping this in view, the total expenditure and income from each treatment was worked out and the data has been presented in Table-19 and illustrated in Figure 12. The total cost of cultivation, gross return and net return per rupee invested were worked out taking in to account the prevailing market price for labour, seed, fertilizer and the value of pesticides and cost of produce ie.grain and straw.

It would be evident from the data in Table -19 that the gross and net returns per hectare were considerably influenced by different treatments. Highest gross (Rs 27859/-) and net return (Rs 13101) was obtained from the treatment T_7 (75% RDF + FYM 10 t ha^{-1} +BF), followed by T_5 (RDF + FYM 5t/ha+BF) and T_6 (75%RDF+FYM10 t/ha) with net return of Rs 11849 /- and Rs 10848 /-,respectively. The least net income (Rs 2159 /-) was obtained from the treatment T_8 (75% RDF + FYM 10 t ha^{-1}). The treatment T_7 also recorded highest B : C ratio of 1.887 followed by T_5 (RDF + FYM 5t/ha+BF) 1.791, T_6 - 1.738. The lowest B : C ratio, was recorded with T_1 (FYM 10 t ha^{-1} + BF). The net return per rupee invested followed the similar trend as that of B : C ratio.

Table 19 Effect of integrated nutrient management on economics of production

Treatment	Cost of Cultivation ($Rs.ha^{-1}$)	Gross return ($Rs.ha^{-1}$)			Net return ($Rs.ha^{-1}$)	Net return/rupee invested	Benefit : Cost
		Grain	Straw	Total			
RDF	14444	17493	1780	19273	4829	0.334	1.334
RDF +FYM 5 t ha^{-1}	14924	21436	2265	23701	8777	0.588	1.588
50% RDF + FYM 10 t ha^{-1}	14482	19474	2006	21480	6998	0.483	1.483
RDF + BF	14514	19669	2113	21782	7268	0.500	1.500
RDF+FYM 5 t ha^{-1} + BF	14964	24459	2354	26813	11849	0.791	1.791
75% RDF + FYM 10 t ha^{-1}	14688	23203	2333	25536	10848	0.738	1.738
75% RDF + FYM 10 t ha^{-1}+ BF	14758	25230	2629	27859	13101	0.887	1.887
FYM 10 t ha^{-1}+ BF	14140	14768	1531	16299	2159	0.152	1.152
GM + FYM 10 t ha^{-1}+ BF	14540	15847	1677	17524	2984	0.205	1.205

DISCUSSION

The investigation was carried out during kharif 2010 and reported have been designated primarily to study the effect of different nutrient management practices in general and integrated nutrient management practices in particular in aromatic rice of the east and south eastern coastal plain zone of on the state of Odisha. In this chapter efforts have been made to establish a cause and effect relationship that exists among the various characters observed.

5.1 CROP GROWTH

The growth has been defined by Webster is a progressive development of an organism. The cumulative effect of which is a number of vegetative growth and characteristics of all the concerned stage of plant growth as well as yield attributes that are determined in later stages of crop growth. The growth during vegetative stages determine the link between sources of accumulation of nutrients that ultimately followed in the reproductive part, during development and ripening. It is one of the promising characteristics of all living being.It refer to increase in volume and weight resulting in formation, enlargement and cell maturity.Growth is controlled by supply of both organic and inorganic compounds required for the synthesis of new protoplasm and cell wall. Plant height, number of tillers,leaf area index and total dry matter accumulation are most important parameters of this vegetative growth. All these above parameters were recorded at monthly intervals commencing from thirty days after transplanting till harvest.

