

PLANTING GEOMETRY, IRRIGATION AND ORGANIC
NUTRIENT MANAGEMENT PRACTICES FOR AEROBIC
RICE IN NORTHERN TRANSITIONAL ZONE OF
KARNATAKA

SHAIK JAFFAR BASHA

DEPARTMENT OF AGRONOMY
COLLEGE OF AGRICULTURE, DHARWAD
UNIVERSITY OF AGRICULTURAL SCIENCES,
DHARWAD – 580 005

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RICE IN NORTHERN TRANSITIONAL ZONE OF
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By

SHAIK JAFFAR BASHA

DEPARTMENT OF AGRONOMY
COLLEGE OF AGRICULTURE, DHARWAD
UNIVERSITY OF AGRICULTURAL SCIENCES,
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JUNE, 2015

DEPARTMENT OF AGRONOMY
COLLEGE OF AGRICULTURE, DHARWAD
UNIVERSITY OF AGRICULTURAL SCIENCES,
DHARWAD

CERTIFICATE

This is to certify that the thesis entitled "PLANTING GEOMETRY, IRRIGATION AND ORGANIC NUTRIENT MANAGEMENT PRACTICES FOR AEROBIC RICE IN NORTHERN TRANSITIONAL ZONE OF KARNATAKA" submitted by Mr. SHAIK JAFFAR BASHA for the degree of DOCTOR OF PHILOSOPHY in AGRONOMY to the University of Agricultural Sciences, Dharwad is a record of research work done by him during the period of his study in this University under my guidance and supervision and the thesis has not previously formed the basis for the award of any degree, diploma, associateship, fellowship or other similar titles.

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4.

(GEETA SHIRNALLI)

5.

(S. R. SALAKINKOP)

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1. INTRODUCTION

Rice (*Oryza sativa* L.) is the most important food crop of India and is a major energy source for about 60 per cent of the world population. Asia's food security largely depends on the irrigated rice which produces three quarter of total rice production. About 90 per cent rice is produced and consumed in Asia, where the demand for rice is on the rise due to increasing population (Amudha *et al.*, 2009). In Asia, irrigated agriculture accounts for 90 per cent of total diverted fresh water and more than 50 per cent of this is used to irrigate rice (Barker *et al.*, 1999). Until recently, this amount of water has been taken for granted, but now the global "water crisis" threatens the sustainability of irrigated rice production. The available amount of water for irrigation is becoming scarce (Postal, 1997). Tuong and Bouman (2003) estimated that by 2025, two million ha of Asia's irrigated dry season rice may experience "Physical water scarcity" and the rest of the approximately 22 million ha of irrigated dry season rice in south and south east Asia may suffer from "economic water scarcity". However, 50 - 55 per cent of total world water will be available for agriculture by 2025 as against 66 - 68 per cent in 1993 (Sivannapan, 2009). Therefore, it has given us a wakeup call to develop and popularize innovative water saving technologies to produce more rice from every drop. It is now evident that rice crop cannot have luxury of water that it had in the past. Thus, most of the increase in rice production has to come from improved varieties and agronomic technologies. Rice production under current inputs and technology is likely to fail to meet the projected demand and there is an urgent need to increase rice productivity per hectare in the world (Leeper, 2010). In India, rice is cultivated round the year in one or the other part of the country, in diverse ecologies spread over 43.95 million ha with a production of 106.19 million tonnes and productivity of 2416 kg ha⁻¹. In Karnataka, it is grown over an area of 1.54 million ha with an annual production of 4.19 million tonnes and a productivity of 2719 kg ha⁻¹ (Anonymous, 2014).

The dominant system of rice cultivation in Asia is transplanting, where in field is kept continuously flooded with 5 to 10 cm water throughout the growing season (Bouman and Tuong, 2001), which ultimately leads to water and nutrient losses through percolation, evaporation and seepage. The total water requirement of rice varied from

1566 mm in a sandy clay loam soil to 2262 mm in a sandy loam soil mainly due to an increase in percolation loss from 57 per cent in clay loam to 66.9 per cent in sandy loam soil (Gupta *et al.*, 2002). On average, 2500 l of water are applied, ranging from 800 to more than 5000 l, to produce 1 kg of rough rice (Bouman, 2009). Water is most limited natural resource of late, due to failure of rains and over exploitation of ground water. The dwindling water resources reveal a grim situation for lowland puddle rice cultivation. Farmers are seeking alternate methods of cultivation for growing rice to combat this water scarce situation. One such method is cultivation of rice under aerobic situation which is characterized by aerated soil environment during the entire period of crop growth. Aerobic rice is projected as sustainable rice production methodology for the immediate future to address water scarcity and also environmental safety in the scenario of global warming (www.aerobicrice.org). International Rice Research Institute (IRRI) developed the "aerobic rice technology" to address the water crisis in tropical agriculture. In aerobic rice systems, wherein the improved rice cultivars are established in non-puddled, non-flooded fields and rice is grown like an upland crop (unsaturated condition) with adequate inputs and supplementary irrigation when rainfall is insufficient (Bouman *et al.*, 2005). Aerobically grown rice has been developed in order to increase water productivity (*i.e.* grain yield over water input) and may be an option for farmers where water has become too scarce or expensive to grow flooded rice and in rainfed areas where rainfall is insufficient for flooded rice production but sufficient for upland crops (Bouman, 2006).

Experiments on aerobic rice have shown that water and labour requirement in aerobic rice were lower to an extent of 50 (only 470-650 mm) and 55 per cent respectively and water productivities were 64-88 per cent higher than the low land rice (Wang Huaqi *et al.*, 2002). It is commercially grown in Brazil and is being pioneered by farmers in northern China. With the application of aerobic rice culture, large areas of the anticipated 37 million ha of water short irrigated low lands and parts of the 40 million ha of rainfed lowlands and uplands, where seasonal rainfall is 600-800 mm in Asia will be rescued from water shortage problems and brought under cultivation resulting to food security at large. This technology greatly helps to minimize methane emission. Irrigated rice fields will cut off the oxygen supply from the atmosphere resulting in the anaerobic fermentation of soil organic matter. Methane, a major end product of

anaerobic fermentation is released from the submerged soil to the atmosphere through roots and stems of rice plants. Continued increase in atmospheric methane concentrations at the current rate of approximately one per cent per year is likely to contribute more to future climatic change than any other gas except carbon dioxide (Cicerone and Oremland, 1988).

Rapid degradation of rice ecologies due to imbalanced use of fertilizers and unscientific water management has put tremendous pressure on the rice growers to make rice farming economically viable and ecologically sustainable under aerobic rice system (ARS). For efficient water use, 2–4 irrigations were needed for maintaining soil moisture potential between 100–200 kPa in the root zone. The water productivity with respect to total water use was projected at 0.89–1.05 g grain/kg water. In this system, rice is sown directly into dry soil and irrigation is given to keep the soil sufficiently moist for good plant growth, but the soil is never flooded. Scientific irrigation scheduling should go with an understanding of soil-water-plant-atmospheric continuum. Irrigation water economy can be aimed through appropriate irrigation schedules. There are several approaches for scheduling irrigation of field crops of which moisture regimes and climatological approach are found to be reliable and dependable. The meteorological approach based on pan evaporation is one of the simplest, reliable, economical and least time consuming methods (Prihar *et al.*, 1976).

It is known that growth and yield of a crop are affected to a great extent by canopy configuration and by the canopy microclimate, which fluctuates under different methods of cultivation. Plant geometry in rice has a direct bearing on the grain yield, since it is an important yield parameter maintaining inadequate or excess plant population often leads to reduction in yield. Finding out the optimum plant population per unit area is of major importance.

Increased prices of manufactured fertilizers and concerns about the sustainability of intensive cropping systems have led some countries to promote organic materials as a source of nutrients for crops and as an amendment to improve soil properties. The supply of nutrients through fertilizers often exceeds the inherent capacities of the soil to store the nutrients for future use, for the reason, most of applied fertilizers are

subjected to losses resulting in low nutrient use efficiency. Organic method was self-sufficient and self-dependent as compared to modern chemical farming with principle of nutrient capturing and relying more on organic inputs is need of the hour (Singh *et al.*, 2001a).

Organic agriculture is developing rapidly and is now practiced in more than 141 countries of the world. Its share of agricultural land and farms continues to grow in many countries. Oceania has the largest share of organic agriculture land (37 %) followed by Europe (24 %) and Latin America (20 %). Consumer demand for organic products is concentrated in North America and Europe, the two regions comprise 96 per cent of global consumption. Asia, Latin America and Oceania are important producers and exporters of organic foods. General acceptance of organic farming is not only due to greater demand for pollution free food but also due to natural advantage of organic farming in supporting the sustainability in agriculture and environment protection.

Organic farming minimizes the use of external inputs and knowledge and aims to optimization of crop productivity rather than its maximization through renewal and strengthening of ecological processes and functions of farm ecosystem (Shukla *et al.*, 2011). The philosophy behind the concept of organic farming is to feed the soil, rather than the crop and it means of giving back to nature what has been taken from it. Organic farming is a crop production system that excludes use of synthetically modified fertilizers, pesticides, growth regulators and livestock food additives. The organic manures have a very complex effect on soil physical environment, nutrient status, moisture content and soil flora and fauna which directly influence plant growth and development. It can sustain the health of the soils, ecosystems and people by combining tradition, innovation and science because it combines crop management and animal husbandry in the agro-ecosystems which are socially acceptable, economical feasible and ecologically sustainable. Application of scientific approaches to organic farming practices holds the possibility of maintaining and in some cases increasing the yield over long run, while sustaining bio-diversity, soil fertility, soil biological cycles and natural ecosystem processes and services that underpin the agriculture.

In aerobic rice among the various practices, optimizing the use of manures and fertilizers is one of the important strategies for increasing productivity of rice. In this direction, integrated management of solid and liquid organic manures needs priority.

The contribution of organic manures is to be judged not only in terms of nutrient contribution, but also by their role in building up nutrient reserves in soil and increasing organic matter level of soil which ultimately improves physical, chemical and biological properties of soil. Using organic sources like farm yard manure, compost, vermicompost, sheep and goat manure and poultry manure in combination with liquid organic manures like cattle urine, panchgavya, vermiwash, bio-digested liquid, jeevamrut *etc.* deserves priority for sustained production and better on farm resource recycling and utilization. Incorporation of organic manures has given a hope to reduce the cost of cultivation and minimize adverse effects of chemical fertilizers. Application of green leaf manures like *Gliricidia*, *Subabul etc.*, add to soil fertility and productivity mainly due to biological nitrogen fixation, addition of organic carbon and release of organic acids and CO₂ in the process of decomposition will solubilize P into available P and enhance of K into soil solution. Liquid organic manures will provide nutrients, growth promoting substances as well as they are microbial enriched products have a role in organic rice production.

In the above back drop, to make the aerobic rice production more sustainable and profitable, field studies were carried out on “Planting geometry, irrigation and organic nutrient management practices for aerobic rice in northern transitional zone of Karnataka” during *kharif* 2013 and 2014 at Main Agricultural Research Station (MARS), University of Agricultural Sciences, Dharwad with the following objectives.

1. To standardize the method of planting and planting geometry for higher productivity of aerobic rice,
2. To work out the optimum irrigation schedule for higher productivity and water use efficiency in aerobic rice,
3. To evaluate various options of organic sources of nutrients to enhance the crop productivity, grain quality and soil health,
4. To work out the economics of different agro techniques, integrated organic nutrient and water management practices in aerobic rice.

3. MATERIAL AND METHODS

Field experiments were carried out at Main Agricultural Research Station, Dharwad on “Planting geometry, irrigation and organic nutrient management practices for aerobic rice in northern transitional zone of Karnataka” during *kharif* 2013 and 2014. The detailed information on different materials used and experimental techniques adopted during the study period are presented in this chapter.

3.1 Field experiment

3.1.1 Location of the Experiment

The experiments were carried out at C block plot no. 65, of the Main Agricultural Research Station, University of Agricultural Sciences, Dharwad which lies between 15°30'6" North latitude, a longitude of 74° 59'12.4" East and at an altitude of 678 m above MSL. It is situated in the Northern Transitional Zone (Zone VIII) of agro- climatic zones of Karnataka. General view of the Experiment-I and II is given in Plate 1 and 2, respectively.

3.1.2 Soil characteristics of experimental site

The soil of the experimental site was medium deep black soil (*Vertic inceptisols*) with a depth of 2-3m and is well drained. A composite soil sample was collected from the experimental site from 0-30 cm depth before starting of the experiment. The soil was air-dried, powdered to pass through 2 mm sieve and was analyzed for physical and chemical characteristics. Soil was analyzed for pH (6.95), electrical conductivity (0.23 ds/m), organic carbon (4.9 g/kg), available NPK (263.42:23.3:285.6 kg ha⁻¹, respectively) and micronutrients viz., Cu, Fe, Mn and Zn (0.88:6.42:8.62:0.65 ppm, respectively). The soil test values obtained along with the methods adopted for their estimation are furnished in Table 1.

3.1.3 Climatic conditions

The Main Agricultural Research Station is situated in Northern transitional zone (Zone-VIII) of Karnataka. This zone receives rainfall from both South-West and North-East monsoons and hence it is well distributed from June to November with lower co-efficient of variation. The mean monthly meteorological data of rainfall,



Plate 1: General view of Experiment – I



Plate 2: General View of Experiment – II

Table 1: Physical and chemical properties of soil in the experimental soil (0-30 cm depth)

Sl. No.	Parameters	Values obtained	Methods adopted
I	Physical properties		
a)	Particle size distribution		
i)	Coarse sand (%)	7.2	International pipette method (Piper, 2002)
ii)	Fine Sand (%)	13.8	
iii)	Silt (%)	29.7	
iv)	Clay (%)	49.3	
b)	Bulk density (Mg/m ³)	1.28	Core sampler method (Black, 1967)
c)	Maximum water holding capacity (%)	51.70	Keens cup method (Piper, 2002)
II	Chemical properties		
a)	pH (1: 2.5)	6.95	Potentiometry (Sparks, 1996)
b)	Electrical conductivity (1:2.5) (dSm ⁻¹)	0.23	Conductivity bridge (Sparks, 1996)
c)	Organic carbon (g/kg)	4.90	Walkley and Black's wet oxidation method (Sparks, 1996)
d)	Available N (kg/ha)	263.42	Alkaline permanganate method (Subbiah & Asija, 1956)
e)	Available P (kg/ha)	23.3	Olsen's method (Sparks, 1996)
f)	Available K (kg/ha)	285.6	Neutral Ammonium acetate extract method (Sparks, 1996)
g)	Available S (ppm)	12.06	Turbidimetric method (Sparks, 1996)
h)	Available Cu (ppm)	0.88	DTPA extractable method (Lindsay and Norvell, 1978)
i)	Available Fe (ppm)	6.42	
j)	Available Mn (ppm)	8.62	
k)	Available Zn (ppm)	0.65	
III	Microbial enumeration		
a)	Free living N fixures cfu g ⁻¹ soil	16.67 x 10 ³	Serial dilution and plate count method (Bunt and Rovira, 1955)
b)	Phosphate solubilizing bacteria (PSB) cfu g ⁻¹ soil	12.67 x 10 ⁴	Serial dilution and plate count method, Pikovskaya's media (Pikovskaya, 1998)
c)	Azospirillum cfu g ⁻¹ soil	0.01 x 10 ⁶	MPN Method (Okon <i>et al.</i> , 1977)
IV	Enzymatic activity		
a)	Dehydrogenase activity (µg TPF g ⁻¹ soil day ⁻¹)	7.68	TPF extractable method (Casida <i>et al.</i> , 1964)
b)	Phosphatase activity (µg pNP g ⁻¹ soil h ⁻¹)	17.23	Evasi and Tabatabai, 1979

temperature and relative humidity during the period of experimental years (2013 and 2014) and normal values for last 60 years (1953-2012) are presented in Table 2 and Fig. 1. The mean standard week meteorological data during the crop growth period for *Kharif* 2013 and 2014 are presented in Table 3 and Fig. 2. The crop growing season was normal, with the total rainfall of 484 mm and 618.6 mm was received in 45 and 48 rainy days during crop growth period of 2013 and 2014 respectively which is optimum for growth and development of rice. Even though total rainfall was below normal (6.6%) during 2013 and above normal (19.3%) during 2014, rainfall of 63 mm during 44th standard week of 2014 at flowering affected the pollination and subsequent grain filling resulting into lower grain yield compared to first year in both the experiments. Likewise, the monthly as well as weekly minimum and maximum temperatures and relative humidity did not deviate from the normal with no differential influence on crop growth and development. During 2013 and 2014, the highest mean monthly maximum temperatures (36.9°C and 36.3°C, respectively) and the lowest mean monthly minimum temperatures (12.7°C and 14.5°C, respectively in 2013 and 2014) were observed during the months of April and December, respectively. Mean monthly maximum relative humidity was 89 per cent in July during 2013 and 89 per cent in June during 2014. Mean monthly minimum relative humidity was 47 per cent in January during 2013 and 42 per cent in March during 2014. Daily evaporation and rainfall data during 2013-14 cropping period are presented in Table 4 and 5.

3.1.4 Cropping history of the experimental site

Previous crops grown in the experimental site during 2012 was cotton.

3.2 Experimental details

3.2.1 Season

The field trials to study “Planting geometry, irrigation and organic nutrient management practices for aerobic rice in northern transitional zone of Karnataka” were carried out during *kharif* 2013 and 2014

3.2.2 Design of layout

The experiment was laid out in split split plot design for Experiment-I and split plot design for Experiment-II with three replications. The plan of layout of the experiment is depicted in Fig. 3 and Fig. 4 for experiment I and II respectively.

Table 2: Mean monthly meteorological data for the experimental year (2013 and 2014) and the mean of past 63 years (1950-2012) at Main Agricultural Research Station, University of Agricultural Sciences, Dharwad

Months	Rainfall (mm)					Mean Temperature (°C)						Mean RH (%)		
	2013	No. of rainy days	2014	No. of rainy days	1950-2012	T max			T min			2013	2014	1950-2012
						2013	2014	1950-2012	2013	2014	1950-2012			
January	0.0	-	0.0	-	0.8	31.2	29.5	28.7	14.5	14.7	14.1	47	53	64.6
February	2.2	-	0.0	-	11.3	32.6	31.0	31.6	16.8	16.1	16.5	51	45	54.4
March	42.0	1	11.4	1	1.5	35.3	34.3	34.9	19.2	18.6	19.6	48	42	63.8
April	10.0	1	44.9	3	48.7	36.9	36.3	36.6	20.2	21.0	20.1	51	49	77.7
May	124.6	6	197.4	7	19.7	35.5	37.8	35.2	21.8	21.1	20.9	61	61	75.3
June	75.4	10	29.3	4	105.4	28.0	29.9	30.2	20.8	21.6	21.7	82	89	86.0
July	177.8	17	242.2	17	153.1	25.4	27.0	27.3	20.3	21.0	20.8	89	84	89.0
August	97.2	10	158.4	19	100.8	26.7	27.0	27.3	19.9	20.4	20.1	85	84	88.5
September	133.6	13	100.2	8	107.2	27.9	28.0	27.9	20.2	20.2	19.9	81	81	86.4
October	75.4	5	103.4	7	125.3	28.8	30.0	29.5	19.4	19.0	18.6	76	71	79.2
November	2.2	-	48.8	2	32.1	29.0	29.0	28.9	15.8	15.5	15.9	64	59	73.3
December	0.0	-	26.2	1	5.1	28.4	27.8	27.8	12.7	14.5	13.2	53	64	68.9
Total	740.4	63	962.2	69	711.0	Mean 30.47	Mean 30.63	Mean 30.49	Mean 18.46	Mean 18.64	Mean 18.45	Mean 65.66	Mean 65.16	Mean 75.69

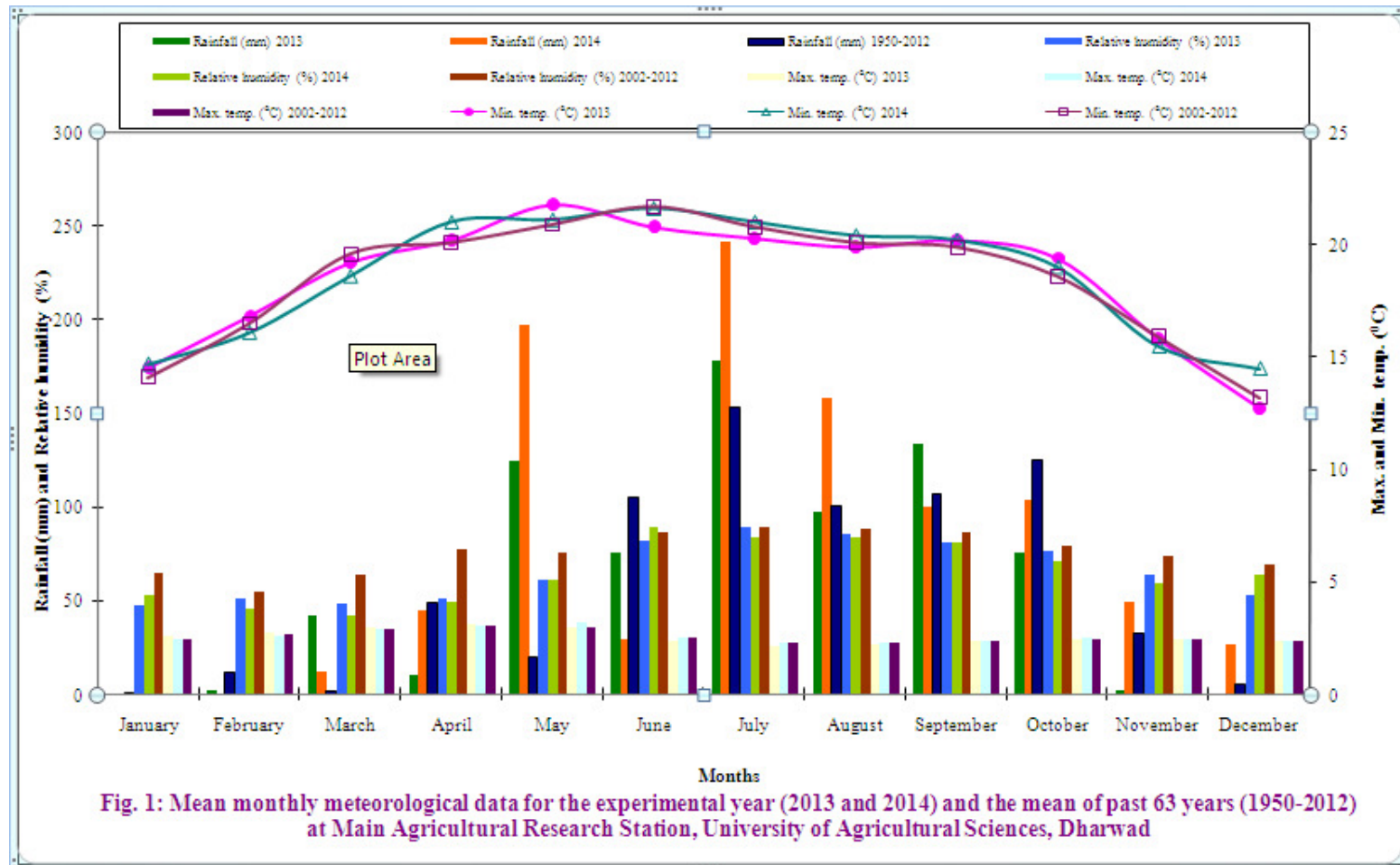


Table 3: Mean standard week meteorological data during the crop growth period for *Kharif* 2013 and 2014 at Main Agricultural Research Station, University of Agricultural Sciences, Dharwad

Standard week	Temperature max. (°C)		Temperature min. (°C)		Relative humidity (%)		Rainfall (total mm)		Evaporation (mm)	
	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014
26 (25 th June-1 st July)	27.30	--	20.57	--	83	--	24.8	--	4.50	--
27 (2 nd -8 th July)	26.66	--	20.57	--	79	--	16.2	--	4.40	--
28 (9 th -15 th July)	25.47	--	20.26	--	79	--	27.8	--	4.54	--
29 (16 th -22 nd July)	25.66	25.34	20.71	21.09	79	87	36.2	48.8	4.05	2.46
30 (23 rd -29 th July)	23.94	25.87	20.09	20.69	80	86	85.6	93.6	3.87	3.11
31 (30 th July-5 th August)	24.99	25.21	20.11	20.94	82	85	59.6	102.6	3.72	2.44
32 (6 th August-12 th August)	27.20	25.47	19.97	20.67	81	84	18.4	47.0	4.60	2.40
33 (13 th -19 th August)	26.30	27.80	20.49	20.29	82	82	12.0	8.0	3.07	3.46
34 (20 th -26 th August)	26.26	29.43	19.53	20.47	79	82	11.6	51.4	3.77	3.94
35 (27 th August-2 nd September)	29.39	25.54	19.27	20.21	78	84	8.0	32.4	4.18	2.37
36 (3 rd -9 th September)	28.56	25.70	20.00	20.46	80	82	9.4	19.4	3.62	2.80
37 (10 th -16 th September)	27.97	28.23	20.97	20.03	81	82	47.7	0	3.47	4.74
38 (17 th -23 rd September)	27.16	27.99	20.39	19.91	82	80	15.8	6.2	2.97	4.14
39 (24 th -30 th September)	26.47	30.66	19.74	20.89	80	78	6.4	70.0	3.14	3.93
40 (1 st -7 th October)	27.47	30.41	19.99	19.94	77	70	10.2	24.8	3.40	3.97
41 (8 th -14 th October)	27.61	29.97	19.98	20.30	78	76	0	14.4	4.08	4.03
42 (15 th -21 st October)	30.33	31.03	19.41	19.41	75	69	17.6	0	3.85	3.74
43 (22 nd -28 th October)	27.84	28.39	20.03	18.94	77	71	35.6	63.0	3.54	3.41
44 (29 th October-4 th November)	27.84	28.96	20.07	15.06	77	55	0	0.4	3.42	3.96
45 (5 th -11 th November)	28.81	29.86	15.86	15.93	69	58	0	0	3.73	3.90
46 (12 th -18 th November)	27.86	28.30	14.03	17.59	56	70	0	48.8	4.01	3.34
47 (19 th -25 th November)	--	28.91	--	15.56	--	63	--	0		3.61

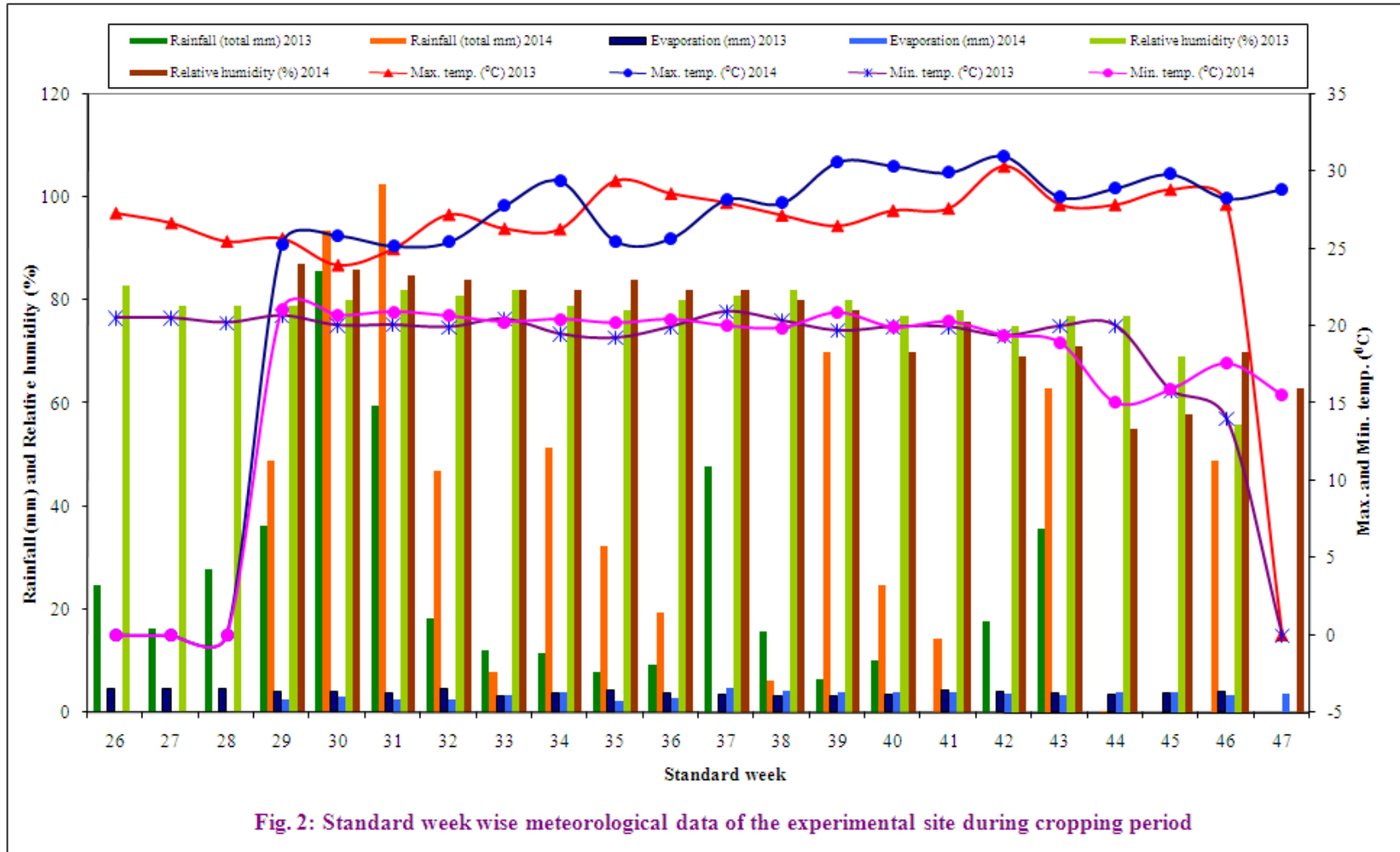


Table 4: Daily Evaporation (ET) and Rainfall data (mm) during crop growth period of 2013

June 2013			July 2013			August 2013		
Date	Rainfall	ETo	Date	Rainfall	ETo	Date	Rainfall	ETo
1-6-13			1-7-13	4.4	3.4	1-8-13	21.2	3.2
2-6-13			2-7-13	2.4	4.5	2-8-13	9.2	3.4
3-6-13			3-7-13	4.2	4.4	3-8-13	15.2	2.7
4-6-13			4-7-13	1.2	4.2	4-8-13	3.0	5.2
5-6-13			5-7-13	0.8	4.3	5-8-13	4.0	3.4
6-6-13			6-7-13	5.6	4.6	6-8-13	12.4	6.8
7-6-13			7-7-13	0.4	4.2	7-8-13	1.2	3.2
8-6-13			8-7-13	1.6	4.6	8-8-13	0.4	5.5
9-6-13			9-7-13	0	3.8	9-8-13	0.2	4.0
10-6-13			10-7-13	1.2	3.2	10-8-13	2.2	4.8
11-6-13			11-7-13	11.8	4.4	11-8-13	2.0	3.4
12-6-13			12-7-13	5.6	4.4	12-8-13	0	4.5
13-6-13			13-7-13	4.4	5.6	13-8-13	2.4	3.1
14-6-13			14-7-13	3.4	4.2	14-8-13	0.6	5.1
15-6-13			15-7-13	1.4	6.2	15-8-13	0	2.5
16-6-13			16-7-13	1.2	3.4	16-8-13	0	3.1
17-6-13			17-7-13	0	4.4	17-8-13	5.8	2.6
18-6-13			18-7-13	2.0	3.8	18-8-13	1.8	2.7
19-6-13			19-7-13	1.2	4.1	19-8-13	1.4	2.4
20-6-13			20-7-13	7.2	4.9	20-8-13	2.8	3.9
21-6-13			21-7-13	11.6	3.4	21-8-13	0.2	3.6
22-6-13			22-7-13	13.6	4.4	22-8-13	2.8	3.7
23-6-13			23-7-13	16.0	3.3	23-8-13	4.0	3.2
24-6-13			24-7-13	15.0	3.6	24-8-13	0.8	3.6
25-6-13			25-7-13	11.6	3.4	25-8-13	0.6	4.6
26-6-13			26-7-13	17.4	3.4	26-8-13	0.4	3.8
27-6-13			27-7-13	16.0	3.8	27-8-13	0.4	4.4
28-6-13			28-7-13	7.6	4.2	28-8-13	0	3.5
29-6-13	0.6	3.2	29-7-13	2.0	5.4	29-8-13	2.2	2.2
30-6-13	2.2	5.0	30-7-13	1.2	4.4	30-8-13	0	7.8
			31-7-13	5.8	3.8	31-8-13		3.8

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September 2013			October 2013			November 2013		
Date	Rainfall	ETo	Date	Rainfall	ETo	Date	Rainfall	ETo
1-9-13	0	3.4	1-10-13	Trace	3.5	1-11-13	0	3.6
2-9-13	5.4	4.2	2-10-13	0	4.0	2-11-13	0	2.3
3-9-13	0.6	4.8	3-10-13	0.6	2.6	3-11-13	0	2.6
4-9-13	0	4.0	4-10-13	0.2	3.5	4-11-13	0	4.1
5-9-13	0	4.6	5-10-13	0.6	4.4	5-11-13	0	4.6
6-9-13	1.2	4.1	6-10-13	8.8	2.5	6-11-13	0	3.3
7-9-13	0.8	2.5	7-10-13	0	3.3	7-11-13	0	3.8
8-9-13	2.8	3.0	8-10-13	0	4.9	8-11-13	0	4.0
9-9-13	4.0	2.4	9-10-13	0	5.0	9-11-13	0	2.9
10-9-13	23.6	3.2	10-10-13	0	2.5	10-11-13	0	3.7
11-9-13	3.0	1.2	11-10-13	0	3.8	11-11-13	0	3.8
12-9-13	3.2	1.7	12-10-13	0	4.5	12-11-13	0	3.7
13-9-13	7.2	5.8	13-10-13	0	3.4	13-11-13		
14-9-13	50.6	7.0	14-10-13	0	4.5	14-11-13		
15-9-13	8.6	2.2	15-10-13	0	4.0	15-11-13		
16-9-13	0.8	3.2	16-10-13	17.6	3.6	16-11-13		
17-9-13	3.2	1.6	17-10-13	0	3.6	17-11-13		
18-9-13	0.6	2.9	18-10-13	0	4.0	18-11-13		
19-9-13	0	3.9	19-10-13	0	3.5	19-11-13		
20-9-13	5.6	4.0	20-10-13	0	4.1	20-11-13		
21-9-13	0.2	1.4	21-10-13	0	4.2	21-11-13		
22-9-13	0.2	4.6	22-10-13	0	5.7	22-11-13		
23-9-13	6.2	2.4	23-10-13	13.0	6.0	23-11-13		
24-9-13	1.4	4.2	24-10-13	19.4	2.4	24-11-13		
25-9-13	0.4	3.2	25-10-13	0.6	2.3	25-11-13		
26-9-13	3.8	3.0	26-10-13	1.2	3.8	26-11-13		
27-9-13	0.6	3.3	27-10-13	12.0	2.4	27-11-13		
28-9-13	0	2.4	28-10-13	1.4	2.2	28-11-13		
29-9-13	0.2	2.9	29-10-13	0	4.6	29-11-13		
30-9-13	0	3.0	30-10-13	0	3.2	30-11-13		
			31-10-13		3.6			

Table 5: Daily Evaporation (ET) and Rainfall data (mm) during crop growth period of 2014

July 2014			August 2014			September 2014		
Date	Rainfall	ETo	Date	Rainfall	ETo	Date	Rainfall	ETo
1-7-14			1-8-14	8.2	2.2	1-9-14	2.0	3.0
2-7-14			2-8-14	1.2	2.8	2-9-14	2.6	3.6
3-7-14			3-8-14	1.6	2.5	3-9-14	1.4	2.4
4-7-14			4-8-14	6.0	4.0	4-9-14	8.2	2.2
5-7-14			5-8-14	6.8	2.8	5-9-14	4.2	2.4
6-7-14			6-8-14	11.0	2.2	6-9-14	2.0	3.0
7-7-14			7-8-14	3.4	1.4	7-9-14	3.6	3.6
8-7-14			8-8-14	10.4	2.0	8-9-14	0	2.0
9-7-14			9-8-14	1.4	1.4	9-9-14	0	4.0
10-7-14			10-8-14	3.0	3.0	10-9-14	0	3.6
11-7-14			11-8-14	17.0	4.0	11-9-14	0	4.0
12-7-14			12-8-14	0.8	2.8	12-9-14	0	6.0
13-7-14			13-8-14	0	6.0	13-9-14	0	4.0
14-7-14			14-8-14	0	2.8	14-9-14	0	4.2
15-7-14			15-8-14	0	3.6	15-9-14	0	5.8
16-7-14	11.8	2.2	16-8-14	0.4	2.4	16-9-14	0	5.6
17-7-14	6.4	2.4	17-8-14	1.2	3.2	17-9-14	0	2.0
18-7-14	3.8	1.8	18-8-14	2.6	2.8	18-9-14	0	6.0
19-7-14	11.0	3.0	19-8-14	3.8	3.4	19-9-14	0	4.4
20-7-14	4.8	2.8	20-8-14	8.4	3.4	20-9-14	6.2	2.2
21-7-14	3.2	3.2	21-8-14	36.6	4.6	21-9-14	0	4.2
22-7-14	7.8	1.8	22-8-14	1.2	4.8	22-9-14	0	6.2
23-7-14	31.0	3.0	23-8-14	2.6	3.2	23-9-14	0	4.0
24-7-14	26.4	1.4	24-8-14	3.2	4.2	24-9-14	43.0	4.4
25-7-14	20.4	2.4	25-8-14	0.4	4.4	25-9-14	15.4	3.6
26-7-14	10.6	4.6	26-8-14	4.4	3.0	26-9-14	0	3.6
27-7-14	1.8	3.4	27-8-14	1.6	2.2	27-9-14	0	4.0
28-7-14	0.2	3.8	28-8-14	8.6	1.2	28-9-14	11.6	3.8
29-7-14	3.2	3.2	29-8-14	9.8	2.0	29-9-14	0	4.1
30-7-14	3.0	1.0	30-8-14	3.6	2.4	30-9-14	0	4.0
31-7-14	75.8	1.8	31-8-14	4.2	2.2			

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October 2014			November 2014		
Date	Rainfall	ETo	Date	Rainfall	ETo
1-10-14	19.2	3.8	1-11-14	0	4.1
2-10-14	0	4.3	2-11-14	0	3.8
3-10-14	0	4.4	3-11-14	0	3.9
4-10-14	0	4.0	4-11-14	0	4.1
5-10-14	0	4.2	5-11-14	0	4.0
6-10-14	5.6	3.7	6-11-14	0	4.0
7-10-14	12.0	3.4	7-11-14	0	4.0
8-10-14	2.4	3.6	8-11-14	0	3.8
9-10-14	0	3.9	9-11-14	0	3.8
10-10-14	0	3.9	10-11-14	0	4.0
11-10-14	0	4.0	11-11-14	0	3.7
12-10-14	0	4.2	12-11-14	0	3.5
13-10-14	0	4.5	13-11-14	0	3.2
14-10-14	0	4.1	14-11-14	25.4	3.0
15-10-14	0	3.9	15-11-14	23.2	3.1
16-10-14	0	3.7	16-11-14	0.2	3.4
17-10-14	0	3.6	17-11-14	0	3.6
18-10-14	0	3.7	18-11-14	0	3.6
19-10-14	0.6	3.9	19-11-14	0	3.7
20-10-14	0	3.5	20-11-14	0	3.5
21-10-14	0	3.9	21-11-14	0	3.8
22-10-14	0	3.8	22-11-14	0	3.7
23-10-14	0	3.6	23-11-14		
24-10-14	0	2.9	24-11-14		
25-10-14	14.6	2.8	25-11-14		
26-10-14	43.4	3.4	26-11-14		
27-10-14	5.0	3.6	27-11-14		
28-10-14	0.4	3.8	28-11-14		
29-10-14	0	3.8	29-11-14		
30-10-14	0	4.0	30-11-14		
31-10-14	0	4.0			

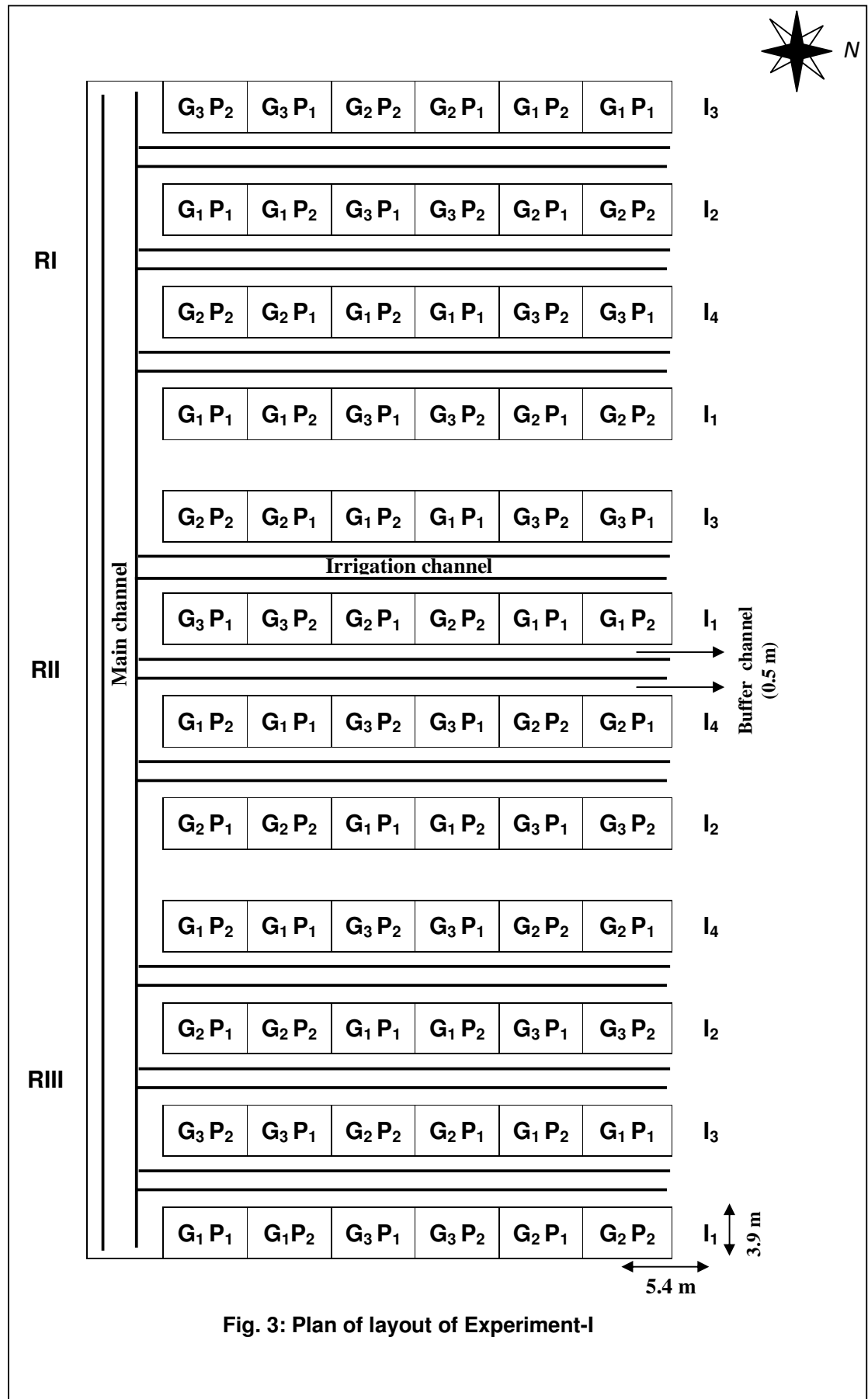


Fig. 3: Plan of layout of Experiment-I

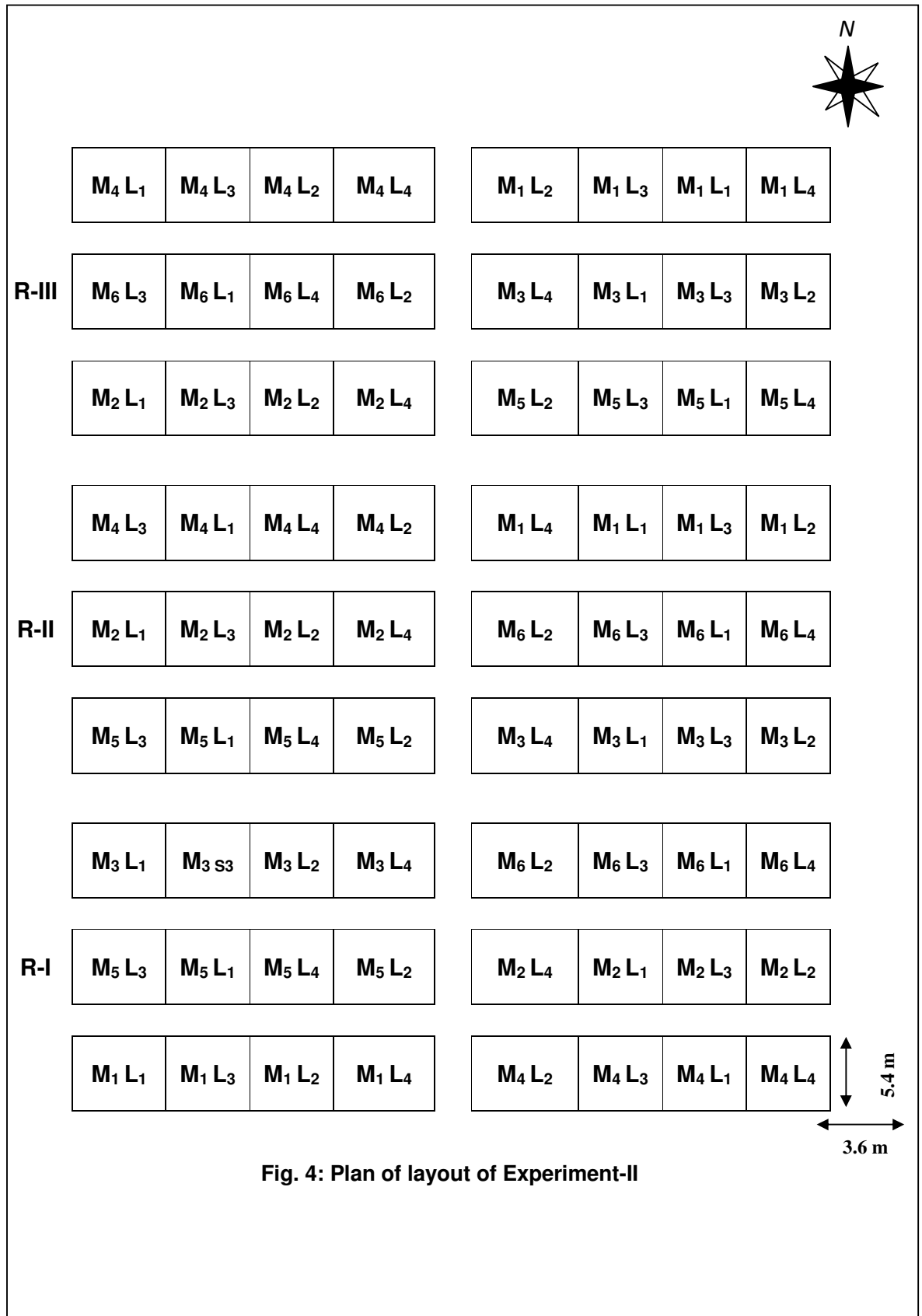


Fig. 4: Plan of layout of Experiment-II

3.2.3 Treatment details

Experiment I: Response of aerobic rice to scheduling of irrigation, planting geometry and methods of planting

The experiment consisted of twenty four treatment combinations comprising of four main plots (irrigation schedule), three sub plots (planting geometry) and two sub sub plots (planting methods) which were replicated thrice. The recommended dose of fertilizer (100:50:50 N, P₂O₅ and K₂O kg ha⁻¹) was applied. At the time of sowing, 33 per cent of recommended dose of nitrogen and complete dose of P₂O₅ and K₂O + 5 t ha⁻¹ FYM were applied to all treatments. The remaining 67 per cent of recommended nitrogen was applied at 20, 40 days after sowing and at panicle initiation stage as top dressing in all treatments.

Main plot: Irrigation schedule (I)

I₁: Irrigation at IW/CPE ratio of 0.8

I₂: Irrigation at IW/CPE ratio of 1.0

I₃: Irrigation at IW/CPE ratio of 1.2

I₄: Irrigation at critical stages of crop growth (tillering, panicle initiation, flowering and grain filling)

Depth of the irrigation – 60 mm

Sub plot: Planting geometry (G)

G₁: 30 cm x 10 cm

G₂: 30 cm x 15 cm

G₃: 30 cm x 20 cm

Sub sub plot: Planting methods (P)

P₁: Sowing of dry seeds

P₂: Sowing of sprouted seeds

Experiment II: Studies on integrated organic nutrient management on growth, yield and quality of aerobic rice in Northern transitional zone of Karnataka

The experiment consisted of twenty four treatment combinations comprising of six main plots (manurial practices) and four sub plots (liquid organic manures) which were replicated thrice.

Main plot: Manurial practices (M)

M₁: Recommended dose of chemical fertilizer (100:50:50 kg N, P₂O₅, K₂O ha⁻¹) (RDF)

M₂: RDF + Farm yard manure (5 t ha⁻¹) + microbial consortium (Azospirillum (ACD 15 and ACD 20) + PSB (*Pseudomonas striata*))

M₃: Farm yard manure (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to recommended dose of nitrogen (RDN)

M₄: Farm yard manure (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to recommended dose of nitrogen (RDN) + microbial consortium

M₅: Farm yard manure (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to recommended dose of nitrogen (RDN) with recommended FYM

M₆: Farm yard manure (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to recommended dose of nitrogen (RDN) with recommended FYM + microbial consortium

Sub plot: Liquid organic manures (L)

L₁: Soil application of jeevamrut @ 500 l ha⁻¹ at 30, 60 and 90 DAS

L₂: Foliar application of cow urine @ 500 l ha⁻¹ at 30, 60 and 90 DAS

L₃: Soil application of biodigester @ 2500 l ha⁻¹ at 30, 60 and 90 DAS

L₄: Control (no liquid manure application)

3.2.4 Plot size

Experiment I

Gross : 5.4 m x 3.9 m = 21.06 m²

Net : (30x10 cm) : 5.0 m x 2.7 m = 13.50 m²

: (30x15 cm) : 4.8 m x 2.7 m = 12.96 m²

: (30x20 cm) : 4.6 m x 2.7 m = 12.42 m²

Experiment II

Gross : 5.4 m x 3.6 m = 19.44 m²

Net : 4.8 m x 2.4 m = 11.52 m²

Spacing : 30 cm x 15 cm

3.2.5 Crop variety

Fine grain and early duration variety of paddy MAS- 26 (Gandhi *et al.*, 2012) released during 2008 specifically for aerobic rice production from UAS, Bengaluru (Carl Pray *et al.*, 2011) was used.

3.3 Cultivation practices

3.3.1 Land preparation

The land was ploughed and cultivated once with mould-board plough and brought to fine tilth with two harrowings. Stubbles and weeds were collected and disposed off from the experimental area. Plots were laid out as per the plan.

3.3.2 Preparation of liquid manures

3.3.2.1 Jeevamrut

Ingredients:

Cow dung: 10 kg, Cow urine: 10 l, Jaggery: 2 kg, Soil from bunds or below tree: 1 kg,
Legume flour: 2 kg

The above ingredients were taken in a 200 l capacity drum and the volume was made up to 200 l with the addition of water. The drum was kept in shade and stirred thrice in a day, and was covered with the lid. After a week the jeevamrut was ready and was used for soil application. It was regularly added to the soil at the rate 500 l ha⁻¹ at 30, 60 and 90 DAS.

3.3.2.2 Cow urine

Fresh cow urine was collected and applied as foliar application @10 per cent @ 500 l ha⁻¹ at 30, 60 and 90 DAS.

3.3.2.3 Bio-digester

The bio-digester liquid was used as a liquid manure. The bio-digester of 16 feet length 10 feet width and 6 feet height was constructed and the dung, urine, organic wastes and botanical plants, mainly neem, calotropis, vitex, lantana, adothoda, ipomea, custard apple, agave *etc.*, were added to the bio-digester containing urine, dung and little quantity of soil was added to the bio-digester and water was let into the tank. The organic matter decomposes and digested liquid manure was ready in 2-3 weeks. It was added to the soil @ 2500 l ha⁻¹ at 30, 60 and 90 DAS.

3.3.3 Fertilizer application

Fertilizers were applied as recommended for drill sown rice crop. At the time of sowing, 33 per cent of recommended dose of nitrogen and complete dose of P₂O₅ and K₂O chemical fertilizer 100:50:50 N: P₂O₅:K₂O kg ha⁻¹ (RDF) and FYM @ 5 t ha⁻¹ was applied to all treatments in advance. The remaining 67 per cent of recommended nitrogen was applied at 20 and 40 DAS and at panicle initiation stage as top dressing in all treatments. In experiment II green leaf manure (*Gliricidia sp.*) on fresh weight basis, Farm yard manure (FYM), and vermicompost on RDN basis were applied as per the treatments in advance. Bio-digester, jeevamrut, and cow urine were applied as per the treatments at 30, 60 and 90 DAS.

3.3.4 Seeds and sowing

Before sowing seeds were soaked in water for 24 hours and kept in gunny bag for 48 hours for sprouting (sprouted seed) and for dry sowing seeds were used as dry

seeds. Seeds were treated with *Pseudomonas* and *Azospirillum* @ 4g per kg. Before sowing furrows were opened at 30 cm apart and hill marking was done at 10, 15 and 20 cm (treatment wise). Two seeds were dibbled per hill at respective treatment spacing viz., 10, 15 and 20 cm apart for experiment I and at 15 cm for experiment II. Basal dose of fertilizers was applied by the side of seed row and covered with soil.

Season	Experiment I		Experiment II	
	Date of sowing	Date of harvesting	Date of sowing	Date of harvesting
<i>Kharif</i> 2013	29-06-2013	12-11-2013	04-07-2013	13-11-2013
<i>Kharif</i> 2014	17-07-2014	22-11-2014	16-07-2014	21-11-2014

3.3.5 Scheduling irrigation

Common irrigation was given after sowing an amount of 60 mm by using parshall flume. As per treatment details, whenever IW/CPE ratio approached the required level as determined from the USWB open pan evaporimeter, 60 mm depth of water was provided. Measured quantity of irrigation water was applied, to each plot with the help of parshall flume. The duration of irrigation for each plot was calculated based on discharge rate ($l \text{ sec}^{-1}$) of parshall flume and pre-decided depth of irrigation (*i.e.* 60 mm in each irrigation). In order to overcome the conveyance losses effect on treatments two buffer channels on either side of the central irrigation canal were made and water was carried only in irrigation channel. Irrigation schedules given during 2013 and 2014 are as follows.

Year	I ₁ -IW/CPE 0.8	I ₂ -IW/CPE 1.0	I ₃ -IW/CPE 1.2	I ₄ -critical stages
2013	04.09.2013	30.08.2013	28.08.2013	16.08.2013
	21.10.2013	13.10.2013	11.10.2013	04.09.2013
				30.09.2013
				20.10.2013
2014	24.10.2014	22.09.2014	19.09.2014	15.09.2014
		23.10.2014	21.10.2014	13.10.2014
		12.11.2014	10.11.2014	07.11.2014

3.3.6 Weed management

In aerobic rice, as weeds posed problem and regular weed management was undertaken. Weed control was done with application of Butachlor and 2, 4-D sodium salt along with inter cultivation twice at 20, 40 DAS and two hand weeding at 20 and 40 DAS to manage weeds. No herbicides were used for weed control in organic manurial plots.

3.3.7 Plant protection measures

To manage the insect pests, neem oil, *Metarrhizium* and *Pseudomonas fluroscence* were used. Neem oil dose depends on the azadiractin content present in it. The blast of paddy was managed by *Pseudomonas fluroscence* @ 10 g l⁻¹ of water at 90 and 105 DAS.

3.3.8 Harvesting and threshing

The crop was harvested after attaining the physiological maturity on 12th November 2013 and 22nd November 2014 of experiment I and on 13th November 2013 and 21st November 2014 of experiment II. Two rows on all sides of each plot were harvested as border rows and the remaining area was the net plot. The crop in each net plot was harvested and threshed separately. Grain and straw were sun dried and weighed separately.

3.4 Collection of experimental data

3.4.1 Growth parameters

3.4.1.1 Plant height

Plant height was recorded at 30, 60 and 90 DAS and at harvest from the base of plant to the base of newly opened leaf from five plants selected randomly and the mean was expressed in cm.

3.4.1.2 Total number of tillers

The total number of tillers of five randomly selected hills were counted at 30, 60 and 90 DAS and at harvest and expressed as number of total tillers m⁻².

3.4.1.3 Leaf area

The leaf area (mean of five hills) was calculated by measuring the length and maximum width of the third leaf from the top and multiplying with the factor (0.75) (Palaniswamy and Gomez, 1974). It was expressed as dm^2 per m^2 . It was calculated at 30, 60 and 90 DAS.

3.4.1.4 Leaf area index (LAI)

Leaf area index is defined as leaf area (assimilatory source) per unit land area. It was calculated at 30, 60 and 90 DAS as per the formula given by Watson (1952).

$$\text{Leaf area index} = \frac{\text{Total leaf area}}{\text{Unit land area}}$$

3.4.1.5 Total dry matter accumulation

Five plants were uprooted at randomly adjacent to net plot rows at 30, 60 and 90 DAS and at harvest. The root portion of the plant was removed. The above total ground portion (leaf and stem) of the plant samples was washed in water and dried in hot air oven at 65°C till constant weight was obtained. The mean dry weight was recorded and expressed in grams m^{-2} .

3.4.1.6 SPAD values

SPAD is a plant analysis technique developed by IRRI, Philippines for nitrogen management in rice crop. SPAD chlorophyll readings were collected from first fully expanded flag leaf from the top of the plant. Observation on five randomly selected plants was done and values were recorded and average values were expressed as SPAD unit values at 30, 60 and 90 DAS.

3.4.1.7 Observations on weeds

The observations on weed growth at different stages were recorded from three randomly selected quadrant areas (0.25 m^2) in each plot.

3.4.1.7.1 Weed flora

Weed flora of the each of the treatments in experimental site was identified and categorized as grasses, sedges and BLWs

3.4.1.7.2 Weed density

Weed counts are taken category wise at 20, 40, 60 DAS and at harvest. At these stages, the three categories of weeds *viz.*, grasses, sedges and BLWs and expressed as number m⁻².

3.4.1.7.3 Weed dry matter

The weeds collected from 0.25 m² area, outside the net plot were dried under shade for 24 hours, followed by oven drying at 60^o C to a constant weight and the dry matter production was expressed as g m⁻². The dry matter production of weeds was recorded at 20, 40, 60 DAS and at harvest.

3.4.1.8 Soil moisture studies

In the gravimetric method, soil moisture content in per cent is made on soil samples of known weight or volume. Soil samples were drawn before each irrigation from different depths in all treatments with help of screw auger. They are collected in air tight aluminum containers. The soil samples are weighed and they were dried in an oven at 105^o C for about 24 hours or to the constant weight . After removing from oven, they were cooled slowly to room temperature and weighed. The difference in weight is expressed as moisture content in per cent in the soil. The moisture content in the soil is calculated by the following formula:-

$$\text{Moisture content on weight basis (\%)} = \frac{\text{Wet weight of the sample} - \text{Dry weight of the sample}}{\text{Dry weight of the sample}} \times 100$$

3.4.1.9 Water use efficiency

Water use efficiency (WUE) was calculated using following formula and expressed as kg ha cm⁻¹

$$\text{WUE} = \frac{\text{Grain Yield (kg ha}^{-1}\text{)}}{\text{Total water used (cm)}}$$

3.4.2 Yield Parameters

3.4.2.1 Productive tillers

Five hills were selected from each net plot and counted the number of tillers per hill which bear the panicles and average values were expressed as productive tillers m^{-2} .

3.4.2.2 Panicle Length

Panicle length of five panicles selected at random from each net plot was recorded from base to tip of the panicle and the mean was computed and expressed in cm.

3.4.2.3 Panicle weight

Mean panicle weight was obtained by weighing five panicles randomly selected from each net plot and mean was expressed as grams per panicle.

3.4.2.4 Number of filled grains panicle⁻¹

Total numbers of filled grains from same five plants selected for panicle length were counted and the mean was computed.

3.4.2.5 Number of unfilled grains panicle⁻¹

Total numbers of unfilled grains from five plants selected at random was panicle counted and the mean was computed.

3.4.2.6 Thousand grain weight

One thousand grains were counted from the five randomly selected plants and the weight was recorded in grams.

3.4.2.7 Grain yield

Grains from corresponding net plots were sun dried for 6 days and the weight of grains of each net plot area was converted and recorded as grain yield kg ha^{-1} .

3.4.2.8 Straw yield

Straw weight from each net plot were sun dried for 6 days and weighed and then converted and recorded as straw yield kg ha^{-1} .

3.4.2.9 Harvest Index

The ratio of economic yield (grain yield) to the biological yield (grain and straw yield) was worked out as harvest index (Donald, 1962).

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

3.5 Physical properties of soil

3.5.1 Maximum water holding capacity

The maximum water holding capacity of soil was determined by Keens cup method after harvest of crop (Piper, 2002).

3.5.2 Particle size distribution

The particle size analysis of soil was determined by adopting the hydrometer method (Piper, 2002).

3.5.3 Bulk density (Mg/m^3)

Bulk density was calculated by using core sample method (Black, 1967)

$$\text{Bulk density (BD)} = \frac{\text{Weight of oven dry soil (g)}}{\text{Volume of core (cm}^3\text{)}}$$

3.6 Economic analysis

3.6.1 Costs

In computing the economics, different variable cost items were considered. The cost includes expenditure on seed, organic manures, chemical fertilizers, plant protection chemicals and labour charges at prevailing market prices during 2013 and 2014. Labour requirement was worked out on the basis of labourers engaged for

performing different field operations. Also to work out the economics of aerobic rice, we considered 20 per cent premium price for organically grown aerobic rice as compared to conventionally grown aerobic rice.

3.6.2 Gross returns

The gross returns was calculated by considering the prices of rice grain and straw prevailing at the time of marketing and yield obtained.

Gross return = Total value of the produce (both grain and straw).

3.6.3 Net returns

The net returns per ha was calculated by deducting the cost of cultivation from the gross returns on per hectare basis.

Net returns = Gross returns - Cost of cultivation.

3.6.4 Benefit Cost Ratio

The benefit cost ratio was worked out by dividing gross returns through total cost of cultivation.

$$\text{B: C ratio} = \frac{\text{Gross returns (₹ ha}^{-1}\text{)}}{\text{Cost of cultivation (₹ ha}^{-1}\text{)}}$$

In addition to the above parameters, the following observations except observations on weeds and soil moisture were recorded in Experiment-II.

3.7 Chemical properties of soil

3.7.1 Soil sampling and analysis

Before the start of experiment, composite soil sample from 0-15 cm depth were collected from the experimental site processed to pass through 2 mm sieve and preserved for further analysis. Treatment wise soil samples from each plot were

collected after harvest of rice crop. The soils were dried in shade, processed to pass through 2 mm sieve and used for further analysis. The soil samples were analyzed for pH, electrical conductivity, organic carbon, available nitrogen, available phosphorus and available potassium content.

3.7.2 pH and electrical conductivity

The soil pH was measured in 1:2.5 soil: water suspension by potentiometry (Sparks, 1996). The clear supernatant solution of above soil water suspension was taken and electrical conductivity was measured using Conductivity Bridge (Sparks, 1996).

3.7.3 Organic carbon

The organic carbon was determined by Walkley and Black's wet oxidation method by oxidizing organic matter as described by Sparks (1996) and expressed in g/kg.

3.7.4 Available nitrogen

The available nitrogen was estimated by alkaline permanganate oxidation method as outlined by Subbiah and Asija (1956) and expressed in kg ha^{-1} .

3.7.5 Available phosphorus

The available phosphorus was determined by Olsen's method using spectrophotometer (660 nm wave length) as outlined by Sparks (1996) and expressed in kg ha^{-1} .

3.7.6 Available potassium

The available potassium was extracted with neutral ammonium acetate (1 N NH_4OAc) and the content of K in the solution was estimated by Flame photometer (Sparks, 1966) and expressed in kg ha^{-1} .

3.7.7 Available sulphur

The solution sulphur was determined by turbidimetric method (Sparks, 1996). The principle for turbidimetric estimation of solution sulphur. The sulphate in solution

reacts with BaCl_2 to form BaSO_4 and this BaSO_4 remains in colloidal state and imparts turbidity to solution. Intensity of turbidity is directly related to sulphate sulphur concentration in solution. Intensity of turbidity is read in spectrophotometer at 420 nm after 5 minutes but before 30 minutes.

3.7.8 DTPA extractable micronutrient (mg kg^{-1})

Twenty gram of air dried soil was shaken with 40 ml of DTPA extracting solution for two hours. The soil suspension was filtered and the content of zinc, iron, copper and manganese were estimated by using Atomic Absorption Spectrophotometer (AAS) (Lindsay and Norvell, 1978).

3.8 Enzyme activity and soil microbial population

3.8.1 Dehydrogenase activity ($\mu\text{g TPF g}^{-1}\text{day}^{-1}$)

The dehydrogenase activity in the soil samples was determined by following the procedure described by Casida *et al.* (1964). Ten grams of soil and 0.2 grams of CaCO_3 were thoroughly mixed and dispensed in the conical flasks. Each flask was added with 3.0 ml of 3 per cent 2, 3, 5 - triphenyl tetrazolium chloride (TTC), 1.0 ml of 1 per cent glucose solution and 8.0 ml of distilled water to leave a thin film of water above soil layer. The flasks were stoppered with rubber bunks and incubated at 30°C for 24 hours. At the end of incubation, the contents of the flask were rinsed down into small beaker and slurry was made by adding 10 ml of methanol. The slurry was filtered through Whatman No.42 filter paper. Repeated rinsing of soil with methanol was continued till the filtrate ran free of red colour. The filtrate was made upto 50 ml with methanol in volumetric flask. The intensity of red colour was measured at 485 nm against blank using spectrometer.

The standard curve preparation: Graded concentration of TTC (2, 3, 5 - triphenyl tetrazolium chloride) (0.0-50.0 μg) were prepared in methanol. In each tube, 5 ml of phosphate buffer (7.4 pH) and adequate amount (153mg) of fresh sodium dithionate ($\text{Na}_2\text{SO}_4 \cdot \text{H}_2\text{O}$) were added. When the reduction was complete pink colour intensity of graded concentration of triphenyl formazon (TPF) was red as before. Enzyme activity was expressed as μg of TPF produced per gram of soil per day.

3.8.2 Phosphatase activity ($\mu\text{g TPF g}^{-1} \text{hr}^{-1}$)

The reaction mixture comprising of 1.0 g of soil, 0.2 ml toluene, 4.0 ml modified universal buffer (pH 7.5) and 1 ml of P- nitro phenol phosphate (PNP) 21 solutions were mixed and incubated at 37 ° C for one hour. One ml of 0.5 M CaCl_2 and 4 ml of 0.5 NaoH were added, swirled and filtered. The intensity of yellow colour was measured at 420 nm against the reagent blank (Evasi and Tabatabai, 1979).

3.8.3 Soil microbial population

The microbial population in the soil before sowing of crop and after harvest was determined by standard serial dilution plate count method. The samples were collected from the experimental plots by carefully uprooting the plants by gentle shaking to remove excess soil. The soil adhering to the roots was carefully collected and analysed for Azospirillum.

Ten grams of soil (treatment wise) weighed and mixed in 90 ml sterilized water blank to give 10^1 dilutions. Subsequent dilutions up to 10^4 were made by transferring serially 1 ml of each dilution to 9 ml of sterilized water blanks. The population of free living N fixtures – Azotobacter, Phosphate solubilizing bacteria (PSB) were estimated by standard serial dilution plate count method and by taking 1 ml from selected dilution of 10^3 , 10^4 were transferred aseptically to petridishes and the desired melted agar media ware added to the respective dilutions. Plating on appropriate media viz., soil extract agar for free living N fixtures – Azotobacter and Pikovskaya's media for P-solubilizers was used. The plates were kept for incubation at $30^\circ\text{C} + 1^\circ\text{C}$ for 24 – 48 h and emerged colony forming units counted.

To enumerate Azospirillum sp. in soil, the most probable number (MPN) method was followed with semi solid Dobreiner medium. The tubes which have turned blue and have developed typical white sub-surface pellicle counted as +ve or –ve and considered for the purpose of calculation by referring to statistical tables of Cochran (1950) and expressed as MPN per gram of soil.

3.9 Plant analysis

Five randomly selected plants from each net plot were oven dried and used for chemical analysis after grinding.

Nitrogen content was determined by digesting the plant samples with concentrated sulphuric acid and digestion mixture. The digested samples were distilled by Micro kjeldhal method in an alkaline condition and titrated against standard acid (Tandon, 1998).

Phosphorus and potassium contents were determined after the samples were digested with diacid mixture (nitric acid + perchloric acid). Phosphorus content was determined by Vanadomolybdate phosphoric yellow colour method and observation was recorded at 430 nm using Spectrophotometer instrument (Tandon, 1998). Potassium content was determined from the same diacid digested extract with the Digital Flame Photometer (Tandon, 1998).

The uptake of nitrogen, phosphorus and potassium by rice crop at harvest was computed by using the following formula.

$$\text{Nutrient uptake (kg ha}^{-1}\text{)} = \frac{\text{Nutrient content (\%)} \times \text{Yield of dry matter (kg)}}{100}$$

Zinc, iron, manganese and copper content were determined in an aliquot of the diacid digested extract by using atomic absorption spectrometer (AAS) method as described by Tandon (1998).

For the estimation of micronutrients (Fe, Mn, Zn and Cu) the straw and grain samples were digested in diacid mixture of conc. HNO₃ and HClO₄ in the ratio of 10: 4. After digestion, the plant and grain samples were analyzed with the help of Atomic Absorption Spectrophotometer (Tandon, 1998). Nutrient uptake in grain and straw of rice was calculated in kg ha⁻¹ for N, P, K and S in relation to dry matter production and their nutrient contents by using the following formula:

$$\text{Nutrient (Fe, Mn, Zn and Cu) uptake (g ha}^{-1}\text{)} = \frac{\text{Nutrient content in dry matter (ppm)} \times \text{Yield of dry matter (kg)}}{1000}$$

3.10 Quality parameters

3.10.1 Milling quality of grain

The hulled rice was subjected to milling for 90 seconds *i.e.*, 5 per cent milling (Chauhan *et al.*, 1994) in "Satake grain testing mill" and the weight was recorded. The milling percentage was calculated by using the following formula and presented in percentage.

$$\text{Milling (\%)} = \frac{\text{Total weight of milled rice (g)}}{\text{Total weight of rough rice with husk (g)}} \times 100$$

3.10.2 Protein content in grain

Crude protein content in the grains and straw of the crop arrived by multiplying the calculated N fraction with the factor 5.95 as suggested by Sadasivam and Manickam (1992).

3.10.3 Starch content (amylase activity)

Starch is an important polysaccharide. It is the storage form of carbohydrate in plants abundantly found in roots, tubers, stems, fruits and cereals. Starch which is composed of several glucose molecules, is a mixture of two types of components namely amylose and amylopectin. Starch is hydrolysed into simple sugars by dilute acids and the quantity of simple sugars by is measured colorimetrically. Amylase activity is done by using anthrone reagent as suggested by Sadasivam and Manickam (1996). The sample is treated with 80 per cent alcohol to remove sugars and then starch is extracted with perchloric acid. In hot acidic medium starch is hydrolysed to glucose and dehydrated to hydromethyl furfural. This compound forms a green coloured product with anthrone.

3.11 Scoring of major pests, disease and natural enemies

3.11.1 Leaf folder

The damaged leaves and total leaves from 10 randomly selected hills were observed in each plot. The percentage of leaf damage was calculated as follows.

$$\text{Per cent incidence} = \frac{\text{Number of damaged leaves}}{\text{Total number of leaves}} \times 100$$

3.11.2 Dead hearts and white ear

Counts were taken on number of stem borer and per cent incidence of dead hearts and white ears from 10 randomly selected hills. The per cent incidence (dead heart/ white ears) was calculated as follows.

$$\text{Per cent incidence} = \frac{\text{Number of dead hearts/white ears}}{\text{Total number of tillers/panicles}} \times 100$$

3.11.3 Rice blast and neck blast

The damaged leaves and total leaves from 10 randomly selected hills were observed in each plot. The percentage of leaf damage was calculated as follows.

$$\text{Per cent incidence} = \frac{\text{Number of damaged leaves/affected panicles}}{\text{Total number of leaves/ panicles}} \times 100$$

3.11.4 Scoring of natural enemies

The natural enemies present on the crop were observed in all the treatments. The observations on adult population of spiders m^{-2} area were observed in each plot at 60 and 90 DAS.

3.12 Statistical analysis

The experimental data obtained were subjected to statistical analysis by adopting Fisher's method of analysis of variance as outlined by Gomez and Gomez (1984). The level of significance used in 'F' test was at 5 per cent. Critical difference (CD) values are given in the table at 5 per cent level of significance, wherever the 'F' test was significant. The mean values of main plot, sub plot and interaction were separately subjected to Duncan' multiple range test using the corresponding error mean sum of squares and degrees of freedom values. Values indicated with same alphabet do not differ significantly.

3.13 Correlation studies

Correlation studies were made between grain yield, yield parameters and growth parameters. The values of correlation coefficient (r) was calculated and tested for their significance at five per cent as per the procedure outlined by Snedekar and Cocoharan (1967).

4. EXPERIMENTAL RESULTS

The results of the field trial entitled “Planting geometry, irrigation and organic nutrient management practices for aerobic rice in northern transitional zone of Karnataka” conducted at Main Agricultural Research Station, Dharwad during *kharif* 2013 and 2014 are presented in this chapter.

4.1 Experiment-I: Response of aerobic rice to scheduling of irrigation, planting geometry and methods of planting

4.1.1 Growth parameters

4.1.1.1 Plant height (cm)

The data on plant height of aerobic rice recorded at different growth stages as influenced by scheduling of irrigation, planting geometry and methods of planting is furnished in Table 6. The pooled data on plant height indicated that the plant height varied significantly across scheduling of irrigation, planting geometry and methods of planting under evaluation and their interactions at all growth stages except at 30 DAS with scheduling of irrigation.

Significantly higher plant height at 60 and 90 DAS and at harvest was recorded with irrigation at critical stages of crop growth (I_4) 42.43 cm, 55.66 cm and 67.12 cm, respectively. Significantly lower plant height (40.59 cm) was recorded with irrigation at IW/CPE of 1.2 (I_3) at 60 DAS; but was at par with I_1 (40.74 cm) and I_2 (40.85 cm). Whereas, irrigation at IW/CPE of 0.8 (I_1) recorded lower plant height at 90 DAS and at harvest (54.44 and 64.41 cm, respectively).

Plant height increased significantly with increase in plant density during both the years as well as with pooled data. Significantly higher plant height at 30, 60 and 90 DAS and at harvest was recorded with planting geometry of 30 cm x 10 cm (G_1) (14.89, 42.95, 57.13 and 67.64 cm respectively); but was at par with G_2 (30 cm x 15 cm) at 30 DAS and at harvest (14.20 and 65.98 cm respectively). Significantly lower plant height was recorded with planting geometry of 30 cm x 20 cm (G_3) at all growth stages (13.15, 39.68, 53.29 and 63.61 cm respectively).

Table 6: Effect of irrigation schedules, planting geometry and planting methods on plant height (cm) at different growth stages of crop growth

Treatments	30 DAS			60 DAS			90 DAS			Harvest		
	2013	2014	Pooled	2013	2014	Pooled	2013	2014	Pooled	2013	2014	Pooled
Irrigation Schedule (I)												
I ₁ -IW/CPE-0.8	14.57a	13.41a	13.99a	40.86b	40.63a	40.74b	55.46b	53.42b	54.44b	65.44b	63.38c	64.41c
I ₂ -IW/CPE-1.0	14.63a	13.46a	14.05a	41.17b	40.53a	40.85b	55.72ab	55.09a	55.40a	65.51b	66.39ab	65.95ab
I ₃ -IW/CPE-1.2	14.67a	13.63a	14.15a	41.15b	40.04a	40.59b	56.04ab	54.97a	55.51a	65.68b	65.33b	65.51bc
I ₄ -Critical stages	14.70a	13.58a	14.14a	43.39a	41.46a	42.43a	56.11a	55.21a	55.66a	66.60a	67.64a	67.12a
S.Em±	0.48	0.17	0.29	0.3	0.56	0.23	0.17	0.1	0.27	0.25	0.53	0.40
Planting geometry (G)												
G ₁ -30 cm x 10 cm	15.46a	14.33a	14.89a	43.32a	42.57a	42.95a	57.76a	56.50a	57.13a	67.87a	67.42a	67.64a
G ₂ -30 cm x 15 cm	14.76ab	13.63a	14.20a	41.28b	40.40b	40.84b	55.93ab	54.74ab	55.33b	66.06a	65.91ab	65.98a
G ₃ -30 cm x 20 cm	13.71b	12.60b	13.15b	40.33b	39.02b	39.68b	53.80b	52.78b	53.29c	63.50b	63.73b	63.61b
S.Em±	0.41	0.29	0.24	0.55	0.72	0.53	0.89	0.72	0.58	2.25	0.77	0.59
Planting methods (P)												
P ₁ -Dry seeds	14.38b	13.43a	13.91b	41.24a	40.53a	40.88a	55.56a	54.52a	55.04a	65.64a	65.68a	65.66a
P ₂ -Sprouted seeds	14.91a	13.61a	14.26a	42.04a	40.80a	41.42a	56.10a	54.82a	55.46a	65.98a	65.68a	65.83a
S.Em±	0.17	0.25	0.11	0.49	0.53	0.36	0.66	0.58	0.56	0.83	0.70	0.57
Interactions (I×G×P)												
I ₁ G ₁ P ₁	15.13a-c	14.20a	14.67a-c	42.23ab	43.10a	42.67a-d	57.17a	55.37a	56.27a	67.50a	65.23a	66.37ab
I ₁ G ₁ P ₂	15.67ab	14.37a	15.02ab	42.77ab	43.60a	43.18a-c	57.50a	55.53a	56.52a	67.80a	65.43a	66.62ab
I ₁ G ₂ P ₁	14.30a-c	13.30a	13.80a-c	40.37ab	40.23a	40.30a-d	55.37a	53.23a	54.30a	65.23a	63.37a	64.30ab
I ₁ G ₂ P ₂	14.93a-c	13.53a	14.23a-c	40.80ab	40.37a	40.58a-d	55.83a	53.47a	54.65a	65.53a	63.53a	64.53ab
I ₁ G ₃ P ₁	13.47bc	12.40a	12.93c	39.23b	38.13a	38.68d	53.27a	51.37a	52.32a	63.13a	61.27a	62.20b
I ₁ G ₃ P ₂	13.93a-c	12.63a	13.28bc	39.73ab	38.33a	39.03b-d	53.63a	51.53a	52.58a	63.47a	61.43a	62.45ab
I ₂ G ₁ P ₁	15.23a-c	14.13a	14.68a-c	43.10ab	42.80a	42.95a-d	57.40a	56.90a	57.15a	67.30a	68.10a	67.70ab
I ₂ G ₁ P ₂	15.53ab	14.37a	14.95ab	43.67ab	43.10a	43.38ab	57.87a	57.23a	57.55a	67.73a	68.47a	68.10ab
I ₂ G ₂ P ₁	14.43a-c	13.50a	13.97a-c	40.23ab	39.77a	40.00a-d	55.53a	54.97a	55.25a	65.43a	66.43a	65.93ab
I ₂ G ₂ P ₂	15.10a-c	13.67a	14.38a-c	40.73ab	39.93a	40.33a-d	56.10a	55.27a	55.68a	65.87a	66.70a	66.28ab
I ₂ G ₃ P ₁	13.53bc	12.47a	13.00 c	39.37b	38.67a	39.02cd	53.47a	52.97a	53.22a	63.27a	64.13a	63.70ab
I ₂ G ₃ P ₂	13.97a-c	12.63a	13.30bc	39.90ab	38.93a	39.42b-d	53.93a	53.20a	53.57a	63.47a	64.50a	63.98ab
I ₃ G ₁ P ₁	15.37a-c	14.53a	14.95ab	41.80ab	41.30a	41.55a-d	57.60a	56.80a	57.20a	67.50a	68.20a	67.85ab
I ₃ G ₁ P ₂	16.10a	14.67a	15.38a	43.53ab	41.80a	42.67a-d	58.27a	57.10a	57.68a	67.83a	65.20a	66.52ab
I ₃ G ₂ P ₁	14.53a-c	13.63a	14.08a-c	40.50ab	39.80a	40.15a-d	55.90a	54.87a	55.38a	66.10a	65.43a	65.77ab
I ₃ G ₂ P ₂	14.97a-c	13.77a	14.37a-c	41.20ab	40.20a	40.70a-d	56.63a	55.10a	55.87a	66.47a	65.77a	66.12ab
I ₃ G ₃ P ₁	13.27c	12.53a	12.90 c	39.67b	38.47a	39.07b-d	53.60a	52.80a	53.20a	62.90a	63.50a	63.20ab
I ₃ G ₃ P ₂	13.77bc	12.67a	13.22bc	40.20ab	38.67a	39.43b-d	54.23a	53.17a	53.70a	63.30a	63.87a	63.58ab
I ₄ G ₁ P ₁	15.07a-c	14.10a	14.58a-c	43.83ab	42.37a	43.10a-c	57.80a	56.40a	57.10a	68.50a	69.23a	68.87ab
I ₄ G ₁ P ₂	15.57ab	14.27a	14.92ab	45.63a	42.50a	44.07a	58.50a	56.67a	57.58a	68.80a	69.47a	69.13a
I ₄ G ₂ P ₁	14.63a-c	13.77a	14.20a-c	42.73ab	41.30a	42.02a-d	55.80a	55.20a	55.50a	66.70a	67.87a	67.28ab
I ₄ G ₂ P ₂	15.17a-c	13.90a	14.53a-c	43.63ab	41.60a	42.62a-d	56.23a	55.80a	56.02a	67.13a	68.17a	67.65ab
I ₄ G ₃ P ₁	13.60bc	12.63a	13.12bc	41.80ab	40.43a	41.12a-d	53.80a	53.40a	53.60a	64.10a	65.43a	64.77ab
I ₄ G ₃ P ₂	14.17a-c	12.80a	13.48bc	42.73ab	40.53a	41.63a-d	54.50a	53.80a	54.15a	64.37a	65.67a	65.02ab
S.Em±	0.63	0.86	0.54	1.7	1.83	1.25	2.3	2.02	1.95	2.88	2.43	1.96

Means followed by the same alphabet do not differ significantly by DMRT (0.05)

Significantly higher plant height (14.26 cm) was recorded with sowing of sprouted seed (P_2) than with sowing of dry seed (P_1) (13.91 cm) at 30 DAS. There was no significant difference between the methods of planting from 60 DAS onwards.

Interaction effects of scheduling of irrigation, planting geometry and methods of planting indicated that $I_3G_1P_2$ (sowing of sprouted seeds at 30 cm x 10 cm with irrigation at IW/CPE of 1.2) recorded significantly higher plant height (15.38 cm) at 30 DAS. Whereas, $I_4G_1P_2$ (sowing of sprouted seeds at 30 cm x 10 cm with irrigation at critical stages) recorded significantly higher plant height at 60 and 90 DAS and at harvest (44.07, 57.58 and 69.13 cm, respectively). Significantly lower plant height was recorded with $I_1G_3P_1$ (sowing of dry seeds at 30 cm x 20 cm with irrigation at IW/CPE of 0.8) at 30, 60 and 90 DAS and at harvest (12.93, 38.68, 52.32 and 62.20 cm, respectively).

4.1.1.2 Number of tillers (m^{-2})

The data pertaining to number of tillers of aerobic rice recorded at different growth stages as influenced by scheduling of irrigation, planting geometry and methods of planting is presented in Table 7. The number of tillers differed significantly due to scheduling of irrigation at all growth stages except at 30 DAS. Irrigation at critical stages recorded significantly higher number of tillers at 60 and 90 DAS and at harvest with (502.41, 566.32 and 639.33 respectively). However, significantly lower number of tillers was recorded with irrigation at IW/CPE of 0.8 (I_3) at 60 and 90 DAS and at harvest (468.62, 519.75 and 594.89, respectively).

Number of tillers increased significantly with increase in plant density during both the years as well as in pooled basis. Significantly higher number of tillers 30, 60 and 90 DAS and at harvest was recorded with planting geometry of 30 cm x 10 cm (G_1) (215.53, 552.72, 642.30 and 748.12 respectively). Significantly lower number of tillers was recorded with planting geometry of 30 cm x 20 cm (G_3) at all growth stages (141.75, 407.34, 453.71 and 501.67, respectively).

Significantly higher number of tillers (179.63) was recorded with sowing of sprouted seeds (P_2) than with sowing of dry seeds (P_1) (171.64) at 30 DAS. There was no significant difference in number of tillers between the methods of planting from 60 DAS onwards.

Table 7: Effect of irrigation schedules, planting geometry and planting methods on number of tillers m⁻² at different growth stages of crop growth

Treatments	30DAS			60DAS			90DAS			Harvest		
	2013	2014	Pooled	2013	2014	Pooled	2013	2014	Pooled	2013	2014	Pooled
Irrigation Schedule (I)												
I ₁ -IW/CPE-0.8	174.78a	161.08a	167.93a	454.55b	482.69b	468.62b	526.14b	513.36b	519.75b	604.09b	585.70b	594.89c
I ₂ -IW/CPE-1.0	177.87a	172.62a	175.25a	456.89b	486.14b	471.52b	528.92b	555.58a	542.25ab	603.72b	626.86a	615.29b
I ₃ -IW/CPE-1.2	179.23a	176.20a	177.71a	459.61b	486.45b	473.03b	534.35b	561.19a	547.77a	603.96b	634.58a	619.27b
I ₄ -Critical stages	183.05a	180.21a	181.63a	488.18a	516.63a	502.41a	556.32a	576.31a	566.32a	624.58a	654.08a	639.33a
S.Em±	2.43	5.54	3.98	8.20	9.83	7.29	6.33	10.37	6.96	5.41	11.86	4.43
Planting geometry (G)												
G ₁ -30 cm x 10 cm	221.64a	209.42a	215.53a	534.39a	571.05a	552.72a	632.71a	651.88a	642.30a	737.98a	758.26a	748.12a
G ₂ -30 cm x 15 cm	171.28b	167.95b	169.61b	463.66b	489.58b	476.62b	529.39b	542.72b	536.06b	594.76b	608.83b	601.79b
G ₃ -30 cm x 20 cm	143.28c	140.22c	141.75c	396.37c	418.30 c	407.34c	447.18c	460.23c	453.71c	494.52c	508.82c	501.67c
S.Em±	3.56	2.55	1.77	6.67	5.32	5.27	8.83	8.06	5.76	10.92	6.70	6.87
Planting methods (P)												
P ₁ -Dry seeds	174.47b	168.80b	171.64b	460.28a	488.61a	474.45a	532.80a	546.94a	539.87a	604.43a	619.76a	612.10a
P ₂ -Sprouted seeds	182.99a	176.26a	179.63a	469.33a	497.35a	483.34a	540.05a	556.29a	548.17a	613.75a	630.84a	622.30a
S.Em±	2.23	1.98	1.64	5.92	5.27	5.09	8.17	8.48	6.93	5.84	8.03	4.92
Interactions (I×G×P)												
I ₁ G ₁ P ₁	208.87a	182.20de	195.54c	511.06a-e	548.83bc	529.95b-d	608.83a-c	579.94c-e	594.39b-d	724.37a	688.82bc	706.60b
I ₁ G ₁ P ₂	224.42a	188.87cd	206.65bc	528.84a-c	564.39a-c	546.61a-c	617.72a-c	588.83b-d	603.27a-c	742.15a	731.04ab	736.59ab
I ₁ G ₂ P ₁	162.95b-e	158.50f-i	160.72d-f	450.33e-h	474.03d-h	462.18e-g	524.39c-f	508.10d-i	516.24d-j	585.13b	565.87d-h	575.50 c
I ₁ G ₂ P ₂	174.80b	165.91e-g	170.35d	460.69c-g	481.43d-g	471.06ef	527.35c-f	516.99d-i	522.17d-i	591.05b	573.28d-g	582.16c
I ₁ G ₃ P ₁	136.61f	132.17j	134.39g	385.40h	412.06i	398.73h	437.60f	438.71i	438.16j	488.69fc	474.25h	481.47d
I ₁ G ₃ P ₂	141.05ef	138.83ij	139.94g	390.95h	415.39hi	403.17h	440.93f	447.60hi	444.27ij	493.14c	480.92gh	487.03d
I ₂ G ₁ P ₁	213.31a	204.42bc	208.87bc	513.28a-e	551.06a-c	532.17b-d	617.72a-c	659.93a-c	638.83ab	722.15a	751.04ab	736.59ab
I ₂ G ₁ P ₂	228.87a	217.76ab	223.31ab	531.06ab	566.61a-c	548.83a-c	628.83ab	677.71ab	653.27ab	731.04a	759.92ab	745.48ab
I ₂ G ₂ P ₁	167.39b-d	162.95e-h	165.17de	453.29d-h	478.47d-g	465.88ef	521.43c-f	536.24d-i	528.84c-h	589.57b	608.83c-f	599.20 c
I ₂ G ₂ P ₂	173.32bc	171.83d-f	172.58d	460.69c-g	484.40d-f	472.55ef	525.87c-f	542.17d-h	534.02c-g	595.50b	616.23c-e	605.87c
I ₂ G ₃ P ₁	139.94ef	137.72ij	138.83g	388.73h	415.39hi	402.06h	436.49f	456.48g-i	446.49ij	489.80 c	509.80gh	499.80d
I ₂ G ₃ P ₂	144.39d-f	141.05h-j	142.72fg	394.29gh	420.94g-i	407.61gh	443.16ef	460.93g-i	452.04h-j	494.25c	515.35gh	504.80d
I ₃ G ₁ P ₁	215.53a	213.31ab	214.42ab	522.17a-d	559.94a-c	541.06a-c	624.38ab	664.38a-c	644.38ab	724.37a	762.15ab	743.26ab
I ₃ G ₁ P ₂	226.64a	222.20ab	224.42ab	533.28ab	568.83a-c	551.06a-c	637.71a	677.71ab	657.71ab	735.48a	773.26ab	754.37ab
I ₃ G ₂ P ₁	167.39b-d	168.87d-g	168.13d	454.77d-h	481.43d-g	468.10ef	522.91c-f	548.09d-g	535.50 c-g	586.61b	616.23c-e	601.42c
I ₃ G ₂ P ₂	174.80b	171.83d-f	173.32d	462.18c-g	488.84de	475.51d-f	530.32c-f	554.02d-g	542.17c-f	599.94b	620.68c-e	610.31c
I ₃ G ₃ P ₁	143.28d-f	138.83ij	141.05g	390.95h	408.73i	399.84h	443.16ef	457.59g-i	450.38h-j	479.81c	514.24gh	497.02d
I ₃ G ₃ P ₂	147.72c-f	142.17h-j	144.94fg	394.29gh	410.95i	402.62h	447.60d-f	465.37f-i	456.48g-j	497.58c	520.90f-h	509.24d
I ₄ G ₁ P ₁	222.20a	215.53ab	218.87ab	562.17a	597.72ab	579.94ab	657.71a	677.71ab	667.71ab	755.48a	793.25a	774.37a
I ₄ G ₁ P ₂	233.31a	231.09a	232.20a	573.28a	611.05a	592.16a	668.82a	688.82a	678.82a	768.81a	806.59a	787.70a
I ₄ G ₂ P ₁	171.83bc	168.87d-g	170.35d	481.43b-f	508.10 cd	494.77c-e	539.21b-e	562.91d-f	551.06c-e	602.90b	629.57cd	616.23c
I ₄ G ₂ P ₂	177.76b	174.80d-f	176.28d	485.88b-e	519.95cd	502.91c-e	543.65b-d	573.28c-e	558.46cd	607.35b	639.94cd	623.64c
I ₄ G ₃ P ₁	144.39d-f	142.17h-j	143.28fg	409.84gh	427.61f-i	418.72f-h	459.82d-f	473.14f-i	466.48fj	504.24c	523.12f-h	513.68d
I ₄ G ₃ P ₂	148.83c-f	148.83g-j	148.83e-g	416.50f-h	435.38e-i	425.94f-h	468.70d-f	482.03e-i	475.37e-j	508.69c	532.01e-h	520.35d
S.Em±	7.72	6.85	5.68	20.52	18.27	17.64	28.32	29.36	24.01	20.23	27.81	17.04

Means followed by the same alphabet do not differ significantly by DMRT (0.05)

Pooled data on interaction effects of scheduling of irrigation, planting geometry and methods of planting indicated that $I_4G_1P_2$ (sowing of sprouted seeds at 30 cm x 10 cm with irrigation at critical stages) recorded significantly higher number of tillers at 30, 60 and 90 DAS and at harvest (232.20, 592.16, 678.82 and 787.70, respectively). However, treatment combinations of $I_4G_1P_1$ (774.37), $I_3G_1P_2$ (754.37), $I_3G_1P_1$ (743.26), $I_2G_1P_2$ (745.48), $I_2G_1P_1$ (736.59), $I_1G_1P_2$ (736.59) and $I_1G_1P_1$ (706.60) were found on par with former treatment combination at harvest on pooled basis. Significantly lower number of tillers was noticed with $I_1G_3P_1$ (sowing of dry seeds at 30 cm x 20 cm with irrigation at IW/CPE of 0.8) at 30, 60 and 90 DAS and at harvest (134.39, 398.73, 438.16 and 481.47, respectively).

4.1.1.3 Leaf area ($\text{dm}^2 \text{m}^{-2}$)

Leaf area of aerobic rice at different growth stages was influenced by scheduling of irrigation, planting geometry and methods of planting (Table 8). The pooled data indicated that the leaf area varied significantly across scheduling of irrigation and planting geometry under evaluation and their interactions at all growth stages except at 30 DAS with scheduling of irrigation.

The variations in leaf area were found to be significant from 60 days onwards with scheduling of irrigations. Significantly higher leaf area at 60 and 90 DAS was recorded with irrigation at critical stages of crop growth (I_4) (218.12 and 304.57 dm^2 , respectively). Significantly lower leaf area was recorded with irrigation at IW/CPE of 0.8 (I_1) at 60 and 90 DAS (203.16 and 280.55 dm^2 , respectively).

Leaf area increased significantly with increase in plant density during both the years as well as in pooled basis. Significantly higher leaf area at 30, 60 and 90 DAS was recorded with planting geometry of 30 cm x 10 cm (G_1) (28.76, 271.65 and 380.42 dm^2 , respectively). Significantly lower leaf area at 30, 60 and 90 DAS was recorded with planting geometry of 30 cm x 20 cm (G_3) (15.60, 156.92 and 217.20 dm^2 , respectively).

Methods of planting did not differed significantly in leaf area at all growth stages.

Table 8: Effect of irrigation schedules, planting geometry and planting methods on leaf area ($\text{dm}^2 \text{m}^{-2}$) at different growth stages of crop growth

Treatments	30 DAS			60 DAS			90 DAS		
	2013	2014	Pooled	2013	2014	Pooled	2013	2014	Pooled
Irrigation Schedule (I)									
I ₁ -IW/CPE-0.8	21.56a	20.99a	21.27a	199.98b	206.34a	203.16b	288.32b	272.78c	280.55c
I ₂ -IW/CPE-1.0	21.80a	21.53a	21.66a	205.00b	212.97a	208.98b	293.43b	294.79b	294.11b
I ₃ -IW/CPE-1.2	21.42a	20.91a	21.16a	202.30b	209.36a	205.83b	289.15b	291.16b	290.15b
I ₄ -Critical stages	22.10a	21.63a	21.86a	213.25a	223.00a	218.12a	301.87a	307.27a	304.57a
S.Em±	0.30	0.21	0.20	2.36	4.59	2.63	2.42	3.28	2.98
Planting geometry (G)									
G ₁ -30 cm x 10 cm	29.16a	28.36a	28.76a	266.70a	276.60a	271.65a	382.13a	378.72a	380.42a
G ₂ -30 cm x 15 cm	20.30b	19.93b	20.11b	194.40b	202.60b	198.50b	279.68b	279.14b	279.41b
G ₃ -30 cm x 20 cm	15.70 c	15.51c	15.60 c	154.29c	159.54c	156.92c	217.76c	216.63c	217.20 c
S.Em±	0.13	0.39	0.22	3.99	3.46	1.86	4.86	3.52	2.92
Planting methods (P)									
P ₁ -Dry seeds	21.57b	21.21b	21.39b	201.48a	209.25a	205.36a	289.75a	288.49a	289.12a
P ₂ -Sprouted seeds	21.86a	21.32a	21.59a	208.79a	216.58a	212.68a	296.64a	294.51a	295.57a
S.Em±	0.09	0.03	0.06	2.52	4.57	2.54	3.91	5.25	2.91
Interactions- (I x G x P)									
I ₁ G ₁ P ₁	28.83a	28.10a	28.46a	255.07b	262.11a	258.59b	368.03a	343.47ab	355.75c
I ₁ G ₁ P ₂	29.30a	28.23a	28.76a	261.81b	271.37a	266.59b	374.43a	352.76a	363.60bc
I ₁ G ₂ P ₁	19.82bc	19.51b	19.66bc	187.36c	192.71bc	190.04c	275.15b	261.82c-g	268.48d
I ₁ G ₂ P ₂	20.29b	19.58b	19.93bc	192.34c	198.91bc	195.62c	278.28b	265.84c-g	272.06d
I ₁ G ₃ P ₁	15.39d	15.24c	15.32d	149.14d	154.02c	151.58d	214.33c	204.15g	209.24e
I ₁ G ₃ P ₂	15.71d	15.29c	15.50d	154.15d	158.89c	156.52d	219.68c	208.63g	214.16e
I ₂ G ₁ P ₁	29.10a	28.46a	28.78a	262.44ab	268.44a	265.44b	375.46a	378.43a	376.95a-c
I ₂ G ₁ P ₂	29.40a	28.56a	28.98a	270.17ab	278.87a	274.52ab	385.06a	384.79a	384.93a-c
I ₂ G ₂ P ₁	20.46b	20.38b	20.42bc	192.29c	200.31bc	196.30 c	276.15b	278.71c-f	277.43d
I ₂ G ₂ P ₂	20.62b	20.55b	20.59bc	195.89c	208.51bc	202.20 c	282.97b	284.06c-e	283.52d
I ₂ G ₃ P ₁	15.51d	15.56c	15.54d	152.01d	158.34c	155.17d	217.65c	219.11fg	218.38e
I ₂ G ₃ P ₂	15.69d	15.64c	15.67d	157.19d	163.32bc	160.25d	223.28c	223.63e-g	223.45e
I ₃ G ₁ P ₁	28.80a	28.06a	28.43a	255.77b	265.07a	260.42b	379.43a	381.70a	380.56a-c
I ₃ G ₁ P ₂	29.23a	28.23a	28.73a	266.81ab	277.44a	272.12ab	386.83a	390.09a	388.46a-c
I ₃ G ₂ P ₁	19.66bc	19.18b	19.42c	187.85c	195.65bc	191.75c	271.62b	274.51c-f	273.06d
I ₃ G ₂ P ₂	19.82bc	19.29b	19.55bc	196.69c	203.36bc	200.02c	276.71b	280.08c-f	278.39d
I ₃ G ₃ P ₁	15.4d	15.29c	15.36d	149.17d	154.97c	152.07d	206.28c	207.63g	206.96e
I ₃ G ₃ P ₂	15.5d	15.39c	15.48d	157.50d	159.67bc	158.59d	214.01c	212.95g	213.48e
I ₄ G ₁ P ₁	29.06a	28.53a	28.80a	273.47ab	290.10a	281.79ab	386.76a	395.06a	390.91ab
I ₄ G ₁ P ₂	29.53a	28.70a	29.11a	288.04a	299.40a	293.72a	401.03a	403.43a	402.23a
I ₄ G ₂ P ₁	20.71b	20.40b	20.55bc	198.96c	207.89bc	203.42c	285.42b	291.2b-d	288.29d
I ₄ G ₂ P ₂	21.00b	20.53b	20.76b	203.82c	213.42b	208.62c	291.15b	296.97bc	294.06d
I ₄ G ₃ P ₁	16.04d	15.78c	15.91d	154.17d	161.34bc	157.75d	220.68c	226.14e-g	223.41e
I ₄ G ₃ P ₂	16.23cd	15.86c	16.04d	161.02d	165.82bc	163.42d	226.21c	230.8d-g	228.52e
S.Em±	1.16	0.89	0.40	7.97	15.81	7.40	13.55	18.20	10.08

Means followed by the same alphabet do not differ significantly by DMRT (0.05)

Interaction effects of scheduling of irrigation, planting geometry and methods of planting indicated that $I_4G_1P_2$ (sowing of sprouted seeds at 30 cm x 20 cm with irrigation at critical stages) recorded significantly higher leaf area at 30, 60 and 90 DAS (29.11, 293.72 and 402.23 dm², respectively). Whereas, treatment combinations of $I_4G_1P_1$ (390.91 dm²), $I_3G_1P_2$ (388.46 dm²), $I_3G_1P_1$ (380.56 dm²), $I_2G_1P_2$ (384.93 dm²) and $I_2G_1P_1$ (376.95 dm²) were found on par with $I_4G_3P_2$ at 90 DAS. Significantly lower leaf area was noticed with $I_1G_3P_1$ (sowing of dry seeds at 30 cm x 20 cm with irrigation at IW/CPE of 0.8) at 30, 60 and 90 DAS (15.32, 151.58 and 209.24 dm², respectively).

4.1.1.4 Leaf area index (LAI)

Leaf area index of aerobic rice recorded at different growth stages as influenced by scheduling of irrigation, planting geometry and methods of planting is furnished in Table 9. The pooled data indicated that the leaf area index varied significantly with scheduling of irrigation and planting geometry under evaluation and their interactions at all growth stages except at 30 DAS with scheduling of irrigation and method of planting at all stages.

The variations in leaf area index were found to be significant from 60 days onwards with scheduling of irrigations. Significantly higher leaf area index at 60 and 90 DAS was recorded with irrigation at critical stages of crop growth (I_4) (2.182 and 3.046, respectively). Significantly lower leaf area index was recorded with irrigation at IW/CPE of 0.8 (I_1) at 60 and 90 DAS (2.032 and 2.806, respectively).

Leaf area index increased significantly with increase in plant density. Significantly higher leaf area index at 30, 60 and 90 DAS was recorded with planting geometry of 30 cm x 10 cm (G_1) (0.288, 2.717 and 3.805, respectively). Significantly lower leaf index at 30, 60 and 90 DAS was recorded with planting geometry of 30 cm x 20 cm (G_3) (0.156, 1.570 and 2.173, respectively) on pooled basis.

Leaf area index did not differ significantly due to different methods of planting at all growth stages.

Interaction effects of scheduling of irrigation, planting geometry and methods of planting indicated that $I_4G_1P_2$ (sowing of sprouted seeds at 30 cm x 10 cm with irrigation at

Table 9: Effect of irrigation schedules, planting geometry and planting methods on leaf area index at different growth stages of crop growth

Treatments	30 DAS			60 DAS			90 DAS		
	2013	2014	Pooled	2013	2014	Pooled	2013	2014	Pooled
Irrigation Schedule (I)									
I ₁ -IW/CPE-0.8	0.216a	0.210a	0.213a	2.000b	2.064a	2.032b	2.892b	2.728c	2.806c
I ₂ -IW/CPE-1.0	0.218a	0.215a	0.217a	2.050b	2.130a	2.090b	2.884b	2.912b	2.942b
I ₃ -IW/CPE-1.2	0.214a	0.209a	0.212a	2.023b	2.094a	2.059b	2.935b	2.948b	2.902b
I ₄ -Critical stages	0.221a	0.216a	0.219a	2.133a	2.230a	2.182a	3.019a	3.073a	3.046a
S.Em±	0.003	0.002	0.002	0.023	0.047	0.025	0.023	0.033	0.027
Planting geometry (G)									
G ₁ -30 cm x 10 cm	0.292a	0.284a	0.288a	2.667a	2.766a	2.717a	3.822a	3.788a	3.805a
G ₂ -30 cm x 15 cm	0.203b	0.199b	0.201b	1.944b	2.026b	1.985b	2.797b	2.792b	2.794b
G ₃ -30 cm x 20 cm	0.157c	0.155c	0.156c	1.544c	1.596c	1.570 c	2.179c	2.167c	2.173c
S.Em±	0.001	0.003	0.002	0.04	0.035	0.02	0.05	0.035	0.028
Planting methods (P)									
P ₁ -Dry seeds	0.216b	0.212a	0.214a	2.015a	2.093a	2.054a	2.898a	2.885a	2.892a
P ₂ -Sprouted seeds	0.219a	0.213a	0.216a	2.088a	2.166a	2.127a	2.967a	2.946a	2.956a
S.Em±	0.001	0.003	0.001	0.02	0.05	0.03	0.04	0.05	0.03
Interactions- (I x G x P)									
I ₁ G ₁ P ₁	0.288a	0.281a	0.285a	2.551b	2.621a	2.586b	3.795a	3.435a-c	3.558c
I ₁ G ₁ P ₂	0.293a	0.282a	0.288a	2.618ab	2.714a	2.666b	3.869a	3.528ab	3.636bc
I ₁ G ₂ P ₁	0.198bc	0.195b	0.197bc	1.874c	1.927bc	1.901c	2.716b	2.618d-h	2.685d
I ₁ G ₂ P ₂	0.203b	0.196b	0.199bc	1.924c	1.989bc	1.956c	2.767b	2.659d-h	2.721d
I ₁ G ₃ P ₁	0.154d	0.153c	0.153d	1.492d	1.541c	1.516d	2.064c	2.042h	2.093e
I ₁ G ₃ P ₂	0.157d	0.153c	0.155d	1.542d	1.590bc	1.566d	2.141c	2.087h	2.142e
I ₂ G ₁ P ₁	0.291a	0.285a	0.288a	2.625ab	2.685a	2.655b	3.681a	3.817a	3.770a-c
I ₂ G ₁ P ₂	0.294a	0.286a	0.290a	2.702ab	2.789a	2.746ab	3.745a	3.901a	3.850a-c
I ₂ G ₂ P ₁	0.205b	0.204b	0.204bc	1.923c	2.003bc	1.963c	2.752b	2.745d-g	2.775d
I ₂ G ₂ P ₂	0.206b	0.206b	0.206bc	1.959c	2.085bc	2.022c	2.783b	2.801d-g	2.835d
I ₂ G ₃ P ₁	0.155d	0.156c	0.155d	1.521d	1.584bc	1.552d	2.144c	2.077h	2.185e
I ₂ G ₃ P ₂	0.157d	0.157c	0.157d	1.573d	1.634bc	1.603d	2.198c	2.130h	2.235e
I ₃ G ₁ P ₁	0.288a	0.281a	0.284a	2.558b	2.651a	2.605b	3.755a	3.785a	3.806a-c
I ₃ G ₁ P ₂	0.292a	0.282a	0.287a	2.668ab	2.775a	2.722ab	3.851a	3.848a	3.885a-c
I ₃ G ₂ P ₁	0.197bc	0.192b	0.194c	1.879c	1.957bc	1.918c	2.762b	2.787d-g	2.731d
I ₃ G ₂ P ₂	0.198bc	0.193b	0.196bc	1.967c	2.034bc	2.000 c	2.830b	2.841d-f	2.784d
I ₃ G ₃ P ₁	0.154d	0.153c	0.154d	1.492d	1.550 c	1.521d	2.177c	2.192gh	2.070e
I ₃ G ₃ P ₂	0.156d	0.154c	0.155d	1.576d	1.597bc	1.587d	2.234c	2.237f-h	2.136e
I ₄ G ₁ P ₁	0.291a	0.285a	0.288a	2.735ab	2.901a	2.818ab	3.868a	3.951a	3.910ab
I ₄ G ₁ P ₂	0.295a	0.287a	0.291a	2.881a	2.994a	2.938a	4.011a	4.035a	4.023a
I ₄ G ₂ P ₁	0.207b	0.204b	0.206bc	1.990 c	2.079bc	2.034c	2.854b	2.912c-e	2.883d
I ₄ G ₂ P ₂	0.210b	0.205b	0.208b	2.038c	2.134b	2.086c	2.912b	2.970b-d	2.941d
I ₄ G ₃ P ₁	0.161cd	0.158c	0.159d	1.542d	1.614bc	1.578d	2.208c	2.262f-h	2.235e
I ₄ G ₃ P ₂	0.162cd	0.159c	0.161d	1.611d	1.659bc	1.635d	2.263c	2.309e-h	2.286e
S.Em±	0.011	0.008	0.004	0.081	0.163	0.081	0.141	0.182	0.1

Means followed by the same alphabet do not differ significantly by DMRT (0.05)

critical stages) recorded significantly higher leaf area index at 30, 60 and 90 DAS (0.291, 2.938 and 4.023, respectively). Whereas, treatment combinations of $I_4G_1P_1$ (3.910), $I_3G_1P_2$ (3.885), $I_3G_1P_1$ (3.806), $I_2G_1P_2$ (3.850) and $I_2G_1P_1$ (3.770) were next in the order at 90 DAS. Significantly lower leaf area index was noticed with $I_1G_3P_1$ (sowing of dry seeds at 30 cm x 20 cm with irrigation at IW/CPE of 0.8) at 30 and 60 DAS (0.153 and 1.516, respectively) and with $I_3G_3P_1$ at 90 DAS (2.070).

4.1.1.5 Soil Plant Analysis Development (SPAD) values

The data on SPAD value as influenced by scheduling of irrigation, planting geometry and methods of planting at 30, 60 and 90 DAS is presented in Table 10.

Scheduling of irrigation did not differ significantly for SPAD readings at 30 and 60 DAS. Irrigation at critical stages of crop growth (I_4) recorded significantly higher SPAD value at 90 DAS (33.96). Significantly lower SPAD values (32.12) were observed in irrigation at IW/CPE of 0.8 (I_1).

Significantly higher SPAD value was recorded with planting geometry of 30 cm x 20 cm (G_3) at 30, 60 and 90 DAS (38.88, 42.74 and 35.90, respectively). Lower SPAD value was recorded with planting geometry of 30 cm x 10 cm (G_1) at 30, 60 and 90 DAS (33.00, 36.76 and 29.54, respectively).

Methods of planting did not differ significantly for SPAD readings at 30, 60 and 90 DAS.

Among the interactions, $I_4G_3P_2$ (sowing of sprouted seeds at planting geometry of 30 cm x 20 cm with scheduling of irrigation at critical stages) recorded significantly higher SPAD value at 30, 60 and 90 DAS (39.12, 43.45 and 37.23, respectively) but was at par with other interactions $I_4G_3P_1$ (37.03), $I_4G_2P_2$ (34.05), $I_4G_2P_1$ (33.85), $I_3G_3P_2$ (35.98), $I_3G_3P_1$ (35.73), $I_3G_2P_2$ (32.95), $I_3G_2P_1$ (32.70), $I_2G_3P_2$ (35.30), $I_2G_3P_1$ (35.08), $I_2G_2P_2$ (32.32), $I_1G_3P_2$ (35.47) and $I_1G_3P_1$ (35.37). Significantly lower SPAD value at 30 DAS was recorded with $I_2G_1P_1$ (32.70) and with $I_1G_1P_1$ at 60 and 90 DAS (35.70 and 28.85 respectively).

Table 10: Effect of irrigation schedules, planting geometry and planting methods on SPAD readings at different growth stages of crop growth

Treatments	30 DAS			60 DAS			90 DAS		
	2013	2014	Pooled	2013	2014	Pooled	2013	2014	Pooled
Irrigation Schedule (I)									
I ₁ -IW/CPE-0.8	36.38a	35.41a	35.89a	39.37a	38.39a	38.88a	32.53b	31.71b	32.12b
I ₂ -IW/CPE-1.0	36.43a	35.32a	35.87a	40.32a	39.33a	39.82a	32.73ab	31.69b	32.21b
I ₃ -IW/CPE-1.2	36.58a	35.46a	36.02a	40.55a	39.50a	40.03a	32.97ab	32.29b	32.63ab
I ₄ -Critical stages	36.71a	35.71a	36.21a	40.75a	39.87a	40.31a	33.32a	34.59a	33.96a
S.Em±	0.58	0.86	0.6	1.03	0.68	0.72	0.22	0.28	0.41
Planting geometry (G)									
G ₁ -30 cm x 10 cm	33.48c	32.53c	33.00 c	37.15c	36.36c	36.76c	29.78b	29.30 c	29.54c
G ₂ -30 cm x 15 cm	36.69b	35.53b	36.11b	40.30b	39.27b	39.78b	32.85ab	32.64b	32.75b
G ₃ -30 cm x 20 cm	39.40a	38.36a	38.88a	43.29a	42.18a	42.74a	36.03a	35.77a	35.90a
S.Em±	0.60	0.85	0.59	0.79	0.82	0.65	1.17	0.47	0.5
Planting methods (P)									
P ₁ -Dry seeds	36.43a	35.36a	35.89a	40.16a	39.17a	39.66a	32.81a	32.45a	32.63a
P ₂ -Sprouted seeds	36.62a	35.58a	36.10a	40.34a	39.38a	39.86a	32.97a	32.69a	32.83a
S.Em±	0.58	0.44	0.3	0.57	0.6	0.45	0.75	0.52	0.43
Interactions- (I x G x P)									
I ₁ G ₁ P ₁	33.23a	32.33c	32.78c	36.13b	35.27c	35.70e	29.37a	28.33f	28.85f
I ₁ G ₁ P ₂	33.47a	32.53c	33.00bc	36.47b	35.47bc	35.97e	29.53a	28.53ef	29.03ef
I ₁ G ₂ P ₁	36.43a	35.33a-c	35.88a-c	39.37ab	38.27a-c	38.82a-e	32.43a	31.37c-f	31.90 c-f
I ₁ G ₂ P ₂	36.63a	35.53a-c	36.08a-c	39.53ab	38.47a-c	39.00a-e	32.60a	31.63b-f	32.12b-f
I ₁ G ₃ P ₁	39.17a	38.27a	38.72a	42.23ab	41.33a-c	41.78a-d	35.53a	35.20a-c	35.37a-d
I ₁ G ₃ P ₂	39.33a	38.47a	38.90a	42.47ab	41.53a-c	42.00a-d	35.73a	35.20a-c	35.47a-d
I ₂ G ₁ P ₁	33.17a	32.23c	32.70 c	37.13ab	36.57a-c	36.85de	29.57a	28.67d-f	29.12ef
I ₂ G ₁ P ₂	33.37a	32.43c	32.90bc	37.27ab	36.73a-c	37.00de	29.73a	28.93d-f	29.33ef
I ₂ G ₂ P ₁	36.53a	35.23a-c	35.88a-c	40.23ab	39.37a-c	39.80a-e	32.63a	31.57b-f	32.10b-f
I ₂ G ₂ P ₂	36.77a	35.47a-c	36.12a-c	40.37ab	39.57a-c	39.97a-e	32.77a	31.87a-f	32.32a-f
I ₂ G ₃ P ₁	39.23a	38.17ab	38.70a	43.37a	41.77a-c	42.57a-c	35.73a	34.43a-f	35.08a-d
I ₂ G ₃ P ₂	39.50a	38.37a	38.93a	43.53a	41.97a-c	42.75ab	35.93a	34.67a-e	35.30a-d
I ₃ G ₁ P ₁	33.43a	32.37c	32.90bc	37.40ab	36.47a-c	36.93de	29.67a	28.57ef	29.12ef
I ₃ G ₁ P ₂	33.67a	32.57c	33.12bc	37.47ab	36.67a-c	37.07de	29.80a	28.80d-f	29.30ef
I ₃ G ₂ P ₁	36.67a	35.43a-c	36.05a-c	40.50ab	39.37a-c	39.93a-e	32.87a	32.53a-f	32.70a-f
I ₃ G ₂ P ₂	36.83a	35.67a-c	36.25a-c	40.67ab	39.53a-c	40.10a-e	33.07a	32.83a-f	32.95a-f
I ₃ G ₃ P ₁	39.37a	38.23ab	38.80a	43.53a	42.40a-c	42.97a	36.13a	35.33a-c	35.73a-d
I ₃ G ₃ P ₂	39.53a	38.47a	39.00a	43.73a	42.57ab	43.15a	36.30a	35.67a-c	35.98a-c
I ₄ G ₁ P ₁	33.67a	32.77c	33.22bc	37.57ab	36.77a-c	37.17c-e	30.23a	31.13c-f	30.68d-f
I ₄ G ₁ P ₂	33.83a	33.00bc	33.42bc	37.77ab	36.97a-c	37.37b-e	30.37a	31.43c-f	30.90 c-f
I ₄ G ₂ P ₁	36.73a	35.67a-c	36.20a-c	40.73ab	39.67a-c	40.20a-e	33.17a	34.53a-e	33.85a-f
I ₄ G ₂ P ₂	36.90a	35.90a-c	36.40ab	40.97ab	39.93a-c	40.45a-e	33.30a	34.80a-d	34.05a-e
I ₄ G ₃ P ₁	39.47a	38.33a	38.90a	43.67a	42.80a	43.23a	36.37a	37.70ab	37.03ab
I ₄ G ₃ P ₂	39.63a	38.60a	39.12a	43.80a	43.10a	43.45a	36.50a	37.97a	37.23a
S.Em±	2.0	1.53	1.04	1.97	2.07	1.57	2.61	1.79	1.48

Means followed by the same alphabet do not differ significantly by DMRT (0.05)

4.1.1.6 Total dry matter (g m^{-2})

The total dry matter of aerobic rice was influenced by scheduling of irrigation, planting geometry and methods of planting recorded at different growth stages (Table 11). The total dry matter differed significantly due to scheduling of irrigation at all growth stages except at 30 DAS. Irrigation at critical stages recorded significantly higher total dry matter was observed at 60 and 90 DAS and at harvest with (422.38, 599.03 and 1182.08 g respectively). However, significantly lower total dry matter was recorded with irrigation at IW/CPE of 0.8 (I_3) at 60 and 90 DAS and at harvest (393.36, 551.32 and 940.60 g, respectively).

Total dry matter per hill increased significantly with increase in plant density. Significantly higher total dry matter 30, 60 and 90 DAS and at harvest was recorded with planting geometry of 30 cm x 10 cm (G_1) (214.91, 508.00, 692.43 and 1231.20g, respectively). Significantly lower total dry matter was recorded with planting geometry of 30 cm x 20 cm (G_1) at all growth stages (144.35, 322.27, 478.84 and 844.87 g, respectively).

Significantly higher total dry matter (179.06 g) was recorded with sowing of sprouted seeds (P_2) than with sowing of dry seeds (P_1) (173.76 g) at 30 DAS. There was no significant difference in total dry matter between the methods of planting from 60 DAS onwards.

Interaction effects of scheduling of irrigation, planting geometry and methods of planting indicated that $I_4G_1P_2$ (sowing of sprouted seeds at 30 cm x 10 cm with irrigation at critical stages) recorded significantly higher total dry matter at 30, 60 and 90 DAS and at harvest (225.53, 536.61, 722.15 and 1390.42g, respectively). Treatment combinations of $I_4G_1P_1$ (1350.98g), $I_3G_1P_2$ (1252.10g), $I_3G_1P_1$ (1217.66g), $I_2G_1P_2$ (1223.21g) and $I_3G_1P_1$ (1187.10g) were found on par with former treatment combination at harvest. Significantly lower total dry matter per hill was noticed with $I_1G_3P_1$ (sowing of dry seeds at 30 cm x 20 cm with irrigation at IW/CPE of 0.8) at 30, 60 and 90 DAS and at harvest (138.56, 312.93, 455.10 and 730.82g, respectively).

Table 11: Effect of irrigation schedules, planting geometry and planting methods on dry matter production (g m⁻²) at different growth stages of crop growth

Treatments	30 DAS			60 DAS			90 DAS			Harvest		
	2013	2014	Pooled	2013	2014	Pooled	2013	2014	Pooled	2013	2014	Pooled
Irrigation Schedule (I)												
I ₁ -IW/CPE-0.8	178.12a	159.60a	168.86a	380.21b	406.50a	393.36b	578.29a	524.35b	551.32b	1012.94b	868.27c	940.60 c
I ₂ -IW/CPE-1.0	180.49a	167.28a	173.89a	384.25b	411.90a	398.08b	578.47a	583.20a	580.83a	1046.45b	996.18b	1021.31b
I ₃ -IW/CPE-1.2	183.49a	171.88a	177.68a	391.35b	416.96a	404.16b	581.65a	608.22a	594.94a	1076.69b	1026.27ab	1051.48b
I ₄ -Critical stages	190.34a	180.12a	185.23a	406.59a	438.16a	422.38a	589.43a	608.62a	599.03a	1270.32a	1093.84a	1182.08a
S.Em±	4.30	5.96	4.74	4.39	9.18	4.67	11.98	7.60	8.49	18.48	27.22	19.37
Planting geometry (G)												
G ₁ -30 cm x 10 cm	222.48a	207.34a	214.91a	488.56a	527.45a	508.00a	694.79a	690.07a	692.43a	1290.01a	1172.38a	1231.20a
G ₂ -30 cm x 15 cm	177.95b	162.02b	169.98b	371.07b	395.33b	383.20b	573.65b	573.00b	573.32b	1125.91b	1015.18b	1070.54b
G ₃ -30 cm x 20 cm	148.90 c	139.81c	144.35c	312.17c	332.37c	322.27c	477.45c	480.22c	478.84c	888.88c	800.86c	844.87c
S.Em±	2.55	2.87	1.11	5.93	7.39	5.40	14.66	14.77	9.29	22.31	23.04	18.50
Planting methods (P)												
P ₁ -Dry seeds	181.05a	166.48a	173.76a	388.77a	415.00a	401.89a	579.55a	577.81a	578.68a	1086.70a	978.80a	1032.75a
P ₂ -Sprouted seeds	185.17b	172.96b	179.06b	392.43a	421.76a	407.10a	584.37a	584.38a	584.37a	1116.50a	1013.47a	1064.99a
S.Em±	1.40	2.11	1.96	6.75	7.92	4.97	8.82	9.29	6.63	21.73	21.31	18.38
Interactions (I×G×P)												
I ₁ G ₁ P ₁	212.20a	198.87ab	205.54a	474.40a	504.39a	489.40a	687.71a	612.16b-e	649.94a-c	1178.77cd	1015.45b-h	1097.11b-e
I ₁ G ₁ P ₂	217.76a	207.76a	212.76a	478.84a	512.17a	495.51a	698.82a	617.72b-d	658.27ab	1212.10b-d	1049.90a-g	1131.00b-e
I ₁ G ₂ P ₁	170.35b-f	139.25gh	154.80d-f	358.48b-d	382.92bc	370.70b-f	562.91b-d	516.24d-i	539.58de	1025.08d-h	871.02e-i	948.05e-i
I ₁ G ₂ P ₂	174.06b-e	145.17f-h	159.61c-f	361.45b-d	388.11bc	374.78b-e	569.57b-d	523.65d-i	546.61de	1051.75c-g	902.13d-i	976.94d-h
I ₁ G ₃ P ₁	146.05f	131.06h	138.56f	302.10d	323.76c	312.93f	474.25d	435.94i	455.10f	791.91h	669.73i	730.82j
I ₁ G ₃ P ₂	148.27f	135.50h	141.89f	305.99d	327.65bc	316.82ef	476.48d	440.38i	458.43f	818.01gh	701.39i	759.70j
I ₂ G ₁ P ₁	215.53a	194.43a-c	204.98a	478.84a	514.39a	496.62a	684.38a	682.15a-c	683.27a	1216.55b-d	1157.66a-c	1187.10a-d
I ₂ G ₁ P ₂	218.87a	204.42a	211.65a	484.40a	522.17a	503.28a	691.04a	689.93ab	690.49a	1249.88a-d	1196.55ab	1223.21a-c
I ₂ G ₂ P ₁	174.80b-d	160.72d-g	167.76b-e	361.45b-d	385.89bc	373.67b-e	567.35b-d	572.54d-h	569.94d	1058.41c-g	1002.12b-h	1030.27c-g
I ₂ G ₂ P ₂	179.98bc	168.13d-f	174.06b-d	364.41b-d	390.33bc	377.37b-d	571.79b-d	579.94c-h	575.87cd	1082.85c-f	1032.49b-g	1057.67b-f
I ₂ G ₃ P ₁	145.50f	135.50h	140.50f	307.10d	327.65bc	317.37ef	477.03d	485.36hi	481.20ef	822.45gh	778.58hi	800.51h-j
I ₂ G ₃ P ₂	148.27f	140.50gh	144.39f	309.32cd	330.98bc	320.15d-f	479.25d	489.25g-i	484.25ef	848.55f-h	809.68g-i	829.11g-j
I ₃ G ₁ P ₁	222.20a	207.76a	214.98a	484.40a	524.39a	504.39a	687.71a	725.48a	706.60a	1246.54a-d	1188.77ab	1217.66a-c
I ₃ G ₁ P ₂	226.64a	218.87a	222.76a	488.84a	532.17a	510.50a	692.15a	735.48a	713.82a	1276.54a-d	1227.66ab	1252.10ab
I ₃ G ₂ P ₁	175.54b-d	160.72d-g	168.13b-e	369.59b-d	385.15bc	377.37b-d	572.54b-d	589.57b-h	581.05cd	1086.56c-f	1028.79b-h	1057.67b-f
I ₃ G ₂ P ₂	179.98bc	167.39d-f	173.69b-d	373.30b-d	392.55bc	382.92bc	576.24b-d	596.98b-g	586.61b-d	1116.18c-e	1063.60a-f	1089.89b-e
I ₃ G ₃ P ₁	146.61f	136.06h	141.33f	314.32b-d	330.42bc	322.37d-f	479.25d	497.58f-i	488.42ef	855.77f-h	810.79g-i	833.28g-j
I ₃ G ₃ P ₂	149.94ef	140.50gh	145.22f	317.65b-d	337.09bc	327.37c-f	482.03cd	504.24e-i	493.14ef	878.54e-h	838.00f-i	858.27f-j
I ₄ G ₁ P ₁	229.98a	212.20a	221.09a	507.73a	547.72a	527.73a	704.37a	725.48a	714.93a	1450.97ab	1250.99ab	1350.98a
I ₄ G ₁ P ₂	236.64a	214.42a	225.53a	511.06a	562.17a	536.61a	712.15a	732.15a	722.15a	1488.74a	1292.09a	1390.42a
I ₄ G ₂ P ₁	182.20b	174.06c-e	178.13bc	388.11bc	416.25bc	402.18b	582.90bc	599.20b-g	591.05b-d	1276.17a-d	1091.00a-e	1183.59a-d
I ₄ G ₂ P ₂	186.65b	180.72b-d	183.69b	391.81b	421.44b	406.63b	585.87b	605.87b-f	595.87b-d	1310.24a-c	1130.26a-d	1220.25a-c
I ₄ G ₃ P ₁	151.61d-f	147.16f-h	149.38ef	318.76b-d	337.09bc	327.92c-f	474.25d	492.03g-i	483.14ef	1031.25d-h	880.76d-i	956.01e-i
I ₄ G ₃ P ₂	154.94c-f	152.16e-h	153.55d-f	322.09b-d	344.31bc	333.20 c-f	477.03d	497.02f-i	487.03ef	1064.57c-g	917.97c-i	991.27d-h
S.Em±	7.56	7.31	6.78	23.39	27.44	17.23	30.55	32.20	22.96	75.29	73.81	63.67

Means followed by the same alphabet do not differ significantly by DMRT (0.05)

4.1.2 Weed parameters

4.1.2.1 Weed Flora

The weed flora of the experimental field consisted of four species of grasses, three species of sedges and thirteen species of broad leaved weeds (Table 12).

Among the grasses, *Echinochloa crus-galli* was the predominant species followed by *Cynodon dactylon*, *Dinebra retroflexa* and *Elusine indica*. Among the sedges, the dominant species was *Cyperus rotundus*. Among the BLWs, *Cyanotis cucullata*, *Commelina benghalensis* and *Euphorbia hirta* were predominant during both the years of study.

4.1.2.2 Weed density (number m⁻²)

The data on weed density as influenced by scheduling of irrigation, planting geometry and methods of planting and their interaction effects differed significantly is presented in Table 13.

Weed density did not differ significantly due to scheduling of irrigation at 20 and 40 DAS during both the years. Significantly higher weed density (58.5) at harvest was recorded with irrigation at IW/CPE of 0.8 (I₁). However, irrigation at critical stages (I₄) resulted in lower weed density (49.8).

Sowing at 30 cm x 20 cm (G₃) recorded in significantly higher weed density at 20 and 40 DAS and at harvest (72.4, 68.8 and 59.8 respectively). However, significantly lower weed density at 20 and 40 DAS and at harvest (59.5, 54.4 and 48.3 respectively) has been observed when seeds were sown at 30 cm x 10 cm (G₁).

Weed density did not differ significantly due to different planting methods.

Interaction effects of scheduling of irrigation, planting geometry and methods of planting influenced the weed density significantly. Treatment combination I₄G₃P₁ (sowing of dry seeds at 30 cm x 20 cm with irrigation at critical stages) recorded significantly higher weed density at 20 DAS (74.4). Whereas, I₃G₃P₁ (sowing of dry seed at 30 cm x 20 cm with irrigation at IW/CPE of 1.2) recorded significantly higher weed density at 40 DAS (71.3) and I₃G₃P₁ (66.4) at harvest. Significantly lower weed

Table 12: Weed flora of the experimental field

S No	Botanical name	Common name	Family
I	Grasses		
1	<i>Echinochloa crus-galli</i> (L.) Beauv.	Barnyard grass	Poaceae
2	<i>Cynodon dactylon</i> (L.) Pers.	Bermuda grass	Poaceae
3	<i>Dinebra retroflexa</i> (Vahl) Panz	Viper grass	Poaceae
4	<i>Eleusine indica</i>	Goose grass	Poaceae
II	Sedges		
1	<i>Cyperus rotundus</i> L.	Purple nut sedge	Cyperaceae
III	Broad leaved weeds		
1	<i>Cyanotis cucullata</i> (Roth) Kunth	Cyanotis	Commelinaceae
2	<i>Commelina benghalensis</i>	Benghal dayflower, tropical spiderwort	Commelinaceae
3	<i>Euphorbia hirta</i> L.	Asthma herb	Euphorbiaceae
4	<i>Mollugo pentaphylla</i>	Daisy-leaved chickweed	Molluginaceae
5	<i>Corchorus trilocalaris</i>	East Indian Mallow	Sparmaniaceae / Malvaceae
6	<i>Physalis minima</i>	Cape Gooseberry, Goldenberry, Husk Cherry,	Solanaceae,
7	<i>Amaranthus viridis</i>	Green Amaranth, pigweed, Prince of Wales feather	Amaranthaceae .
8	<i>Cleome viscosa</i> L.	Wild mustard	Capparidaceae
9	<i>Ageratum conyzoides</i> L.	Goat weed	Asteraceae
10	<i>Parthenium hysterophorus</i>	Carrot Grass, Congress grass	Asteraceae

Table 13: Effect of irrigation schedules, planting geometry and planting methods on weed density (number m⁻²)

Treatments	20 DAS			40 DAS			Harvest		
	2013	2014	Pooled	2013	2014	Pooled	2013	2014	Pooled
Irrigation Schedule (I)									
I ₁ -IW/CPE-0.8	7.92 (62.5) a	8.35 (69.3) a	8.14 (65.9) a	8.52 (72.4) a	6.94 (47.9) a	7.78 (60.1) a	7.71 (59.1) a	7.63 (57.9) a	7.67 (58.5) a
I ₂ -IW/CPE-1.0	7.91 (62.2) a	8.33 (69) a	8.12 (65.6) a	8.62 (74) a	7.11 (50.3) a	7.9 (62.1) a	7.2 (51.5) b	7.56 (56.7) a	7.38 (54.1) b
I ₃ -IW/CPE-1.2	7.93 (62.7) a	8.32 (68.9) a	8.13 (65.8) a	8.57 (73.3) a	6.98 (48.6) a	7.82 (60.9) a	7.16 (51) b	7.53 (56.4) a	7.36 (53.7) b
I ₄ -Critical stages	8.13 (65.9) a	8.24 (67.6) a	8.19 (66.7) a	8.64 (74.4) a	7.06 (49.5) a	7.89 (61.9) a	7.1 (50.1) b	7.06 (49.5) b	7.08 (49.8) c
S.Em±	0.07	0.05	0.04	0.07	0.09	0.05	0.06	0.04	0.03
Planting geometry (G)									
G ₁ -30 cm x 10 cm	7.53 (56.2) c	7.95 (62.8) b	7.74 (59.5) c	8.12 (65.4) c	6.61 (43.3) c	7.4 (54.4) c	6.89 (47.1) c	7.06 (49.5) c	6.98 (48.3) c
G ₂ -30 cm x 15 cm	7.92 (62.4) b	8.39 (69.9) a	8.16 (66.2) b	8.57 (73.1) b	6.97 (48.2) b	7.82 (60.6) b	7.3 (52.9) b	7.46 (55.3) b	7.38 (54.1) b
G ₃ -30 cm x 20 cm	8.47 (71.3) a	8.59 (73.4) a	8.53 (72.4) a	9.08 (82) a	7.49 (55.7) a	8.32 (68.8) a	7.69 (58.8) a	7.81 (60.7) a	7.75 (59.8) a
S.Em±	0.04	0.06	0.04	0.05	0.05	0.02	0.07	0.07	0.04
Planting methods (P)									
P ₁ -Dry seeds	8.05 (64.5) a	8.37 (69.7) a	8.21 (67.1) a	8.64 (74.4) a	7.1 (50.1) a	7.91 (62.3) a	7.36 (54) a	7.51 (56.1) a	7.44 (55) a
P ₂ -Sprouted seeds	7.9 (62.1) a	8.25 (67.7) a	8.08 (64.9) a	8.54 (72.6) a	6.95 (48) a	7.79 (60.3) a	7.22 (51.9) a	7.38 (54.2) a	7.3 (53.1) a
S.Em±	0.06	0.05	0.05	0.05	0.07	0.05	0.06	0.05	0.05
Interactions- (I x G x P)									
I ₁ G ₁ P ₁	7.51 (56) hi	8.05 (64.4) b-e	7.79 (60.2) cd	8.11 (65.3) de	6.66 (44) d-f	7.42 (54.7) e-g	7.33 (53.3) b-g	7.24 (52) c-i	7.29 (52.7) c-h
I ₁ G ₁ P ₂	7.45 (55.1) hi	7.94 (62.7) c-e	7.7 (58.9) cd	7.97 (63.1) e	6.46 (41.3) f	7.26 (52.2) fg	7.18 (51.1) c-g	7.12 (50.2) e-j	7.15 (50.7) d-i
I ₁ G ₂ P ₁	7.97 (63.1) a-i	8.48 (71.6) a-d	8.23 (67.3) a-d	8.59 (73.3) a-e	6.99 (48.4) a-f	7.84 (60.9) b-f	7.77 (60) a-c	7.74 (59.6) a-d	7.76 (59.8) a-c
I ₁ G ₂ P ₂	7.8 (60.4) c-i	8.35 (69.3) a-e	8.08 (64.9) a-d	8.51 (72) b-e	6.86 (46.7) b-f	7.73 (59.3) c-g	7.69 (58.7) a-c	7.6 (57.3) a-g	7.65 (58) b-d
I ₁ G ₃ P ₁	8.48 (71.6) a-d	8.69 (75.1) a	8.59 (73.3) ab	9.04 (81.3) ab	7.39 (54.2) a-d	8.26 (67.8) a-c	8.24 (67.6) a	8.11 (65.3) a	8.18 (66.4) a
I ₁ G ₃ P ₂	8.33 (68.9) a-f	8.56 (72.9) a-c	8.45 (70.9) ab	8.92 (79.1) a-c	7.3 (52.9) a-e	8.15 (66) a-d	8.03 (64) ab	7.97 (63.1) ab	8 (63.6) ab
I ₂ G ₁ P ₁	7.57 (56.9) g-i	8.05 (64.4) b-e	7.82 (60.7) cd	8.22 (67.1) de	6.73 (44.9) c-f	7.51 (56) e-g	6.89 (47.1) e-g	7.27 (52.4) c-i	7.08 (49.8) e-i
I ₂ G ₁ P ₂	7.42 (54.7) i	7.97 (63.1) c-e	7.7 (58.9) cd	8.11 (65.3) de	6.56 (42.7) ef	7.38 (54) e-g	6.76 (45.3) fg	7.18 (51.1) d-j	6.97 (48.2) f-i
I ₂ G ₂ P ₁	7.89 (61.8) b-i	8.43 (70.7) a-d	8.16 (66.2) a-d	8.67 (74.7) a-d	7.15 (50.7) a-f	7.94 (62.7) a-e	7.27 (52.4) c-g	7.63 (57.8) a-f	7.45 (55.1) c-f
I ₂ G ₂ P ₂	7.74 (59.6) d-i	8.3 (68.4) a-e	8.03 (64) b-d	8.54 (72.4) b-e	6.99 (48.4) a-f	7.8 (60.4) b-g	7.15 (50.7) c-g	7.51 (56) b-h	7.34 (53.3) c-g
I ₂ G ₃ P ₁	8.51 (72) a-c	8.69 (75.1) a	8.6 (73.6) ab	9.14 (83.1) ab	7.69 (58.7) a	8.45 (70.9) a	7.63 (57.8) a-d	7.94 (62.7) ab	7.79 (60.2) a-c
I ₂ G ₃ P ₂	8.3 (68.4) a-g	8.54 (72.4) a-c	8.42 (70.4) ab	9.04 (81.3) ab	7.54 (56.4) a-c	8.33 (68.9) ab	7.48 (55.6) b-e	7.8 (60.4) a-c	7.64 (58) b-d
I ₃ G ₁ P ₁	7.54 (56.4) hi	7.97 (63.1) c-e	7.76 (59.8) cd	8.08 (64.9) de	6.56 (42.7) ef	7.37 (53.8) e-g	6.8 (45.8) e-g	7.24 (52) c-i	7.03 (48.9) f-i
I ₃ G ₁ P ₂	7.39 (54.2) i	7.89 (61.8) de	7.65 (58) d	7.94 (62.7) e	6.43 (40.9) f	7.22 (51.8) g	6.67 (44) g	7.05 (49.3) f-j	6.86 (46.7) g-i
I ₃ G ₂ P ₁	8 (63.6) a-i	8.51 (72) a-d	8.26 (67.8) a-c	8.56 (72.9) a-e	6.96 (48) a-f	7.8 (60.4) b-g	7.27 (52.4) c-g	7.66 (58.2) a-e	7.47 (55.3) c-f
I ₃ G ₂ P ₂	7.83 (60.9) c-i	8.41 (70.2) a-e	8.13 (65.6) a-d	8.51 (72) b-e	6.76 (45.3) c-f	7.69 (58.7) c-g	7.15 (50.7) c-g	7.54 (56.4) a-h	7.35 (53.6) c-g
I ₃ G ₃ P ₁	8.48 (71.6) a-d	8.64 (74.2) ab	8.56 (72.9) ab	9.21 (84.4) a	7.66 (58.2) ab	8.48 (71.3) a	7.63 (57.8) a-d	7.92 (62.2) ab	7.78 (60) a-c
I ₃ G ₃ P ₂	8.35 (69.3) a-e	8.51 (72) a-d	8.44 (70.7) ab	9.12 (82.7) ab	7.54 (56.4) a-c	8.37 (69.6) ab	7.48 (55.6) b-e	7.8 (60.4) a-c	7.65 (58) b-d
I ₄ G ₁ P ₁	7.72 (59.1) e-i	7.94 (62.7) c-e	7.83 (60.9) cd	8.3 (68.4) c-e	6.83 (46.2) c-f	7.6 (57.3) d-g	6.8 (45.8) e-g	6.76 (45.3) ij	6.78 (45.6) hi
I ₄ G ₁ P ₂	7.6 (57.3) f-i	7.8 (60.4) e	7.7 (58.9) cd	8.19 (66.7) de	6.67 (44) d-f	7.47 (55.3) e-g	6.7 (44.4) g	6.63 (43.6) j	6.67 (44) i
I ₄ G ₂ P ₁	8.19 (66.7) a-h	8.38 (69.8) a-e	8.29 (68.2) a-c	8.64 (74.2) a-d	7.12 (50.2) a-f	7.92 (62.2) a-e	7.12 (50.2) c-g	7.02 (48.9) g-j	7.08 (49.6e-i)
I ₄ G ₂ P ₂	7.97 (63.1) a-i	8.25 (67.6) a-e	8.11 (65.3) a-d	8.56 (72.9) a-e	6.96 (48) a-f	7.81 (60.4) b-g	6.96 (48) d-g	6.96 (48) h-j	6.96 (48) f-i
I ₄ G ₃ P ₁	8.69 (75.1) a	8.61 (73.8) ab	8.65 (74.4) a	9.12 (82.7) ab	7.48 (55.6) a-d	8.34 (69.1) ab	7.63 (57.8) a-d	7.54 (56.4) a-h	7.59 (57.1) b-e
I ₄ G ₃ P ₂	8.62 (73.8) ab	8.48 (71.6) a-d	8.55 (72.7) ab	9.04 (81.3) ab	7.3 (52.9) a-e	8.22 (67.1) a-c	7.42 (54.7) b-f	7.42 (54.7) b-h	7.42 (54.7) c-f
S.Em±	0.21	0.18	0.17	0.19	0.23	0.17	0.20	0.17	0.15

Means followed by the same alphabet do not differ significantly by DMRT (0.05) ; () Figures in parentheses are original values.

density was observed with $I_4G_1P_2$ (sowing of sprouted seeds at 30 cm x 10 cm with irrigation at critical stages) at harvest (44).

4.1.2.3 Weed dry matter ($g\ m^{-2}$)

Weed dry matter recorded at various growth stages of aerobic rice is presented in Table 14. The data on weed dry matter did not differ significantly due to scheduling of irrigation at 20 and 40 DAS during both the years. Significantly higher weed dry matter (68.8 g) at harvest was recorded with irrigation at IW/CPE of 0.8 (I_1). However, irrigation at critical stages (I_4) resulted in lower weed dry matter (58.2 g).

Sowing at 30 cm x 20 cm (G_3) recorded in significantly higher weed dry matter at 20 DAS, 40 DAS and at harvest (45, 57.8 and 70.8 g respectively). Whereas, significantly lower weed dry matter at 20 and 40 DAS and at harvest (37.1, 42.6 and 52.5 g respectively) was observed when seeds were sown at 30 cm x 10 cm (G_1).

Weed dry matter did not differ significantly due to different planting methods except at 20 DAS, where sowing of sprouted seeds recorded significantly lower weed dry matter (39.8 g)

Interaction effects of scheduling of irrigation, planting geometry and methods of planting influenced the weed dry matter significantly. Treatment combination $I_2G_3P_1$ (sowing of dry seeds at 30 cm x 20 cm with irrigation at IW/CPE of 1.0) recorded significantly higher weed dry matter at 20 and 40 DAS (48.0 and 60.9 g respectively) whereas $I_1G_3P_1$ (sowing of dry seed at 30 cm x 20 cm with irrigation at IW/CPE of 0.8) recorded significantly higher weed dry matter at harvest (77.2 g). Significantly lower weed dry matter was observed with $I_4G_1P_2$ (sowing of sprouted seeds at 30 cm x 15 cm with irrigation at critical stages) at harvest (46.3 g) on pooled basis.

4.1.3 Yield parameters

4.1.3.1 Productive tillers m^{-2}

The productive tillers was differed significantly by scheduling of irrigation, planting geometry and methods of planting and their interaction effects at harvest (Table 15).

Table 14: Effect of irrigation schedules, planting geometry and planting methods on weed dry matter (g m⁻²)

Treatments	20 DAS			40 DAS			Harvest		
	2013	2014	Pooled	2013	2014	Pooled	2013	2014	Pooled
Irrigation Schedule (I)									
I ₁ -IW/CPE-0.8	6.3 (39.3) a	6.55 (42.5) a	6.43 (40.9) a	7.41 (54.7) a	6.33 (39.9) a	6.9 (47.3) a	8.36 (69.6) a	8.26 (68) a	8.31 (68.8) a
I ₂ -IW/CPE-1.0	6.42 (41) a	6.68 (44.3) a	6.55 (42.6) a	7.7 (59) a	6.67 (44.3) a	7.2 (51.6) a	7.74 (59.7) b	8.11 (65.7) b	7.93 (62.7) b
I ₃ -IW/CPE-1.2	6.15 (37.5) a	6.38 (40.3) a	6.26 (38.9) a	7.64 (58.1) a	6.59 (43.2) a	7.13 (50.7) a	7.77 (60.2) b	8.28 (68.4) a	8.03 (64.3) b
I ₄ -Critical stages	6.33 (39.7) a	6.51 (42) a	6.42 (40.8) a	7.52 (56.3) a	6.46 (41.6) a	7.01 (49) a	7.67 (58.8) b	7.6 (57.7) c	7.64 (58.2) c
S.Em±	0.08	0.09	0.08	0.09	0.1	0.09	0.07	0.03	0.05
Planting geometry (G)									
G ₁ -30 cm x 10 cm	5.96 (35.1) c	6.28 (39.1) c	6.13 (37.1) c	7.07 (49.5) c	6 (35.6) c	6.56 (42.6) c	7.17 (51.1) c	7.37 (53.9) c	7.27 (52.5) c
G ₂ -30 cm x 15 cm	6.24 (38.6) b	6.52 (42.2) b	6.38 (40.4) b	7.53 (56.3) b	6.42 (40.9b)	7 (48.6) b	8.14 (65.8) b	8.3 (68.6) b	8.22 (67.2) b
G ₃ -30 cm x 20 cm	6.7 (44.5) a	6.78 (45.6) a	6.74 (45) a	8.1 (65.3) a	7.12 (50.3) a	7.63 (57.8a)	8.35 (69.3) a	8.52 (72.3) a	8.44 (70.8) a
S.Em±	0.04	0.04	0.03	0.06	0.05	0.03	0.05	0.05	0.04
Planting methods (P)									
P ₁ -Dry seeds	6.38 (40.4) a	6.61 (43.3) a	6.5 (41.8) a	7.62 (57.9) a	6.59 (43.2) a	7.12 (50.6) a	7.95 (63.1) a	8.12 (65.8) a	8.04 (64.5) a
P ₂ -Sprouted seeds	6.22 (38.4) b	6.45 (41.3) b	6.34 (39.8) b	7.51 (56.2) a	6.44 (41.3) a	7 (48.7) a	7.82 (61.1) a	8.01 (64) a	7.92 (62.6) a
S.Em±	0.04	0.05	0.03	0.07	0.05	0.05	0.06	0.07	0.05
Interactions- (I x G x P)									
I ₁ G ₁ P ₁	6.07 (36.4) f-j	6.37 (40.1) b-f	6.22 (38.3) g-k	7.04 (49.2) fg	5.98 (35.3) f-h	6.53 (42.3) g-i	7.8 (60.4) e	7.69 (58.7) d-f	7.74 (59.5) e-h
I ₁ G ₁ P ₂	5.94 (34.8) h-j	6.24 (38.5) d-f	6.09 (36.7) j-l	6.91 (47.3) g	5.82 (33.5) h	6.4 (40.4) i	7.67 (58.4) ef	7.57 (56.9) e-f	7.62 (57.7) f-i
I ₁ G ₂ P ₁	6.31 (39.3) b-h	6.63 (43.6) a-e	6.47 (41.5) c-h	7.39 (54.3) c-g	6.24 (38.5) e-h	6.84 (46.4) d-i	8.59 (73.3) a-c	8.48 (71.5) a-c	8.54 (72.4) ab
I ₁ G ₂ P ₂	6.18 (37.7) d-i	6.49 (41.7) a-f	6.34 (39.7) e-k	7.28 (52.7) d-g	6.1 (36.8) e-h	6.72 (44.7) e-i	8.52 (72.1) a-d	8.38 (69.7) a-d	8.45 (70.9) a-c
I ₁ G ₃ P ₁	6.76 (45.2) ab	6.84 (46.4) a-c	6.8 (45.8) a-c	7.99 (63.5) a-d	7 (48.5) a-c	7.51 (56) a-c	8.87 (78.3) a	8.75 (76.1) a	8.81 (77.2) a
I ₁ G ₃ P ₂	6.56 (42.5) a-e	6.72 (44.8) a-e	6.64 (43.7) a-f	7.86 (61.3) a-e	6.86 (46.7) a-d	7.38 (54) a-d	8.7 (75.3) ab	8.67 (74.8) ab	8.69 (75.1) ab
I ₂ G ₁ P ₁	6.18 (37.7) d-i	6.49 (41.7) a-f	6.34 (39.7) e-k	7.28 (52.5) d-g	6.24 (38.5) e-h	6.78 (45.5) e-i	7.05 (49.3) fg	7.48 (55.5) e-h	7.27 (52.4) h-k
I ₂ G ₁ P ₂	5.93 (34.8) h-j	6.29 (39.2) c-f	6.12 (37) i-l	7.16 (50.8) e-g	6.1 (36.8) e-h	6.66 (43.8) e-i	6.93 (47.6) g	7.32 (53.2) f-h	7.13 (50.4) i-k
I ₂ G ₂ P ₁	6.49 (41.7) a-g	6.79 (45.7) a-d	6.64 (43.7) a-f	7.73 (59.3) a-f	6.64 (43.7) b-e	7.21 (51.5) b-e	8.11 (65.3) b-e	8.48 (71.5) a-c	8.3 (68.4) a-d
I ₂ G ₂ P ₂	6.26 (38.8) c-i	6.64 (43.7) a-e	6.45 (41.3) d-i	7.59 (57.2) a-g	6.5 (41.9) c-f	7.07 (49.5) c-g	7.99 (63.5) b-e	8.35 (69.2) a-d	8.17 (66.3) b-e
I ₂ G ₃ P ₁	6.91 (47.3) a	7 (48.7) a	6.96 (48) a	8.29 (68.3) a	7.34 (53.5) a	7.83 (60.9) a	8.24 (67.5) a-e	8.58 (73.2) ab	8.41 (70.3) a-c
I ₂ G ₃ P ₂	6.77 (45.5) ab	6.86 (46.7ab)	6.82 (46.1) ab	8.14 (65.9) a-c	7.18 (51.2) ab	7.68 (58.5) ab	8.08 (64.9) b-e	8.48 (71.5) a-c	8.29 (68.2) a-d
I ₃ G ₁ P ₁	5.81 (33.3) ij	6.18 (37.9) ef	6.01 (35.6) kl	7.21 (51.6) d-g	6.14 (37.3) e-h	6.7 (44.5) e-i	7.12 (50.3) fg	7.66 (58.3) d-g	7.4 (54.3) g-j
I ₃ G ₁ P ₂	5.68 (31.9) j	6.01 (35.7) f	5.85 (33.8) l	7.07 (49.6) e-g	6.02 (35.9) f-h	6.58 (42.7) f-i	6.95 (47.9) g	7.49 (55.7) e-h	7.22 (51.8) h-k
I ₃ G ₂ P ₁	6.16 (37.6) d-i	6.48 (41.6) a-f	6.32 (39.6) f-k	7.61 (57.5) a-g	6.52 (42.1) c-f	7.09 (49.8) c-f	8.12 (65.5) b-e	8.6 (73.5) ab	8.36 (69.5) a-c
I ₃ G ₂ P ₂	6.02 (35.9) g-j	6.29 (39.2) c-f	6.16 (37.5) h-l	7.49 (55.7) b-g	6.4 (40.5) d-g	6.97 (48.1) c-h	7.99 (63.5) b-e	8.5 (71.9) a-c	8.25 (67.7) b-e
I ₃ G ₃ P ₁	6.66 (43.9) a-c	6.73 (44.9) a-e	6.69 (44.4) a-d	8.23 (67.3) ab	7.28 (52.5) a	7.77 (59.9) a	8.31 (68.5) a-e	8.76 (76.3) a	8.54 (72.4) ab
I ₃ G ₃ P ₂	6.55 (42.4) a-f	6.56 (42.7) a-f	6.55 (42.5) b-g	8.2 (66.8) ab	7.16 (50.9) ab	7.7 (58.9) ab	8.13 (65.7) b-e	8.67 (74.8) ab	8.41 (70.3) a-c
I ₄ G ₁ P ₁	6.1 (36.8) e-j	6.4 (40.5) b-f	6.26 (38.7) g-k	7 (48.7) fg	5.92 (34.7) gh	6.49 (41.7) hi	6.98 (48.4) g	6.91 (47.3) gh	6.95 (47.9) jk
I ₄ G ₁ P ₂	5.98 (35.3) h-j	6.26 (38.8) d-f	6.13 (37.1) h-l	6.85 (46.5g)	5.75 (32.7) h	6.33 (39.6) i	6.86 (46.7) g	6.8 (45.9) h	6.83 (46.3) k
I ₄ G ₂ P ₁	6.32 (39.6) b-h	6.49 (41.7) a-f	6.42 (40.7) d-j	7.58 (57.1) a-g	6.58 (42.9) c-e	7.1 (50) c-f	7.94 (62.5) c-e	7.88 (61.7) b-f	7.91 (62.1) c-g
I ₄ G ₂ P ₂	6.18 (37.7) d-i	6.34 (39.9) b-f	6.26 (38.8) g-k	7.55 (56.5) a-g	6.4 (40.5) d-g	7 (48.5) c-h	7.83 (60.9) de	7.76 (59.7) c-f	7.8 (60.3) d-g
I ₄ G ₃ P ₁	6.78 (45.5) ab	6.85 (46.5) a-c	6.81 (46) ab	8.13 (65.7) a-c	7.15 (50.7) ab	7.66 (58.2) ab	8.24 (67.5) a-e	8.18 (66.5) a-e	8.21 (67) b-e
I ₄ G ₃ P ₂	6.62 (43.3) a-d	6.7 (44.4) a-e	6.66 (43.9) a-e	7.99 (63.5) a-d	6.99 (48.4) a-c	7.51 (55.9) a-c	8.18 (66.5) a-e	8.08 (64.9) a-f	8.13 (65.7) b-f
S.Em±	0.14	0.16	0.1	0.23	0.16	0.16	0.2	0.23	0.16

Means followed by the same alphabet do not differ significantly by DMRT (0.05) ; () Figures in parentheses are original values

Among the irrigation schedules, significantly higher productive tillers (511.76) were recorded with irrigation at critical stages (I_4). However, irrigation at IW/CPE of 0.8 (I_1) resulted in lower productive tillers (448.69). Among the planting geometry, sowing at 30 cm x 10 cm (G_1) recorded in significantly higher productive tillers (583.00) where as significantly lower productive tillers (367.77) were observed when seeds were sown at 30 cm x 20 cm (G_3). Productive tillers at harvest did not differ significantly due to different planting methods.

Interaction effects of scheduling of irrigation, planting geometry and methods of planting influenced the productive tillers significantly. Treatment combination $I_4G_1P_2$ (sowing of sprouted seeds at 30 cm x 20 cm with irrigation at critical stages) produced significantly higher productive tillers (631.05) and was on par with $I_4G_1P_1$ (613.27), $I_3G_1P_2$ (594.39), $I_3G_1P_1$ (585.50) and $I_2G_1P_2$ (581.05). Significantly lower productive tillers (344.31) were observed with $I_1G_3P_1$ (sowing of dry seeds at 30 cm x 20 cm with irrigation at IW/CPE of 0.8).

4.1.3.2 Number of filled grains panicle⁻¹

Number of filled grains panicle⁻¹ as influenced by scheduling of irrigation, planting geometry and methods of planting and their interaction effects is presented in Table 15.

Significantly higher number of filled grains panicle⁻¹ (83.53) was recorded with irrigation at critical stages (I_4). Whereas irrigation at IW/CPE of 0.8 (I_1) resulted in lower number of filled grains panicle⁻¹ (75.38). Among the planting geometry, sowing at 30 cm x 20 cm (G_3) recorded in significantly higher number of filled grains panicle⁻¹ (83.95). However significantly lower number of filled grains panicle⁻¹ (74.44) was observed when seeds were sown at 30 cm x 10 cm (G_1). Number of filled grains panicle⁻¹ at harvest did not differ significantly due to different planting methods.

Interaction effects of scheduling of irrigation, planting geometry and methods of planting indicated that $I_4G_3P_2$ (sowing of sprouted seeds at 30 cm x 20 cm with irrigation at critical stages) produced significantly higher number of filled grains panicle⁻¹

Table 15: Effect of irrigation schedules, planting geometry and planting methods on productive tillers m⁻², filled grains and unfilled grains panicle⁻¹ at harvest

Treatments	Productive tillers m ⁻²			Filled grains panicle ⁻¹			Unfilled grains panicle ⁻¹		
	2013	2014	Pooled	2013	2014	Pooled	2013	2014	Pooled
Irrigation Schedule (I)									
I ₁ -IW/CPE-0.8	449.55b	447.45c	448.50c	83.74b	67.01b	75.38c	12.94a	24.73a	18.84a
I ₂ -IW/CPE-1.0	457.94b	481.52b	469.73b	84.57b	72.68a	78.62b	13.16a	21.06b	17.11b
I ₃ -IW/CPE-1.2	466.89b	494.17ab	480.53b	85.27b	73.23a	79.25b	12.98a	21.04b	17.01b
I ₄ -Critical stages	512.50a	509.54a	511.02a	92.53a	74.53a	83.53a	8.14b	21.63b	14.89c
S.Em±	6.31	5.45	5.12	0.48	0.59	0.47	0.13	0.43	0.28
Planting geometry (G)									
G ₁ -30 cm x 10 cm	574.66a	591.33a	583.00a	80.62c	68.26c	74.44c	15.08a	28.19a	21.63a
G ₂ -30 cm x 15 cm	472.73b	482.91b	477.82b	86.66b	71.73b	79.20b	11.17b	21.52b	16.34b
G ₃ -30 cm x 20 cm	367.77c	375.27c	371.52c	92.31a	75.60a	83.95a	9.18c	16.64c	12.91c
S.Em±	4.43	9.12	5.18	0.55	0.59	0.31	0.06	0.34	0.16
Planting methods (P)									
P ₁ -Dry seeds	467.26a	478.59a	472.92a	86.29a	71.79a	79.04a	11.94a	22.22a	17.08a
P ₂ -Sprouted seeds	476.18a	487.75a	481.97a	86.76a	71.93a	79.35a	11.67a	22.02a	16.84a
S.Em±	7.29	4.74	4.94	0.59	0.68	0.51	0.22	0.36	0.27
Interactions- (I x G x P)									
I ₁ G ₁ P ₁	542.17b-e	539.95c-e	541.06c-e	77.53j	63.00f	70.27g	16.33a	30.87a	23.60a
I ₁ G ₁ P ₂	551.06a-d	548.83b-d	549.95cd	78.27ij	63.67ef	70.97g	16.20a	30.87a	23.53a
I ₁ G ₂ P ₁	453.29fg	450.33fg	451.81fg	83.53f-j	66.87d-f	75.20d-g	12.47b	24.40bc	18.43c-e
I ₁ G ₂ P ₂	457.73e-g	454.77fg	456.25fg	83.87e-j	67.13d-f	75.50d-g	12.20b	23.93bc	18.07c-e
I ₁ G ₃ P ₁	344.31h	342.09i	343.20i	89.40b-f	70.47b-f	79.93c-e	10.33b	19.20d-f	14.77f-h
I ₁ G ₃ P ₂	348.75h	348.75i	348.75i	89.87b-f	70.93a-f	80.40 cd	10.13b	19.13d-f	14.63f-h
I ₂ G ₁ P ₁	553.28a-d	582.16a-c	567.72bc	78.47ij	68.80 c-f	73.63fg	16.47a	27.13ab	21.80ab
I ₂ G ₁ P ₂	564.39a-c	597.72ab	581.05a-c	78.93h-j	69.13b-f	74.03e-g	16.20a	26.93ab	21.57ab
I ₂ G ₂ P ₁	459.21e-g	479.95f	469.58f	84.67d-i	72.80a-d	78.73c-f	12.73b	20.67cd	16.70d-f
I ₂ G ₂ P ₂	466.62e-g	491.80ef	479.21f	85.13d-i	73.13a-d	79.13c-f	12.47b	20.47c-e	16.47d-f
I ₂ G ₃ P ₁	348.75h	366.52hi	357.63hi	89.87b-f	75.87a-c	82.87bc	10.73b	15.67f	13.20g-j
I ₂ G ₃ P ₂	355.41h	370.96hi	363.19hi	90.33b-f	76.33a-c	83.33a-c	10.33b	15.47f	12.90h-j
I ₃ G ₁ P ₁	566.61a-c	604.38a	585.50a-c	79.20h-j	69.33b-f	74.27e-g	16.27a	27.13ab	21.70ab
I ₃ G ₁ P ₂	575.50a-c	613.27a	594.39a-c	79.53g-j	69.67b-f	74.60d-g	16.07a	26.93ab	21.50ab
I ₃ G ₂ P ₁	465.14e-g	491.80ef	478.47f	85.13d-i	73.20a-d	79.17c-f	12.67b	20.73cd	16.70d-f
I ₃ G ₂ P ₂	475.51d-g	499.21d-f	487.36ef	85.67c-h	73.53a-d	79.60 c-f	12.20b	20.40 c-e	16.30e-g
I ₃ G ₃ P ₁	355.41h	374.29hi	364.85hi	90.80b-e	76.67a-c	83.73a-c	10.47b	15.60f	13.03h-j
I ₃ G ₃ P ₂	363.19h	382.07hi	372.63hi	91.27b-d	77.00ab	84.13a-c	10.20b	15.47f	12.83h-j
I ₄ G ₁ P ₁	613.27ab	613.27a	613.27ab	86.27b-g	71.00a-e	78.63c-f	11.67b	27.93ab	19.80bc
I ₄ G ₁ P ₂	631.05a	631.05a	631.05a	86.73b-f	71.47a-e	79.10 c-f	11.40b	27.73ab	19.57b-d
I ₄ G ₂ P ₁	494.77c-g	491.80ef	493.28ef	92.40a-c	74.93a-d	83.67a-c	7.40 c	20.80 cd	14.10f-i
I ₄ G ₂ P ₂	509.58c-f	503.65d-f	506.62d-f	92.87ab	72.27a-d	82.57c	7.20 c	20.73cd	13.97f-i
I ₄ G ₃ P ₁	410.95gh	406.50gh	408.73gh	98.27a	78.60a	88.43ab	5.80 c	16.47ef	11.13ij
I ₄ G ₃ P ₂	415.39gh	410.95gh	413.17gh	98.67a	78.93a	88.80a	5.40 c	16.13f	10.77j
S.Em±	25.25	16.41	17.12	2.04	2.34	1.75	0.76	1.26	0.94

Means followed by the same alphabet do not differ significantly by DMRT (0.05)

(88.80) and was closely followed by $I_4G_3P_1$ (88.43), $I_3G_3P_2$ (84.13), $I_3G_3P_1$ (83.73), $I_4G_2P_1$ (83.67), $I_2G_3P_2$ (83.33), and $I_2G_3P_1$ (82.87). Significantly lower number of filled grains panicle⁻¹ (70.27) was observed with $I_1G_1P_1$ (sowing of dry seeds at 30 cm x 10 cm with irrigation at IW/CPE of 0.8). Lower number of filled grains panicle⁻¹ was observed during second year when compared to first year.

4.1.3.3 Number of unfilled grains panicle⁻¹

Scheduling of irrigation, planting geometry and methods of planting and their interaction effects influenced number of unfilled grains panicle⁻¹ (Table 15).

Among the irrigation schedules, significantly lower number of unfilled grains panicle⁻¹ (14.89) was recorded with irrigation at critical stages (I_4). However, irrigation at IW/CPE of 0.8 (I_1) resulted in higher number of unfilled grains panicle⁻¹ (18.84). Sowing at 30 cm x 20 cm (G_3) recorded significantly lower number of unfilled grains panicle⁻¹ (12.91). However, significantly higher number of unfilled grains panicle⁻¹ (21.63) was observed when seeds were sown at 30 cm x 10 cm (G_1). Different planting methods did not differ significantly in number of unfilled grains panicle⁻¹ at harvest.

Interaction effects of scheduling of irrigation, planting geometry and methods of planting indicated that $I_4G_3P_2$ (sowing of sprouted seeds at 30 cm x 20 cm with irrigation at critical stages) produced significantly lower number of unfilled grains panicle⁻¹ (10.77) and was on par with $I_4G_3P_1$ (11.13), $I_3G_3P_2$ (12.83), $I_3G_3P_1$ (13.03), $I_2G_3P_2$ (12.90) and $I_2G_3P_1$ (13.20). Sowing of dry seeds at 30 cm x 10 cm with irrigation at IW/CPE of 0.8 ($I_1G_1P_1$) recorded significantly higher number of unfilled grains panicle⁻¹ (23.60). Comparatively higher number of unfilled grains panicle⁻¹ was observed during second year when compared to first year.

4.1.3.4 Panicle length (cm)

The data on panicle length as influenced by scheduling of irrigation, planting geometry and methods of planting and their interaction at harvest is furnished in Table 16.

Among the irrigation schedules, significantly higher panicle length (25.09 cm) was recorded with irrigation at critical stages (I_4). However, irrigation at IW/CPE of 0.8

Table 16: Effect of irrigation schedules, planting geometry and planting methods on panicle length, panicle weight and test weight at harvest

Treatments	Panicle length (cm)			Panicle weight (g)			Test weight (g)		
	2013	2014	Pooled	2013	2014	Pooled	2013	2014	Pooled
Irrigation Schedule (I)									
I ₁ -IW/CPE-0.8	22.14b	22.04c	22.09c	2.50b	1.87b	2.18c	20.73a	20.70a	20.72a
I ₂ -IW/CPE-1.0	22.37b	24.32b	23.34b	2.52b	2.18a	2.35b	20.91a	20.85a	20.88a
I ₃ -IW/CPE-1.2	22.54b	24.59b	23.57b	2.53b	2.19a	2.36b	21.08a	21.00a	21.04a
I ₄ -Critical stages	24.56a	25.62a	25.09a	2.88a	2.29a	2.58a	21.86a	21.68a	21.77a
S.Em±	0.32	0.23	0.22	0.05	0.06	0.03	0.34	0.3	0.31
Planting geometry (G)									
G ₁ -30 cm x 10 cm	21.00 c	22.28c	21.64c	2.28c	1.80 c	2.04c	20.11c	20.04c	20.08c
G ₂ -30 cm x 15 cm	22.86b	24.10b	23.48b	2.50b	2.08b	2.29b	21.11b	21.03b	21.07b
G ₃ -30 cm x 20 cm	24.84a	26.05a	25.44a	3.04a	2.51a	2.78a	22.22a	22.10a	22.16a
S.Em±	0.24	0.38	0.26	0.04	0.006	0.02	0.3	0.19	0.16
Planting methods (P)									
P ₁ -Dry seeds	22.74a	23.99a	23.36a	2.58a	2.11a	2.34a	21.06a	20.99a	21.03a
P ₂ -Sprouted seeds	23.06a	24.30a	23.68a	2.63a	2.15a	2.39a	21.23a	21.12a	21.18a
S.Em±	0.34	0.35	0.28	0.03	0.03	0.02	0.34	0.35	0.24
Interactions- (I x G x P)									
I ₁ G ₁ P ₁	20.20e	20.17f	20.18g	2.13f	1.50j	1.82k	19.75a	19.72a	19.74a
I ₁ G ₁ P ₂	20.37de	20.23ef	20.30g	2.24d-f	1.59ij	1.92jk	19.83a	19.80a	19.82a
I ₁ G ₂ P ₁	21.87c-e	21.77d-f	21.82e-g	2.39d-f	1.81hi	2.10g-j	20.68a	20.62a	20.65a
I ₁ G ₂ P ₂	22.33b-e	22.20 c-f	22.27d-g	2.45c-f	1.86g-i	2.16f-i	20.77a	20.74a	20.76a
I ₁ G ₃ P ₁	23.83a-e	23.77a-f	23.80b-f	2.86b	2.19d-f	2.53d	21.62a	21.60a	21.61a
I ₁ G ₃ P ₂	24.23a-e	24.13a-f	24.18a-f	2.92b	2.24cd	2.58cd	21.75a	21.72a	21.74a
I ₂ G ₁ P ₁	20.37de	22.47c-f	21.42fg	2.24d-f	1.89f-i	2.07g-j	19.82a	19.80a	19.81a
I ₂ G ₁ P ₂	20.73c-e	22.67b-f	21.70e-g	2.28d-f	1.92e-h	2.10g-j	19.90a	19.84a	19.87a
I ₂ G ₂ P ₁	22.13c-e	24.07a-f	23.10 c-g	2.32d-f	2.06d-h	2.19f-h	20.75a	20.70a	20.73a
I ₂ G ₂ P ₂	22.37b-e	24.27a-f	23.32c-g	2.36d-f	2.09d-h	2.23fg	20.82a	20.76a	20.79a
I ₂ G ₃ P ₁	24.13a-e	26.10a-c	25.12a-d	2.92b	2.54a-c	2.73bc	21.95a	21.86a	21.91a
I ₂ G ₃ P ₂	24.47a-d	26.33a-c	25.40a-d	2.98b	2.58ab	2.78b	22.23a	22.15a	22.19a
I ₃ G ₁ P ₁	20.43de	22.53b-f	21.48fg	2.15ef	1.82hi	1.99i-k	19.95a	19.87a	19.91a
I ₃ G ₁ P ₂	20.70 c-e	22.77b-f	21.73e-g	2.20d-f	1.86g-i	2.03h-j	20.08a	20.05a	20.07a
I ₃ G ₂ P ₁	22.43b-e	24.37a-e	23.40 c-g	2.45c-f	2.16d-g	2.31f	20.86a	20.78a	20.82a
I ₃ G ₂ P ₂	22.77a-e	24.83a-d	23.80b-f	2.49c-e	2.19d-f	2.34ef	21.00a	20.95a	20.98a
I ₃ G ₃ P ₁	24.27a-e	26.33a-c	25.30a-d	2.93b	2.54a-c	2.74bc	22.16a	22.10a	22.13a
I ₃ G ₃ P ₂	24.63a-c	26.73ab	25.68a-c	2.98b	2.58ab	2.78b	22.45a	22.23a	22.34a
I ₄ G ₁ P ₁	22.43b-e	23.53a-f	22.98c-g	2.46c-f	1.89f-i	2.18f-i	20.62a	20.50a	20.56a
I ₄ G ₁ P ₂	22.77a-e	23.87a-f	23.32c-g	2.50 cd	1.92e-h	2.21f-h	20.95a	20.76a	20.86a
I ₄ G ₂ P ₁	24.37a-d	25.43a-d	24.90a-e	2.75bc	2.22de	2.49de	21.95a	21.84a	21.90a
I ₄ G ₂ P ₂	24.63a-c	25.87a-d	25.25a-d	2.82b	2.28b-d	2.55d	22.04a	21.83a	21.94a
I ₄ G ₃ P ₁	26.40ab	27.33a	26.87ab	3.35a	2.70a	3.03a	22.66a	22.53a	22.60a
I ₄ G ₃ P ₂	26.73a	27.67a	27.20a	3.38a	2.72a	3.05a	22.95a	22.64a	22.80a
S.Em±	1.18	1.21	0.95	0.1	0.09	0.05	1.18	1.2	1.13

Means followed by the same alphabet do not differ significantly by DMRT (0.05)

(I₁) resulted in lower panicle length (22.09 cm). Among the planting geometry, sowing at 30 cm x 20 cm (G₃) recorded significantly higher panicle length (25.44 cm) where as significantly lower panicle length (21.64 cm) were observed when seeds were sown at 30 cm x 10 cm (G₁). Panicle length at harvest did not differ significantly due to planting methods.

Interaction effects of scheduling of irrigation, planting geometry and methods of planting influenced the panicle length significantly. Treatment combination I₄G₃P₂ (sowing of sprouted seeds at 30 cm x 20 cm with irrigation at critical stages) produced significantly higher panicle length (27.20 cm) and was on par with I₄G₃P₁ (26.87 cm), I₄G₂P₂ (25.25 cm), I₄G₂P₁ (24.90 cm), I₃G₃P₂ (25.68 cm), I₃G₃P₁ (25.30 cm), I₂G₃P₂ (25.40 cm), I₂G₃P₁ (25.12cm) and I₁G₃P₂ (24.18 cm) Significantly lower panicle length (20.18cm) were observed with I₁G₁P₁ (sowing of dry seed at 30 cm x 10 cm with irrigation at IW/CPE of 0.8).

4.1.3.5 Panicle weight (g)

Scheduling of irrigation, planting geometry and methods of planting and their interaction effects significantly influence panicle weight (Table 16).

Significantly higher panicle weight (2.58g) was recorded with irrigation at critical stages (I₄). Whereas, irrigation at IW/CPE of 0.8 (I₁) resulted in lower panicle weight (2.18g). Sowing at 30 cm x 20 cm (G₃) recorded in significantly higher panicle weight (2.78g). However, significantly lower panicle weight (2.04g) was observed when seeds were sown at 30 cm x 10 cm (G₁).

Panicle weight did not differ significantly due to different planting methods.

Interaction effects of scheduling of irrigation, planting geometry and methods of planting indicated that I₄G₃P₂ (sowing of sprouted seeds at 30 cm x 20 cm with irrigation at critical stages) produced significantly higher panicle weight (3.05g) and was closely followed by I₄G₃P₁ (3.03g). Significantly lower panicle weight (1.82g) was observed with I₁G₁P₁ (sowing of dry seeds at 30 cm x 10 cm with irrigation at IW/CPE of 0.8). Lower panicle weight was observed during second year when compared to first year.

4.1.3.6 Thousand grain weight (g)

Thousand grain weight did not differ significantly due to scheduling of irrigation, and methods of planting and their interactions (Table 16).

Sowing at 30 cm x 20 cm (G_3) recorded in significantly higher thousand grain weight (22.16 g). Whereas, significantly lower thousand grain weight (20.08) was observed when seeds were sown at 30 cm x 10 cm (G_1) on pooled basis.

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

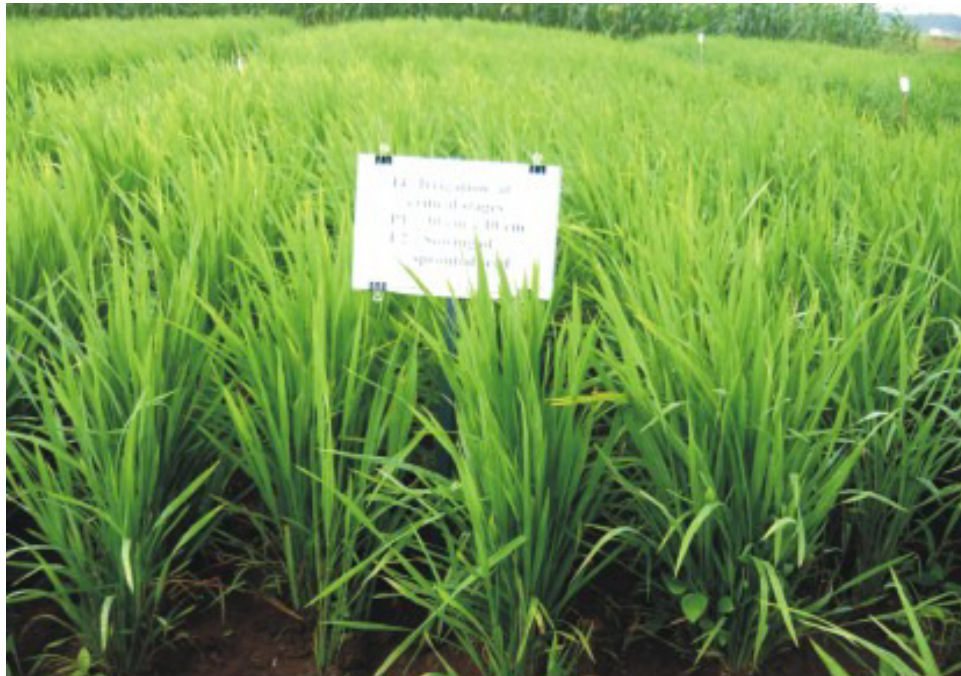
Grain yield of aerobic rice significantly influenced by scheduling of irrigation, planting geometry and methods of planting and their interaction effects (Table 17).

The pooled data of two years showed that, among the irrigation schedules, significantly higher grain yield (3914 kg ha^{-1}) was recorded with irrigation at critical stages (I_4) over rest of the treatments. Whereas, irrigation at IW/CPE of 0.8 (I_1) resulted in significantly lower grain yield (3205 kg ha^{-1}). Among the planting geometry, sowing at 30 cm x 10 cm (G_1) recorded in significantly higher grain yield (3958 kg ha^{-1}) where as significantly lower grain yield (3009 kg ha^{-1}) was observed when seeds were sown at 30 cm x 20 cm (G_3). Different planting methods did not differ significantly in grain yield.

Interaction effects of scheduling of irrigation, planting geometry and methods of planting influenced the grain yield significantly. Treatment combination $I_4G_1P_2$ (sowing of sprouted seeds at 30 cm x 10 cm with irrigation at critical stages) produced significantly higher grain yield (4383 kg ha^{-1}) and was on par with $I_4G_1P_1$ (4296 kg ha^{-1}). Significantly lower grain yield (2644 kg ha^{-1}) was observed with $I_1G_3P_1$ (sowing of dry seed at 30 cm x 20 cm with irrigation at IW/CPE of 0.8). Comparatively lower grain yield was observed during second year of investigation (Plate 3).