The crop grew to an average height of 42 cm at 30 DAT which increased progressively to 102.20cm at 60 DAT and 113cm at 90 DAT .At harvest this plant height either remain constant or slightly increased. The maximum plant height was observed in the treatment with application of RDF, FYM and biofertilizer. At harvest the treatment T_1,T_2,T_3,T_4,T_8 and T_9 were at par. This indicated that supply of nutrient under these treatments were sufficient to meet the demand of the crop and thereby maintained similar plant height. The positive role of different nutrients ie. Nitrogen Phosphorus and Potassium for cell division and enlargement is already an established fact. However when organic sources of nutrients are applied and supplemented with inorganic sources of nutrients, the nutrient availability of the plant is enhanced and ultimately help in increasing plant height. The results are in agreement with the findings of Sarawgi and Sarawgi(2004a). Sarawgi and Sarawgi(2004b). Jha *et al* (2006),Roul *et al* (2007), Netam *et al* (2008) and Davari and Sharma (2010).

Use of 75% RDF(30:15:15 NPK/ha) with blending of FYM and Biofertilizer (T_7) recorded significantly highest number of tillers as compared to other treatments at all the stages of growth, however it was statistically similar to treatmentsT_6 and T_5 at all the growth stages. This might be due to the fact that this treatment led to steady supply of essential plant nutrients and their greater availability during the entire period of plant growth. The increase plant height helped in increasing the photosynthetic area for photosynthesis in plant which in turn helped in formation of new tillers.Similar finding were also reported by Sarawgi and Sarawgi(2004b).,Jha *et al* (2006),and Netam *et. al* (2008).

Application of 75% RDF(30:15:15 NPK/ha) with blending of N and P through FYM and Biofertilizer (T_7) excelled in producing the heaviest plants which were at par with T_6,T_5,T_4 and T_2,respectively .The highest value of dry matter accumulation in these treatments might be due to higher availability and translocation of nutrients during the developmental phase growth which ultimately facilitated better photosynthesis and resulted in higher dry matter accumulation. Sing *et. al* (2001), Jha *et. al*(2006),Roul *et al* (2007),and Netam *et al* (2008) also reported similar results. The highest dry matter accumulation in treatment T_7 might also be due to the fact that 75% recommended dose of fertilizer was blended with 10 tons of FYM and biofertilizer that helped in slow release of nutrients and reduced losses of nutrient during developmental stages which helped in production of photosynthates which in turn helped maximum dry matter accumulation in plant.

The performance of organic,inorganic and combined sources of nutrients in CGR and RGR remained in the same line of growth characters like plant height, number of tillers, foliage growth and dry matter production. The CGR was maximum between 30-60 DAT i.e in the grand growth stage of the crop. This might be attributed to higher LAI and higher accumulation of photosynthates. Such findings are in agreement with Basumatry and Talukdar (1998) and Dahiphale *et al*. (2002).

5.2 YIELD ATTRIBUTES

The integrated nutrient management showed positive response to number of effective tillers.Perusal of the data revealed that integrated nutrient management practices and application of only chemical fertilizer though have positive bearing on length of panicle, but statistically were at par. However the highest panicle length was obtained in the integrated nutrient management treatments, application of 75% RDF(30:15:15 kg NPK per ha) with blending of N and P through FYM and biofertilizer (T_7) , closely followed by the same treatment without application of biofertilizer (T_6).

In case of the integrated nutrient management treatments the number of spikelets per panicle, sterility percentage and test weight remained almost at par. But significant difference were recorded between sole application of RDF, its increment or decrement and combination with FYM and biofertilizer. This might be due to higher and balanced availability of nutrients to the plants. Similar results have also been found by Murali and Setty (2001), Mandal *et al*. (2004), Ghose *et al*. (2005), Bhaskar *et al*. (2005) and Lal *et al*. (2009).

The application of organic sources of nutrients alone or in combination with inorganic sources of nutrients might have helped in improving the nutrient availability for a prolonged period during crop growth and development stages, ultimately influenced the reproductive stage and resulted in more number of spikelets , filled grains per panicle and test weight. Similar results have also been obtained by Dahiphale *et al*. (20024), Sarawgi and Sarawgi (2004), Mandal *et al*. (2004), Chandrkar *et al*. (2004), Bhaskar *et al*.(2005), Paraye *et al*. (2006) and Lal *et al*.(2009).