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

The data on straw yield differed significantly due to scheduling of irrigation, planting geometry and methods of planting and their interaction effects (Table 17).



At tillering stage



At grain filling stage

Plate 3b. $I_4G_1P_2$ - Sowing of sprouted seed at 30 cm x 10 cm with irrigations at critical stages

Table 17: Effect of irrigation schedules, planting geometry and planting methods on Grain yield, Straw yield and harvest index of aerobic rice

Treatments	Grain yield (kg/ha)			Straw yield (kg/ha)			Harvest Index (%)		
	2013	2014	Pooled	2013	2014	Pooled	2013	2014	Pooled
Irrigation Schedule (I)									
I ₁ -IW/CPE-0.8	3699b	2711c	3205c	4529c	4149c	4339d	45.26a	39.85a	42.56a
I ₂ -IW/CPE-1.0	3802b	3105b	3454b	4696bc	4793b	4745c	45.03a	39.56a	42.30a
I ₃ -IW/CPE-1.2	3901b	3191ab	3546b	4848b	4956b	4902b	44.88a	39.44a	42.16a
I ₄ -Critical stages	4504a	3324a	3914a	5826a	5374a	5600a	43.85a	38.43a	41.14a
S.Em±	74.64	56.69	51.85	78.87	75.23	37	0.49	0.51	0.49
Planting geometry (G)									
G ₁ -30 cm x 10 cm	4465a	3452a	3958a	6013a	5808a	5911a	42.67c	37.32c	39.99c
G ₂ -30 cm x 15 cm	4082b	3162b	3622b	5067b	4905b	4986b	44.69b	39.24b	41.96b
G ₃ -30 cm x 20 cm	3383c	2635c	3009c	3844c	3741c	3793c	46.91a	41.40a	44.16a
S.Em±	60.49	34.6	34.05	61.2	61.21	49.47	0.65	0.49	0.39
Planting methods (P)									
P ₁ -Dry seeds	3933a	3036a	3485a	4897a	4723a	4810a	44.86a	39.44a	42.15a
P ₂ -Sprouted seeds	4020a	3130a	3575a	5053a	4913a	4983a	44.65a	39.20a	41.92a
S.Em±	48.21	37.27	31.10	72.69	66.61	60.25	0.52	0.43	0.34
Interactions- (I x G x P)									
I ₁ G ₁ P ₁	4134c-g	3014d-i	3574e-g	5436b-e	4954e-g	5195e-h	43.20a	37.85a-c	40.53b-f
I ₁ G ₁ P ₂	4230 c-g	3112c-h	3671d-f	5605b-d	5154d-f	5380d-g	43.09a	37.69a-c	40.39c-f
I ₁ G ₂ P ₁	3768g-i	2747g-i	3258hi	4559f	4155h-j	4357jk	45.28a	39.88a-c	42.58a-f
I ₁ G ₂ P ₂	3852f-h	2836f-i	3344gh	4692ef	4318g-j	4505ij	45.10a	39.64a-c	42.37a-f
I ₁ G ₃ P ₁	3058j	2229k	2644l	3382g	3082l	3232m	47.49a	42.09a	44.79a
I ₁ G ₃ P ₂	3154j	2327jk	2741kl	3501g	3229kl	3365lm	47.39a	41.97a	44.68a
I ₂ G ₁ P ₁	4245c-g	3441a-d	3843c-e	5625b-d	5699b-e	5662c-f	43.01a	37.65a-c	40.33c-f
I ₂ G ₁ P ₂	4344c-f	3545a-c	3945cd	5799bc	5916a-c	5858cd	42.82a	37.45a-c	40.14d-f
I ₂ G ₂ P ₁	3873e-h	3148c-g	3511f-h	4725ef	4801f-h	4763h-j	45.08a	39.62a-c	42.35a-f
I ₂ G ₂ P ₂	3944e-g	3230b-f	3587e-g	4851d-f	4966e-g	4909g-j	44.84a	39.39a-c	42.12a-f
I ₂ G ₃ P ₁	3162j	2588i-k	2875j-l	3526g	3607j-l	3567lm	47.33a	41.72ab	44.53ab
I ₂ G ₃ P ₂	3245ij	2680h-j	2963jk	3651g	3769i-l	3710lm	47.13a	41.54ab	44.33a-c
I ₃ G ₁ P ₁	4333c-g	3519a-c	3926cd	5785bc	5872a-d	5829cd	42.84a	37.50a-c	40.17d-f
I ₃ G ₁ P ₂	4434b-e	3625ab	4030bc	5955b	6085a-c	6020bc	42.69a	37.32a-c	40.00ef
I ₃ G ₂ P ₁	3965e-g	3228b-f	3597e-g	4869d-f	4955e-g	4912g-j	44.91a	39.47a-c	42.19a-f
I ₃ G ₂ P ₂	4050d-g	3322a-e	3686d-f	5014c-f	5141d-f	5078f-i	44.70a	39.26a-c	41.98a-f
I ₃ G ₃ P ₁	3274ij	2683h-j	2979jk	3683g	3773i-l	3728lm	47.11a	41.62ab	44.36a-c
I ₃ G ₃ P ₂	3352h-j	2771g-i	3062ij	3784g	3911i-k	3848kl	47.02a	41.45a-c	44.23a-d
I ₄ G ₁ P ₁	4958ab	3633ab	4296ab	6842a	6267ab	6555ab	42.03a	36.73bc	39.38ef
I ₄ G ₁ P ₂	5043a	3723a	4383a	7060a	6515a	6788a	41.68a	36.35c	39.02f
I ₄ G ₂ P ₁	4560a-d	3350a-e	3955cd	5814bc	5339c-f	5577c-f	43.96a	38.52a-c	41.24a-f
I ₄ G ₂ P ₂	4643a-c	3438a-d	4041bc	6013b	5565b-f	5789c-e	43.61a	38.17a-c	40.89a-f
I ₄ G ₃ P ₁	3866e-h	2855f-i	3361gh	4523f	4175h-j	4349jk	46.12a	40.62a-c	43.37a-e
I ₄ G ₃ P ₂	3954e-g	2947e-i	3451f-h	4705ef	4384g-i	4545ij	45.69a	40.20a-c	42.95a-f
S.Em±	167	129.1	90.4	251.8	230.7	187.9	1.79	1.47	1.19

Means followed by the same alphabet do not differ significantly by DMRT (0.05)

Significantly higher straw yield (5600 kg ha^{-1}) was recorded with irrigation at critical stages (I_4). However, irrigation at IW/CPE of 0.8 (I_1) resulted in lower straw yield (4339 kg ha^{-1}) on pooled basis. Sowing at $30 \text{ cm} \times 10 \text{ cm}$ (G_1) recorded in significantly higher straw yield (5911 kg ha^{-1}) whereas significantly lower straw yield (3793 kg ha^{-1}) was observed when seeds were sown at $30 \text{ cm} \times 20 \text{ cm}$ (G_3). Straw yield did not differ significantly due to different planting methods.

Interaction effects of scheduling of irrigation, planting geometry and methods of planting influenced the straw yield significantly. Treatment combination $I_4G_1P_2$ (sowing of sprouted seeds at $30 \text{ cm} \times 10 \text{ cm}$ with irrigation at critical stages) produced significantly higher straw yield (6788 kg ha^{-1}) and was on par with $I_4G_1P_1$ (6555 kg ha^{-1}). Significantly lower straw yield (3232 kg ha^{-1}) was observed with $I_1G_3P_1$ (sowing of dry seed at $30 \text{ cm} \times 20 \text{ cm}$ with irrigation at IW/CPE of 0.8).

4.1.3.9 Harvest Index (%)

Harvest index did not differ significantly due to scheduling of irrigation and methods of planting (Table 17).

Sowing at $30 \text{ cm} \times 20 \text{ cm}$ (G_3) recorded significantly higher harvest index (44.16%). However, significantly lower harvest index (39.99%) was observed when seeds were sown at $30 \text{ cm} \times 10 \text{ cm}$ (G_1).

Interaction effects of scheduling of irrigation, planting geometry and methods of planting influenced the harvest index significantly. Treatment combination $I_1G_3P_1$ (sowing of dry seeds at $30 \text{ cm} \times 20 \text{ cm}$ with irrigation at IW/CPE of 0.8) produced significantly higher harvest index (44.79%) and was on par with $I_1G_3P_2$ (44.68%). Significantly lower harvest index (39.02%) was observed with $I_4G_1P_2$ (sowing of sprouted seeds at $30 \text{ cm} \times 10 \text{ cm}$ with irrigation at critical stages). Lower harvest index was observed during second year when compared to first year.

4.1.4 Physical properties of Soil

4.1.4.1 Bulk density (Mg/m^3)

The data on soil bulk density as influenced by scheduling of irrigation, planting geometry and methods of planting and their interaction effects did not differ significantly (Table 18).

Table 18: Effect of irrigation schedules, planting geometry and planting methods on bulk density, maximum water holding capacity and milling quality

Treatments	BD (Mg/m ³)			MWHC (%)			Milling (%)		
	2013	2014	Pooled	2013	2014	Pooled	2013	2014	Pooled
Irrigation Schedule (I)									
I ₁ -IW/CPE-0.8	1.29a	1.28a	1.28a	51.59a	51.62a	51.61a	71.27a	71.27a	71.27a
I ₂ -IW/CPE-1.0	1.28a	1.28a	1.28a	51.58a	51.60a	51.59a	71.27a	71.23a	71.25a
I ₃ -IW/CPE-1.2	1.28a	1.28a	1.28a	51.58a	51.62a	51.60a	71.39a	71.34a	71.37a
I ₄ -Critical stages	1.28a	1.28a	1.28a	51.60a	51.65a	51.62a	71.84a	71.75a	71.79a
S.Em±	0.007	0.01	0.004	0.14	0.37	0.23	0.16	0.42	0.16
Planting geometry (G)									
G ₁ -30 cm x 10 cm	1.29a	1.28a	1.28a	51.67a	51.72a	51.70a	71.85a	71.83a	71.84a
G ₂ -30 cm x 15 cm	1.28a	1.28a	1.28a	51.56a	51.60a	51.58a	71.47a	71.40a	71.44a
G ₃ -30 cm x 20 cm	1.28a	1.28a	1.28a	51.54a	51.54a	51.54a	71.00a	70.95a	70.98a
S.Em±	0.005	0.009	0.004	0.27	0.24	0.15	0.63	0.30	0.30
Planting methods (P)									
P ₁ -Dry seeds	1.28a	1.28a	1.28a	51.56a	51.59a	51.57a	71.36a	71.33a	71.34a
P ₂ -Sprouted seeds	1.28a	1.28a	1.28a	51.62a	51.66a	51.64a	71.53a	71.47a	71.50a
S.Em±	0.01	0.01	0.01	0.39	0.37	0.29	0.38	0.3	0.28
Interactions- (I x G x P)									
I ₁ G ₁ P ₁	1.29a	1.29a	1.29a	51.60a	51.65a	51.63a	71.63a	71.70a	71.67a
I ₁ G ₁ P ₂	1.29a	1.28a	1.29a	51.70a	51.76a	51.73a	71.67a	71.70a	71.68a
I ₁ G ₂ P ₁	1.28a	1.28a	1.28a	51.53a	51.55a	51.54a	71.37a	71.33a	71.35a
I ₁ G ₂ P ₂	1.29a	1.28a	1.28a	51.65a	51.68a	51.67a	71.43a	71.40a	71.42a
I ₁ G ₃ P ₁	1.29a	1.28a	1.28a	51.50a	51.52a	51.51a	70.57a	70.53a	70.55a
I ₁ G ₃ P ₂	1.28a	1.28a	1.28a	51.58a	51.56a	51.57a	70.97a	70.93a	70.95a
I ₂ G ₁ P ₁	1.29a	1.28a	1.28a	51.62a	51.67a	51.65a	71.63a	71.60a	71.62a
I ₂ G ₁ P ₂	1.28a	1.28a	1.28a	51.71a	51.75a	51.73a	71.70a	71.73a	71.72a
I ₂ G ₂ P ₁	1.29a	1.29a	1.29a	51.48a	51.53a	51.51a	71.27a	71.20a	71.23a
I ₂ G ₂ P ₂	1.29a	1.28a	1.28a	51.52a	51.60a	51.56a	71.37a	71.33a	71.35a
I ₂ G ₃ P ₁	1.28a	1.28a	1.28a	51.55a	51.50a	51.53a	70.67a	70.63a	70.65a
I ₂ G ₃ P ₂	1.28a	1.28a	1.28a	51.60a	51.55a	51.58a	70.97a	70.87a	70.92a
I ₃ G ₁ P ₁	1.28a	1.28a	1.28a	51.65a	51.70a	51.68a	71.67a	71.60a	71.63a
I ₃ G ₁ P ₂	1.28a	1.28a	1.28a	51.68a	51.74a	51.71a	71.87a	71.73a	71.80a
I ₃ G ₂ P ₁	1.29a	1.29a	1.29a	51.52a	51.56a	51.54a	71.30a	71.33a	71.32a
I ₃ G ₂ P ₂	1.28a	1.28a	1.28a	51.60a	51.64a	51.62a	71.47a	71.43a	71.45a
I ₃ G ₃ P ₁	1.28a	1.28a	1.28a	51.50a	51.50a	51.50a	70.97a	70.93a	70.95a
I ₃ G ₃ P ₂	1.28a	1.28a	1.28a	51.52a	51.58a	51.55a	71.07a	71.03a	71.05a
I ₄ G ₁ P ₁	1.29a	1.29a	1.29a	51.68a	51.74a	51.71a	72.27a	72.23a	72.25a
I ₄ G ₁ P ₂	1.29a	1.28a	1.28a	51.72a	51.78a	51.75a	72.40a	72.37a	72.38a
I ₄ G ₂ P ₁	1.28a	1.28a	1.28a	51.56a	51.60a	51.58a	71.63a	71.53a	71.58a
I ₄ G ₂ P ₂	1.28a	1.28a	1.28a	51.62a	51.65a	51.64a	71.93a	71.67a	71.80a
I ₄ G ₃ P ₁	1.28a	1.28a	1.28a	51.50a	51.52a	51.51a	71.33a	71.27a	71.30a
I ₄ G ₃ P ₂	1.28a	1.27a	1.27a	51.54a	51.58a	51.56a	71.47a	71.43a	71.45a
S.Em±	0.029	0.019	0.02	1.36	1.28	0.99	1.31	1.02	0.97

Means followed by the same alphabet do not differ significantly by DMRT (0.05)

4.1.4.2 Maximum water holding capacity (%)

Maximum water holding capacity did not differ significantly by scheduling of irrigation, planting geometry and methods of planting and their interactions (Table 18).

4.1.5 Quality parameters

4.1.5.1 Milling per cent (%)

The milling per cent did not differ significantly by scheduling of irrigation, planting geometry and methods of planting and their interaction effects (Table 18).

4.1.6 Water requirement and water use efficiency

4.1.6.1 Soil moisture (%) before irrigation

During 2013, soil moisture content observed was 19.77, 21.25 and 22.40 per cent before irrigation at 0-15, 15-30 and 30-60 cm depth respectively during first irrigation. Whereas, it was 17.41, 18.30 and 19.67 per cent during second irrigation in scheduling of irrigation at 0.8 IW/CPE ratio (I_1). Irrigation at 1.0 IW/CPE ratio (I_2) recorded 20.95, 21.97 and 22.23 per cent during first irrigation and 17.16, 20.18 and 21.99 per cent during second irrigation (Table 19). Irrigation at 1.2 IW/CPE ratio (I_3) recorded 20.07, 20.52 and 23.60 per cent during first irrigation and 18.92, 19.42 and 20.54 during second irrigation (Table 20). Soil moisture of 25.24, 26.05 and 28.57 per cent during first irrigation, 21.89, 22.37 and 22.46 per cent during second irrigation, 23.03, 23.20 and 23.25 per cent during third irrigation and 24.58, 25.95 and 27.07 per cent during fourth irrigation at 0-15, 15-30 and 30-60 cm depth (Table 21) was recorded with irrigation at critical stages of crop growth (I_4).

During 2014, 19.76, 19.05 and 20.75 per cent soil moisture was observed before irrigation at 0-15, 15-30 and 30-60 cm depth during first irrigation in scheduling of irrigation at 0.8 IW/CPE ratio (I_1). Irrigation at 1.0 IW/CPE ratio (I_2) recorded 19.37, 20.83 and 23.08 per cent during first irrigation, 20.70, 22.20 and 24.29 per cent during second irrigation and 19.07, 20.52 and 22.04 during third irrigation (Table 22).

Table 20: Effect of irrigation schedules, planting geometry and planting methods on soil moisture (%) before irrigation during 2013

Treatments	I ₃ – I irrigation (28.8.2013)			I ₃ – II irrigation (11.10.2013)		
	0-15 cm	15-30 cm	30-60 cm	0-15 cm	15-30 cm	30-60 cm
Irrigation Schedule (I)						
I ₁ -IW/CPE-0.8						
I ₂ -IW/CPE-1.0						
I ₃ -IW/CPE-1.2	20.07	20.52	23.60	18.92	19.42	20.54
I ₄ -Critical stages						
Planting geometry (G)						
G ₁ -30 cm×10 cm	18.04	19.14	22.08	16.08	18.07	18.86
G ₂ -30cm ×15 cm	20.78	20.07	23.47	18.24	18.16	19.52
G ₃ -30cm ×20 cm	21.40	22.36	25.25	22.45	22.03	23.26
Planting methods (P)						
P ₁ -Dry seeds	20.50	21.53	24.28	19.45	19.49	20.58
P ₂ -Sprouted seeds	19.64	19.51	22.91	18.39	19.35	20.50
Interactions- (I × G × P)						
I ₁ G ₁ P ₁						
I ₁ G ₁ P ₂						
I ₁ G ₂ P ₁						
I ₁ G ₂ P ₂						
I ₁ G ₃ P ₁						
I ₁ G ₃ P ₂						
I ₂ G ₁ P ₁						
I ₂ G ₁ P ₂						
I ₂ G ₂ P ₁						
I ₂ G ₂ P ₂						
I ₂ G ₃ P ₁						
I ₂ G ₃ P ₂						
I ₃ G ₁ P ₁	19.52	20.72	22.66	14.60	16.95	21.32
I ₃ G ₁ P ₂	16.55	17.55	21.49	17.55	19.18	16.39
I ₃ G ₂ P ₁	18.96	18.58	24.33	20.18	20.27	16.30
I ₃ G ₂ P ₂	22.60	21.56	22.60	16.30	16.05	22.73
I ₃ G ₃ P ₁	23.03	25.29	25.86	23.57	21.25	24.12
I ₃ G ₃ P ₂	19.76	19.42	24.63	21.33	22.81	22.39
I ₄ G ₁ P ₁						
I ₄ G ₁ P ₂						
I ₄ G ₂ P ₁						
I ₄ G ₂ P ₂						
I ₄ G ₃ P ₁						
I ₄ G ₃ P ₂						

Table 21: Effect of irrigation schedules, planting geometry and planting methods on soil moisture (%) before irrigation during 2013

Treatments	I ₄ I irrigation (16.8.2013)			I ₄ II irrigation (4.9.2013)			I ₄ III irrigation (30.9.2013)			I ₄ IV irrigation (20.10.2013)		
	0-15 cm	15-30 cm	30-60 cm	0-15 cm	15-30 cm	30-60 cm	0-15 cm	15-30 cm	30-60 cm	0-15 cm	15-30 cm	30-60 cm
Irrigation Schedule (I)												
I ₁ -IW/CPE-0.8												
I ₂ -IW/CPE-1.0												
I ₃ -IW/CPE-1.2												
I ₄ -Critical stages	25.24	26.05	28.57	21.89	22.37	22.46	23.03	23.20	23.25	24.58	25.95	27.07
Planting geometry (G)												
G ₁ -30 cm×10 cm	24.50	24.74	27.96	20.52	20.66	20.93	20.73	21.74	21.25	20.52	24.13	25.24
G ₂ -30cm ×15 cm	25.26	25.55	28.37	20.85	21.26	21.86	23.20	22.98	22.82	25.31	25.91	26.91
G ₃ -30cm ×20 cm	25.96	27.87	29.38	24.30	25.19	24.59	25.15	24.88	25.70	27.91	27.81	29.08
Planting methods (P)												
P ₁ -Dry seeds	25.29	26.67	28.49	22.06	22.46	22.51	23.30	23.69	24.32	24.80	26.87	27.30
P ₂ -Sprouted seeds	25.18	25.43	28.64	21.72	22.28	22.40	22.75	22.71	22.18	24.36	25.02	26.84
Interactions (I×G×P)												
I ₁ G ₁ P ₁												
I ₁ G ₁ P ₂												
I ₁ G ₂ P ₁												
I ₁ G ₂ P ₂												
I ₁ G ₃ P ₁												
I ₁ G ₃ P ₂												
I ₂ G ₁ P ₁												
I ₂ G ₁ P ₂												
I ₂ G ₂ P ₁												
I ₂ G ₂ P ₂												
I ₂ G ₃ P ₁												
I ₂ G ₃ P ₂												
I ₃ G ₁ P ₁												
I ₃ G ₁ P ₂												
I ₃ G ₂ P ₁												
I ₃ G ₂ P ₂												
I ₃ G ₃ P ₁												
I ₃ G ₃ P ₂												
I ₄ G ₁ P ₁	24.38	27.07	27.29	19.85	22.13	22.9	20.52	21.93	21.87	21.92	23.68	25.34
I ₄ G ₁ P ₂	24.62	22.40	28.62	21.19	19.19	18.95	20.94	21.55	20.62	19.12	24.58	25.13
I ₄ G ₂ P ₁	24.84	23.56	28.68	22.99	19.21	20.33	22.87	23.44	23.16	24.93	28.74	27.04
I ₄ G ₂ P ₂	25.67	27.54	28.06	18.71	23.30	23.38	23.52	22.52	22.47	25.69	23.07	26.77
I ₄ G ₃ P ₁	26.66	29.39	29.50	23.35	26.03	24.30	26.50	25.69	27.94	27.54	28.19	29.53
I ₄ G ₃ P ₂	25.25	26.34	29.25	25.25	24.35	24.88	23.80	24.07	23.46	28.28	27.42	28.63

Table 22: Effect of irrigation schedules, planting geometry and planting methods on soil moisture (%) before irrigation during 2014

Irrigation at 1.2 IW/CPE ratio (I_3) recorded 20.29, 21.83 and 23.53 per cent during first irrigation, 21.19, 22.75 and 24.80 per cent during second irrigation and 19.29, 20.87 and 22.59 during third irrigation (Table 23). Soil moisture of 22.37, 24.57 and 26.05 per cent during first irrigation, 24.18, 25.72 and 27.79 per cent during second irrigation and 21.90, 22.76 and 24.25 per cent during third irrigation at 0-15, 15-30 and 30-60 cm depth (Table 24) was recorded with irrigation at critical stages of crop growth (I_4).

4.1.6.2 Total water requirement (cm)

Total water use ranged from 46.38 to 55.18 cm depending on irrigation schedules (Table 25). Scheduling irrigation at critical stages of the crop growth (I_4) registered the higher total water used (55.18 cm) followed by irrigation at 1.2 IW/CPE ratio (51.47 cm). Lower water used by irrigation at 0.8 IW/CPE ratio (46.38 cm).

4.1.6.3 Water use efficiency (kg ha-cm^{-1})

The data on water use efficiency as influenced by irrigation schedules is presented in Table 26.

There was no significant influence of scheduling irrigation on water use efficiency except during second year. Where, Scheduling of irrigation at critical stages (I_4) recorded significantly higher water use efficiency ($66.65 \text{ kg ha-cm}^{-1}$) and was on par with irrigations scheduled at 1.0 IW/CPE ratio (I_2) and 1.2 IW/CPE ratio (I_3) (64.73 and $63.36 \text{ kg ha-cm}^{-1}$ respectively). Irrigations scheduled at 0.8 IW/CPE ratio (I_1) recorded the lower water use efficiency ($60.82 \text{ kg ha-cm}^{-1}$)

Sowing at 30 cm x 10 cm (G_1) recorded significantly higher water use efficiency ($78.18 \text{ kg ha-cm}^{-1}$). Whereas significantly lower water use efficiency ($59.35 \text{ kg ha-cm}^{-1}$) was observed when seeds were sown at 30 cm x 20 cm (G_3). Water use efficiency did not differ significantly due to different planting methods.

Water use efficiency differed significantly due to the interaction of scheduling of irrigation, planting geometry and methods of planting. $I_2G_1P_2$ produced significantly higher water use efficiency ($79.71 \text{ kg ha-cm}^{-1}$) and was on par with $I_4G_1P_2$ ($79.43 \text{ kg ha-cm}^{-1}$),

Table 24: Effect of irrigation schedules, planting geometry and planting methods on soil moisture (%) before irrigation during 2014

Treatments	I ₄ - I irrigation (15.9.2014)			I ₄ .II irrigation (13.10.2014)			I ₄ .III irrigation (7.11.2014)		
	0-15 cm	15-30 cm	30-60 cm	0-15 cm	15-30 cm	30-60 cm	0-15 cm	15-30 cm	30-60 cm
Irrigation Schedule (I)									
I ₁ -IW/CPE-0.8									
I ₂ -IW/CPE-1.0									
I ₃ -IW/CPE-1.2									
I ₄ -Critical stages	22.37	24.57	26.05	24.18	25.72	27.79	21.90	22.76	24.25
Planting geometry (G)									
G ₁ -30 cm×10 cm	20.18	23.26	24.74	22.55	24.17	26.13	18.96	20.17	22.59
G ₂ -30cm ×15 cm	22.44	24.96	25.55	23.32	25.38	27.96	20.45	22.44	24.02
G ₃ -30cm ×20 cm	24.49	25.50	27.87	26.67	27.63	29.29	26.28	25.67	26.13
Planting methods (P)									
P ₁ -Dry seeds	23.08	24.63	26.44	24.84	26.11	28.29	22.57	23.33	24.48
P ₂ -Sprouted seeds	21.65	24.51	25.66	23.52	25.33	27.29	21.23	22.18	24.01
Interactions- (I × G × P)									
I ₁ G ₁ P ₁									
I ₁ G ₁ P ₂									
I ₁ G ₂ P ₁									
I ₁ G ₂ P ₂									
I ₁ G ₃ P ₁									
I ₁ G ₃ P ₂									
I ₂ G ₁ P ₁									
I ₂ G ₁ P ₂									
I ₂ G ₂ P ₁									
I ₂ G ₂ P ₂									
I ₂ G ₃ P ₁									
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I ₃ G ₂ P ₁									
I ₃ G ₂ P ₂									
I ₃ G ₃ P ₁									
I ₃ G ₃ P ₂									
I ₄ G ₁ P ₁	21.10	22.84	22.40	22.99	24.56	26.80	18.91	19.89	22.95
I ₄ G ₁ P ₂	19.25	23.67	27.07	22.11	23.77	25.46	19.01	20.44	22.23
I ₄ G ₂ P ₁	23.65	25.66	27.54	24.43	25.89	28.11	21.51	21.30	24.77
I ₄ G ₂ P ₂	21.22	24.25	23.56	22.20	24.87	27.80	19.39	23.57	23.26
I ₄ G ₃ P ₁	24.50	25.38	29.39	27.10	27.89	29.95	27.28	28.80	25.73
I ₄ G ₃ P ₂	24.47	25.62	26.34	26.24	27.36	28.62	25.28	22.54	26.53

Table 25: Total water use (cm) of aerobic rice as influenced by irrigation schedules

Treatments	Common irrigation*			Effective rainfall			Irrigation water			Total water used		
	2013	2014	Pooled	2013	2014	Pooled	2013	2014	Pooled	2013	2014	Pooled
Irrigation Schedule (I)												
I ₁ -IW/CPE-0.8	6.00	6.00	6.00	30.19	32.57	31.38	12.00 (2)	6.00 (1)	9.00	48.19	44.57	46.38
I ₂ -IW/CPE-1.0	6.00	6.00	6.00	33.00	23.97	28.49	12.00 (2)	18.00 (3)	15.00	51.00	47.97	49.49
I ₃ -IW/CPE-1.2	6.00	6.00	6.00	34.57	26.37	30.47	12.00 (2)	18.00 (3)	15.00	52.57	50.37	51.47
I ₄ -Critical stages	6.00	6.00	6.00	30.48	25.88	28.18	24.00 (4)	18.00 (3)	21.00	60.48	49.88	55.18
Planting geometry (G)												
G ₁ -30 cm x 10 cm	6.00	6.00	6.00	32.06	27.20	29.63	15.00	15.00	15.00	53.06	48.20	50.63
G ₂ -30 cm x 15 cm	6.00	6.00	6.00	32.06	27.20	29.63	15.00	15.00	15.00	53.06	48.20	50.63
G ₃ -30 cm x 20 cm	6.00	6.00	6.00	32.06	27.20	29.63	15.00	15.00	15.00	53.06	48.20	50.63
Planting methods (P)												
P ₁ -Dry seeds	6.00	6.00	6.00	32.06	27.20	29.63	15.00	15.00	15.00	53.06	48.20	50.63
P ₂ -Sprouted seeds	6.00	6.00	6.00	32.06	27.20	29.63	15.00	15.00	15.00	53.06	48.20	50.63
Interactions (I×G×P)												
I ₁ G ₁ P ₁	6.00	6.00	6.00	30.19	32.57	31.38	12.00	6.00	9.00	48.19	44.57	46.38
I ₁ G ₁ P ₂	6.00	6.00	6.00	30.19	32.57	31.38	12.00	6.00	9.00	48.19	44.57	46.38
I ₁ G ₂ P ₁	6.00	6.00	6.00	30.19	32.57	31.38	12.00	6.00	9.00	48.19	44.57	46.38
I ₁ G ₂ P ₂	6.00	6.00	6.00	30.19	32.57	31.38	12.00	6.00	9.00	48.19	44.57	46.38
I ₁ G ₃ P ₁	6.00	6.00	6.00	30.19	32.57	31.38	12.00	6.00	9.00	48.19	44.57	46.38
I ₁ G ₃ P ₂	6.00	6.00	6.00	30.19	32.57	31.38	12.00	6.00	9.00	48.19	44.57	46.38
I ₂ G ₁ P ₁	6.00	6.00	6.00	33.00	23.97	28.49	12.00	18.00	15.00	51.00	47.97	49.49
I ₂ G ₁ P ₂	6.00	6.00	6.00	33.00	23.97	28.49	12.00	18.00	15.00	51.00	47.97	49.49
I ₂ G ₂ P ₁	6.00	6.00	6.00	33.00	23.97	28.49	12.00	18.00	15.00	51.00	47.97	49.49
I ₂ G ₂ P ₂	6.00	6.00	6.00	33.00	23.97	28.49	12.00	18.00	15.00	51.00	47.97	49.49
I ₂ G ₃ P ₁	6.00	6.00	6.00	33.00	23.97	28.49	12.00	18.00	15.00	51.00	47.97	49.49
I ₂ G ₃ P ₂	6.00	6.00	6.00	33.00	23.97	28.49	12.00	18.00	15.00	51.00	47.97	49.49
I ₃ G ₁ P ₁	6.00	6.00	6.00	34.57	26.37	30.47	12.00	18.00	15.00	52.57	50.37	51.47
I ₃ G ₁ P ₂	6.00	6.00	6.00	34.57	26.37	30.47	12.00	18.00	15.00	52.57	50.37	51.47
I ₃ G ₂ P ₁	6.00	6.00	6.00	34.57	26.37	30.47	12.00	18.00	15.00	52.57	50.37	51.47
I ₃ G ₂ P ₂	6.00	6.00	6.00	34.57	26.37	30.47	12.00	18.00	15.00	52.57	50.37	51.47
I ₃ G ₃ P ₁	6.00	6.00	6.00	34.57	26.37	30.47	12.00	18.00	15.00	52.57	50.37	51.47
I ₃ G ₃ P ₂	6.00	6.00	6.00	34.57	26.37	30.47	12.00	18.00	15.00	52.57	50.37	51.47
I ₄ G ₁ P ₁	6.00	6.00	6.00	30.48	25.88	28.18	24.00	18.00	21.00	60.48	49.88	55.18
I ₄ G ₁ P ₂	6.00	6.00	6.00	30.48	25.88	28.18	24.00	18.00	21.00	60.48	49.88	55.18
I ₄ G ₂ P ₁	6.00	6.00	6.00	30.48	25.88	28.18	24.00	18.00	21.00	60.48	49.88	55.18
I ₄ G ₂ P ₂	6.00	6.00	6.00	30.48	25.88	28.18	24.00	18.00	21.00	60.48	49.88	55.18
I ₄ G ₃ P ₁	6.00	6.00	6.00	30.48	25.88	28.18	24.00	18.00	21.00	60.48	49.88	55.18
I ₄ G ₃ P ₂	6.00	6.00	6.00	30.48	25.88	28.18	24.00	18.00	21.00	60.48	49.88	55.18

* For the establishment of the crop () Figures in parentheses indicate total number of irrigations

Table 26: Effect of irrigation schedules, planting geometry and planting methods on water use efficiency (kg ha-cm⁻¹) at harvest

Treatments	Grain yield (kg/ha)			Total water used (cm)			WUE (kg ha-cm ⁻¹)		
	2013	2014	Pooled	2013	2014	Pooled	2013	2014	Pooled
Irrigation Schedule (I)									
I ₁ -IW/CPE-0.8	3699b	2711c	3205c	48.19	44.57	46.38	76.77a	60.82b	69.10a
I ₂ -IW/CPE-1.0	3802b	3105b	3454b	51.00	47.97	49.49	74.55a	64.73ab	69.79a
I ₃ -IW/CPE-1.2	3901b	3191ab	3546b	52.57	50.37	51.47	74.21a	63.36ab	68.90a
I ₄ -Critical stages	4504a	3324a	3914a	60.48	49.88	55.18	74.47a	66.65a	70.93a
S.Em±	74.64	56.69	51.85				1.45	1.15	1.06
Planting geometry (G)									
G ₁ -30 cm x 10 cm	4465a	3452a	3958a	53.06	48.20	50.63	84.26a	71.55a	78.18a
G ₂ -30 cm x 15 cm	4082b	3162b	3622b	53.06	48.20	50.63	77.00b	65.54b	71.52b
G ₃ -30 cm x 20 cm	3383c	2635c	3009c	53.06	48.20	50.63	63.73c	54.58c	59.35c
S.Em±	60.49	34.6	34.05				1.06	0.73	0.68
Planting methods (P)									
P ₁ -Dry seeds	3933a	3036a	3485a	53.06	48.20	50.63	74.17a	62.92a	68.79a
P ₂ -Sprouted seeds	4020a	3130a	3575a	53.06	48.20	50.63	75.83a	64.86a	70.58a
S.Em±	48.21	37.27	31.10				0.94	0.77	0.7
Interactions- (I x G x P)									
I ₁ G ₁ P ₁	4134c-g	3014d-i	3574e-g	48.19	44.57	46.38	85.79ab	67.62a-e	77.06a-d
I ₁ G ₁ P ₂	4230 c-g	3112c-h	3671d-f	48.19	44.57	46.38	87.78a	69.82a-d	79.15a
I ₁ G ₂ P ₁	3768g-i	2747g-i	3258hi	48.19	44.57	46.38	78.19ab	61.63d-i	70.24f
I ₁ G ₂ P ₂	3852f-h	2836f-i	3344gh	48.19	44.57	46.38	79.93ab	63.63c-h	72.10 c-f
I ₁ G ₃ P ₁	3058j	2229k	2644l	48.19	44.57	46.38	63.46d	50.01k	57.00g
I ₁ G ₃ P ₂	3154j	2327jk	2741kl	48.19	44.57	46.38	65.45cd	52.21jk	59.09g
I ₂ G ₁ P ₁	4245c-g	3441a-d	3843c-e	51.00	47.97	49.49	83.24ab	71.73a-c	77.66a-c
I ₂ G ₁ P ₂	4344c-f	3545a-c	3945cd	51.00	47.97	49.49	85.18ab	73.90a	79.71a
I ₂ G ₂ P ₁	3873e-h	3148c-g	3511f-h	51.00	47.97	49.49	75.94b	65.62a-f	70.94ef
I ₂ G ₂ P ₂	3944e-g	3230b-f	3587e-g	51.00	47.97	49.49	77.33ab	67.33a-e	72.49c-f
I ₂ G ₃ P ₁	3162j	2588i-k	2875j-l	51.00	47.97	49.49	62.00d	53.95i-k	58.10g
I ₂ G ₃ P ₂	3245ij	2680h-j	2963jk	51.00	47.97	49.49	63.63d	55.87g-k	59.87g
I ₃ G ₁ P ₁	4333c-g	3519a-c	3926cd	52.57	50.37	51.47	82.42ab	69.86a-d	76.28a-e
I ₃ G ₁ P ₂	4434b-e	3625ab	4030bc	52.57	50.37	51.47	84.34ab	71.97a-c	78.29ab
I ₃ G ₂ P ₁	3965e-g	3228b-f	3597e-g	52.57	50.37	51.47	75.42bc	64.09b-g	69.88f
I ₃ G ₂ P ₂	4050d-g	3322a-e	3686d-f	52.57	50.37	51.47	77.04ab	65.95a-f	71.61d-f
I ₃ G ₃ P ₁	3274ij	2683h-j	2979jk	52.57	50.37	51.47	62.28d	53.27i-k	57.87g
I ₃ G ₃ P ₂	3352h-j	2771g-i	3062ij	52.57	50.37	51.47	63.76d	55.01h-k	59.48g
I ₄ G ₁ P ₁	4958ab	3633ab	4296ab	60.48	49.88	55.18	81.98ab	72.83ab	77.85a-c
I ₄ G ₁ P ₂	5043a	3723a	4383a	60.48	49.88	55.18	83.38ab	74.64a	79.43a
I ₄ G ₂ P ₁	4560a-d	3350a-e	3955cd	60.48	49.88	55.18	75.40bc	67.16a-e	71.67d-f
I ₄ G ₂ P ₂	4643a-c	3438a-d	4041bc	60.48	49.88	55.18	76.77ab	68.93a-d	73.22b-f
I ₄ G ₃ P ₁	3866e-h	2855f-i	3361gh	60.48	49.88	55.18	63.92d	57.24f-k	60.90g
I ₄ G ₃ P ₂	3954e-g	2947e-i	3451f-h	60.48	49.88	55.18	65.38cd	59.08e-j	62.53g
S.Em±	167	129.1	90.4				3.26	2.67	1.74

Means followed by the same alphabet do not differ significantly by DMRT (0.05)

$I_1G_1P_2$ (79.15 kg ha-cm⁻¹), $I_3G_1P_2$ (78.29 kg ha-cm⁻¹), $I_4G_1P_1$ (77.85 kg ha-cm⁻¹), $I_2G_1P_1$ (77.66 kg ha-cm⁻¹), $I_1G_1P_1$ (77.06 kg ha-cm⁻¹) and $I_3G_1P_1$ (76.28 kg ha-cm⁻¹). Significantly lower water use efficiency was noticed in $I_1G_3P_1$ (57.00 kg ha-cm⁻¹) as compared to other treatment combinations.

4.1.7 Economic Analysis

4.1.7.1 Net returns

Net returns of aerobic rice as influenced by scheduling of irrigation, planting geometry and methods of planting and their interaction effects is presented in Table 27.

Among the irrigation schedules, significantly higher net returns (₹ 32,917 ha⁻¹) was recorded with irrigation at critical stages (I_4). However, irrigation at IW/CPE of 0.8 (I_1) resulted in lower net returns (₹ 22,229 ha⁻¹). Among the planting geometry, sowing at 30 cm x 10 cm (G_1) recorded in significantly higher net returns (₹ 33,909 ha⁻¹) where as significantly lower net returns (₹ 18,838 ha⁻¹) was observed when seeds were sown at 30 cm x 20 cm (G_3) on pooled basis. Net returns did not differ significantly due to different planting methods.

Interaction effects of scheduling of irrigation, planting geometry and methods of planting influenced the net returns significantly. Treatment combination $I_4G_1P_2$ (sowing of sprouted seeds at 30 cm x 10 cm with irrigation at critical stages) produced significantly higher net returns (₹ 40,482 ha⁻¹) and was on par with $I_4G_1P_1$ (₹ 39,024 ha⁻¹). Significantly lower net returns (₹ 13,409 ha⁻¹) was observed with $I_1G_3P_1$ (sowing of dry seeds at 30 cm x 20 cm with irrigation at IW/CPE of 0.8). Lower net returns were observed during second year when compared to first year.

4.1.7.2 Benefit: cost

Benefit: cost of aerobic rice significantly influenced by scheduling of irrigation, planting geometry and methods of planting and their interactions (Table 27).

Among the irrigation schedules, significantly higher Benefit:cost of 2.21 was recorded with irrigation at critical stages (I_4). However, irrigation at IW/CPE of 0.8 (I_1) resulted in lower Benefit: cost of 1.83 on pooled basis. Among the planting geometry,

Table 27: Effect of irrigation schedules, planting geometry and planting methods on economics of aerobic rice

Treatments	Gross Returns (₹)			Cost of cultivation (₹)			Net returns (₹)			BCratio		
	2013	2014	Pooled	2013	2014	Pooled	2013	2014	Pooled	2013	2014	Pooled
Irrigation Schedule (I)												
I ₁ -IW/CPE-0.8	56320b	42100 c	49210 c	26106	27856	26981	30214b	14244c	22229c	2.16b	1.51c	1.83c
I ₂ -IW/CPE-1.0	57927b	48268b	53097b	26106	28356	27231	31820b	19911b	25866b	2.22b	1.70b	1.96b
I ₃ -IW/CPE-1.2	59467b	49635ab	54551b	26106	28356	27231	33361b	21279ab	27320b	2.28b	1.75ab	2.01b
I ₄ -Critical stages	68882a	51915a	60399a	26606	28356	27481	42276a	23559a	32917a	2.59a	1.83a	2.21a
S.Em±	1033	807	693				1033	807	693	0.04	0.02	0.02
Planting geometry (G)												
G ₁ -30 cm x 10 cm	68525a	54129a	61327a	26418	28418	27418	42107a	25711a	33909a	2.59a	1.90a	2.25a
G ₂ -30 cm x 15 cm	62213b	49178b	55696b	26194	28194	27194	36019b	20984b	28502b	2.37b	1.74b	2.06b
G ₃ -30 cm x 20 cm	51208c	40631c	45920 c	26082	28082	27082	25126c	12549c	18838c	1.96c	1.45c	1.70 c
S.Em±	864	470	477				864	470	477	0.03	0.02	0.02
Planting methods (P)												
P ₁ -Dry seeds	59959a	47231a	53595a	26231	28231	27231	33728a	18999a	26364a	2.28a	1.67a	1.98a
P ₂ -Sprouted seeds	61338a	48728a	55033a	26231	28231	27231	35107a	20497a	27802a	2.34a	1.72a	2.03a
S.Em±	681	541	496				681	541	496	0.03	0.02	0.02
Interactions (I×G×P)												
I ₁ G ₁ P ₁	63312c-f	47150f-j	55231de	26293	28043	27168	37019c-h	19107e-i	28063d-f	2.41c-g	1.68f-i	2.04d-f
I ₁ G ₁ P ₂	64825c-f	48722e-i	56774cd	26293	28043	27168	38532c-h	20679c-h	29606c-e	2.47c-g	1.74d-h	2.10 c-e
I ₁ G ₂ P ₁	57311fg	42613i-k	49962fg	26069	27819	26944	31242hi	14794h-j	23018gh	2.20g	1.53i-k	1.87fg
I ₁ G ₂ P ₂	58620ef	44022h-k	51321ef	26069	27819	26944	32551f-h	16203g-j	24377fg	2.25g	1.58g-k	1.92ef
I ₁ G ₃ P ₁	46194h	34288m	40241j	25957	27707	26832	20237j	6581l	13409k	1.78h	1.24m	1.51i
I ₁ G ₃ P ₂	47657h	35807lm	41732ij	25957	27707	26832	21700j	8100kl	14900jk	1.84h	1.29lm	1.56hi
I ₂ G ₁ P ₁	65055c-f	53873a-e	59464bc	26293	28543	27418	38762c-h	25330a-e	32046b-d	2.47c-g	1.89a-e	2.18cd
I ₂ G ₁ P ₂	66615c-f	55546a-c	61081b	26293	28543	27418	40322c-f	27003a-c	33663bc	2.53c-f	1.95a-c	2.24bc
I ₂ G ₂ P ₁	58947ef	48873d-i	53910d-f	26069	28319	27194	32878f-h	20554d-h	26716e-g	2.26fg	1.73e-h	1.99d-f
I ₂ G ₂ P ₂	60067ef	50186c-h	55127de	26069	28319	27194	33998e-h	21867c-g	27933d-f	2.30fg	1.77c-g	2.04d-f
I ₂ G ₃ P ₁	47794h	39839k-m	43817h-j	25957	28207	27082	21837j	11632j-l	16735i-k	1.84h	1.41k-m	1.63hi
I ₂ G ₃ P ₂	49081h	41289j-l	45185hi	25957	28207	27082	23124j	13082i-k	18103ij	1.89h	1.46j-l	1.68hi
I ₃ G ₁ P ₁	66447c-e	55138a-d	60793b	26293	28543	27418	40154c-g	26595a-d	33375bc	2.53c-f	1.93a-d	2.23c
I ₃ G ₁ P ₂	68031cd	56835ab	62433b	26293	28543	27418	41738c-e	28292ab	35015b	2.59c-e	1.99ab	2.29bc
I ₃ G ₂ P ₁	60379d-f	50147c-h	55263de	26069	28319	27194	34310e-h	21828c-g	28069d-f	2.32e-g	1.77c-g	2.04d-f
I ₃ G ₂ P ₂	61714d-f	51649b-g	56682cd	26069	28319	27194	35645d-h	23330b-f	29488c-e	2.37d-g	1.82b-f	2.10 c-e
I ₃ G ₃ P ₁	49519h	41335j-l	45427hi	25957	28207	27082	23562j	13128i-k	18345ij	1.91h	1.47j-l	1.69hi
I ₃ G ₃ P ₂	50712gh	42705i-k	46709gh	25957	28207	27082	24755ij	14498h-j	19627hi	1.95h	1.51i-k	1.73gh
I ₄ G ₁ P ₁	76254ab	57129ab	66692a	26793	28543	27668	49461ab	28586ab	39024a	2.85ab	2.00ab	2.42ab
I ₄ G ₁ P ₂	77662a	58637a	68150a	26793	28543	27668	50869a	30094a	40482a	2.90a	2.05a	2.48a
I ₄ G ₂ P ₁	69654bc	52239b-f	60947b	26569	28319	27444	43085b-d	23920a-e	33503bc	2.62b-d	1.84b-f	2.23c
I ₄ G ₂ P ₂	71015a-c	53697a-e	62356b	26569	28319	27444	44446a-c	25378a-e	34912b	2.67a-c	1.90a-e	2.28bc
I ₄ G ₃ P ₁	58647ef	44145h-k	51396ef	26457	28207	27332	32190gh	15938g-j	24064fg	2.22g	1.57h-k	1.89fg
I ₄ G ₃ P ₂	60061ef	45642g-k	52852d-f	26457	28207	27332	33604f-h	17435f-j	25520e-g	2.27fg	1.62g-j	1.94ef
S.Em±	2361	1876	1303				2361	1876	1303	0.08	0.05	0.05

Means followed by the same alphabet do not differ significantly by DMRT (0.05)

sowing at 30 cm x 10 cm (G_1) recorded in significantly higher Benefit: cost of 2.25 where as significantly lower Benefit: cost of 1.70 was observed when seeds were sown at 30 cm x 20 cm (G_3) on pooled basis. Benefit: cost did not differ significantly due to different planting methods.

Interaction effects of scheduling of irrigation, planting geometry and methods of planting influenced the net returns significantly. Treatment combination $I_4G_1P_2$ (sowing of sprouted seeds at 30 cm x 10 cm with irrigation at critical stages) produced significantly higher Benefit: cost of 2.48 and was on par with $I_4G_1P_1$ (2.42). Significantly lower Benefit: cost of 1.51 was observed with $I_1G_3P_1$ (sowing of dry seeds at 30 cm x 20 cm with irrigation at IW/CPE of 0.8). Lower Benefit: cost was observed during second year when compared to first year.

4.1.8 Correlation coefficient (r)

The grain yield exhibited significant positive correlation with growth parameters like plant height at 90 DAS ($r=0.929$), number of tillers hill⁻¹ at 90 DAS ($r=0.905$), leaf area at 90 DAS ($r=0.858$), leaf area index at 90 DAS ($r=0.858$) and total dry matter accumulation at harvest ($r=0.995$) indicating that the grain yield was greatly determined by these traits (Table 28).

Among the yield parameters, the grain yield showed significant positive correlation with number of productive tillers m⁻² ($r=0.936$) and straw yield ($r=0.992$). While it exhibited negative correlation with panicle length ($r=0.367$), panicle weight ($r=0.518$), thousand grain weight ($r=0.511$) and number of filled grains panicle⁻¹ ($r=0.332$). Water use efficiency ($r=0.879$) showed significant positive influence on the grain yield.

Table 28: Correlation for yield with growth and yield parameters and water use efficiency as influenced by irrigation schedules, planting geometry and planting methods at different growth stages of aerobic rice

Sl. No.	Parameters	Correlation coefficient (r)
Growth parameters		
1	Plant height at 90 DAS	0.929**
2	Number of tillers m ⁻² at 90 DAS	0.905**
3	Leaf Area at 90 DAS	0.858**
4	Leaf Area Index at 90 DAS	0.858**
5	Total Dry Matter m ⁻² at harvest	0.995**
Yield parameters		
6	Number of productive tillers m ⁻²	0.936**
7	Panicle length (cm)	-0.367
8	Panicle weight (g)	-0.518**
9	1000 grain weight (g)	-0.511*
10	Number of filled grains per panicle	-0.332
11	Straw yield	0.992**
12	Water use efficiency	0.879**

**Correlation is significant at P = 0.01 level (2-tailed)

*Correlation is significant at P = 0.05 level (2-tailed)

4.2 Experiment–II: Studies on integrated organic nutrient management on growth, yield and quality of aerobic rice in Northern transitional zone of Karnataka

4.2.1 Growth parameters

4.2.1.1 Plant height (cm)

Plant height of aerobic rice recorded at different growth stages as influenced by manurial practices and liquid organic manures is furnished in Table 29. The pooled data on plant height indicated that the plant height varied significantly across manurial practices and liquid organic manures under evaluation and their interactions at all growth stages.

Irrespective of liquid organic manures, application of RDF + FYM + microbial consortium (M_2) recorded significantly higher plant height over rest of the treatments at 30, 60 and 90 DAS and at harvest (14.83, 38.78, 53.33 and 63.97 cm, respectively) but, was at par with application of RDF (M_1) at 30, 60 DAS and at harvest (13.60, 36.28 and 62.00 cm, respectively). Significantly lower plant height was recorded with application of FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN (M_3) at 30, 60 and 90 DAS and at harvest (9.54, 28.41, 42.70 and 56.05 cm, respectively).

Among the liquid organic manures, soil application of biodigester @ 2500 l ha⁻¹ at 30, 60 and 90 DAS (L_3) recorded significantly higher plant height at 30, 60 and 90 DAS and at harvest (12.56, 34.78, 49.39 and 61.65 cm, respectively) but was at par with foliar application of cow urine @ 500 l ha⁻¹ at 30, 60 and 90 DAS (L_2) at 30, 60 and 90 DAS and at harvest (11.96, 33.93, 48.75 and 60.52 cm, respectively). Significantly lower plant height was recorded with control (L_4) at 30, 60 and 90 DAS and at harvest (11.17, 31.07, 45.36 and 57.13 cm, respectively).

Among the treatment combinations, integrated application of RDF + FYM + microbial consortium with soil application of biodigester @ 2500 l ha⁻¹ at 30, 60 and 90 DAS and at harvest (M_2L_3) recorded significantly higher plant height (15.68, 40.07, 54.75 and 65.62 cm, respectively) but was at par with other treatment combinations

Table 29: Effect of manurial practices and liquid organic manures on plant height (cm) at different growth stages of crop growth

Treatments	30 DAS			60 DAS			90 DAS			Harvest		
	2013	2014	Pooled	2013	2014	Pooled	2013	2014	Pooled	2013	2014	Pooled
Manurial practices (M)												
M ₁ -RDF (100:50:50 kg N, P ₂ O ₅ , K ₂ O ha ⁻¹)	14.46ab	12.75a	13.60a	36.98ab	35.58ab	36.28ab	50.36ab	51.08ab	50.72b	62.11ab	61.88ab	62.00ab
M ₂ -RDF+FYM+MC	16.08a	13.58a	14.83a	39.52a	38.04a	38.78a	52.63a	54.03a	53.33a	63.97a	63.97a	63.97a
M ₃ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN	10.10d	8.98b	9.54d	29.26e	27.56d	28.41e	42.16e	43.25c	42.70d	56.06d	56.04b	56.05d
M ₄ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN+MC	11.03cd	9.14b	10.08cd	31.23de	28.73cd	29.98de	44.17de	44.60 c	44.38d	57.36cd	57.34ab	57.35cd
M ₅ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN+FYM	12.72bc	9.56b	11.14bc	33.80 cd	31.01cd	32.40 cd	46.83cd	48.28b	47.55c	59.07b-d	58.83ab	58.95b-d
M ₆ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN+FYM+MC	13.51b	9.80b	11.65b	35.47bc	32.13bc	33.80bc	48.14bc	49.29b	48.72bc	60.58bc	60.01ab	60.30bc
S.Em±	0.69	0.35	0.42	0.86	1.29	0.87	0.85	1.03	0.71	1.02	2.05	0.95
Liquid organic manures (L)												
L ₁ -Jeevamrut @ 500 litres ha ⁻¹ at 30, 60 and 90 DAS	12.71ab	10.39bc	11.55bc	34.21ab	32.44a	33.33b	47.52ab	48.69a	48.11a	59.68ab	59.87ab	59.77ab
L ₂ -Cow urine @ 500 litres ha ⁻¹ at 30, 60and 90 DAS	13.12ab	10.80ab	11.96ab	34.87a	32.98a	33.93ab	48.14a	49.36a	48.75a	60.49ab	60.54ab	60.52a
L ₃ -Bio digester @ 2500 litres ha ⁻¹ at 30, 60 and 90 DAS	13.64a	11.48a	12.56a	35.76a	33.80a	34.78a	48.64a	50.14a	49.39a	61.82a	61.49a	61.65a
L ₄ -Control (no liquid manure application)	12.47b	9.87c	11.17c	32.67b	29.47b	31.07c	45.22b	45.49b	45.36b	57.44b	56.81b	57.13b
S.Em±	0.35	0.27	0.25	0.61	0.64	0.45	0.8	0.59	0.57	1.28	1.27	0.97
Interactions- (M X L)												
M ₁ L ₁	14.20a-f	12.37bc	13.28b-e	36.77a-g	35.63a-e	36.20b-f	50.33a-c	51.23a-e	50.78a-e	62.60ab	62.23ab	62.42a-d
M ₁ L ₂	14.50a-f	12.77ab	13.63b-d	37.13a-f	36.23a-d	36.68a-f	51.27ab	51.87a-d	51.57a-d	62.93ab	62.77ab	62.85a-c
M ₁ L ₃	15.10a-e	13.93ab	14.52a-c	38.50a-c	36.97a-c	37.73a-d	51.60ab	52.83a-d	52.22a-d	63.53ab	63.37ab	63.45a-c
M ₁ L ₄	14.03a-g	11.93b-d	12.98c-f	35.53a-h	33.47b-f	34.50d-h	48.23a-f	48.37d-j	48.30d-i	59.37ab	59.17ab	59.27a-e
M ₂ L ₁	15.37a-d	13.27ab	14.32a-c	39.40ab	38.33ab	38.87a-c	53.10a	54.30a-c	53.70a-c	63.53ab	64.47a	64.00a-c
M ₂ L ₂	16.27ab	13.77ab	15.02ab	39.90ab	38.97a	39.43ab	53.27a	54.93ab	54.10ab	64.27ab	64.93a	64.60ab
M ₂ L ₃	16.73a	14.63a	15.68a	40.50a	39.63a	40.07a	53.73a	55.77a	54.75a	65.70a	65.53a	65.62a
M ₂ L ₄	15.97a-c	12.63ab	14.30a-c	38.27a-d	35.23a-e	36.75a-e	50.43a-c	51.13a-e	50.78a-e	62.37ab	60.93ab	61.65a-e
M ₃ L ₁	9.93j	8.77e	9.35j-l	29.20kl	27.93g-i	28.57l-n	42.63e-g	43.63j-l	43.13kl	55.90ab	56.23ab	56.07c-e
M ₃ L ₂	10.20ij	9.10e	9.65j-l	29.83j-l	28.47f-i	29.15k-n	42.87e-g	44.27j-l	43.57j-l	56.33ab	56.77ab	56.55b-e
M ₃ L ₃	10.63h-j	9.63e	10.13h-l	30.50i-l	28.97f-i	29.73j-m	43.27d-g	44.97h-k	44.12i-l	57.67ab	57.83ab	57.75a-e
M ₃ L ₄	9.63j	8.40e	9.02l	27.50l	24.87i	26.18n	39.87g	40.13l	40.00l	54.33b	53.33b	53.83e
M ₄ L ₁	11.03h-j	8.93e	9.98h-l	31.30h-l	28.97f-i	30.13j-m	44.33c-g	44.77h-k	44.55h-k	57.73ab	56.47ab	57.10b-e
M ₄ L ₂	11.27g-j	9.43e	10.35g-l	31.90g-l	29.47f-i	30.68i-m	44.87b-g	45.63f-k	45.25g-k	58.30ab	57.97ab	58.13a-e
M ₄ L ₃	11.87f-j	9.97de	10.92g-l	32.50e-k	30.63e-h	31.57h-l	45.37b-g	46.37e-k	45.87f-k	59.47ab	59.77ab	59.62a-e
M ₄ L ₄	9.93j	8.23e	9.08kl	29.23kl	25.83hi	27.53mn	42.10fg	41.63kl	41.87kl	53.93b	55.17ab	54.55be
M ₅ L ₁	12.47d-j	9.37e	10.92g-l	33.37d-k	31.33d-g	32.35g-k	47.10a-f	48.60d-i	47.85d-j	58.63ab	59.33ab	58.98a-e
M ₅ L ₂	12.93d-i	9.77e	11.35e-j	34.37c-j	31.77c-g	33.07f-j	47.50a-f	49.23d-h	48.37d-i	59.97ab	59.87ab	59.92a-e
M ₅ L ₃	13.27c-h	10.23de	11.75d-h	35.10b-i	32.83c-g	33.97e-i	48.20a-f	49.97c-g	49.08c-h	61.33ab	60.77ab	61.05a-e
M ₅ L ₄	12.20e-j	8.87e	10.53g-l	32.37f-l	28.10g-i	30.23j-m	44.50 c-g	45.33g-k	44.92h-k	56.33ab	55.33ab	55.83c-e
M ₆ L ₁	13.23c-h	9.63e	11.43e-i	35.20b-i	32.47c-g	33.83e-i	47.60a-f	49.63c-h	48.62d-i	59.67ab	60.47ab	60.07a-e
M ₆ L ₂	13.53b-h	9.97de	11.75d-h	36.10a-h	32.97c-g	34.53d-h	49.10a-e	50.23d-f	49.67b-g	61.13ab	60.97ab	61.05a-e
M ₆ L ₃	14.23a-f	10.47c-e	12.35d-g	37.47a-e	33.77b-f	35.62c-g	49.67a-d	50.93b-e	50.30a-f	63.20ab	61.67ab	62.43a-d
M ₆ L ₄	13.03d-i	9.13e	11.08f-k	33.10e-k	29.33f-i	31.22h-g	46.20b-g	46.37e-k	46.28e-k	58.33ab	56.93ab	57.63a-e
S.Em±	0.86	0.66	0.61	1.48	1.57	1.09	1.96	1.44	1.39	3.15	3.12	2.38

Means followed by the same alphabet do not differ significantly by DMRT (0.05)

except, M₃L₁, M₃L₂, M₃L₄, M₄L₁, M₄L₄ and M₅L₄ at harvest. Significantly lower plant height was recorded with M₃L₄ (9.02, 26.18, 40.00 and 53.83 cm, respectively) at 30, 60 and 90 DAS and at harvest.

4.2.1.2 Number of tillers (m⁻²)

Number of tillers varied significantly due to manurial practices and liquid organic manures under experimentation and their interactions at all growth stages (Table 30).

Irrespective of liquid organic manures, application of RDF + FYM + microbial consortium (M₂) recorded significantly higher number of tillers at 30, 60 and 90 DAS and at harvest (157.58, 435.70, 510.50 and 604.10, respectively). Significantly lower number of tillers was recorded with application of FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN (M₃) at 30, 60 and 90 DAS and at harvest (92.58, 334.41, 383.48 and 420.70, respectively).

Soil application of biodigester @ 2500 l ha⁻¹ at 30, 60 and 90 DAS recorded significantly higher number of tillers at 30, 60 and 90 DAS and at harvest (133.57, 402.92, 457.98 and 519.45, respectively) but was at par with foliar application of cow urine @ 500 l ha⁻¹ at 60 and 90 DAS (387.99 and 441.81, respectively). Significantly lower number of tillers was recorded with control at 30, 60 and 90 DAS and at harvest (108.14, 356.01, 405.64 and 464.64, respectively).

Among the treatment combinations, integrated application of RDF + FYM + microbial consortium with soil application of biodigester @ 2500 l ha⁻¹ at 30, 60 and 90 DAS and at harvest recorded significantly higher number of tillers (173.32, 466.62, 537.72 and 621.42, respectively) but was at par with other treatment combinations M₂L₂ (616.23) M₂L₁ (602.16) and M₁L₃ (584.39) at harvest. Significantly lower number of tillers were recorded with M₃L₄ (82.95, 312.56, 364.41 and 388.11, respectively) at 30, 60 and 90 DAS and at harvest.

4.2.1.3 Leaf area (dm² m⁻²)

Among the manurial practices, application of RDF + FYM + microbial consortium (M₂) recorded significantly higher leaf area at 30, 60 and 90 DAS over rest

Table 30: Effect of manurial practices and liquid organic manures on number of tillers m⁻² at different growth stages of crop growth

Treatments	30 DAS			60 DAS			90 DAS			Harvest		
	2013	2014	Pooled	2013	2014	Pooled	2013	2014	Pooled	2013	2014	Pooled
Manurial practices (M)												
M ₁ -RDF (100:50:50 kg N, P ₂ O ₅ , K ₂ O ha ⁻¹)	150.36b	129.99b	140.17b	416.25a	431.81a	424.03a	455.88b	474.03b	464.95b	550.69b	565.50a	558.09b
M ₂ -RDF+FYM+MC	169.61a	145.54a	157.58a	426.25a	445.14a	435.70a	509.21a	511.80a	510.50a	603.64a	604.38a	604.01a
M ₃ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN	92.58e	92.58e	92.58f	332.93c	335.89b	334.41d	374.78d	392.18d	383.48e	414.40d	426.99d	420.70d
M ₄ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN+MC	97.40e	104.43d	100.92e	344.41bc	347.74b	346.08cd	388.85d	404.03cd	396.44de	418.11d	441.07cd	429.59d
M ₅ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN+FYM	110.36d	108.14d	109.25d	361.08bc	368.11b	364.59bc	408.48cd	422.18cd	415.33cd	463.29c	482.54bc	472.92c
M ₆ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN+FYM+MC	119.99c	119.62c	119.80 c	373.67b	376.63b	375.15b	430.70bc	435.51c	433.10 c	476.99c	494.40b	485.69c
S.Em±	2.51	2.15	2.02	11.91	12.22	8.51	12.45	10.17	8.98	6.16	13.76	5.19
Liquid organic manures (L)												
L ₁ -Jeevamrut @ 500 litres ha ⁻¹ at 30, 60 and 90 DAS	120.48bc	110.61c	115.54c	366.88bc	379.22bc	373.05bc	422.67bc	438.23b	430.45b	481.93ab	503.65b	492.79b
L ₂ -Cow urine @ 500 litres ha ⁻¹ at 30, 60and 90 DAS	125.42b	120.48b	122.95b	384.90ab	391.07ab	387.99ab	433.29ab	450.33ab	441.81ab	491.31ab	516.24ab	503.78b
L ₃ -Bio digester @ 2500 litres ha ⁻¹ at 30, 60 and 90 DAS	133.07a	134.06a	133.57a	398.73a	407.12a	402.92a	449.09a	466.87a	457.98a	506.12a	532.79a	519.45a
L ₄ -Control (no liquid manure application)	114.56c	101.72d	108.14d	352.56c	359.47c	356.01c	406.87c	404.40 c	405.64c	472.05b	457.24c	464.64c
S.Em±	2.35	2.01	1.48	7.12	8.69	6.03	7.8	7.12	5.64	9.7	7.77	4.95
Interactions- (M X L)												
M ₁ L ₁	148.13c-e	124.43d-h	136.28de	408.85a-e	428.11a-d	418.48b-e	453.29b-e	478.47b-f	465.88c-f	540.69a-c	562.91b-f	551.80 cd
M ₁ L ₂	152.58cd	131.84c-f	142.21c-e	425.14a-d	439.96a-c	432.55a-d	454.77b-e	488.84b-e	471.80 c-e	546.61ab	577.72a-e	562.17cd
M ₁ L ₃	157.02b-d	145.17bc	151.10 c	429.59a-c	456.25ab	442.92a-c	481.43a-d	496.25a-d	488.84b-d	580.68a	588.09a-d	584.39a-c
M ₁ L ₄	143.69de	118.51f-i	131.10ef	401.44a-f	402.92b-f	402.18c-f	434.03c-h	432.55e-k	433.29e-i	534.76a-c	533.28d-h	534.02de
M ₂ L ₁	162.95bc	139.25b-d	151.10 c	410.33a-e	439.96a-c	425.14a-d	502.17ab	514.02a-c	508.10a-c	596.98a	607.35a-c	602.16ab
M ₂ L ₂	173.32ab	151.10ab	162.21b	448.84ab	454.77ab	451.81ab	521.43a	527.35ab	524.39ab	610.31a	622.16ab	616.23a
M ₂ L ₃	183.69a	162.95a	173.32a	454.77a	478.47a	466.62a	528.84a	546.61a	537.72a	613.27a	629.57a	621.42a
M ₂ L ₄	158.50b-d	128.88d-g	143.69cd	391.07c-h	407.37b-e	399.22c-g	484.40a-c	459.21c-h	471.80 c-e	594.01a	558.46c-g	576.24bc
M ₃ L ₁	90.36ij	84.44lm	87.40lm	331.82h-j	330.34f-h	331.08ij	373.30g-i	385.15j-l	379.22j-l	414.77d-f	429.59l-n	422.18jk
M ₃ L ₂	94.81h-j	96.29j-l	95.55kl	334.78h-j	343.67e-h	339.23h-j	376.26g-i	398.48i-l	387.37i-l	416.25d-f	435.51l-n	425.88jk
M ₃ L ₃	99.25h-j	109.62h-j	104.43jk	354.04e-j	355.52e-h	354.78f-j	388.11f-i	417.74g-l	402.92h-l	431.07d-f	462.18i-l	446.62h-j
M ₃ L ₄	85.92j	79.99m	82.95m	311.08j	314.04h	312.56j	361.45i	367.37l	364.41l	395.52ef	380.70n	388.11k
M ₄ L ₁	94.81h-j	97.77j-l	96.29kl	330.34ij	343.67e-h	337.00h-j	376.26g-i	399.96h-l	388.11i-l	411.81ef	438.47k-n	425.14jk
M ₄ L ₂	99.25h-j	106.66i-k	102.95jk	345.15f-j	354.04e-h	349.59g-j	388.11f-i	410.33g-l	399.22h-l	426.62d-f	451.81j-m	439.22ij
M ₄ L ₃	108.14g-i	127.39d-g	117.77gh	374.78c-i	365.89d-h	370.33e-i	419.22d-i	429.59f-k	424.40f-j	439.96d-f	479.95h-l	459.95g-j
M ₄ L ₄	87.40j	85.92lm	86.66lm	327.37ij	327.37gh	327.37ij	371.81hi	376.26kl	374.04kl	394.03f	394.03mn	394.03k
M ₅ L ₁	108.14g-i	103.69i-k	105.92i-k	355.52e-j	361.45d-h	358.48f-j	410.33e-i	417.74g-l	414.03g-k	454.77d-f	484.40h-l	469.58g-i
M ₅ L ₂	111.10gh	114.06g-i	112.58g-j	368.85d-j	371.81c-h	370.33e-i	420.70 c-i	436.99e-j	428.85e-i	471.06b-f	499.21g-k	485.14f-h
M ₅ L ₃	118.51fg	122.95e-h	120.73fg	382.18c-i	388.11b-g	385.15d-h	428.11c-h	448.84d-i	438.47e-h	475.51b-f	512.54f-j	494.02fg
M ₅ L ₄	103.69g-j	91.84k-m	97.77kl	337.74g-j	351.08e-h	344.41h-j	374.78g-i	385.15j-l	379.96j-l	451.81d-f	434.03l-n	442.92ij
M ₆ L ₁	118.51fg	114.06g-i	116.28g-i	364.41e-j	371.81c-h	368.11f-i	420.70 c-i	434.03e-k	427.36e-i	472.55b-f	499.21g-k	485.88f-h
M ₆ L ₂	121.47fg	122.95e-h	122.21fg	386.63c-i	382.18c-h	384.41d-h	438.47c-g	439.96d-j	439.22e-h	476.99b-e	511.06f-j	494.02fg
M ₆ L ₃	131.84ef	136.28b-e	134.06de	397.00b-g	398.48b-g	397.74c-g	448.84b-f	462.18c-g	455.51d-g	496.25b-d	524.39e-i	510.32ef
M ₆ L ₄	108.14g-i	105.17i-k	106.66h-k	346.63f-j	354.04e-h	350.34g-j	414.77e-i	405.89g-l	410.33g-l	462.18c-f	442.92k-n	452.55h-j
S.Em±	5.75	4.93	3.63	17.45	21.29	14.78	19.11	17.45	13.82	23.93	19.05	12.15

Means followed by the same alphabet do not differ significantly by DMRT (0.05)

of the treatments (19.02, 192.54 and 277.96 dm²). Significantly lower leaf area was recorded with application of FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN (M₃) at 30, 60 and 90 DAS over rest of the treatments (16.41, 162.87 and 217.50 dm²) (Table 31).

Among the liquid organic manures, soil application of biodigester @ 2500 l ha⁻¹ (L₃) at 60 and 90 DAS recorded significantly higher leaf area (185.14 and 265.44 dm², respectively). Significantly lower leaf area at 60 and 90 DAS was recorded with control (167.73 and 229.45 dm², respectively).

Among the treatment combinations, integrated application of RDF + FYM + microbial consortium with soil application of biodigester @ 2500 l ha⁻¹ at 30, 60 and 90 DAS (M₂L₃) recorded significantly higher leaf area at 30, 60 and 90 DAS (19.75, 204.05 and 295.26 dm²) but was at par with M₂L₂ (283.60 dm²), M₁L₃ (275.41 dm²), M₆L₃ (274.46 dm²) and M₂L₁ (272.25 dm²) at 90 DAS. Significantly lower leaf area was recorded with M₃L₄ at 30, 60 and 90 DAS (15.97, 156.38 and 199.16 dm², respectively).

4.2.1.4 Leaf area index (LAI)

The data on leaf area index as influenced by manurial practices and liquid organic manures and their interactions at 30, 60 and 90 DAS is furnished in Table 32.

Irrespective of liquid organic manures, application of RDF + FYM + microbial consortium (M₂) recorded significantly higher leaf area index at 30, 60 and 90 DAS over rest of the treatments (0.190, 1.926 and 2.780, respectively). Significantly lower leaf area index was recorded with application of FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN (M₃) at 30, 60 and 90 DAS (0.164, 1.629 and 2.175 respectively).

Among the liquid organic manures, soil application of biodigester @ 2500 l ha⁻¹ (L₃) at 60 and 90 DAS recorded significantly higher leaf area index (1.852 and 2.655, respectively). However, significantly lower leaf area index at 60 and 90 DAS was recorded with control (1.677 and 2.295 respectively).

Among the treatment combinations, integrated application of RDF + FYM + microbial consortium with soil application of biodigester @ 2500 l ha⁻¹ at 30, 60 and

Table 31: Effect of manurial practices and liquid organic manures on leaf area ($\text{dm}^2 \text{m}^{-2}$) at different growth stages of crop growth

Treatments	30 DAS			60 DAS			90 DAS		
	2013	2014	Pooled	2013	2014	Pooled	2013	2014	Pooled
Manurial practices (M)									
M ₁ -RDF (100:50:50 kg N, P ₂ O ₅ , K ₂ O ha ⁻¹)	18.98ab	17.33ab	18.16b	183.15ab	176.80ab	179.97b	262.67a	247.64b	255.16b
M ₂ -RDF+FYM+MC	20.04a	17.99a	19.02a	194.18a	190.90a	192.54a	280.65a	275.28a	277.96a
M ₃ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN	17.28b	15.54c	16.41c	164.45c	161.29b	162.87d	222.12c	212.87c	217.50 c
M ₄ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN+MC	17.50b	15.79bc	16.64c	168.41bc	166.26b	167.33cd	231.49bc	219.84c	225.67c
M ₅ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN+FYM	17.92b	16.09bc	17.00 c	176.44a-c	171.97b	174.20bc	253.66ab	245.52b	249.59b
M ₆ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN+FYM+MC	18.18b	16.32bc	17.25c	184.39ab	178.04ab	181.22b	263.48a	255.63ab	259.55ab
S.Em±	0.55	0.50	0.25	5.41	5.08	3.27	8.96	6.98	6.88
Liquid organic manures (L)									
L ₁ -Jeevamrut @ 500 litres ha ⁻¹ at 30, 60 and 90 DAS	18.25a	16.39a	17.32a	176.33ab	172.13bc	174.23bc	246.56bc	238.04b	242.30 c
L ₂ -Cow urine @ 500 litres ha ⁻¹ at 30, 60and 90 DAS	18.47a	16.70a	17.58a	180.79ab	175.86ab	178.33ab	258.07ab	248.11b	253.09b
L ₃ -Bio digester @ 2500 litres ha ⁻¹ at 30, 60 and 90 DAS	18.72a	17.10a	17.91a	187.31a	182.97a	185.14a	269.28a	261.61a	265.44a
L ₄ -Control (no liquid manure application)	17.83a	15.85a	16.84a	169.58b	165.88c	167.73c	235.47c	223.43c	229.45d
S.Em±	0.33	0.44	0.38	4.22	3.04	2.43	4.74	3.60	2.96
Interactions- (M X L)									
M ₁ L ₁	18.80a-d	17.18a-d	17.99a-e	180.36a-c	175.60b-g	177.98b-h	259.37b-e	241.40 c-f	250.39d-g
M ₁ L ₂	19.09a-d	17.53a-d	18.31a-e	185.67a-c	177.89a-g	181.78b-f	268.97a-d	254.55b-e	261.76b-f
M ₁ L ₃	19.26a-d	17.89a-c	18.58a-d	189.83a-c	183.43a-e	186.63a-d	281.15ab	269.66a-c	275.41a-c
M ₁ L ₄	18.78a-d	16.73a-d	17.75a-e	176.74a-c	170.27b-g	173.50 c-i	241.18c-g	224.96e-g	233.07g-j
M ₂ L ₁	20.09a-c	17.66a-d	18.88a-c	191.60a-c	187.83a-c	189.71a-c	274.46a-d	270.04a-c	272.25a-d
M ₂ L ₂	20.33ab	18.35ab	19.34ab	196.54ab	191.23ab	193.88ab	286.06ab	281.15ab	283.60ab
M ₂ L ₃	20.53a	18.98a	19.75a	205.38a	202.71a	204.05a	298.90a	291.62a	295.26a
M ₂ L ₄	19.22a-d	16.98a-d	18.10a-e	183.20a-c	181.83a-f	182.52b-f	263.17a-e	258.31b-d	260.74b-f
M ₃ L ₁	17.20d	15.40 cd	16.30de	163.14bc	158.94e-g	161.04g-i	216.05fg	206.93gh	211.49jk
M ₃ L ₂	17.40 cd	15.67cd	16.53c-e	165.67bc	163.45c-g	164.56e-i	227.64e-g	215.62f-h	221.63h-k
M ₃ L ₃	17.60b-d	16.07b-d	16.83c-e	171.18a-c	167.83b-g	169.51c-i	238.71d-g	236.71d-f	237.71f-i
M ₃ L ₄	16.91d	15.02d	15.97e	157.81c	154.96g	156.38i	206.09g	192.23h	199.16k
M ₄ L ₁	17.46cd	15.69cd	16.58c-e	167.16bc	163.65c-g	165.41e-i	225.60e-g	215.58f-h	220.59i-k
M ₄ L ₂	17.62b-d	15.95b-d	16.79c-e	169.63a-c	167.85b-g	168.74d-i	236.71d-g	225.42e-g	231.07g-j
M ₄ L ₃	17.86a-d	16.31b-d	17.09b-e	176.09a-c	176.78b-g	176.44b-i	249.15b-f	239.66d-f	244.41e-i
M ₄ L ₄	17.04d	15.20d	16.12e	160.74bc	156.74fg	158.74hi	214.51fg	198.71gh	206.61k
M ₅ L ₁	17.89a-d	16.09b-d	16.99b-e	173.36a-c	169.87b-g	171.62c-i	247.82b-f	242.73c-f	245.28e-h
M ₅ L ₂	18.09a-d	16.20b-d	17.14b-e	180.05a-c	174.72b-g	177.38b-h	258.95b-e	250.06c-e	254.51c-g
M ₅ L ₃	18.29a-d	16.55a-d	17.42a-e	187.87a-c	182.12a-f	184.99a-e	268.93a-d	261.88b-d	265.41b-e
M ₅ L ₄	17.42cd	15.51cd	16.47c-e	164.47bc	161.18d-g	162.83f-i	238.95d-g	227.40e-g	233.18g-j
M ₆ L ₁	18.06a-d	16.33b-d	17.20b-e	182.34a-c	176.92b-g	179.63b-g	256.06b-e	251.57c-e	253.82c-g
M ₆ L ₂	18.29a-d	16.49a-d	17.39b-e	187.20a-c	180.03a-g	183.61b-e	270.11a-d	261.84b-d	265.97b-e
M ₆ L ₃	18.75a-d	16.80a-d	17.78a-e	193.49a-c	184.96a-d	189.23a-c	278.82a-c	270.11a-c	274.46a-d
M ₆ L ₄	17.62b-d	15.67cd	16.64c-e	174.52a-c	170.27b-g	172.39c-i	248.93b-f	239.00d-f	243.96e-i
S.Em±	0.82	0.76	0.69	10.36	7.45	5.95	11.62	8.82	255.16b

Means followed by the same alphabet do not differ significantly by DMRT (0.05)

Table 32: Effect of manurial practices and liquid organic manures on leaf area index at different growth stages of crop growth

Treatments	30 DAS			60 DAS			90 DAS		
	2013	2014	Pooled	2013	2014	Pooled	2013	2014	Pooled
Manurial practices (M)									
M ₁ -RDF (100:50:50 kg N, P ₂ O ₅ K ₂ O ha ⁻¹)	0.190ab	0.173ab	0.182a	1.832a-c	1.768ab	1.800b	2.627a	2.477b	2.552ab
M ₂ -RDF+FYM+MC	0.200a	0.180a	0.190a	1.942a	1.909a	1.926a	2.807a	2.753a	2.780a
M ₃ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN	0.173b	0.155c	0.164c	1.645c	1.613b	1.629d	2.221c	2.129c	2.175c
M ₄ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN+MC	0.175b	0.158bc	0.166bc	1.684bc	1.663b	1.673cd	2.315bc	2.199c	2.257c
M ₅ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN+FYM	0.179b	0.161bc	0.170bc	1.765a-c	1.720b	1.742bc	2.537ab	2.455b	2.496b
M ₆ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN+FYM+MC	0.182ab	0.163bc	0.173b	1.844ab	1.781ab	1.812b	2.635a	2.557ab	2.596ab
S.Em±	0.005	0.005	0.002	0.057	0.05	0.028	0.091	0.07	0.07
Liquid organic manures (L)									
L ₁ -Jeevamrut @ 500 litres ha ⁻¹ at 30, 60 and 90 DAS	0.183a	0.164a	0.173a	1.763ab	1.722b	1.742bc	2.466bc	2.381c	2.423c
L ₂ -Cow urine @ 500 litres ha ⁻¹ at 30, 60and 90 DAS	0.185a	0.167a	0.176a	1.808ab	1.759ab	1.783b	2.581ab	2.481b	2.531b
L ₃ -Bio digester @ 2500 litres ha ⁻¹ at 30, 60 and 90 DAS	0.187a	0.171a	0.179a	1.873a	1.830a	1.852a	2.693a	2.616a	2.655a
L ₄ -Control (no liquid manure application)	0.178a	0.159a	0.168a	1.696b	1.659b	1.677c	2.355c	2.235d	2.295d
S.Em±	0.003	0.004	0.003	0.04	0.033	0.023	0.047	0.033	0.033
Interactions- (M X L)									
M ₁ L ₁	0.188a-d	0.172a-e	0.180a-e	1.804a-d	1.756a-e	1.780b-j	2.594b-e	2.414d-g	2.504c-g
M ₁ L ₂	0.191a-d	0.175a-e	0.183a-e	1.857a-d	1.779a-e	1.818b-h	2.690a-d	2.546b-e	2.618b-f
M ₁ L ₃	0.193a-d	0.179a-c	0.186a-d	1.898a-d	1.834a-d	1.866a-e	2.812ab	2.697a-c	2.754a-c
M ₁ L ₄	0.188a-d	0.167a-e	0.178a-e	1.768a-d	1.703b-e	1.735c-k	2.412c-g	2.250f-h	2.331g-j
M ₂ L ₁	0.201a-c	0.177a-d	0.189a-c	1.916a-d	1.878a-c	1.897a-c	2.745a-d	2.701a-c	2.723a-d
M ₂ L ₂	0.203ab	0.184ab	0.193ab	1.966ab	1.912ab	1.939ab	2.861ab	2.812ab	2.836ab
M ₂ L ₃	0.205a	0.190a	0.198a	2.054a	2.027a	2.041a	2.989a	2.916a	2.953a
M ₂ L ₄	0.192a-d	0.170a-e	0.181a-e	1.832a-d	1.818a-e	1.825b-h	2.632a-e	2.583b-d	2.608b-f
M ₃ L ₁	0.172d	0.154c-e	0.163de	1.632b-d	1.590de	1.611i-k	2.161fg	2.070hi	2.115i-k
M ₃ L ₂	0.174cd	0.157c-e	0.165c-e	1.657b-d	1.635b-e	1.646g-k	2.277e-g	2.156g-i	2.217h-k
M ₃ L ₃	0.176b-d	0.161b-e	0.168c-e	1.712a-d	1.678b-e	1.695d-k	2.387d-g	2.367d-g	2.377f-i
M ₃ L ₄	0.169d	0.150e	0.160e	1.578d	1.550e	1.564k	2.061g	1.922i	1.992k
M ₄ L ₁	0.175b-d	0.157c-e	0.166c-e	1.672b-d	1.637b-e	1.654f-k	2.256e-g	2.156g-i	2.206h-k
M ₄ L ₂	0.176b-d	0.160b-e	0.168c-e	1.696b-d	1.679b-e	1.688e-k	2.367d-g	2.254f-h	2.311g-j
M ₄ L ₃	0.179a-d	0.163b-e	0.171b-e	1.761a-d	1.768a-e	1.765b-j	2.492b-f	2.397d-g	2.444e-h
M ₄ L ₄	0.170d	0.152de	0.161e	1.608cd	1.568de	1.588jk	2.145fg	1.987i	2.066jk
M ₅ L ₁	0.179a-d	0.161b-e	0.170b-e	1.734a-d	1.699b-e	1.716c-k	2.478b-f	2.428c-g	2.453d-h
M ₅ L ₂	0.181a-d	0.162b-e	0.171b-e	1.801a-d	1.747b-e	1.774b-j	2.590b-e	2.501c-f	2.545c-g
M ₅ L ₃	0.183a-d	0.166a-e	0.174b-e	1.879a-d	1.821a-e	1.850b-f	2.690a-d	2.619b-d	2.654b-e
M ₅ L ₄	0.174cd	0.155c-e	0.165c-e	1.645b-d	1.612c-e	1.628h-k	2.390d-g	2.274e-h	2.332g-j
M ₆ L ₁	0.181a-d	0.163b-e	0.172b-e	1.824a-d	1.769a-e	1.796b-i	2.561b-e	2.516c-f	2.538c-g
M ₆ L ₂	0.183a-d	0.165a-e	0.174b-e	1.872a-d	1.800a-e	1.836b-g	2.701a-d	2.619b-d	2.660b-e
M ₆ L ₃	0.188a-d	0.168a-e	0.178a-e	1.935a-c	1.850a-d	1.892a-d	2.788a-c	2.701a-c	2.745a-c
M ₆ L ₄	0.176b-d	0.157c-e	0.166c-e	1.745a-d	1.703b-e	1.724c-k	2.490b-f	2.390d-g	2.440e-h
S.Em±	0.008	0.007	0.007	0.1	0.081	0.057	0.115	0.081	0.081

Means followed by the same alphabet do not differ significantly by DMRT (0.05)

90 DAS (M_2L_3) recorded significantly higher leaf area index at 30, 60 and 90 DAS (0.198, 2.041 and 2.953 respectively) but was at par with M_2L_2 (2.836), M_1L_3 (2.754), M_6L_3 (2.745) and M_2L_1 (2.723) at 90 DAS. Significantly lower leaf area index was recorded with M_3L_4 at 30, 60 and 90 DAS (0.160, 1.564 and 1.992, respectively).

4.2.1.5 Soil Plant Analysis Development (SPAD) values

The data on SPAD value significantly influenced by manurial practices at 30, 60 and 90 DAS (Table 33). Among the manurial practices, application of RDF + FYM + microbial consortium (M_2) recorded significantly higher SPAD value at 30, 60 and 90 DAS over rest of the treatments (36.82, 40.84 and 34.51, respectively) but was at par with M_1 (35.89, 39.09 and 32.89) at 30, 60 and 90 DAS and with, M_6 (34.48 and 37.68) and M_5 (33.49 and 36.60) at 30 and 60 DAS. Significantly lower SPAD value was recorded with M_3 at 30, 60 and 90 DAS (31.82, 35.02 and 28.95, respectively).

Among the liquid organic manures, there was no significant effect on SPAD values at 30DAS. However, soil application of biodigester @ 2500 l ha⁻¹ at 30, 60 and 90 DAS (L_3) recorded significantly higher SPAD value (38.51 and 32.17) but was at par with L_2 (37.91 and 31.55) and L_1 (37.43 and 30.99) at 60 and 90 DAS. Significantly lower SPAD value (36.17) was recorded with L_4 (36.17 and 29.75) at 60 and 90 DAS.

Among the treatment combinations, application of RDF + FYM + microbial consortium with soil application of biodigester @ 2500 l ha⁻¹ at 30, 60 and 90 DAS (M_2L_3) recorded significantly higher SPAD value (38.40, 41.97 and 35.37, respectively). Whereas, treatment combinations M_2L_2 (34.80), M_2L_1 (34.23), M_1L_3 (33.88), M_2L_4 (33.65), M_1L_2 (33.40), M_1L_1 (32.83), M_6L_3 (32.15), M_1L_4 (31.43) and M_6L_2 (31.28) were found on par with former treatment combination at harvest. Significantly lower SPAD value was recorded with M_3L_4 at 30, 60 and 90 DAS (31.32, 34.00 and 27.27, respectively).

4.2.1.6 Total dry matter (g m⁻²)

The data pertaining to total dry matter of aerobic rice recorded at different growth stages as influenced by manurial practices and liquid organic manures is presented in Table 34.

Table 33: Effect of manurial practices and liquid organic manures on SPAD readings at different growth stages of crop growth

Treatments	30 DAS			60 DAS			90 DAS		
	2013	2014	Pooled	2013	2014	Pooled	2013	2014	Pooled
Manurial practices (M)									
M ₁ -RDF (100:50:50 kg N, P ₂ O ₅ , K ₂ O ha ⁻¹)	35.38ab	36.40a	35.89ab	38.62a	39.57a	39.09ab	32.18a	33.60b	32.89ab
M ₂ -RDF+FYM+MC	36.73a	36.91a	36.82a	40.43a	41.25a	40.84a	33.56a	35.47a	34.51a
M ₃ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN	31.28b	32.35a	31.82c	33.67a	36.37a	35.02b	27.78a	30.11d	28.95c
M ₄ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN+MC	32.15ab	33.68a	32.91bc	34.78a	36.81a	35.79b	28.57a	30.72cd	29.64c
M ₅ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN+FYM	32.93ab	34.05a	33.49a-c	36.00a	37.19a	36.60ab	28.06a	31.63cd	29.85bc
M ₆ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN+FYM+MC	34.38ab	34.58a	34.48a-c	36.98a	38.39a	37.68ab	29.12a	32.59bc	30.85bc
S.Em±	1.48	1.44	1.07	2.1	1.81	1.46	2.0	0.57	0.93
Liquid organic manures (L)									
L ₁ -Jeevamrut @ 500 litres ha ⁻¹ at 30, 60 and 90 DAS	33.56a	34.51a	34.04a	36.56a	38.29a	37.43ab	29.69ab	32.28a	30.99ab
L ₂ -Cow urine @ 500 litres ha ⁻¹ at 30, 60 and 90 DAS	33.86a	34.89a	34.38a	36.96a	38.85a	37.91ab	30.28ab	32.82a	31.55a
L ₃ -Bio digester @ 2500 litres ha ⁻¹ at 30, 60 and 90 DAS	34.44a	35.49a	34.96a	37.58a	39.44a	38.51a	30.83a	33.51a	32.17a
L ₄ -Control (no liquid manure application)	33.37a	33.75a	33.56a	35.87a	36.47a	36.17b	28.70b	30.81a	29.75b
S.Em±	0.7	0.9	0.65	0.85	1.03	0.65	0.64	0.88	0.51
Interactions- (M X L)									
M ₁ L ₁	35.10ab	36.13a	35.62ab	38.27a-c	39.23a	38.75a-e	32.23a-e	33.43a-c	32.83a-g
M ₁ L ₂	35.17ab	36.47a	35.82ab	38.37a-c	39.83a	39.10a-e	32.83a-d	33.97a-c	33.40a-f
M ₁ L ₃	36.17ab	37.43a	36.80ab	39.27a-c	40.57a	39.92a-d	33.20a-c	34.57a-c	33.88a-d
M ₁ L ₄	35.07ab	35.57a	35.32ab	38.57a-c	38.63a	38.60a-e	30.43a-f	32.43a-c	31.43a-i
M ₂ L ₁	35.77ab	36.73a	36.25ab	40.13a-c	41.33a	40.73a-c	33.33a-c	35.13a-c	34.23a-c
M ₂ L ₂	36.37ab	37.13a	36.75ab	40.73ab	41.87a	41.30ab	33.87ab	35.73ab	34.80ab
M ₂ L ₃	39.17a	37.63a	38.40a	41.37a	42.57a	41.97a	34.27a	36.47a	35.37a
M ₂ L ₄	35.63ab	36.13a	35.88ab	39.47a-c	39.23a	39.35a-e	32.77a-d	34.53a-c	33.65a-e
M ₃ L ₁	31.20b	32.20a	31.70b	33.53b-c	36.23a	34.88de	27.53d-f	30.23a-c	28.88b-i
M ₃ L ₂	31.37b	32.53a	31.95b	33.93b-c	36.87a	35.40 c-e	28.17c-f	30.87a-c	29.52e-i
M ₃ L ₃	31.40b	33.20a	32.30b	34.33a-c	37.23a	35.78c-e	28.77d-f	31.47a-c	30.12c-i
M ₃ L ₄	31.17b	31.47a	31.32b	32.87c	35.13a	34.00e	26.67f	27.87c	27.27i
M ₄ L ₁	32.27b	33.50a	32.88ab	34.67a-c	36.93a	35.80 c-e	28.47b-f	30.93a-c	29.70d-i
M ₄ L ₂	32.37b	33.93a	33.15ab	34.93a-c	37.23a	36.08b-e	28.93a-f	31.23a-c	30.08c-i
M ₄ L ₃	32.40b	34.43a	33.42ab	35.77a-c	37.93a	36.85a-e	29.33a-f	31.97a-c	30.65b-i
M ₄ L ₄	31.57b	32.83a	32.20b	33.73bc	35.13a	34.43de	27.53d-f	28.73bc	28.13hi
M ₅ L ₁	32.70b	33.97a	33.33ab	35.93a-c	37.23a	36.58a-e	27.63d-f	31.43a-c	29.53e-i
M ₅ L ₂	33.43ab	34.33a	33.88ab	36.47a-c	37.87a	37.17a-e	28.47b-f	31.97a-c	30.22c-i
M ₅ L ₃	32.97b	35.13a	34.05ab	36.77a-c	38.43a	37.60a-e	28.97a-f	32.73a-c	30.85d-i
M ₅ L ₄	32.60b	32.77a	32.68b	34.83a-c	35.23a	35.03de	27.17ef	30.40a-c	28.78g-i
M ₆ L ₁	34.33ab	34.53a	34.43ab	36.83a-c	38.77a	37.80a-e	28.93a-f	32.53a-c	30.73b-i
M ₆ L ₂	34.47ab	34.93a	34.70ab	37.33a-c	39.43a	38.38a-e	29.43a-f	33.13a-c	31.28a-i
M ₆ L ₃	34.53ab	35.10a	34.82ab	37.97a-c	39.93a	38.95a-e	30.47s-f	33.83a-c	32.15a-h
M ₆ L ₄	34.17ab	33.73a	33.95ab	35.77a-c	35.43a	35.60 c-e	27.63d-f	30.87a-c	29.25f-i
S.Em±	1.72	2.2	1.6	2.09	2.54	1.59	1.58	2.17	1.26

Means followed by the same alphabet do not differ significantly by DMRT (0.05)

Irrespective of liquid organic manures, application of RDF + FYM + microbial consortium (M_2) recorded significantly higher total dry matter at 30, 60 and 90 DAS and at harvest (158.97, 369.69, 559.30 and 1140.44g, respectively). Significantly lower total dry matter was recorded with application of FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN (M_3) at 30, 60 and 90 DAS and at harvest (103.51, 278.12, 383.20 and 746.59g, respectively).

Among the liquid organic manures, soil application of biodigester @ 2500 l ha⁻¹ at 30, 60 and 90 DAS recorded significantly higher total dry matter at 30, 60 and 90 DAS and at harvest (145.73, 350.03, 492.11 and 972.25 g, respectively) but was at par with L_2 at 60 and 90 DAS (333.30 and 470.51g respectively). Significantly lower total dry matter was recorded with control at 30, 60 and 90 DAS and at harvest (108.38, 285.53, 405.21 and 780.35 g, respectively).

Among the treatment combinations, integrated application of RDF + FYM + microbial consortium with soil application of biodigester @ 2500 l ha⁻¹ at 30, 60 and 90 DAS and at harvest (M_2L_3) recorded significantly higher total dry matter (178.50, 406.26, 589.57 and 1238.39g, respectively) but was at par with M_2L_2 (1185.81 g) at harvest. Significantly lower total dry matter was recorded with M_3L_4 (85.18, 248.86, 328.49 and 633.27, respectively) at 30, 60 and 90 DAS and at harvest.

4.2.2 Yield parameters

4.2.2.1 Productive tillers m⁻²

Irrespective of liquid organic manures, manurial practices influenced the number of productive tillers at harvest (Table 35). Application of RDF + FYM + microbial consortium (M_2) recorded significantly higher number of productive tillers (438.66) over rest of the treatments. Significantly lower number of productive tillers (340.71) was recorded with application of FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN (M_3). During first year, application of RDF + FYM + microbial consortium (M_2) recorded significantly higher number of productive tillers (427.74) over rest of the treatments but was at par with M_1 (398.11) and M_6 (394.41).

Table 34: Effect of manurial practices and liquid organic manures on dry matter production m⁻² at different growth stages of crop growth

Treatments	30 DAS			60 DAS			90 DAS			Harvest		
	2013	2014	Pooled	2013	2014	Pooled	2013	2014	Pooled	2013	2014	Pooled
Manurial practices (M)												
M ₁ -RDF (100:50:50 kg N, P ₂ O ₅ , K ₂ O ha ⁻¹)	147.76b	135.91b	141.84b	353.48ab	354.78ab	354.13ab	586.98a	474.03b	530.50a	1139.70a	947.31b	1043.51b
M ₂ -RDF+FYM+MC	166.65a	151.28a	158.97a	374.59a	364.78a	369.69a	604.94a	513.65a	559.30a	1223.03a	1057.86a	1140.44a
M ₃ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN	104.06e	102.95d	103.51e	276.45c	279.79d	278.12d	411.07b	355.33e	383.20 c	785.48b	707.71e	746.59d
M ₄ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN+MC	110.54de	109.43d	109.99e	285.16c	295.16cd	290.16cd	422.18b	377.74de	399.96bc	799.73b	745.30de	772.52cd
M ₅ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN+FYM	122.77cd	119.25c	121.01d	305.53bc	320.15bc	312.84cd	432.18b	407.00 cd	419.59bc	827.70b	798.25cd	812.97cd
M ₆ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN+FYM+MC	133.32c	125.73c	129.52c	319.23a-c	331.26a-c	325.25bc	462.18b	428.85c	445.51b	854.36b	882.88c	853.62c
S.Em±	3.97	2.78	2.59	19.76	11.61	10.94	21.90	10.71	14.77	53.21	22.01	26.92
Liquid organic manures (L)												
L ₁ -Jeevamrut @ 500 litres ha ⁻¹ at 30, 60 and 90 DAS	128.63c	116.41c	122.52c	317.13b	318.73bc	317.93b	487.61a	427.49a	457.55b	939.54b	851.27b	895.40b
L ₂ -Cow urine @ 500 litres ha ⁻¹ at 30, 60and 90 DAS	136.78b	129.74b	133.26b	332.44b	334.16ab	333.30ab	499.95a	441.07a	470.51ab	976.32ab	887.20ab	931.76b
L ₃ -Bio digester @ 2500 litres ha ⁻¹ at 30, 60 and 90 DAS	148.13a	143.32a	145.73a	349.72a	350.34a	350.03a	526.74a	457.49a	492.11a	1017.18a	927.31a	972.25a
L ₄ -Control (no liquid manure application)	109.87d	106.90d	108.38d	277.01c	294.04c	285.53c	432.06b	378.36b	405.21c	820.29c	740.42c	780.35c
S.Em±	2.11	2.42	1.69	5.92	9.46	6.01	13.10	12.97	11.30	17.31	23.16	13.95
Interactions- (M X L)												
M ₁ L ₁	143.69d-f	131.84c-f	137.76de	351.82b-d	354.04a-d	352.93b-e	588.83a-c	474.03a-e	531.43a-d	1133.22cd	939.91b-f	1036.56cd
M ₁ L ₂	151.84c-e	143.69bc	147.76cd	371.81a-c	371.81a-c	371.81a-c	607.35ab	484.40a-d	545.87a-c	1187.2b-d	988.05a-e	1087.6b-d
M ₁ L ₃	165.91bc	154.06ab	159.98bc	398.48a	385.15ab	391.81ab	636.97a	508.10a-c	572.54a	1233.95a-c	1030.2a-d	1132.11bc
M ₁ L ₄	129.62fg	114.06e-h	121.84gh	291.82e-g	308.12b-f	299.97f-h	514.76b-e	429.59b-g	472.18b-g	1004.34ef	831.03e-h	917.69ef
M ₂ L ₁	162.95bc	143.69bc	153.32bc	371.81a-c	356.26a-d	364.04a-d	607.35ab	513.28a-c	560.31ab	1210.2a-d	1045.08a-c	1127.67bc
M ₂ L ₂	175.54ab	154.80ab	165.17b	396.26ab	385.89ab	391.07ab	621.42a	528.10ab	574.76a	1270.24ab	1101.37ab	1185.81ab
M ₂ L ₃	187.39a	169.61a	178.50a	414.03a	398.48a	406.26a	638.45a	540.69a	589.57a	1325.79a	1151.00a	1238.39a
M ₂ L ₄	140.73d-f	137.02b-d	138.88de	316.26d-f	318.49b-f	317.38d-g	552.54a-d	472.55a-e	512.54a-e	1085.82de	933.98b-f	1009.90de
M ₃ L ₁	114.06gh	92.58ij	103.32j-l	271.82f-h	274.05ef	272.94g-i	410.33e-g	360.70f-h	385.52g-j	802.88g-k	725.11h-j	764.00h-j
M ₃ L ₂	102.95hi	108.14g-i	105.55jk	287.38e-h	286.64d-f	287.01f-i	425.14e-g	372.56e-h	398.85f-j	819.18g-j	737.70g-j	778.44g-i
M ₃ L ₃	114.06gh	125.91c-g	119.99g-i	303.67d-f	303.67c-f	303.67e-h	454.77d-g	385.15d-h	419.96e-j	851.03g-i	770.29f-j	810.66f-i
M ₃ L ₄	85.18j	85.18j	85.18m	242.94h	254.79f	248.86i	354.04g	302.93h	328.49j	668.82k	597.72j	633.27k
M ₄ L ₁	102.95hi	99.25h-j	101.10kl	282.93e-h	291.08d-f	287.01f-i	420.70e-g	379.96d-h	400.33f-j	807.33g-j	747.33j	777.33g-i
M ₄ L ₂	117.03gh	114.06e-h	115.54h-j	294.04e-g	303.67c-f	298.86f-h	433.29e-g	397.00d-h	415.14f-j	834.73g-i	779.92f-j	807.33f-i
M ₄ L ₃	130.36fg	132.58c-e	131.47e-g	309.60d-f	316.26b-f	312.93e-g	460.69d-g	410.33c-h	435.51e-i	872.51f-h	819.18e-i	845.84f-h
M ₄ L ₄	91.84ij	91.84ij	91.84lm	254.05gh	269.60ef	261.83hi	374.04fg	323.67gh	348.85ij	684.38jk	634.75ij	659.56jk
M ₅ L ₁	118.51gh	112.58f-h	115.54h-j	305.90d-f	313.30b-f	309.60e-h	439.22e-g	409.59c-h	424.40e-i	828.81g-i	797.70e-i	813.25f-i
M ₅ L ₂	130.36fg	125.17c-g	127.77e-h	317.01d-f	323.67a-f	320.34d-g	436.25e-g	420.70b-g	428.48e-i	862.14g-i	832.51e-h	847.32f-h
M ₅ L ₃	136.28ef	136.28d-d	136.28d-f	329.60 c-e	340.71a-e	335.15c-f	470.32d-f	439.22a-f	454.77d-h	899.17f-h	871.02c-h	885.10fg
M ₅ L ₄	105.92hi	102.95h-j	104.43j-l	269.60f-h	302.93c-f	286.27f-i	382.92fg	358.48f-h	370.70h-j	720.67i-k	691.78h-j	706.23i-k
M ₆ L ₁	129.62fg	118.51d-h	124.06f-h	318.49d-f	323.67a-f	321.08d-g	459.21d-g	427.36b-g	443.29d-h	854.73g-i	852.51d-h	853.62f-h
M ₆ L ₂	142.95d-f	132.58c-e	137.76de	328.12c-e	333.30a-f	330.71c-f	476.25d-f	443.66a-f	459.95c-h	884.36f-h	883.62c-h	883.99fg
M ₆ L ₃	154.80 cd	141.47bc	148.13cd	342.93cd	357.74a-d	350.34b-e	499.21c-e	461.44a-f	480.32b-f	920.65fg	922.13b-g	921.39ef
M ₆ L ₄	105.92hi	110.36g-i	108.14i-k	287.38e-h	310.34b-f	298.86f-h	414.03e-g	382.92d-h	398.48f-j	757.70h-k	753.26f-j	755.48h-j
S.Em±	5.18	5.94	4.14	14.50	23.18	14.74	32.09	31.77	27.69	42.41	56.74	

Means followed by the same alphabet do not differ significantly by DMRT (0.05)

Table 35: Effect of manurial practices and liquid organic manures on productive tillers hill⁻¹, filled grains and unfilled grains panicle⁻¹ at harvest

Treatments	Productive tillers m ⁻²			Filled grains panicle ⁻¹			Unfilled grains panicle ⁻¹		
	2013	2014	Pooled	2013	2014	Pooled	2013	2014	Pooled
Manurial practices (M)									
M ₁ -RDF (100:50:50 kg N, P ₂ O ₅ , K ₂ O ha ⁻¹)	398.11ab	395.89b	397.00b	88.62 b	75.22 b	81.92 b	6.55 d	14.20 c	10.38 c
M ₂ -RDF+FYM+MC	427.74a	449.58a	438.66a	93.97a	79.77 a	86.87 a	5.78 d	13.03 c	9.41 c
M ₃ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN	331.08d	350.34b	340.71c	75.47 d	64.07 e	69.77 d	12.87 a	27.78 a	20.33 a
M ₄ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN+MC	350.71cd	372.19b	361.45c	76.60 d	65.08 e	70.84 d	12.50 a	26.83 a	19.67 a
M ₅ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN+FYM	374.04bc	394.41b	384.22b	81.17 c	68.92 d	75.04 c	9.60 b	20.37 b	14.98 b
M ₆ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN+FYM+MC	394.41ab	404.03ab	399.22b	83.20 c	70.67 c	76.93 c	8.57 c	19.08 b	13.83 b
S.Em±	12.62	15.92	7.13	1.21	0.50	0.75	0.31	0.74	0.38
Liquid organic manures (L)									
L ₁ -Jeevamrut @ 500 litres ha ⁻¹ at 30, 60 and 90 DAS	381.44a	396.01a	388.73a	81.91 b	69.53 b	75.72 b	9.12 b	19.43 b	14.28 b
L ₂ -Cow urine @ 500 litres ha ⁻¹ at 30, 60and 90 DAS	393.79a	408.35a	401.07a	84.56 ab	71.81 ab	78.18 ab	8.64 bc	18.68 b	13.66 bc
L ₃ -Bio digester @ 2500 litres ha ⁻¹ at 30, 60 and 90 DAS	403.91a	417.98a	410.95a	87.34 a	74.16 a	80.75 a	8.28 c	18.01 b	13.14 c
L ₄ -Control (no liquid manure application)	338.24b	355.27b	346.76b	78.87 c	66.98 c	72.92 c	11.20 a	24.74 a	17.97 a
S.Em±	8.78	9.07	7.89	1.05	0.87	0.92	0.23	0.50	0.30
Interactions- (M X L)									
M ₁ L ₁	397.00a-g	392.55b-f	394.78c-h	86.87 b-g	73.53 b-g	80.20 d-g	6.20 hi	13.47 e-g	9.83 g
M ₁ L ₂	410.33a-f	408.85a-e	409.59b-g	90.33 a-e	76.73 a-e	83.53 b-e	6.00 hi	12.93 fg	9.47 g
M ₁ L ₃	419.22a-e	419.22a-d	419.22a-e	94.53 a-c	80.27 a-c	87.40 a-c	5.60 i	12.53 g	9.07 g
M ₁ L ₄	365.89c-j	362.93c-f	364.41f-j	82.73 d-j	70.33 c-h	76.53 e-j	8.40 g	17.87 d	13.13 ef
M ₂ L ₁	432.55a-c	451.81ab	442.18a-c	92.40 a-d	78.47 a-d	85.43 b-d	5.40 i	12.33 g	8.87 g
M ₂ L ₂	439.96ab	459.21ab	449.58ab	95.47 ab	81.07 ab	88.27 ab	5.20 i	11.87 g	8.53 g
M ₂ L ₃	456.25a	476.99a	466.62a	100.5 3a	85.40 a	92.97 a	5.00 i	11.40 g	8.20 g
M ₂ L ₄	382.18b-i	410.33a-e	396.26c-h	87.47 b-f	74.13 b-f	80.80 c-f	7.53 gh	16.53 d-f	12.03 f
M ₃ L ₁	331.82g-j	349.59d-f	340.71i-k	74.53 h-j	63.33 gh	68.93 kl	12.93 bc	27.60 b	20.27 b
M ₃ L ₂	340.71f-j	361.45c-f	351.08h-k	76.20 f-j	64.67 f-h	70.43 i-l	12.53 bc	26.47 bc	19.50 bc
M ₃ L ₃	351.08e-j	371.81c-f	361.45g-j	77.60 f-j	65.87 f-h	71.73 h-l	11.80 cd	25.67 bc	18.73 b-d
M ₃ L ₄	300.71j	318.49f	309.60k	73.53 ij	62.40 h	67.97 kl	14.20 ab	31.40 a	22.80 a
M ₄ L ₁	354.04d-j	374.78c-f	364.41f-j	75.53 g-j	64.20 f-h	69.87 j-l	12.20 cd	25.47 bc	18.83 b-d
M ₄ L ₂	361.45c-j	388.11b-f	374.78e-j	77.87 f-j	66.20 f-h	72.03 h-l	11.47 cd	24.53 bc	18.00 b-d
M ₄ L ₃	368.85b-j	385.15b-f	377.00d-j	80.87 d-j	68.60 d-h	74.73 f-k	11.13 c-e	23.80 bc	17.47 cd
M ₄ L ₄	318.49ij	340.71ef	329.60jk	72.13 j	61.33 h	66.73 l	15.20 a	33.53 a	24.37 a
M ₅ L ₁	376.26b-i	397.00b-e	386.63d-i	79.53 e-j	67.53 e-h	73.53 g-l	9.40 e-g	19.53 d	14.47 e
M ₅ L ₂	395.52a-h	414.77a-e	405.14b-g	83.93 c-i	71.33 b-h	77.63 e-i	8.87 fg	18.53 d	13.70 ef
M ₅ L ₃	401.44a-g	425.14a-d	413.29b-f	84.60 b-i	71.73 b-h	78.17 e-h	8.60 fg	17.53 d	13.07 ef
M ₅ L ₄	322.93h-j	340.71ef	331.82jk	76.60 f-j	65.07 f-h	70.83 i-l	11.53 cd	25.87 bc	18.70 b-d
M ₆ L ₁	397.00a-g	410.33a-e	403.66b-g	82.60 d-j	70.13 c-h	76.37 f-j	8.60 fg	18.20 d	13.40 ef
M ₆ L ₂	414.77a-e	417.74a-d	416.25b-e	83.53 c-j	70.87 c-h	77.20 e-i	7.80 gh	17.73 d	12.77 ef
M ₆ L ₃	426.62a-d	429.59a-c	428.11a-d	85.93 b-h	73.07 b-g	79.50 d-g	7.53 gh	17.13 de	12.33 ef
M ₆ L ₄	339.23f-j	358.48c-f	348.85h-k	80.73 e-j	68.60 d-h	74.67 f-k	10.33 d-f	23.27 c	16.80 d
S.Em±	21.48	22.22	15.17	3.42	3.02	2.14	0.58	1.23	0.73

Means followed by the same alphabet do not differ significantly by DMRT (0.05)

During second year, application of RDF + FYM + microbial consortium (M_2) recorded significantly higher number of productive tillers (449.58) over rest of the treatments but was at par with M_6 (404.03).

Among the liquid organic manures, soil application of biodigester @ 2500 l ha⁻¹ at 30, 60 and 90 DAS recorded significantly higher number of productive tillers (410.95) but was at par with foliar application of cow urine @ 500 l ha⁻¹ at 30, 60 and 90 DAS (401.07) and soil application of jeevamrut @ 500 l ha⁻¹ at 30, 60 and 90 DAS (388.73). Significantly lower number of productive tillers (346.76) was recorded with control.

Among the treatment combinations, application of RDF + FYM + microbial consortium with soil application of biodigester @ 2500 l ha⁻¹ at 30, 60 and 90 DAS (M_2L_3) recorded significantly higher number of productive tillers per hill (466.62) but was at par with M_2L_2 (449.58), M_2L_1 (442.18), M_6L_3 (428.11) and M_1L_3 (419.22). Significantly lower number of productive tillers was recorded with M_1L_3 (309.60).

4.2.2.2 Number of filled grains panicle⁻¹

The data on number of filled grains panicle⁻¹ as influenced by manurial practices and liquid organic manures at harvest is furnished in Table 35.

Irrespective of liquid organic manures, manurial practices influenced the number of filled grains panicle⁻¹ at harvest. Application of RDF + FYM + microbial consortium (M_2) recorded significantly higher number of filled grains panicle⁻¹ (86.87) over rest of the treatments. Significantly lower numbers of filled grains panicle⁻¹ (69.77) were recorded with application of FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN (M_3).

Among the liquid organic manures, soil application of biodigester @ 2500 l ha⁻¹ at 30, 60 and 90 DAS (L_3) recorded significantly higher number of filled grains panicle⁻¹ (80.75) but was at par (78.18) with foliar application of cow urine @ 500 l ha⁻¹ at 30, 60 and 90 DAS (L_2). Significantly lower number of filled grains panicle⁻¹ (72.92) were recorded with control (L_4).

Among the treatment combinations, application of RDF + FYM + microbial consortium with soil application of biodigester @ 2500 l ha⁻¹ at 30, 60 and 90 DAS (M₂L₃) recorded significantly higher number of filled grains panicle⁻¹ (92.97) but was at par with M₂L₂ (88.27) and M₁L₃ (87.40). Significantly lower number of filled grains panicle⁻¹ was recorded with M₄L₄ (66.73).

4.2.2.3 Number of unfilled grains panicle⁻¹

Among manurial practices, manurial practices influenced the number of unfilled grains panicle⁻¹ (Table 35). Application of RDF + FYM + microbial consortium (M₂) recorded significantly lower number of unfilled grains panicle⁻¹ (9.41) over rest of the treatments but was at par (10.38) with application of RDF (M₁). Significantly higher numbers of unfilled grains panicle⁻¹ (20.33) were recorded with application of FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN (M₃).

Among the liquid organic manures, soil application of biodigester @ 2500 l ha⁻¹ at 30, 60 and 90 DAS (L₃) recorded significantly lower number of unfilled grains panicle⁻¹ (13.14) but was at par (13.66) with foliar application of cow urine @ 500 l ha⁻¹ at 30, 60 and 90 DAS (L₂). Significantly higher number of unfilled grains panicle⁻¹ (17.97) were recorded with control (L₄).

Among the treatment combinations, application of RDF + FYM + microbial consortium with soil application of biodigester @ 2500 l ha⁻¹ at 30, 60 and 90 DAS (M₂L₃) recorded significantly lower number of unfilled grains panicle⁻¹ (8.20) but was at par with M₂L₂ (8.53), M₂L₁ (8.87), M₁L₃ (9.07), M₁L₂ (9.47) and M₁L₁ (9.83). Significantly higher number of unfilled grains panicle⁻¹ was recorded with M₃L₄ (22.80).

4.2.2.4 Panicle length (cm)

The data on panicle length as influenced by manurial practices and liquid organic manures at harvest is presented in Table 36.

Application of RDF + FYM + microbial consortium (M₂) recorded significantly higher panicle length (27.10 cm) over rest of the treatments. Significantly lower panicle length (21.93 cm) was recorded with application of FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN (M₃).

Table 36: Effect of manurial practices and liquid organic manures on panicle length, panicle weight and test weight at harvest

Treatments	Panicle length (cm)			Panicle weight (g)			Test weight (g)		
	2013	2014	Pooled	2013	2014	Pooled	2013	2014	Pooled
Manurial practices (M)									
M ₁ -RDF (100:50:50 kg N, P ₂ O ₅ , K ₂ O ha ⁻¹)	23.60 b	24.47 b	24.03 b	2.46 b	2.09 b	2.27 b	21.60 a	21.56 a	21.58 a
M ₂ -RDF+FYM+MC	26.61 a	27.59 a	27.10 a	3.07 a	2.61 a	2.84 a	22.65 a	22.61 a	22.63 a
M ₃ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN	21.41 c	22.46 d	21.93 d	1.97 d	1.67 d	1.82 d	20.30 a	20.28 a	20.29 a
M ₄ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN+MC	21.61 c	22.73 cd	22.17 d	2.01 d	1.71 cd	1.86 d	20.45 a	20.42 a	20.43 a
M ₅ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN+FYM	22.76 b	23.84 b-d	23.30 c	2.29 c	1.95 bc	2.12 c	21.63 a	21.56 a	21.60 a
M ₆ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN+FYM+MC	22.90 b	24.03 bc	23.47 bc	2.34 bc	1.99 b	2.16 bc	21.77 a	21.67 a	21.72 a
S.Em±	0.26	0.44	0.18	0.05	0.07	0.04	0.82	1.16	1.65
Liquid organic manures (L)									
L ₁ -Jeevamrut @ 500 litres ha ⁻¹ at 30, 60 and 90 DAS	23.06 a	24.10 b	23.58 b	2.32 b	1.97 b	2.15 bc	21.30 a	21.24 a	21.27 a
L ₂ -Cow urine @ 500 litres ha ⁻¹ at 30, 60 and 90 DAS	23.47 a	24.48 ab	23.98 ab	2.37 b	2.01 b	2.19 b	21.76 a	21.72 a	21.74 a
L ₃ -Bio digester @ 2500 litres ha ⁻¹ at 30, 60 and 90 DAS	23.74 a	24.87 a	24.31 a	2.49 a	2.11 a	2.30 a	21.99 a	21.94 a	21.97 a
L ₄ -Control (no liquid manure application)	22.32 b	23.30 c	22.81 c	2.25 c	1.92 b	2.09 c	20.54 a	20.51 a	20.53 a
S.Em±	0.24	0.26	0.25	0.02	0.03	0.02	0.52	0.51	0.53
Interactions- (M X L)									
M ₁ L ₁	23.40 cd	24.50 c-g	23.95 cd	2.45 c	2.08 c	2.27 c-e	21.46 a	21.42 a	21.44 a
M ₁ L ₂	23.87 cd	24.77 c-f	24.32 c	2.48 c	2.11 c	2.30 cd	21.87 a	21.85 a	21.86 a
M ₁ L ₃	24.17 b-d	25.10 b-e	24.63 bc	2.55 c	2.17 c	2.36 c	22.14 a	22.10 a	22.12 a
M ₁ L ₄	22.97 d-f	23.50 e-g	23.23 cd	2.35 c-e	2.00 c-e	2.18 c-f	20.92 a	20.88 a	20.90 a
M ₂ L ₁	26.53 ab	27.50 a-c	27.02 a	2.95 b	2.51 b	2.73 b	22.56 a	22.48 a	22.52 a
M ₂ L ₂	26.77 a	27.80 ab	27.28 a	3.00 b	2.55 b	2.78 b	22.93 a	22.87 a	22.90 a
M ₂ L ₃	27.17 a	28.27 a	27.72 a	3.45 a	2.93 a	3.19 a	23.25 a	23.18 a	23.22 a
M ₂ L ₄	25.97 a-c	26.80 a-d	26.38 ab	2.88 b	2.45 b	2.67 b	21.85 a	21.90 a	21.88 a
M ₃ L ₁	21.37 d-f	22.37 e-g	21.87 de	1.94 h-j	1.65 hi	1.80 ij	20.21 a	20.18 a	20.20 a
M ₃ L ₂	21.97 d-f	22.97 e-g	22.47 c-e	1.99 f-j	1.69 f-i	1.84 ij	20.88 a	20.84 a	20.86 a
M ₃ L ₃	22.10 d-f	23.20 e-g	22.65 c-e	2.06 e-j	1.75 e-i	1.91 h-j	20.95 a	20.92 a	20.94 a
M ₃ L ₄	20.20 f	21.30 g	20.75 e	1.87 j	1.59 i	1.73 j	19.15 a	19.18 a	19.17 a
M ₄ L ₁	21.47 d-f	22.57 e-g	22.02 de	1.98 g-j	1.68 g-i	1.83 ij	20.35 a	20.28 a	20.32 a
M ₄ L ₂	22.20 d-f	23.37 e-g	22.78 c-e	2.05 e-j	1.74 e-i	1.90 h-j	21.05 a	21.04 a	21.05 a
M ₄ L ₃	22.37 d-f	23.47 e-g	22.92 c-e	2.10 d-j	1.79 d-i	1.95 g-i	21.16 a	21.14 a	21.15 a
M ₄ L ₄	20.40 e-f	21.50 fg	20.95 e	1.92 ij	1.63 hi	1.78 ij	19.23 a	19.20 a	19.22 a
M ₅ L ₁	22.70 d-f	23.80 d-g	23.25 cd	2.28 c-g	1.94 c-g	2.11 d-g	21.56 a	21.50 a	21.53 a
M ₅ L ₂	22.97 d-f	23.87 d-g	23.42 cd	2.31 c-g	1.96 c-f	2.14 d-f	21.87 a	21.85 a	21.86 a
M ₅ L ₃	23.20 de	24.50 c-g	23.85 cd	2.35 c-e	2.00 c-e	2.18 c-f	22.12 a	22.05 a	22.09 a
M ₅ L ₄	22.17 d-f	23.20 e-g	22.68 c-e	2.23 c-i	1.90 c-h	2.07 f-h	20.97 a	20.85 a	20.91 a
M ₆ L ₁	22.87 d-f	23.87 d-g	23.37 cd	2.32 c-f	1.97 c-e	2.15 d-f	21.65 a	21.55 a	21.60 a
M ₆ L ₂	23.07 de	24.10 d-g	23.58 cd	2.36 c-e	2.01 c-e	2.19 c-f	21.95 a	21.84 a	21.90 a
M ₆ L ₃	23.47 cd	24.67 c-f	24.07 cd	2.40 cd	2.04 cd	2.22 c-f	22.34 a	22.24 a	22.29 a
M ₆ L ₄	22.20 d-f	23.50 e-g	22.85 c-e	2.27 c-h	1.93 c-g	2.10 e-g	21.12 a	21.06 a	21.09 a
S.Em±	0.82	0.95	0.66	0.10	0.08	0.06	1.44	1.41	1.42

Means followed by the same alphabet do not differ significantly by DMRT (0.05)

Among the liquid organic manures, soil application of biodigester @ 2500 l ha⁻¹ at 30, 60 and 90 DAS (L₃) recorded significantly higher panicle length (24.31cm) but was at par (23.98 cm) with foliar application of cow urine @ 500 l ha⁻¹ at 30, 60 and 90 DAS (L₂). Significantly lower panicle length (22.81cm) were recorded with control (L₄).

Among the treatment combinations, application of RDF + FYM + microbial consortium with soil application of biodigester @ 2500 l ha⁻¹ at 30, 60 and 90 DAS (M₂L₃) recorded significantly higher panicle length (27.72cm) but was at par with M₂L₂ (27.28 cm) and M₂L₁ (27.02 cm). Significantly lower panicle length was recorded with M₃L₄ (20.75 cm).

4.2.2.5 Panicle weight (g)

Application of RDF + FYM + microbial consortium (M₂) recorded significantly higher panicle weight (2.84 g) over rest of the treatments (Table 36). Significantly lower panicle weight (1.82 g) was recorded with application of FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN (M₃).

Among the liquid organic manures, soil application of biodigester @ 2500 l ha⁻¹ at 30, 60 and 90 DAS (L₃) recorded significantly higher panicle weight (2.30 g). Significantly lower panicle weight (2.09 g) was recorded with control (L₄).

Among the treatment combinations, application of RDF + FYM + microbial consortium with soil application of biodigester @ 2500 l ha⁻¹ at 30, 60 and 90 DAS (M₂L₃) recorded significantly higher panicle weight (3.19 g). Significantly lower panicle weight was recorded with M₃L₄ (1.73g).

4.2.2.6 Thousand grain weight (g)

Thousand grain weight did not differ significantly influenced by manurial practices and liquid organic manures (Table 36).

4.2.2.7 Grain yield (kg ha⁻¹)

Grain yield significantly influenced by manurial practices and liquid organic manures and their interactions (Table 37).

Application of RDF + FYM + microbial consortium (M_2) recorded significantly higher grain yield (4086 kg ha^{-1}) over rest of the treatments. Significantly lower grain yield (2683 kg ha^{-1}) was recorded with application of FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN (M_3). During first year organic manurial treatments showed significantly lower grain yield. Whereas, during second year grain yield data showed that RDF (3092 kg ha^{-1}) was at par with organics FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN + FYM (2951 kg ha^{-1}).

Among the liquid organic manures, soil application of biodigester @ 2500 l ha^{-1} at 30, 60 and 90 DAS (L_3) recorded significantly higher grain yield (3396 kg ha^{-1}) but was at par with foliar application of cow urine @ 500 l ha^{-1} at 30, 60 and 90 DAS (L_2) and soil application of jeevamrut @ 500 l ha^{-1} at 30, 60 and 90 DAS (L_1) (3334 and 3278 kg ha^{-1} respectively). Significantly lower grain yield (2910 kg ha^{-1}) was recorded with control (L_4).

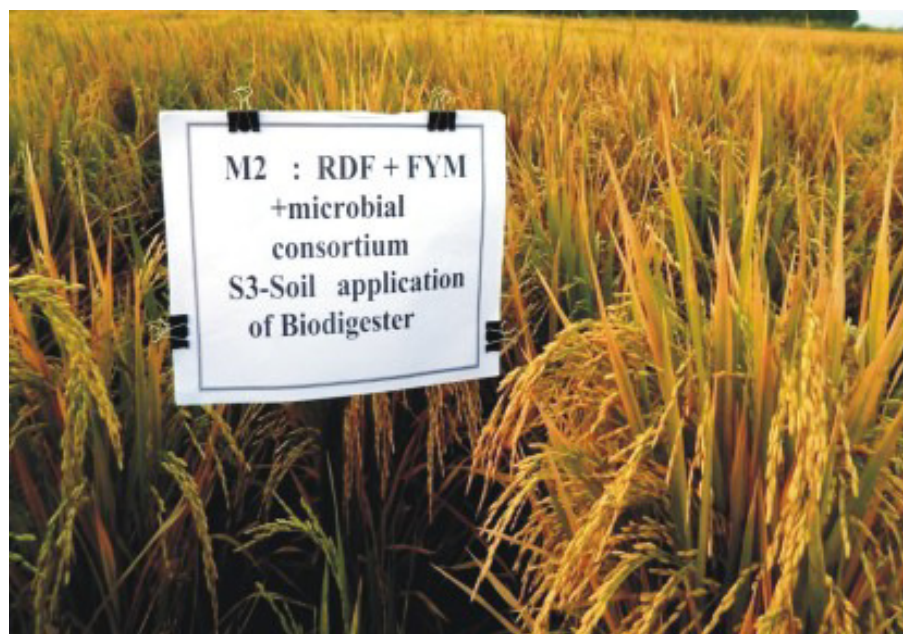
Among the treatment combinations, integrated application of RDF + FYM + microbial consortium and soil application of biodigester @ 2500 l ha^{-1} at 30, 60 and 90 DAS (M_2L_3) (Plate 4) recorded significantly higher grain yield (4262 kg ha^{-1}) over other treatments but was at par with M_2L_2 (4195 kg ha^{-1}) and M_2L_1 (4122 kg ha^{-1}). First year grain yield data showed that RDF without liquid organic manure combination M_1L_4 (3887 kg ha^{-1}) was at par with organics FYM + vermicompost + green leaf manure equivalent to RDN + FYM with liquid organic manure application M_6L_3 (3514 kg ha^{-1}), M_6L_2 (3454 kg ha^{-1}) and M_6L_1 (3384 kg ha^{-1}). Second year grain yield data showed better effect of organic combinations indicating RDF + FYM without liquid organic manure combination M_2L_4 (3248 kg ha^{-1}) was at par with organic combination of FYM + vermicompost + green leaf manure equivalent to RDN + FYM with liquid organic manure application M_6L_3 (3098 kg ha^{-1}), M_6L_2 (3042 kg ha^{-1}) and M_6L_1 (2978 kg ha^{-1}). Significantly lower grain yield was recorded with M_3L_4 (2346 kg ha^{-1}) (Plate 5).

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

Irrespective of liquid organic manures, manurial practices influenced the straw yield (Table 37). Application of RDF + FYM + microbial consortium (M_2) recorded significantly higher straw yield (5380 kg ha^{-1}) over rest of the treatments. Significantly



At tillering stage



At grain filling stage

Plate 4. M₂L₃ - RDF + FYM + Microbial consotium with soil application of Biodigester



At tillering stage



At grain filling stage

Plate 5. M₆L₃- FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN + FYM(5 t ha⁻¹) + microbial consortium + biodigester @ 2500 l/ha at 30,60 and 90 DAS

Table 37: Effect of manurial practices and liquid organic manures on Grain yield, Straw yield and harvest index of aerobic rice

Treatments	Grain yield (kg/ha)			Straw yield (kg/ha)			Harvest index (%)		
	2013	2014	Pooled	2013	2014	Pooled	2013	2014	Pooled
Manurial practices (M)									
M ₁ -RDF (100:50:50 kg N, P ₂ O ₅ , K ₂ O ha ⁻¹)	4241 b	3092 b	3666 b	5219 a	4739 b	4979 b	44.96 a	39.59 a	42.28 a
M ₂ -RDF+FYM+MC	4642 a	3529 a	4086 a	5522 a	5237 a	5380 a	45.79 a	40.35 a	43.06 a
M ₃ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN	2994 d	2373 d	2683 e	3661 b	3627 d	3644 d	45.09 a	39.64 a	42.37 a
M ₄ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN+MC	3046 d	2495 d	2771 e	3732 b	3838 d	3785 d	45.03 a	39.41 a	42.23 a
M ₅ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN+FYM	3264 c	2776 c	3020 d	3753 b	3990 cd	3871 cd	46.60 a	41.11 a	43.85 a
M ₆ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN+FYM+MC	3353 c	2951 bc	3152 c	3888 b	4278 c	4083 c	46.38 a	40.92 a	43.64 a
S.Em±	39.04	59.46	38.32	97.63	111.0	79.66	0.61	0.77	0.87
Liquid organic manures (L)									
L ₁ -Jeevamrut @ 500 litres ha ⁻¹ at 30, 60 and 90 DAS	3645 a	2912 a	3278 a	4250 c	4236 c	4243 c	46.20 a	40.68 a	43.43 a
L ₂ -Cow urine @ 500 litres ha ⁻¹ at 30, 60and 90 DAS	3705 a	2964 a	3334 a	4504 b	4490 b	4497 b	45.19 a	39.79 a	42.49 a
L ₃ -Bio digester @ 2500 litres ha ⁻¹ at 30, 60 and 90 DAS	3772 a	3020 a	3396 a	4782 a	4785 a	4784 a	44.18 a	38.71 a	41.44 a
L ₄ -Control (no liquid manure application)	3239 b	2582 b	2910 b	3647 d	3628 d	3638 d	47.00 a	41.51 a	44.25 a
S.Em±	65.62	63.63	52.28	76.07	74.26	53.39	0.99	0.98	0.99
Interactions- (M X L)									
M ₁ L ₁	4287 bc	3125 b-f	3706 de	5116 cd	4644 c-e	4880 de	45.62 a	40.22 a	42.90 a
M ₁ L ₂	4357 a-c	3176 b-e	3767 cd	5508 bc	5001 b-d	5255 cd	44.18 a	38.82 a	41.52 a
M ₁ L ₃	4432 ab	3234 a-d	3833 b-d	5827 ab	5298 b	5563 bc	43.26 a	37.96 a	40.63 a
M ₁ L ₄	3887 cd	2832 d-h	3360 ef	4425 ef	4013 f-h	4219 f-h	46.77 a	41.36 a	44.09 a
M ₂ L ₁	4684 ab	3560 a-c	4122 a-c	5374 bc	5095 bc	5235 cd	46.60 a	41.12 a	43.86 a
M ₂ L ₂	4764 ab	3625 ab	4195 ab	5803 ab	5509 ab	5656 b	45.09 a	39.67 a	42.37 a
M ₂ L ₃	4842 a	3682 a	4262 a	6191 a	5875 a	6033 a	43.92 a	38.52 a	41.21 a
M ₂ L ₄	4279 bc	3248 a-d	3764 cd	4721 de	4469 d-f	4595 ef	47.54 a	42.07 a	44.79 a
M ₃ L ₁	3089 e-h	2458 h-j	2774 i-k	3707 g-i	3687 h-j	3697 ij	45.49 a	40.01 a	42.76 a
M ₃ L ₂	3099 e-h	2452 h-j	2776 i-k	3843 f-h	3801 g-i	3822 h-j	44.66 a	39.29 a	42.00 a
M ₃ L ₃	3164 e-g	2512 h-j	2838 h-k	4050 fg	4019 f-h	4035 g-i	43.89 a	38.43 a	41.15 a
M ₃ L ₄	2624 h	2068 j	2346 l	3044 j	2999 k	3022 l	46.32 a	40.83 a	43.59 a
M ₄ L ₁	3109 e-h	2534 g-j	2822 h-k	3731 g-i	3801 g-i	3766 ij	45.48 a	39.76 a	42.60 a
M ₄ L ₂	3173 e-g	2605 f-i	2889 g-j	3903 f-h	4005 f-h	3954 g-i	44.84 a	39.41 a	42.15 a
M ₄ L ₃	3229 ef	2656 e-i	2943 f-j	4165 e-g	4350 e-g	4257 f-h	43.69 a	37.91 a	40.81 a
M ₄ L ₄	2674 gh	2186 ij	2430 kl	3129 ij	3197 jk	3163 kl	46.10 a	40.57 a	43.35 a
M ₅ L ₁	3314 ef	2817 d-h	3066 f-j	3712 g-i	3944 f-i	3828 h-j	47.24 a	41.67 a	44.47 a
M ₅ L ₂	3384 d-f	2881 d-h	3133 f-i	3925 f-h	4177 e-h	4051 g-i	46.30 a	40.85 a	43.58 a
M ₅ L ₃	3449 d-f	2938 d-h	3194 f-i	4173 e-g	4444 d-f	4309 fg	45.23 a	39.79 a	42.49 a
M ₅ L ₄	2909 f-h	2469 h-j	2689 j-l	3200 ij	3395 i-k	3298 kl	47.63 a	42.12 a	44.87 a
M ₆ L ₁	3384 d-f	2978 d-h	3181 f-i	3858 f-h	4244 e-h	4051 g-i	46.76 a	41.28 a	44.01 a
M ₆ L ₂	3454 d-f	3042 d-g	3248 f-h	4041 f-g	4449 d-f	4245 f-h	46.06 a	40.67 a	43.34 a
M ₆ L ₃	3514 de	3098 c-f	3306 fg	4287 e-g	4724 c-e	4506 ef	45.08 a	39.65 a	42.36 a
M ₆ L ₄	3059 e-h	2687 e-i	2873 h-j	3365h-j	3695 h-j	3530 jk	47.62 a	42.09 a	44.84 a
S.Em±	160.7	155.9	128.1	186.3	181.9	130.8	1.78	1.75	1.77

Means followed by the same alphabet do not differ significantly by DMRT (0.05)

lower straw yield (3644 kg ha^{-1}) was recorded with application of FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN (M_3).

Among the liquid organic manures, soil application of biodigester @ 2500 l ha^{-1} at 30, 60 and 90 DAS (L_3) recorded significantly higher straw yield (4784 kg ha^{-1}). Significantly lower straw yield (3638 kg ha^{-1}) was recorded with control (L_4).

Among the treatment combinations, integrated application of RDF + FYM + microbial consortium and soil application of biodigester @ 2500 l ha^{-1} at 30, 60 and 90 DAS (M_2L_3) recorded significantly higher straw yield (6033 kg ha^{-1}) over other treatments. First year straw yield data showed that RDF without liquid organic manure combination M_1L_4 (4425 kg ha^{-1}) was at par with organics FYM + vermicompost + green leaf manure equivalent to RDN + FYM with liquid organic manure application M_6L_3 (4287 kg ha^{-1}), M_6L_2 (4041 kg ha^{-1}) and M_6L_1 (3858 kg ha^{-1}). Second year straw yield data showed better effect of organic combinations indicating RDF + FYM + soil application of jeevamrut @ 500 l ha^{-1} at 30, 60 and 90 DAS combination M_2L_1 (5095 kg ha^{-1}) was at par with organic combination of FYM + vermicompost + green leaf manure equivalent to RDN + FYM with liquid organic manure application M_6L_3 (4724 kg ha^{-1}). Significantly lower straw yield was recorded with M_1L_3 (3022 kg ha^{-1}).

4.2.2.9 Harvest Index

Harvest index did not differ significantly influenced by integrated application of manurial practices and liquid organic manures (Table 37).

4.2.3 Microbial population

4.2.3.1 Free living N fixers population ($\times 10^3 \text{ cfu g soil}^{-1}$)

The data on free living N fixers population as influenced by manurial practices and liquid organic manures at flowering and harvest is furnished in Table 38. It was noticed that N fixers population increased during second year compared to first year of experimentation.

N fixers population was significantly influenced by manurial practices and liquid organic manures and their interactions at flowering and harvest. Among the manurial practices, application of FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3)

Table 38: Effect of manurial practices and liquid organic manures on N fixures ($\times 10^3$ cfu g^{-1} soil) and PSB ($\times 10^4$ cfu g^{-1} soil) in rhizosphere

Treatments	N fixures						PSB					
	Flowering			Harvest			Flowering			Harvest		
	2013	2014	Pooled	2013	2014	Pooled	2013	2014	Pooled	2013	2014	Pooled
Manurial practices (M)												
M ₁ -RDF (100:50:50 kg N, P ₂ O ₅ , K ₂ O ha ⁻¹)	21.00f	24.25f	22.63f	19.25f	21.58f	20.42f	18.33f	19.00f	18.67f	14.67f	15.33f	15.00f
M ₂ -RDF+FYM+MC	25.00e	28.42e	26.71e	23.42e	25.75e	24.58e	28.67c	34.42c	31.54c	26.33c	32.08c	29.21c
M ₃ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN	31.00d	34.00d	32.50d	28.00d	30.33d	29.17d	20.33e	24.25e	22.29e	17.67e	21.67e	19.67e
M ₄ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN+MC	33.00 c	36.00 c	34.50 c	30.00 c	32.33c	31.17c	32.67b	40.33b	36.50b	30.33b	38.00b	34.17b
M ₅ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN+FYM	36.92b	40.00b	38.46b	34.00b	36.33b	35.17b	22.25d	26.58d	24.42d	19.67d	23.92d	21.79d
M ₆ -FYM (1/3) +VC (1/3) +GLM (1/3) qui.RDN+FYM+MC	39.08a	42.25a	40.67a	36.25a	38.58a	37.42a	38.42a	46.75a	42.58a	36.08a	44.42a	40.25a
S.Em±	0.27	0.21	0.16	0.21	0.38	0.29	0.25	0.36	0.26	0.49	0.37	0.38
Liquid organic manures (L)												
L ₁ -Jeevamrut @ 500 litres ha ⁻¹ at 30, 60 and 90 DAS	31.44b	34.78b	33.11b	29.11b	31.44b	30.28b	27.22b	32.33b	29.78b	24.56b	29.67b	27.11b
L ₂ -Cow urine @ 500 litres ha ⁻¹ at 30, 60and 90 DAS	30.56c	33.39c	31.97c	27.72c	30.06c	28.89c	26.33c	31.44c	28.89c	23.67c	28.78c	26.22c
L ₃ -Bio digester @ 2500 litres ha ⁻¹ at 30, 60 and 90 DAS	32.67a	36.11a	34.39a	30.44a	32.78a	31.61a	28.44a	33.56a	31.00a	25.78a	30.89a	28.33a
L ₄ -Control (no liquid manure application)	29.33d	32.33d	30.83d	26.67d	29.00d	27.83d	25.11d	30.22d	27.67d	22.50d	27.61d	25.06d
S.Em±	0.18	0.19	0.12	0.19	0.24	0.20	0.18	0.18	0.18	0.18	0.18	0.18
Interactions- (M X L)												
M ₁ L ₁	21.33n	24.67n	23.00o	19.67o	22.00mn	20.83o	18.67mn	19.33o	19.00o	15.00no	15.67o	15.33p
M ₁ L ₂	20.67n	23.33no	22.00p	18.33op	20.67no	19.50op	18.00n	18.67o	18.33o	14.33o	15.00o	14.67p
M ₁ L ₃	22.67m	26.67m	24.67n	21.67n	24.00l	22.83n	20.00lm	20.67n	20.33n	16.33mn	17.00n	16.67o
M ₁ L ₄	19.33o	22.33o	20.83q	17.33p	19.67o	18.50p	16.67o	17.33p	17.00p	13.00p	13.67p	13.33q
M ₂ L ₁	25.67k	29.33l	27.50l	24.33m	26.67k	25.50m	29.33g	35.33g	32.33g	27.00g	33.00g	30.00g
M ₂ L ₂	24.33l	27.33m	25.83m	22.33n	24.67l	23.50n	28.00h	33.67h	30.83h	25.67h	31.33h	28.50h
M ₂ L ₃	26.67k	30.67l	28.67k	25.67lm	28.00jk	26.83lm	30.33fg	36.00g	33.17g	28.00fg	33.67g	30.83g
M ₂ L ₄	23.33lm	26.33m	24.83n	21.33n	23.67lm	22.50n	27.00h	32.67h	29.83h	24.67h	30.33h	27.50h
M ₃ L ₁	31.33hi	34.67ij	33.00h	28.67j	31.00hi	29.83ij	20.67kl	24.33l	22.50lm	18.00kl	21.67lm	19.83lm
M ₃ L ₂	30.67i	33.33jk	32.00i	27.33jk	29.67ij	28.50jk	20.00lm	24.00l	22.00m	17.33lm	21.33lm	19.33mn
M ₃ L ₃	32.67gh	35.67hi	34.17g	29.67hi	32.00gh	30.83hi	22.00jk	26.00jk	24.00jk	19.33jk	23.33jk	21.33jk
M ₃ L ₄	29.33j	32.33k	30.83j	26.33kl	28.67j	27.50kl	18.67mn	22.67m	20.67n	16.00mn	20.33m	18.17n
M ₄ L ₁	33.33g	36.67gh	35.00g	30.67gh	33.00fg	31.83gh	33.00e	40.67e	36.83e	30.67e	38.33e	34.50e
M ₄ L ₂	32.67gh	35.67hi	34.17g	29.67hi	32.00gh	30.83hi	32.33e	40.00e	36.17e	30.00e	37.67e	33.83e
M ₄ L ₃	34.67f	37.33fg	36.00f	31.33fg	33.67fg	32.50fg	34.33d	42.00d	38.17d	32.00d	39.67d	35.83d
M ₄ L ₄	31.33hi	34.33ij	32.83hi	28.33ij	30.67hi	29.50ij	31.00f	38.67f	34.83f	28.67f	36.33f	32.50f
M ₅ L ₁	37.33cd	40.67cd	39.00d	34.67cd	37.00 cd	35.83cd	22.67j	27.00j	24.83j	20.00j	24.33j	22.17j
M ₅ L ₂	36.33de	39.33de	37.83e	33.33de	35.67de	34.50de	21.67jk	26.00jk	23.83j-l	19.00jk	23.33jk	21.17j-l
M ₅ L ₃	38.67bc	41.67bc	40.17c	35.67bc	38.00bc	36.83bc	24.00i	28.33i	26.17i	21.33i	25.67i	23.50i
M ₅ L ₄	35.33ef	38.33ef	36.83f	32.33ef	34.67ef	33.50ef	20.67kl	25.00kl	22.83k-m	18.33kl	22.33kl	20.33k-m
M ₆ L ₁	39.67ab	42.67b	41.17b	36.67b	39.00b	37.83b	39.00ab	47.33ab	43.17ab	36.67ab	45.00ab	40.83ab
M ₆ L ₂	38.67bc	41.33bc	40.00 c	35.33bc	37.67bc	36.50bc	38.00b	46.33b	42.17b	35.67b	44.00b	39.83b
M ₆ L ₃	40.67a	44.67a	42.67a	38.67a	41.00a	39.83a	40.00a	48.33a	44.17a	37.67a	46.00a	41.83a
M ₆ L ₄	37.33cd	40.33cd	38.83d	34.33cd	36.67cd	35.50 cd	36.67c	45.00 c	40.83c	34.33c	42.67c	38.50 c
S.Em±	0.45	0.46	0.31	0.48	0.59	0.51	0.45	0.44	0.44	0.45	15.33f	0.45
Initial	16.67						12.67					

Means followed by the same alphabet do not differ significantly by DMRT (0.05)

equivalent to RDN with recommended FYM + microbial consortium (M_6) recorded significantly higher N fixers population at flowering and harvest (40.67 and 37.42×10^3 cfu g soil⁻¹) over other treatments. Significantly lower N fixers population was recorded with application of RDF at flowering and harvest (22.63 and 20.42×10^3 cfu g⁻¹ soil).

Among the liquid organic manures, soil application of biodigester @ 2500 l ha^{-1} at 30, 60 and 90 DAS (L_3) recorded significantly higher N fixers population at flowering and harvest (34.39 and 31.61×10^3 cfu g⁻¹ soil). Significantly lower N fixers population was recorded with control (30.83 and 27.83×10^3 cfu g⁻¹ soil) at flowering and harvest.

Among the treatment combinations, integrated application of FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN with recommended FYM + microbial consortium with soil application of biodigester @ 2500 l ha^{-1} at 30, 60 and 90 DAS (M_6L_3) recorded significantly higher N fixers population (42.67 and 39.83×10^3 cfu g⁻¹ soil) at flowering and harvest. Significantly lower N fixers population was recorded with M_1L_4 at flowering and harvest (20.83 and 18.50×10^3 cfu g⁻¹ soil).

4.2.3.2 Phosphorus solubilizing bacterial (PSB) population ($\times 10^4$ cfu g soil⁻¹)

Irrespective of liquid organic manures, application of FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN with recommended FYM + microbial consortium (M_6) recorded significantly higher PSB population at flowering and harvest (42.58 and 40.25×10^4 cfu g⁻¹ soil) over other treatments (Table 38). Significantly lower PSB population was recorded with application of RDF at flowering and harvest (18.67 and 15.00×10^4 cfu g⁻¹ soil).

Among the liquid organic manures, soil application of biodigester @ 2500 l ha^{-1} at 30, 60 and 90 DAS (L_3) recorded significantly higher PSB population at flowering and harvest (31.00 and 28.33×10^4 cfu g⁻¹ soil). Significantly lower PSB population was recorded with control (27.67 and 25.06×10^4 cfu g⁻¹ soil).

Among the treatment combinations, integrated application of FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN with recommended

FYM + microbial consortium with soil application of biodigester @ 2500 l ha⁻¹ at 30, 60 and 90 DAS (M₆L₃) recorded significantly higher PSB population (44.17 and 41.83 x10⁴ cfu g⁻¹ soil) but was at par with M₆L₁ (43.17 and 40.83 x10⁴ cfu g⁻¹ soil). Significantly lower PSB population was recorded with M₁L₄ at flowering and harvest (17.00 and 13.33 x10⁴ cfu g⁻¹ soil).

4.2.3.3 *Azospirillum* spp. population (x 10⁶ cfu g⁻¹ soil)

The data on *Azospirillum* spp. population as influenced by manurial practices and liquid organic manures at flowering and harvest is presented in Table 39.

The data on *Azospirillum* spp. population was significantly influenced by manurial practices and liquid organic manures and their interactions at flowering and harvest. Irrespective of liquid organic manures, application of FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN with recommended FYM + microbial consortium (M₆) recorded significantly higher *Azospirillum* spp. population at flowering and harvest (2.94 and 0.51 x10⁶ cfu g⁻¹ soil) over other treatments. Significantly lower *Azospirillum* spp. population was recorded with application of RDF at flowering and harvest (0.09 and 0.03 x10⁶ cfu g⁻¹ soil).

Among the liquid organic manures, soil application of biodigester @ 2500 l ha⁻¹ at 30, 60 and 90 DAS (L₃) recorded significantly higher *Azospirillum* spp. population at flowering and harvest (1.90 and 0.31 x10⁶ cfu g⁻¹ soil). Significantly lower *Azospirillum* spp. population was recorded with control (0.74 and 0.11 x10⁶ cfu g⁻¹ soil).

Among the treatment combinations, integrated application of FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN with recommended FYM + microbial consortium with soil application of biodigester @ 2500 l ha⁻¹ at 30, 60 and 90 DAS (M₆L₃) recorded significantly higher *Azospirillum* spp. population (3.95 and 0.80 x10⁶ cfu g⁻¹ soil) but was at par with M₆L₁ (3.65 x10⁶ cfu g⁻¹ soil) at flowering. Significantly lower *Azospirillum* spp. population was recorded with M₁L₄ at flowering and harvest (0.05 and 0.02 x10⁶ cfu g⁻¹ soil).

Table 39: Effect of manurial practices and liquid organic manures on *Azospirillum* spp. ($\times 10^6$ cfu g^{-1} soil) in rhizosphere at flowering and harvest

Treatments	Flowering			Harvest		
	2013	2014	Pooled	2013	2014	Pooled
Manurial practices (M)						
M ₁ -RDF (100:50:50 kg N, P ₂ O ₅ K ₂ O ha ⁻¹)	0.08c	0.10 c	0.09c	0.02d	0.03d	0.03d
M ₂ -RDF+FYM+MC	1.56b	1.75b	1.65b	0.17c	0.20 c	0.19c
M ₃ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN	0.31c	0.43c	0.37c	0.05d	0.06d	0.05d
M ₄ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN+MC	2.30a	2.76a	2.53a	0.31b	0.43b	0.37b
M ₅ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN+FYM	0.43c	0.58c	0.51c	0.07d	0.09cd	0.08d
M ₆ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN+FYM+MC	2.76a	3.12a	2.94a	0.43a	0.58a	0.51a
S.Em±	0.17	0.17	0.17	0.02	0.03	0.03
Liquid organic manures (L)						
L ₁ -Jeevamrut @ 500 litres ha ⁻¹ at 30, 60 and 90 DAS	1.50b	1.75b	1.62b	0.19b	0.27b	0.23b
L ₂ -Cow urine @ 500 litres ha ⁻¹ at 30, 60and 90 DAS	1.01c	1.25c	1.13c	0.15c	0.19c	0.17c
L ₃ -Bio digester @ 2500 litres ha ⁻¹ at 30, 60 and 90 DAS	1.79a	2.02a	1.90a	0.27a	0.35a	0.31a
L ₄ -Control (no liquid manure application)	0.66d	0.81d	0.74d	0.10d	0.13d	0.11d
S.Em±	0.05	0.06	0.05	0.01	0.01	0.01
Interactions- (M X L)						
M ₁ L ₁	0.10i	0.11k	0.11l	0.02j	0.03k	0.03jk
M ₁ L ₂	0.06i	0.08k	0.07l	0.02j	0.03k	0.02k
M ₁ L ₃	0.12i	0.15k	0.14l	0.04j	0.05jk	0.04jk
M ₁ L ₄	0.04i	0.06k	0.05l	0.01j	0.02k	0.02k
M ₂ L ₁	1.73de	1.87ef	1.80ef	0.19d-f	0.22e-g	0.21ef
M ₂ L ₂	1.43ef	1.53fg	1.48fg	0.15e-h	0.17f-h	0.16e-h
M ₂ L ₃	2.13cd	2.47cd	2.30 cd	0.22de	0.26de	0.24de
M ₂ L ₄	0.95g	1.12gh	1.03hi	0.13f-i	0.15g-i	0.14f-i
M ₃ L ₁	0.32hi	0.48i-k	0.40j-l	0.05j	0.07i-k	0.06i-k
M ₃ L ₂	0.27hi	0.32jk	0.30kl	0.04j	0.05jk	0.05jk
M ₃ L ₃	0.48hi	0.71h-j	0.60jk	0.06ij	0.08i-k	0.07i-k
M ₃ L ₄	0.17i	0.21jk	0.19kl	0.03j	0.04jk	0.04jk
M ₄ L ₁	2.83b	3.53b	3.18b	0.32c	0.48c	0.40 c
M ₄ L ₂	1.73de	2.23de	1.98de	0.27cd	0.32d	0.30d
M ₄ L ₃	3.53a	3.77ab	3.65a	0.48b	0.71b	0.60b
M ₄ L ₄	1.10fg	1.50fg	1.30gh	0.17e-g	0.21e-g	0.19e-g
M ₅ L ₁	0.48hi	0.71h-j	0.60jk	0.08h-j	0.10h-k	0.09h-k
M ₅ L ₂	0.32hi	0.48i-k	0.40j-l	0.07h-j	0.08i-k	0.08h-k
M ₅ L ₃	0.71gh	0.88hi	0.80ij	0.09g-j	0.12h-j	0.11g-j
M ₅ L ₄	0.21i	0.25jk	0.23kl	0.05j	0.07i-k	0.06i-k
M ₆ L ₁	3.53a	3.77ab	3.65a	0.48b	0.71b	0.60b
M ₆ L ₂	2.23c	2.83c	2.53c	0.32c	0.48c	0.40 c
M ₆ L ₃	3.77a	4.13a	3.95a	0.71a	0.88a	0.80a
M ₆ L ₄	1.50ef	1.73f	1.62e-g	0.21d-f	0.25d-f	0.23de
S.Em±	0.14	0.15	0.12	0.02	0.02	0.02
Initial				0.01		

Means followed by the same alphabet do not differ significantly by DMRT (0.05)

4.2.4 Enzymatic activity

4.2.4.1 Dehydrogenase enzyme activity ($\mu\text{g TPF g}^{-1} \text{ soil day}^{-1}$)

Among the manurial practices, application of FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN with recommended FYM + microbial consortium (M_6) recorded significantly higher dehydrogenase at flowering and harvest (14.64 and $13.10 \mu\text{g TPF g}^{-1} \text{ soil day}^{-1}$) over other treatments (Table 40). Significantly lower dehydrogenase was recorded with application of RDF at flowering and harvest (11.03 and $9.50 \mu\text{g TPF g}^{-1} \text{ soil day}^{-1}$).

Among the liquid organic manures, soil application of biodigester @ 2500 l ha^{-1} at 30, 60 and 90 DAS (L_3) recorded significantly higher dehydrogenase at flowering and harvest (13.83 and $12.39 \mu\text{g TPF g}^{-1} \text{ soil day}^{-1}$). Significantly lower dehydrogenase was recorded with control (12.28 and $10.71 \mu\text{g TPF g}^{-1} \text{ soil day}^{-1}$).

Among the treatment combinations, integrated application of FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN with recommended FYM + microbial consortium with soil application of biodigester @ 2500 l ha^{-1} at 30, 60 and 90 DAS (M_6L_3) recorded significantly higher dehydrogenase (15.72 and $14.27 \mu\text{g TPF g}^{-1} \text{ soil day}^{-1}$) but was on par with M_5L_3 and M_6L_1 (15.07 and $15.04 \mu\text{g TPF g}^{-1} \text{ soil day}^{-1}$) at flowering and with M_5L_3 ($15.04 \mu\text{g TPF g}^{-1} \text{ soil day}^{-1}$) at harvest. Significantly lower dehydrogenase was recorded with M_1L_4 at flowering and harvest (10.46 and $8.93 \mu\text{g TPF g}^{-1} \text{ soil day}^{-1}$).

4.2.4.2 Phosphatase enzyme activity ($\mu\text{g pNP g}^{-1} \text{ soil h}^{-1}$)

Phosphatase enzyme was significantly influenced by manurial practices and liquid organic manures at flowering and harvest (Table 40).

Among the manurial practices, application of FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN with recommended FYM + microbial consortium (M_6) recorded significantly higher phosphatase at flowering and harvest (28.53 and $27.27 \mu\text{g pNP g}^{-1} \text{ soil h}^{-1}$) over other treatments but was at par with M_5 (28.13 and $26.88 \mu\text{g pNP g}^{-1} \text{ soil h}^{-1}$). Significantly lower phosphatase was recorded with application of RDF at flowering and harvest (22.03 and $20.87 \mu\text{g pNP g}^{-1} \text{ soil h}^{-1}$).

Table 40: Effect of manurial practices and liquid organic manures on dehydrogenase ($\mu\text{g TPF g}^{-1} \text{ soil day}^{-1}$) and phosphatase ($\mu\text{g pNP g}^{-1} \text{ soil h}^{-1}$) enzymes

Treatments	Flowering						Harvest					
	Dehydrogenase			Phosphatase			Dehydrogenase			Phosphatase		
	2013	2014	Pooled	2013	2014	Pooled	2013	2014	Pooled	2013	2014	Pooled
Manurial practices (M)												
M ₁ -RDF (100:50:50 kg N, P ₂ O ₅ , K ₂ O ha ⁻¹)	10.05d	12.01d	11.03e	21.04d	23.02e	22.03d	8.54d	10.46e	9.50d	19.90d	21.84e	20.87d
M ₂ -RDF+FYM+MC	10.96c	12.84c	11.90d	22.95c	24.82d	23.88c	9.45d	11.35d	10.40 c	21.69c	23.38d	22.53c
M ₃ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN	12.07b	13.99b	13.03c	24.62b	26.64c	25.63b	10.56c	12.45c	11.50b	23.51b	25.36c	24.43b
M ₄ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN+MC	12.40b	14.28b	13.34c	25.03b	27.00 c	26.01b	10.88bc	12.77c	11.82b	23.88b	25.62c	24.75b
M ₅ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN+FYM	13.29a	15.09a	14.19b	27.29a	28.98b	28.13a	11.75ab	13.57b	12.66a	26.11a	27.66b	26.88a
M ₆ -FYM (1/3) +VC (1/3) +GLM (1/3) qui.RDN+FYM+MC	13.70a	15.58a	14.64a	27.52a	29.54a	28.53a	12.15a	14.06a	13.10a	26.40a	28.15a	27.27a
S.Em±	0.18	0.25	0.1	0.38	0.15	0.21	0.35	0.11	0.19	0.22	0.14	0.14
Liquid organic manures (L)												
L ₁ -Jeevamrut @ 500 litres ha ⁻¹ at 30, 60 and 90 DAS	12.37b	14.28a	13.33b	25.30b	27.33b	26.31b	10.86b	12.76b	11.81b	24.21b	25.99b	25.10b
L ₂ -Cow urine @ 500 litres ha ⁻¹ at 30, 60and 90 DAS	11.73c	13.56b	12.65c	24.11c	26.02c	25.06c	10.16c	12.01c	11.08c	22.89c	24.68c	23.79c
L ₃ -Bio digester @ 2500 litres ha ⁻¹ at 30, 60 and 90 DAS	12.88a	14.79a	13.83a	25.97a	28.02a	26.99a	11.43a	13.34a	12.39a	24.82a	26.67a	25.74a
L ₄ -Control (no liquid manure application)	11.34d	13.22b	12.28d	23.59c	25.29d	24.44d	9.77c	11.65d	10.71d	22.41c	23.99d	23.20d
S.Em±	0.13	0.17	0.11	0.19	0.09	0.1	0.16	0.1	0.09	0.17	0.09	0.09
Interactions- (M X L)												
M ₁ L ₁	10.22j-l	12.19j-l	11.21lm	21.68j	23.54i	22.61h	8.73lm	10.58k-m	9.66kl	20.52i	22.45ij	21.49h
M ₁ L ₂	9.87kl	11.75kl	10.81lm	20.28k	22.35j	21.32i	8.28m	10.19lm	9.24lm	19.13j	21.23k	20.18i
M ₁ L ₃	10.61i-k	12.68h-l	11.64j-l	22.35h-j	24.45h	23.40h	9.15j-m	11.22jk	10.19jk	21.24g-i	23.05i	22.15h
M ₁ L ₄	9.52l	11.40l	10.46m	19.86k	21.73j	20.80i	8.01m	9.84m	8.93m	18.72j	20.62k	19.67i
M ₂ L ₁	11.23h-j	13.11g-k	12.17i-k	23.34g-i	25.24g	24.29g	9.76i-l	11.67ij	10.72ij	22.45fg	23.86h	23.16g
M ₂ L ₂	10.53i-l	12.41i-l	11.47kl	22.45h-j	24.32h	23.39h	8.98k-m	10.86kl	9.92kl	21.05hi	22.83j	21.94h
M ₂ L ₃	11.71f-h	13.64e-i	12.68g-i	23.87f-h	25.75fg	24.81fg	10.26g-k	12.23f-i	11.25g-i	22.53fg	24.58g	23.56fg
M ₂ L ₄	10.39j-l	12.19j-l	11.29lm	22.12ij	23.98hi	23.05h	8.78lm	10.64k-m	9.71kl	20.72i	22.23j	21.48h
M ₃ L ₁	12.32d-g	14.30 c-g	13.31d-g	25.25d-f	27.42e	26.34e	10.85d-i	12.72d-j	11.79e-h	24.12de	25.98ef	25.05e
M ₃ L ₂	11.67f-h	13.55e-j	12.61g-i	23.86f-h	25.72fg	24.79fg	10.09h-k	11.96g-j	11.03hi	22.72f	24.45gh	23.59fg
M ₃ L ₃	12.85c-e	14.78b-f	13.82c-e	26.13cd	28.25cd	27.19cd	11.42c-g	13.34c-e	12.38c-e	25.05cd	26.86cd	25.96cd
M ₃ L ₄	11.45g-i	13.33f-j	12.39h-j	23.23g-i	25.15g	24.19g	9.86h-l	11.76h-j	10.81ij	22.15f-h	24.13gh	23.14g
M ₄ L ₁	12.63c-f	14.56b-g	13.60d-f	25.65c-e	27.76de	26.71de	11.15d-h	13.13c-e	12.14d-f	24.52c-e	26.34de	25.43de
M ₄ L ₂	11.97e-h	13.86d-i	12.92f-i	24.35e-g	26.28f	25.32f	10.39f-j	12.25f-i	11.32g-i	23.23ef	24.84g	24.04f
M ₄ L ₃	13.20b-d	14.96b-e	14.08cd	26.24cd	28.33cd	27.29cd	11.72b-e	13.53cd	12.63cd	25.13cd	26.85cd	25.99cd
M ₄ L ₄	11.80e-h	13.73d-i	12.76f-i	23.86f-h	25.62fg	24.74fg	10.26g-k	12.15f-i	11.21hi	22.64f	24.46gh	23.55fg
M ₅ L ₁	13.68bc	15.57a-c	14.63bc	27.72ab	29.64b	28.68b	12.06b-d	13.96bc	13.01bc	26.63ab	28.45b	27.54b
M ₅ L ₂	13.16b-d	14.65b-f	13.90 c-e	26.86bc	28.73c	27.80 c	11.58b-f	13.23c-e	12.41c-e	25.53b-d	27.42c	26.48c
M ₅ L ₃	14.12ab	16.01ab	15.07ab	28.35a	30.42a	29.39ab	12.72ab	14.52ab	13.62ab	27.17a	29.12ab	28.15ab
M ₅ L ₄	12.19d-h	14.12c-h	13.16e-h	26.22cd	27.12e	26.67de	10.65e-i	12.58e-h	11.62f-h	25.09cd	25.64f	25.37de
M ₆ L ₁	14.12ab	15.96ab	15.04ab	28.15ab	30.36a	29.26ab	12.58a-c	14.52ab	13.55b	27.02a	28.86b	27.94b
M ₆ L ₂	13.20b-d	15.13b-d	14.17cd	26.84bc	28.72c	27.78c	11.64b-f	13.56cd	12.60 cd	25.68bc	27.32c	26.50 c
M ₆ L ₃	14.78a	16.67a	15.72a	28.85a	30.92a	29.89a	13.32a	15.22a	14.27a	27.78a	29.54a	28.66a
M ₆ L ₄	12.68c-f	14.56b-g	13.62d-f	26.23cd	28.15cd	27.19cd	11.04d-i	12.94d-f	11.99d-g	25.13cd	26.86cd	26.00 cd
S.Em±	0.32	0.43	0.27	0.47	0.23	0.26	0.39	0.25	0.23	19.90d	0.22	0.23
Initial	7.68			17.23			7.68			17.23		

Means followed by the same alphabet do not differ significantly by DMRT (0.05)

Among the liquid organic manures, soil application of biodigester @ 2500 l ha⁻¹ at 30, 60 and 90 DAS (L₃) recorded significantly higher phosphatase at flowering and harvest (26.99 and 25.74 µg pNP g⁻¹ soil h⁻¹). Significantly lower phosphatase was recorded with control (24.44 and 23.20 µg pNP g⁻¹ soil h⁻¹).

Among the treatment combinations, integrated application of FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN with recommended FYM + microbial consortium with soil application of biodigester @ 2500 l ha⁻¹ at 30, 60 and 90 DAS (M₆L₃) recorded significantly higher phosphatase (29.89 and 28.66 µg pNP g⁻¹ soil h⁻¹) but was at par with M₅L₃ and M₆L₁ (29.39 and 29.26 µg pNP g⁻¹ soil h⁻¹) at flowering and with M₅L₃ (28.15 µg pNP g⁻¹ soil h⁻¹) at harvest. Significantly lower phosphatase was recorded with M₁L₄ at flowering and harvest (20.80 and 19.67 µg pNP g⁻¹ soil h⁻¹).

4.2.5 Physical properties of Soil

4.2.5.1 Bulk density (Mg/m³)

The data on soil bulk density as influenced by manurial practices and liquid organic manures at harvest is furnished in Table 41.

Soil bulk density did not differ significantly influenced by integrated application of manurial practices and liquid organic manures though there was decrease in bulk density due to application of organic manures to soil.

4.2.5.2 Maximum water holding capacity (%)

The data on maximum water holding capacity was significantly influenced by manurial practices and liquid organic manures and their interactions at harvest (Table 41). Application of FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN with recommended FYM + microbial consortium (M₆) recorded significantly higher maximum water holding capacity (54.21%) over other treatments but was at par with application of FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN with recommended FYM (54.13%), FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN + microbial consortium

Table 41: Effect of manurial practices and liquid organic manures on bulk density and maximum water holding capacity of soil at harvest

Treatments	Bulk density (Mg/m ³)			Maximum water holding capacity (%)		
	2013	2014	Pooled	2013	2014	Pooled
Manurial practices (M)						
M ₁ -RDF (100:50:50 kg N, P ₂ O ₅ K ₂ O ha ⁻¹)	1.277a	1.274a	1.275a	51.92b	52.07b	51.99b
M ₂ -RDF+FYM+MC	1.270a	1.261a	1.266a	52.34ab	52.61ab	52.47ab
M ₃ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN	1.264a	1.255a	1.260a	53.24ab	53.45ab	53.34ab
M ₄ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN+MC	1.262a	1.253a	1.257a	53.26ab	53.48ab	53.37ab
M ₅ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN+FYM	1.254a	1.243a	1.249a	54.04a	54.21a	54.13a
M ₆ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN+FYM+MC	1.251a	1.241a	1.246a	54.07a	54.36a	54.21a
S.Em±	0.019	0.019	0.013	0.65	0.62	0.6
Liquid organic manures (L)						
L ₁ -Jeevamrut @ 500 litres ha ⁻¹ at 30, 60 and 90 DAS	1.261a	1.249a	1.255a	53.28ab	53.51ab	53.39b
L ₂ -Cow urine @ 500 litres ha ⁻¹ at 30, 60and 90 DAS	1.270a	1.264a	1.267a	52.86b	53.03b	52.94bc
L ₃ -Bio digester @ 2500 litres ha ⁻¹ at 30, 60 and 90 DAS	1.251a	1.241a	1.246a	53.80a	54.08a	53.94a
L ₄ -Control (no liquid manure application)	1.270a	1.264a	1.267a	52.63b	52.83b	52.73c
S.Em±	0.007	0.007	0.007	0.3	0.33	0.17
Interactions- (M X L)						
M ₁ L ₁	1.275a	1.270a	1.273a	51.85b	52.10 c	51.98gh
M ₁ L ₂	1.280a	1.280a	1.280a	51.75b	51.85c	51.80gh
M ₁ L ₃	1.272a	1.266a	1.269a	52.33ab	52.55a-c	52.44e-h
M ₁ L ₄	1.280a	1.280a	1.280a	51.74b	51.78c	51.76h
M ₂ L ₁	1.268a	1.253a	1.261a	52.42ab	52.63a-c	52.53e-h
M ₂ L ₂	1.275a	1.270a	1.273a	51.98b	52.20bc	52.09f-h
M ₂ L ₃	1.262a	1.250a	1.256a	53.00ab	53.45a-c	53.23c-g
M ₂ L ₄	1.276a	1.270a	1.273a	51.95b	52.15bc	52.05f-h
M ₃ L ₁	1.262a	1.250a	1.256a	53.43ab	53.62a-c	53.53b-e
M ₃ L ₂	1.272a	1.265a	1.269a	52.94ab	53.14a-c	53.04c-h
M ₃ L ₃	1.250a	1.240a	1.245a	53.95ab	54.17a-c	54.06a-d
M ₃ L ₄	1.273a	1.265a	1.269a	52.63ab	52.85a-c	52.74d-h
M ₄ L ₁	1.261a	1.248a	1.255a	53.45ab	53.65a-c	53.55a-e
M ₄ L ₂	1.271a	1.262a	1.267a	52.96ab	53.18a-c	53.07c-h
M ₄ L ₃	1.245a	1.237a	1.241a	53.98ab	54.20a-c	54.09a-d
M ₄ L ₄	1.272a	1.263a	1.268a	52.65ab	52.88a-c	52.77d-h
M ₅ L ₁	1.252a	1.238a	1.245a	54.25ab	54.50a-c	54.38a-c
M ₅ L ₂	1.262a	1.254a	1.258a	53.76ab	53.86a-c	53.81a-e
M ₅ L ₃	1.240a	1.228a	1.234a	54.76a	54.98ab	54.87ab
M ₅ L ₄	1.261a	1.253a	1.257a	53.40ab	53.50a-c	53.45b-f
M ₆ L ₁	1.250a	1.236a	1.243a	54.28ab	54.55a-c	54.42a-c
M ₆ L ₂	1.260a	1.252a	1.256a	53.78ab	53.92a-c	53.85a-e
M ₆ L ₃	1.235a	1.225a	1.230a	54.79a	55.15a	54.97a
M ₆ L ₄	1.260a	1.251a	1.256a	53.42ab	53.80a-c	53.61a-e
S.Em±	0.018	0.019	0.017	0.75	0.82	0.42
Initial		1.28			51.70	

Means followed by the same alphabet do not differ significantly by DMRT (0.05)

(53.37%), FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN (53.34%) and RDF + FYM + microbial consortium (52.47%). Significantly lower maximum water holding capacity (51.99%) was recorded with application of RDF (M₁).

Among the liquid organic manures, soil application of biodigester @ 2500 l ha⁻¹ at 30, 60 and 90 DAS (L₃) recorded significantly higher maximum water holding capacity (53.94%). Significantly lower maximum water holding capacity (52.73%) was recorded with control (L₄).

Among the treatment combinations, integrated application of FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN with recommended FYM + microbial consortium with soil application of biodigester @ 2500 l ha⁻¹ at 30, 60 and 90 DAS (M₆L₃) recorded significantly higher maximum water holding capacity (54.97%) but was at par with M₅L₃ (54.87%), M₆L₁ (54.42%), M₅L₁ (54.38%), M₄L₃ (54.09%), M₃L₃ (54.06%), M₆L₂ (53.85%), M₆L₄ (53.61%) and M₄L₁ (53.55%). Significantly lower maximum water holding capacity (51.76%) was recorded with M₁L₄.

4.2.6 Chemical properties of the soil

4.2.6.1 pH

The data on soil pH as influenced by manurial practices and liquid organic manures at harvest is furnished in Table 42.

Application of FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN with recommended FYM + microbial consortium (M₆) recorded significantly higher pH (7.17) over other treatments but was at par with application of FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN with recommended FYM (7.24), FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN + microbial consortium (7.22), FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN (7.19) and RDF + FYM + microbial consortium (M₂) (7.14). Significantly lower pH (6.98) was recorded with application of RDF (M₁).

Table 42: Effect of manurial practices and liquid organic manures on pH, EC, organic carbon content of soil

Treatments	pH			EC (dSm ⁻¹)			Organic carbon (g kg ⁻¹)		
	2013	2014	Pooled	2013	2014	Pooled	2013	2014	Pooled
Manurial practices (M)									
M ₁ -RDF (100:50:50 kg N, P ₂ O ₅ , K ₂ O ha ⁻¹)	6.97b	6.99b	6.98c	0.23a	0.24a	0.23a	5.07d	5.15f	5.11f
M ₂ -RDF+FYM+MC	7.01ab	7.07ab	7.04bc	0.24a	0.25a	0.24a	5.16cd	5.34e	5.25e
M ₃ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN	7.06ab	7.12ab	7.09ab	0.25a	0.26a	0.26a	5.16cd	5.49d	5.32d
M ₄ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN+MC	7.08ab	7.15ab	7.11ab	0.25a	0.27a	0.26a	5.34bc	5.63c	5.49c
M ₅ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN+FYM	7.10ab	7.17a	7.13ab	0.25a	0.27a	0.26a	5.41b	5.71b	5.56b
M ₆ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN+FYM+MC	7.14a	7.20a	7.17a	0.25a	0.27a	0.26a	5.56a	5.86a	5.71a
S.Em±	0.04	0.05	0.02	0.006	0.009	0.009	0.05	0.02	0.02
Liquid organic manures (L)									
L ₁ -Jeevamrut @ 500 litres ha ⁻¹ at 30, 60 and 90 DAS	7.08ab	7.14ab	7.11b	0.25a	0.27a	0.26a	5.35b	5.60b	5.47b
L ₂ -Cow urine @ 500 litres ha ⁻¹ at 30, 60and 90 DAS	7.03ab	7.08ab	7.05bc	0.24a	0.25a	0.25a	5.26b	5.47c	5.36c
L ₃ -Bio digester @ 2500 litres ha ⁻¹ at 30, 60 and 90 DAS	7.14a	7.22a	7.18a	0.26a	0.28a	0.27a	5.50a	5.80a	5.65a
L ₄ -Control (no liquid manure application)	6.99b	7.02b	7.01c	0.23a	0.24a	0.23a	5.03 c	5.25d	5.14d
S.Em±	0.04	0.04	0.04	0.009	0.014	0.014	0.03	0.03	0.03
Interactions- (M X L)									
M ₁ L ₁	6.87c	6.90b	6.89f	0.24a	0.25a	0.25a	5.07ef	5.22fg	5.15gh
M ₁ L ₂	6.97a-c	6.99ab	6.98d-f	0.22a	0.23a	0.23a	5.07ef	5.07g	5.07gh
M ₁ L ₃	7.07a-c	7.10ab	7.09b-e	0.24a	0.24a	0.24a	5.22de	5.22fg	5.22f-h
M ₁ L ₄	6.97a-c	6.98ab	6.98d-f	0.21a	0.22a	0.22a	4.93f	5.07g	5.00h
M ₂ L ₁	7.03a-c	7.10ab	7.07b-f	0.24a	0.25a	0.25a	5.22de	5.37ef	5.30e-g
M ₂ L ₂	7.01a-c	7.06ab	7.04c-f	0.23a	0.24a	0.24a	5.07ef	5.22fg	5.15gh
M ₂ L ₃	7.06a-c	7.15ab	7.11b-e	0.25a	0.27a	0.26a	5.37cd	5.67cd	5.52c-e
M ₂ L ₄	6.92bc	6.96ab	6.94ef	0.22a	0.23a	0.23a	4.98ef	5.07g	5.02h
M ₃ L ₁	7.13a-c	7.19ab	7.16a-d	0.26a	0.28a	0.27a	5.22de	5.52de	5.37d-f
M ₃ L ₂	7.03a-c	7.08ab	7.06c-f	0.25a	0.26a	0.26a	4.98ef	5.37ef	5.17f-h
M ₃ L ₃	7.09a-c	7.17ab	7.13b-e	0.26a	0.28a	0.27a	5.37cd	5.82bc	5.60b-d
M ₃ L ₄	6.99a-c	7.02ab	7.01c-f	0.22a	0.23a	0.23a	5.07ef	5.22fg	5.15gh
M ₄ L ₁	7.15a-c	7.22ab	7.19a-c	0.26a	0.28a	0.27a	5.37cd	5.67cd	5.52c-e
M ₄ L ₂	7.05a-c	7.10ab	7.08b-f	0.25a	0.26a	0.25a	5.37cd	5.52de	5.45d-f
M ₄ L ₃	7.11a-c	7.21ab	7.16a-d	0.26a	0.29a	0.28a	5.52bc	5.97ab	5.75bc
M ₄ L ₄	7.01a-c	7.05ab	7.03c-f	0.22a	0.23a	0.23a	5.07ef	5.37ef	5.22f-h
M ₅ L ₁	7.16a-c	7.24ab	7.20a-c	0.26a	0.28a	0.27a	5.52bc	5.82bc	5.67bc
M ₅ L ₂	7.02a-c	7.08ab	7.05c-f	0.25a	0.26a	0.26a	5.37cd	5.67cd	5.52c-e
M ₅ L ₃	7.22ab	7.30ab	7.26ab	0.26a	0.29a	0.28a	5.67ab	5.97ab	5.82ab
M ₅ L ₄	7.01a-c	7.04ab	7.03c-f	0.24a	0.25a	0.25a	5.07ef	5.37ef	5.22f-h
M ₆ L ₁	7.12a-c	7.20ab	7.16a-d	0.26a	0.28a	0.27a	5.67ab	5.97ab	5.82ab
M ₆ L ₂	7.10a-c	7.15ab	7.12b-e	0.25a	0.26a	0.26a	5.67ab	5.97ab	5.82ab
M ₆ L ₃	7.31a	7.36a	7.34a	0.26a	0.29a	0.28a	5.82a	6.12a	5.97a
M ₆ L ₄	7.04a-c	7.07ab	7.06c-f	0.25a	0.26a	0.25a	5.07ef	5.37ef	5.22f-h
S.Em±	0.1	0.11	0.05	0.018	0.020	0.020	0.08	0.08	0.08
Initial		6.95			0.23			4.90	

Means followed by the same alphabet do not differ significantly by DMRT (0.05)

Among the liquid organic manures, soil application of biodigester @ 2500 l ha⁻¹ at 30, 60 and 90 DAS (L₃) recorded significantly higher pH (7.18). Significantly lower pH (7.01) was recorded with control (L₄).