5.3 GRAIN YIELD, STRAW YIELD AND HARVEST INDEX

The data pertaining grain yield, straw yield, straw to grain ratio and harvest index clearly depicted that application of 75% RDF(30:15:15 kg NPK per ha), blended with FYM (10 tons per ha) and biofertilizer (T_7) resulted in higher grain yield and straw yield over other integrated nutrient management treatments, however the harvest index was higher without application of biofertilizer in the same treatment. Application of organic sources along with recommended dose of fertilizer showed significant response with regard to all the characters.

The higher grain and straw yield might be due to combined application of organic and inorganic sources that resulted in greater availability of essential nutrient to the plant, improvement of soil environment which facilitated in better root proliferation leading to higher absorption of nutrients and ultimately resulting in higher yield.

Comparatively higher value of harvest index in different treatments might be due to fact that relatively lower value of straw yield increased the harvest index in these treatments. It is well known that the organic sources like that of green manure , farmyard manure and biofertilizer helped in continuous supply of nutrients, various enzymes and hormones which ultimately reduced nutrient loss and enhance the nutrient use efficiency and yield. Similar results have also been found by Rao *et al*. (1998), Pandey *et al*.(1999), Pal *et al*.(2001), Pandey and Nandeha (2004), Sarawgi and Sarawgi (2004), Jha *et al*. (2006) and Dahiphale and Khandagale (2007) and Lal *et al*. (2009).

5.4 QUALITY CHARACTER

The integrated nutrient management treatments were unable to produce significant variation for length and breadth of kernel in local aromatic rice. Similar results have also been found by Singh *et al*. (2000) and Mandal *et al*. (2004). However, higher value of hulling%, milling% and head rice recovery were obtained by integrating both inorganic and organic source of nutrients. This was due to application of farmyard manure which released nutrient for longer time and increased the quality of local aromatic rice. Similar findings were also noted in scented rice by Kumar *et al*. (1999), Pandey *et al*. (1999), Zhang and Shao. (1999), Singh *et al*. (2000), Prakash *et al*. (2002), Jha *et al*.(2006), Manjunath *et al*.(2008).

The alkali spreading value was not influenced due to integrated nutrient management practices. Similar results were also been obtained by Rao *et al*. (1998), Sharma *et al*. (2002)

5.5 ECONOMICS

The effect of different treatments can only be assessed with the gross and net profit from the treatments. Among different integrated nutrient management treatments application 75% RDF with blending of N and P through FYM and biofertilizer resulted in highest gross return of Rs 27859/- per ha, net return Rs 13101/- per ha and B:C ratio of 1.88. The lowest values of these parameters were obtained with application of only organic sources without combining the same with inorganic sources.

SUMMERY AND CONCLUSION

Rice is the most important food grain crop of Asian countries especially for India. During last 4 decades greater emphasis has been given to increase the production potential which can meet the ever growing population of our country. To fulfill this requirement improved agro-techniques only can make it possible to become self sufficient in food grain production. The major portion of rice growing area of our country in general and the state of Odisha in particular is diverted to the coarse and medium slender rice varieties. Very less area have been diverted to the production of fine and scented rice including local aromatic types. The local aromatic types are tall in height, low responsive to input, long duration and low yielders. Thus farmer only in exceptional cases grow these local aromatic types in larger area for special purpose. The local aromatic rice including the Basmati types due to higher market value and quality is the need of the day. Their yield and quality can only be sustained by combined use of organic manure, inorganic fertilizer and biofertilizer, which in turn will improve the quality of product and restore soil physico-chemical and biological property without decreasing production potential of crop. An experiment entitled " Integrated nutrient management in aromatic rice" carried out during *kharif* 2010 at the Central Research Station, Orissa University of Agriculture and Technology. The results of the investigation are summarised below

1. The application of 75% RDF with blending of N and P through FYM and biofertilizer produced significantly highest plant height, number of tillers per m^2 and dry matter accumulation at harvest. All the treatments involving integration of organics and inorganics were statistically at par. However, they lies difference between sole

inorganic and sole organics with respect to plant height, number of tillers and dry matter accumulation in all stages.