Among the treatment combinations, integrated application of FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN with recommended FYM + microbial consortium with soil application of biodigester @ 2500 l ha⁻¹ at 30, 60 and 90 DAS (M₆L₃) recorded significantly higher pH (7.34) but was at par with other treatment interactions except M₁L₁ (6.89).

4.2.6.2 EC (dSm⁻¹)

Soil EC did not differ significantly influenced by integrated application of manurial practices and liquid organic manures (Table 42).

4.2.6.3 Organic carbon (g/kg)

The data on soil organic carbon was significantly influenced by manurial practices and liquid organic manures and their interactions (Table 42). Application of FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN with recommended FYM + microbial consortium (M₆) recorded significantly higher organic carbon (5.71 g/kg) over other treatments. Significantly lower organic carbon (5.11 g/kg) was recorded with application of RDF (M₁).

Among the liquid organic manures, soil application of biodigester @ 2500 l ha⁻¹ at 30, 60 and 90 DAS (L₃) recorded significantly higher organic carbon (5.65 g/kg). Significantly lower organic carbon (5.14 g/kg) was recorded with control (L₄).

Among the treatment combinations, integrated application of FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN with recommended FYM + microbial consortium with soil application of biodigester @ 2500 l ha⁻¹ at 30, 60 and 90 DAS (M₆L₃) recorded significantly higher organic carbon (5.97 g/kg) but was at par with M₆L₂ (5.82 g/kg), M₆L₁ (5.82 g/kg) and M₅L₃ (5.82 g/kg). Significantly lower organic carbon (5.00 g/kg) was recorded with control M₁L₄.

4.2.6.4 Available soil nitrogen (kg ha^{-1})

Soil nitrogen significantly influenced by manurial practices and liquid organic manures and their interactions (Table 43).

Among the manurial practices, application of FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN + FYM + microbial consortium (M_6) recorded significantly higher available soil nitrogen ($302.62 \text{ kg ha}^{-1}$) over rest of the treatments. Significantly lower available soil nitrogen ($264.99 \text{ kg ha}^{-1}$) was recorded with application of RDF (M_1).

Among the liquid organic manures, soil application of biodigester @ 2500 l ha^{-1} at 30, 60 and 90 DAS (L_3) recorded significantly higher available soil nitrogen ($297.92 \text{ kg ha}^{-1}$). Significantly lower available soil nitrogen ($275.97 \text{ kg ha}^{-1}$) was recorded with control (L_4).

Among the treatment combinations, application of FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN + FYM + microbial consortium with soil application of biodigester @ 2500 l ha^{-1} at 30, 60 and 90 DAS (M_6L_3) recorded significantly higher available soil nitrogen ($310.46 \text{ kg ha}^{-1}$) but was at par with M_6L_1 ($304.19 \text{ kg ha}^{-1}$), M_5L_3 ($304.19 \text{ kg ha}^{-1}$) and M_4L_3 ($304.19 \text{ kg ha}^{-1}$). Significantly lower available soil nitrogen ($241.47 \text{ kg ha}^{-1}$) was recorded with M_1L_4 .

4.2.6.5 Available soil phosphorus (kg ha^{-1})

The data on available soil phosphorus as influenced by manurial practices and liquid organic manures at harvest is furnished in Table 43.

Irrespective of liquid organic manures, application of FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN + FYM + microbial consortium (M_6) recorded significantly higher available soil phosphorus (29.10 kg ha^{-1}) over rest of the treatments. Significantly lower available soil phosphorus (27.01 kg ha^{-1}) was recorded with application of RDF (M_1).

Table 43: Effect of manurial practices and liquid organic manures on available N, P, K and S in soil

Treatments	N (kg/ha)			P (kg/ha)			K (kg/ha)			S (ppm)		
	2013	2014	Pooled	2013	2014	Pooled	2013	2014	Pooled	2013	2014	Pooled
Manurial practices (M)												
M ₁ -RDF (100:50:50 kg N, P ₂ O ₅ , K ₂ O ha ⁻¹)	261.86e	268.13e	264.99e	26.16d	27.86d	27.01e	295.68b	303.52c	299.6c	13.07c	13.11c	13.09d
M ₂ -RDF+FYM+MC	274.40d	280.67d	277.54d	26.93c	28.69c	27.81d	296.80b	305.76bc	301.28c	13.33bc	13.38bc	13.36cd
M ₃ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN	285.38c	291.65c	288.51c	27.22c	29.28b	28.25c	298.76b	308.84bc	303.8bc	13.69a-c	13.74a-c	13.72bc
M ₄ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN+MC	290.08b	296.35b	293.22b	27.76b	29.82a	28.79b	299.32ab	310.52bc	304.92bc	13.95ab	14.01a-c	13.98ab
M ₅ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN+FYM	291.65b	297.92b	294.78b	27.91b	28.87bc	28.38c	308.00ab	313.6ab	310.8ab	14.16a	14.21ab	14.18ab
M ₆ -FYM (1/3) +VC (1/3) +GLM (1/3) qui.RDN+FYM+MC	299.49a	305.76a	302.62a	28.43a	29.77a	29.10a	312.76a	319.4a	316.12a	14.46a	14.51a	14.48a
S.Em±	1.09	1.39	1.00	0.16	0.15	0.08	4.11	2.45	2.39	0.24	0.28	0.56
Liquid organic manures (L)												
L ₁ -Jeevamrut @ 500 litres ha ⁻¹ at 30, 60 and 90 DAS	288.51b	294.78b	291.65b	28.14b	29.79b	28.96b	303.15ab	311.55ab	307.35ab	13.98ab	14.03ab	14.01b
L ₂ -Cow urine @ 500 litres ha ⁻¹ at 30, 60and 90 DAS	279.10 c	285.38c	282.24c	27.53c	29.15c	28.33c	300.35bc	308.75ab	304.55bc	13.56bc	13.61bc	13.59b
L ₃ -Bio digester @ 2500 litres ha ⁻¹ at 30, 60 and 90 DAS	294.78a	301.06a	297.92a	28.89a	30.57a	29.73a	308.37a	316.77a	312.57a	14.47a	14.52a	14.49a
L ₄ -Control (no liquid manure application)	272.83d	279.10d	275.97d	25.04d	26.69d	25.86d	295.68c	304.08b	299.88c	13.09c	13.14c	13.11c
S.Em±	1.55	1.53	1.17	0.16	0.16	0.13	2.46	2.98	2.01	0.25	0.21	0.16
Interactions- (M X L)												
M ₁ L ₁	275.97de	282.24ef	279.10ef	26.43f-h	28.13h-j	27.28fg	295.68cd	303.52a	299.6de	13.26a-d	13.29b-e	13.28d-h
M ₁ L ₂	250.88f	257.15g	254.02g	25.92g-i	27.62i-k	26.77gh	294.5cd	302.40ab	298.48de	12.94b-d	12.98c-e	12.96f-h
M ₁ L ₃	282.24c-e	288.51de	285.38de	27.54c-f	29.24d-h	28.39de	299.0b-d	306.88b	302.96c-e	13.85a-d	13.89a-e	13.87a-g
M ₁ L ₄	238.34g	244.61h	241.47h	24.73i	26.43kl	25.58i	293.4d	301.28b	297.36e	12.24d	12.29e	12.27h
M ₂ L ₁	275.97de	282.24ef	279.10ef	27.42d-f	29.12e-h	28.27d-f	296.8cd	305.76ab	301.28c-e	13.52a-d	13.58a-e	13.55b-h
M ₂ L ₂	269.70e	275.97f	272.83f	26.93e-g	28.63g-i	27.78e-g	295.6cd	304.64b	300.16de	13.13a-d	13.17b-e	13.15e-h
M ₂ L ₃	282.24c-e	288.51de	285.38de	28.54b-d	30.48a-e	29.51bc	300.1b-d	309.12b	304.6b-e	14.04a-d	14.09a-e	14.07a-f
M ₂ L ₄	269.70e	275.97f	272.83f	24.82i	26.52kl	25.67i	294.5cd	303.52b	299.04de	12.63cd	12.68de	12.66gh
M ₃ L ₁	288.5b-d	294.78cd	291.65cd	28.32b-d	30.38a-e	29.35b-d	299.0b-d	309.12ab	304.08c-e	13.93a-d	13.97a-e	13.95a-g
M ₃ L ₂	282.24c-e	288.51de	285.38de	26.92e-g	28.98f-h	27.95ef	296.8cd	306.88ab	301.8c-e	13.43a-d	13.48a-e	13.46c-h
M ₃ L ₃	294.78bc	301.06bc	297.92bc	28.53b-d	30.59a-d	29.56bc	303.5b-d	313.60ab	308.5b-e	14.35a-d	14.39a-d	14.37a-e
M ₃ L ₄	275.97de	282.24ef	279.10ef	25.12i	27.18j-l	26.15hi	295.6cd	305.76b	300.7de	13.04a-d	13.13b-e	13.09e-h
M ₄ L ₁	294.78bc	301.06bc	297.92bc	28.83bc	30.89a-c	29.86a-c	300.1b-d	311.36ab	305.7b-e	14.12a-d	14.18a-d	14.15a-f
M ₄ L ₂	288.5b-d	294.78cd	291.65cd	28.13b-e	30.19b-f	29.16b-d	297.9b-d	309.12ab	303.52c-e	13.73a-d	13.79a-e	13.76b-g
M ₄ L ₃	301.06ab	307.33ab	304.19ab	29.05ab	31.11ab	30.08ab	304.6b-d	315.84ab	310.2b-e	14.62a-c	14.68a-c	14.65a-d
M ₄ L ₄	275.97de	282.24ef	279.10ef	25.03i	27.09j-l	26.06hi	294.5cd	305.76b	300.1de	13.32a-d	13.37a-e	13.35d-h
M ₅ L ₁	294.78bc	301.06bc	297.92bc	28.72b-d	29.70 c-g	29.21b-d	312.4a-d	318.08ab	315.2a-d	14.33a-d	14.39a-d	14.36a-e
M ₅ L ₂	288.5b-d	294.78cd	291.65cd	28.32b-d	29.22d-h	28.72c-e	305.7a-d	311.36ab	308.5b-e	13.92a-d	13.97a-e	13.95a-g
M ₅ L ₃	301.06ab	307.33ab	304.19ab	29.45ab	30.44a-e	29.94ab	318.08ab	323.68ab	320.88ab	14.84ab	14.87ab	14.86ab
M ₅ L ₄	282.24c-e	288.51de	285.38de	25.13i	26.12l	25.62i	295.68cd	301.28b	298.48de	13.54a-d	13.59a-e	13.57b-h
M ₆ L ₁	301.06ab	307.33ab	304.19ab	29.14ab	30.48a-e	29.81bc	314.7a-c	321.44ab	318.0a-c	14.73a-c	14.77a-c	14.75a-c
M ₆ L ₂	294.78bc	301.06bc	297.92bc	28.93b	30.28a-f	29.60bc	311.3a-d	318.08ab	314.7a-d	14.22a-d	14.28a-d	14.25a-f
M ₆ L ₃	307.33a	313.60a	310.46a	30.23a	31.57a	30.90a	324.8a	331.52a	328.16a	15.13a	15.18a	15.16a
M ₆ L ₄	294.78bc	301.06bc	297.92bc	25.42hi	26.76kl	26.09hi	300.1b-d	306.88ab	303.52c-e	13.74a-d	13.79a-e	13.77b-g
S.Em±	3.8	3.74	2.87	0.40	0.40	0.34	6.04	7.31	4.94	0.62	0.53	0.40
Initial	263.42			23.30			285.6			12.06		

Means followed by the same alphabet do not differ significantly by DMRT (0.05)

Among the liquid organic manures, soil application of biodigester @ 2500 l ha⁻¹ at 30, 60 and 90 DAS (L₃) recorded significantly higher available soil phosphorus (29.73 kg ha⁻¹). Significantly lower available soil phosphorus (25.86 kg ha⁻¹) was recorded with control (L₄).

Among the treatment combinations, application of FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN + FYM + microbial consortium with soil application of biodigester @ 2500 l ha⁻¹ at 30, 60 and 90 DAS (M₆L₃) recorded significantly higher available soil phosphorus (30.90 kg ha⁻¹) but was at par with M₅L₃ (29.94 kg ha⁻¹) and M₄L₃ (30.08 kg ha⁻¹). Significantly lower available soil phosphorus (25.58 kg ha⁻¹) was recorded with M₁L₄.

4.2.6.6 Available soil potassium (kg ha⁻¹)

Among the manurial practices, application of FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN + FYM + microbial consortium (M₆) recorded significantly higher available soil potassium (316.12 kg ha⁻¹) over rest of the treatments (Table 43). Significantly lower available soil potassium (299.6 kg ha⁻¹) was recorded with application of RDF (M₁).

Among the liquid organic manures, soil application of biodigester @ 2500 l ha⁻¹ at 30, 60 and 90 DAS (L₃) recorded significantly higher available soil potassium (312.57 kg ha⁻¹). Significantly lower available soil potassium (299.88 kg ha⁻¹) was recorded with control (L₄).

Among the treatment combinations, application of FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN + FYM + microbial consortium with soil application of biodigester @ 2500 l ha⁻¹ at 30, 60 and 90 DAS (M₆L₃) recorded significantly higher available soil potassium (328.16 kg ha⁻¹) but was at par with M₅L₃ (320.88 kg ha⁻¹), M₆L₁ (318.0 kg ha⁻¹), M₆L₃ (314.7 kg ha⁻¹) and M₅L₁ (315.2 kg ha⁻¹). Significantly lower available soil potassium (297.36 kg ha⁻¹) was recorded with M₁L₄.

4.2.6.7 Available soil sulphur (kg ha^{-1})

The data on available soil sulphur as influenced by manurial practices and liquid organic manures at harvest is presented in Table 43.

Irrespective of liquid organic manures, application of FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN + FYM + microbial consortium (M_6) recorded significantly higher available soil sulphur (14.48 ppm) over rest of the treatments but was at par (14.18 ppm) with application of RDF (M_1). Significantly lower available soil sulphur (13.09 ppm) was recorded with application of RDF (M_1).

Among the liquid organic manures, soil application of biodigester @ 2500 l ha^{-1} at 30, 60 and 90 DAS (L_3) recorded significantly higher available soil sulphur (14.49 ppm). Significantly lower available soil sulphur (13.11 ppm) was recorded with control (L_4).

Among the treatment combinations, integrated application of FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN + FYM + microbial consortium with soil application of biodigester @ 2500 l ha^{-1} at 30, 60 and 90 DAS (M_6L_3) recorded significantly higher available soil sulphur (15.16 ppm) but was at par with M_5L_3 (14.86 ppm), M_6L_1 (14.75 ppm), M_4L_3 (14.65 ppm), M_3L_3 (14.37 ppm), M_5L_1 (14.36 ppm), M_6L_2 (14.25 ppm), M_4L_1 (14.15 ppm), M_2L_3 (14.07 ppm), M_5L_2 (13.95 ppm), M_3L_1 (13.95 ppm) and M_1L_3 (13.87 ppm). Significantly lower available soil sulphur (12.27 ppm) was recorded with M_1L_4 .

4.2.6.8 DTPA extractable iron (Fe) in soil (ppm)

The data on DTPA extractable soil iron was significantly influenced by manurial practices and liquid organic manures and their interactions (Table 44). Application of FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN with recommended FYM + microbial consortium (M_6) recorded significantly higher DTPA extractable soil iron (7.63 ppm) over other treatments but was at par (7.57 ppm) with application of FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN with recommended FYM (M_5). Significantly lower DTPA extractable soil iron (6.87 ppm) was recorded with application of RDF (M_1).

Table 44: Effect of manurial practices and liquid organic manures on available Fe, Mn, Cu and Zn in soil

Treatments	Fe (ppm)			Mn (ppm)			Cu (ppm)			Zn (ppm)		
	2013	2014	Pooled	2013	2014	Pooled	2013	2014	Pooled	2013	2014	Pooled
Manurial practices (M)												
M ₁ -RDF (100:50:50 kg N, P ₂ O ₅ , K ₂ O ha ⁻¹)	6.82d	6.92d	6.87d	8.86 c	9.25b	9.06 c	0.96f	0.99f	0.97f	0.69e	0.73f	0.71f
M ₂ -RDF+FYM+MC	7.05c	7.17c	7.11c	9.05bc	9.65ab	9.35bc	1.07e	1.11e	1.09e	0.74d	0.80e	0.77e
M ₃ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN	7.22b	7.42b	7.32b	9.15ab	9.95ab	9.55ab	1.21d	1.26d	1.24d	0.78c	0.87d	0.83d
M ₄ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN+MC	7.28b	7.50b	7.39b	9.18ab	10.08a	9.63ab	1.25c	1.29c	1.27c	0.80 c	0.90 c	0.85c
M ₅ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN+FYM	7.45a	7.70a	7.57a	9.25ab	10.25a	9.75ab	1.33b	1.39b	1.36b	0.84b	0.96b	0.90b
M ₆ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN+FYM+MC	7.50a	7.77a	7.63a	9.29a	10.38a	9.83a	1.37a	1.43a	1.40a	0.87a	1.00a	0.94a
S.Em±	0.05	0.05	0.04	0.06	0.22	0.12	0.01	0.008	0.007	0.008	0.008	0.005
Liquid organic manures (L)												
L ₁ -Jeevamrut @ 500 litres ha ⁻¹ at 30, 60 and 90 DAS	7.34a	7.54a	7.44b	9.25ab	10.04a	9.65a	1.22b	1.26b	1.24b	0.81b	0.89b	0.85b
L ₂ -Cow urine @ 500 litres ha ⁻¹ at 30, 60and 90 DAS	7.20b	7.39b	7.29c	9.17b	9.97a	9.57a	1.19c	1.23c	1.21c	0.79c	0.87b	0.83c
L ₃ -Bio digester @ 2500 litres ha ⁻¹ at 30, 60 and 90 DAS	7.43a	7.62a	7.52a	9.34a	10.15a	9.74a	1.26a	1.31a	1.29a	0.83a	0.93a	0.88a
L ₄ -Control (no liquid manure application)	6.91c	7.10 c	7.01d	8.75c	9.55b	9.15b	1.13d	1.17d	1.15d	0.72d	0.81c	0.76d
S.Em±	0.03	0.04	0.02	0.04	0.11	0.06	0.008	0.006	0.005	0.005	0.007	0.004
Interactions- (M X L)												
M ₁ L ₁	6.91kl	7.00jk	6.96jk	8.95d-i	9.34d-f	9.15f-h	0.96no	0.99o	0.98m	0.70l-n	0.73kl	0.72k
M ₁ L ₂	6.84l	6.93k	6.89k	8.91e-j	9.30ef	9.11f-h	0.95no	0.98o	0.97m	0.69mn	0.72kl	0.71kl
M ₁ L ₃	7.02i-l	7.13h-k	7.08ij	9.02c-i	9.43c-f	9.23e-h	0.97no	1.01no	0.99m	0.72k-m	0.76i-k	0.74jk
M ₁ L ₄	6.51m	6.61l	6.56l	8.55j	8.94f	8.75h	0.94o	0.97o	0.96m	0.66n	0.69l	0.68l
M ₂ L ₁	7.16g-k	7.32f-j	7.24hi	9.14b-h	9.73a-f	9.44b-g	1.08l	1.12l	1.10k	0.74i-l	0.81g-i	0.78i
M ₂ L ₂	7.03i-l	7.18h-k	7.11ij	9.10b-i	9.69a-f	9.40b-g	1.05lm	1.08lm	1.07k	0.73j-m	0.79h-j	0.76ij
M ₂ L ₃	7.19f-j	7.25g-k	7.22hi	9.24a-e	9.85a-f	9.55a-g	1.15k	1.19k	1.17j	0.78g-i	0.85fj	0.82h
M ₂ L ₄	6.80l	6.94k	6.87k	8.72j	9.31ef	9.02gh	1.01mn	1.04mn	1.03l	0.69mn	0.74j-l	0.72k
M ₃ L ₁	7.35d-h	7.54c-g	7.45e-g	9.26a-e	10.05a-e	9.66a-f	1.21h-k	1.26hi	1.24hi	0.80f-h	0.88ef	0.84gh
M ₃ L ₂	7.20f-j	7.39e-i	7.30gh	9.21a-f	10.01a-e	9.61a-f	1.20i-k	1.25ij	1.23i	0.77h-j	0.86fg	0.82h
M ₃ L ₃	7.43b-g	7.64b-f	7.54d-f	9.35a-c	10.16a-e	9.76a-e	1.28e-g	1.33fg	1.31ef	0.83d-f	0.93de	0.88ef
M ₃ L ₄	6.90kl	7.10i-k	7.00jk	8.78h-j	9.57b-f	9.18f-h	1.15k	1.20k	1.18j	0.72k-m	0.81g-i	0.77ij
M ₄ L ₁	7.41c-g	7.62b-f	7.52ef	9.31a-d	10.21a-e	9.76a-e	1.27e-h	1.31g	1.29fg	0.82e-g	0.92de	0.87fg
M ₄ L ₂	7.25e-i	7.46d-h	7.36f-h	9.20a-g	10.11a-e	9.66a-f	1.24f-i	1.29g-i	1.27f-i	0.80f-h	0.90ef	0.85f-h
M ₄ L ₃	7.50a-e	7.73a-d	7.62c-e	9.39a-c	10.30a-d	9.85a-c	1.30d-f	1.36ef	1.33de	0.85c-e	0.96cd	0.91de
M ₄ L ₄	6.96j-l	7.18h-k	7.07ij	8.82g-j	9.71a-f	9.27d-h	1.17jk	1.21jk	1.19j	0.73j-m	0.82gh	0.78i
M ₅ L ₁	7.58a-d	7.83a-c	7.71b-d	9.39a-c	10.38a-c	9.89ab	1.36b-d	1.42cd	1.39c	0.87b-d	0.99bc	0.93cd
M ₅ L ₂	7.41c-g	7.65b-f	7.53d-f	9.31a-d	10.30a-d	9.81a-d	1.33c-e	1.39de	1.36cd	0.85c-e	0.96cd	0.91de
M ₅ L ₃	7.68ab	7.94ab	7.81ab	9.49ab	10.50ab	10.00a	1.39bc	1.46bc	1.43b	0.89bc	1.01bc	0.95bc
M ₅ L ₄	7.11h-k	7.36f-i	7.24hi	8.80h-j	9.81a-f	9.31c-g	1.23g-j	1.29g-i	1.26g-i	0.76h-k	0.88ef	0.82h
M ₆ L ₁	7.63a-c	7.90ab	7.77a-c	9.45ab	10.54ab	10.00a	1.41ab	1.47b	1.44b	0.90ab	1.03ab	0.97ab
M ₆ L ₂	7.45b-f	7.72a-e	7.59de	9.31a-d	10.40a-c	9.86a-c	1.35b-d	1.41d	1.38c	0.88bc	1.01bc	0.95bc
M ₆ L ₃	7.75a	8.03a	7.89a	9.54a	10.65a	10.10a	1.46a	1.53a	1.50a	0.93a	1.07a	1.00a
M ₆ L ₄	7.16g-k	7.43d-i	7.30gh	8.84f-j	9.93a-e	9.39b-g	1.25f-i	1.30gh	1.28f-h	0.77h-j	0.90ef	0.84gh
S.Em±	0.08	0.1	0.05	0.11	0.28	0.16	0.02	0.01	0.01	0.01	0.01	0.01
Initial	6.42			8.62			0.88			0.65		

Means followed by the same alphabet do not differ significantly by DMRT (0.05)

Among the liquid organic manures, soil application of biodigester @ 2500 l ha⁻¹ at 30, 60 and 90 DAS (L₃) recorded significantly higher DTPA extractable soil iron (7.52 ppm). Significantly lower DTPA extractable soil iron (7.01 ppm) was recorded with control (L₄).

Among the treatment combinations, integrated application of FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN with recommended FYM + microbial consortium with soil application of biodigester @ 2500 l ha⁻¹ at 30, 60 and 90 DAS (M₆L₃) recorded significantly higher DTPA extractable soil iron (7.89 ppm) but was at par with M₅L₃ (7.81 ppm) and M₆L₁ (7.77 ppm). Significantly lower DTPA extractable soil iron (6.56 ppm) was recorded with M₁L₄.

4.2.6.9 DTPA extractable manganese (Mn) in soil (ppm)

The data on available soil manganese as influenced by manurial practices and liquid organic manures at harvest is furnished in Table 44.

Application of FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN with recommended FYM + microbial consortium (M₆) recorded significantly higher DTPA extractable soil manganese (9.83 ppm) over other treatments but was at par with application of FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN with recommended FYM (M₅), FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN + microbial consortium (M₄) and FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN (M₃) (9.75 ppm, 9.63 ppm and 9.55 ppm). Significantly lower DTPA extractable soil manganese (9.06 ppm) was recorded with application of RDF (M₁).

Among the liquid organic manures, soil application of biodigester @ 2500 l ha⁻¹ at 30, 60 and 90 DAS (L₃) recorded significantly higher DTPA extractable soil manganese (9.74 ppm) but was at par with soil application of jeevamrut @ 500 l ha⁻¹ at 30, 60 and 90 DAS (9.65 ppm) and foliar application of cow urine @ 500 l ha⁻¹ at 30, 60 and 90 DAS (9.57 ppm). Significantly lower DTPA extractable soil manganese (9.15 ppm) was recorded with control (L₄).

Among the treatment combinations, integrated application of FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN with recommended

FYM + microbial consortium with soil application of biodigester @ 2500 l ha⁻¹ at 30, 60 and 90 DAS (M₆L₃) recorded significantly higher DTPA extractable soil manganese (10.10 ppm) but was at par with M₆L₁ (10.00 ppm), M₅L₃ (10.00 ppm), M₆L₂ (9.86 ppm), M₅L₂ (9.81 ppm), M₅L₁ (9.89 ppm), M₄L₃ (9.85 ppm), M₄L₁ (9.76 ppm), M₄L₂ (9.66 ppm), M₃L₃ (9.76 ppm), M₃L₁ (9.66 ppm) and M₂L₃ (9.55 ppm). Significantly lower DTPA extractable soil manganese (8.75 ppm) was recorded with M₁L₄.

4.2.6.10 DTPA extractable copper (Cu) in soil (ppm)

The data on DTPA extractable soil copper was significantly influenced by manurial practices and liquid organic manures and their interactions at harvest (Table 44). Application of FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN with recommended FYM + microbial consortium (M₆) recorded significantly higher DTPA extractable soil copper (1.40 ppm) over other treatments. Significantly lower DTPA extractable soil copper (0.97 ppm) was recorded with application of RDF (M₁).

Among the liquid organic manures, soil application of biodigester @ 2500 l ha⁻¹ at 30, 60 and 90 DAS (L₃) recorded significantly higher DTPA extractable soil copper (1.29 ppm). Significantly lower DTPA extractable soil copper (1.15 ppm) was recorded with control (L₄).

Among the treatment combinations, integrated application of FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN with recommended FYM + microbial consortium with soil application of biodigester @ 2500 l ha⁻¹ at 30, 60 and 90 DAS (M₆L₃) recorded significantly higher DTPA extractable soil copper (1.50 ppm). Significantly lower DTPA extractable soil copper (0.96 ppm) was recorded with M₁L₄.

4.2.6.11 DTPA extractable zinc (Zn) in soil (ppm)

The data on available soil zinc as influenced by manurial practices and liquid organic manures at harvest is presented in Table 44.

The data on DTPA extractable soil zinc was significantly influenced by manurial practices and liquid organic manures and their interactions at harvest. Application of

FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN with recommended FYM + microbial consortium (M₆) recorded significantly higher DTPA extractable soil zinc (0.94 ppm) over other treatments. Significantly lower DTPA extractable soil copper (0.71 ppm) was recorded with application of RDF (M₁).

Among the liquid organic manures, soil application of biodigester @ 2500 l ha⁻¹ at 30, 60 and 90 DAS (L₃) recorded significantly higher DTPA extractable soil copper (0.88 ppm). Significantly lower DTPA extractable soil copper (0.76 ppm) was recorded with control (L₄).

Among the treatment combinations, integrated application of FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN with recommended FYM + microbial consortium with soil application of biodigester @ 2500 l ha⁻¹ at 30, 60 and 90 DAS (M₆L₃) recorded significantly higher DTPA extractable soil copper (1.00 ppm) and M₆L₃ (0.97 ppm). Significantly lower DTPA extractable soil zinc (0.68 ppm) was recorded with M₃L₄.

4.2.7 Nutrient uptake

4.2.7.1 Nitrogen content (%) and nitrogen uptake (kg ha⁻¹)

Nitrogen content and uptake by grain and straw significantly influenced by manurial practices and liquid organic manures (Table 45 and 46).

4.2.7.1.1 Nitrogen uptake by grain (kg ha⁻¹)

Irrespective of liquid organic manures, application of RDF + FYM + microbial consortium (M₂) recorded significantly higher nitrogen uptake by grain (58.80 kg ha⁻¹) over rest of the treatments. Significantly lower nitrogen uptake by grain (28.43 kg ha⁻¹) was recorded with application of FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN (M₃).

Soil application of biodigester @ 2500 l ha⁻¹ at 30, 60 and 90 DAS (L₃) recorded significantly higher nitrogen uptake by grain (43.84 kg ha⁻¹) but was at par with foliar application of cow urine @ 500 l ha⁻¹ at 30, 60 and 90 DAS (42.38 kg ha⁻¹). Significantly lower nitrogen uptake by grain (32.98 kg ha⁻¹) was recorded with control (L₄).

Table 45: Effect of manurial practices and liquid organic manures on N content (%) in grain and straw

Treatments	Grain			Straw			Total		
	2013	2014	Pooled	2013	2014	Pooled	2013	2014	Pooled
Manurial practices (M)									
M ₁ -RDF (100:50:50 kg N, P ₂ O ₅ , K ₂ O ha ⁻¹)	1.49	1.21	1.35	0.70	0.61	0.66	2.19	1.82	2.00
M ₂ -RDF+FYM+MC	1.56	1.28	1.42	0.72	0.67	0.69	2.28	1.94	2.11
M ₃ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN	1.12	0.98	1.05	0.54	0.51	0.53	1.66	1.49	1.58
M ₄ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN+MC	1.14	1.00	1.07	0.56	0.53	0.54	1.70	1.52	1.61
M ₅ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN+FYM	1.24	1.03	1.14	0.56	0.54	0.55	1.80	1.58	1.69
M ₆ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN+FYM+MC	1.26	1.05	1.16	0.56	0.54	0.55	1.82	1.59	1.71
S.Em±	0.02	0.01	0.01	0.02	0.01	0.006	0.03	0.02	0.01
CD (0.05)	0.05	0.04	0.04	0.06	0.04	0.02	0.09	0.06	0.04
Liquid organic manures (L)									
L ₁ -Jeevamrut @ 500 litres ha ⁻¹ at 30, 60 and 90 DAS	1.30	1.09	1.19	0.61	0.56	0.58	1.90	1.65	1.77
L ₂ -Cow urine @ 500 litres ha ⁻¹ at 30, 60 and 90 DAS	1.34	1.13	1.24	0.61	0.58	0.60	1.95	1.72	1.83
L ₃ -Bio digester @ 2500 litres ha ⁻¹ at 30, 60 and 90 DAS	1.37	1.16	1.26	0.67	0.60	0.63	2.03	1.75	1.89
L ₄ -Control (no liquid manure application)	1.20	0.99	1.10	0.55	0.53	0.54	1.75	1.52	1.63
S.Em±	0.02	0.02	0.01	0.02	0.02	0.013	0.02	0.02	0.02
CD (0.05)	0.05	0.05	0.04	0.05	0.05	0.04	0.06	0.06	0.04
Interactions- (M X L)									
M ₁ L ₁	1.47	1.19	1.33	0.70	0.63	0.67	2.17	1.82	2.00
M ₁ L ₂	1.54	1.26	1.40	0.70	0.63	0.67	2.24	1.89	2.07
M ₁ L ₃	1.54	1.26	1.40	0.77	0.63	0.70	2.31	1.89	2.10
M ₁ L ₄	1.40	1.12	1.26	0.63	0.56	0.60	2.03	1.68	1.86
M ₂ L ₁	1.54	1.26	1.40	0.70	0.63	0.67	2.24	1.89	2.07
M ₂ L ₂	1.61	1.33	1.47	0.70	0.70	0.70	2.31	2.03	2.17
M ₂ L ₃	1.61	1.33	1.47	0.77	0.70	0.74	2.38	2.03	2.21
M ₂ L ₄	1.47	1.19	1.33	0.70	0.63	0.67	2.17	1.82	2.00
M ₃ L ₁	1.12	0.98	1.05	0.56	0.49	0.53	1.68	1.47	1.58
M ₃ L ₂	1.12	0.98	1.05	0.56	0.49	0.53	1.68	1.47	1.58
M ₃ L ₃	1.19	1.05	1.12	0.56	0.56	0.56	1.75	1.61	1.68
M ₃ L ₄	1.05	0.91	0.98	0.49	0.49	0.49	1.54	1.40	1.47
M ₄ L ₁	1.12	0.98	1.05	0.56	0.49	0.53	1.68	1.47	1.58
M ₄ L ₂	1.19	1.05	1.12	0.56	0.56	0.56	1.75	1.61	1.68
M ₄ L ₃	1.19	1.05	1.12	0.63	0.56	0.60	1.82	1.61	1.72
M ₄ L ₄	1.05	0.91	0.98	0.49	0.49	0.49	1.54	1.40	1.47
M ₅ L ₁	1.26	1.05	1.16	0.56	0.56	0.56	1.82	1.61	1.72
M ₅ L ₂	1.26	1.05	1.16	0.56	0.56	0.56	1.82	1.61	1.72
M ₅ L ₃	1.33	1.12	1.23	0.63	0.56	0.60	1.96	1.68	1.82
M ₅ L ₄	1.12	0.91	1.02	0.49	0.49	0.49	1.61	1.40	1.51
M ₆ L ₁	1.26	1.05	1.16	0.56	0.56	0.56	1.82	1.61	1.72
M ₆ L ₂	1.33	1.12	1.23	0.56	0.56	0.56	1.89	1.68	1.79
M ₆ L ₃	1.33	1.12	1.23	0.63	0.56	0.60	1.96	1.68	1.82
M ₆ L ₄	1.12	0.91	1.02	0.49	0.49	0.49	1.61	1.40	1.51
S.Em±	0.04	0.04	0.03	0.04	0.04	0.03	0.05	0.06	0.04
CD (0.05)	0.12	0.12	0.09	0.12	0.13	0.09	0.15	0.16	0.11

Table 46: Effect of manurial practices and liquid organic manures on N uptake (kg/ha) by grain and straw

Treatments	Grain			Straw			Total		
	2013	2014	Pooled	2013	2014	Pooled	2013	2014	Pooled
Manurial practices (M)									
M ₁ -RDF (100:50:50 kg N, P ₂ O ₅ , K ₂ O ha ⁻¹)	63.15b	37.43b	50.29b	36.78a	29.20b	32.99b	99.93b	66.64b	83.28b
M ₂ -RDF+FYM+MC	72.42a	45.17a	58.80a	39.73a	35.05a	37.39a	112.15a	80.22a	96.19a
M ₃ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN	33.55d	23.30d	28.43d	19.92b	18.44e	19.18d	53.47d	41.75d	47.61d
M ₄ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN+MC	34.83d	24.97d	29.90d	21.09b	20.29de	20.69cd	55.92d	45.26d	50.59d
M ₅ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN+FYM	40.67c	28.76c	34.71c	21.12b	21.71cd	21.42c	61.80 c	50.47c	56.13c
M ₆ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN+FYM+MC	42.41c	31.15c	36.78c	21.88b	23.32c	22.60 c	64.29c	54.48c	59.39c
S.Em±	0.91	0.84	0.71	0.99	0.8	0.61	1.74	1.52	1.22
Liquid organic manures (L)									
L ₁ -Jeevamrut @ 500 litres ha ⁻¹ at 30, 60 and 90 DAS	48.15b	32.01b	40.08b	26.29b	24.03b	25.16c	74.43c	56.05b	65.24c
L ₂ -Cow urine @ 500 litres ha ⁻¹ at 30, 60and 90 DAS	50.81ab	33.95ab	42.38a	27.81b	26.53ab	27.17b	78.62b	60.48a	69.55b
L ₃ -Bio digester @ 2500 litres ha ⁻¹ at 30, 60 and 90 DAS	52.44a	35.23a	43.84a	32.46a	28.82a	30.64a	84.91a	64.05a	74.48a
L ₄ -Control (no liquid manure application)	39.95c	26.00 c	32.98c	20.46c	19.30 c	19.88d	60.42d	45.30 c	52.86d
S.Em±	1.01	0.81	0.65	0.8	0.95	0.64	1.15	1.31	0.84
Interactions- (M X L)									
M ₁ L ₁	63.14c	37.32c-f	50.23d	36.02cd	29.45c-f	32.74c	99.16de	66.78cd	82.97de
M ₁ L ₂	67.04bc	40.10b-d	53.57d	38.64cd	31.63b-e	35.14bc	105.68cd	71.73bc	88.70 cd
M ₁ L ₃	68.16bc	40.64bc	54.40 cd	44.74ab	33.16bc	38.95b	112.91bc	73.81bc	93.36c
M ₁ L ₄	54.28d	31.67f-i	42.97e	27.70ef	22.56f-k	25.13e-g	81.98f	54.24e-g	68.11f
M ₂ L ₁	72.06ab	44.74ab	58.40bc	37.51cd	32.18b-d	34.85bc	109.58bc	76.92b	93.25c
M ₂ L ₂	76.77a	48.15a	62.46ab	40.55bc	38.71ab	39.63b	117.32b	86.85a	102.09b
M ₂ L ₃	78.02a	49.10a	63.56a	47.89a	41.22a	44.55a	125.90a	90.31a	108.11a
M ₂ L ₄	62.82c	38.71b-e	50.77d	32.97de	28.10 c-f	30.54cd	95.79e	66.81cd	81.30e
M ₃ L ₁	34.53h-j	24.14k-n	29.34hi	20.86g-k	17.97h-k	19.42h-j	55.39j-l	42.12h-j	48.75jk
M ₃ L ₂	34.65h-j	23.88k-n	29.26hi	21.44f-j	18.43h-k	19.93g-j	56.09j-l	42.30h-j	49.19jk
M ₃ L ₃	37.54hi	26.31i-m	31.92g-i	22.53f-h	22.59f-k	22.56e-h	60.06ij	48.90f-i	54.48ij
M ₃ L ₄	27.50j	18.88n	23.19j	14.85k	14.79k	14.82j	42.35m	33.67j	38.01k
M ₄ L ₁	34.93h-j	24.89j-n	29.91hi	21.04g-k	18.82g-k	19.93g-j	55.97j-l	43.72g-j	49.84jk
M ₄ L ₂	37.83g-i	27.40i-l	32.62g-i	21.79f-i	22.28f-k	22.03e-i	59.62i-k	49.68f-h	54.65ij
M ₄ L ₃	38.37f-i	27.76h-l	33.07gh	26.33fg	24.31e-i	25.32ef	64.71h-j	52.07e-h	58.39hi
M ₄ L ₄	28.19j	19.82mn	24.00j	15.21jk	15.74jk	15.47j	43.39m	35.56j	39.48l
M ₅ L ₁	41.70e-h	29.64g-k	35.67fg	20.60g-k	21.92f-k	21.26f-i	62.30ij	51.56e-h	56.93i
M ₅ L ₂	42.57e-h	30.15g-k	36.36fg	21.91f-i	23.31f-j	22.61e-h	64.48h-j	53.46e-g	58.97g-i
M ₅ L ₃	45.79e-g	32.84e-i	39.32ef	26.38fg	25.06d-h	25.72ef	72.17lgh	57.90d-f	65.04fg
M ₅ L ₄	32.63ij	22.41l-n	27.52ij	15.61i-k	16.56i-j	16.09j	48.24lm	38.97j	43.61kl
M ₆ L ₁	42.51e-h	31.34f-j	36.92fg	21.69f-j	23.86f-i	22.77e-h	64.20h-j	55.20ef	59.70g-i
M ₆ L ₂	46.01ef	34.02d-h	40.01ef	22.51f-h	24.83d-h	23.67e-h	68.52g-i	58.85d-f	63.69f-h
M ₆ L ₃	46.79e	34.75c-g	40.77ef	26.91fg	26.55c-g	26.73de	73.70g	61.30de	67.50f
M ₆ L ₄	34.32h-j	24.51k-n	29.41hi	16.43h-k	18.06h-k	17.24ij	50.75k-m	42.57h-j	46.66k
S.Em±	2.48	1.98	1.59	1.97	2.33	1.58	2.83	3.21	20.6

Means followed by the same alphabet do differ significantly by DMRT (0.05)

Among the treatment combinations, application of RDF + FYM + microbial consortium with soil application of biodigester @ 2500 l ha⁻¹ at 30, 60 and 90 DAS (M₂L₃) recorded significantly higher nitrogen uptake by grain (63.56 kg ha⁻¹) but was at par with M₂L₂ (62.46 kg ha⁻¹). Significantly lower nitrogen uptake by grain (23.19 kg ha⁻¹) was recorded with M₃L₄.

4.2.7.1.2 Nitrogen uptake by straw (kg ha⁻¹)

Application of RDF + FYM + microbial consortium (M₂) recorded significantly higher nitrogen uptake by straw (37.39 kg ha⁻¹) over rest of the treatments. Significantly lower nitrogen uptake by straw (19.18 kg ha⁻¹) was recorded with application of FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN (M₃).

Among the liquid organic manures, soil application of biodigester @ 2500 l ha⁻¹ at 30, 60 and 90 DAS (L₃) recorded significantly higher nitrogen uptake by straw (30.64 kg ha⁻¹). Significantly lower nitrogen uptake by straw (19.88 kg ha⁻¹) was recorded with control (L₄).

Among the treatment combinations, application of RDF + FYM + microbial consortium with soil application of biodigester @ 2500 l ha⁻¹ at 30, 60 and 90 DAS (M₂L₃) recorded significantly higher nitrogen uptake by grain (44.55 kg ha⁻¹). Significantly lower nitrogen uptake by straw (14.82 kg ha⁻¹) was recorded with M₃L₄.

4.2.7.1.3 Total nitrogen uptake by grain and straw (kg ha⁻¹)

Irrespective of liquid organic manures, application of RDF + FYM + microbial consortium (M₂) recorded significantly higher total nitrogen uptake by grain and straw (96.19 kg ha⁻¹) over rest of the treatments. Significantly lower total nitrogen uptake by grain and straw (47.61 kg ha⁻¹) was recorded with application of FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN (M₃).

Soil application of biodigester @ 2500 l ha⁻¹ at 30, 60 and 90 DAS (L₃) recorded significantly higher total nitrogen uptake by grain and straw (74.48 kg ha⁻¹). Significantly lower total nitrogen uptake by grain and straw (52.86 kg ha⁻¹) was recorded with control (L₄).

Among the treatment combinations, application of RDF + FYM + microbial consortium with soil application of biodigester @ 2500 l ha⁻¹ at 30, 60 and 90 DAS (M₂L₃) recorded significantly higher total nitrogen uptake by grain and straw (108.11 kg ha⁻¹). Significantly lower nitrogen uptake by grain and straw (38.01 kg ha⁻¹) was recorded with M₃L₄.

4.2.7.2 Phosphorus content (%) and uptake (kg ha⁻¹)

The data on phosphorus content and uptake by grain and straw as influenced by manurial practices and liquid organic manures at harvest is furnished in Table 47 and 48.

4.2.7.2.1 Phosphorus uptake by grain (kg ha⁻¹)

Among the manurial practices, application of RDF + FYM + microbial consortium (M₂) recorded significantly higher phosphorus uptake by grain (12.54 kg ha⁻¹) over rest of the treatments. Significantly lower phosphorus uptake by grain (6.18 kg ha⁻¹) was recorded with application of FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN (M₃).

Soil application of biodigester @ 2500 l ha⁻¹ at 30, 60 and 90 DAS (L₃) recorded significantly higher phosphorus uptake by grain (9.63 kg ha⁻¹) but was at par with foliar application of cow urine @ 500 l ha⁻¹ at 30, 60 and 90 DAS (9.27 kg ha⁻¹). Significantly lower phosphorus uptake by grain (7.00 kg ha⁻¹) was recorded with control (L₄).

Integrated application of RDF + FYM + microbial consortium with soil application of biodigester @ 2500 l ha⁻¹ at 30, 60 and 90 DAS (M₂L₃) recorded significantly higher phosphorus uptake by grain (13.59 kg ha⁻¹) but was at par with M₂L₂ (13.39 kg ha⁻¹) and M₂L₁ (12.72 kg ha⁻¹). Significantly lower phosphorus uptake by grain (4.91 kg ha⁻¹) was recorded with M₃L₄.

4.2.7.2.2 Phosphorus uptake by straw (kg ha⁻¹)

Application of RDF + FYM + microbial consortium (M₂) recorded significantly higher phosphorus uptake by straw (8.52 kg ha⁻¹) over rest of the treatments. Significantly lower phosphorus uptake by straw (4.45 kg ha⁻¹) was recorded with

Table 47: Effect of manurial practices and liquid organic manures on P content (%) in grain and straw

Treatments	Grain			Straw			Total		
	2013	2014	Pooled	2013	2014	Pooled	2013	2014	Pooled
Manurial practices (M)									
M ₁ -RDF (100:50:50 kg N, P ₂ O ₅ , K ₂ O ha ⁻¹)	0.31	0.26	0.29	0.17	0.13	0.15	0.48	0.39	0.44
M ₂ -RDF+FYM+MC	0.33	0.28	0.30	0.18	0.14	0.16	0.50	0.42	0.46
M ₃ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN	0.24	0.22	0.23	0.14	0.11	0.12	0.38	0.32	0.35
M ₄ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN+MC	0.25	0.23	0.24	0.14	0.11	0.13	0.40	0.34	0.37
M ₅ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN+FYM	0.27	0.25	0.26	0.14	0.12	0.13	0.41	0.37	0.39
M ₆ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN+FYM+MC	0.27	0.25	0.26	0.15	0.12	0.14	0.42	0.37	0.40
S.Em±	0.006	0.005	0.004	0.002	0.001	0.001	0.007	0.005	0.004
CD (0.05)	0.02	0.014	0.012	0.007	0.005	0.004	0.022	0.016	0.014
Liquid organic manures (L)									
L ₁ -Jeevamrut @ 500 litres ha ⁻¹ at 30, 60 and 90 DAS	0.28	0.25	0.27	0.15	0.12	0.14	0.43	0.37	0.40
L ₂ -Cow urine @ 500 litres ha ⁻¹ at 30, 60 and 90 DAS	0.29	0.26	0.27	0.16	0.13	0.14	0.45	0.38	0.41
L ₃ -Bio digester @ 2500 litres ha ⁻¹ at 30, 60 and 90 DAS	0.30	0.26	0.28	0.17	0.13	0.15	0.46	0.39	0.43
L ₄ -Control (no liquid manure application)	0.25	0.22	0.23	0.14	0.11	0.12	0.39	0.33	0.36
S.Em±	0.005	0.005	0.003	0.001	0.001	0.001	0.005	0.005	0.003
CD (0.05)	0.01	0.014	0.009	0.003	0.003	0.002	0.014	0.015	0.010
Interactions- (M X L)									
M ₁ L ₁	0.31	0.26	0.29	0.17	0.13	0.15	0.48	0.39	0.44
M ₁ L ₂	0.31	0.26	0.29	0.17	0.13	0.15	0.48	0.39	0.44
M ₁ L ₃	0.32	0.27	0.30	0.19	0.14	0.16	0.51	0.41	0.46
M ₁ L ₄	0.30	0.25	0.28	0.16	0.13	0.14	0.46	0.38	0.42
M ₂ L ₁	0.33	0.28	0.31	0.17	0.14	0.16	0.50	0.42	0.46
M ₂ L ₂	0.34	0.29	0.32	0.18	0.15	0.16	0.52	0.44	0.48
M ₂ L ₃	0.34	0.29	0.32	0.19	0.15	0.17	0.53	0.44	0.48
M ₂ L ₄	0.30	0.25	0.28	0.16	0.13	0.14	0.46	0.38	0.42
M ₃ L ₁	0.24	0.22	0.23	0.13	0.11	0.12	0.37	0.32	0.35
M ₃ L ₂	0.24	0.22	0.23	0.14	0.11	0.12	0.38	0.32	0.35
M ₃ L ₃	0.26	0.24	0.25	0.15	0.12	0.13	0.41	0.35	0.38
M ₃ L ₄	0.22	0.20	0.21	0.12	0.10	0.11	0.34	0.29	0.32
M ₄ L ₁	0.25	0.23	0.24	0.14	0.11	0.13	0.39	0.34	0.36
M ₄ L ₂	0.27	0.25	0.26	0.15	0.12	0.14	0.42	0.37	0.39
M ₄ L ₃	0.27	0.25	0.26	0.16	0.12	0.14	0.43	0.37	0.40
M ₄ L ₄	0.22	0.20	0.21	0.12	0.10	0.11	0.34	0.29	0.32
M ₅ L ₁	0.28	0.26	0.27	0.13	0.13	0.13	0.41	0.38	0.40
M ₅ L ₂	0.28	0.26	0.27	0.15	0.13	0.14	0.43	0.38	0.41
M ₅ L ₃	0.29	0.27	0.28	0.16	0.13	0.15	0.45	0.40	0.42
M ₅ L ₄	0.23	0.21	0.22	0.13	0.10	0.12	0.36	0.31	0.33
M ₆ L ₁	0.28	0.26	0.27	0.15	0.13	0.14	0.43	0.38	0.41
M ₆ L ₂	0.29	0.27	0.28	0.15	0.13	0.14	0.44	0.40	0.42
M ₆ L ₃	0.29	0.27	0.28	0.16	0.13	0.15	0.45	0.40	0.42
M ₆ L ₄	0.23	0.21	0.22	0.13	0.10	0.12	0.36	0.31	0.33
S.Em±	0.011	0.012	0.008	0.003	0.003	0.002	0.01	0.013	0.008
CD (0.05)	0.03	0.03	0.022	0.008	0.008	0.005	0.03	0.036	0.024

Table 48: Effect of manurial practices and liquid organic manures on P uptake (kg/ha) by grain and straw

Treatments	Grain			Straw			Total		
	2013	2014	Pooled	2013	2014	Pooled	2013	2014	Pooled
Manurial practices (M)									
M ₁ -RDF (100:50:50 kg N, P ₂ O ₅ , K ₂ O ha ⁻¹)	13.18b	8.03b	10.61b	9.05b	6.18b	7.61b	22.23b	14.21b	18.22b
M ₂ -RDF+FYM+MC	15.25a	9.82a	12.54a	9.73a	7.31a	8.52a	24.98a	17.13a	21.05a
M ₃ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN	7.23d	5.13e	6.18d	4.97d	3.93e	4.45e	12.20e	9.05e	10.62e
M ₄ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN+MC	7.73d	5.72d	6.72d	5.38cd	4.41d	4.89d	13.10de	10.13d	11.61d
M ₅ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN+FYM	8.87c	6.85c	7.86c	5.38cd	4.93c	5.16d	14.26cd	11.78c	13.02c
M ₆ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN+FYM+MC	9.18c	7.36c	8.27c	5.77c	5.34c	5.56c	14.96c	12.71c	13.83c
S.Em±	0.31	0.18	0.2	0.18	0.15	0.11	0.44	0.3	0.29
Liquid organic manures (L)									
L ₁ -Jeevamrut @ 500 litres ha ⁻¹ at 30, 60 and 90 DAS	10.46a	7.31a	8.89b	6.41c	5.31c	5.86c	16.87c	12.62c	14.75c
L ₂ -Cow urine @ 500 litres ha ⁻¹ at 30, 60and 90 DAS	10.89a	7.65a	9.27ab	7.16b	5.79b	6.47b	18.05b	13.43b	15.74b
L ₃ -Bio digester @ 2500 litres ha ⁻¹ at 30, 60 and 90 DAS	11.29a	7.98a	9.63a	8.19a	6.31a	7.25a	19.48a	14.28a	16.88a
L ₄ -Control (no liquid manure application)	8.31b	5.68b	7.00 c	5.10d	3.99d	4.54d	13.41d	9.67d	11.54d
S.Em±	0.28	0.24	0.17	0.12	0.1	0.08	0.28	0.25	0.17
Interactions- (M X L)									
M ₁ L ₁	13.32de	8.11c-e	10.71b	8.70 c	6.04c-e	7.37d	22.02de	14.15d-f	18.09cd
M ₁ L ₂	13.54c-e	8.22c-e	10.88b	9.35c	6.50bc	7.92cd	22.89cd	14.72de	18.80 c
M ₁ L ₃	14.17b-d	8.75b-d	11.46b	11.07ab	7.15d	9.11b	25.24b	15.90 cd	20.57b
M ₁ L ₄	11.69ef	7.05d-i	9.37cd	7.07d	5.02fg	6.05ef	18.76fg	12.07g-j	15.42ef
M ₂ L ₁	15.50a-c	9.94a-c	12.72a	9.14c	7.14b	8.14c	24.63bc	17.08bc	20.86b
M ₂ L ₂	16.24ab	10.54ab	13.39a	10.45a	7.99a	9.22b	26.69ab	18.53ab	22.61a
M ₂ L ₃	16.50a	10.69a	13.59a	11.76b	8.51a	10.13a	28.26a	19.20a	23.73a
M ₂ L ₄	12.77de	8.13c-e	10.45bc	7.56d	5.59d-f	6.57e	20.33ef	13.72e-h	17.02d
M ₃ L ₁	7.44i-l	5.26i-k	6.35h-j	4.78h-j	3.97ij	4.38ij	12.22kl	9.23m-o	10.73kl
M ₃ L ₂	7.46il	5.32i-k	6.39h-j	5.36gh	4.10h-j	4.73i	12.82kl	9.41n	11.11k
M ₃ L ₃	8.24g-k	5.89f-k	7.07g-i	6.07e-g	4.72f-i	5.40gh	14.31jk	10.61j-m	12.46ij
M ₃ L ₄	5.78l	4.04k	4.91k	3.65k	2.92l	3.29k	9.43m	6.96p	8.20n
M ₄ L ₁	7.74h-l	5.73g-k	6.73hi	5.23g-i	4.28g-j	4.76i	12.97kl	10.02k-n	11.49jk
M ₄ L ₂	8.58g-k	6.36e-j	7.47f-h	5.85fg	4.91f-h	5.38gh	14.43i-k	11.27i-l	12.85hi
M ₄ L ₃	8.70g-k	6.49e-j	7.60e-h	6.67d-f	5.32ef	5.99e-g	15.37h-j	11.81h-k	13.59hi
M ₄ L ₄	5.89l	4.28k	5.08jk	3.76k	3.12kl	3.44k	9.65m	7.40op	8.52mn
M ₅ L ₁	9.31g-j	7.17d-i	8.24d-g	4.82h-j	3.12kl	4.92hi	14.13jk	12.20f-j	13.16hi
M ₅ L ₂	9.49f-i	7.34d-h	8.42d-g	5.88fg	5.31ef	5.60fg	15.38h-j	12.66e-i	14.02gh
M ₅ L ₃	9.98f-h	7.83d-f	8.90de	6.68d-f	5.90 c-e	6.29e	16.66hi	13.72e-h	15.19e-g
M ₅ L ₄	6.70kl	5.05jk	5.88i-k	4.16jk	3.48j-l	3.82jk	10.86lm	8.54n-p	9.70mn
M ₆ L ₁	9.48f-i	7.63d-g	8.56d-f	5.78fg	5.42d-f	5.60fg	15.26h-j	13.05e-i	14.16f-h
M ₆ L ₂	10.04f-h	8.10 c-e	9.07d	6.07e-g	5.90 c-e	5.98e-g	16.11h-j	14.00d-g	15.05e-g
M ₆ L ₃	10.16fg	8.20 c-e	9.18cd	6.87de	6.27cd	6.57e	17.03gh	14.47de	15.75e
M ₆ L ₄	7.04j-ol	5.52h-k	6.28h-j	4.38i-k	3.78jk	4.08j	11.42lm	9.30l-o	10.36kl
S.Em±	0.69	0.59	0.43	0.3	0.26	0.2	0.69	0.62	0.43

Means followed by the same alphabet do not differ significantly by DMRT (0.05)

application of FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN (M₃).

Among the liquid organic manures, soil application of biodigester @ 2500 l ha⁻¹ at 30, 60 and 90 DAS (L₃) recorded significantly higher phosphorus uptake by straw (7.25 kg ha⁻¹). Significantly lower phosphorus uptake by straw (4.54 kg ha⁻¹) was recorded with control (L₄).

Among the treatment combinations, application of RDF + FYM + microbial consortium with soil application of biodigester @ 2500 l ha⁻¹ at 30, 60 and 90 DAS (M₂L₃) recorded significantly higher phosphorus uptake by grain (10.13 kg ha⁻¹). Significantly lower phosphorus uptake by straw (3.29 kg ha⁻¹) was recorded with M₃L₄.

4.2.7.2.3 Total phosphorus uptake by grain and straw (kg ha⁻¹)

The data on total phosphorus uptake by grain and straw was significantly influenced by manurial practices and liquid organic manures at harvest. Among the manurial practices, application of RDF + FYM + microbial consortium (M₂) recorded significantly higher total phosphorus uptake by grain and straw (21.05 kg ha⁻¹) over rest of the treatments. Significantly lower total phosphorus uptake by grain and straw (10.62 kg ha⁻¹) was recorded with application of FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN (M₃).

Soil application of biodigester @ 2500 l ha⁻¹ at 30, 60 and 90 DAS (L₃) recorded significantly higher total phosphorus uptake by grain and straw (16.88 kg ha⁻¹). Significantly lower total phosphorus uptake by grain and straw (11.54 kg ha⁻¹) was recorded with control (L₄).

Integrated application of RDF + FYM + microbial consortium with soil application of biodigester @ 2500 l ha⁻¹ at 30, 60 and 90 DAS (M₂L₃) recorded significantly higher total phosphorus uptake by grain and straw (23.73 kg ha⁻¹) but was at par with M₂L₂ (22.61 kg ha⁻¹). Significantly lower phosphorus uptake by grain and straw (8.20 kg ha⁻¹) was recorded with M₃L₄. Similar trend was noticed during 2013 and 2014.

4.2.7.3 Potassium content (%) and uptake (kg ha^{-1})

The data on potassium content and uptake by grain and straw as influenced by manurial practices and liquid organic manures at harvest is presented in Table 49 and 50.

4.2.7.3.1 Potassium uptake by grain (kg ha^{-1})

Among the manurial practices, application of RDF + FYM + microbial consortium (M_2) recorded significantly higher potassium uptake by grain (11.19 kg ha^{-1}) over rest of the treatments. Significantly lower potassium uptake by grain (5.36 kg ha^{-1}) was recorded with application of FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN (M_3).

Soil application of biodigester @ 2500 l ha^{-1} at 30, 60 and 90 DAS (L_3) recorded significantly higher potassium uptake by grain (8.40 kg ha^{-1}) but was at par with foliar application of cow urine @ 500 l ha^{-1} at 30, 60 and 90 DAS (8.11 kg ha^{-1}). Significantly lower potassium uptake by grain (6.03 kg ha^{-1}) was recorded with control (L_4).

Among the treatment combinations, application of RDF + FYM + microbial consortium with soil application of biodigester @ 2500 l ha^{-1} at 30, 60 and 90 DAS (M_2L_3) recorded significantly higher potassium uptake by grain (12.49 kg ha^{-1}) but was at par with M_2L_2 (11.87 kg ha^{-1}) and M_2L_1 (11.67 kg ha^{-1}). Significantly lower potassium uptake by grain (4.01 kg ha^{-1}) was recorded with M_3L_4 .

4.2.7.3.2 Potassium uptake by straw (kg ha^{-1})

Irrespective of liquid organic manures, application of RDF + FYM + microbial consortium (M_2) recorded significantly higher potassium uptake by straw (74.85 kg ha^{-1}) over rest of the treatments. Significantly lower potassium uptake by straw (42.82 kg ha^{-1}) was recorded with application of FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN (M_3).

Among the liquid organic manures, soil application of biodigester @ 2500 l ha^{-1} at 30, 60 and 90 DAS (L_3) recorded significantly higher potassium uptake by straw (64.22 kg ha^{-1}). Significantly lower potassium uptake by straw (40.84 kg ha^{-1}) was recorded with control (L_4).

Table 49: Effect of manurial practices and liquid organic manures on K content (%) in grain and straw

Treatments	Grain			Straw			Total		
	2013	2014	Pooled	2013	2014	Pooled	2013	2014	Pooled
Manurial practices (M)									
M ₁ -RDF (100:50:50 kg N, P ₂ O ₅ , K ₂ O ha ⁻¹)	0.27	0.23	0.25	1.42	1.21	1.31	1.69	1.43	1.56
M ₂ -RDF+FYM+MC	0.29	0.25	0.27	1.48	1.28	1.38	1.77	1.53	1.65
M ₃ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN	0.21	0.19	0.20	1.23	1.11	1.17	1.43	1.29	1.36
M ₄ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN+MC	0.22	0.20	0.21	1.26	1.15	1.20	1.48	1.34	1.41
M ₅ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN+FYM	0.23	0.21	0.22	1.26	1.15	1.20	1.48	1.35	1.42
M ₆ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN+FYM+MC	0.24	0.22	0.23	1.30	1.18	1.24	1.53	1.40	1.47
S.Em±	0.006	0.006	0.003	0.02	0.02	0.01	0.02	0.02	0.01
CD (0.05)	0.02	0.02	0.01	0.05	0.06	0.03	0.07	0.07	0.03
Liquid organic manures (L)									
L ₁ -Jeevamrut @ 500 litres ha ⁻¹ at 30, 60 and 90 DAS	0.24	0.21	0.23	1.32	1.17	1.25	1.56	1.39	1.47
L ₂ -Cow urine @ 500 litres ha ⁻¹ at 30, 60 and 90 DAS	0.25	0.23	0.24	1.39	1.24	1.31	1.64	1.47	1.55
L ₃ -Bio digester @ 2500 litres ha ⁻¹ at 30, 60 and 90 DAS	0.26	0.23	0.24	1.40	1.26	1.33	1.66	1.49	1.57
L ₄ -Control (no liquid manure application)	0.22	0.19	0.20	1.18	1.04	1.11	1.40	1.23	1.31
S.Em±	0.003	0.006	0.003	0.01	0.01	0.01	0.01	0.01	0.01
CD (0.05)	0.01	0.02	0.01	0.04	0.03	0.02	0.04	0.04	0.03
Interactions- (M X L)									
M ₁ L ₁	0.26	0.22	0.24	1.38	1.17	1.27	1.64	1.39	1.51
M ₁ L ₂	0.27	0.23	0.25	1.43	1.22	1.32	1.70	1.45	1.57
M ₁ L ₃	0.28	0.24	0.26	1.48	1.27	1.38	1.76	1.51	1.64
M ₁ L ₄	0.26	0.22	0.24	1.38	1.17	1.27	1.64	1.39	1.51
M ₂ L ₁	0.30	0.26	0.28	1.53	1.33	1.43	1.83	1.59	1.71
M ₂ L ₂	0.30	0.26	0.28	1.53	1.33	1.43	1.83	1.59	1.71
M ₂ L ₃	0.31	0.27	0.29	1.58	1.38	1.48	1.89	1.65	1.77
M ₂ L ₄	0.25	0.21	0.23	1.28	1.07	1.18	1.53	1.28	1.41
M ₃ L ₁	0.21	0.19	0.20	1.24	1.12	1.18	1.45	1.31	1.38
M ₃ L ₂	0.22	0.20	0.21	1.30	1.18	1.24	1.52	1.38	1.45
M ₃ L ₃	0.22	0.20	0.21	1.30	1.18	1.24	1.52	1.38	1.45
M ₃ L ₄	0.18	0.16	0.17	1.06	0.94	1.00	1.24	1.10	1.17
M ₄ L ₁	0.22	0.20	0.21	1.28	1.16	1.22	1.50	1.36	1.43
M ₄ L ₂	0.23	0.21	0.22	1.33	1.22	1.27	1.56	1.43	1.49
M ₄ L ₃	0.23	0.21	0.22	1.33	1.22	1.27	1.56	1.43	1.49
M ₄ L ₄	0.19	0.17	0.18	1.10	0.99	1.04	1.29	1.16	1.22
M ₅ L ₁	0.22	0.20	0.21	1.23	1.12	1.18	1.45	1.32	1.39
M ₅ L ₂	0.24	0.22	0.23	1.34	1.23	1.29	1.58	1.45	1.52
M ₅ L ₃	0.24	0.22	0.23	1.34	1.23	1.29	1.58	1.45	1.52
M ₅ L ₄	0.20	0.18	0.19	1.12	1.01	1.06	1.32	1.19	1.25
M ₆ L ₁	0.23	0.21	0.22	1.27	1.16	1.21	1.50	1.37	1.43
M ₆ L ₂	0.25	0.23	0.24	1.38	1.27	1.32	1.63	1.50	1.56
M ₆ L ₃	0.25	0.23	0.24	1.38	1.27	1.32	1.63	1.50	1.56
M ₆ L ₄	0.21	0.19	0.20	1.16	1.05	1.10	1.37	1.24	1.30
S.Em±	0.01	0.013	0.006	0.03	0.02	0.02	0.03	0.03	0.02
CD (0.05)	0.03	0.04	0.02	0.09	0.07	0.05	0.09	0.09	0.07

Table 50: Effect of manurial practices and liquid organic manures on K uptake (kg/ha) by grain and straw

Treatments	Grain			Straw			Total		
	2013	2014	Pooled	2013	2014	Pooled	2013	2014	Pooled
Manurial practices (M)									
M ₁ -RDF (100:50:50 kg N, P ₂ O ₅ , K ₂ O ha ⁻¹)	11.36b	7.03b	9.19b	74.23b	57.30b	65.77b	85.59b	64.33b	74.96b
M ₂ -RDF+FYM+MC	13.51a	8.87a	11.19a	82.37a	67.34a	74.85a	95.88a	76.21a	86.04a
M ₃ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN	6.25e	4.47e	5.36f	45.19c	40.46e	42.82e	51.43d	44.93e	48.18e
M ₄ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN+MC	6.67de	4.93e	5.80e	47.38c	44.31de	45.84de	54.05cd	49.24de	51.64d
M ₅ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN+FYM	7.38cd	5.72d	6.55d	47.54c	46.18d	46.86d	54.93cd	51.89d	53.41d
M ₆ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN+FYM+MC	7.90 c	6.36c	7.13c	50.73c	50.99c	50.86c	58.62c	57.35c	57.98c
S.Em±	0.25	0.2	0.09	1.83	1.27	0.99	1.88	1.42	1.0
Liquid organic manures (L)									
L ₁ -Jeevamrut @ 500 litres ha ⁻¹ at 30, 60 and 90 DAS	8.92b	6.29b	7.60b	56.91c	50.08c	53.50 c	65.83c	56.37c	61.10 c
L ₂ -Cow urine @ 500 litres ha ⁻¹ at 30, 60and 90 DAS	9.49ab	6.74ab	8.11a	62.98b	55.90b	59.44b	72.47b	62.64b	67.55b
L ₃ -Bio digester @ 2500 litres ha ⁻¹ at 30, 60 and 90 DAS	9.82a	6.98a	8.40a	67.90a	60.54a	64.22a	77.72a	67.52a	72.62a
L ₄ -Control (no liquid manure application)	7.15c	4.91c	6.03c	43.83d	37.86d	40.84d	50.98d	42.77d	46.87d
S.Em±	0.25	0.21	0.15	1.3	1.09	0.89	1.22	1.13	0.89
Interactions- (M X L)									
M ₁ L ₁	11.12cd	6.88b-d	9.00b-d	70.80d	54.05d-g	62.43d	81.92d	60.93d-g	71.43d
M ₁ L ₂	11.75cd	7.28bc	9.52bc	78.69cd	61.03cd	69.86c	90.45cd	68.30 cd	79.37c
M ₁ L ₃	12.45bc	7.75d	10.10b	86.35bc	67.39bc	76.87b	98.80bc	75.15bc	86.97b
M ₁ L ₄	10.10de	6.21b-g	8.16d-f	61.10e	46.74g-k	53.92e-g	71.20e	52.95g-j	62.08e-g
M ₂ L ₁	14.04ab	9.30a	11.67a	82.12bc	67.65bc	74.88bc	96.17bc	76.94b	86.55b
M ₂ L ₂	14.29ab	9.46a	11.87a	88.94ab	73.05b	81.00b	103.23b	82.51b	92.87b
M ₂ L ₃	15.04a	9.95a	12.49a	97.91a	80.84a	89.38a	112.95a	90.79a	101.87a
M ₂ L ₄	10.68cd	6.78b-e	8.73c-e	60.49ef	47.81f-j	54.15e-g	71.18e	54.59f-j	62.88e-g
M ₃ L ₁	6.46g-j	4.63g-j	5.55ij	45.90hi	41.30j-l	43.60ij	52.36ij	45.93j-l	49.15jk
M ₃ L ₂	6.82f-i	4.90f-j	5.86h-j	49.95f-h	44.82h-k	47.39g-i	56.77g-i	49.73h-k	53.25h-j
M ₃ L ₃	6.99f-i	5.03e-i	6.01h-j	52.70e-h	47.47f-j	50.08f-i	59.68f-i	52.50g-k	56.09g-j
M ₃ L ₄	4.72j	3.30j	4.01k	32.19j	28.26n	30.22l	36.92k	31.56m	34.24m
M ₄ L ₁	6.81f-i	5.08e-i	5.94h-j	47.83hi	44.01i-k	45.92hi	54.64g-j	49.09i-k	51.86ij
M ₄ L ₂	7.32f-h	5.46b-h	6.39g-i	51.94e-h	48.72f-j	50.33f-i	59.25f-i	54.18f-j	56.72f-i
M ₄ L ₃	7.41f-h	5.53c-h	6.47g-i	55.38e-h	53.02d-h	54.20e-g	62.79e-h	58.55e-h	60.67e-g
M ₄ L ₄	5.14ij	3.66ij	4.40k	34.39j	31.47mn	32.93kl	39.52k	35.13m	37.33m
M ₅ L ₁	7.31f-h	5.63c-h	6.47g-i	45.76hi	44.12h-k	44.94h-j	53.07h-j	49.75h-k	51.41j
M ₅ L ₂	8.10fg	6.35b-g	7.23fg	52.56e-h	51.48e-i	52.02f-h	60.66f-i	57.83f-i	59.24f-h
M ₅ L ₃	8.30e-g	6.48b-f	7.39fg	55.99e-h	54.82d-g	55.41ef	64.29e-g	61.30d-g	62.80e-g
M ₅ L ₄	5.82h-j	4.40h-j	5.11jk	35.87j	34.29l-n	35.08kl	41.68k	38.69lm	40.19lm
M ₆ L ₁	7.76f-h	6.23b-g	6.99f-h	49.05g-i	49.37f-j	49.21f-i	56.81g-i	55.59f-i	56.20g-j
M ₆ L ₂	8.65ef	6.97b-d	7.81ef	55.79e-h	56.30d-f	56.05d-f	64.44e-g	63.27d-f	63.86ef
M ₆ L ₃	8.73ef	7.13b-d	7.93d-f	59.11e-g	59.71c-e	59.41de	67.83ef	66.84c-e	67.34de
M ₆ L ₄	6.45g-j	5.11e-i	5.78h-j	38.95ij	38.57k-m	38.76jk	45.40jk	43.68kl	44.54kl
S.Em±	0.62	0.52	0.37	3.18	2.67	2.19	3.0	2.77	2.18

Means followed by the same alphabet do not differ significantly by DMRT (0.05)

Integrated application of RDF + FYM + microbial consortium with soil application of biodigester @ 2500 l ha⁻¹ at 30, 60 and 90 DAS (M₂L₃) recorded significantly higher potassium uptake by grain (89.38 kg ha⁻¹). Significantly lower potassium uptake by straw (30.22 kg ha⁻¹) was recorded with M₃L₄.

4.2.7.3.3 Total potassium uptake by grain and straw (kg ha⁻¹)

Among the manurial practices, application of RDF + FYM + microbial consortium (M₂) recorded significantly higher total potassium uptake by grain and straw (86.04 kg ha⁻¹) over rest of the treatments. Significantly lower total potassium uptake by grain and straw (48.18 kg ha⁻¹) was recorded with application of FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN (M₃).

Soil application of biodigester @ 2500 l ha⁻¹ at 30, 60 and 90 DAS (L₃) recorded significantly higher total potassium uptake by grain and straw (72.62 kg ha⁻¹). Significantly lower total potassium uptake by grain and straw (46.87 kg ha⁻¹) was recorded with control (L₄).

Among the treatment combinations, application of RDF + FYM + microbial consortium with soil application of biodigester @ 2500 l ha⁻¹ at 30, 60 and 90 DAS (M₂L₃) recorded significantly higher total potassium uptake by grain and straw (101.87 kg ha⁻¹). Significantly lower potassium uptake by grain and straw (34.24 kg ha⁻¹) was recorded with M₃L₄.

4.2.7.4 Iron content (ppm) and uptake (g ha⁻¹)

The data on iron content and uptake by grain and straw as influenced by manurial practices and liquid organic manures at harvest is presented in Table 51 and 52.

4.2.7.4.1 Iron uptake by grain (g ha⁻¹)

Irrespective of liquid organic manures, application of RDF + FYM + microbial consortium (M₂) recorded significantly higher iron uptake by grain (297.84 g ha⁻¹) over rest of the treatments. Significantly lower iron uptake by grain (167.93 g ha⁻¹) was

Table 51: Effect of manurial practices and liquid organic manures on Fe content (ppm) in grain and straw

Treatments	Grain			Straw			Total		
	2013	2014	Pooled	2013	2014	Pooled	2013	2014	Pooled
Manurial practices (M)									
M ₁ -RDF (100:50:50 kg N, P ₂ O ₅ , K ₂ O ha ⁻¹)	72.43	66.93	69.68	104.99	99.99	102.49	177.42	166.92	172.17
M ₂ -RDF+FYM+MC	75.38	69.38	72.38	116.82	109.82	113.32	192.20	179.20	185.70
M ₃ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN	64.38	60.38	62.38	80.53	81.53	81.03	144.91	141.91	143.41
M ₄ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN+MC	65.40	61.10	63.25	81.80	82.80	82.30	147.20	143.90	145.55
M ₅ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN+FYM	67.45	62.75	65.10	91.15	93.15	92.15	158.60	155.90	157.25
M ₆ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN+FYM+MC	68.47	63.47	65.97	92.51	94.51	93.51	160.97	157.97	159.47
S.Em±	2.49	2.13	1.70	2.28	1.44	1.33	3.90	2.67	2.42
CD (0.05)	7.85	6.71	5.37	7.19	4.52	4.19	12.29	8.40	7.64
Liquid organic manures (L)									
L ₁ -Jeevamrut @ 500 litres ha ⁻¹ at 30, 60 and 90 DAS	68.74	63.82	66.28	94.38	93.38	93.88	163.12	157.20	160.16
L ₂ -Cow urine @ 500 litres ha ⁻¹ at 30, 60 and 90 DAS	69.33	64.41	66.87	95.20	94.20	94.70	164.53	158.61	161.57
L ₃ -Bio digester @ 2500 litres ha ⁻¹ at 30, 60 and 90 DAS	69.78	64.86	67.32	95.83	94.83	95.33	165.61	159.70	162.66
L ₄ -Control (no liquid manure application)	67.82	62.90	65.36	93.13	92.13	92.63	160.94	155.03	157.98
S.Em±	1.36	0.86	0.91	1.11	0.98	0.71	1.77	1.17	1.10
CD (0.05)	3.89	2.46	2.60	3.19	2.82	2.04	5.07	3.36	3.16
Interactions- (M X L)									
M ₁ L ₁	72.23	66.73	69.48	104.65	99.65	102.15	176.88	166.38	171.63
M ₁ L ₂	72.95	67.45	70.20	105.72	100.72	103.22	178.67	168.17	173.42
M ₁ L ₃	73.23	67.73	70.48	106.24	101.24	103.74	179.47	168.97	174.22
M ₁ L ₄	71.32	65.82	68.57	103.35	98.35	100.85	174.67	164.17	169.42
M ₂ L ₁	75.34	69.34	72.34	116.72	109.72	113.22	192.06	179.06	185.56
M ₂ L ₂	75.82	69.82	72.82	117.45	110.45	113.95	193.27	180.27	186.77
M ₂ L ₃	76.15	70.15	73.15	118.06	111.06	114.56	194.21	181.21	187.71
M ₂ L ₄	74.21	68.21	71.21	115.04	108.04	111.54	189.25	176.25	182.75
M ₃ L ₁	64.21	60.21	62.21	80.35	81.35	80.85	144.56	141.56	143.06
M ₃ L ₂	64.82	60.82	62.82	81.05	82.05	81.55	145.87	142.87	144.37
M ₃ L ₃	65.22	61.22	63.22	81.65	82.65	82.15	146.87	143.87	145.37
M ₃ L ₄	63.25	59.25	61.25	79.08	80.08	79.58	142.33	139.33	140.83
M ₄ L ₁	65.18	60.88	63.03	81.53	82.53	82.03	146.71	143.41	145.06
M ₄ L ₂	65.78	61.48	63.63	82.35	83.35	82.85	148.13	144.83	146.48
M ₄ L ₃	66.28	61.98	64.13	82.78	83.78	83.28	149.06	145.76	147.41
M ₄ L ₄	64.35	60.05	62.20	80.55	81.55	81.05	144.90	141.60	143.25
M ₅ L ₁	67.22	62.52	64.87	90.75	92.75	91.75	157.97	155.27	156.62
M ₅ L ₂	67.78	63.08	65.43	91.65	93.65	92.65	159.43	156.73	158.08
M ₅ L ₃	68.45	63.75	66.10	92.55	94.55	93.55	161.00	158.30	159.65
M ₅ L ₄	66.35	61.65	64.00	89.65	91.65	90.65	156.00	153.30	154.65
M ₆ L ₁	68.26	63.26	65.76	92.25	94.25	93.25	160.51	157.51	159.01
M ₆ L ₂	68.83	63.83	66.33	92.98	94.98	93.98	161.81	158.81	160.31
M ₆ L ₃	69.35	64.35	66.85	93.72	95.72	94.72	163.07	160.07	161.57
M ₆ L ₄	67.42	62.42	64.92	91.08	93.08	92.08	158.50	155.50	157.00
S.Em±	3.32	2.10	2.22	2.73	2.41	1.75	4.33	2.87	2.70
CD (0.05)	9.52	6.02	6.38	7.82	6.90	5.01	12.42	8.23	7.74

Table 52: Effect of manurial practices and liquid organic manures on Fe uptake (g ha⁻¹) by grain and straw

Treatments	Grain			Straw			Total		
	2013	2014	Pooled	2013	2014	Pooled	2013	2014	Pooled
Manurial practices (M)									
M ₁ -RDF (100:50:50 kg N, P ₂ O ₅ , K ₂ O ha ⁻¹)	307.22b	207.32b	257.27b	548.30b	474.22b	511.26b	855.52b	681.54b	768.53b
M ₂ -RDF+FYM+MC	350.58a	245.10a	297.84a	644.93a	575.30a	610.12a	995.51a	820.40a	907.96a
M ₃ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN	192.94c	142.92e	167.93e	294.91e	296.22d	295.56d	487.85d	439.14d	463.49d
M ₄ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN+MC	198.64c	151.87de	175.26de	305.40de	318.17d	311.79d	504.04d	470.05d	487.04d
M ₅ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN+FYM	219.97c	174.54cd	197.26cd	343.09cd	372.20 c	357.64c	563.06c	546.74c	554.90 c
M ₆ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN+FYM+MC	229.52c	187.46bc	208.49c	360.03c	404.35c	382.19c	589.54c	591.82c	590.68c
S.Em±	10.9	7.62	7.46	12.41	12.02	8.18	17.51	16.9	13.09
Liquid organic manures (L)									
L ₁ -Jeevamrut @ 500 litres ha ⁻¹ at 30, 60 and 90 DAS	252.99a	187.23a	220.11a	409.18c	400.24c	404.71c	662.18c	587.47c	624.82c
L ₂ -Cow urine @ 500 litres ha ⁻¹ at 30, 60and 90 DAS	259.36a	192.24a	225.80a	438.35b	428.55b	433.45b	697.71b	620.79b	659.25b
L ₃ -Bio digester @ 2500 litres ha ⁻¹ at 30, 60 and 90 DAS	265.11a	196.84a	230.98a	469.30a	459.24a	464.27a	734.41a	656.08a	695.25a
L ₄ -Control (no liquid manure application)	221.78b	163.17b	192.47b	347.61d	338.95d	343.28d	569.39d	502.12d	535.75d
S.Em±	6.16	5.0	4.37	8.62	7.13	5.55	10.45	7.5	6.42
Interactions- (M X L)									
M ₁ L ₁	309.36cd	209.24c-e	259.30 cd	535.11d	463.36ef	499.23f	844.47e	672.60d-f	758.53f
M ₁ L ₂	318.85b-d	214.78b-e	266.81c	581.79cd	502.81de	542.30de	900.64de	717.59cd	809.11de
M ₁ L ₃	323.99a-d	219.23b-d	271.61bc	620.25bc	535.78cd	578.02cd	944.25cd	755.01bc	849.63cd
M ₁ L ₄	276.69de	186.04d-i	231.36de	456.03e	394.91h-j	425.47g	732.72f	580.95h-j	656.84g
M ₂ L ₁	354.36a-c	246.83a-c	300.60ab	626.26bc	558.75bc	592.50 c	980.62bc	805.58b	893.10 c
M ₂ L ₂	361.97ab	252.85ab	307.41a	681.30ab	607.81abn	644.55d	1043.27ab	860.66a	951.97b
M ₂ L ₃	368.38a	258.51a	313.44a	729.26a	651.68a	690.47a	1097.64a	910.18a	1003.91a
M ₂ L ₄	317.59b-d	222.21a-d	269.90bc	542.93d	482.96e	512.95ef	860.52e	705.18c-e	782.85ef
M ₃ L ₁	198.27f-h	146.99i-k	172.63j-l	297.11i-k	300.58lm	298.85l	495.39kl	447.57m	471.48k
M ₃ L ₂	200.85f-h	150.17h-k	175.51i-l	310.43h-k	312.68k-m	311.55j-l	511.27jk	462.85lm	487.06k
M ₃ L ₃	206.83f-h	152.95g-k	179.89g-k	330.76g-j	331.98kl	331.37j-l	537.60i-k	484.93k-m	511.26jk
M ₃ L ₄	165.82h	121.56k	143.69l	241.32k	239.63n	240.48m	407.14m	361.19n	384.17l
M ₄ L ₁	203.18f-h	154.80g-k	178.99h-k	303.71i-k	313.36k-m	308.54kl	506.89jk	468.15lm	487.52k
M ₄ L ₂	207.73f-h	159.10f-k	183.41g-k	320.97g-j	333.67kl	327.32j-l	528.70i-k	492.77k-m	510.73jk
M ₄ L ₃	211.78f-h	163.34f-j	187.56f-j	345.55f-j	364.66i-k	355.11ij	557.33h-k	528.00jk	542.67ij
M ₄ L ₄	171.89gh	130.26jk	151.07kl	251.37k	261.00mn	256.18m	423.25lm	391.26n	407.26l
M ₅ L ₁	221.27fg	176.63e-i	198.95e-j	337.63f-j	365.93i-k	351.78i-k	558.91h-k	542.55i-k	550.73ij
M ₅ L ₂	229.93ef	182.26d-i	206.10e-j	360.34f-i	390.96h-j	375.65hi	590.27g-j	573.22h-j	581.75hi
M ₅ L ₃	235.83ef	187.67d-i	211.75e-h	386.92fg	420.42i	403.67gh	622.75gh	608.08gh	615.42gh
M ₅ L ₄	192.85f-h	151.62h-k	172.23j-l	287.46jk	311.50k-m	299.48l	480.32k-m	463.11lm	471.72k
M ₆ L ₁	231.53ef	188.89d-h	210.21e-i	355.26f-j	399.46g-j	377.36hi	586.79g-j	588.35hi	587.57hi
M ₆ L ₂	236.86ef	194.29d-g	215.57e-g	375.24f-h	423.36f-h	399.30gh	612.10g-i	617.65f-h	614.87gh
M ₆ L ₃	243.86ef	199.34d-f	221.60ef	403.04ef	450.93e-g	426.99g	646.91g	650.27e-j	648.59g
M ₆ L ₄	205.83f-h	167.32f-j	186.58f-j	306.55h-k	343.67j-l	325.11j-l	512.38jk	510.99kl	511.69jk
S.Em±	15.09	12.27	10.71	21.14	17.47	13.61	25.59	681.54b	15.73

Means followed by the same alphabet do not differ significantly by DMRT (0.05)

recorded with application of FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN (M_3).

Among the liquid organic manures, soil application of biodigester @ 2500 l ha⁻¹ at 30, 60 and 90 DAS (L_3) recorded significantly higher iron uptake by grain (230.98 g ha⁻¹) but was at par with foliar application of cow urine @ 500 l ha⁻¹ at 30, 60 and 90 DAS (225.80 g ha⁻¹) and soil application of jeevamrut @ 500 l ha⁻¹ at 30, 60 and 90 DAS (220.11 g ha⁻¹). Significantly lower iron uptake by grain (192.47 g ha⁻¹) was recorded with control (L_4).

Integrated application of RDF + FYM + microbial consortium with soil application of biodigester @ 2500 l ha⁻¹ at 30, 60 and 90 DAS (M_2L_3) recorded significantly higher iron uptake by grain (313.44 g ha⁻¹) but was at par with M_2L_2 (307.41 g ha⁻¹) and M_2L_1 (300.6 g ha⁻¹). Significantly lower iron uptake by grain (143.69 g ha⁻¹) was recorded with M_3L_4 .

4.2.7.4.2 Iron uptake by straw (g ha⁻¹)

Among the manurial practices, application of RDF + FYM + microbial consortium (M_2) recorded significantly higher iron uptake by straw (610.12 g ha⁻¹) over rest of the treatments. Significantly lower iron uptake by straw (295.56 g ha⁻¹) was recorded with application of FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN (M_3).

Soil application of biodigester @ 2500 l ha⁻¹ at 30, 60 and 90 DAS (L_3) recorded significantly higher iron uptake by straw (464.27 g ha⁻¹). Significantly lower iron uptake by straw (343.28 g ha⁻¹) was recorded with control (L_4).

Among the treatment combinations, integrated application of RDF + FYM + microbial consortium with soil application of biodigester @ 2500 l ha⁻¹ at 30, 60 and 90 DAS (M_2L_3) recorded significantly higher iron uptake by grain (690.47 g ha⁻¹). Significantly lower iron uptake by straw (240.48 g ha⁻¹) was recorded with M_3L_4 .

4.2.7.4.3 Total iron uptake by grain and straw (g ha^{-1})

Irrespective of liquid organic manures, application of RDF + FYM + microbial consortium (M_2) recorded significantly higher total iron uptake by grain and straw (907.96 g ha^{-1}) over rest of the treatments. Significantly lower total iron uptake by grain and straw (463.49 g ha^{-1}) was recorded with application of FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN (M_3).

Soil application of biodigester @ 2500 l ha^{-1} at 30, 60 and 90 DAS (L_3) recorded significantly higher total iron uptake by grain and straw (695.25 g ha^{-1}). Significantly lower total iron uptake by grain and straw (535.75 g ha^{-1}) was recorded with control (L_4).

Among the treatment combinations, application of RDF + FYM + microbial consortium with soil application of biodigester @ 2500 l ha^{-1} at 30, 60 and 90 DAS (M_2L_3) recorded significantly higher total iron uptake by grain and straw ($1003.91 \text{ g ha}^{-1}$). Significantly lower iron uptake by grain and straw (384.17 g ha^{-1}) was recorded with M_3L_4 .

4.2.7.5 Manganese content (ppm) and uptake (g ha^{-1})

The data on manganese content and uptake by grain and straw as influenced by manurial practices and liquid organic manures at harvest is furnished in Table 53 and 54.

4.2.7.5.1 Manganese uptake by grain (g ha^{-1})

Among the manurial practices, application of RDF + FYM + microbial consortium (M_2) recorded significantly higher manganese uptake by grain (358.77 g ha^{-1}) over rest of the treatments. Significantly lower manganese uptake by grain (208.86 g ha^{-1}) was recorded with application of FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN (M_3).