2. The application of 75% RDF with blending of N and P through FYM and biofertilizer (T_7) produced significantly highest panicle length over others, but it was at par to treatments T_6, T_5, T_4, T_3 and T_2. T_7 also resulted significantly highest number of filled grains per panicles although it was comparable to treatments T_6 and T_5. T_7 also produced significantly least number of sterile grain which were at par with T_5, T_6 and T_2. Different integrated nutrient management treatment were not able to produce significance difference in rest of the other yield parameters.

3. The application of 75% RDF with blending of N and P through FYM and biofertilizer (T_7) produced significantly higher grain and straw yield as compared to other treatments, but closely followed by T_5 and at par with each other. Whereas straw and harvest index remained unaffected due to different integrated nutrient manamenent treatments.

4. In the integrated nutrient management treatments the application of 75% RDF with blending of N and P through FYM biofertilizer recorded higher value of head rice recovery percentage. Whereas, hulling and milling percent did not influenced significantly.

5. With respect to different the integrated nutrient management treatments the application of 75% RDF with blending of N and P through FYM biofertilizer (T_7) recorded highest value for gross return (Rs 27859/- per ha), net return (13,101/- per ha) and B:C ratio 1.88.

CONCLUSION

Based on the findings of the experiment the local aromatic rice variety Thakursuna is suitable for the farmers for Odisha region in respect to its higher grain yield 27.13 per hectare and net income (Rs 13101/-/ha) and B;C ratio 1.88.

Application of 75% RDF with blending of N and P through FYM with biofertilizer proved superior over rest of the integrated nutrient management treatments, which also realized highest grain yield 27.13 q ha^{-1}, net monitory return (Rs 13101/-/ha) and the B:C ratio 1.88.

But for quality produce the application of 75% RDF with blending of N and P through FYM with biofertilizer was found to be superior over rest of the integrated nutrient management treatments.

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APPENDIX -1: Cost of inputs in cultivation of aromatic rice

Inputs	Rate(ì)	Treatments								
		T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9
Land Preparation	70/MD	300	300	300	300	300	300	300	300	300
Seed	30/kg	1500	1500	1500	1500	1500	1500	1500	1500	1500
FYM	450/5t	450	450	450	450	450	450	450	450	450
Bed preparation	300/h	280	280	280	280	280	280	280	280	280
Water management	70/MD	70	70	70	70	70	70	70	70	70
Cleaning field bund	70/MD	420	420	420	420	420	420	420	420	420
Land preparation	300/h	1200	1200	1200	1200	1200	1200	1200	1200	1200
Final field preparation for transplanting	300/h	600	600	600	600	600	600	600	600	600
FYM	450/5t	-	450	600		-	450	600	600	600
Fertilizer	40:30:30/ 824	824	824	412	824	824	618	618	-	-
Biofertilizer	30/kg	-	-	-	150	150	-	150	150	150
Green manuring	750/q	-	-	-	-	-	-	-	-	570
Fertilizer manure application	70/MD	70	70	70	70	70	70	70	70	70
Transplanting	70/MD	2940	2940	2940	2940	2940	2940	2940	2940	2940
Weeding	70/MD	1680	1680	1680	1750	1680	1680	1450	1680	1680
Fungicide	250/10 ml	250	250	250	250	250	250	250	250	250
Spraying	70/MD	70	70	70	70	70	70	70	70	70
Top dressing	70/MD	70	70	70	70	70	70	70	70	70
Water management	70/MD	350	350	350	350	350	350	350	350	350
Harvest	70/MD	2100	2130	2100	2200	2100	2200	2200	2100	2100
Threshing	70/MD	1270	1270	1120	1270	1190	1270	1240	1040	1100
Cost of cultivation (ì)		14444	14924	14482	14514	14964	14668	14758	14140	14540
Gross return(ì)		19273	23701	21480	21782	26813	25536	27865	16299	17524
Net return(ì)		4829	8777	6998	7268	11849	10848	13101	2159	2984