Soil application of biodigester @ 2500 l ha^{-1} at 30, 60 and 90 DAS (L_3) recorded significantly higher manganese uptake by grain (282.10 g ha^{-1}) but was at par with foliar application of cow urine @ 500 l ha^{-1} at 30, 60 and 90 DAS (275.54 g ha^{-1}) and soil

Table 53: Effect of manurial practices and liquid organic manures on Mn content (ppm) in grain and straw

Treatments	Grain			Straw			Total		
	2013	2014	Pooled	2013	2014	Pooled	2013	2014	Pooled
Manurial practices (M)									
M ₁ -RDF (100:50:50 kg N, P ₂ O ₅ , K ₂ O ha ⁻¹)	87.33	81.83	84.58	113.59	108.59	111.09	200.92	190.42	195.67
M ₂ -RDF+FYM+MC	90.38	84.38	87.38	126.60	118.60	122.60	216.98	202.98	209.98
M ₃ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN	79.29	75.79	77.54	87.29	89.29	88.29	166.58	165.08	165.83
M ₄ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN+MC	80.29	76.29	78.29	88.39	90.39	89.39	168.68	166.68	167.68
M ₅ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN+FYM	82.30	77.80	80.05	98.86	101.86	100.36	181.16	179.66	180.41
M ₆ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN+FYM+MC	83.37	78.37	80.87	100.11	103.11	101.61	183.49	181.49	182.49
S.Em±	1.22	1.25	0.79	1.68	1.31	1.04	2.36	1.97	1.58
CD (0.05)	3.84	3.94	2.49	5.28	4.13	3.28	7.42	6.21	4.99
Liquid organic manures (L)									
L ₁ -Jeevamrut @ 500 litres ha ⁻¹ at 30, 60 and 90 DAS	83.67	78.92	81.29	102.29	101.79	102.04	185.95	180.70	183.33
L ₂ -Cow urine @ 500 litres ha ⁻¹ at 30, 60and 90 DAS	84.25	79.50	81.87	102.99	102.49	102.74	187.23	181.98	184.61
L ₃ -Bio digester @ 2500 litres ha ⁻¹ at 30, 60 and 90 DAS	84.69	79.94	82.31	103.56	103.06	103.31	188.25	183.00	185.62
L ₄ -Control (no liquid manure application)	82.71	77.96	80.33	101.06	100.56	100.81	183.76	178.51	181.14
S.Em±	0.95	0.80	0.55	0.88	0.81	0.55	1.33	1.18	0.73
CD (0.05)	2.72	2.29	1.57	2.53	2.33	1.58	3.80	3.37	2.09
Interactions- (M X L)									
M ₁ L ₁	87.12	81.62	84.37	113.32	108.32	110.82	200.44	189.94	195.19
M ₁ L ₂	87.83	82.33	85.08	114.25	109.25	111.75	202.08	191.58	196.83
M ₁ L ₃	88.12	82.62	85.37	114.68	109.68	112.18	202.80	192.30	197.55
M ₁ L ₄	86.23	80.73	83.48	112.12	107.12	109.62	198.35	187.85	193.10
M ₂ L ₁	90.42	84.42	87.42	126.65	118.65	122.65	217.07	203.07	210.07
M ₂ L ₂	90.76	84.76	87.76	127.13	119.13	123.13	217.89	203.89	210.89
M ₂ L ₃	91.23	85.23	88.23	127.85	119.85	123.85	219.08	205.08	212.08
M ₂ L ₄	89.12	83.12	86.12	124.75	116.75	120.75	213.87	199.87	206.87
M ₃ L ₁	79.14	75.64	77.39	87.12	89.12	88.12	166.26	164.76	165.51
M ₃ L ₂	79.76	76.26	78.01	87.85	89.85	88.85	167.61	166.11	166.86
M ₃ L ₃	80.13	76.63	78.38	88.25	90.25	89.25	168.38	166.88	167.63
M ₃ L ₄	78.13	74.63	76.38	85.95	87.95	86.95	164.08	162.58	163.33
M ₄ L ₁	80.05	76.05	78.05	88.12	90.12	89.12	168.17	166.17	167.17
M ₄ L ₂	80.72	76.72	78.72	88.82	90.82	89.82	169.54	167.54	168.54
M ₄ L ₃	81.16	77.16	79.16	89.35	91.35	90.35	170.51	168.51	169.51
M ₄ L ₄	79.24	75.24	77.24	87.25	89.25	88.25	166.49	164.49	165.49
M ₅ L ₁	82.13	77.63	79.88	98.65	101.65	100.15	180.78	179.28	180.03
M ₅ L ₂	82.65	78.15	80.40	99.24	102.24	100.74	181.89	180.39	181.14
M ₅ L ₃	83.25	78.75	81.00	100.12	103.12	101.62	183.37	181.87	182.62
M ₅ L ₄	81.16	76.66	78.91	97.42	100.42	98.92	178.58	177.08	177.83
M ₆ L ₁	83.15	78.15	80.65	99.85	102.85	101.35	183.00	181.00	182.00
M ₆ L ₂	83.76	78.76	81.26	100.62	103.62	102.12	184.38	182.38	183.38
M ₆ L ₃	84.23	79.23	81.73	101.12	104.12	102.62	185.35	183.35	184.35
M ₆ L ₄	82.35	77.35	79.85	98.86	101.86	100.36	181.21	179.21	180.21
S.Em±	2.32	1.96	1.34	2.16	1.99	1.35	3.25	2.88	1.79
CD (0.05)	6.67	5.61	3.85	6.20	5.72	3.86	9.32	8.26	5.13

Table 54: Effect of manurial practices and liquid organic manures on Mn uptake (g ha⁻¹) by grain and straw

Treatments	Grain			Straw			Total		
	2013	2014	Pooled	2013	2014	Pooled	2013	2014	Pooled
Manurial practices (M)									
M ₁ -RDF (100:50:50 kg N, P ₂ O ₅ , K ₂ O ha ⁻¹)	370.66b	252.73b	311.69b	593.87b	515.36b	554.62b	964.53b	768.09b	866.31b
M ₂ -RDF+FYM+MC	419.91a	297.64a	358.77a	699.45a	622.08a	660.76a	1119.35a	919.72a	1019.53a
M ₃ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN	237.78d	179.93d	208.86d	319.81e	324.35e	322.08d	557.60d	504.28e	530.94d
M ₄ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN+MC	244.30d	190.10d	217.20d	330.59de	347.47e	339.03d	574.89d	537.57e	556.23d
M ₅ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN+FYM	268.78c	216.16c	242.47c	371.11cd	406.49d	388.80 c	639.89c	622.65d	631.27c
M ₆ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN+FYM+MC	279.28c	231.44c	255.36c	389.93c	441.84c	415.89c	669.21c	673.28c	671.25c
S.Em±	6.83	5.56	4.43	13.88	10.51	10.1	17.86	14.75	13.81
Liquid organic manures (L)									
L ₁ -Jeevamrut @ 500 litres ha ⁻¹ at 30, 60 and 90 DAS	307.35a	230.68a	269.02a	444.42c	436.28c	440.35c	751.77c	666.97c	709.37c
L ₂ -Cow urine @ 500 litres ha ⁻¹ at 30, 60and 90 DAS	314.54a	236.53a	275.54a	474.65b	466.38b	470.51b	789.20b	702.91b	746.05b
L ₃ -Bio digester @ 2500 litres ha ⁻¹ at 30, 60 and 90 DAS	321.65a	242.54a	282.10a	507.25a	499.35a	503.30a	828.90a	741.90a	785.40a
L ₄ -Control (no liquid manure application)	270.26b	202.24b	236.25b	376.86d	369.71d	373.28d	647.12d	571.95d	609.53d
S.Em±	6.0	5.32	4.37	8.44	9.62	6.51	9.25	9.99	7.02
Interactions- (M X L)									
M ₁ L ₁	373.82de	254.23d-f	314.03b	580.15d	503.04e-g	541.59e	953.97e	757.27ef	855.62f
M ₁ L ₂	382.58cd	260.33c-f	321.46b	629.95cd	546.95c-e	588.45de	1012.53de	807.29de	909.91de
M ₁ L ₃	390.79b-d	267.78b-e	329.29b	669.32c	581.77cd	625.54cd	1060.11cd	849.55cd	954.83d
M ₁ L ₄	335.45ef	228.56d-k	282.01c	496.07e	429.68g-i	462.88f	831.53f	658.24h-k	744.88g
M ₂ L ₁	424.01a-c	299.92a-c	361.97a	681.54bc	605.42bc	643.48c	1105.55bc	905.34bc	1005.44c
M ₂ L ₂	432.61ab	307.10ab	369.86a	737.21ab	656.63ab	696.92b	1169.82ab	963.73ab	1066.77b
M ₂ L ₃	441.55a	313.73a	377.64a	792.66a	704.74a	748.70a	1234.20a	1018.46a	1126.33a
M ₂ L ₄	381.45cd	269.82b-d	325.63b	586.38d	521.52d-f	553.95e	967.83e	791.33de	879.58ef
M ₃ L ₁	244.68h-k	185.78k-m	215.23ij	323.65i-l	328.22j-l	325.93kl	568.33jk	514.00no	541.17k
M ₃ L ₂	246.84g-k	187.36k-m	217.10ij	337.39i-k	341.38jk	339.38jk	584.22jk	528.74mn	556.48k
M ₃ L ₃	253.69g-k	192.28i-m	222.98g-i	357.19g-j	363.42ij	360.31i-k	610.88i-k	555.70l-n	583.29jk
M ₃ L ₄	205.91k	154.31m	180.11k	261.03l	264.37l	262.70m	466.95m	418.68p	442.81l
M ₄ L ₁	248.31g-k	192.37i-m	220.34h-j	329.11i-k	343.34jk	336.22jk	577.41jk	535.70mn	556.56k
M ₄ L ₂	255.94g-j	199.46h-l	227.70f-i	347.51h-j	364.40ij	355.96jk	603.45i-k	563.86l-n	583.66jk
M ₄ L ₃	261.74g-i	204.24g-l	232.99e-i	372.96f-j	396.55h-j	384.75h-j	634.70h-j	600.79j-m	617.75ij
M ₄ L ₄	211.23jk	164.32lm	187.77jk	272.78kl	285.60kl	279.19lm	484.01lm	449.92op	466.96l
M ₅ L ₁	272.38g-i	218.71f-k	245.55d-i	366.25g-j	400.35h-j	383.30h-j	638.62h-j	619.07i-l	628.85ij
M ₅ L ₂	279.94g-i	225.47e-k	252.71c-h	389.05f-i	427.82g-i	408.44g-i	668.99g-i	653.29h-k	661.14hi
M ₅ L ₃	287.03gh	231.56d-j	259.30 c-f	417.25fg	457.32f-h	437.28fg	704.28gh	688.88f-i	696.58gh
M ₅ L ₄	235.78i-k	188.90j-m	212.34i-k	311.90j-l	340.45jk	326.17kl	547.68kl	529.35mn	538.51k
M ₆ L ₁	280.90g-i	233.08d-i	256.99c-g	385.84f-i	437.33g-i	411.59gh	666.75g-i	670.41g-j	668.58hi
M ₆ L ₂	289.35gh	239.49d-h	264.42c-e	406.81f-h	461.07f-h	433.94f-h	696.16gh	700.56f-h	698.36gh
M ₆ L ₃	295.12fg	245.65d-g	270.39cd	434.11f	492.34e-g	463.22f	729.23g	737.99e-g	733.61g
M ₆ L ₄	251.75g-k	207.53g-l	229.64e-i	332.98i-k	376.63ij	354.80jk	584.72jk	584.16k-n	584.44jk
S.Em±	14.70	13.04	10.72	20.69	23.59	15.97	22.68	24.49	17.20

Means followed by the same alphabet do not differ significantly by DMRT (0.05)

application of jeevamrut @ 500 l ha⁻¹ at 30, 60 and 90 DAS (269.02 g ha⁻¹). Significantly lower iron uptake by grain (236.25 g ha⁻¹) was recorded with control (L₄).

Integrated application of RDF + FYM + microbial consortium with soil application of biodigester @ 2500 l ha⁻¹ at 30, 60 and 90 DAS (M₂L₃) recorded significantly higher manganese uptake by grain (377.64 g ha⁻¹) but was at par with M₂L₂ (369.86 g ha⁻¹) and M₂L₁ (361.97 g ha⁻¹). Significantly lower manganese uptake by grain (180.11 g ha⁻¹) was recorded with M₃L₄.

4.2.7.5.2 Manganese uptake by straw (g ha⁻¹)

Irrespective of liquid organic manures, application of RDF + FYM + microbial consortium (M₂) recorded significantly higher manganese uptake by straw (660.76 g ha⁻¹) over rest of the treatments. Significantly lower manganese uptake by straw (322.08 g ha⁻¹) was recorded with application of FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN (M₃).

Soil application of biodigester @ 2500 l ha⁻¹ at 30, 60 and 90 DAS (L₃) recorded significantly higher manganese uptake by straw (503.30 g ha⁻¹). Significantly lower manganese uptake by straw (373.28 g ha⁻¹) was recorded with control (L₄).

Among the treatment combinations, integrated application of RDF + FYM + microbial consortium with soil application of biodigester @ 2500 l ha⁻¹ at 30, 60 and 90 DAS (M₂L₃) recorded significantly higher manganese uptake by grain (748.70 g ha⁻¹). Significantly lower manganese uptake by straw (262.70 g ha⁻¹) was recorded with M₃L₄.

4.2.7.5.3 Total manganese uptake by grain and straw (g ha⁻¹)

Among the manurial practices, application of RDF + FYM + microbial consortium (M₂) recorded significantly higher total manganese uptake by grain and straw (1019.53 g ha⁻¹) over rest of the treatments. Significantly lower total manganese uptake by grain and straw (530.94 g ha⁻¹) was recorded with application of FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN (M₃).

Soil application of biodigester @ 2500 l ha⁻¹ at 30, 60 and 90 DAS (L₃) recorded significantly higher total manganese uptake by grain and straw (785.40 g ha⁻¹).

Significantly lower total manganese uptake by grain and straw (609.53 g ha^{-1}) was recorded with control (L_4).

Integrated application of RDF + FYM + microbial consortium with soil application of biodigester @ 2500 l ha^{-1} at 30, 60 and 90 DAS (M_2L_3) recorded significantly higher total manganese uptake by grain and straw ($1126.33 \text{ g ha}^{-1}$). Significantly lower manganese uptake by grain and straw (442.81 g ha^{-1}) was recorded with M_3L_4 .

4.2.7.6 Zinc content (ppm) and uptake (g ha^{-1})

The data on zinc content and uptake as influenced by manurial practices and liquid organic manures at harvest is presented in Table 55 and 56.

4.2.7.6.1 Zinc uptake by grain (g ha^{-1})

The data on zinc uptake by grain was significantly influenced by manurial practices and liquid organic manures at harvest. Among the manurial practices, application of RDF + FYM + microbial consortium (M_2) recorded significantly higher zinc uptake by grain (146.74 g ha^{-1}) over rest of the treatments. Significantly lower zinc uptake by grain (82.70 g ha^{-1}) was recorded with application of FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN (M_3).

Among the liquid organic manures, soil application of biodigester @ 2500 l ha^{-1} at 30, 60 and 90 DAS (L_3) recorded significantly higher zinc uptake by grain (114.15 g ha^{-1}) but was at par with foliar application of cow urine @ 500 l ha^{-1} at 30, 60 and 90 DAS (111.24 g ha^{-1}) and soil application of jeevamrut @ 500 l ha^{-1} at 30, 60 and 90 DAS (108.47 g ha^{-1}). Significantly lower zinc uptake by grain (94.87 g ha^{-1}) was recorded with control (L_4).

Among the treatment combinations, integrated application of RDF + FYM + microbial consortium with soil application of biodigester @ 2500 l ha^{-1} at 30, 60 and 90 DAS (M_2L_3) recorded significantly higher zinc uptake by grain (154.76 g ha^{-1}) but was at par with M_2L_2 (151.58 g ha^{-1}) and M_2L_1 (147.75 g ha^{-1}). Significantly lower zinc uptake by grain (70.97 g ha^{-1}) was recorded with M_3L_4 .

Table 55: Effect of manurial practices and liquid organic manures on Zn content (ppm) in grain and straw

Treatments	Grain			Straw			Total		
	2013	2014	Pooled	2013	2014	Pooled	2013	2014	Pooled
Manurial practices (M)									
M ₁ -RDF (100:50:50 kg N, P ₂ O ₅ , K ₂ O ha ⁻¹)	36.27	32.47	34.37	23.61	22.81	23.21	59.88	55.28	57.58
M ₂ -RDF+FYM+MC	37.66	33.66	35.66	26.39	25.19	25.79	64.06	58.86	61.46
M ₃ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN	32.15	29.15	30.65	17.74	18.04	17.89	49.89	47.19	48.54
M ₄ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN+MC	32.67	29.47	31.07	18.00	18.30	18.15	50.67	47.77	49.22
M ₅ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN+FYM	33.65	30.25	31.95	20.23	20.53	20.38	53.88	50.78	52.33
M ₆ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN+FYM+MC	34.21	30.61	32.41	20.62	21.22	20.92	54.82	51.82	53.32
S.Em±	0.73	0.83	0.64	0.67	0.73	0.39	0.79	1.15	0.71
CD (0.05)	2.30	2.62	2.01	2.11	2.29	1.23	2.48	3.61	2.25
Liquid organic manures (L)									
L ₁ -Jeevamrut @ 500 litres ha ⁻¹ at 30, 60 and 90 DAS	34.37	30.87	32.62	21.05	20.96	21.00	55.42	51.83	53.63
L ₂ -Cow urine @ 500 litres ha ⁻¹ at 30, 60 and 90 DAS	34.62	31.12	32.87	21.21	21.13	21.17	55.83	52.25	54.04
L ₃ -Bio digester @ 2500 litres ha ⁻¹ at 30, 60 and 90 DAS	34.87	31.37	33.12	21.38	21.30	21.34	56.24	52.66	54.45
L ₄ -Control (no liquid manure application)	33.88	30.38	32.13	20.76	20.67	20.71	54.63	51.05	52.84
S.Em±	0.67	0.46	0.44	0.59	0.38	0.32	1.23	0.57	0.69
CD (0.05)	1.92	1.33	1.27	1.69	1.10	0.92	3.53	1.62	1.99
Interactions- (M X L)									
M ₁ L ₁	36.23	32.43	34.33	23.54	22.74	23.14	59.77	55.17	57.47
M ₁ L ₂	36.52	32.72	34.62	23.78	22.98	23.38	60.30	55.70	58.00
M ₁ L ₃	36.72	32.92	34.82	23.88	23.08	23.48	60.60	56.00	58.30
M ₁ L ₄	35.62	31.82	33.72	23.22	22.42	22.82	58.84	54.24	56.54
M ₂ L ₁	37.63	33.63	35.63	26.35	25.15	25.75	63.98	58.78	61.38
M ₂ L ₂	37.85	33.85	35.85	26.55	25.35	25.95	64.40	59.20	61.80
M ₂ L ₃	38.05	34.05	36.05	26.72	25.52	26.12	64.77	59.57	62.17
M ₂ L ₄	37.12	33.12	35.12	25.95	24.75	25.35	63.07	57.87	60.47
M ₃ L ₁	32.15	29.15	30.65	17.72	18.02	17.87	49.87	47.17	48.52
M ₃ L ₂	32.35	29.35	30.85	17.83	18.13	17.98	50.18	47.48	48.83
M ₃ L ₃	32.45	29.45	30.95	17.95	18.25	18.10	50.40	47.70	49.05
M ₃ L ₄	31.64	28.64	30.14	17.45	17.75	17.60	49.09	46.39	47.74
M ₄ L ₁	32.52	29.32	30.92	17.92	18.22	18.07	50.44	47.54	48.99
M ₄ L ₂	32.76	29.56	31.16	18.05	18.35	18.20	50.81	47.91	49.36
M ₄ L ₃	33.25	30.05	31.65	18.32	18.62	18.47	51.57	48.67	50.12
M ₄ L ₄	32.14	28.94	30.54	17.72	18.02	17.87	49.86	46.96	48.41
M ₅ L ₁	33.45	30.05	31.75	20.12	20.42	20.27	53.57	50.47	52.02
M ₅ L ₂	33.72	30.32	32.02	20.28	20.58	20.43	54.00	50.90	52.45
M ₅ L ₃	34.18	30.78	32.48	20.55	20.85	20.70	54.73	51.63	53.18
M ₅ L ₄	33.23	29.83	31.53	19.98	20.28	20.13	53.21	50.11	51.66
M ₆ L ₁	34.25	30.65	32.45	20.62	21.22	20.92	54.87	51.87	53.37
M ₆ L ₂	34.52	30.92	32.72	20.78	21.38	21.08	55.30	52.30	53.80
M ₆ L ₃	34.54	30.94	32.74	20.85	21.45	21.15	55.39	52.39	53.89
M ₆ L ₄	33.52	29.92	31.72	20.21	20.81	20.51	53.73	50.73	52.23
S.Em±	1.64	1.14	1.08	1.45	0.94	0.79	3.02	1.39	1.70
CD (0.05)	4.71	3.26	3.363.0	4.15	2.70	2.26	8.65	3.98	4.87

Table 56: Effect of manurial practices and liquid organic manures on Zn uptake (g ha⁻¹) by grain and straw

Treatments	Grain			Straw			Total		
	2013	2014	Pooled	2013	2014	Pooled	2013	2014	Pooled
Manurial practices (M)									
M ₁ -RDF (100:50:50 kg N, P ₂ O ₅ , K ₂ O ha ⁻¹)	154.07b	100.39b	127.23b	123.50b	108.42b	115.96b	277.57b	208.81b	243.19b
M ₂ -RDF+FYM+MC	174.94a	118.54a	146.74a	146.11a	132.19a	139.15a	321.05a	250.73a	285.89a
M ₃ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN	96.29d	69.12d	82.70d	64.87d	65.91e	65.39d	161.15d	135.03d	148.09d
M ₄ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN+MC	99.46d	73.73d	86.59d	67.14d	70.61de	68.88d	166.60d	144.34d	155.47d
M ₅ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN+FYM	110.15c	84.21c	97.18c	75.94cd	81.85cd	78.89c	186.10 c	166.05c	176.07c
M ₆ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN+FYM+MC	114.82c	90.45bc	102.63c	80.47c	90.89c	85.68c	195.29c	181.34c	188.31c
S.Em±	2.43	3.31	2.12	4.03	4.1	2.79	4.55	6.31	3.94
Liquid organic manures (L)									
L ₁ -Jeevamrut @ 500 litres ha ⁻¹ at 30, 60 and 90 DAS	126.51a	90.43a	108.47a	91.46b	90.17b	90.81c	217.97b	180.60 c	199.29c
L ₂ -Cow urine @ 500 litres ha ⁻¹ at 30, 60and 90 DAS	129.48a	92.99a	111.24a	97.90ab	96.63ab	97.27b	227.38ab	189.62b	208.50b
L ₃ -Bio digester @ 2500 litres ha ⁻¹ at 30, 60 and 90 DAS	133.04a	95.26a	114.15a	104.79a	103.51a	104.15a	237.82a	198.77a	218.30a
L ₄ -Control (no liquid manure application)	110.79b	78.94b	94.87b	77.88c	76.26c	77.07d	188.66c	155.21d	171.93d
S.Em±	3.61	2.43	2.37	3.15	2.51	2.01	5.56	3.04	3.2
Interactions- (M X L)									
M ₁ L ₁	155.61bc	100.96b-d	128.28de	120.27cd	106.04d-g	113.15e	275.87cd	206.99d-f	241.43d
M ₁ L ₂	159.03a-c	103.78b-d	131.41c-e	131.32bc	114.92c-e	123.12c-e	290.35c	218.70de	254.53d
M ₁ L ₃	162.88a-c	106.72a-c	134.80b-d	138.94bc	122.91b-d	130.93cd	301.82bc	229.63cd	265.72cd
M ₁ L ₄	138.76cd	90.08c-g	114.42ef	103.47de	89.81g-k	96.64f	242.24de	179.89g-i	211.06e
M ₂ L ₁	176.20ab	119.29ab	147.75a-c	142.41bc	128.38bc	135.40bc	318.62a-c	247.67bc	283.14bc
M ₂ L ₂	180.34ab	122.81a	151.58ab	153.77ab	139.89ab	146.83ab	334.11ab	262.70ab	298.41ab
M ₂ L ₃	184.73a	124.78a	154.76a	166.06a	150.10a	158.08a	350.79a	274.88a	312.84a
M ₂ L ₄	158.50a-c	107.27a-c	132.89cd	122.18cd	110.39c-f	116.29de	280.68cd	217.66de	249.17d
M ₃ L ₁	99.10e-g	71.40g-i	85.25i-k	65.09fg	66.82l-n	65.95j-l	164.19g-i	138.21lm	151.20jk
M ₃ L ₂	99.91e-g	72.36g-i	86.14i-k	68.44fg	69.35k-n	68.90h-l	168.36f-i	141.71k-m	155.03jk
M ₃ L ₃	103.26e-g	73.66g-i	88.46h-k	72.35fg	73.63i-n	72.99h-k	175.61f-i	147.28kl	161.45ij
M ₃ L ₄	82.88g	59.06i	70.97k	53.57g	53.86n	53.71l	136.46i	112.92n	124.69l
M ₄ L ₁	100.87e-g	74.53f-i	87.70h-k	67.15fg	69.74j-n	68.44h-l	168.02f-i	144.26k-m	156.14jk
M ₄ L ₂	104.19e-g	77.22e-i	90.70g-j	70.18fg	73.97i-n	72.07h-k	174.37f-i	151.18j-l	162.78ij
M ₄ L ₃	107.31e-g	79.73e-h	93.52g-j	75.51fg	80.74h-l	78.13g-j	182.82f-h	160.47h-l	171.65g-j
M ₄ L ₄	85.45fg	63.45hi	74.45jk	55.74g	58.01mn	56.87kl	141.19hi	121.46mn	131.32kl
M ₅ L ₁	111.43d-g	84.74d-g	98.09f-i	74.08fg	80.00h-l	77.04g-j	185.52f-h	164.74h-k	175.13g-j
M ₅ L ₂	114.06d-f	87.61c-g	100.84f-i	79.44e-g	86.11g-l	82.78f-i	193.50fg	173.72g-j	183.61f-i
M ₅ L ₃	118.31de	91.09c-g	104.70f-i	86.15ef	92.36f-i	89.26fg	204.46e-g	183.45gh	193.96e-g
M ₅ L ₄	96.80e-g	73.39g-i	85.10i-k	64.10fg	68.90l-n	66.50i-l	160.90g-i	142.30k-m	151.60jk
M ₆ L ₁	115.86de	91.67c-g	103.76f-i	79.76e-g	90.04g-j	84.90f-h	195.62fg	181.71gh	188.66e-h
M ₆ L ₂	119.35de	94.17c-f	106.76f-h	84.25ef	95.55e-h	89.90fg	203.60e-g	189.72fg	196.66e-g
M ₆ L ₃	121.73de	95.56c-e	108.65fg	89.70ef	101.34e-g	95.52f	211.43ef	196.91e-g	204.17ef
M ₆ L ₄	102.32e-g	80.41e-h	91.36g-j	68.19fg	76.60h-m	72.40h-k	170.51f-i	157.01h-l	163.76h-j
S.Em±	8.85	5.95	5.81	7.72	6.15	4.94	13.64	7.45	7.84

Means followed by the same alphabet do not differ significantly by DMRT (0.05)

4.2.7.6.2 Zinc uptake by straw (g ha^{-1})

Irrespective of liquid organic manures, application of RDF + FYM + microbial consortium (M_2) recorded significantly higher zinc uptake by straw (139.15 g ha^{-1}) over rest of the treatments. Significantly lower zinc uptake by straw (65.39 g ha^{-1}) was recorded with application of FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN (M_3).

Among the liquid organic manures, soil application of biodigester @ 2500 l ha^{-1} at 30, 60 and 90 DAS (L_3) recorded significantly higher zinc uptake by straw (104.15 g ha^{-1}). Significantly lower zinc uptake by straw (77.07 g ha^{-1}) was recorded with control (L_4).

Integrated application of RDF + FYM + microbial consortium with soil application of biodigester @ 2500 l ha^{-1} at 30, 60 and 90 DAS (M_2L_3) recorded significantly higher zinc uptake by grain (158.08 g ha^{-1}) but was at par with M_2L_2 (146.83 g ha^{-1}). Significantly lower zinc uptake by straw (53.71 g ha^{-1}) was recorded with M_3L_4 .

4.2.7.6.3 Total zinc uptake by grain and straw (g ha^{-1})

Application of RDF + FYM + microbial consortium (M_2) recorded significantly higher total zinc uptake by grain and straw (285.89 g ha^{-1}) over rest of the treatments. Significantly lower total zinc uptake by grain and straw (148.09 g ha^{-1}) was recorded with application of FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN (M_3).

Among the liquid organic manures, soil application of biodigester @ 2500 l ha^{-1} at 30, 60 and 90 DAS (L_3) recorded significantly higher total zinc uptake by grain and straw (218.30 g ha^{-1}). Significantly lower total zinc uptake by grain and straw (171.93 g ha^{-1}) was recorded with control (L_4).

Integrated application of RDF + FYM + microbial consortium with soil application of biodigester @ 2500 l ha^{-1} at 30, 60 and 90 DAS (M_2L_3) recorded

significantly higher total zinc uptake by grain and straw (312.84 g ha^{-1}) but was at par with M_2L_2 (298.41 g ha^{-1}). Significantly lower zinc uptake by grain and straw (124.69 g ha^{-1}) was recorded with M_3L_4 .

4.2.7.7 Copper content (ppm) and uptake (g ha^{-1})

The data on copper content and uptake as influenced by manurial practices and liquid organic manures at harvest is presented in Table 57 and 58.

4.2.7.7.1 Copper uptake by grain (g ha^{-1})

Among the manurial practices, application of RDF + FYM + microbial consortium (M_2) recorded significantly higher copper uptake by grain (87.60 g ha^{-1}) over rest of the treatments. Significantly lower copper uptake by grain (43.71 g ha^{-1}) was recorded with application of FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN (M_3).

Soil application of biodigester @ 2500 l ha^{-1} at 30, 60 and 90 DAS (L_3) recorded significantly higher copper uptake by grain (64.66 g ha^{-1}) but was at par with foliar application of cow urine @ 500 l ha^{-1} at 30, 60 and 90 DAS (62.69 g ha^{-1}) and soil application of jeevamrut @ 500 l ha^{-1} at 30, 60 and 90 DAS (60.54 g ha^{-1}). Significantly lower copper uptake by grain (52.60 g ha^{-1}) was recorded with control (L_4).

Among the treatment combinations, integrated application of RDF + FYM + microbial consortium with soil application of biodigester @ 2500 l ha^{-1} at 30, 60 and 90 DAS (M_2L_3) recorded significantly higher copper uptake by grain (93.28 g ha^{-1}) but was at par with M_2L_2 (90.79 g ha^{-1}) and M_2L_1 (88.09 g ha^{-1}). Significantly lower copper uptake by grain (36.58 g ha^{-1}) was recorded with M_3L_4 .

4.2.7.7.2 Copper uptake by straw (g ha^{-1})

Irrespective of liquid organic manures, application of RDF + FYM + microbial consortium (M_2) recorded significantly higher copper uptake by straw (70.94 g ha^{-1}) over rest of the treatments. Significantly lower copper uptake by straw (28.95 g ha^{-1}) was recorded with application of FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN (M_3).

Table 57: Effect of manurial practices and liquid organic manures on Cu content (ppm) in grain and straw

Treatments	Grain			Straw			Total		
	2013	2014	Pooled	2013	2014	Pooled	2013	2014	Pooled
Manurial practices (M)									
M ₁ -RDF (100:50:50 kg N, P ₂ O ₅ , K ₂ O ha ⁻¹)	21.24	18.44	19.84	11.71	11.21	11.46	32.95	29.65	31.30
M ₂ -RDF+FYM+MC	22.68	19.68	21.18	13.65	12.65	13.15	36.33	32.33	34.33
M ₃ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN	17.21	15.21	16.21	7.81	8.01	7.91	25.02	23.22	24.12
M ₄ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN+MC	17.62	15.42	16.52	7.97	8.17	8.07	25.59	23.59	24.59
M ₅ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN+FYM	18.68	16.28	17.48	9.41	9.71	9.56	28.09	25.99	27.04
M ₆ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN+FYM+MC	19.19	16.59	17.89	9.65	10.05	9.85	28.84	26.64	27.74
S.Em±	0.58	0.73	0.52	0.21	0.43	0.30	0.70	0.76	0.58
CD (0.05)	1.83	2.29	1.64	0.67	1.36	0.93	2.21	2.38	1.82
Liquid organic manures (L)									
L ₁ -Jeevamrut @ 500 litres ha ⁻¹ at 30, 60 and 90 DAS	19.32	16.82	18.07	9.97	9.90	9.93	29.28	26.72	28.00
L ₂ -Cow urine @ 500 litres ha ⁻¹ at 30, 60and 90 DAS	19.62	17.12	18.37	10.13	10.07	10.10	29.76	27.19	28.47
L ₃ -Bio digester @ 2500 litres ha ⁻¹ at 30, 60 and 90 DAS	19.90	17.40	18.65	10.27	10.21	10.24	30.17	27.60	28.89
L ₄ -Control (no liquid manure application)	18.91	16.41	17.66	9.76	9.69	9.73	28.67	26.10	27.39
S.Em±	0.48	0.48	0.36	0.17	0.21	0.17	0.49	0.47	0.38
CD (0.05)	1.37	1.37	1.02	0.49	0.60	0.47	1.42	1.34	1.10
Interactions- (M X L)									
M ₁ L ₁	21.12	18.32	19.72	11.65	11.15	11.40	32.77	29.47	31.12
M ₁ L ₂	21.52	18.72	20.12	11.88	11.38	11.63	33.40	30.10	31.75
M ₁ L ₃	21.68	18.88	20.28	11.96	11.46	11.71	33.64	30.34	31.99
M ₁ L ₄	20.62	17.82	19.22	11.35	10.85	11.10	31.97	28.67	30.32
M ₂ L ₁	22.59	19.59	21.09	13.58	12.58	13.08	36.17	32.17	34.17
M ₂ L ₂	22.85	19.85	21.35	13.78	12.78	13.28	36.63	32.63	34.63
M ₂ L ₃	23.12	20.12	21.62	13.92	12.92	13.42	37.04	33.04	35.04
M ₂ L ₄	22.14	19.14	20.64	13.32	12.32	12.82	35.46	31.46	33.46
M ₃ L ₁	17.14	15.14	16.14	7.75	7.95	7.85	24.89	23.09	23.99
M ₃ L ₂	17.45	15.45	16.45	7.92	8.12	8.02	25.37	23.57	24.47
M ₃ L ₃	17.68	15.68	16.68	8.05	8.25	8.15	25.73	23.93	24.83
M ₃ L ₄	16.58	14.58	15.58	7.52	7.72	7.62	24.10	22.30	23.20
M ₄ L ₁	17.43	15.23	16.33	7.88	8.08	7.98	25.31	23.31	24.31
M ₄ L ₂	17.78	15.58	16.68	8.05	8.25	8.15	25.83	23.83	24.83
M ₄ L ₃	18.05	15.85	16.95	8.15	8.35	8.25	26.20	24.20	25.20
M ₄ L ₄	17.23	15.03	16.13	7.78	7.98	7.88	25.01	23.01	24.01
M ₅ L ₁	18.58	16.18	17.38	9.35	9.65	9.50	27.93	25.83	26.88
M ₅ L ₂	18.78	16.38	17.58	9.45	9.75	9.60	28.23	26.13	27.18
M ₅ L ₃	19.13	16.73	17.93	9.64	9.94	9.79	28.77	26.67	27.72
M ₅ L ₄	18.23	15.83	17.03	9.21	9.51	9.36	27.44	25.34	26.39
M ₆ L ₁	19.04	16.44	17.74	9.58	9.98	9.78	28.62	26.42	27.52
M ₆ L ₂	19.35	16.75	18.05	9.72	10.12	9.92	29.07	26.87	27.97
M ₆ L ₃	19.72	17.12	18.42	9.92	10.32	10.12	29.64	27.44	28.54
M ₆ L ₄	18.65	16.05	17.35	9.38	9.78	9.58	28.03	25.83	26.93
S.Em±	1.17	1.17	0.87	0.42	0.51	0.41	1.21	1.14	0.94
CD (0.05)	3.36	3.36	2.50	1.21	1.46	1.16	3.48	3.28	2.69

Table 58: Effect of manurial practices and liquid organic manures on Cu uptake by (g ha⁻¹) grain and straw

Treatments	Grain			Straw			Total		
	2013	2014	Pooled	2013	2014	Pooled	2013	2014	Pooled
Manurial practices (M)									
M ₁ -RDF (100:50:50 kg N, P ₂ O ₅ , K ₂ O ha ⁻¹)	90.00b	57.06b	73.53b	61.08b	52.98b	57.03b	151.08b	110.04b	130.56b
M ₂ -RDF+FYM+MC	105.50a	69.69a	87.60a	75.61a	66.26a	70.94a	181.12a	135.96a	158.54a
M ₃ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN	51.33e	36.09e	43.71d	28.67d	29.23d	28.95d	80.00d	65.32d	72.66d
M ₄ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN+MC	53.67de	38.36de	46.01d	29.82d	31.46d	30.64d	83.49d	69.82d	76.66d
M ₅ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN+FYM	61.04cd	45.29cd	53.17c	35.42c	38.79c	37.11c	96.46c	84.08c	90.27c
M ₆ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN+FYM+MC	64.36c	49.07c	56.71c	37.60 c	42.99c	40.29c	101.95c	92.06c	97.00 c
S.Em±	2.57	2.51	2.05	1.09	1.77	1.14	3.13	2.96	2.48
Liquid organic manures (L)									
L ₁ -Jeevamrut @ 500 litres ha ⁻¹ at 30, 60 and 90 DAS	71.53a	49.55a	60.54a	43.78b	42.59c	43.18c	115.30b	92.14b	103.72c
L ₂ -Cow urine @ 500 litres ha ⁻¹ at 30, 60and 90 DAS	73.96a	51.42a	62.69a	47.31ab	46.22b	46.76b	121.28ab	97.64ab	109.46b
L ₃ -Bio digester @ 2500 litres ha ⁻¹ at 30, 60 and 90 DAS	76.17a	53.14a	64.66a	50.88a	49.74a	50.31a	127.05a	102.89a	114.97a
L ₄ -Control (no liquid manure application)	62.28b	42.92b	52.60b	36.83c	35.93d	36.38d	99.11c	78.85c	88.98d
S.Em±	2.22	1.93	1.45	1.3	1.03	1.01	2.19	1.95	1.51
Interactions- (M X L)									
M ₁ L ₁	90.18cd	57.27b-f	73.73cd	59.34e	51.35e-g	55.35e	149.52d	108.63de	129.07d
M ₁ L ₂	93.59b-d	59.23a-e	76.41c	65.42c-e	56.85c-e	61.13c-e	159.01d	116.07d	137.54cd
M ₁ L ₃	96.25a-d	61.25a-d	78.75bc	69.50 cd	60.35cd	64.92cd	165.75cd	121.60 cd	143.68c
M ₁ L ₄	79.98de	50.49c-g	65.24de	50.06f	43.36g-j	46.71f	130.04e	93.85e-h	111.95e
M ₂ L ₁	106.23a-c	69.96ab	88.09ab	72.95bc	64.03bc	68.49bc	179.19bc	133.98bc	156.59b
M ₂ L ₂	109.33ab	72.25ab	90.79a	80.05ab	70.16ab	75.10ab	189.38ab	142.41ab	165.89ab
M ₂ L ₃	112.16a	74.40a	93.28a	86.49a	76.10a	81.30a	198.65a	150.51a	174.58a
M ₂ L ₄	94.30b-d	62.17a-c	78.23bc	62.95de	54.76d-f	58.86de	157.25d	116.93d	137.09cd
M ₃ L ₁	52.73f-h	37.06g-i	44.90i-k	28.74i-k	29.40l-n	29.07i-k	81.47j-l	66.46l-n	73.96kl
M ₃ L ₂	53.66f-h	38.16g-i	45.91h-k	30.47h-k	31.01l-n	30.74i-k	84.13i-k	69.17k-m	76.65k
M ₃ L ₃	55.77f-h	39.13g-i	47.45g-k	32.58g-k	33.30k-m	32.94h-j	88.35h-j	72.43k-m	80.39jk
M ₃ L ₄	43.17h	29.99i	36.58k	22.89k	23.23n	23.06k	66.07l	53.22n	59.64m
M ₄ L ₁	54.05f-h	38.42g-i	46.24h-k	29.53h-k	30.80l-n	30.17i-k	83.59i-k	69.22k-m	76.40k
M ₄ L ₂	56.04f-h	40.52g-i	48.28g-k	31.41h-k	33.15k-m	32.28h-j	87.45i-k	73.67j-m	80.56jk
M ₄ L ₃	58.37f-h	41.97f-i	50.17f-j	34.01g-j	36.15j-l	35.08g-i	92.37g-j	78.12l-i	85.25h-k
M ₄ L ₄	46.21gh	32.53hi	39.37jk	24.34jk	25.75mn	25.05jk	70.55kl	58.28mn	64.4lm
M ₅ L ₁	61.95fg	45.41d-i	53.68e-i	34.91g-j	37.83i-l	36.37g-i	96.86f-j	83.24g-k	90.05g-j
M ₅ L ₂	63.90e-g	47.32c-h	55.61e-i	37.25g-i	41.03h-k	39.14f-h	101.15f-i	88.35f-j	94.75f-i
M ₅ L ₃	65.49ef	49.42c-g	57.45e-h	40.22gh	44.02g-j	42.12fg	105.71f-h	93.43e-i	99.57fg
M ₅ L ₄	52.83f-h	39.00g-i	45.92h-k	29.29i-k	32.31lm	30.80i-k	82.12j-l	71.31k-m	76.71k
M ₆ L ₁	64.01e-g	49.16c-g	56.59e-i	37.19g-i	42.12h-j	39.66f-h	101.20f-i	91.29f-i	96.24f-h
M ₆ L ₂	67.26ef	51.07c-g	59.17e-g	39.27g-i	45.10g-i	42.19fg	106.54fg	96.17e-g	101.35e-g
M ₆ L ₃	68.98ef	52.69c-g	60.83ef	42.47fg	48.55f-h	45.51f	111.44f	101.24ef	106.34ef
M ₆ L ₄	57.17f-h	43.34e-i	50.25f-j	31.46h-k	36.18j-l	33.82hi	88.63h-j	79.52h-l	84.07i-k
S.Em±	5.44	4.73	3.57	3.19	2.53	2.48	5.36	4.79	3.70

Means followed by the same alphabet do not differ significantly by DMRT (0.05)

Among the liquid organic manures, soil application of biodigester @ 2500 l ha⁻¹ at 30, 60 and 90 DAS (L₃) recorded significantly higher copper uptake by straw (50.31 g ha⁻¹). Significantly lower copper uptake by straw (36.38 g ha⁻¹) was recorded with control (L₄).

Integrated application of RDF + FYM + microbial consortium with soil application of biodigester @ 2500 l ha⁻¹ at 30, 60 and 90 DAS (M₂L₃) recorded significantly higher zinc uptake by grain (81.30 g ha⁻¹) but was at par with M₂L₂ (75.10 g ha⁻¹). Significantly lower copper uptake by straw (23.06 g ha⁻¹) was recorded with M₃L₄.

4.2.7.7.3 Total copper uptake by grain and straw (g ha⁻¹)

Among the manurial practices, application of RDF + FYM + microbial consortium (M₂) recorded significantly higher total copper uptake by grain and straw (158.54 g ha⁻¹) over rest of the treatments. Significantly lower total copper uptake by grain and straw (72.66 g ha⁻¹) was recorded with application of FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN (M₃).

Soil application of biodigester @ 2500 l ha⁻¹ at 30, 60 and 90 DAS (L₃) recorded significantly higher total copper uptake by grain and straw (114.97 g ha⁻¹). Significantly lower total copper uptake by grain and straw (88.98 g ha⁻¹) was recorded with control (L₄).

Among the treatment combinations, integrated application of RDF + FYM + microbial consortium with soil application of biodigester @ 2500 l ha⁻¹ at 30, 60 and 90 DAS (M₂L₃) recorded significantly higher total copper uptake by grain and straw (174.58 g ha⁻¹) but was at par with M₂L₂ (165.89 g ha⁻¹). Significantly lower copper uptake by grain and straw (59.64 g ha⁻¹) was recorded with M₃L₄.

4.2.8 Pests and disease study

4.2.8.1 Observation on major pests and diseases

4.2.8.1.1 Leaf folder incidence (%)

Leaf folder incidence as influenced by manurial practices and liquid organic manures and their interactions at 60 and 90 DAS is furnished in Table 59.

The data on leaf folder incidence significantly influenced by manurial practices and liquid organic manures at 60 and 90 DAS. Irrespective of liquid organic manures, significantly lower leaf folder incidence was recorded with application of FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN + FYM + microbial consortium at 60 and 90 DAS (1.14 and 1.38%) and was on par with application of FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN + FYM at 60 and 90 DAS (1.23 and 1.45%). Application of RDF (M₁) recorded significantly higher leaf folder incidence at 60 and 90 DAS over rest of the treatments (3.91 and 4.27%).

Among the liquid organic manures, foliar application of cow urine @ 500 l ha⁻¹ at 30, 60 and 90 DAS (L₂) recorded significantly lower leaf folder incidence at 60 and 90 DAS (1.35 and 1.59%). However, significantly higher leaf folder incidence was recorded with control (L₄) at 60 and 90 DAS (3.33 and 3.63%)

Application of FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN + FYM + microbial consortium with foliar application of cow urine @ 500 l ha⁻¹ at 30, 60 and 90 DAS (M₆L₂) recorded significantly lower leaf folder incidence at 60 and 90 DAS (0.68 and 0.88%). Significantly higher leaf folder incidence was recorded with integrated application of RDF + without liquid organic manure (M₁L₄) at 60 and 90 DAS (4.82 and 5.12%) but was at par with M₁L₃ (4.6 and 5.02%) and M₂L₄ (4.58 and 4.9%).

4.2.8.1.2 Dead heart incidence (%)

The data on dead heart incidence as influenced by manurial practices and liquid organic manures and their interactions at 60 DAS is furnished in Table 60.

Irrespective of liquid organic manures, significantly lower dead heart incidence was recorded with application of FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN + FYM + microbial consortium at 60 DAS (1.28%) and was on par with M₅ (1.35%), M₄ (1.45%) and M₃ (1.53%). Application of RDF (M₁) recorded significantly higher dead heart incidence at 60 DAS (3.42%).

Among the liquid organic manures, foliar application of cow urine @ 500 l ha⁻¹ at 30, 60 and 90 DAS (L₂) recorded significantly lower dead heart incidence at 60 DAS

Table 59: Effect of manurial practices and liquid organic manures on leaf folder incidence (%) at 60 and 90 DAS

Treatments	60 DAS			90 DAS		
	2013	2014	Pooled	2013	2014	Pooled
Manurial practices (M)						
M ₁ -RDF (100:50:50 kg N, P ₂ O ₅ , K ₂ O ha ⁻¹)	11.14 (3.79) a	11.5 (4.03) a	11.32 (3.91) a	11.69 (4.16) a	12 (4.38) a	11.84 (4.27) a
M ₂ -RDF+FYM+MC	9.73 (2.98) b	10.14 (3.21) b	9.94 (3.09) b	10.31 (3.31) b	10.5 (3.43b)	10.4 (3.37) b
M ₃ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN	7.94 (2.02) c	8.24 (2.17) c	8.09 (2.09) c	8.67 (2.38) c	8.73 (2.41) c	8.7 (2.39) c
M ₄ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN+MC	7.83 (1.96) c	8.09 (2.08) c	7.96 (2.02) c	8.53 (2.29) c	8.59 (2.33) c	8.56 (2.31) c
M ₅ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN+FYM	6.15 (1.18) d	6.46 (1.29) d	6.3 (1.23) d	6.94 (1.48) d	6.77 (1.42) d	6.86 (1.45) d
M ₆ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN+FYM+MC	5.88 (1.08) d	6.18 (1.19) d	6.03 (1.14) d	6.76 (1.42) d	6.55 (1.33) d	6.66 (1.38) d
S.Em±	0.13	0.11	0.12	0.15	0.15	0.15
Liquid organic manures (L)						
L ₁ -Jeevamrut @ 500 litres ha ⁻¹ at 30, 60 and 90 DAS	7.78 (1.93) c	8.06 (2.06) c	7.92 (1.99) c	8.46 (2.25) c	8.45 (2.27) c	8.46 (2.26) c
L ₂ -Cow urine @ 500 litres ha ⁻¹ at 30, 60 and 90 DAS	6.3 (1.28) d	6.66 (1.42) d	6.48 (1.35) d	7.09 (1.58) b	7.08 (1.6) d	7.08 (1.59) d
L ₃ -Bio digester @ 2500 litres ha ⁻¹ at 30, 60 and 90 DAS	8.26 (2.23) b	8.58 (2.39) b	8.42 (2.31) b	8.99 (2.59) d	9.07 (2.66) b	9.03 (2.62) b
L ₄ -Control (no liquid manure application)	10.1 (3.23) a	10.44 (3.44) a	10.27 (3.33) a	10.73 (3.6) a	10.81 (3.67) a	10.77 (3.63) a
S.Em±	0.14	0.14	0.14	0.13	0.13	0.13
Interactions- (M X L)						
M ₁ L ₁	10.82 (3.53) b	11.08 (3.7) b	10.95 (3.62) b	11.38 (3.9) b	11.67 (4.1) b	11.52 (4) b
M ₁ L ₂	9.08 (2.5) c	9.51 (2.73) c	9.29 (2.62) c	9.68 (2.83) c	10.02 (3.03) c	9.85 (2.93c)
M ₁ L ₃	12.28 (4.53a)	12.47 (4.67) a	12.37 (4.6) a	12.78 (4.9) a	13.08 (5.13) a	12.93 (5.02a)
M ₁ L ₄	12.37 (4.6) a	12.95 (5.03) a	12.66 (4.82) a	12.91 (5) a	13.21 (5.23) a	13.06 (5.12) a
M ₂ L ₁	9.14 (2.53) c	9.56 (2.77) c	9.35 (2.65) c	9.74 (2.87c)	9.91 (2.97) c	9.82 (2.92) c
M ₂ L ₂	6.93 (1.47) de	7.47 (1.7) d	7.2 (1.58) d	7.62 (1.77) d-f	7.83 (1.87) d-f	7.72 (1.82) d-f
M ₂ L ₃	10.66 (3.43) b	11.03 (3.67b)	10.85 (3.55b)	11.18 (3.77) b	11.38 (3.9) b	11.28 (3.83) b
M ₂ L ₄	12.19 (4.47) a	12.51 (4.7) a	12.35 (4.58) a	12.69 (4.83) a	12.87 (4.97) a	12.78 (4.9) a
M ₃ L ₁	7.31 (1.63) d	7.54 (1.73) d	7.42 (1.68) d	8.03 (1.97) de	8.03 (1.97) de	8.03 (1.97) de
M ₃ L ₂	6.18 (1.17) de	6.45 (1.27) de	6.31 (1.22) de	6.94 (1.47) ef	6.94 (1.47) e-h	6.94 (1.47) e-g
M ₃ L ₃	7.17 (1.57) d	7.54 (1.73) d	7.35 (1.65) d	8.1 (2) d	8.23 (2.07) d	8.17 (2.03) d
M ₃ L ₄	11.08 (3.7) b	11.43 (3.93) b	11.25 (3.82) b	11.62 (4b.07)	11.72 (4.13) b	11.67 (4.1) b
M ₄ L ₁	7.23 (1.6) d	7.46 (1.7) d	7.35 (1.65) d	7.97 (1.9de3)	7.97 (1.93) d-f	7.97 (1.93) de
M ₄ L ₂	6.18 (1.17) de	6.45 (1.27) de	6.31 (1.22) de	6.94 (1.47) ef	6.94 (1.47) e-h	6.94 (1.47) e-g
M ₄ L ₃	7.08 (1.53) d	7.46 (1.7) d	7.27 (1.62) d	7.82 (1.87) de	7.96 (1.93) d-f	7.89 (1.9) d-f
M ₄ L ₄	10.82 (3.53) b	10.98 (3.63b)	10.9 (3.58) b	11.38 (3.9) b	11.48 (3.97) b	11.43 (3.93) b
M ₅ L ₁	6.35 (1.23) de	6.61 (1.33) de	6.48 (1.28) de	6.94 (1.47) ef	6.7 (1.37) gh	6.82 (1.42) fg
M ₅ L ₂	4.89 (0.73) fg	5.22 (0.83) fg	5.06 (0.78) fg	5.82 (1.03) gh	5.53 (0.93) ij	5.68 (0.98) hi
M ₅ L ₃	6.18 (1.17) de	6.54 (1.3) de	6.36 (1.23) de	7.02 (1.5) d-f	6.95 (1.47) e-h	6.99 (1.48) e-g
M ₅ L ₄	7.17 (1.57) d	7.46 (1.7) d	7.31 (1.63) d	7.98 (1.93) de	7.9 (1.9) d-f	7.94 (1.92) d-f
M ₆ L ₁	5.81 (1.03) ef	6.09 (1.13) ef	5.95 (1.08) ef	6.69 (1.37) fg	6.44 (1.27) hi	6.57 (1.32) gh
M ₆ L ₂	4.54 (0.63) g	4.89 (0.73) g	4.72 (0.68) g	5.53 (0.93) h	5.22 (0.83) j	5.38 (0.88) i
M ₆ L ₃	6.17 (1.17) de	6.44 (1.27) de	6.31 (1.22) de	7.01 (1.5) d-f	6.85 (1.43) f-h	6.93 (1.47) e-g
M ₆ L ₄	6.99 (1.5) de	7.31 (1.63) d	7.15 (1.57) d	7.82 (1.87) de	7.68 (1.8) d-g	7.75 (1.83) d-f
S.Em±	0.36	0.34	0.35	0.33	0.33	0.33

Means followed by the same alphabet do not differ significantly by DMRT (0.05) ; () Figures in parentheses are original values.

Table 60: Effect of manurial practices and liquid organic manures on dead heart (%) at 60 DAS and white ear head (%) at 90 DAS and Harvest

Treatments	60 DAS			90 DAS			Harvest		
	2013	2014	Pooled	2013	2014	Pooled	2013	2014	Pooled
Manurial practices (M)									
M ₁ -RDF (100:50:50 kg N, P ₂ O ₅ , K ₂ O ha ⁻¹)	10.11 (3.16) a	10.95 (3.68) a	10.53 (3.42) a	8.28 (2.19) a	9.12 (2.61) a	8.7 (2.4) a	9.03 (2.56) a	9.79 (2.98) a	9.41 (2.77) a
M ₂ -RDF+FYM+MC	8.41 (2.31) b	9.06 (2.63) b	8.73 (2.47) b	6.78 (1.66) b	7.67 (1.98) b	7.22 (1.8b2)	7.55 (1.93) b	8.29 (2.24) b	7.92 (2.08) b
M ₃ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN	6.68 (1.43) c	7.22 (1.64) c	6.95 (1.53) c	5.18 (0.88) c	5.85 (1.09) c	5.52 (0.99c)	5.83 (1.13) c	6.46 (1.34) c	6.14 (1.23) c
M ₄ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN+MC	6.50 (1.34) c	7.04 (1.56) cd	6.77 (1.45) c	4.85 (0.8) c	5.71 (1.06) cd	5.28 (0.93) c	5.62 (1.04) cd	6.27 (1.26) c	5.94 (1.15) cd
M ₅ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN+FYM	6.44 (1.28) c	6.76 (1.41) cd	6.6 (1.35) c	5.05 (0.82) c	5.43 (0.93) cd	5.24 (0.88) c	5.27 (0.88) cd	5.63 (1) d	5.45 (0.94) de
M ₆ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN+FYM+MC	6.24 (1.22) c	6.57 (1.34) d	6.4 (1.28) c	4.78 (0.75) c	5.19 (0.87) d	4.99 (0.81) c	5.01 (0.82) d	5.4 (0.93) d	5.2 (0.88) e
S.Em±	0.18	0.16	0.17	0.18	0.16	0.16	0.18	0.16	0.17
Liquid organic manures (L)									
L ₁ -Jeevamrut @ 500 litres ha ⁻¹ at 30, 60 and 90 DAS	7.16 (1.62) c	7.66 (1.85) c	7.41 (1.73) c	5.69 (1.03) c	6.3 (1.26) c	6 (1.15) c	6.16 (1.22) c	6.7 (1.43) c	6.43 (1.33) c
L ₂ -Cow urine @ 500 litres ha ⁻¹ at 30, 60and 90 DAS	5.47 (0.95) d	6.12 (1.19) d	5.8 (1.07) d	3.36 (0.38) d	4.29 (0.59) d	3.82 (0.49) d	4.13 (0.56) d	4.9 (0.78) d	4.52 (0.67) d
L ₃ -Bio digester @ 2500 litres ha ⁻¹ at 30, 60 and 90 DAS	7.77 (1.96) b	8.31 (2.23) b	8.04 (2.09) b	6.41 (1.37) b	7.01 (1.62) b	6.71 (1.49) b	6.83 (1.56) b	7.42 (1.81) b	7.12 (1.68) b
L ₄ -Control (no liquid manure application)	9.18 (2.63) a	9.63 (2.9) a	9.41 (2.77) a	7.83 (1.95) a	8.38 (2.22) a	8.1 (2.08) a	8.41 (2.23) a	8.87 (2.48) a	8.64 (2.36) a
S.Em±	0.16	0.15	0.15	0.17	0.12	0.14	0.19	0.16	0.17
Interactions- (M X L)									
M ₁ L ₁	9.79 (2.9) b	10.61 (3.4) b	10.2 (3.15) b	7.97 (1.93) bc	8.77 (2.33) bc	8.37 (2.13) bc	8.7 (2.3) b	9.44 (2.7) b	9.07 (2.5) b
M ₁ L ₂	7.76 (1.83) d-f	8.77 (2.33) d-f	8.27 (2.08) de	5.3 (0.87) e-g	6.44 (1.27) f-i	5.87 (1.07) e-g	6.34 (1.23e-g)	7.32 (1.63) d-f	6.83 (1.43) d-f
M ₁ L ₃	11.38 (3.9) a	12.15 (4.43) a	11.76 (4.17) a	9.85 (2.93) a	10.56 (3.37) a	10.21 (3.15) a	10.45 (3.3) a	11.13 (3.73) a	10.79 (3.52) a
M ₁ L ₄	11.52 (4) a	12.28 (4.53) a	11.9 (4.27) a	10.02 (3.03) a	10.72 (3.47) a	10.37 (3.25) a	10.61 (3.4) a	11.28 (3.83) a	10.95 (3.62) a
M ₂ L ₁	7.83 (1.87de)	8.45 (2.17) d-f	8.14 (2.02) de	6.26 (1.2) d-f	7.01 (1.5) d-f	6.64 (1.35) de	6.93 (1.47) c-e	7.62 (1.77) c-e	7.27 (1.62) c-e
M ₂ L ₂	4.96 (0.77) j	5.89 (1.07) h-j	5.42 (0.92) h-j	2.31 (0.17) i	3.91 (0.47) k	3.11 (0.32) h	3.77 (0.43) ij	4.91 (0.73) i-l	4.34 (0.58) h-k
M ₂ L ₃	9.56 (2.77) bc	10.13 (3.1) bc	9.84 (2.93) bc	8.31 (2.1) b	8.96 (2.43) b	8.64 (2.27) b	8.83 (2.37) b	9.44 (2.7) b	9.14 (2.53) b
M ₂ L ₄	11.28 (3.83) a	11.77 (4.17) a	11.53 (4) a	10.24 (3.17a)	10.77 (3.5) a	10.51 (3.33) a	10.67 (3.43) a	11.18 (3.77) a	10.93 (3.6) a
M ₃ L ₁	6.41 (1.27) g-i	6.91 (1.47) gh	6.66 (1.37f-h)	5.17 (0.83) e-g	5.79 (1.03) g-j	5.48 (0.93) e-g	5.56 (0.97) e-g	6.14 (1.17) f-i	5.85 (1.07) e-g
M ₃ L ₂	4.99 (0.77) j	5.62 (0.97) ij	5.31 (0.87) ij	3.25 (0.33) i	4.16 (0.53) k	3.7 (0.43) h	3.85 (0.47) h-j	4.65 (0.67) j-l	4.25 (0.57) i-k
M ₃ L ₃	6.49 (1.3) f-i	7.08 (1.53) gh	6.79 (1.42) fg	5.29 (0.87) e-g	5.98 (1.1) g-j	5.63 (0.98) e-g	5.66 (1) e-g	6.33 (1.23) e-h	5.99 (1.12) e-g
M ₃ L ₄	8.83 (2.37) b-d	9.27 (2.6) cd	9.05 (2.48) b-d	7.02 (1.5) cd	7.47 (1.7) de	7.25 (1.6) d	8.24 (2.07) bc	8.71 (2.3) bc	8.47 (2.18) bc
M ₄ L ₁	6.34 (1.23) g-j	6.85 (1.43) gh	6.59 (1.33) f-h	4.86 (0.73) fg	5.71 (1) h-j	5.28 (0.87) fg	5.49 (0.93) e-g	6.07 (1.13) f-i	5.78 (1.03) f-h
M ₄ L ₂	4.99 (0.77) j	5.62 (0.97) ij	5.31 (0.87) ij	2.92 (0.27) i	3.9 (0.47) k	3.41 (0.37) h	3.85 (0.47) h-j	4.65 (0.67) j-l	4.25 (0.57) i-k
M ₄ L ₃	6.14 (1.17) h-j	6.75 (1.4) g-i	6.44 (1.28) f-i	4.6 (0.67) gh	5.31 (0.87) j	4.96 (0.77) g	5.24 (0.87) f-i	5.97 (1.1) g-j	5.6 (0.98) f-i
M ₄ L ₄	8.52 (2.2) c-e	8.96 (2.43) de	8.74 (2.32) c-e	7.02 (1.53) cd	7.92 (1.9) cd	7.47 (1.72) cd	7.91 (1.9) b-d	8.38 (2.13) b-d	8.14 (2.02) b-d
M ₅ L ₁	6.45 (1.27) f-i	6.7 (1.37) g-i	6.57 (1.32) f-h	5.11 (0.8) e-g	5.43 (0.9) ij	5.27 (0.85) fg	5.31 (0.87) f-h	5.62 (0.97) g-j	5.47 (0.92) f-i
M ₅ L ₂	5.22 (0.83) ij	5.62 (0.97) ij	5.42 (0.9) h-j	3.44 (0.37) hi	3.9 (0.47) k	3.67 (0.42) h	3.73 (0.43) ij	4.16 (0.53) kl	3.95 (0.48) jk
M ₅ L ₃	6.53 (1.3) f-i	6.87 (1.43) gh	6.7 (1.37) fg	5.21 (0.83) e-g	5.63 (0.97) h-j	5.42 (0.9) fg	5.42 (0.9) e-g	5.81 (1.03) g-j	5.62 (0.97) f-i
M ₅ L ₄	7.55 (1.73) d-g	7.83 (1.87) e-g	7.69 (1.8) ef	6.45 (1.27) de	6.77 (1.4) e-g	6.61 (1.33) de	6.61 (1.33) d-f	6.94 (1.47) e-g	6.78 (1.4) d-f
M ₆ L ₁	6.18 (1.17) h-j	6.44 (1.27) hi	6.31 (1.22) g-j	4.77 (0.7) g	5.11 (0.8) j	4.94 (0.75) g	4.98 (0.77) g-i	5.3 (0.87) h-k	5.14 (0.82) g-j
M ₆ L ₂	4.89 (0.73) j	5.22 (0.83) j	5.06 (0.78) j	2.92 (0.27) i	3.44 (0.37) k	3.18 (0.32) h	3.25 (0.33) j	3.73 (0.43) l	3.49 (0.38) k
M ₆ L ₃	6.52 (1.3) f-i	6.92 (1.47) gh	6.72 (1.38) fg	5.21 (0.83) e-g	5.63 (0.97) h-j	5.42 (0.9) fg	5.4 (0.9) e-g	5.81 (1.03) g-j	5.6 (0.97) f-i
M ₆ L ₄	7.37 (1.67) e-h	7.68 (1.8) fg	7.53 (1.73) e-g	6.24 (1.2) d-f	6.6 (1.33) e-h	6.42 (1.27) d-f	6.4 (1.27) e-g	6.75 (1.4) e-g	6.57 (1.33) e-g
S.Em±	0.4	0.36	0.38	0.42	0.31	0.36	0.43	0.36	0.43

Means followed by the same alphabet do not differ significantly by DMRT (0.05) ; () Figures in parentheses are original values: The figures outside the parenthesis are arcsine transformed values

(1.07%). However, significantly higher dead heart incidence was recorded with control (L_4) at 60 DAS (2.77%)

Integrated application of FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN + FYM + microbial consortium with foliar application of cow urine @ 500 l ha⁻¹ at 30, 60 and 90 DAS (M_6L_2) recorded significantly lower dead heart incidence at 60 DAS (0.78%). Significantly higher dead heart incidence was recorded with integrated application of RDF + without liquid organic manure (M_1L_4) at 60 DAS (4.27%) but was at par with but was at par with M_1L_3 (4.17%) and M_2L_4 (4.00%).

4.2.8.1.3 White ear head incidence (%)

White ear incidence as influenced by manurial practices and liquid organic manures and their interactions at 90 DAS and at harvest is presented in Table 60.

Significantly lower white ear incidence was recorded with application of FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN + FYM + microbial consortium at 90 DAS and at harvest (0.81 and 0.88%) and was on par with M_5 (0.88%), M_4 (0.93%) and M_3 (0.99%) at 90 DAS and with M_5 (0.94%) at harvest. Application of RDF (M_1) recorded significantly higher white ear incidence at 90 DAS and at harvest (2.4 and 2.77%).

Among the liquid organic manures, foliar application of cow urine @ 500 l ha⁻¹ at 30, 60 and 90 DAS (L_2) recorded significantly lower white ear incidence at 90 DAS and at harvest (0.49 and 0.67%). However, significantly higher white ear incidence was recorded with control (L_4) at 90 DAS and at harvest (2.08 and 2.36%)

Integrated application of FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN + FYM + microbial consortium with foliar application of cow urine @ 500 l ha⁻¹ at 30, 60 and 90 DAS (M_6L_2) recorded significantly lower white ear incidence at 90 DAS and at harvest (0.32 and 0.38%). Significantly higher white ear incidence was recorded with integrated application of RDF + without liquid organic manure (M_1L_4) at 90 DAS and at harvest (3.25 and 3.65%) but was at par with but was at par with M_1L_3 (3.15 and 3.52%) and M_2L_4 (3.33 and 3.6%).

4.2.8.1.4 Leaf blast incidence (%)

The data on leaf blast incidence as influenced by manurial practices and liquid organic manures and their interactions at 30 and 60 DAS is presented in Table 61.

Irrespective of liquid organic manures, significantly lower leaf blast incidence was recorded with application of FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN + FYM + microbial consortium at 30 and 60 DAS (0.78 and 1.66%) and was on par with M₅ (0.84 and 1.73%). Application of RDF (M₁) recorded significantly higher leaf blast incidence at 30 and 60 DAS (2.47 and 3.65%).

Among the liquid organic manures, foliar application of cow urine @ 500 l ha⁻¹ at 30, 60 and 90 DAS (L₂) recorded significantly lower leaf blast incidence at 30 and 60 DAS (0.64 and 1.5%). However, significantly higher leaf blast incidence was recorded with control (L₄) at 30 and 60 DAS (2.33 and 3.19%)

Among the treatment combinations, application of FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN + FYM + microbial consortium with foliar application of cow urine @ 500 l ha⁻¹ at 30, 60 and 90 DAS (M₆L₂) recorded significantly lower leaf blast incidence at 30 and 60 DAS (0.28 and 1.17%). Significantly higher leaf blast incidence was recorded with M₂L₄ at 30 DAS (3.40%) and with M₁L₄ at 60 DAS (4.50%).

4.2.8.1.5 Neck blast incidence (%)

Neck blast incidence as influenced by manurial practices and liquid organic manures and their interactions at 90 DAS and at harvest is furnished in Table 62.

The data on neck blast incidence significantly influenced by manurial practices and liquid organic manures at 90 DAS and at harvest. Significantly lower neck blast incidence was recorded with application of FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN + FYM + microbial consortium at 90 DAS and at harvest (0.9 and 0.78%) and was on par with M₅ (0.97 and 0.84%). Application of RDF (M₁) recorded significantly higher neck blast incidence at 90 DAS and at harvest (1.83 and 1.58%).

Table 61: Effect of manurial practices and liquid organic manures on leaf blast incidence (%) at 30 and 60 DAS

Treatments	30 DAS			60 DAS		
	2013	2014	Pooled	2013	2014	Pooled
Manurial practices (M)						
M ₁ -RDF (100:50:50 kg N, P ₂ O ₅ , K ₂ O ha ⁻¹)	8.42 (2.26) a	9.24 (2.68) a	8.83 (2.47) a	10.5 (3.39) a	11.31 (3.91) a	10.91 (3.65) a
M ₂ -RDF+FYM+MC	6.99 (1.73) b	7.83 (2.04) b	7.41 (1.88) b	8.55 (2.36) b	9.37 (2.78) b	8.96 (2.57) b
M ₃ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN	6.68 (1.43) bc	7.22 (1.64) c	6.95 (1.53) bc	8.36 (2.16) bc	8.97 (2.48) c	8.67 (2.32) bc
M ₄ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN+MC	6.22 (1.24) c	6.8 (1.46) c	6.51 (1.35) c	7.99 (1.98) c	8.63 (2.29) c	8.31 (2.13) c
M ₅ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN+FYM	4.93 (0.78) d	5.32 (0.9) d	5.12 (0.84) d	7.25 (1.62) d	7.74 (1.83) d	7.5 (1.73) d
M ₆ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN+FYM+MC	4.62 (0.72) d	5.06 (0.83) d	4.84 (0.78) d	7.09 (1.55) d	7.59 (1.77) d	7.34 (1.66) d
S.Em±	0.18	0.15	0.17	0.13	0.12	0.13
Liquid organic manures (L)						
L ₁ -Jeevamrut @ 500 litres ha ⁻¹ at 30, 60 and 90 DAS	6.1 (1.18) c	6.64 (1.4) c	6.37 (1.29) c	8.05 (2) c	8.67 (2.32) c	8.36 (2.16) c
L ₂ -Cow urine @ 500 litres ha ⁻¹ at 30, 60 and 90 DAS	3.97 (0.53) d	4.78 (0.74) d	4.37 (0.64) d	6.58 (1.34) d	7.33 (1.66) d	6.95 (1.5) d
L ₃ -Bio digester @ 2500 litres ha ⁻¹ at 30, 60 and 90 DAS	6.82 (1.52) b	7.39 (1.77) b	7.11 (1.65) b	8.64 (2.34) b	9.29 (2.69) b	8.96 (2.51) b
L ₄ -Control (no liquid manure application)	8.35 (2.2) a	8.82 (2.45) a	8.59 (2.33) a	9.89 (3.02) a	10.46 (3.37) a	10.18 (3.19) a
S.Em±	0.19	0.16	0.17	0.13	0.11	0.12
Interactions- (M X L)						
M ₁ L ₁	8.1 (2) c	8.89 (2.4) b	8.5 (2.2) b	10.18 (3.13) b	10.98 (3.63) b	10.58 (3.38) b
M ₁ L ₂	5.49 (0.93) d	6.6 (1.33) c-f	6.04 (1.13c-g)	8.25 (2.07) c	9.21 (2.57) c	8.73 (2.32) c
M ₁ L ₃	9.96 (3) ab	10.67 (3.43) a	10.31 (3.22) a	11.72 (4.13) a	12.47 (4.67) a	12.09 (4.4) a
M ₁ L ₄	10.13 (3.1ab)	10.82 (3.53) a	10.47 (3.32) a	11.86 (4.23) a	12.6 (4.77) a	12.23 (4.5) a
M ₂ L ₁	6.43 (1.27) d	7.17 (1.57) c	6.8 (1.42) c	7.91 (1.9) cd	8.71 (2.3) cd	8.31 (2.1) c-e
M ₂ L ₂	2.75 (0.23) g	4.18 (0.53) hi	3.47 (0.38) h	5.33 (0.87) h	6.46 (1.27) h	5.89 (1.07) h
M ₂ L ₃	8.44 (2.17) c	9.08 (2.5) b	8.76 (2.33) b	9.62 (2.8) b	10.35 (3.23) b	9.98 (3.02) b
M ₂ L ₄	10.35 (3.23) a	10.88 (3.57a)	10.62 (3.4) a	11.33 (3.87) a	11.96 (4.7) a	11.65 (4.08) a
M ₃ L ₁	6.41 (1.27) d	6.91 (1.47) cd	6.66 (1.37) cd	8.11 (2) cd	8.7 (2.3) cd	8.4 (2.15) cd
M ₃ L ₂	4.99 (0.77) de	5.62 (0.97) d-g	5.31 (0.87) d-g	7.01 (1.5) d-f	7.69 (1.8) ef	7.35 (1.65) e-g
M ₃ L ₃	6.49 (1.3) d	7.08 (1.53) c	6.79 (1.42) c	8.17 (2.03) c	8.83 (2.37) c	8.5 (2.2) cd
M ₃ L ₄	8.83 (2.37) bc	9.27 (2.6) b	9.05 (2.48) b	10.13 (3.1) b	10.67 (3.43) b	10.4 (3.27) b
M ₄ L ₁	6.07 (1.13) de	6.6 (1.33) c-f	6.33 (1.23) c-f	7.82 (1.87) c-e	8.44 (2.17) c-e	8.13 (2.02) c-f
M ₄ L ₂	4.65 (0.67) ef	5.31 (0.87) f-h	4.98 (0.77) fg	6.78 (1.4) e-g	7.48 (1.7) fg	7.13 (1.55) fg
M ₄ L ₃	5.86 (1.07) de	6.5 (1.3) c-f	6.18 (1.18) c-g	7.68 (1.8) c-e	8.38 (2.13) c-f	8.03 (1.97) c-f
M ₄ L ₄	8.32 (2.1) c	8.77 (2.33) b	8.55 (2.22) b	9.68 (2.83) b	10.24 (3.17) b	9.96 (3) b
M ₅ L ₁	4.99 (0.77) de	5.31 (0.87) f-h	5.15 (0.82) e-g	7.25 (1.6) c-e	7.69 (1.8) ef	7.47 (1.7) d-f
M ₅ L ₂	3.25 (0.33) fg	3.73 (0.43) i	3.49 (0.38) h	6.18 (1.17) f-h	6.7 (1.37) gh	6.44 (1.27) gh
M ₅ L ₃	5.11 (0.8) de	5.52 (0.93) e-g	5.31 (0.87) d-g	7.33 (1.63) c-e	7.85 (1.87) d-f	7.59 (1.75) d-f
M ₅ L ₄	6.36 (1.23) d	6.7 (1.37) c-e	6.53 (1.3) c-e	8.26 (2.07) c	8.71 (2.3) cd	8.48 (2.18) cd
M ₆ L ₁	4.63 (0.67) ef	4.98 (0.77) gh	4.8 (0.72) g	7.01 (1.5) d-f	7.47 (1.7) fg	7.24 (1.6) fg
M ₆ L ₂	2.67 (0.23) g	3.25 (0.33) i	2.96 (0.28) h	5.91 (1.07) gh	6.45 (1.27) h	6.18 (1.17) h
M ₆ L ₃	5.08 (0.8) de	5.52 (0.93) e-g	5.3 (0.87) d-g	7.33 (1.63) c-e	7.85 (1.87) d-f	7.59 (1.75) d-f
M ₆ L ₄	6.12 (1.17) de	6.5 (1.3) c-f	6.31 (1.23) c-f	8.1 (2) cd	8.58 (2.23) c-e	8.34 (2.12) c-e
S.Em±	0.46	0.4	0.43	0.33	0.28	0.31

Means followed by the same alphabet do not differ significantly by DMRT (0.05) ; () Figures in parentheses are original values.

Table 62: Effect of manurial practices and liquid organic manures on neck blast incidence (%) and 90 DAS and harvest

Treatments	90 DAS			Harvest		
	2013	2014	Pooled	2013	2014	Pooled
Manurial practices (M)						
M ₁ -RDF (100:50:50 kg N, P ₂ O ₅ , K ₂ O ha ⁻¹)	7.3 (1.78) a	7.58 (1.89) a	7.44 (1.83) a	6.53 (1.48) a	7.04 (1.68) a	6.78 (1.58) a
M ₂ -RDF+FYM+MC	6.56 (1.52) b	7.09 (1.76) b	6.82 (1.64) b	5.79 (1.25) b	6.54 (1.52) a	6.16 (1.38) b
M ₃ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN	6.19 (1.24) bc	6.77 (1.46) b	6.48 (1.35) bc	5.14 (0.93) c	5.88 (1.14) b	5.51 (1.03) c
M ₄ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN+MC	5.72 (1.07) cd	6.34 (1.28) c	6.03 (1.18) c	4.91 (0.84) c	5.67 (1.06) b	5.29 (0.95) cd
M ₅ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN+FYM	5.36 (0.91) de	5.72 (1.03) d	5.54 (0.97) d	4.93 (0.78) c	5.32 (0.9) bc	5.12 (0.84) cd
M ₆ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN+FYM+MC	5.12 (0.84) e	5.5 (0.96) d	5.31 (0.9) d	4.62 (0.72) c	5.06 (0.83) c	4.84 (0.78) d
S.Em±	0.16	0.13	0.14	0.2	0.18	0.19
Liquid organic manures (L)						
L ₁ -Jeevamrut @ 500 litres ha ⁻¹ at 30, 60 and 90 DAS	5.79 (1.04) c	6.25 (1.21) c	6.02 (1.12) c	5.03 (0.8) c	5.61 (0.98) c	5.32 (0.89) c
L ₂ -Cow urine @ 500 litres ha ⁻¹ at 30, 60 and 90 DAS	3.71 (0.44) d	4.19 (0.56) d	3.95 (0.5) d	2.71 (0.24) d	3.46 (0.38) d	3.08 (0.31) d
L ₃ -Bio digester @ 2500 litres ha ⁻¹ at 30, 60 and 90 DAS	6.55 (1.37) b	7.05 (1.57) b	6.8 (1.47) b	5.9 (1.14) b	6.51 (1.36) b	6.2 (1.25) b
L ₄ -Control (no liquid manure application)	8.12 (2.05) a	8.51 (2.25) a	8.31 (2.15) a	7.64 (1.82) a	8.09 (2.03) a	7.86 (1.93) a
S.Em±	0.17	0.15	0.15	0.22	0.19	0.21
Interactions- (M X L)						
M ₁ L ₁	7.09 (1.53) d-f	7.32 (1.63) c	7.2 (1.58) cd	6.24 (1.2) cd	6.75 (1.4) cd	6.49 (1.3) c-e
M ₁ L ₂	3.69 (0.43) lm	4.13 (0.53) ij	3.91 (0.48) jk	2.67 (0.23) f	3.29 (0.37) g	2.98 (0.3) h
M ₁ L ₃	9.14 (2.53) a-c	9.38 (2.67) ab	9.26 (2.6) ab	8.51 (2.2) ab	8.96 (2.43) ab	8.73 (2.32) ab
M ₁ L ₄	9.27 (2.6) ab	9.5 (2.73) ab	9.38 (2.67) ab	8.7 (2.3) ab	9.14 (2.53) ab	8.92 (2.42) ab
M ₂ L ₁	5.62 (0.97) g-i	6.45 (1.27) c-e	6.03 (1.12) d-f	4.6 (0.67) de	5.59 (0.97) de	5.1 (0.82) e
M ₂ L ₂	2.86 (0.27) m	2.95 (0.27) k	2.9 (0.27) k	2.06 (0.13) f	2.75 (0.23) g	2.41 (0.18) h
M ₂ L ₃	7.84 (1.87) c-e	8.51 (2.2) b	8.18 (2.03) bc	7.16 (1.57) bc	7.9 (1.9) bc	7.53 (1.73) b-d
M ₂ L ₄	9.91 (2.97) a	10.46 (3.3) a	10.18 (3.13) a	9.33 (2.63) a	9.91 (2.97) a	9.62 (2.8) a
M ₃ L ₁	5.89 (1.07) f-h	6.43 (1.27) c-e	6.16 (1.17) d-f	4.9 (0.77) de	5.56 (0.97) de	5.23 (0.87) e
M ₃ L ₂	4.37 (0.6) i-l	5.09 (0.8) f-i	4.73 (0.7) g-j	2.81 (0.27) f	3.85 (0.47) fg	3.33 (0.37) gh
M ₃ L ₃	5.98 (1.1) f-h	6.6 (1.33) c-e	6.29 (1.22) d-f	5.01 (0.8) de	5.78 (1.03) de	5.39 (0.92) e
M ₃ L ₄	8.51 (2.2) bc	8.96 (2.43) b	8.74 (2.32) b	7.83 (1.87) a-c	8.31 (2.1) b	8.07 (1.98) a-c
M ₄ L ₁	5.6 (0.97) g-i	6.17 (1.17) c-f	5.88 (1.07) e-g	4.84 (0.73) de	5.49 (0.93) de	5.16 (0.83) e
M ₄ L ₂	4.02 (0.5) j-m	4.77 (0.7) g-j	4.39 (0.6) h-j	2.81 (0.27) f	3.85 (0.47) fg	3.33 (0.37) gh
M ₄ L ₃	5.29 (0.87) g-j	5.98 (1.1) d-g	5.63 (0.98) e-h	4.53 (0.67) de	5.37 (0.9) de	4.95 (0.78) ef
M ₄ L ₄	7.98 (1.93) b-d	8.45 (2.17) b	8.21 (2.05) bc	7.47 (1.7) bc	7.98 (1.93) bc	7.73 (1.82) b-d
M ₅ L ₁	5.42 (0.9) g-i	5.72 (1) d-g	5.57 (0.95) e-h	4.99 (0.77) de	5.31 (0.87) de	5.15 (0.82) e
M ₅ L ₂	3.88 (0.47) k-m	4.29 (0.57) h-j	4.08 (0.52) i-k	3.25 (0.33) ef	3.73 (0.43) fg	3.49 (0.38) f-h
M ₅ L ₃	5.52 (0.93) g-i	5.92 (1.07) d-g	5.72 (1) e-g	5.11 (0.8) de	5.53 (0.93) de	5.32 (0.87) e
M ₅ L ₄	6.61 (1.33) e-g	6.94 (1.47) cd	6.78 (1.4) de	6.36 (1.23) cd	6.7 (1.37) cd	6.53 (1.3) c-e
M ₆ L ₁	5.11 (0.8) h-k	5.42 (0.9) e-h	5.27 (0.85) f-i	4.63 (0.67) de	4.98 (0.77) ef	4.8 (0.72) e-g
M ₆ L ₂	3.44 (0.37) lm	3.9 (0.47) jk	3.67 (0.42) jk	2.67 (0.23) f	3.25 (0.33) g	2.96 (0.28) h
M ₆ L ₃	5.52 (0.93) g-i	5.92 (1.07) d-g	5.72 (1) e-g	5.08 (0.8) de	5.52 (0.93) de	5.3 (0.87) e
M ₆ L ₄	6.42 (1.27) f-h	6.77 (1.4) cd	6.59 (1.33) de	6.12 (1.17) cd	6.5 (1.3) c-e	6.31 (1.23) de
S.Em±	0.42	0.36	0.39	0.56	0.47	0.51

Means followed by the same alphabet do not differ significantly by DMRT (0.05) ; () Figures in parentheses are original value

Foliar application of cow urine @ 500 l ha⁻¹ at 30, 60 and 90 DAS (L₂) recorded significantly lower neck blast incidence at 90 DAS and at harvest (0.5 and 0.31%). However, significantly higher neck blast incidence was recorded with control (L₄) 90 DAS and at harvest (2.15 and 1.93%)

Among the treatment combinations, application of FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN + FYM + microbial consortium with foliar application of cow urine @ 500 l ha⁻¹ at 30, 60 and 90 DAS (M₆L₂) recorded significantly lower neck blast incidence at 90 DAS and at harvest (0.42 and 0.28%). Significantly higher neck blast incidence was recorded with M₂L₄ at 90 DAS and at harvest (3.13 and 2.8%) and was on par with M₁L₄ (2.67 and 2.42%) and M₁L₃ (2.6 and 2.32%).

4.2.8.2 Observation on natural enemies

4.2.8.2.1 Spider population (per m²)

The occurrence of spider population as influenced by manurial practices and liquid organic manures and their interactions at 60 and 90 DAS is furnished in Table 63.

Irrespective of liquid organic manures, significantly higher spider population was recorded with application of FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN + FYM + microbial consortium at 60 and 90 DAS (5.08 and 6.67) and was on par with M₅ (4.67 and 6.33). Application of RDF (M₁) recorded significantly lower spider population at 60 and 90 DAS (2.5 and 3.42).

Among the liquid organic manures, foliar application of cow urine @ 500 l ha⁻¹ at 30, 60 and 90 DAS (L₂) recorded significantly higher spider population at 60 and 90 DAS (4.5 and 6.72). However, significantly lower spider population was recorded with control (L₄) at 60 and 90 DAS (3.06 and 3.83).

Integrated application of FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN + FYM + microbial consortium with foliar application of cow urine @ 500 l ha⁻¹ at 30, 60 and 90 DAS (M₆L₂) recorded significantly higher spider population at 60 and 90 DAS (5.83 and 7.83). Significantly lower spider population was recorded with M₁L₁ at 60 and 90 DAS (1.67 and 2).

Table 63: Effect of manurial practices and liquid organic manures on spider population (per m²) at 60 and 90 DAS

Treatments	60DAS			90DAS		
	2013	2014	Pooled	2013	2014	Pooled
Manurial practices (M)						
M ₁ -RDF (100:50:50 kg N, P ₂ O ₅ , K ₂ O ha ⁻¹)	1.61 (2.17) e	1.81 (2.83) d	1.71 (2.5) d	1.87 (3.08) e	2.04 (3.75) c	1.95 (3.42) d
M ₂ -RDF+FYM+MC	1.74 (2.58) d	1.92 (3.25) d	1.83 (2.92) c	2.1 (4) d	2.25 (4.67) b	2.17 (4.33) c
M ₃ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN	1.88 (3.08) c	2.28 (4.75) c	2.08 (3.92) b	2.3 (4.9c2)	2.65 (6.58) a	2.48 (5.75) b
M ₄ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN+MC	1.95 (3.33) bc	2.34 (5) bc	2.14 (4.17) b	2.35 (5.0bc8)	2.68 (6.75) a	2.52 (5.92) b
M ₅ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN+FYM	2.07 (3.83) ab	2.44 (5.5) ab	2.26 (4.67) a	2.44 (5.5) ab	2.76 (7.17) a	2.6 (6.33) ab
M ₆ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN+FYM+MC	2.17 (4.25) a	2.53 (5.92) a	2.35 (5.08) a	2.5 (5.83) a	2.82 (7.5) a	2.66 (6.67) a
S.Em±	0.04	0.04	0.02	0.04	0.05	0.04
Liquid organic manures (L)						
L ₁ -Jeevamrut @ 500 litres ha ⁻¹ at 30, 60 and 90 DAS	1.88 (3.11) b	2.2 (4.44) b	2.04 (3.78) b	2.27 (4.72) b	2.54 (6.06) b	2.4 (5.39) b
L ₂ -Cow urine @ 500 litres ha ⁻¹ at 30, 60 and 90 DAS	2.07 (3.83) a	2.36 (5.17) a	2.22 (4.5) a	2.55 (6.06) a	2.79 (7.39) a	2.67 (6.72) a
L ₃ -Bio digester @ 2500 litres ha ⁻¹ at 30, 60 and 90 DAS	1.99 (3.5) ab	2.29 (4.83) ab	2.14 (4.17) ab	2.33 (5) b	2.6 (6.33) b	2.46 (5.67) b
L ₄ -Control (no liquid manure application)	1.68 (2.39) c	2.03 (3.72) c	1.85 (3.06) c	1.89 (3.17) c	2.21 (4.5) c	2.05 (3.83) c
S.Em±	0.05	0.04	0.04	0.05	0.03	0.04
Interactions- (M X L)						
M ₁ L ₁	1.56 (2) e-g	1.77 (2.67) h-j	1.67 (2.33) g-i	1.86 (3) f-h	2.03 (3.67) hi	1.94 (3.33) hi
M ₁ L ₂	1.77 (2.67) c-f	1.95 (3.3f-i3)	1.86 (3) e-h	2.2 (4.33) b-f	2.34 (5) e-g	2.27 (4.6d-g7)
M ₁ L ₃	1.77 (2.67) c-f	1.95 (3.33) f-i	1.86 (3) e-h	1.95 (3.33) e-g	2.11 (4) gh	2.03 (3.67) g-i
M ₁ L ₄	1.34 (1.33) g	1.56 (2) j	1.45 (1.67) i	1.46 (1.67) h	1.68 (2.33) j	1.57 (2) j
M ₂ L ₁	1.68 (2.33) d-g	1.86 (3) g-j	1.77 (2.67) f-i	2.11 (4) c-f	2.27 (4.67) f-h	2.19 (4.33) e-h
M ₂ L ₂	1.95 (3.33) a-e	2.11 (4) d-g	2.03 (3.67c-g)	2.4 (5.33) a-d	2.54 (6) c-e	2.47 (5.67) b-e
M ₂ L ₃	1.86 (3) b-f	2.03 (3.67) e-h	1.94 (3.33) d-h	2.2 (4.33) b-f	2.34 (5) e-g	2.27 (4.67) d-g
M ₂ L ₄	1.46 (1.67) fg	1.68 (2.33) ij	1.57 (2) hi	1.68 (2.33) gh	1.86 (3) j	1.77 (2.67) ij
M ₃ L ₁	1.86 (3) b-f	2.27 (4.67) c-f	2.06 (3.83) b-f	2.34 (5) a-e	2.68 (6.67b-d)	2.51 (5.83) b-e
M ₃ L ₂	2.04 (3.67) a-d	2.41 (5.33) a-d	2.23 (4.5) a-e	2.61 (6.33) ab	2.91 (8) ab	2.76 (7.17) ab
M ₃ L ₃	1.95 (3.33) a-e	2.34 (5) b-e	2.15 (4.17) a-f	2.41 (5.33) a-d	2.73 (7) b-d	2.57 (6.17) a-d
M ₃ L ₄	1.68 (2.33) d-g	2.11 (4) d-g	1.9 (3.17) e-h	1.86 (3) f-h	2.27 (4.67) f-h	2.06 (3.83) f-i
M ₄ L ₁	1.95 (3.33) a-e	2.34 (5) b-e	2.15 (4.17) a-f	2.34 (5) a-e	2.68 (6.67b-d)	2.51 (5.83) b-e
M ₄ L ₂	2.04 (3.67) a-d	2.41 (5.33) a-d	2.23 (4.5) a-e	2.61 (6.33) ab	2.91 (8) ab	2.76 (7.17) ab
M ₄ L ₃	2.03 (3.67) a-d	2.41 (5.33) a-d	2.22 (4.5) a-e	2.4 (5.33) a-d	2.73 (7) b-d	2.57 (6.17) a-d
M ₄ L ₄	1.77 (2.67) c-f	2.2 (4.33) c-f	1.99 (3.5) c-g	2.04 (3.67) d-g	2.41 (5.33) ef	2.23 (4.5) e-h
M ₅ L ₁	2.04 (3.67) a-d	2.41 (5.33) a-d	2.23 (4.5) a-e	2.41 (5.33) a-d	2.73 (7) b-d	2.57 (6.17) a-d
M ₅ L ₂	2.27 (4.67) ab	2.61 (6.33) ab	2.44 (5.5) ab	2.73 (7) a	3.03 (8.67) a	2.88 (7.83) a
M ₅ L ₃	2.11 (4) a-d	2.48 (5.67) a-c	2.3 (4.83) a-d	2.48 (5.67) a-d	2.8 (7.33) a-c	2.64 (6.5) a-c
M ₅ L ₄	1.86 (3) b-f	2.27 (4.67) c-f	2.06 (3.83) b-f	2.11 (4) c-f	2.48 (5.67) d-f	2.3 (4.83) d-g
M ₆ L ₁	2.2 (4.33a-c)	2.54 (6) a-c	2.37 (5.17) a-c	2.54 (6) a-c	2.86 (7.67) ab	2.7 (6.83) a-c
M ₆ L ₂	2.34 (5) a	2.68 (6.67) a	2.51 (5.83) a	2.73 (7) a	3.03 (8.67) a	2.88 (7.83) a
M ₆ L ₃	2.2 (4.33) a-c	2.54 (6) a-c	2.37 (5.17) a-c	2.54 (6) a-c	2.86 (7.67) ab	2.7 (6.83) a-c
M ₆ L ₄	1.94 (3.33) a-e	2.34 (5) b-e	2.14 (4.17) a-f	2.19 (4.33) b-f	2.54 (6) c-e	2.37 (5.17) c-f
S.Em±	0.12	0.1	0.11	0.12	0.08	0.1

Means followed by the same alphabet do not differ significantly by DMRT (0.05) ; () Figures in parentheses are original values. The figures outside the parenthesis are squareroot transformed values

4.2.9 Quality parameters

4.2.9.1 Milling quality (%)

Milling per cent did not differ significantly influenced by integrated application of manurial practices and liquid organic manures (Table 64).

4.2.9.2 Protein content in grain (%)

The data on protein per cent in grain as influenced by manurial practices and liquid organic manures at harvest is presented in Table 64.

The data on protein per cent was significantly influenced by manurial practices and liquid organic manures at harvest. Irrespective of liquid organic manures, application of RDF + FYM + microbial consortium (M₂) recorded significantly higher protein per cent (8.43%) over rest of the treatments. Significantly lower protein per cent (6.25%) was recorded with application of FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN (M₃).

Soil application of biodigester @ 2500 l ha⁻¹ at 30, 60 and 90 DAS (L₃) recorded significantly higher protein per cent (7.50%) but was at par (7.36%) with foliar application of cow urine @ 500 l ha⁻¹ at 30, 60 and 90 DAS (L₂). Significantly lower protein per cent (6.53%) was recorded with control (L₄).

Integrated application of RDF + FYM + microbial consortium with soil application of biodigester @ 2500 l ha⁻¹ at 30, 60 and 90 DAS (M₂L₃) and integrated application of RDF + FYM + microbial consortium with soil application of biodigester @ 2500 l ha⁻¹ at 30, 60 and 90 DAS (M₂L₂) recorded significantly higher protein per cent (8.75% and 8.75% respectively) but was at par with M₂L₁ (8.33 g ha⁻¹), M₁L₃ (8.33 g ha⁻¹) and M₁L₂ (8.33 g ha⁻¹). Significantly lower protein per cent (5.83%) was recorded with M₃L₄.

4.2.9.3 Starch content in grain (%)

The data on starch per cent in grain as influenced by manurial practices and liquid organic manures at harvest is presented in Table 64.

Table 64: Effect of manurial practices and liquid organic manures on milling per cent, protein and starch content in grain

Treatments	Milling (%)			Protein (%)			Starch (%)		
	2013	2014	Pooled	2013	2014	Pooled	2013	2014	Pooled
Manurial practices (M)									
M ₁ -RDF (100:50:50 kg N, P ₂ O ₅ , K ₂ O ha ⁻¹)	71.73a	72.44a	72.09a	8.85b	7.18b	8.02b	20.99a	21.03b	21.01ab
M ₂ -RDF+FYM+MC	72.23a	72.93a	72.58a	9.27a	7.60a	8.43a	21.72a	21.85a	21.78a
M ₃ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN	69.17a	69.84a	69.50a	6.66d	5.83e	6.25d	20.20a	20.25c	20.22b
M ₄ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN+MC	69.65a	70.35a	70.00a	6.77d	5.94de	6.35d	20.81a	20.88bc	20.85ab
M ₅ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN+FYM	70.67a	71.35a	71.01a	7.39c	6.14cd	6.77c	20.66a	20.69bc	20.67b
M ₆ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN+FYM+MC	71.10a	71.81a	71.45a	7.50 c	6.25c	6.87c	21.15a	21.20b	21.17ab
S.Em±	1.3	1.16	1.01	0.1	0.08	0.07	0.73	0.2	0.31
Liquid organic manures (L)									
L ₁ -Jeevamrut @ 500 litres ha ⁻¹ at 30, 60 and 90 DAS	70.58a	71.21a	70.89a	7.71b	6.46b	7.08b	20.72b	20.76ab	20.74b
L ₂ -Cow urine @ 500 litres ha ⁻¹ at 30, 60and 90 DAS	70.86a	71.57a	71.21a	7.98ab	6.73ab	7.36a	21.08ab	21.12ab	21.10ab
L ₃ -Bio digester @ 2500 litres ha ⁻¹ at 30, 60 and 90 DAS	71.49a	72.34a	71.92a	8.12a	6.87a	7.50a	21.33a	21.41a	21.37a
L ₄ -Control (no liquid manure application)	70.10a	70.71a	70.40a	7.15c	5.90 c	6.53c	20.57b	20.63b	20.60b
S.Em±	0.56	0.54	0.53	0.1	0.1	0.07	0.19	0.2	0.17
Interactions- (M X L)									
M ₁ L ₁	71.47a	72.10a	71.78a	8.75bc	7.08bc	7.91bc	20.45bc	20.48b	20.47c
M ₁ L ₂	71.67a	72.40a	72.03a	9.16ab	7.50ab	8.33ab	20.93bc	20.97ab	20.95bc
M ₁ L ₃	72.77a	73.60a	73.18a	9.16ab	7.50ab	8.33ab	21.45a-c	21.47ab	21.46a-c
M ₁ L ₄	71.03a	71.67a	71.35a	8.33cd	6.66cd	7.50 cd	21.14a-c	21.18ab	21.16bc
M ₂ L ₁	72.07a	72.70a	72.38a	9.16ab	7.50ab	8.33ab	21.45a-c	21.49ab	21.47a-c
M ₂ L ₂	72.13a	72.83a	72.48a	9.58a	7.91a	8.75a	22.05ab	22.11ab	22.08ab
M ₂ L ₃	73.10a	73.97a	73.53a	9.58a	7.91a	8.75a	22.54a	22.85a	22.70a
M ₂ L ₄	71.63a	72.23a	71.93a	8.75bc	7.08bc	7.91bc	20.85bc	20.93ab	20.89bc
M ₃ L ₁	69.07a	69.67a	69.37a	6.66gh	5.83de	6.25f-h	20.18c	20.23b	20.21c
M ₃ L ₂	69.37a	70.03a	69.70a	6.66gh	5.83de	6.25f-h	20.21c	20.24b	20.23c
M ₃ L ₃	69.47a	70.30a	69.88a	7.08fg	6.25de	6.66fg	20.24c	20.30b	20.27c
M ₃ L ₄	68.77a	69.37a	69.07a	6.25h	5.41e	5.83h	20.17c	20.22b	20.20 c
M ₄ L ₁	69.27a	69.93a	69.60a	6.66gh	5.83de	6.25f-h	20.71bc	20.80ab	20.76bc
M ₄ L ₂	69.83a	70.53a	70.18a	7.08fg	6.25de	6.66fg	20.81bc	20.87ab	20.84bc
M ₄ L ₃	70.43a	71.27a	70.85a	7.08fg	6.25de	6.66fg	21.10a-c	21.13ab	21.12bc
M ₄ L ₄	69.07a	69.67a	69.37a	6.25h	5.41e	5.83h	20.63bc	20.72b	20.68bc
M ₅ L ₁	70.60a	71.17a	70.88a	7.50ef	6.25de	6.87ef	20.30 c	20.33b	20.32c
M ₅ L ₂	70.97a	71.67a	71.32a	7.50ef	6.25de	6.87ef	21.05a-c	21.10ab	21.08bc
M ₅ L ₃	71.57a	72.43a	72.00a	7.91de	6.66cd	7.29de	21.10a-c	21.13ab	21.12bc
M ₅ L ₄	69.53a	70.13a	69.83a	6.66gh	5.41e	6.04gh	20.17c	20.20b	20.19c
M ₆ L ₁	71.00a	71.67a	71.33a	7.50ef	6.25de	6.87ef	21.21a-c	21.24ab	21.23bc
M ₆ L ₂	71.20a	71.93a	71.57a	7.91de	6.66cd	7.29de	21.40a-c	21.44ab	21.42a-c
M ₆ L ₃	71.63a	72.47a	72.05a	7.91de	6.66cd	7.29de	21.52a-c	21.57ab	21.55a-c
M ₆ L ₄	70.57a	71.17a	70.87a	6.66gh	5.41e	6.04gh	20.48bc	20.53b	20.51c
S.Em±	1.39	1.32	1.55	0.24	0.25	0.19	0.46	0.6	0.41

Means followed by the same alphabet do not differ significantly by DMRT (0.05)

Application of RDF + FYM + microbial consortium (M_2) recorded significantly higher starch per cent (21.78%) over rest of the treatments but was at par with application of FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN + FYM + microbial consortium (21.17%), RDF (21.01%) and FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN + microbial consortium (20.85%). Significantly lower starch per cent (20.22%) was recorded with application of FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN (M_3).

Among the liquid organic manures, soil application of biodigester @ 2500 l ha⁻¹ at 30, 60 and 90 DAS (L_3) recorded significantly higher starch per cent (21.37%) but was at par (21.10%) with foliar application of cow urine @ 500 l ha⁻¹ at 30, 60 and 90 DAS (L_2). Significantly lower starch per cent (20.6%) was recorded with control (L_4).

Among the treatment combinations, integrated application of RDF + FYM + microbial consortium with soil application of biodigester @ 2500 l ha⁻¹ at 30, 60 and 90 DAS (M_2L_3) recorded significantly higher starch per cent (22.70%) but was at par with M_2L_2 (22.08%), M_6L_3 (21.55%), M_2L_1 (21.47%), M_1L_3 (21.46%) and M_6L_2 (21.42%). Significantly lower starch per cent (20.20%) was recorded with M_3L_4 . Similar trend was noticed during 2013 and 2014.

4.10 Economic analysis

4.10.1 Net returns (₹ ha⁻¹)

Net returns of aerobic rice as influenced by manurial practices and liquid organic manures and their interactions is presented in Table 65.

Irrespective of liquid organic manures, manurial practices influenced the net returns. Application of RDF + FYM + microbial consortium (M_2) recorded significantly higher net returns (₹ 33,168 ha⁻¹) over rest of the treatments. Significantly lower net returns (₹ 15,528 ha⁻¹) was recorded with application of FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN (M_3). During first year organic manurial treatments showed significantly lower net returns. Whereas, during second year net returns data showed that RDF (₹ 20,580 ha⁻¹) was at par with organics FYM (1/3)

Table 65: Effect of manurial practices and liquid organic manures on economics (₹) of aerobic rice

Treatments	Gross returns (₹)			Cost of cultivation (₹)			Net returns (₹)			BCratio		
	2013	2014	Pooled	2013	2014	Pooled	2013	2014	Pooled	2013	2014	Pooled
Manurial practices (M)												
M ₁ -RDF (100:50:50 kg N, P ₂ O ₅ , K ₂ O ha ⁻¹)	64590b	48024cd	56307bc	26194	27444	26819	38396b	20580b	29488b	2.47a	1.75a	2.11a
M ₂ -RDF+FYM+MC	70514a	54640a	62577a	28784	30034	29409	41730a	24606a	33168a	2.45a	1.82a	2.14a
M ₃ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN	53960d	43485e	48722d	32569	33819	33194	21391e	9666e	15528e	1.65b	1.28d	1.47c
M ₄ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN+MC	54909d	45758de	50334d	32659	33909	33284	22250de	11849de	17050de	1.68b	1.35cd	1.51bc
M ₅ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN+FYM	58588c	50631bc	54609c	35069	36319	35694	23519cd	14312cd	18915d	1.67b	1.39bc	1.53bc
M ₆ -FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN+FYM+MC	60214c	53859ab	57036b	35159	36409	35784	25055c	17450bc	21252c	1.71b	1.48b	1.60b
S.Em±	607	1048	630				607	1048	630	0.03	0.02	0.02
Liquid organic manures (L)												
L ₁ -Jeevamrut @ 500 litres ha ⁻¹ at 30, 60 and 90 DAS	61291a	50038a	55664a	32114	33364	32739	29177a	16674a	22925a	1.94a	1.51a	1.73a
L ₂ -Cow urine @ 500 litres ha ⁻¹ at 30, 60 and 90 DAS	62494a	51103a	56799a	32114	33364	32739	30380a	17739a	24060a	1.98a	1.55a	1.76a
L ₃ -Bio digester @ 2500 litres ha ⁻¹ at 30, 60 and 90 DAS	63818a	52293a	58056a	33614	34864	34239	30204a	17429a	23817a	1.93a	1.51a	1.72a
L ₄ -Control (no liquid manure application)	54246b	44163b	49204b	29114	30364	29739	25132b	13799b	19465b	1.90a	1.47a	1.69a
S.Em±	1037	997	823				1037	997	823	0.03	0.03	0.02
Interactions- (M X L)												
M ₁ L ₁	65134b-f	48394c-g	56764c-g	26569	27819	27194	38565a	20575a-e	29570ab	2.45a	1.74ab	2.10a
M ₁ L ₂	66506a-e	49465a-g	57986b-f	26569	27819	27194	39937a	21646a-d	30792ab	2.50a	1.78a	2.14a
M ₁ L ₃	67875a-d	50574a-g	59225b-e	28069	29319	28694	39806a	21255a-e	30531ab	2.42a	1.72a-c	2.07a
M ₁ L ₄	58843e-h	43661g-i	51252f-h	23569	24819	24194	35274a	18842a-f	27058bc	2.50a	1.76ab	2.13a
M ₂ L ₁	70950a-c	54935a-d	62943a-c	29159	30409	29784	41791a	24526ab	33159ab	2.43a	1.81a	2.12a
M ₂ L ₂	72499ab	56259a-c	64379ab	29159	30409	29784	43340a	25850a	34595a	2.49a	1.85a	2.17a
M ₂ L ₃	73979a	57423a	65701a	30659	31909	31284	43320a	25514ab	34417a	2.41a	1.80a	2.11a
M ₂ L ₄	64627b-f	49941a-g	57284c-f	26159	27409	26784	38468a	22532a-c	30500ab	2.47a	1.82a	2.15a
M ₃ L ₁	55602g-i	44981f-i	50292gh	32944	34194	33569	22658bc	10787f-h	16723d-g	1.69b	1.32de	1.50bc
M ₃ L ₂	55906g-i	44995f-i	50450gh	32944	34194	33569	22962bc	10801f-h	16881d-g	1.70b	1.32de	1.51bc
M ₃ L ₃	57205f-h	46221e-h	51713f-h	34444	35694	35069	22761bc	10527f-h	16644d-g	1.66b	1.29de	1.48bc
M ₃ L ₄	47127j	37741i	42434i	29944	31194	30569	17183c	6547h	11865g	1.57b	1.21e	1.39c
M ₄ L ₁	55962g-i	46372e-h	51167f-h	33034	34284	33659	22928bc	12088f-h	17508d-g	1.69b	1.35de	1.52bc
M ₄ L ₂	57209f-h	47769d-h	52489e-h	33034	34284	33659	24175bc	13485d-h	18830d-f	1.73b	1.39de	1.56bc
M ₄ L ₃	58412e-h	48970b-g	53691d-h	34534	35784	35159	23878bc	13186e-h	18532d-g	1.69b	1.37de	1.53bc
M ₄ L ₄	48052j	39922hi	43987i	30034	31284	30659	18018bc	8638gh	13328fg	1.60b	1.28de	1.44bc
M ₅ L ₁	59387d-h	51270a-g	55328d-g	35444	36694	36069	23943bc	14576c-h	19259d-f	1.68b	1.40de	1.54bc
M ₅ L ₂	60776d-g	52578a-f	56677c-g	35444	36694	36069	25332bc	15884c-g	20608de	1.71b	1.43de	1.57bc
M ₅ L ₃	62116d-g	53802a-e	57959b-f	36944	38194	37569	25172bc	15608c-g	20390de	1.68b	1.41de	1.55bc
M ₅ L ₄	52071h-j	44874f-i	48473hi	32444	33694	33069	19627bc	11180f-h	15404e-g	1.60b	1.33de	1.47bc
M ₆ L ₁	60709d-g	54274a-e	57492c-f	35534	36784	36159	25175bc	17490b-f	21333c-e	1.71b	1.48c-e	1.59b
M ₆ L ₂	62068d-g	55555a-d	58811b-e	35534	36784	36159	26534b	18771a-f	22652cd	1.75b	1.51b-d	1.63b
M ₆ L ₃	63322c-g	56770ab	60046a-d	37034	38284	37659	26288b	18486a-f	22387cd	1.71b	1.48c-e	1.60b
M ₆ L ₄	54756g-j	48837b-g	51796f-h	32534	33784	33159	22222bc	15053c-g	18637d-f	1.68b	1.45de	1.56bc
S.Em±	2540	2442	2018				2540	2442	2018	0.08	0.08	0.05

Means followed by the same alphabet do not differ significantly by DMRT (0.05)

+ vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN + FYM (` 17,450 ha^{-1}).

Soil application of foliar application of cow urine @ 500 l ha⁻¹ at 30, 60 and 90 DAS (L₂) recorded significantly higher net returns (` 24,060 ha^{-1}) but was at par with biodigester @ 2500 l ha⁻¹ at 30, 60 and 90 DAS (L₃) and soil application of jeevamrut @ 500 l ha⁻¹ at 30, 60 and 90 DAS (L₁) (` 23,817 ha^{-1} and ` 22,925 ha^{-1} respectively). Significantly lower net returns (` 19,465 ha^{-1}) were recorded with control (L₄). Similar trend was noticed during 2013 and 2014.

Among the treatment combinations, integrated application of RDF + FYM + microbial consortium and soil application of cowurine @ 500 l ha⁻¹ at 30, 60 and 90 DAS (M₂L₂) recorded significantly higher net returns (` 34,595 ha^{-1}) over other treatments but was at par with M₂L₃ (` 34,417 ha^{-1}), M₂L₁ (` 33,159 ha^{-1}), M₁L₂ (` 30,792 ha^{-1}), M₁L₃ (` 30,531 ha^{-1}), and M₁L₁ (` 29,570 ha^{-1}). Second year grain yield data showed better effect of organic combinations indicating RDF + FYM without liquid organic manure combination M₂L₄ (` 22,532 ha^{-1}) was at par with organic combination of FYM + vermicompost + green leaf manure equivalent to RDN + FYM with liquid organic manure application M₆L₂ (` 18,771 ha^{-1}) and M₆L₃ (` 18,486 ha^{-1}). Significantly lower net returns was recorded with M₃L₄ (` 11,865 ha^{-1}) on pooled basis. Lower net return was observed during second year when compared to first year.

4.10.2 Benefit: Cost ratio

Benefit: Cost ratio of aerobic rice as influenced by manurial practices and liquid organic manures and their interactions is presented in Table 65.

Among the manurial practices application of RDF + FYM + microbial consortium (M₂) recorded significantly higher Benefit: Cost ratio of 2.14 over rest of the treatments. Significantly lower Benefit: Cost ratio of 1.47 was recorded with application of FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN (M₃).

Benefit: Cost ratio of aerobic rice does not differ significantly due to liquid organic manures during both the years and also on pooled basis.

Among the treatment combinations, integrated application of RDF + FYM + microbial consortium and soil application of cowurine @ 500 l ha⁻¹ at 30, 60 and 90 DAS (M₂L₂) recorded significantly higher Benefit: Cost ratio of 2.17 over other treatments but was at par with M₂L₄ (2.15), M₁L₂ (2.14), M₁L₄ (2.13), M₂L₁ (2.12), M₂L₃ (2.11), M₁L₁ (2.10), and M₁L₃ (2.07). Significantly lower Benefit: Cost ratio of 1.39 was recorded with M₃L₄ on pooled basis. Lower Benefit: Cost ratio was observed during second year when compared to first year.

4.11 Correlation coefficient (r)

The grain yield exhibited significant positive correlation with growth parameters like plant height at 90 DAS (r=0.968), number of tillers hill⁻¹ at 90 DAS (r=0.982), leaf area at 90 DAS (r=0.872), leaf area index at 90 DAS (r=0.872) and total dry matter accumulation at harvest (r=0.987) indicating that the grain yield was greatly determined by these traits (Table 66).

Among the yield parameters, the grain yield showed significant positive correlation with number of productive tillers m⁻² (r=0.964) panicle length (r=0.949), panicle weight (r=0.927), thousand grain weight (r=0.868) and number of filled grains panicle⁻¹ (r=0.887) and straw yield (r=0.958).

Table 66: Correlation for yield with growth and yield parameters as influenced by manurial practices and liquid organic manures at different growth stages of aerobic rice

Sl. No.	Parameters	Correlation coefficient (r)
Growth parameters		
1	Plant height at 90 DAS	0.968**
2	Number of tillers m ⁻² at 90 DAS	0.982**
3	Leaf Area at 90 DAS	0.872**
4	Leaf Area Index at 90 DAS	0.872**
5	Total Dry Matter m ⁻² at harvest	0.987**
Yield parameters		
6	Number of productive tillers m ⁻²	0.964**
7	Panicle length (cm)	0.949**
8	Panicle weight (g)	0.927**
9	1000 grain weight (g)	0.868**
10	Number of filled grains per panicle	0.887**
11	Straw yield	0.958**

**Correlation is significant at P = 0.01 level (2-tailed)

5. DISCUSSION

Results of the field experiments entitled “Planting geometry, irrigation and organic nutrient management practices for aerobic rice in northern transitional zone of Karnataka” conducted during *kharif* 2013 and 2014 at Main Agricultural Research Station (MARS), University of Agricultural Sciences (UAS), Dharwad are discussed in this chapter.

Cultivating rice in rainfed ecosystem, by adopting aerobic rice culture technique provide ample scope to increase production of rice on one hand and achieve sustainable production of cereals on the other.

Water is becoming increasingly scarce and most of the Asian nations including India are expected to face serious water scarcity in next 10-15 years, thus threatening the sustainability of irrigated rice production. To safeguard food security and preserve previous water resources, ways must be explored to grow rice using less water (Belder *et al.*, 2004). Under continuous presence of ponded water, there are huge losses of water by evaporation, seepage and percolation out of the root zone (Castaneda *et al.*, 2002). A new water saving technology is to grow rice aerobically, that is in non puddled and non flooded soil with irrigation. Aerobic rice production is one such alternative method, which is known to use less water than that of lowland rice. Yield being a complex character, is the sum of many morphological and biochemical events that occur during the crop growth and development.

The productivity of rice is mainly affected by soil and climatic conditions, but nutrient management practice also plays an important role. It is desired that the soil should have the required nutrients in sufficient quantities and in optimum proportion to meet the requirement of crop. Presently, the chemical fertilizers are used as a major source of nutrients. But the escalating cost, coupled with increasing demand for chemical fertilizers and depleting soil health necessitates the safe and efficient use of organics in rice production. Further in aerobic rice production soil organic matter management is crucial as it helps to conserve more rain water. These practices gaining much popularity to enhance and maintain soil fertility status and soil water holding capacity for obtaining sustainable crop yields.

Concept of organic farming is to feed the soil rather than the crops to maintain soil health and it is a means of giving back to nature what has been taken from it. As it excludes the use of chemical fertilizer and pesticides from the perspective of eco-service management has many advantages over conventional agriculture. A recent study by Pimentel *et al.* (2005), at Rodale Institute over 22 years, showed greater advantage of animal based organic system than conventional system.

However, under arable production system organic manures suffers from the drawback of slow release of nutrients at initial stages, may cause significant reduction in crop yield and results in lower farm income which can be overcome by judicious combination of organic manures by tracing the positive aspects of green manures, crop residues, composts and liquid manures and a more synchronized system can be achieved to maintain long-term soil fertility which can sustain higher productivity of crops. Hence, an integrated organic nutrient supply system provides an ideal nutrition for a crop through proper combination of various sources of nutrients.

Hence, the present investigation was undertaken with an objective to find out the agro techniques for optimum and integrated organic nutrient management practice in aerobic rice cultivation which is sustainable and ecologically sound. This study has brought-out some useful results and they have been critically analyzed and discussed in this chapter under the following subheads.

5.1 Weather and crop growth

Environment is the foster parent of plants. The fluctuations in weather conditions are true reflection on the expected yield. Rice being a tropical plant where temperature, light and moisture are the principal factors that influence the rice yield. The field trial was conducted under rainfed conditions in northern transitional tract (Zone 8) of Dharwad. The normal and actual weather data that prevailed during *kharif* 2013 and 2014, deviation from the normal with respect to rainfall, maximum and minimum temperature and mean relative humidity are presented in Fig. 1.

Rice productivity depends more on rainfall distribution than on total seasonal rainfall. However, decrease in production might be due to untimely irregular rainfall received during growing season of rice. Wet spells during flowering and harvesting

results in poor fertilization and subsequent loss in yield. Whereas, chronic dry spell of relatively short duration can often results in substantial yield losses, especially if they occur around flowering stage. Actual rainfall during the crop growth period was slightly less than the normal rainfall (6.6%) during 2013 and more than the normal during 2014 (19.3%). Sowings were delayed by 20 days during second year of experimentation due to late receipt of monsoons *i.e.* in third week July and rice crop attained physiological maturity one week earlier when compared to first year where receipt of rains is in last week of June. However, lower grain yield during second year was recorded due to receipt of untimely rainfall of 63 mm during 44th standard week of 2014 at flowering affected the pollination and subsequent grain filling when compared to first year in both the experiments (Fig. 2). The higher rainfall was in the month of July during 2013 and 2014 (177.8 and 242.2 mm, respectively) followed by September (133.6 mm) in 2013 and August (158.4 mm) in 2014. The lower rainfall was in the month of November (48.8 mm) in 2014. Likewise, the monthly as well as weekly minimum and maximum temperatures and relative humidity did not deviate from the normal with no differential influence on crop growth and development. Whereas, Mean maximum and minimum temperature and relative humidity were slightly lower than the normal during July and August. During fertilization rice is more sensitive to cold temperature. Weather was warm and humid during growth period, which was congenial for better growth of the crop. However, the crop received a total of 484 mm and 618.6 mm was received in 45 and 48 rainy days during crop growth period of 2013 and 2014 respectively. By and large weather conditions were more congenial for the growth and yield of aerobic rice.

5.2 Experiment–I: Response of aerobic rice to scheduling of irrigation, planting geometry and methods of planting

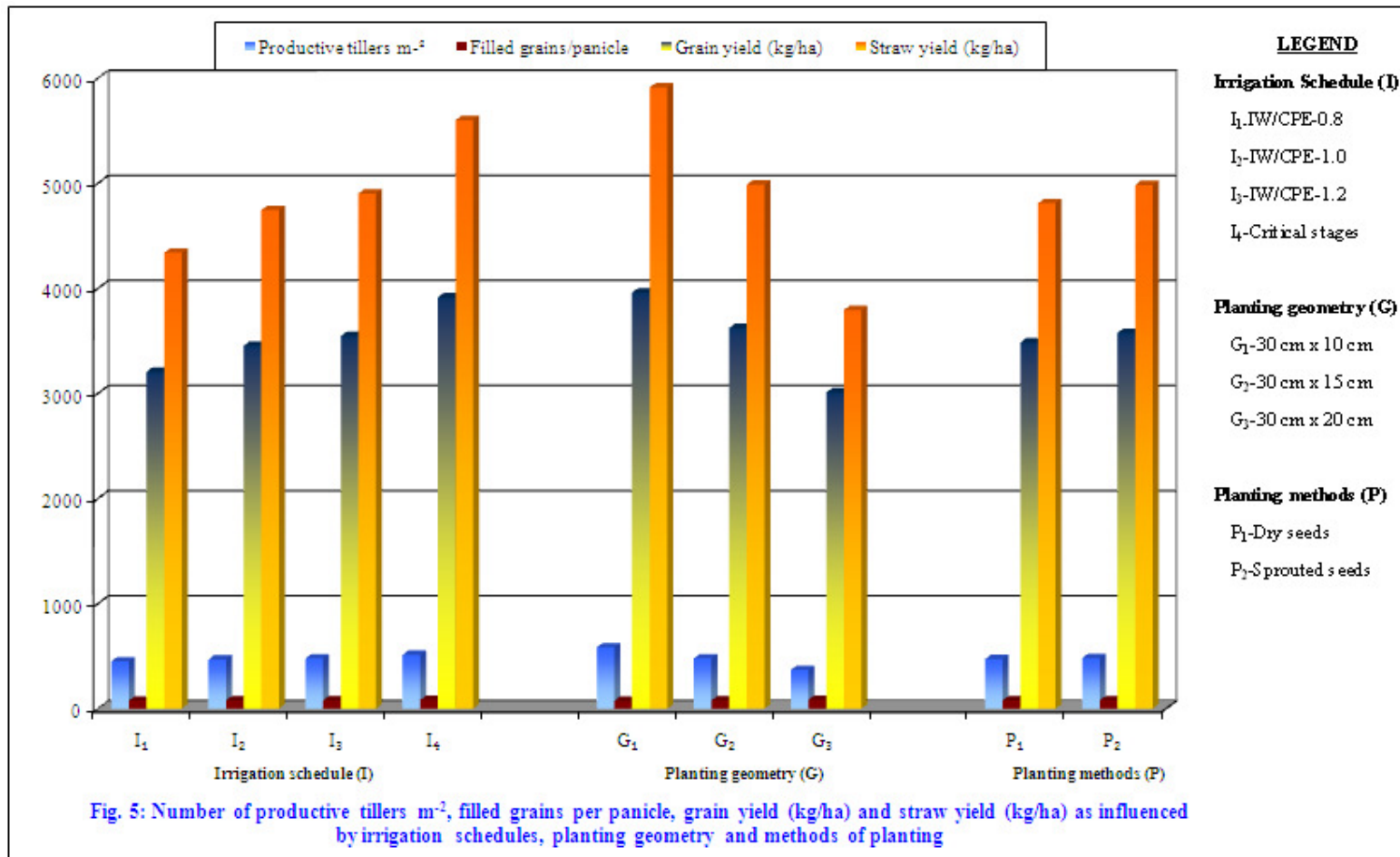
5.2.1 Effect of irrigation schedules at different stages on growth and yield

Economic yield of the crop is influenced by many factors such as water, temperature etc which play important role in affecting the internal processes of the crop directly or indirectly. The microclimate can be manipulated by proper agronomic practice and maintenance of optimum soil moisture in the root zone, which will help in augmenting the production of aerobic rice.

Scheduling irrigations at critical stages of crop growth (I_4) recorded significantly higher grain yield (3914 kg ha^{-1}) compared to all other irrigation schedules. It was mainly due to adequate moisture availability to the crop in this treatment. Improved yield was attributed to higher growth parameter and total dry matter production (Table 11) and superior yield attributing parameters (Table 15 and Fig. 5) like number of productive tillers m^{-2} (511.76), number of filled grains panicle $^{-1}$ (83.53), more panicle length (25.09 cm), higher panicle weight (2.58 g) (Table 16) and less chaffy grains panicle $^{-1}$ (14.89) (Table 15). The better performance of aerobic rice was possible when the soil is maintained at saturation throughout the growth period in sandy loam soils (Malla Reddy *et al.*, 2013).

The higher stature of yield attributes viz., number of panicles m^{-2} , total number of grains panicle $^{-1}$ and number of filled grains panicle $^{-1}$ was recorded with I_4 . The yield parameters were higher with irrigation at critical stages due to increase in leaf area leading to higher photosynthates and accumulation of more assimilates which led to increased sink size. Similarly they were less with IW/CPE ratios of 0.8 due to reduced translocation to sink. The elevated stature might also be presumably due to the increased moisture content and thereby the effective translocation of photosynthates efficiently to sink, contributing to the better development of yield contributing characters (Fig. 5). These results are in conformity with those of Maheswari *et al.* (2007) and Lin Xian Qing *et al.* (2005). The lower stature of yield attributes of rice under aerobic culture was noticed with irrigation schedule at IW/CPE ratio of 0.8. Similar findings were reported by Belder *et al.* (2005).

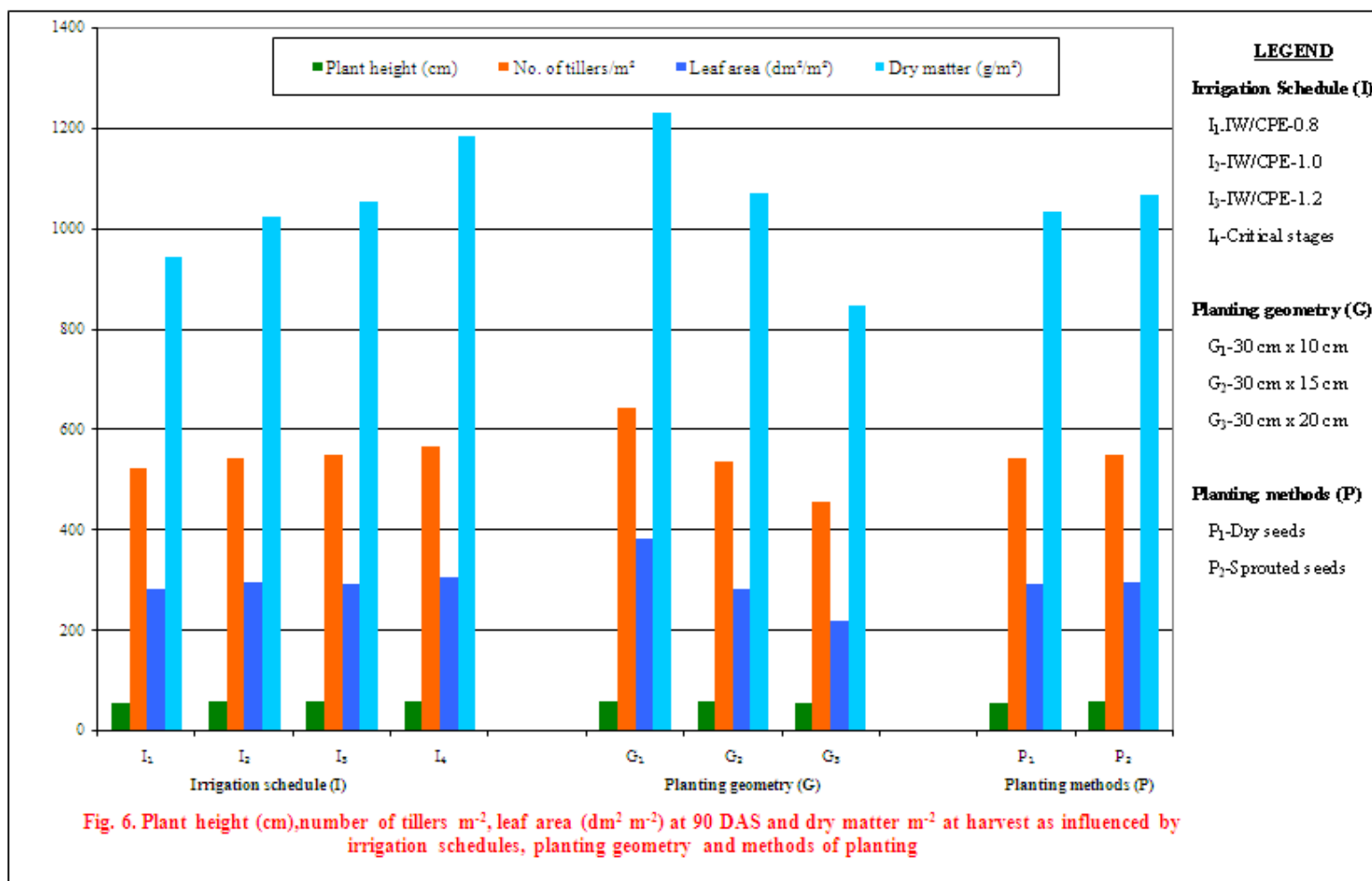
The irrigations at 0.8 IW/CPE ratio throughout (I_1) recorded the lower grain yield (3205 kg ha^{-1}). It was due to less water supplied to the crop during this period. Lower yield was attributed to lesser growth parameter and total dry matter production (Table 11) and lower yield attributing parameters (Table 15) like number of productive tillers m^{-2} (448.69), number of filled grains panicle $^{-1}$ (75.38), lower panicle length (22.09 cm), lower panicle weight (2.18 g) (Table 16) and more chaffy grains panicle $^{-1}$ (18.84) (Table 15). Chaudhry and Pandey (1968) found that the lower grain yield was obtained, when the plant was allowed to wilt twice, once at tillering and again at flowering time. The present findings are analogous to the report of Singh *et al.* (1935), Matsushima (1962) and Yamada (1965). The lower stature of yield attributes of rice



under aerobic culture was noticed with irrigation schedule at IW/CPE ratio of 0.8 (Ramanamurthy, 2010). Similar findings were reported by Belder *et al.* (2005). The reduction in grain yield in delayed irrigations at 0.8 IW/CPE ratio throughout (I_1) can be attributed to significantly less productive tillers m^{-2} (448.69), less filled grains per panicle (75.38) and lower total dry matter production ($940.60 g m^{-2}$) (Table 15). The greatest reduction in yield was in I_1 which received delayed irrigations at 0.8 IW/CPE ratio throughout crop growth stage causing stress at tillering, flowering and grain filling stages. It was due to high weed growth and competition.

Grain yield (Fig. 5) of rice increased significantly with increase in irrigation schedule from IW/CPE of 0.8 to irrigation at critical stages. The improvement in yield was due to better availability of moisture, which in turn leads to efficient physiological activity. High level of dry matter production and efficient translocation of photosynthates from source to sink might be responsible for the production of increased level of yield structure. Rice plants when grown under saturated condition, develop more plant stature, leaf area, root volume, productive tillers, resulting in higher yields (Ramanamurthy and Reddy, 2013). These results are in accordance with those of Jadhav *et al.* (2003); Singh *et al.* (2003) Ambrocio Castaneda *et al.* (2004) and Maheswari *et al.* (2007).

Growth of rice as indicated by the plant height, leaf area index, dry matter production, total number of tillers m^{-2} (Fig. 6) were influenced by irrigation schedules. At these stages of observation, the higher stature of growth parameters were produced with the irrigation schedule at critical stages, while the plants of shortest stature with the lowest leaf area, total number of tillers m^{-2} and dry matter production were observed with irrigation schedule at IW/CPE of 0.8. Reduction in growth parameters under IW/CPE ratio of 0.8 and 1.0 might be due to that the lower moisture levels might have decreased cell volume, cell elongation, intercellular spaces and thickening of cell wall while better growth with irrigation at critical stages might be due to cell turgidity and cell elongation, and increased nutrient uptake. It could also be attributed to the fact that higher moisture levels might have accelerated the synthesis of more chlorophyll and amino acids and stimulated the cellular activity, which is useful for the process of cell division and meristematic growth, resulting in the enhanced growth stature. Similar results of increase in growth stature with increased moisture levels have been reported by Maheswari *et al.* (2007); Singh and Namdeo (2004) and Qinghua Shi *et al.* (2002).



Increase in dry matter production per unit area is a first step towards achieving higher grain yield. Dry matter production is an important pre-requisite for higher yield as it signifies photosynthetic ability of a crop and also indicates other synthetic process during development sequences. Irrigations at critical stages of crop growth (I_4) recorded higher dry matter accumulation (1182.08 g m^{-2}). It was due better crop growth like plant height (55.66 cm) at 90 DAS, number of tillers m^{-2} at (566.32), leaf area (304.57 dm^2) and leaf area index (3.046) at 90 DAS compared to all other irrigation schedules.

Improvement in yield components in irrigations at critical stages of crop growth (I_4) was due to higher total dry matter production (1182.08 g m^{-2}) which contributed to increased number of productive tillers m^{-2} (511.76) compared to irrigations scheduled at IW/CPE ratio 0.8 throughout (Table 15). The photosynthetic activity of plant largely depends upon total dry matter accumulation and leaf area index. These parameters were higher in Irrigations at critical stages of crop growth (I_4) over other irrigation schedules. This helped the photosynthetic area to remain active for longer period and was responsible for overall growth of plant. In the present investigation, leaf area index was higher in Irrigations at critical stages of crop growth (I_4) compared to rest of the irrigation schedules (Table 9).

Delayed irrigations at 0.8 IW/CPE ratio throughout the crop growth stages (I_1) resulted in reduction in LAI (2.806) at 90 DAS (Table 9) which had greater effects on growth and yield. Phogat *et al.* (1984) and Chetti *et al.* (1997) reported that relative water content of leaf decreased with decreasing soil moisture content and resulted in increased leaf temperature and reduction in sink capacity. Further, it decreased the net photosynthesis due to increase in the rate of photo respiration consequently decreased the grain yield.

Reduced stature of growth parameters of rice was noticed with irrigation schedules at IW/CPE ratio of 0.8 which was obviously due to supply of moisture, denying satisfactory level of growth, probably due to proline accumulation, moisture stress and sterility coefficient as confirmed by Maheswari *et al.* (2007) and high soil impedance created due to aerobic conditions (Lafitte and Bennett, 2002). It might have been also due to inhibition of leaf production and decline in leaf area, leading to retarded leaf growth and light interception, and hence reduced canopy photosynthesis. Drought stress affects both cell

division and enlargement, though cell division appears to be less sensitive to water deficit than cell enlargement. Leaf area expansion is reduced as soon as the soil dries below saturation (Bouman *et al.*, 2007).

Straw yield differed significantly due to moisture stress at different growth stages. Significantly higher straw yield (5600 kg ha^{-1}) was obtained in irrigations at critical stages of crop growth (I_4) (Table 17 and Fig. 5). Moisture stress due to delayed irrigations at 0.8 IW/CPE ratio throughout had significantly lower straw yield (4339 kg ha^{-1}) as compared to other irrigation schedules. The higher straw yield obtained with irrigations at critical stages of crop growth (I_4) could be attributed to better vegetative growth as indicated by taller plants (55.66 cm) at 90 DAS, number of tillers (566.32 m^{-2}) and more total dry matter accumulation (1182.08 g m^{-2}) at harvest as compared to other treatments. Delayed irrigations at 0.8 IW/CPE ratio throughout (I_1) growth stages showed retarded growth. This was ascribed to moisture stress as indicated by less available soil moisture held in root zone at higher tension which also resulted in hastened senescence reducing photosynthetically active surfaces and consequently lowered the straw yield. These results are in conformity with the findings of Patel *et al.* (1994) and Santosh Mujalde *et al.* (2004).

The effect of irrigation scheduling on weed parameters was non significant up to 40DAS stage during both the years which is mainly due to the receipt of sufficient rainfall (due to which IW/CPE ratio and critical stage treatments could not be imposed), thereby nullifying the influence of different irrigation schedules on weed density and dry weights especially during the critical period of crop weed competition. However, towards the later stages of crop growth, irrigations scheduled at critical stages, during both the years, resulted in significantly lesser total weed density and their corresponding dry weights than with other irrigation schedules studied. This might be due to the favourable growing conditions created for crop growth upon the receipt of more irrigations than the other irrigation schedules, during both the years, which might have smothered the growth of weeds, thus depriving them of the basic growth resources and thereby resulting in reduced crop weed competition at later stages of crop growth. These results are in conformity with those of Samar Singh *et al.* (2008) and Subramanyam *et al.* (2007).

5.2.2 Effect of irrigation schedules on total water requirement and water use efficiency

The higher total water used was in irrigations at critical stages throughout (I_4 : 55.18 cm ha⁻¹) and lower total water used by crop was under delayed irrigations at 0.8 IW/CPE ratio throughout (I_1 : 46.38 cm ha⁻¹).

The water use efficiency does not varied significantly due to irrigation schedules except during second year. Higher WUE of 66.65 kg ha-cm⁻¹ was recorded with irrigations at critical stages (I_4) followed by irrigations at 1.0 IW/CPE ratio (I_2 : 64.73 kg ha-cm⁻¹) and irrigations at 1.2 IW/CPE ratio (I_2 : 63.36 kg ha-cm⁻¹) (Table 26). It was due to proportionate increase in the yield of aerobic rice against water use. Lower WUE was recorded with delayed irrigations at 0.8 IW/CPE ratio throughout (60.82 kg ha-cm⁻¹).

5.2.3 Effect of planting geometry on growth and yield of aerobic rice

Economic yield is expressed as a function of factors that contributes to yield which are known as yield attributes. The variations in yield due to treatments could be attributed to the variations in the yield attributing parameters. The main yield attributes in rice are number of productive tillers m⁻², filled grains panicle⁻¹ and 1000 grain weight. Closer spacing of 30 cm x 10 cm (G_1) has recorded significantly higher grain yield (3958 kg ha⁻¹) as compare to 30 cm x 15 cm (3622 kg ha⁻¹) and 30 cm x 20 cm (3009 kg ha⁻¹) (Table 17 and Fig. 5). The measure in higher yield with closer spacing might be due to higher yield parameters such as productive tillers m⁻² (583.00) (Table 15). These results are in accordance with the findings of Chandrakar and Chandravanshi (1988), Makarim *et al.* (2002) and Rao *et al.* (2005). The yield of aerobic rice varieties could be increased by increasing the planting density in order to produce more panicles from main stem, thus improving the sink strength by increasing the ratio of superior to inferior grains (Fengtong *et al.*, 2011). Parashiva *et al.* (2011) reported that rice grown with a spacing of 30 x 15 cm recorded significantly the higher grain yield (47.2 q ha⁻¹) compared to 30 x 30 cm (45.5 q ha⁻¹) and 30 x 40 cm (41.9 q ha⁻¹). Sandeep Nayak *et al.* (2014) observed that the higher grain yield of 3476 kg ha⁻¹ was observed with a plant population of 47 hills m⁻² and it was significantly superior to 35, 28, 20 drum seeded and 33 hills m⁻² transplanting paddy.

The variation in the yield could be explained in terms of yield attributes. Number of productive tillers m^{-2} is the important yield attributing parameters affecting grain yield. Significantly higher number of productive tillers m^{-2} (583.00) was recorded at optimum planting of 30 cm x 10 cm as compared to spacing of 30 cm x 15 cm (477.82) and 30 cm x 20 cm (367.77). Better availability and efficient use of nutrients, moisture and efficient harvest of solar energy by the plants might have helped in higher production of productive tillers m^{-2} at closer spacing of 30 cm x 10 cm. These results are in conformity with the findings of Satyavarma *et al.* (2005).

Significantly higher number of filled grains panicle⁻¹ (83.95), panicle length (25.44 cm), panicle weight (2.78 g) and test weight (22.16 g) was recorded by wider spacing of 30 x 20 cm as compared to closer spacing (Fig. 5). These results are in accordance with the findings of Pedroso (1987) and Zhu Defeng *et al.* (2002). Rehashri Kalita *et al.* (2006) studied the performance of rice at different spacing of 20 cm x 10 cm, 15 cm x 10 cm and 10 cm x 10 cm, and found that closer spacing recorded decreased yield components including filled grains per panicle, panicle length and panicle weight. Effective tillers hill⁻¹ and number of filled grains panicle⁻¹ were significantly higher in wider spacing (20 cm x 20 cm) as compared to closer spacing (20 cm x 10 cm) (Satyavarma *et al.*, 2005).

The grain yield in any grain crop is dependent on photosynthetic source, which could build up a sound source in terms of plant height and number of tillers to support and hold the leaves to increase total dry matter and later leading to higher grain yield (Fig. 6). In this study, significantly higher plant height (67.64 cm) at harvest was recorded with closer spacing of 30 cm x 10 cm as compared to wider spacing of 30 cm x 20 cm (63.61 cm) and 30 cm x 15 cm (65.98 cm) (Table 6). The higher plant height which might be attributed due to more competition among plants in closer spacing for resources leads to higher plant height.

Tillering was greatly increased by 30 cm x 10 cm spacing as compared to 30 cm x 20 cm spacing. Because of dense deep and active root system which came in contact with more surface area of soil by which more amount of moisture and nutrients were supplied for the growth of the plant (tillers). This might have lead to the production of more productive tillers m^{-2} . These results are in conformity with findings of Choudhary

et al. (1991). Crusciol *et al.* (2000) studied the effect of row spacing (30, 40 and 50 cm) in upland rice and found that closer spacing increased plant tillering, number of culms and panicle unit area⁻¹, while row spacing of 30 cm recorded the highest grain yield. Uphoff and Randriamiharison (2002) reported that one or two additional weeding is possible in wider spacing as compared to closer spacing before the plants complete their growth and begins flowering. This would have provided still more oxygen to the soil and increased yield from 0.5 to 2.0 t ha⁻¹ with each additional weeding.

Total number of tillers m⁻² was differed significantly from 30 days onwards. Significantly more tillers at 90 DAS were recorded in closer spacing of 30 cm x 10 cm (642.30 m⁻²) as compared to rest of two spacings *i.e.* 30 cm x 15 cm (536.06 m⁻²) and 30 cm x 20 cm (453.71 m⁻²) (Table 7 and Fig. 6). Higher number of tillers m⁻² noticed with closer spacing (30 cm x 10 cm) was due to better utilization of available nutrients whereas less number of tillers m⁻² was noticed in wider spacing (30 cm x 20 cm). This could be due to more plant density, which have resulted in more competition among the plants for nutrients, moisture and light. These results are in conformity with the findings of Crusciol *et al.* (2000).

Significantly higher total dry matter was recorded with closer spacing of 30 cm x 10 cm (1231.20 g m⁻²) at harvest as compared to wider spacing of 30 cm x 20 cm (844.87 g m⁻²) and 30 cm x 15 cm (1070.54 g m⁻²) (Table 11 and Fig. 6). Increased total dry matter influenced the higher grain yield. The higher total dry mater m⁻² might be due to higher number of tillers m⁻². These results are in conformity with the findings of Sinha and Prasad (1994) who reported that higher dry matter accumulation through increased shoots, which bear physiologically active green leaves, provided room for increased photosynthetic activity. Closer spacing (10 cm x 15 cm) recorded the higher growth attributing characters like leaf area index, dry matter accumulation and crop growth rate (Ray *et al.*, 2000).

It is well known that persistence of the assimilatory surface area is a prerequisite for prolonged photosynthetic activity and ultimately crop productivity. Significantly higher leaf area m⁻² (380.42 dm²) at 90 DAS was recorded with closer spacing of 30 cm x 10 cm as compared to 30 cm x 20 cm (217.20 dm²) and spacing of 30 cm x 15 cm (279.41 dm²) (Table 8). Higher production and translocation of photosynthates towards

sink could be due to higher leaf area m^{-2} at closer spacing of 30 cm x 10 cm which influenced higher grain yield. Leaf area index was significantly higher at closer spacing of 30 cm x 10 cm at 60 and 90DAS (2.717 and 3.805) as compared to 30 cm x 15 cm (1.985 and 2.794) and 30 cm x 20 cm (1.570 and 2.173) (Table 9). This was due to increased leaf area. Lower leaves are more shaded and become unproductive as the mean photosynthetic rate of all leaves decreased and respiration would exceed their photosynthesis (Yoshida, 1981). This could have further reduced the production and translocation of photosynthates towards sink and resulted in lower grain yield with wider spacing of 30 cm x 20 cm. These results are in accordance with the findings of Raju *et al.* (1989) and Shrirame *et al.* (2000) who reported that maximum number of leaf area and total number of tillers m^{-2} were higher at closer spacing than the wider spacing.

Higher water use efficiency was observed 30 cm x 10 cm ($78.18 \text{ kg ha cm}^{-1}$) due to higher yield with less water (Table 26). It was also due to better root volume and root growth, which has influenced on better utilization of moisture from the soil. Similar trends, was observed by Shashidhar *et al.* (2006) and Sridhara (2008). Various spacing had a significant influence on the straw yield. Significantly higher straw yield was recorded with the closer spacing of 30 cm x 10 cm (5911 kg ha^{-1}) compared to 30 cm x 15 cm (4986 kg ha^{-1}) and 30 cm x 20 cm (3793 kg ha^{-1}). This might be due to higher plant population having tall growth and accumulated lower photosynthates to transfer but closer spacing has accumulated higher photosynthates in vegetative parts, which leads to higher straw yield in closer spacing. These results are in conformity with the findings of Patel (2000), Ray *et al.* (2000), Guilani *et al.* (2003) and Sandeep Nayak *et al.* (2014).

5.2.4 Interactions of scheduling of irrigation, planting geometry and planting methods on yield

Interaction effects of scheduling of irrigation, planting geometry and methods of planting influenced the grain yield significantly. Treatment combination of sowing of sprouted seeds at 30 cm x 10 cm with irrigation at critical stages ($I_4G_1P_2$) produced

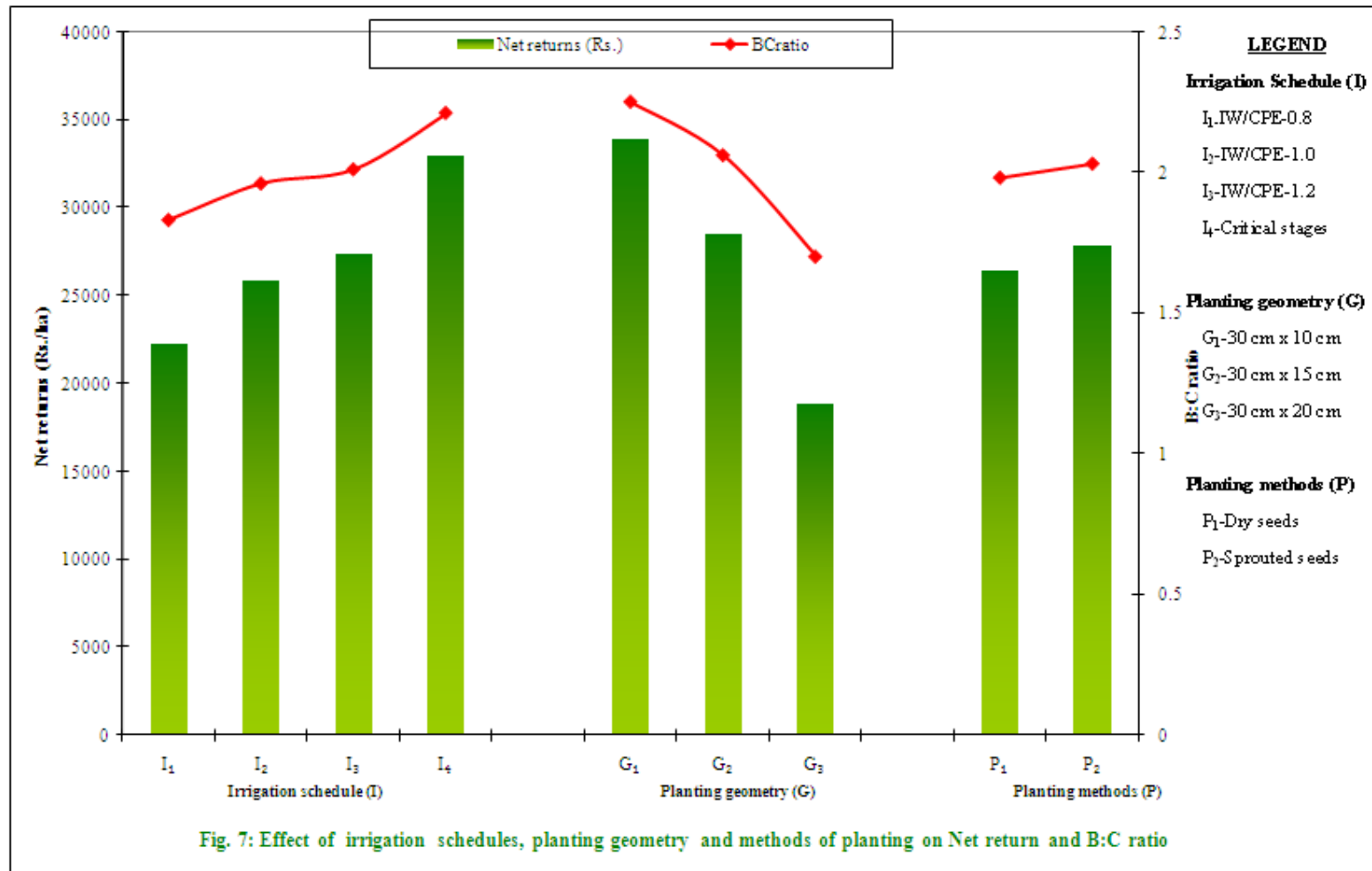
significantly higher grain yield (4383 kg ha^{-1}) and straw yield (6788 kg ha^{-1}) and was on par with $I_4G_1P_1$ (4296 kg ha^{-1} and 6555 kg ha^{-1}). Improved yield was attributed to higher growth parameter and total dry matter production (1390.42 g m^{-2}) and superior yield attributing parameters (Table 11 and 15) like number of productive tillers m^{-2} (631.05). Significantly lower grain yield (2644 kg ha^{-1}) and straw yield (3232 kg ha^{-1}) was observed with sowing of dry seed at $30 \text{ cm} \times 20 \text{ cm}$ with irrigation at IW/CPE of 0.8 ($I_1G_3P_1$).

5.2.5 Interactions of scheduling of irrigation, planting geometry and planting methods on water use efficiency

There was no significant influence of scheduling irrigation on water use efficiency except during second year. Where, Scheduling irrigation at critical stages (I_4) recorded higher water use efficiency ($66.65 \text{ kg ha-cm}^{-1}$) and was on par with irrigations scheduled at 1.0 IW/CPE ratio (I_2) and 1.2 IW/CPE ratio throughout (I_3) (64.73 and $63.36 \text{ kg ha-cm}^{-1}$ respectively). Irrigations scheduled at 0.8 IW/CPE ratio (I_1) recorded the lower water use efficiency ($60.82 \text{ kg ha-cm}^{-1}$). Dense planting (G_1) recorded in significantly higher water use efficiency ($78.18 \text{ kg ha-cm}^{-1}$) due to higher grain yield (3958 kg ha^{-1}). $I_2G_1P_2$ recorded significantly higher water use efficiency ($79.71 \text{ kg ha-cm}^{-1}$). Similarly, the interaction of $I_4G_1P_2$ (Sowing of sprouted seeds at $30 \text{ cm} \times 10 \text{ cm}$ with irrigations at critical stages) recorded higher WUE ($74.64 \text{ kg ha-cm}^{-1}$) over other interactions during 2014. The grain yield was positively correlated with WUE ($r=0.879^{**}$).

5.2.6 Economics

Among the irrigation schedules, significantly higher net return ($\text{₹ } 32,917 \text{ ha}^{-1}$) and Benefit: Cost ratio of 2.21 was recorded with irrigation at critical stages (I_4) (Table 27 and Fig. 7). However, irrigation at IW/CPE of 0.8 (I_1) resulted in lower net return ($\text{₹ } 22,229 \text{ ha}^{-1}$) and Benefit: Cost ratio of 1.83. Thomas *et al.* (2003) reported that net return was significantly higher with increased frequency of irrigation. Among the planting geometry, sowing at $30 \text{ cm} \times 10 \text{ cm}$ (G_1) recorded significantly higher net returns ($\text{₹ } 33,909 \text{ ha}^{-1}$) and Benefit: Cost ratio of 2.25 whereas, significantly lower net returns ($\text{₹ } 18,838 \text{ ha}^{-1}$) and Benefit: Cost of 1.70 was observed when seeds were sown at $30 \text{ cm} \times 20 \text{ cm}$ (G_3).



Interaction effects of scheduling of irrigation, planting geometry and methods of planting influenced the net returns significantly. Treatment combination $I_4G_1P_2$ (sowing of sprouted seeds at 30 cm x 10 cm with irrigation at critical stages) produced significantly higher net return ($\text{₹ } 40,482 \text{ ha}^{-1}$) and Benefit: Cost ratio of 2.48 but, was on par with $I_4G_1P_1$ ($\text{₹ } 39,024 \text{ ha}^{-1}$ and 2.42). Significantly lower net return ($\text{₹ } 13,409 \text{ ha}^{-1}$) was observed with sowing of dry seeds at 30 cm x 20 cm with irrigation at IW/CPE of 0.8 ($I_1G_3P_1$).

5.3 Experiment–II: Studies on integrated organic nutrient management on growth, yield and quality of aerobic rice in Northern transitional zone of Karnataka

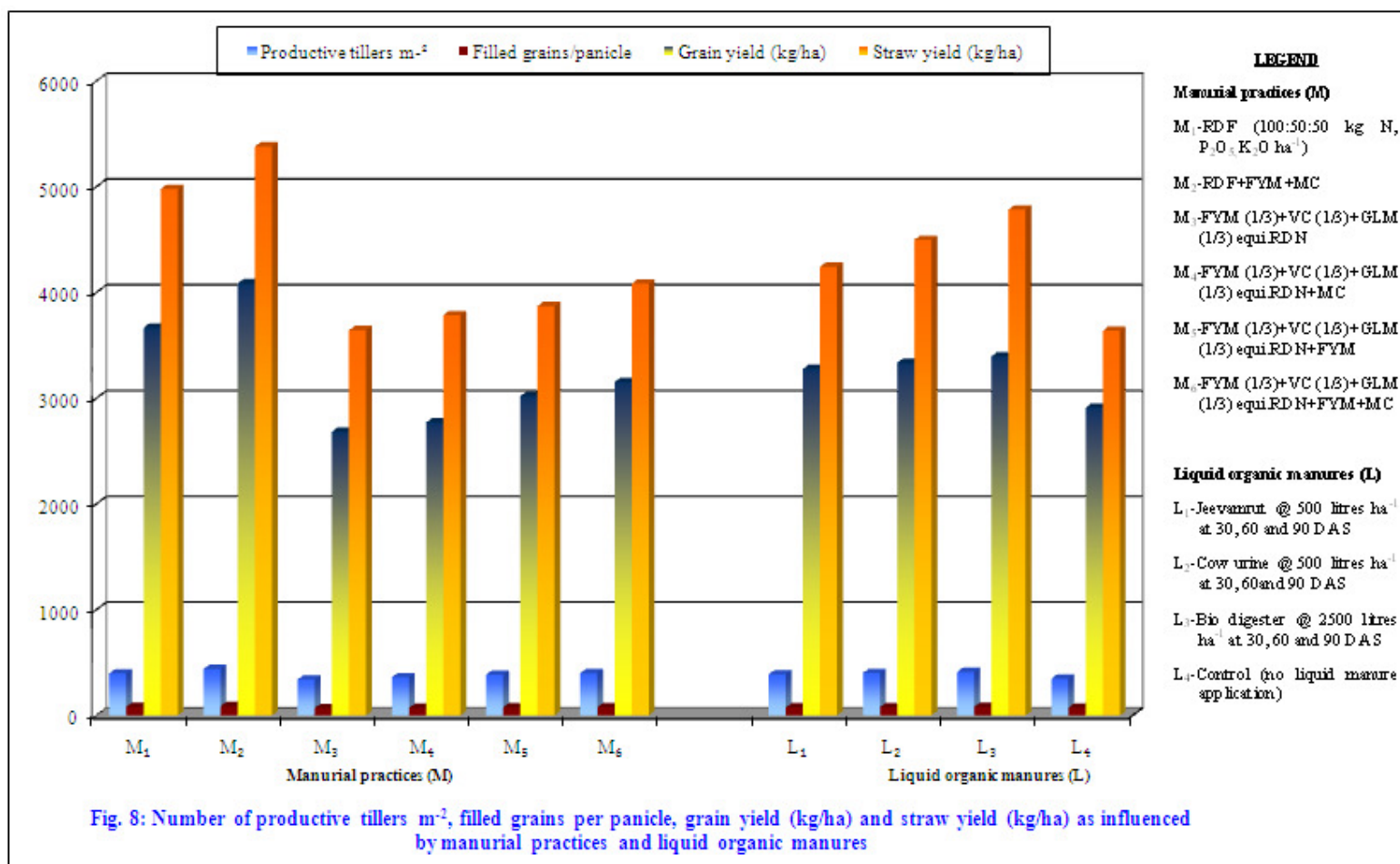
5.3.1 Growth and yield of aerobic rice as influenced by integrated nutrient source

The pre-requisite for getting higher yields in any crop is higher total dry matter production (TDM) and its partitioning into various plant parts coupled with maximum translocation of photosynthates to the sink. Total dry matter accumulation (TDMA) is the sum of dry matter accumulation in individual plant parts which depends on the moisture, nutrients and availability of light. The dry matter accumulation influences the economic yield on one hand, while production of dry matter dependent upon supply of adequate quantity of plant nutrients. The amount of nutrients present in soil and their availability in tune with the synchrony of crop demand is essential to decide the plant growth and yield. The economic yield is a fraction of the total biological yield of the crop and dry matter production, is an important determinant of the grain yield (Donald, 1962).

Among several factors responsible for increase in rice production, adequate supply of essential nutrients in balanced way is one of the key factors for getting higher yield. Much of the nutrients required by the rice crop comes from the soil, but is insufficient to meet the nutrient requirements for high yields. The NPK ratio of 4:2:1 is considered to be optimum, but in reality a wide ratio of 10:9:1 prevalent in the country (Tandon, 2001). In India for that reason, mainly balanced and integrated fertilization has received more attention.

The results show that integrated nutrient management practices significantly influenced the yield attributes in aerobic rice. Application of RDF + FYM + microbial consortium (M₂) recorded significantly higher grain yield (4086 kg ha⁻¹) over rest of the treatments (Table 37 and Fig. 8). This significant increase in grain yield may be due to the high yielding parameters like productive tillers m⁻², number of filled grains panicle⁻¹, panicle length, panicle weight, 1000 grain weight and significant reduction in chaffiness (Table 35 and Table 36). Sudha and Chandini (2002) reported that application of FYM @ 5 t ha⁻¹ had positive influence on growth and yield attributes of rice and resulted in higher grain yield of 4.54 t ha⁻¹ and straw yield of 5.15 t ha⁻¹ along with the application of 105:52.5:52.5 NPK kg ha⁻¹ supplied through chemical sources. The increase in yield was due to the promotion of tillers and panicles with the supply of FYM. Further, they observed that Nitrogen application results in increased amount of interception of photosynthetically active radiation and greater photosynthesis by crop and the supply of secondary nutrient like Mg as well as micronutrients through FYM improved the chlorophyll content and caused reduction of chaffy percentage. Similar results were also reported by Murali and Setty (2001), Das *et al.* (2002) and Barik *et al.* (2006).

The variation in yield could also be explained in terms of other yield attributes like, number of productive tillers m⁻². Significantly higher productive tillers m⁻² (438.66) was recorded with application of RDF + FYM + microbial consortium as compared to different combinations of manurial practices. More productive tillers m⁻² at harvest might be due to better availability of nutrients and reduced mortality of tillers which in turn resulted in higher uptake of nutrients. Adequate quantity of macro nutrients and moisture during panicle differentiation stage might have helped to obtain higher number of grains panicle⁻¹ and better availability of moisture and aeration of roots, which might have helped to retain more number of productive tillers m⁻² at harvest (Fig. 8). These results are in conformity with the findings of Ravi and Srivastava (1997) and Barik *et al.* (2006). Alagesan (1997) also proved the positive correlation between N application and formation of higher productive tillers m⁻². Use of recommended dose of nitrogen, phosphorus and potassium through integrated sources might have helped in inducing good vegetative growth (Dhurandher and Tripathi, 1999) and this produced higher number of panicles leading to higher yield.



Significantly higher number of filled grains panicle⁻¹ (86.87) was observed with RDF + FYM + microbial consortium. Higher number of filled grains panicle⁻¹ might be due to better translocation of accumulated dry matter to the sink (grain). These results are in accordance with the findings of Sarwad *et al.* (1996) and Ravi and Srivasthava (1997). The decreased number of chaffy grains (9.41) was noticed with application of RDF + FYM + microbial consortium. This may be due to less leaching loss of nutrients and more availability of photosynthates for better grain filling as a consequence of higher leaf area and higher dry matter. Increase in filled grain might be due to N induced enhancement in photosynthetic activity and these resulted in the translocation of photosynthates and amino acids from the leaves and culms to the grain. This work is in accordance with findings of Belder *et al.* (2005) and Dhyani and Mishra (1994).

Significantly higher panicle length (27.10 cm) and higher panicle weight (2.84 g) was observed with application of RDF + FYM + microbial consortium. This increased panicle length and panicle weight, which may be attributed to higher concentration of nutrients, applied through soil application. Hence, more availability for uptake and steady supply of nutrients which enhanced the dry matter production due to more availability of photosynthates. These results are corroborate with the findings of Jena *et al.* (2006).

The effect of various nutrient management practices on straw yield was found significant. Application of RDF + FYM + microbial consortium (5380 kg ha⁻¹) recorded significantly higher straw yield compare to M₁ (4979 kg ha⁻¹) (Table 37). Significant increase in straw yield was mainly due to increased dry matter production which indicated by higher growth attributing characters like plant height, more number of tillers, leaf area and leaf area index. These results are in conformity with the findings of Kenchaiah (1997) who reported that higher growth indices recorded in rice had positive association with dry matter accumulation in growth parameters. This result was also supported by Panda *et al.* (1995) who reported that grain yield and straw yield increased with increase in nutrient uptake.

The growth parameters viz., plant height, number of tillers, leaf area, leaf area index, and total dry matter accumulation of aerobic rice was significantly influenced by various manurial practices. The yield in any grain crop is dependent on photosynthetic

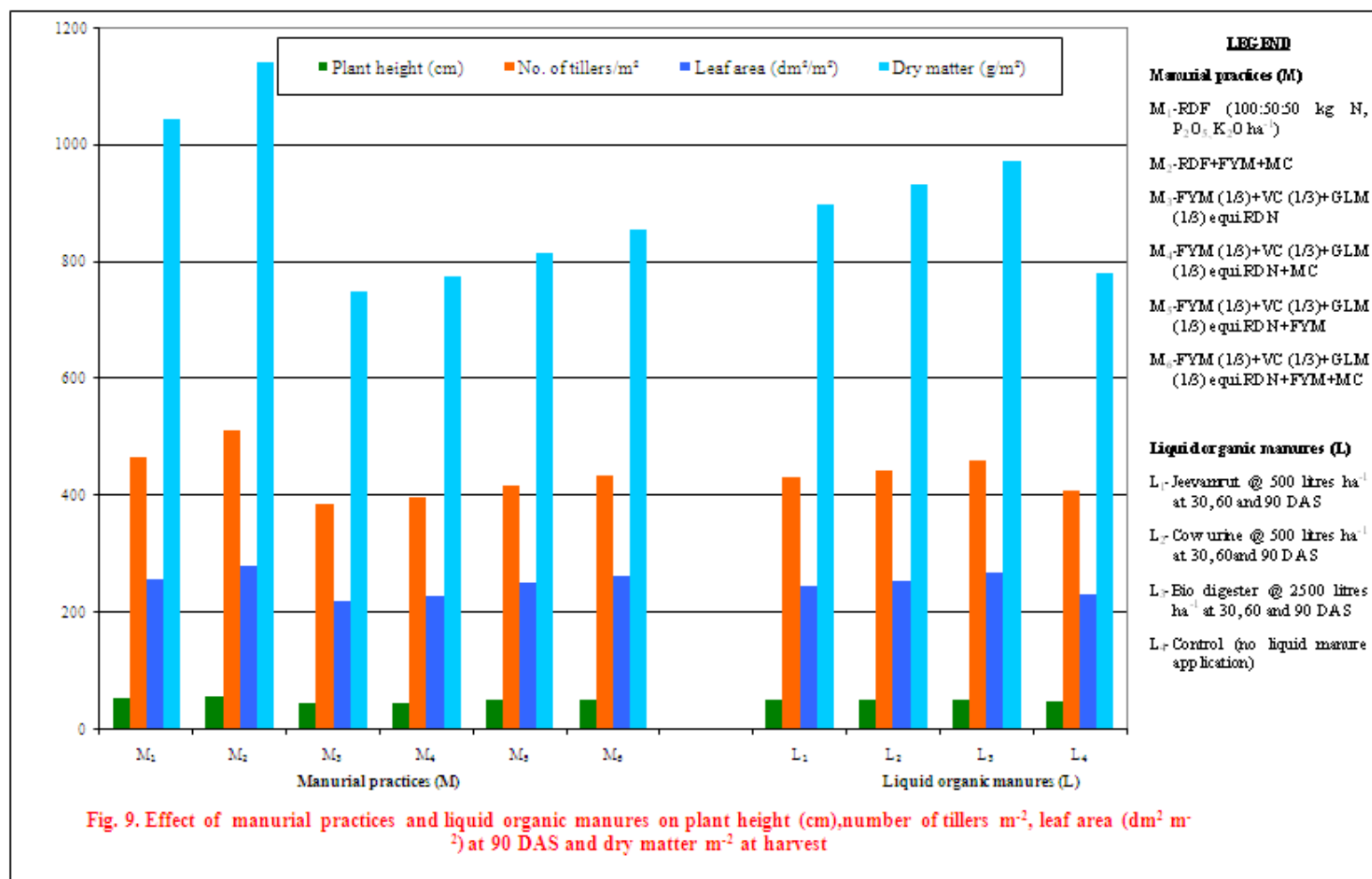
source, which could build up a sound source in terms of plant height and number of tillers to support and hold the leaves to increase total dry matter and later leading to higher grain yield (Fig. 9).

In this study, integrated application of organic and inorganic sources exhibited significant difference with respect to plant height from 60 DAS to harvest. Significantly higher plant height of 63.97 cm at harvest was recorded with RDF + FYM + microbial consortium (Table 29). This could be due to solubility and accelerated release of nitrogen by chemical fertilizer and organic manure by providing an opportunity for aerobic rice to utilize higher quantum of nutrients. Devaraju *et al.* (1998) opined that adequate supply of plant nutrients influenced plant growth. Ravi and Srivastava (1997) also reported release of greater percentage of nutrients at later stages by organic sources of nutrients.

Total number of tillers m^{-2} was significantly differed from 60 days onwards. Application of RDF + FYM + microbial consortium (604.01) has recorded significantly higher tillers m^{-2} at harvest as compared to M_1 (558.09) (Table 30 and Fig. 9). Higher number of tillers m^{-2} noticed with RDF + FYM + microbial consortium and it was due to better utilization of available nutrients and slow release of nutrients from the organic sources at later stages of crop growth which might have resulted in increased number of tillers at harvest (Fig. 9). Similar findings were documented by Babu and Reddy (2000). Tiller number increased with nitrogen supply and is in accordance with the findings of Shanmugam (1983) and Krishna Kumar (1986).

Significantly higher leaf area ($277.96 \text{ dm}^2 \text{ m}^{-2}$) at 90 DAS was recorded with RDF + FYM + microbial consortium as compared to RDF ($255.16 \text{ dm}^2 \text{ m}^{-2}$) (Table 31). Higher production and translocation of photosynthates towards sink might be due to higher leaf area m^{-2} in plants by supplying nutrients through organic and inorganic sources which influenced higher grain yield. It is well known that persistence of the assimilatory surface area is a prerequisite for prolonged photosynthetic activity and ultimately crop productivity.

Leaf area index was significantly higher in combined application of RDF + FYM + microbial consortium (2.780 LAI at 90 DAS) compared to M_1 (2.552 LAI at 90 DAS) and M_2 (5.30 LAI at 90 DAS (Table 32). Increased LAI mainly due to higher



nutrient uptake leading to increased leaf area due to the application of organic and inorganic sources of nutrients has also been documented by Kenchaiah (1997). These results are corroborate with the findings of Vasanthi and Kumaraswamy (2008) and Murali and Setty (2001) who reported that maximum number of functional leaves per hill, leaf area and total number of tillers per hill were higher by application of FYM @ 5 t ha⁻¹ combined with NPK at 150-75-75 kg ha⁻¹.

Application of RDF + FYM + microbial consortium recorded significantly higher total dry matter production, but there was no significant difference in harvest index. This may be the reason to get higher straw yield. Because of more leaf area and more light interception, dry matter production was increased significantly resulting into significant increase in straw yield. These results confirm the findings of Sharu and Meerabai (2001) who reported that application of equal ratio of chemical fertilizer and organic manure increased the nutrient levels. As the nitrogen supply increased, the extra protein content might have induced the plant leaves to grow larger and made more surface area for photosynthesis. Higher nutrient uptake by plant may increase the metabolic activity of the plant leading to a greater accumulation of dry matter and subsequently increased grain yield.

Significantly higher total dry matter (1140.44 g m⁻²) was recorded with application of RDF + FYM + microbial consortium. Application of FYM helped in balanced availability of nutrients at all stages. Improved soil aggregation, higher quantity of nutrient availability and enhanced soil microbial activity, resulting in congenial soil condition which improved uptake of nutrients resulted in higher dry matter (Fig. 9). Dry matter has influence on grain yield. Higher dry matter m⁻² might be due to more number of tillers m⁻². These results are in conformity with the findings of Vasanthi and Kumaraswamy (2008) who reported that higher dry matter accumulation through increased shoots, bear physiologically active green leaves, provided room for increased photosynthetic activity.

5.3.2 Effect of various solid organic sources on yield, yield components, growth parameters and quality parameters of aerobic rice

Among several factors responsible for sustained aerobic rice production, adequate supply of essential nutrients in a balanced way is one of the important factors

for getting higher yield. Initial vigour, vegetative and reproductive growth of plant plays an important role in realizing potential yield of crop. The organic sources have been the traditional means of maintaining soil fertility. Most of the organic manure contain not all the essential nutrients and therefore provide a “balanced” source of nutrients for crops and the organic matter that is applied through organic manures have a very complex effect on soil and on plant growth and development. Application of organics leads to the sustained release of nutrients during the entire crop growing period and minimize the nutrient losses due to increased absorption of nutrients.

In this trial the nutrients equivalent to recommended dose of nitrogen (RDN) along with FYM, microbial consortium and without recommended FYM, microbial consortium was applied as main plots. The nutrients were supplemented through FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN. In sub plots the treatments were superimposed with liquid organic manures biodigester and jeevamrut as soil application and the foliar spray of cow urine and their combinations were evaluated in aerobic rice production.

Among the organic manurial practices, application of FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN + 5 t FYM + microbial consortium recorded significantly higher grain yield (3152 kg ha^{-1}) and straw yield (4083 kg ha^{-1}) over FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN as it helped in optimizing the availability of nutrients coincides with crop demand. The application of FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN + 5 t FYM + microbial consortium recorded significantly higher grain yield and straw yield of (3152 kg ha^{-1} and 4083 kg ha^{-1} respectively). This might be due integrated application of FYM which could be attributed to the availability of nutrients throughout the crop growth and its higher uptake by the crop apart from favourable effect of FYM on soil physicochemical and biological properties. These results are in conformity with the findings of Singh and Verma (1999).

The higher grain yield and straw yield with integrated application of FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN + 5 t FYM + microbial consortium over FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN is due to higher yield parameters such as productive tillers m^{-2}

(399.22), filled grains per panicle (76.93), panicle length (23.47), panicle weight (2.16) and thousand grain weight (21.72) (Table 35 and Table 36). Use of higher dose of nitrogen, phosphorus and potassium through organic sources has optimized the availability of nutrients and helped in inducing good vegetative growth (Dhurandher and Tripathi, 1999 and Rajashekara Reddy, 2006) and this resulted in more number of tillers and higher number of panicles leading to higher yield. The increased productive tillers, panicle length and panicle weight was noticed with the combined application of organics equivalent to RDN + FYM (M₆) which was on par with application of RDF (M₁) may be attributed to steady supply of nutrients which enhanced the dry matter production due to more availability of photosynthates. As a result of application of nutrients in the form of organics resulted in higher number of grains panicle⁻¹. These results are in accordance with earlier findings of Raghuraj Singh *et al.* (2001), Sudha and Chandini (2002) Rao *et al.* (1996) and Babu and Reddy (2000).

The higher grain yield and straw yield is due to application of FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN + 5 t FYM + microbial consortium was attributed to dry matter production and its distribution. The data revealed that beneficial effect of FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN + 5 t FYM + microbial consortium was superior over FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN. The dry matter accumulation was significantly higher with FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN + 5 t FYM + microbial consortium in all the growth stages (158.97, 369.69, 559.30 and 1140.44 g m⁻² at 30, 60 and 90 DAS and at harvest stages respectively). Further, the higher total dry matter production and its accumulation were influenced by assimilatory surface area as reported by Beena and Balachandran (2002).

Greater dry matter accumulation noticed at different stages of the crop in treatment receiving organics equivalent to RDN along with farmyard manure. This might have resulted in higher photosynthesis and higher rate of growth as evidenced by higher values of plant height, number of tillers and leaf area m⁻² (Table 29, 30, 31 and Fig.9). Higher grain and straw yield of rice as a result of higher dry matter accumulation were also reported by Siddaram (2009). As a consequent improved uptake of nutrients

has led to more vegetative growth of the plants and also dry matter production. Higher dry matter production was perhaps due to higher leaf area and higher number of tillers m^{-2} which recorded at all the growth stages. This has provided more photosynthetically active leaf area which resulted in higher dry matter accumulation. Apart from this, nitrogen might have involved in various physiological activities like increased photosynthetically active surface area and better light interception. As nitrogen could enhance number of tillers production and leaf area development, naturally total dry matter production also increased with different organic sources. Similar results were reported by Reddy (1985) and Rajeswari (1990).

5.3.3 Effect of liquid organic manures on yield, yield components, growth parameters and quality parameters of aerobic rice

The liquid organic manures such as biodigester, jeevamrut, amrut pani, cow urine, biosol, panchagavya and vermiwash are the important liquid organic manures commonly used in organic farming practices to supplement the nutrient requirement of crop and also to induce promotion of growth and yield. The soil and foliar application of these liquid manures provide readily available nutrients and their application directly to the foliage result in higher use efficiency. These liquid organic manures provide balanced nutrition to the crops for their proper growth and development. Application of liquid organic manures mainly jeevamrut, cow urine and biodigester help in getting better vegetative and reproductive growth of crop as they provide nutrients as well as contain growth substances which are produced through microbial processes. They also enhance the decomposition process organic manures result in greater release and availability of nutrients. These results are in conformity with the findings of Hundekar (1992).

The grain yield and straw yield of aerobic rice was significantly influenced by the application of liquid organic manures. The, Significantly higher grain and straw yields were recorded with soil application of biodigester @ 2500 l ha^{-1} at 30, 60 and 90 DAS (3396 kg ha^{-1} and 4784 kg ha^{-1} respectively) over other organic treatments and was on par with foliar application of cow urine @ 500 l ha^{-1} at 30, 60 and 90 DAS (L_2) and soil application of jeevamrut @ 500 l ha^{-1} at 30, 60 and 90 DAS (L_1) ($3334, 3278$

and 4497, 4243 kg ha⁻¹ respectively). (Table 37 and Fig. 8). This is mediated by micro biological processes due to improved soil microbial and enzymatic activity. Soil application of biodigester or jeevamrut or foliar sprays of cow urine recorded higher grain yield and straw yield which might be due to liquid organic manures contains nutrients, beneficial microorganisms and plant growth promoters. Ramanathan (2006) reported application of panchagavya produced significantly higher grain yield (5430 kg ha⁻¹) over no panchagavya spray (4990 kg ha⁻¹) in combination with different organic manure treatments in case of rice. Similarly, Yadav and Lourduraj (2006) showed that foliar spray of panchagavya recorded significantly higher values of all the yield parameters of rice.

The grain yield and straw yield are the manifestation of various growth and yield attributing characters. The important yield components like productive tillers m⁻², filled grains per panicles, panicle length and panicle weight is higher with soil application of biodigester @ 2500 l ha⁻¹ at 30, 60 and 90 DAS (Table 35 and 36) and was on par with foliar application of cow urine @ 500 l ha⁻¹ at 30, 60 and 90 DAS. These results are in conformity with the findings of the Boomiraj (2003) who found that increase in fruit weight of bhendi with panchagavya spray.

The grain yield and straw yield increased due to application of any one of the liquid organic manures viz., biodigester, jeevamrut and cow urine spray at 30, 60 and 90 DAS might be due to the presence of growth promoting hormones and nutrients uric acid in cow urine and thus also acted as biopesticide. These nutrients and organic contents of liquid organic manures had a beneficial effect on growth parameters like plant height, number of tillers m⁻², leaf area m⁻² and total dry matter production (Table 29, 30, 31 and 34) by increasing the photosynthetic area due to which higher assimilation of photosynthates and their accumulation in plants was noticed. The better source and sink capacity was developed due to application of liquid organic manures as indicated by better dry matter production and its accumulation in assimilatory surface area and reproductive parts during the vegetative and reproductive phases of crop growth. Application of liquid organic manures at 30, 60 and 90 DAS enhanced the yield as both acted as a plant growth promoter and nutrient sources. Their application increased growth development and yield of the crop as their application coincides with the crop demand for higher nutrient.

Significant increase in yield and yield components with the application of biodigester @ 2500 l ha⁻¹ at 30, 60 and 90 DAS (Table 35, 36 and 37) and was on par with foliar application of cow urine @ 500 l ha⁻¹ at 30, 60 and 90 DAS (L₂) and soil application of jeevamrut @ 500 l ha⁻¹ at 30, 60 and 90 DAS might be due to supply of uric acid by cow urine, the contents mainly gibberlic acid, auxins and other growth promoting hormones present in jeevamrut and biodigester. The beneficial effect of panchagavya was mainly attributed to the presence of large quantities of IAA and GA which are physiologically active in photosynthesis and other processes (Somasundaram, 2003). He also reported that when it was sprayed, it has created stimuli in the plant system which, in turn, increased the production of growth regulating substances in the cell system. Increase in yield of sunflower, maize and green gram (Somasundaram, 2003) and French bean (Selvaraj *et al.*, 2005) was also observed with panchagavya spray. Higher grain yield and straw yield was due to higher availability of nutrients as indicated by increased uptake of nutrients which depicted through increased total dry matter production.

5.3.4 Interactions of manurial practices and liquid organic manures on yield

The combination of solid organic manures with liquid organic manures will maximize the production without affecting soil fertility and productivity.

Among the treatment combinations, integrated application of RDF + FYM + microbial consortium and soil application of biodigester @ 2500 l ha⁻¹ at 30, 60 and 90 DAS (M₂L₃) recorded significantly higher grain yield (4262 kg ha⁻¹) over other treatments but was at par with M₂L₂ (4195 kg ha⁻¹) and M₂L₁ (4122 kg ha⁻¹). First year grain yield data showed that RDF without liquid organic manure combination M₁L₄ (3887 kg ha⁻¹) was at par with organics FYM + vermicompost + green leaf manure equivalent to RDN + FYM with liquid organic manure application M₆L₃ (3514 kg ha⁻¹), M₆L₂ (3454 kg ha⁻¹) and M₆L₁ (3384 kg ha⁻¹). Second year grain yield data showed better effect of organic combinations indicating RDF + FYM without liquid organic manure combination M₂L₄ (3248 kg ha⁻¹) was at par with organic combination of FYM + vermicompost + green leaf manure equivalent to RDN + FYM with liquid organic manure application M₆L₃ (3098 kg ha⁻¹), M₆L₂ (3042 kg ha⁻¹) and M₆L₁ (2978 kg ha⁻¹). This may be due to higher supply of directly available nutrients such as nitrogen to the

plants and these organic manures improves the proportion of water stable aggregates of the soil. This was attributed to cementing action of polysaccharides and other organic compounds released during the decomposition of organic matters, provided better soil environment thus leading to taller plants, increased number of leaves, tillers and intern the final yield. The organic manures have slow release of nitrogen due to its slow mineralization, which helped in the availability of nutrients commensurate with the growth of the plants and development and thus resulted in higher yield (Channabasanagowda *et al.*, 2008). These findings are in accordance with those of Shwetha and Babalad (2008), who had reported 25 to 35 per cent increase in seed yield of soybean with the application of beejamrut, jeevamrut and panchagavya along with different organic manures.

Higher grain yield and straw yield was evidenced by M₂L₃ due to higher values of growth components like leaf area (295.26 dm²), LAI (2.953) and total dry matter production m⁻² (1238.39 g) of the aerobic rice at 90DAS. The development of leaf area is an important factor that could affect crop response to added nitrogen. Larger leaf area development aids in more interception of light leading to higher dry matter production (Vijayalakshmi and Nagarajan, 1994). Similarly there was, considerable increase in other growth components like number of tillers and total dry matter production of the aerobic rice at 30, 60 and 90 DAS and at harvest (Table 30 and 34). The higher number of tillers might be due to greater availability of nutrients. Similar findings were documented by Babu and Reddy (2000) who reported that slow release of nutrients from the organic sources at later stages of crop growth which might have resulted in increased number of tillers. Tiller number increased with nitrogen supply and is in accordance with the findings of Umapathy *et al.* (1994). The higher yield could be traced back to significant differences in dry matter production and its accumulation.

Significantly higher total dry matter (1238.39 g m⁻²) was recorded with integrated application of RDF + FYM + microbial consortium and soil application of biodigester @ 2500 l ha⁻¹ at 30, 60 and 90 DAS (M₂L₃). This might be due to application of organic sources improved the soil aggregation, higher nutrient availability and enhanced soil microbial activity resulted in congenial soil condition. Nitrogen might have involved in various physiological activities like increased photosynthetic activity and better light interception intern resulted in higher dry matter accumulation.

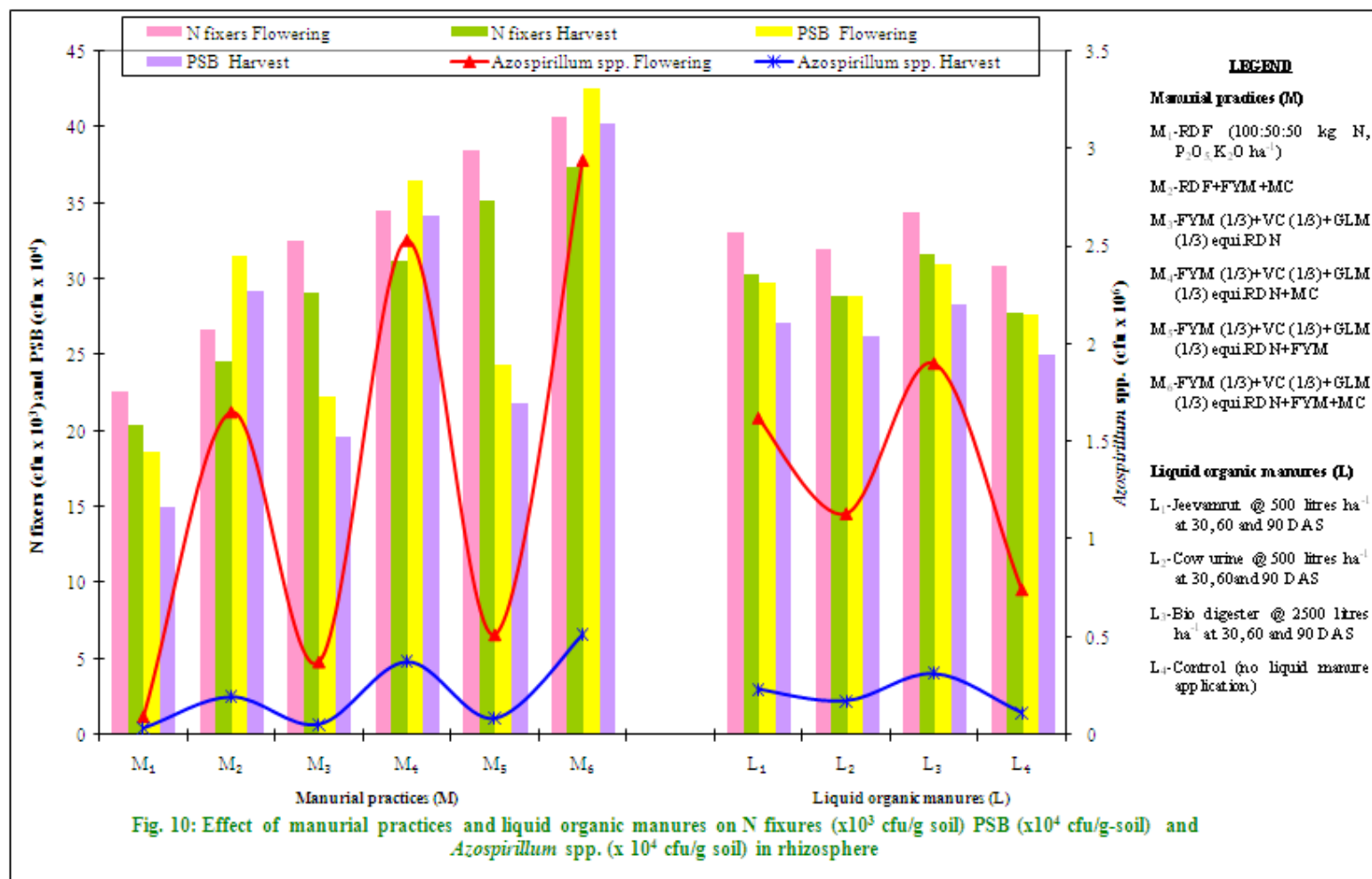
As nitrogen could enhance tillers production and leaf area development, naturally total dry matter production also increased with different organic sources. Similar results were reported by Reddy (1985) and Rajeswari (1990).

Application of RDF + FYM + microbial consortium and soil application of biodigester @ 2500 l ha⁻¹ at 30, 60 and 90 DAS (M₂L₃) recorded significantly higher number of productive tillers m⁻² (466.62), high filled grains per panicle (92.97) higher panicle length (27.72 cm) and higher panicle weight (3.19g) at harvest. However, it was on par with M₂L₂ (Table 35 and 36). These results are in conformity with the findings of Alagesan (1997) who proved the positive correlation between N application and formation of productive tillers. Use of higher dose of nitrogen, phosphorus and potassium through organic sources might have helped in inducing good vegetative growth (Dhurandher and Tripathi, 1999 and Rajashekara Reddy, 2006) and this produced higher number of panicles leading to higher yield. The increased panicle length and panicle weight may be attributed to steady supply of nutrients which enhanced the dry matter production with enhanced assimilation of photosynthates. Increase in filled grain and thousand-grain weight (Table 35 and 36) under different organic sources might be due to N induced enhancement in photosynthetic activity and further translocation of photosynthates and amino acids from the leaves and culms to the grain. This work is in accordance with findings of Belder *et al.* (2005) and Dhyani and Mishra (1994).

5.3.5 Microbial population

Improved microbial population in soil is due to application of biofertilizers and organic manures. The rhizosphere microbial population recorded at flowering stage and after harvest.

Application of FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN with recommended FYM + microbial consortium (M₆) recorded significantly higher N fixers (40.67 and 37.42 x10³ cfu g⁻¹ soil), PSB (42.58 and 40.25 x10⁴ cfu g⁻¹ soil) and *Azospirillum* spp. population (2.94 and 0.51 x10⁶ cfu g⁻¹ soil) at flowering and harvest respectively (Table 38, 39 and Fig. 10). The rate of increase in the population of these microflora during grand growth period and decline subsequently till harvest corroborated with the growth and maturity of the crop. The findings are in conformity



with the results of Ponmurugan and Gopi (2006), Saini *et al.* (2005) and Mar Vazquez *et al.* (2000), who reported the synergistic interactions between introduced microbial inoculants and the native microorganisms in the rhizosphere of crop. Iswandi Anas *et al.* (2011) and Arshad and Frankenderger (1993) reported that the rice root exudates containing some organic compounds as source of nutrition for microorganisms and encourages colonization in the population of *Azospirillum* spp. and PSB during flowering stage of rice crop.

Among the liquid organic manures, soil application of biodigester @ 2500 l ha⁻¹ at 30, 60 and 90 DAS recorded significantly higher N fixers (34.39 and 31.61 x10³ cfu g⁻¹ soil) PSB (31.00 and 28.33 x10⁴ cfu g⁻¹ soil). *Azospirillum* sp. population (1.90 and 0.31 x10⁶ cfu g⁻¹ soil) at flowering and harvest respectively. This might be due to leachates of biodigester which has helped to improve the soil physical, chemical and biological properties leading to overall improvement in soil health in the long run. Similar views were expressed by Mondal *et al.* (2003). The reason ascribed for improved nutrient status with increased level of jaggery and pulse flour and decreasing in the level of incubation period could be difference in the microbial activity (Sudhanshu Sudhakar Kasbe *et al.*, 2009). Similarly, observation on positive role of sugar on microbial activity was documented by Buenaventurada and Tokiwa (2007). Majumdar *et al.* (2006) inferred that application of urine to the soil results in increased microflora of soil. Jeevamrutha was able to improve the microbial population when supplied on N basis.

Among the treatment combinations, integrated application of FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN with recommended FYM + microbial consortium with soil application of biodigester @ 2500 l ha⁻¹ at 30, 60 and 90 DAS (M₆L₃) recorded significantly higher N fixers (42.67 and 39.83 x10³ cfu g⁻¹ soil), PSB (44.17 and 41.83 x10⁴ cfu g⁻¹ soil) and *Azospirillum* spp. population (3.95 and 0.80 x10⁶ cfu g⁻¹ soil) at flowering and harvest respectively. Use of liquid organic manures with organic manures was also helpful in improving the microbial population. These observations indicate that repeated use of liquid organic manures would help in enhanced bacterial activity and ultimately in improved soil fertility. Further continuous use of liquid organic manures with organic manures can improve microbial activity in

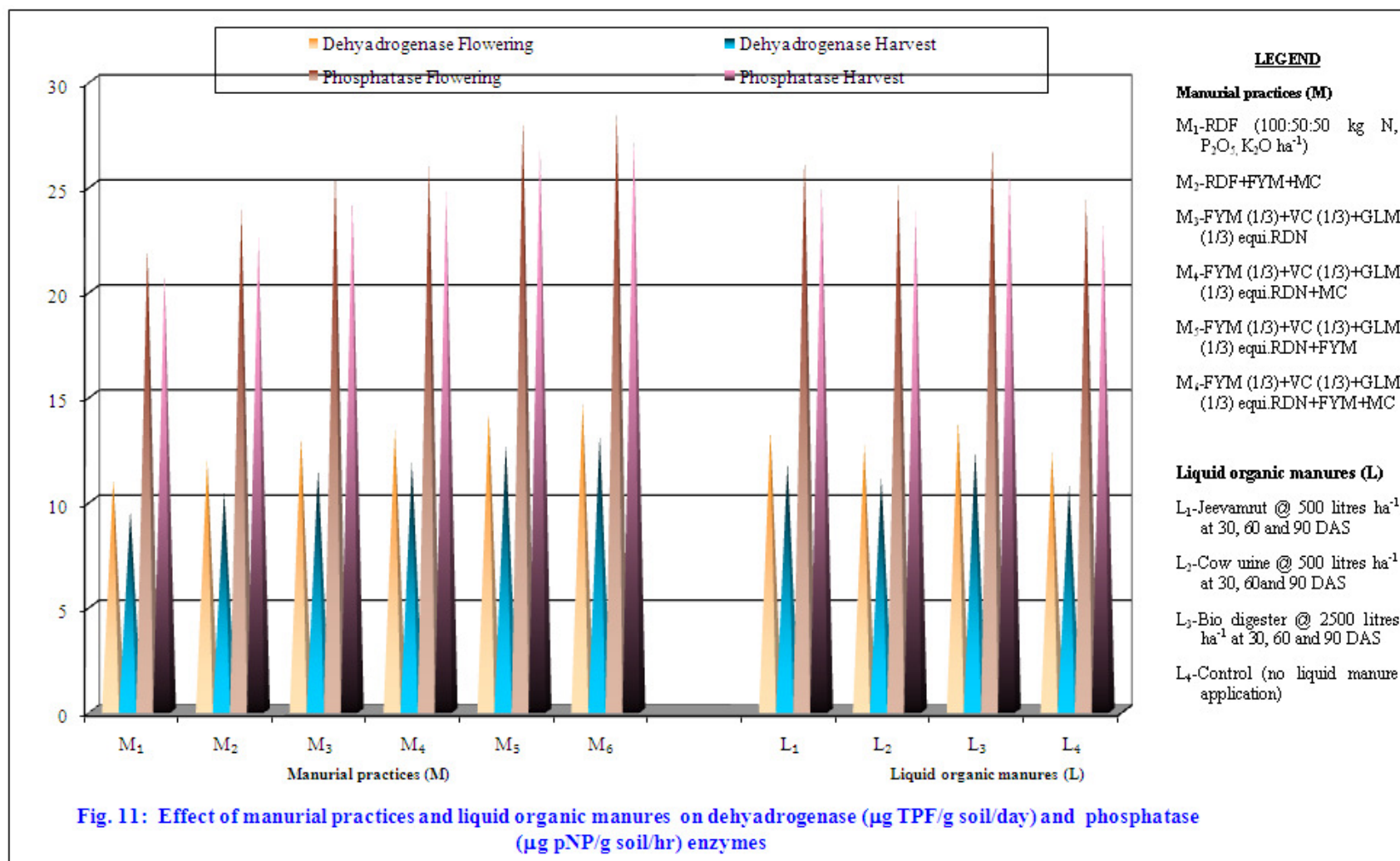
soil and these improving the fertility in short run and have not indicated yield advantage (Sudhanshu Sudhakar Kasbe *et al.*, 2009). The increased microbial biomass was mainly attributed to high microbial activity (Zaman *et al.*, 1998).

5.3.6 Enzymatic activity

5.3.6.1 Dehydrogenase activity

Higher dehydrogenase activity in soil was recorded with application of FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN with recommended FYM + microbial consortium (14.64 and 13.10 $\mu\text{g TPF g}^{-1} \text{ soil day}^{-1}$) at flowering and harvest (Table 40, and Fig. 11). Among the liquid organic manures, soil application of biodigester @ 2500 l ha^{-1} at 30, 60 and 90 DAS (L_3) recorded significantly higher dehydrogenase at flowering and harvest (13.83 and 12.39 $\mu\text{g TPF g}^{-1} \text{ soil day}^{-1}$). Integrated application of FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN with recommended FYM + microbial consortium with soil application of biodigester @ 2500 l ha^{-1} at 30, 60 and 90 DAS (M_6L_3) recorded significantly higher dehydrogenase (15.72 and 14.27 $\mu\text{g TPF g}^{-1} \text{ soil day}^{-1}$).

The higher dehydrogenase activity after addition of organic manure could be due to increased microbial population, which is known to stimulate the dehydrogenase activity in soil (Watts *et al.*, 2010). Dehydrogenase activity is also impacted by the changes in soil organic carbon (Aon and Colaneri, 2001) as higher level of organic carbon stimulated microbial activity and therefore, enzyme synthesis. Similar results were observed by Meena *et al.* (2014). Tejada *et al.* (2010) reported higher dehydrogenase enzyme activity in soil due to application of vermicompost obtained from cow dung continuously for three years. This was attributed to greater labile fraction of organic matter. The maximum dehydrogenase activity was recorded with 100 per cent substitution of RDN with vermicompost, poultry manure, biogas slurry and FYM (Reddy, 1997). Incorporation of green manures enhanced soil enzyme activity (Ramalingam and Kannaiyan, 2006). The results were in conformity with the findings of Mishra *et al.* (2008).



5.3.6.2 Phosphatase activity

Among the manurial practices, application of FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN with recommended FYM + microbial consortium (M₆) recorded significantly higher phosphatase at flowering and harvest (28.53 and 27.27 $\mu\text{g pNP g}^{-1} \text{ soil h}^{-1}$) (Table 40 and Fig. 11). Soil application of biodigester @ 2500 l ha⁻¹ at 30, 60 and 90 DAS (L₃) recorded significantly higher phosphatase at flowering and harvest (26.99 and 25.74 $\mu\text{g pNP g}^{-1} \text{ soil h}^{-1}$). Among the treatment combinations, integrated application of FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN with recommended FYM + microbial consortium with soil application of biodigester @ 2500 l ha⁻¹ at 30, 60 and 90 DAS (M₆L₃) recorded significantly higher phosphatase (29.89 and 28.66 $\mu\text{g pNP g}^{-1} \text{ soil h}^{-1}$)

The maximum phosphatase activity in soil under organic nutrient management practice due to incorporation of organic manures that increase decomposition process thereby increase the microbial activity. Addition of organic amendments and adoption of management practices that increase soil organic matter lead to increased enzyme activity. Plant roots stimulate enzyme activity because of their positive effect on microbial activity and production of exudates rich in substrates acted on by enzymes. Due to continuous addition of organic manures in the form of FYM, vermicompost, green manure and bio-fertilizers, enzyme activity in soil increased under organic nutrient management practice when compared to inorganic nutrient management practice. Similar results were obtained by Tejada *et al.* (2010). The higher phosphatase activity was recorded (Meena *et al.*, 2014) with 100 per cent substitution of RDN with concentrate organic manure (wellgrow formulations). Sriramachandrasekharan and Ravichandran (2011) reported that the addition of organic substances to the soil served as a carbon source that enhanced microbial biomass and phosphatase activity, showing that these enzymes are of microbiological origin (Bohem *et al.*, 2005). Incorporation of green manures enhanced soil enzyme activity (Ramalingam and Kannaiyan, 2006).

5.3.7 Effect of different nutrient management practices on soil physical properties

5.3.7.1 Maximum water holding capacity

Among the different manurial practices, the maximum water holding capacity of soil ranged from 51.99 per cent to 54.21 per cent (Table 41). The maximum water holding capacity of soil in organic treatment recorded 54.21 per cent which was significantly higher than the maximum water holding capacity under inorganic nutrient management practice (51.99%). Integrated application of FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN with recommended FYM + microbial consortium with soil application of biodigester @ 2500 l ha⁻¹ at 30, 60 and 90 DAS (M₆L₃) recorded significantly higher maximum water holding capacity (54.97%). The higher maximum water holding capacity of soil could be attributed to the addition of organic materials from external sources as well as due to continuous return of large amount of crop residues in the form of roots and stubbles to soil (Sudhir and Siddaramappa, 1995). Addition of organic manures which includes FYM, vermicompost, green manures, *etc.*, increases the pore space and improves the structure of soil thereby increasing the water holding capacity of soil. Verma and Sharma (2007) reported that addition of organic manures especially FYM improved the soil physical properties like maximum water holding capacity, bulk density and aggregate stability. The results obtained are in close conformity with the findings of Brar *et al.* (2013).

5.3.8 Effect of different nutrient management practices on soil chemical properties

5.3.8.1 Soil pH

Among the different nutrient management practices, the soil pH ranged from 6.98 to 7.17 (Table 42). The soil pH in 100 per cent organic treatment recorded 7.17 and was significantly higher than the soil pH under inorganic nutrient management practice (6.98). Whalen *et al.* (2000) reported that cattle manure increased soil pH in acid soils.

5.3.8.2 Organic carbon

Among the different manurial practices, the organic carbon content in the soil ranged from 5.11 g kg^{-1} to 5.71 g kg^{-1} (Table 42). The organic carbon content in soil in 100 per cent inorganic treatment recorded 5.11 g kg^{-1} which was significantly lower than the organic carbon content under organic nutrient management practice (5.71 g kg^{-1}). Integrated application of FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN with recommended FYM + microbial consortium with soil application of biodigester @ 2500 l ha^{-1} at 30, 60 and 90 DAS (M_6L_3) recorded significantly higher organic carbon (5.97 g kg^{-1}). The higher organic carbon content in soil could be attributed to the addition of organic materials external sources as well as due to continuous return of large amount of crop residues in the form of roots and stubbles to soil (Sudhir and Siddaramappa, 1995). Singh *et al.* (2001b) reported the similar results of low organic carbon content in soil in treatment receiving only 100 per cent NPK. Incorporation of organic amendments resulted in increased organic carbon status might be due to improvement of physical and biological properties of soil (Nayyar, 2002).

Organic matter application adds organic carbon to soil during decomposition process. Addition of FYM or any other organic manure improved the physical properties like BD, maximum water holding capacity, aggregate stability and soil porosity thereby improving the aeration providing favourable condition for the root proliferation in the soil and increasing above ground growth of the crop, contributing to the higher yield. Higher amount of organic carbon content in soil in organic plots could be due to greater C input through FYM and other organic manures applied (Kundu *et al.*, 2007 and Kukal *et al.*, 2009). The higher above ground growth of crop will contribute to the addition of organic material in the form of stubble addition to the soil which act as a source of energy to the micro-organism thereby increasing the decomposition process and add more of nutrients to the soil. This increases the organic carbon content in soil in the treatment receiving organic manure application. The lower organic carbon content in soil was recorded in the 100 per cent inorganic nutrient management practice (5.11 g kg^{-1}) might be due to no addition of organic manures which did not create much favourable soil environment (Kumari *et al.*, 2011). Application of different sources of organic manures increased the organic carbon

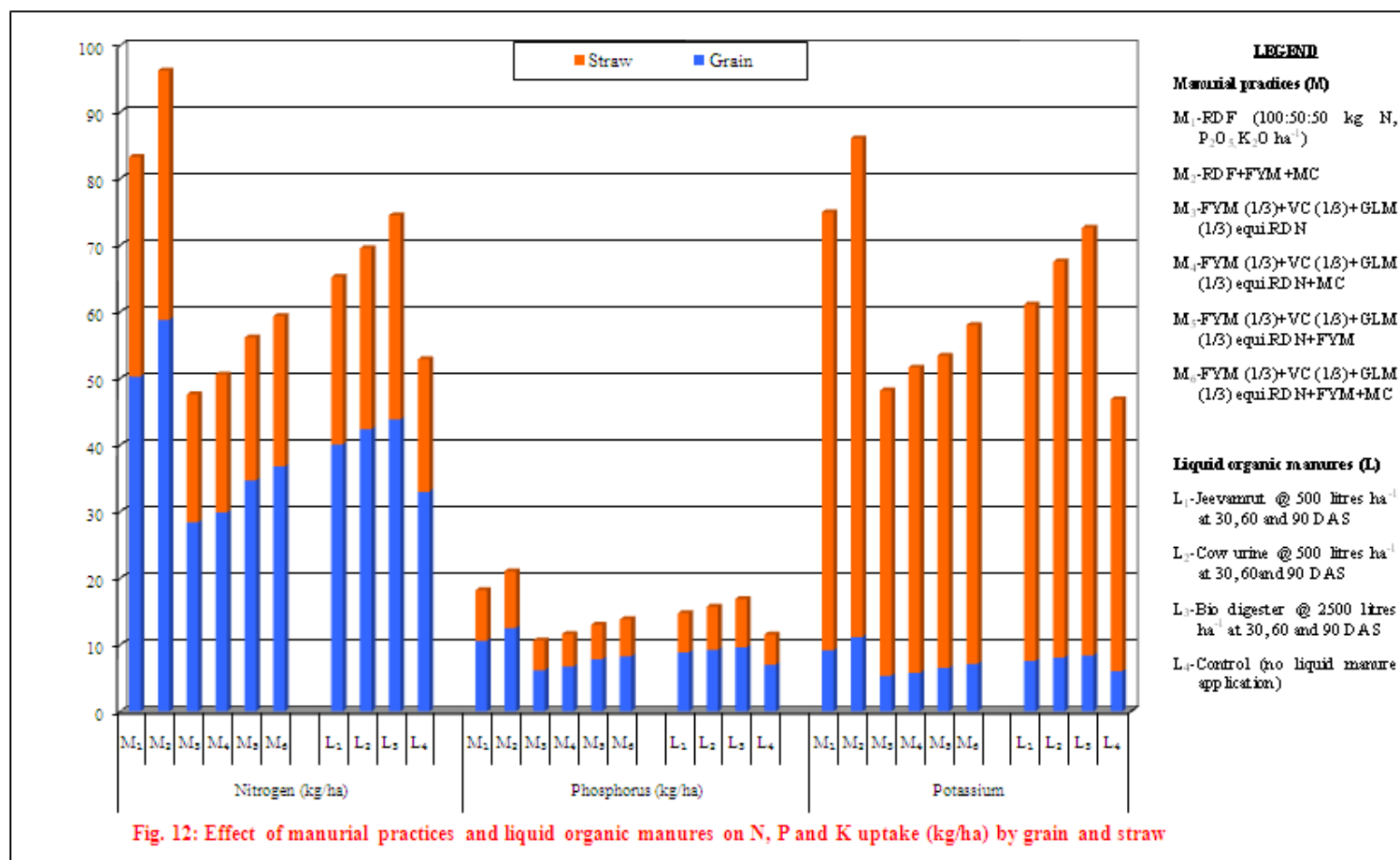
content of soil. It is mainly attributed to the slow decomposition rate of organic matter under FYM, vermicompost and green leaf manure, liquid organic manures *viz.*, cow urine, biodigester and jeevamrutha. This might be due to increased root growth, which was added to soil after death. Similar results were obtained by Patiram and Singh (1993), Ranjan Bhattacharya *et al.* (2004) and Sathiyasundaram (2005).

Benbi and Brar (2009) reported that soil organic carbon in Punjab state of India increased from 2.90 to 4.00 g kg⁻¹ (38%) between 1981 and 2006, largely resulting from irrigation, optimal fertilization and an increase in crop productivity. In a study conducted with the object to determine the effect of years of practicing organic farming on the status of various soil health indicators by using analysis of variance technique (ANOVA) in the selected agro-climatic zones of northern Karnataka revealed that the rise in organic carbon content was from 2.7 to 5.7 g kg⁻¹ from fifth to fifteenth year (Manjunatha *et al.*, 2013).

5.3.9 Effect of different nutrient management practices on nutrient uptake and soil nutrient status

5.3.9.1 Nutrient uptake

Significantly higher total nitrogen (96.19 kg ha⁻¹), phosphorus (21.05 kg ha⁻¹) and potassium (86.04 kg ha⁻¹) uptake was observed with recommended dose of fertilizers (100:50:50 kg N: P: K ha⁻¹) along with 5 t of FYM ha⁻¹ (Table 46, 48, 50 and Fig. 12). Among the organic manurial practices, application of FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN + 5 t FYM + microbial consortium recorded higher nutrient uptake of N (59.39 kg ha⁻¹), P (13.83 kg ha⁻¹), and K (57.98 kg ha⁻¹). The comparative overview of grain yield and nutrient supply clearly indicated strong positive relation established between N supplied in each treatment and the grain yield. The increment was higher due to slow release of nutrients through organic manures and enriching available pool of nitrogen. The present findings are in close association with Sharma and Mitra (1990) and Paikaray *et al.* (2001). According to Deepa Thomas (1996), higher N levels had marked influence on N, P and K uptake due to increased dry matter production. The present findings are in close association with Use of higher dose of nitrogen might have helped for good vegetative growth and root system, which increased the higher N uptake by plants and hence increased yield and



yield components of rice (Sharma and Mitra,1990; Paikaray *et al.*, 2001). Mankotia *et al.* (2008) recorded higher values of nutrient uptake from the rice - wheat cropping system with 5 tonnes of FYM ha⁻¹, followed by 2.5 tonnes of FYM ha⁻¹ along with mushroom spent compost at 1.25 t ha⁻¹.

In case of organic manures potassium uptake was more and this might be due to less loss and less fixation of potassium in the soil. These results are in conformity with the findings of Meek *et al.* (1979) who reported that fixation of K was more rapid in calcareous soil but can be reduced by applying organic sources. Among the major nutrients P and K are known to influence the quality aspects and the N is better utilized only in the presence of P and K. When FYM are added to the soil complex, nitrogenous compounds break down slowly and make steady N supply throughout the growth period of the crop. This might have attributed to more availability and subsequent uptake by the crop. These results were conformity with the findings of Siddaram (2009).

The increase in uptake of N (74.48 kg ha⁻¹), P (16.88 kg ha⁻¹), and K (72.62 kg ha⁻¹) with soil application of biodigester was ascribed to increased biological efficiency of crop plants and creating greater source and sink capacities in the plant system, that might have helped in absorption of the nutrients. It may also be due to increased leaf area index in biodigester treatments indicating increased photosynthetic efficiency of plants leading to increased uptake of nutrients.

Combined application of manurial practices and liquid organic manure sources, increased the uptake of nutrients. The treatment combinations of RDF + FYM + microbial consortium and soil application of biodigester @ 2500 l ha⁻¹ at 30, 60 and 90 DAS (M₂L₃) are evidenced by nutrient uptake of 108.11, 23.73 and 101.87 N, P and K. The greater yield level in relation to supply clearly indicates a strong positive relation between N supplied in each treatment and the grain yield. Higher N levels had marked influence on N, P and K uptake due to increased dry matter production.

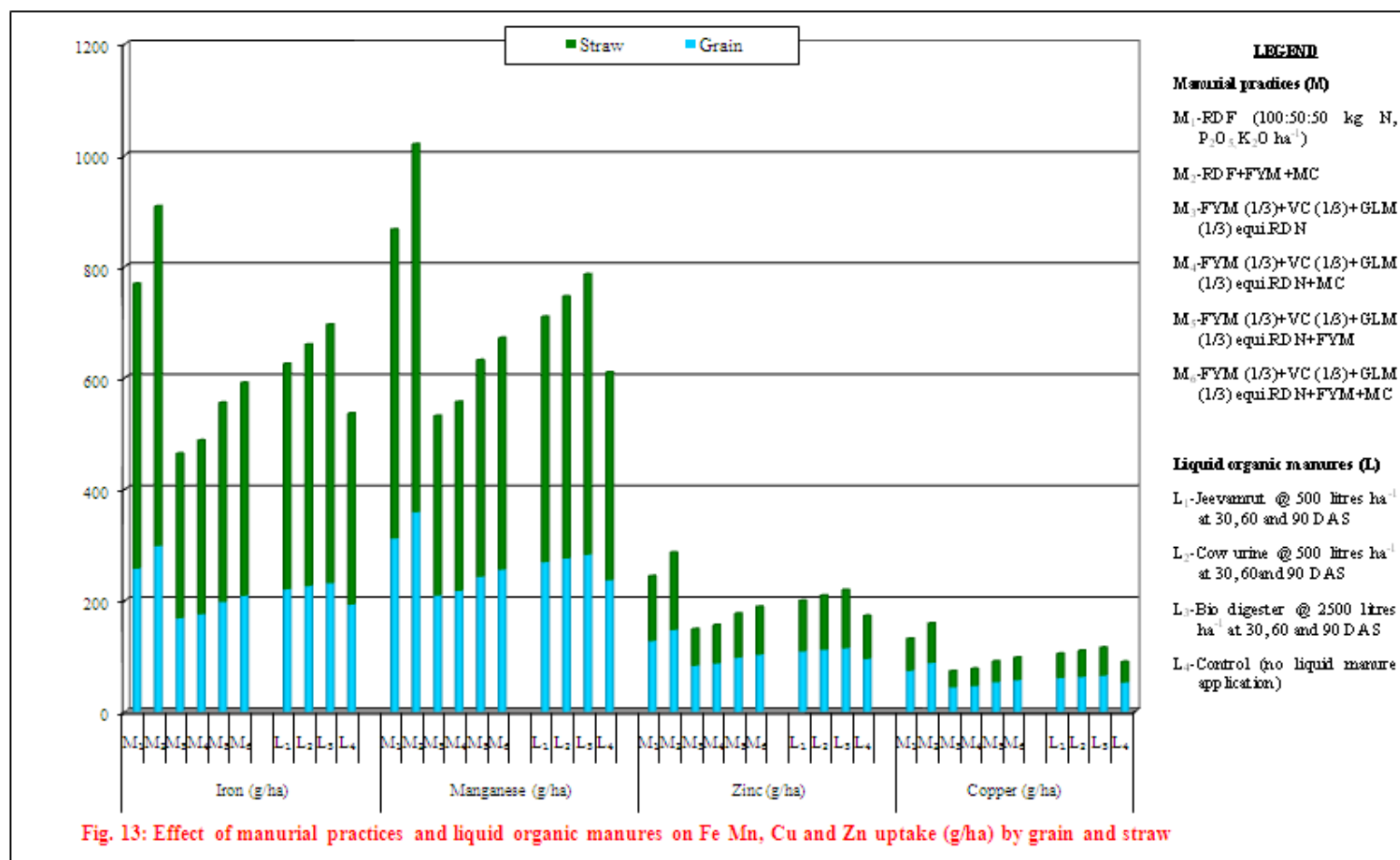
Increased uptake of nutrients may be attributed to improved nutrient availability as a consequence of synergistic relationship between the organic manures and inorganic sources. Similar results were reported by Katyal and Sharma (1979), Subramanian and Kumaraswamy (1989) and Jadhav *et al.* (2008). FYM is known to have a favorable effect on soil structure, texture and tilth and thus facilitates quick and greater

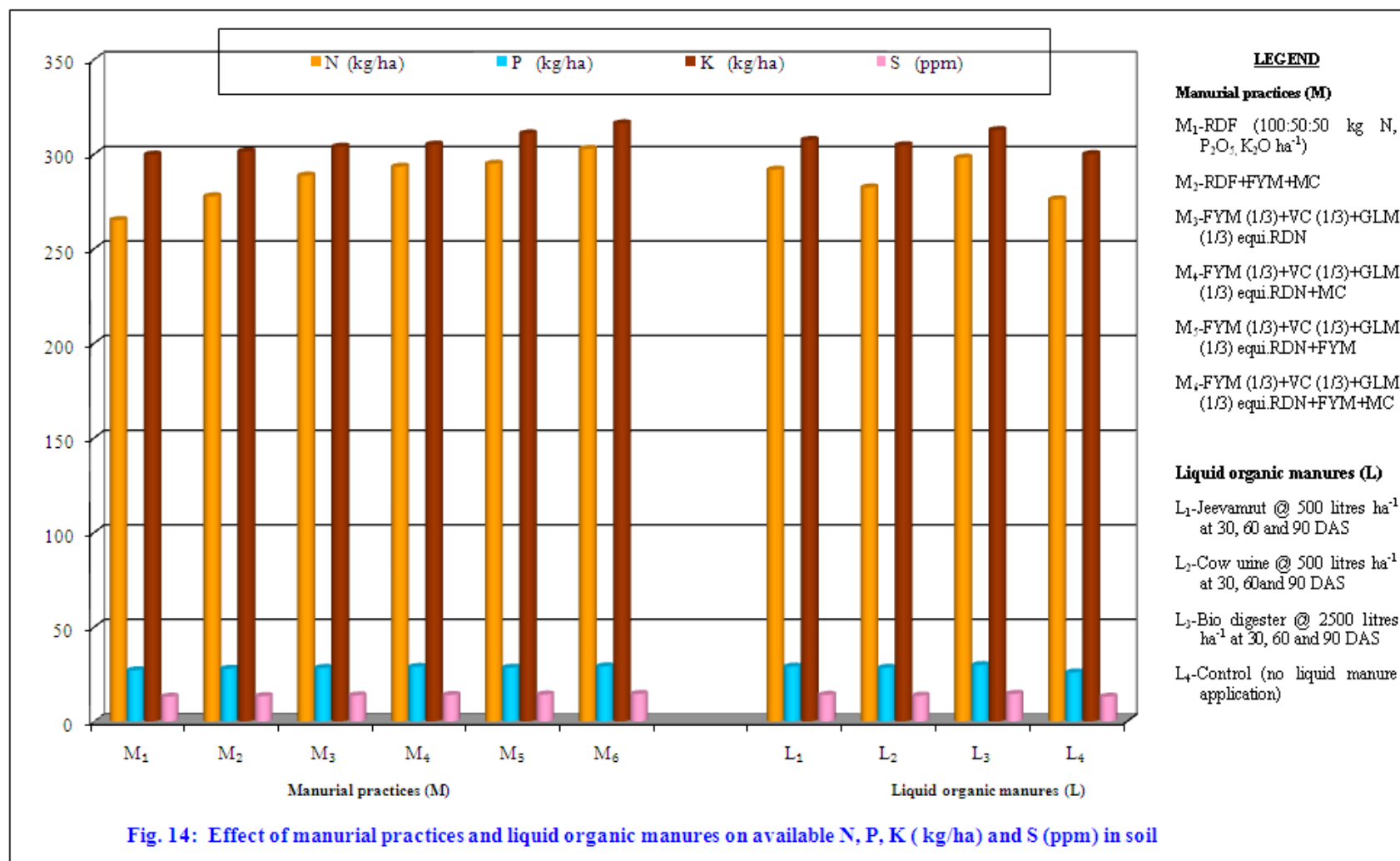
availability of plant nutrients and provides a better environment for root growth and proliferation, thereby creating more absorptive surface for uptake of nutrients (Jadhav *et al.*, 2008).

Irrespective of liquid organic manures, application of RDF + FYM + microbial consortium (M₂) recorded significantly higher total iron, manganese, zinc and copper uptake by grain and straw (907.96, 1019.53, 285.89 and 158.54 g ha⁻¹, respectively) over rest of the treatments (Table 52, 54, 56, 58 and Fig. 13). It is evident from the pooled data that application of N through chemical fertilizer significantly improved the Fe uptake in grain and straw over rest of the treatments. Increasing rate of N increased the Fe uptake by rice (Duhan and Singh, 2002). Application of urea enhance the uptake of Mn by the plant and the interaction between Mn and N was found to be positive (Das, 2000). There are ample evidences that uptake of Mn is metabolically mediated (More, 1972). In majority of studies, there has been a significant positive correlation in between organic matter and available Zn in soils. Duhan and Singh (2002) reported that Cu uptake by rice crop increased with increasing dose of fertilizer N up to 120 kg ha⁻¹ and this increase was mainly due to the increase in grain yield of rice. Increased uptake of Zn, Fe, Mn and Cu by rice due to nitrogen fertilization has been reported by a number of earlier workers (Nayar *et al.*, 1980; Pande *et al.*, 1985; Salam & Subramanian, 1988; Narang *et al.*, 1990).

5.3.9.2 Soil nutrient status

Significantly higher amount of nitrogen (302.62 kg ha⁻¹), phosphorus (29.10 kg ha⁻¹), potassium (316.12 kg ha⁻¹) and sulphur (14.48 ppm) (Table 43 and Fig. 14) found in soil after harvest of the crop was observed with FYM + vermicompost + green leaf manure equivalent to RDN along with 5 t of FYM ha⁻¹ + microbial consortium (M₆) Significantly lower amount of nitrogen (264.99 kg ha⁻¹), phosphorus (27.01 kg ha⁻¹), potassium (299.6 kg ha⁻¹) and sulphur (13.09 ppm) in soil after harvest of the crop was observed with RDF. In general application of organic manures improved the NPK status of soil. It was mainly due to mineralization of nitrogen from organic manures through increased activity of soil organisms (Singh *et al.*, 1996). The results are in conformity with the findings of Subramanian and Kumarswamy (1989). FYM appeared to contain higher concentration of macro and micronutrients that contributed for higher solubility





and nutrient uptake. Similar views were expressed by Keelara (2001) and Devegowda (1997) and Suresh and Ramasubba Reddy (2002). The organic manure integration with biodigester liquid might have helped to improve the soil physical, chemical and biological properties leading to overall improvement in soil health in the long run. Similar views are expressed by Mondal *et al.* (2003).

Addition of organics enhanced the available nutrient status of soil considerably due to mineralization of native soil and unavailable forms of nutrients in addition to applied nutrients (Yadav and Chhipa, 2007). The significant increase in available N content of soil may be attributed to the higher beneficial soil microbial population mainly free living N fixers in soil of aerobic rice production situation and release of organic acids due to increased microbial activity which mineralize the nitrogen contained in the applied FYM as reported by Bharadwaj and Omanwar (1994) and Yaduvanshi (2001). The significant increase in available P content could also be attributed to the organic manure mediated complexation of cations like Cu, Mg and Al responsible for fixation of P in soil (Sushma *et al.*, 2007) which reduce the fixation of applied P and further P solubilisation through phosphorus solubilizers. The increase in available K in soil due to decomposition of products of FYM which contain various organic acids, might have aided in release of non-exchangeable K to the water soluble forms (Chitra and Janaki, 1999).

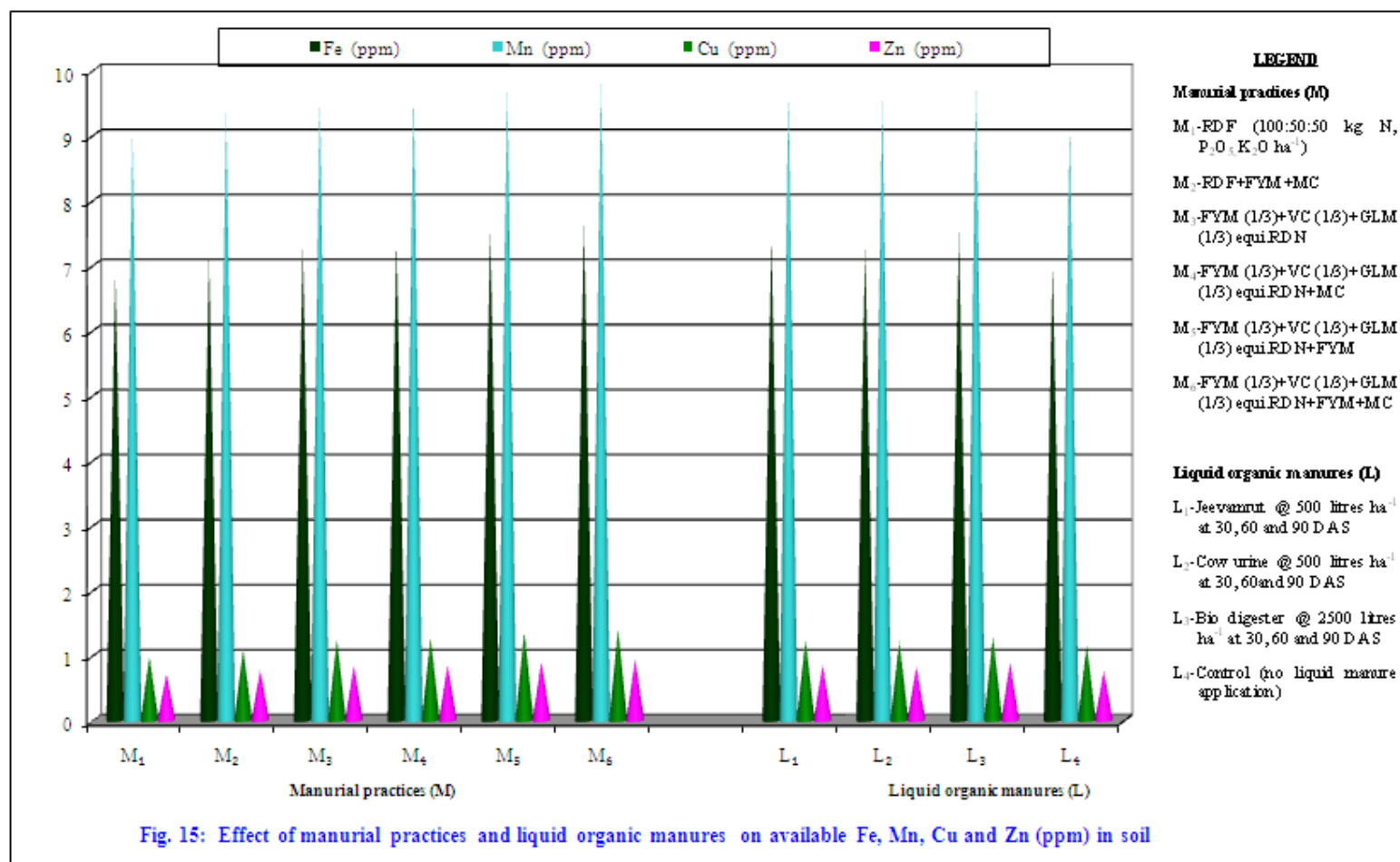
Higher available nitrogen ($297.92 \text{ kg ha}^{-1}$), phosphorus (29.73 kg ha^{-1}), potassium ($312.57 \text{ kg ha}^{-1}$) and sulphur (14.49 ppm) was recorded with soil application of biodigester @ 2500 l ha^{-1} at 30, 60 and 90DAS (Table 43). This might be due to higher quantity of biodigester applied compared to jeevamrut and cowurine, further biodigester is microbial rich liquid manure and has beneficial effect on soil biological activity and availability of nitrogen, phosphorus and potassium. The beneficial effect of jeevamrut was reported by Palekar (2006) and VasanthKumar (2006) which they attributed to huge quantity of microbial load and growth hormones. They have enhanced the soil biomass thereby sustaining the availability and uptake of applied as well as native soil nutrients which ultimately resulted better growth and yield of crops.

Among the treatment combinations, application of FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN + FYM + microbial consortium with

soil application of biodigester @ 2500 l ha⁻¹ at 30, 60 and 90 DAS (M₆L₃) recorded significantly higher available soil nitrogen (310.46 kg ha⁻¹) phosphorus (30.90 kg ha⁻¹), potassium (328.16 kg ha⁻¹) and sulphur (15.16 ppm) found in soil after harvest of the crop. Zaman *et al.* (2000) reported that total N, exchangeable K, available P and S were favorably influenced by the application of organic sources of nitrogen and potassium.

Application of FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN with recommended FYM + microbial consortium (M₆) recorded significantly higher DTPA extractable soil iron (7.63 ppm), manganese (9.83ppm), copper (1.40 ppm) and zinc (0.94 ppm) over other treatments. Irrespective of the treatments, the available micronutrient status (Zn, Fe, Cu and Mn) observed under organic and integrated nutrient treatments were higher over chemical fertilizers alone and the contents were higher in second year than first year (Table 44 and Fig. 15). Considering the critical limits of Zn (0.65 mg kg⁻¹), Cu (0.2 mg kg⁻¹), Fe (4.5 mg kg⁻¹) and Mn (1 mg kg⁻¹), all the treatments were under sufficiency range. More micronutrient build up was observed during second year over first year in all the integrated nutrient treatments. The results are well supported by the findings of Ramesh *et al.* (2006) and Banik and Sharma (2008). The higher availability of micronutrients in soil particularly with use of organics may be ascribed to mineralization, reduction in fixation of nutrients by organic matter and complexing properties of humic substances released from organics with micronutrients (Prasad *et al.*, 2010).

The treatments with organic manures either increased or retained the critical fertility status of micronutrients. Organic manures on decomposition produce a variety of biochemical substances (organic acids, polyphenols, amino acids and poly saccharides) which stimulate the solubility, transport and availability of micronutrients. Effectiveness of organics may be ascribed to their ability after degradation to form water soluble complexes with iron and other ions. Perhaps, humic substances and organic acids formed after decomposition of crop residue by micro flora may help in the translocation of iron which can be transported only with difficulty within the plant. The most significant influence of organics in increasing the solubility and availability of iron in the soil is through solubilization and mass flow in the immediate vicinity of plant (Prasad *et al.*, 2010).



5.3.10 Protein content

The values of quality parameters like protein content is high (8.43%) with RDF + FYM + microbial consortium (M_2) due to the increased nitrogen uptake (58.80 kg ha^{-1}) by the crop. The higher protein content (7.50%) in grain was recorded with soil application of biodigester @ 2500 l ha^{-1} at 30, 60 and 90 DAS which was on par with foliar application of cow urine @ 500 l ha^{-1} at 30, 60 and 90 DAS (Table 64). This might be due to the presence of essential plant nutrient especially nitrogen and plant growth promoting substances in biodigester and cow urine which increased the protein content significantly. The results are in accordance with the findings of Singh and Singh (1968).

5.3.11 Milling percent

The quality parameters were not altered conspicuously by different nutrient supply packages as well as their interactions. Milling per cent did not differ significantly influenced by integrated application of manurial practices and liquid organic manures (Table 64). Similar findings of non significant differences in milling quality of rice among different combinations of organic sources of nutrition were reported by Davari and Sharma (2010).

5.3.12 Starch content

Application of RDF + FYM + microbial consortium (M_2) recorded significantly higher starch per cent (21.78%) over rest of the treatments (Table 64) but was at par with application of FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN + FYM + microbial consortium (21.17%), RDF (21.01%) and FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN + microbial consortium (20.85%). Significant improvement in starch content was observed with the application of organics during second year when compared to first year. Organic rice pose better nutritional quality (Saha *et al.*, 2007) and fetches higher market price. Amylase content was markedly higher with exclusive organic nutrition treatments compared to RDF during second year. Conspicuous improvement in quality aspects of rice under organic farming was also reported Raju *et al.* (2004). The starch content and milling per cent were higher with soil application of biodigester @ 2500 l ha^{-1} at 30, 60

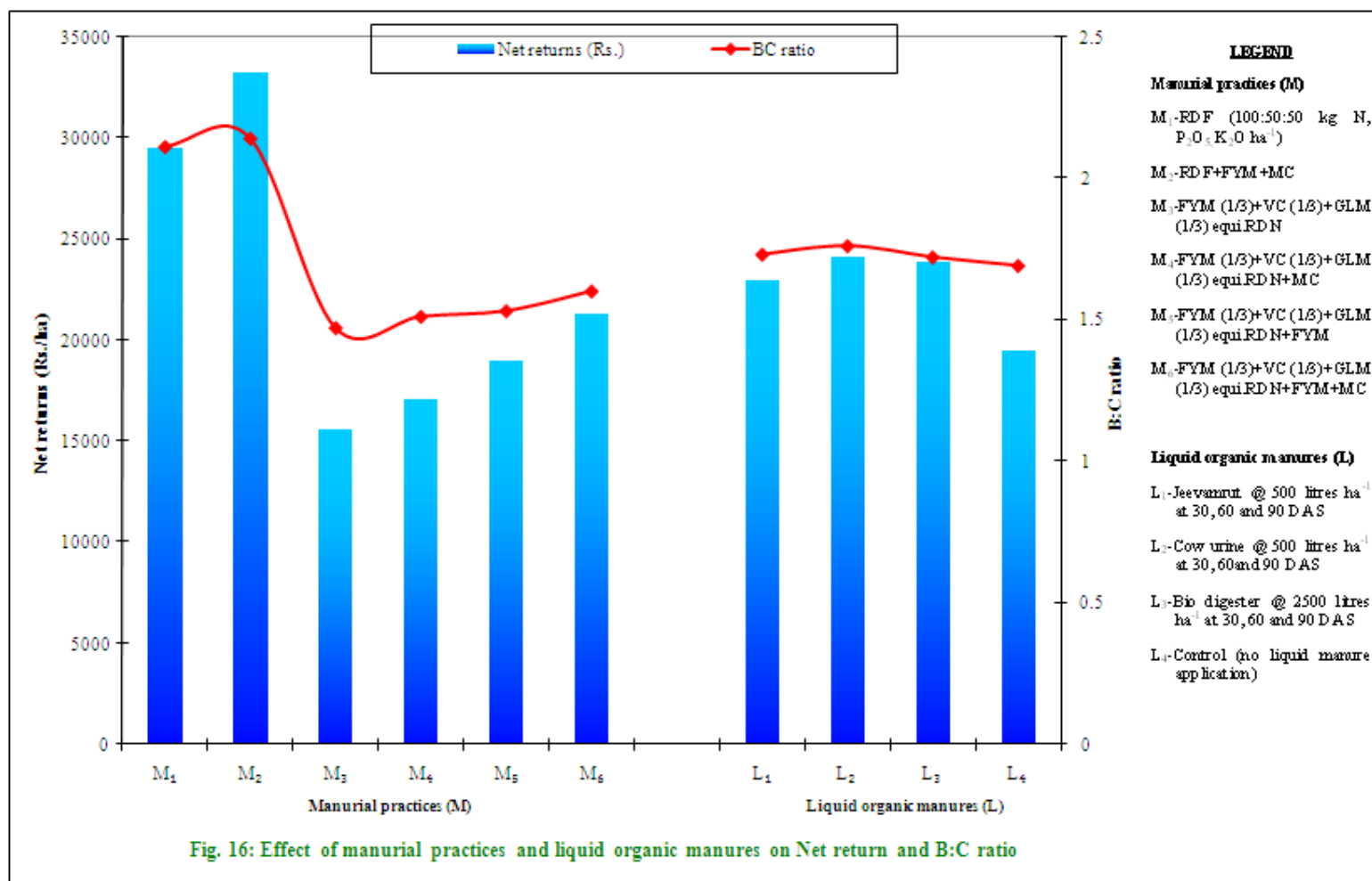
and 90 DAS which was on par with foliar application of cow urine @ 500 l ha⁻¹ at 30, 60 and 90 DAS (Table 24). The increase in quality attributes with either biodigester or cowurine might be ascribed to the beneficial effects of liquid organics.

5.3.13 Pest and disease incidence

Infestation of stem borer and incidence blast incidence was significantly higher with application of RDF followed by integrated use RDF + FYM + microbial consortium and organic nutrient management irrespective of the combinations (Table 60 and 61). Markedly lesser infestation of leaf folder in organically manured plots compared to plots received chemical fertilizers was reported by Singh *et al.* (1996). Further, comparatively poor canopy growth and number of tillers in organic manurial treatments might have created less favourable condition for the pest to buildup. Near similar observations was made by Hegde and Nagappa (2011) who recorded higher per cent leaf damage in line planting and random planting methods over System of Rice Intensification (SRI) and Integrated Crop Management (ICM) rice planting methods under irrigated rice ecosystem. Soils with a high functional diversity of microorganisms, which occur very often under organic agriculture practice, develop disease and insect suppressive properties and can help to induce resistance in plants (FileBbach *et al.*, 2007).

5.3.14 Economics

Application of RDF + FYM + microbial consortium (M₂) recorded significantly higher net returns (₹ 33,168 ha⁻¹) and Benefit: cost of 2.14 over rest of the treatments (Table 65 and Fig. 16). Significantly lower net returns (₹ 15,528 ha⁻¹) and Benefit: cost of 1.47 was recorded with application of FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN (M₃). Higher cost of production besides reduced yields lead to decreased returns from different exclusive organic farming treatments. Similar findings were also reported by Basavarajappa *et al.* (2007). Soil application of foliar application of cow urine @ 500 l ha⁻¹ at 30, 60 and 90 DAS (L₂) recorded significantly higher net returns (₹ 24,060 ha⁻¹) and Benefit: Cost ratio of 1.76 but was at par with biodigester @ 2500 l ha⁻¹ at 30, 60 and 90 DAS (L₃) and soil application of jeevamrut @ 500 l ha⁻¹ at 30, 60 and 90 DAS (L₁) (₹ 23,817 ha⁻¹ and ₹ 22,925 ha⁻¹ respectively). Among the treatment combinations, integrated application of RDF + FYM + microbial consortium and soil application of cowurine @ 500 l ha⁻¹ at 30, 60 and 90 DAS (M₂L₂)



recorded significantly higher net return ($\text{₹ } 34,595 \text{ ha}^{-1}$) and Benefit: Cost ratio of 2.17 over other treatments. The results are in conformity with Mehla and Panwar (2000), Mathew *et al.* (2008), Rajanna (2010) and Yogananda *et al.* (2010).

5.4 Results of practical utility

Any genuine innovation is rendered useless, if it has no practical utility. The adoption of technology by farmers being the main objective, a technology can be more easily adopted, if the farming community is convinced about its benefits. The results obtained in the present investigation revealed the following practical utilities for sustainable production of aerobic rice.

- Irrigation schedules at critical stages of crop growth resulted higher yield during *kharif* season in medium deep black soils.
- Sowing of aerobic rice at closer spacing of 30 cm x 10 cm realized higher grain yield and net returns.
- Integrated application of RDF + 5 t ha⁻¹FYM + microbial consortium and soil application of biodigester @ 2500 l ha⁻¹ at 30, 60 and 90 DAS could help in enhancing the productivity and net returns of aerobic rice under rainfed situations.
- Application of liquid organic manures, jeevamrut @ 500 l ha⁻¹ or cow urine @ 500 l ha⁻¹ or biodigester @ 2500 l ha⁻¹ had added advantage to increase the use efficiency of organic manures and for getting higher yield of aerobic rice.
- The organic nutrient management practices improved the maximum water holding capacity, soil organic carbon, soil available nitrogen, phosphorus, potassium, sulphur, soil microbial and enzyme activities.

5.5 Future line of work

- Interaction among irrigation, nutrient management and weed management in aerobic rice needs further investigation.
- Long term effect of organic manures on soil physical, chemical and biological properties along with quality parameters and yield needs further investigation.

6. SUMMARY AND CONCLUSIONS

Field experiments were carried out at Main Agricultural Research Station, Dharwad to investigate on “Planting geometry, irrigation and organic nutrient management practices for aerobic rice in northern transitional zone of Karnataka” on deep black soil (*Vertic inceptisols*) during *kharif* 2013 and 2014. The experiments were laid out in split split plot design for experiment I and split plot design for experiment II with three replications. The experiment I consisted of twenty four treatment combinations comprising of four main plots (scheduling of irrigation), three sub plots (planting geometry) and two sub sub plots (planting methods). Whereas, the experiment II consisted of twenty four treatment combinations comprising of six main plots (manurial practices) and four sub plots (liquid organic manures) which were replicated thrice. The results of two years of experimentation are summarized in this chapter.

6.1 Experiment-I: Response of aerobic rice to scheduling of irrigation, planting geometry and methods of planting

Scheduling irrigations at critical stages of crop growth recorded significantly higher grain yield (3914 kg ha^{-1}) and straw yield (5600 kg ha^{-1}) compared to all other irrigation schedules. Improved yield was attributed to superior yield attributing parameters like number of productive tillers m^{-2} (511.76), number of filled grains panicle $^{-1}$ (83.53), more panicle length (25.09 cm), higher panicle weight (2.58 g) and less chaffy grains panicle $^{-1}$ (14.89).

Irrigations at critical stages of crop growth recorded higher dry matter accumulation (1182.08 g m^{-2}) at harvest, plant height (55.66 cm), number of tillers m^{-2} at (566.32), leaf area (304.57 dm^2) and leaf area index (3.046) at 90 DAS compared to all other irrigation schedules.

The effect of irrigation scheduling on weed parameters was non significant up to 40 DAS during both the years. However, at later stages of crop growth, irrigations scheduled at critical stages, during both the years, resulted in significantly lesser total weed density (49.8 m^{-2}) and their corresponding dry weight (58.2 g m^{-2}) than with other irrigation schedules studied.

Higher WUE of $66.65 \text{ kg ha-cm}^{-1}$ was recorded with irrigations at critical stages. Among the irrigation schedules, significantly higher net returns ($\text{₹ } 32,917 \text{ ha}^{-1}$) and Benefit: Cost ratio of 2.21 was recorded with irrigation at critical stages.

Closer spacing of $30 \text{ cm} \times 10 \text{ cm}$ recorded significantly higher grain yield (3958 kg ha^{-1}) and straw yield (5911 kg ha^{-1}) as compared to $30 \text{ cm} \times 15 \text{ cm}$ (3622 and 4986 kg ha^{-1}) and $30 \text{ cm} \times 20 \text{ cm}$ (3009 and 3793 kg ha^{-1}). Significantly higher number of productive tillers m^{-2} (583) was recorded at optimum planting of $30 \text{ cm} \times 10 \text{ cm}$. Significantly higher number of filled grains panicle $^{-1}$ (83.95), panicle length (25.44 cm), panicle weight (2.78 g) and test weight (22.16 g) was recorded with wider spacing of $30 \times 20 \text{ cm}$ as compared to closer spacing.

Significantly higher plant height (67.64 cm) at harvest, tillers (642.30 m^{-2}) at 90 DAS, total dry matter (1231.20 g m^{-2}) at harvest, leaf area m^{-2} (380.42 dm^2) and leaf area index (3.805) was recorded with closer spacing of $30 \text{ cm} \times 10 \text{ cm}$. Sowing at $30 \text{ cm} \times 20 \text{ cm}$ (G_3) recorded significantly higher weed density (72.4 , 68.8 and 59.8 respectively) and weed dry matter (45 , 57.8 and 70.8 g respectively) at 20, 40DAS and at harvest.

Among the planting geometry, sowing at $30 \text{ cm} \times 10 \text{ cm}$ (G_1) recorded in significantly higher net returns ($\text{₹ } 33,909 \text{ ha}^{-1}$) and Benefit: Cost ratio of 2.25.

Interaction effects of scheduling of irrigation, planting geometry and methods of planting influenced the grain yield significantly. Treatment combination of sowing of sprouted seeds at $30 \text{ cm} \times 10 \text{ cm}$ with irrigation at critical stages ($I_4G_1P_2$) produced significantly higher grain yield (4383 kg ha^{-1}), straw yield (6788 kg ha^{-1}) and productive tillers m^{-2} (631.05). Whereas, sowing of sprouted seeds at $30 \text{ cm} \times 10 \text{ cm}$ with irrigation at IW/CPE of 1.0 ($I_2G_1P_2$) recorded significantly higher water use efficiency ($79.71 \text{ kg ha-cm}^{-1}$). Sowing of sprouted seeds at $30 \text{ cm} \times 10 \text{ cm}$ with irrigation at critical stages ($I_4G_1P_2$) produced significantly higher net returns ($\text{₹ } 40,482 \text{ ha}^{-1}$) and Benefit: Cost ratio of 2.48.

6.2 Experiment II: Studies on integrated organic nutrient management on growth, yield and quality of aerobic rice in Northern transitional zone of Karnataka

Among the manurial practices, application of RDF + FYM + microbial consortium recorded significantly higher grain yield (4086 kg ha^{-1}), straw yield (5380 kg ha^{-1}), productive tillers m^{-2} (438.66), filled grains panicle $^{-1}$ (86.87), panicle length (27.10 cm), higher panicle weight (2.84 g) and less chaffy grains panicle $^{-1}$ (9.41).

Further it also recorded higher dry matter accumulation (1182.08 g m^{-2}) at harvest, plant height (53.33 cm), number of tillers m^{-2} at (510.50), leaf area (277.96 dm^2) and leaf area index (2.780) at 90 DAS compared to other treatments.

Application of FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN with recommended FYM + microbial consortium recorded significantly higher N fixers (40.67 and $37.42 \times 10^3 \text{ cfu g soil}^{-1}$), PSB (42.58 and $40.25 \times 10^4 \text{ cfu g soil}^{-1}$) and *Azospirillum* spp. population (2.94 and $0.51 \times 10^6 \text{ cfu g soil}^{-1}$) at flowering and harvest respectively.

Higher dehydrogenase (14.64 and $13.10 \mu\text{g TPFg soil}^{-1} \text{ day}^{-1}$) and phosphatase (28.53 and $27.27 \mu\text{g pNP g soil}^{-1} \text{ hr}^{-1}$) activity in soil was recorded with application of FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN with recommended FYM + microbial consortium at flowering and harvest.

Irrespective of liquid organic manures, significantly lower leaf folder, stem borer, blast incidence and higher spider population was recorded with application of FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN + FYM + microbial consortium.

Application of FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN with recommended FYM + microbial consortium recorded higher maximum water holding capacity (54.21%) and organic carbon (5.71 g/kg).

Significantly higher amount of available nitrogen ($302.62 \text{ kg ha}^{-1}$), phosphorus (29.10 kg ha^{-1}), potassium ($316.12 \text{ kg ha}^{-1}$) and sulphur (14.48 ppm) found in soil after

harvest of the crop was observed with FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN along with 5 t of FYM ha⁻¹ + microbial consortium.

Application of FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN with recommended FYM + microbial consortium recorded significantly higher DTPA extractable soil iron (7.63 ppm), manganese (9.83ppm), copper (1.40 ppm) and zinc (0.94 ppm) over other treatments.

Significantly higher total nitrogen (96.19 kg ha⁻¹), phosphorus (21.05 kg ha⁻¹), potassium (86.04 kg ha⁻¹), iron (907.96 g ha⁻¹), manganese (1019.53 g ha⁻¹), zinc (285.89 g ha⁻¹) and copper (158.54 g ha⁻¹) uptake by grain and straw was observed with RDF + FYM + microbial consortium.

Higher protein (8.43%) and starch (21.78%) was observed with RDF + FYM + microbial consortium.

Application of RDF + FYM + microbial consortium (M₂) recorded significantly higher net returns (₹ 33,168 ha⁻¹) and Benefit: cost of 2.14.

Among the liquid organic manure treatments, soil application of biodigester @ 2500 l ha⁻¹ at 30, 60 and 90 DAS recorded significantly higher number of productive tillers hill⁻¹ (18.49), filled grains panicle⁻¹ (80.75), panicle length (24.31cm) panicle weight (2.30 g), grain yield (3396 kg ha⁻¹), straw yield (4083 kg ha⁻¹) and lower unfilled grains panicle⁻¹ (18.01), but was at par with foliar application of cow urine @ 500 l ha⁻¹ at 30, 60 and 90 DAS and soil application of jeevamrut @ 500 l ha⁻¹ at 30, 60 and 90 DAS.

Soil application of biodigester @ 2500 l ha⁻¹ at 30, 60 and 90 DAS recorded higher dry matter accumulation (972.25 g m⁻²) at harvest. It was due better crop growth like plant height (49.39 cm), number of tillers m⁻² (457.98), leaf area (265.44 dm²) and leaf area index (2.655) at 90 DAS compared to all other treatments.

Among the liquid organic manures, soil application of biodigester @ 2500 l ha⁻¹ at 30, 60 and 90 DAS recorded significantly higher N fixers (34.39 and 31.61 x10³ cfu g

soil⁻¹) PSB (31.00 and 28.33 x10⁴ cfu g soil⁻¹) and *Azospirillum* spp. population (1.90 and 0.31 x10⁴ cfu g soil⁻¹) at flowering and harvest respectively.

Among the liquid organic manures, soil application of biodigester @ 2500 l ha⁻¹ at 30, 60 and 90 DAS (L₃) recorded significantly higher dehydrogenase (13.83 and 12.39 µg TPFg soil⁻¹ day⁻¹) and phosphatase (26.99 and 25.74 µg pNP g soil⁻¹ hr⁻¹) at flowering and harvest.

Significantly lower leaf folder, stem borer, blast incidence and higher spider population were recorded with foliar application of cow urine @ 500 l ha⁻¹ at 30, 60 and 90 DAS.

Soil application of biodigester @ 2500 l ha⁻¹ at 30, 60 and 90 DAS recorded higher maximum water holding capacity (53.94%) and organic carbon (5.65g/kg).

Higher available nitrogen (297.92 kg ha⁻¹), phosphorus (29.73 kg ha⁻¹), potassium (312.57 kg ha⁻¹) and sulphur (14.49 ppm) was recorded with soil application of biodigester @ 2500 l ha⁻¹ at 30, 60 and 90 DAS.

Soil application of biodigester @ 2500 l ha⁻¹ at 30, 60 and 90 DAS recorded higher DTPA extractable soil iron (7.52 ppm), manganese (9.74 ppm), copper (1.29 ppm) and zinc (0.88 ppm) over other treatments.

Higher total nitrogen (74.48 kg ha⁻¹), phosphorus (16.88 kg ha⁻¹), potassium (72.62 kg ha⁻¹), iron (695.25 g ha⁻¹), manganese (785.40 g ha⁻¹), zinc (218.30 g ha⁻¹) and copper (114.97 g ha⁻¹) uptake by grain and straw was observed with soil application of biodigester @ 2500 l ha⁻¹ at 30, 60 and 90 DAS.

Higher protein (7.50%) and starch (21.37%) in grains was observed with soil application of biodigester @ 2500 l ha⁻¹ at 30, 60 and 90 DAS.

Foliar application of cow urine @ 500 l ha⁻¹ at 30, 60 and 90 DAS (L₂) recorded significantly higher net return (₹ 24,060 ha⁻¹) and Benefit: Cost ratio of 1.76.

Integrated application of RDF + FYM @ 5 t ha⁻¹ + microbial consortium and soil application of biodigester @ 2500 l ha⁻¹ at 30, 60 and 90 DAS recorded significantly higher number of productive tillers m⁻² (466.62), filled grains panicle⁻¹

(92.97), panicle length (27.72 cm), panicle weight (3.19 g), grain yield (4262 kg ha⁻¹), straw yield (6033 kg ha⁻¹) and lower unfilled grains panicle⁻¹ (11.40) over other treatments.

Integrated application of RDF + FYM @ 5 t ha⁻¹ + microbial consortium and soil application of biodigester @ 2500 l ha⁻¹ at 30, 60 and 90 DAS recorded higher dry matter accumulation (1238.39 g m⁻²) at harvest. It was due better crop growth like plant height (54.75 cm), number of tillers m⁻² (537.72), leaf area (295.26 dm²) and leaf area index (2.953) at 90 DAS compared to all other treatments.

Among the treatment combinations, integrated application of FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN with recommended FYM + microbial consortium with soil application of biodigester @ 2500 l ha⁻¹ at 30, 60 and 90 DAS (M₆L₃) recorded significantly higher N fixers (42.67 and 39.83 x10³ cfu g⁻¹ soil), PSB (44.17 and 41.83 x10⁴ cfu g⁻¹ soil) and *Azospirillum* spp. population (3.95 and 0.80 x10⁴ cfu g⁻¹ soil) at flowering and harvest respectively.

Integrated application of FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN with recommended FYM + microbial consortium with soil application of biodigester @ 2500 l ha⁻¹ at 30, 60 and 90 DAS recorded significantly higher dehydrogenase (15.72 and 14.27 µg TPF g⁻¹ soil day⁻¹) and phosphatase (29.89 and 28.66 µg pNP g⁻¹ soil h⁻¹) at flowering and harvest.

Integrated application of FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN with recommended FYM + microbial consortium with foliar application of cow urine @ 500 l ha⁻¹ at 30, 60 and 90 DAS recorded lower leaf folder, stem borer, blast incidence and higher spider population

Integrated application of FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN with recommended FYM + microbial consortium with soil application of biodigester @ 2500 l ha⁻¹ at 30, 60 and 90 DAS recorded higher maximum water holding capacity (54.97%) and organic carbon (5.97 g/kg).

Integrated application of FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN with recommended FYM + microbial consortium with soil

application of biodigester @ 2500 l ha⁻¹ at 30, 60 and 90 DAS recorded higher available nitrogen (310.46 kg ha⁻¹), phosphorus (30.90 kg ha⁻¹), potassium (328.16 kg ha⁻¹) and sulphur (15.16 ppm) found in soil after harvest of the crop.

Higher DTPA extractable soil iron (7.89 ppm), manganese (10.10 ppm), copper (1.50 ppm) and zinc (1.00 ppm) was observed with Integrated application of FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN with recommended FYM + microbial consortium with soil application of biodigester @ 2500 l ha⁻¹ at 30, 60 and 90 DAS.

Significantly higher total nitrogen (108.11 kg ha⁻¹), phosphorus (23.73 kg ha⁻¹), potassium (101.87 kg ha⁻¹), iron (1003.91 g ha⁻¹), manganese (1126.33 g ha⁻¹), zinc (312.84 g ha⁻¹) and copper (174.58 g ha⁻¹) uptake by grain and straw was observed with integrated application of RDF + FYM @ 5 t ha⁻¹ + microbial consortium and soil application of biodigester @ 2500 l ha⁻¹ at 30, 60 and 90 DAS.

Integrated application of RDF + FYM @ 5 t ha⁻¹ + microbial consortium and soil application of biodigester @ 2500 l ha⁻¹ at 30, 60 and 90 DAS recorded higher protein (8.75%) and starch (22.70%).

Among the treatment combinations, integrated application of RDF + FYM + microbial consortium and foliar application of cowurine @ 500 l ha⁻¹ at 30, 60 and 90 DAS (M₂L₂) recorded significantly higher net returns (₹ 34,595 ha⁻¹) and Benefit: Cost ratio of 2.17 over other treatments.

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* - *Originals not seen*

Appendix I: Chemical composition of media used**Free living N fixers (Azotobacter) – per 1000 ml**

K ₂ HPO ₄	- 1.0 g
MgSO ₄	- 0.2 g
CaCO ₃	-1.0 g
NaCl	- 0.2 g
Glucose	- 10 g
Agar	- 16 g
pH	- 7.2

Phosphate Solubilizing Bacteria - per 1000 ml

Glucose	- 10 g
Yeast extract	- 0.5 g
MgSO ₄	-0.25 g
CaCl ₂	-0.10 g
Agar	- 16 g
TCP	-5 g

Azospirillum – per 1000 ml

Malic acid	- 5 g
NaOH/KOH	-3 g
K ₂ HPO ₄	-0.5 g
FeSO ₄ H ₂ O	- 0.1 g
MnSO ₄	-0.1 g
MgSO ₄ 7H ₂ O	-0.1 g
NaCl	- 0.02 g
CaCl ₂ H ₂ O	- 0.01 g
Na ₂ MoO ₄	- 0.002 g
Agar	- 2 g
BTB (0.5% alcohol)	- 2 ml
pH	- 6.5

Appendix II: Price of input and outputs in calculating cost of cultivation

Sl. No.	Particulars	Unit	Price (₹)	
			2013	2014
A	Inputs			
1)	Seeds	Per kg	32.0	32.0
2)	Manures and fertilizers			
	i) Urea	Per kg	6.0	6.0
	ii) DAP	Per kg	25.0	25.0
	iii) MOP	Per kg	17.7	17.7
	iv) Farmyard manure	Per tonne	500	500
	v) Vermicompost	Per tonne	2000	2000
	vi) Green leaf manure	Per tonne	250	250
	vii) Azospirillum	Per kg	60.0	60.0
	viii) PSB	Per kg	60.0	60.0
3)	Fermented organics			
	i) Jeevamrut	Per litre	1.50	1.50
	ii) Cow urine	Per litre	1.50	1.50
	iii) Biodigester	Per litre	0.50	0.50
4)	Biopesticides			
	i) Metarrhizium	Per kg	200	200
	ii) Pseudomonas	Per kg	100	100
5)	Chemicals			
	i) Butachlor	Per litre	350	350
	ii) 2,4-D Sodium salt	Per kg	280	280
	iii) Azadirachtin	Per litre	300	300
3)	Labour			
	i) Man/Woman	Per day	157	235
B)	Outputs			
	i) Paddy	kg	14.00	14.00
	ii) Paddy (organic 20% premium)	kg	16.80	16.80
	iii) Straw	kg	1.00	1.00

Appendix III: Chemical composition of FYM, vermicompost and green leaf manure (Gliricidia)

Sl. No.	Particulars	Nutrients (%)		
		Nitrogen	Phosphorus	Potassium
1.	FYM	0.5	0.35	0.50
2.	Vermicompost	1.0	0.86	0.98
3.	GLM (Gliricidia)	0.5	0.23	0.32

Appendix IV: Analytical values of Jeevamrut, Cow urine and Biodigester

Sl. No.	Parameters	Unit	Jeevamrut	Cow urine	Bio-digester
1.	pH	-	7.07	7.12	7.29
2.	Soluble salt (EC)	dsm^{-1}	3.40	1.79	1.09
3.	Total Nitrogen	ppm	770	1200	255
4.	Total Phosphorus	ppm	166	800	79
5.	Total Potassium	ppm	126	1100	42
6.	Total Zinc	ppm	4.29	1.31	0.52
7.	Total Copper	ppm	1.58	0.42	1.24
8.	Total Iron	ppm	282	32.24	9.60
9.	Total Manganese	ppm	10.7	1.14	8.30

Appendix V: Details of cost of cultivation in interactions of irrigation schedules, planting geometry and methods of planting during 2013

Particulars	I ₁ G ₁ P ₁	I ₁ G ₁ P ₂	I ₁ G ₂ P ₁	I ₁ G ₂ P ₂	I ₁ G ₃ P ₁	I ₁ G ₃ P ₂	I ₂ G ₁ P ₁	I ₂ G ₁ P ₂	I ₂ G ₂ P ₁	I ₂ G ₂ P ₂	I ₂ G ₃ P ₁	I ₂ G ₃ P ₂	I ₃ G ₁ P ₁	I ₃ G ₁ P ₂	I ₃ G ₂ P ₁	I ₃ G ₂ P ₂	I ₃ G ₃ P ₁	I ₃ G ₃ P ₂	I ₄ G ₁ P ₁	I ₄ G ₁ P ₂	I ₄ G ₂ P ₁	I ₄ G ₂ P ₂	I ₄ G ₃ P ₁	I ₄ G ₃ P ₂	
Land preparation																									
Ploughing	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000
Cultivation	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
Harrowing	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800
Sowing																									
Seeds	672	672	448	448	336	336	672	672	448	448	336	336	672	672	448	448	336	336	672	672	448	448	336	336	
Seed Treat	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	
Sowing	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	
Manures																									
FYM	2500	2500	2500	2500	2500	2500	2500	2500	2500	2500	2500	2500	2500	2500	2500	2500	2500	2500	2500	2500	2500	2500	2500	2500	
Fertilizers																									
UREA	1049	1049	1049	1049	1049	1049	1049	1049	1049	1049	1049	1049	1049	1049	1049	1049	1049	1049	1049	1049	1049	1049	1049	1049	
DAP	2717	2717	2717	2717	2717	2717	2717	2717	2717	2717	2717	2717	2717	2717	2717	2717	2717	2717	2717	2717	2717	2717	2717	2717	
MOP	1475	1475	1475	1475	1475	1475	1475	1475	1475	1475	1475	1475	1475	1475	1475	1475	1475	1475	1475	1475	1475	1475	1475	1475	
Application charges	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	
Herbicides	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	
Hand weeding	2500	2500	2500	2500	2500	2500	2500	2500	2500	2500	2500	2500	2500	2500	2500	2500	2500	2500	2500	2500	2500	2500	2500	2500	
Intercultivation	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	
Plant protection	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	
Irrigation	750	750	750	750	750	750	750	750	750	750	750	750	750	750	750	750	750	750	750	1250	1250	1250	1250	1250	
Harvesting and threshing	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	
Total	26293	26293	26069	26069	25957	25957	26293	26293	26069	26069	25957	25957	26293	26293	26069	26069	25957	25957	26793	26793	26569	26569	26457	26457	

Appendix VI: Details of cost of cultivation in interactions of of irrigation schedules, planting geometry and methods of planting during 2014

Particulars	I ₁ G ₁ P ₁	I ₁ G ₁ P ₂	I ₁ G ₂ P ₁	I ₁ G ₂ P ₂	I ₁ G ₃ P ₁	I ₁ G ₃ P ₂	I ₂ G ₁ P ₁	I ₂ G ₁ P ₂	I ₂ G ₂ P ₁	I ₂ G ₂ P ₂	I ₂ G ₃ P ₁	I ₂ G ₃ P ₂	I ₃ G ₁ P ₁	I ₃ G ₁ P ₂	I ₃ G ₂ P ₁	I ₃ G ₂ P ₂	I ₃ G ₃ P ₁	I ₃ G ₃ P ₂	I ₄ G ₁ P ₁	I ₄ G ₁ P ₂	I ₄ G ₂ P ₁	I ₄ G ₂ P ₂	I ₄ G ₃ P ₁	I ₄ G ₃ P ₂	
Land preparation																									
Ploughing	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000
Cultivation	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
Harrowing	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800
Sowing																									
Seeds	672	672	448	448	336	336	672	672	448	448	336	336	672	672	448	448	336	336	672	672	448	448	336	336	336
Seed Treat	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
Sowing	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500
Manures																									
FYM	2500	2500	2500	2500	2500	2500	2500	2500	2500	2500	2500	2500	2500	2500	2500	2500	2500	2500	2500	2500	2500	2500	2500	2500	2500
Fertilizers																									
UREA	1049	1049	1049	1049	1049	1049	1049	1049	1049	1049	1049	1049	1049	1049	1049	1049	1049	1049	1049	1049	1049	1049	1049	1049	1049
DAP	2717	2717	2717	2717	2717	2717	2717	2717	2717	2717	2717	2717	2717	2717	2717	2717	2717	2717	2717	2717	2717	2717	2717	2717	2717
MOP	1475	1475	1475	1475	1475	1475	1475	1475	1475	1475	1475	1475	1475	1475	1475	1475	1475	1475	1475	1475	1475	1475	1475	1475	1475
Application charges	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
Herbicides	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800
Hand weeding	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000
Intercultivation	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
Plant protection	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500
Irrigation	500	500	500	500	500	500	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
Harvesting and threshing	4500	4500	4500	4500	4500	4500	4500	4500	4500	4500	4500	4500	4500	4500	4500	4500	4500	4500	4500	4500	4500	4500	4500	4500	4500
Total	28043	28043	27819	27819	27707	27707	28543	28543	28319	28319	28207	28207	28543	28543	28319	28319	28207	28207	28543	28543	28319	28319	28207	28207	

Appendix VII: Details of cost of cultivation in interactions of different manurial practices and liquid organic manures during 2013

Particulars	M ₁ L ₁	M ₁ L ₂	M ₁ L ₃	M ₁ L ₄	M ₂ L ₁	M ₂ L ₂	M ₂ L ₃	M ₂ L ₄	M ₃ L ₁	M ₃ L ₂	M ₃ L ₃	M ₃ L ₄	M ₄ L ₁	M ₄ L ₂	M ₄ L ₃	M ₄ L ₄	M ₅ L ₁	M ₅ L ₂	M ₅ L ₃	M ₅ L ₄	M ₆ L ₁	M ₆ L ₂	M ₆ L ₃	M ₆ L ₄	
Land preparation																									
Ploughing	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000
Cultivation	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
Harrowing	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800
Sowing																									
seeds	448	448	448	448	448	448	448	448	448	448	448	448	448	448	448	448	448	448	448	448	448	448	448	448	448
Seed Treat	30	30	30	30	120	120	120	120	30	30	30	30	120	120	120	120	30	30	30	30	120	120	120	120	120
sowing	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200
Manures																									
FYM					2500	2500	2500	2500	3333	3333	3333	3333	3333	3333	3333	3333	5833	5833	5833	5833	5833	5833	5833	5833	5833
VC									6666	6666	6666	6666	6666	6666	6666	6666	6666	6666	6666	6666	6666	6666	6666	6666	6666
GLM									1667	1667	1667	1667	1667	1667	1667	1667	1667	1667	1667	1667	1667	1667	1667	1667	1667
Jeevamrut	2250				2250				2250				2250				2250				2250				
cow urine		2250				2250				2250				2250				2250				2250			
Biodigester			3750				3750				3750				3750				3750				3750		
Fertilizers																									
UREA	1049	1049	1049	1049	1049	1049	1049	1049																	
DAP	2717	2717	2717	2717	2717	2717	2717	2717																	
MOP	1475	1475	1475	1475	1475	1475	1475	1475																	
Application charges	1750	1750	1750	1000	1750	1750	1750	1000	1750	1750	1750	1000	1750	1750	1750	1000	1750	1750	1750	1000	1750	1750	1750	1000	1000
Herbicides	800	800	800	800	800	800	800	800																	
Hand weeding	2500	2500	2500	2500	2500	2500	2500	2500	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000
Intercultivation	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800
Plant protection	1500	1500	1500	1500	1500	1500	1500	1500	750	750	750	750	750	750	750	750	750	750	750	750	750	750	750	750	750
Irrigation	1250	1250	1250	1250	1250	1250	1250	1250	1250	1250	1250	1250	1250	1250	1250	1250	1250	1250	1250	1250	1250	1250	1250	1250	1250
Harvesting and threshing	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000
Total	26569	26569	28069	23569	29159	29159	30659	26159	32944	32944	34444	29944	33034	33034	34534	30034	35444	35444	36944	32444	35534	35534	37034	32534	

Appendix VIII: Details of cost of cultivation in interactions of different manurial practices and liquid organic manures during 2014

Particulars	M ₁ L ₁	M ₁ L ₂	M ₁ L ₃	M ₁ L ₄	M ₂ L ₁	M ₂ L ₂	M ₂ L ₃	M ₂ L ₄	M ₃ L ₁	M ₃ L ₂	M ₃ L ₃	M ₃ L ₄	M ₄ L ₁	M ₄ L ₂	M ₄ L ₃	M ₄ L ₄	M ₅ L ₁	M ₅ L ₂	M ₅ L ₃	M ₅ L ₄	M ₆ L ₁	M ₆ L ₂	M ₆ L ₃	M ₆ L ₄	
Land preparation																									
Ploughing	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000
Cultivation	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
Harrowing	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800
Sowing																									
seeds	448	448	448	448	448	448	448	448	448	448	448	448	448	448	448	448	448	448	448	448	448	448	448	448	448
Seed Treat	30	30	30	30	120	120	120	120	30	30	30	30	120	120	120	120	30	30	30	30	120	120	120	120	120
sowing	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500
Manures																									
FYM					2500	2500	2500	2500	3333	3333	3333	3333	3333	3333	3333	3333	5833	5833	5833	5833	5833	5833	5833	5833	5833
VC									6666	6666	6666	6666	6666	6666	6666	6666	6666	6666	6666	6666	6666	6666	6666	6666	6666
GLM									1667	1667	1667	1667	1667	1667	1667	1667	1667	1667	1667	1667	1667	1667	1667	1667	1667
Jeevamrut	2250				2250				2250				2250				2250				2250				
Cow urine		2250				2250				2250			2250					2250				2250			
Biodigester			3750				3750				3750				3750				3750					3750	
Fertilizers																									
UREA	1049	1049	1049	1049	1049	1049	1049	1049																	
DAP	2717	2717	2717	2717	2717	2717	2717	2717																	
MOP	1475	1475	1475	1475	1475	1475	1475	1475																	
Application charges	1750	1750	1750	1000	1750	1750	1750	1000	1750	1750	1750	1000	1750	1750	1750	1000	1750	1750	1750	1000	1750	1750	1750	1750	1000
Herbicides	800	800	800	800	800	800	800	800																	
Hand weeding	3000	3000	3000	3000	3000	3000	3000	3000	4500	4500	4500	4500	4500	4500	4500	4500	4500	4500	4500	4500	4500	4500	4500	4500	4500
Intercultivation	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
Plant protection	1500	1500	1500	1500	1500	1500	1500	1500	750	750	750	750	750	750	750	750	750	750	750	750	750	750	750	750	750
Irrigation	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
Harvesting and threshing	4500	4500	4500	4500	4500	4500	4500	4500	4500	4500	4500	4500	4500	4500	4500	4500	4500	4500	4500	4500	4500	4500	4500	4500	4500
Total	27819	27819	29319	24819	30409	30409	31909	27409	34194	34194	35694	31194	34284	34284	35784	31284	36694	36694	38194	33694	36784	36784	38284	33784	

PLANTING GEOMETRY, IRRIGATION AND ORGANIC NUTRIENT MANAGEMENT PRACTICES FOR AEROBIC RICE IN NORTHERN TRANSITIONAL ZONE OF KARNATAKA

SHAIK JAFFAR BASHA

2015

Dr. R. BASAVARAJAPPA
Major Adviser

ABSTRACT

Field experiments were conducted in two successive seasons, namely “Response of aerobic rice to scheduling of irrigation, planting geometry and methods of planting” and “Studies on integrated organic nutrient management on growth, yield and quality of aerobic rice in Northern transitional zone of Karnataka” during *khari* 2013-14 and 2014-15 at Main Agricultural Research Station, UAS, Dharwad. The pooled data of two years showed that, treatment combination of sowing of sprouted seeds at 30 cm x 10 cm with irrigation at critical stages produced significantly higher grain yield (4383 kg ha⁻¹), straw yield (6788 kg ha⁻¹) and productive tillers m⁻² (631), higher net returns (₹ 40,482 ha⁻¹) and BCR of 2.48. Whereas, sowing of sprouted seeds at 30 cm x 10 cm with irrigation at IW/CPE of 1.0 recorded significantly higher WUE (79.71 kg ha-cm⁻¹). In second trial, Integrated application of RDF + FYM @ 5 t ha⁻¹ + microbial consortium and soil application of biodigester @ 2500 l ha⁻¹ at 30, 60 and 90 DAS recorded significantly higher grain yield (4262 kg ha⁻¹), straw yield (6033 kg ha⁻¹), number of productive tillers m⁻² (466), filled grains panicle⁻¹ (92.97), panicle length (27.72 cm), panicle weight (3.19 g) and higher dry matter accumulation (1238.39 g m⁻²) at harvest. Integrated application of FYM (1/3) + VC (1/3) + GLM (*Gliricidia*) (1/3) equivalent to RDN with recommended FYM + microbial consortium with soil application of biodigester @ 2500 l ha⁻¹ at 30, 60 and 90 DAS recorded significantly higher MWHC, organic carbon, available NPK and sulphur, higher N fixers, PSB, *Azospirillum* spp. population, dehydrogenase and phosphatase activity. Integrated application of RDF + FYM + microbial consortium and foliar application of cowurine @ 500 l ha⁻¹ at 30, 60 and 90 DAS recorded significantly higher net returns (₹ 34,595 ha⁻¹) and BCR of 2.17.