

**NITROGEN AND WEED MANAGEMENT FOR
MAXIMIZING THE PRODUCTIVITY AND
QUALITY OF AROMATIC RICE UNDER
AEROBIC CULTURE IN SOUTHERN
AGRO-CLIMATIC ZONE OF
ANDHRA PRADESH**

BY
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M.Sc. (Ag.)

**THESIS SUBMITTED TO THE
ACHARYA N. G. RANGA AGRICULTURAL UNIVERSITY
IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE AWARD OF THE DEGREE OF**

**DOCTOR OF PHILOSOPHY IN AGRICULTURE
(AGRONOMY)**

CHAIRPERSON: Dr. D. SRINIVASULU REDDY



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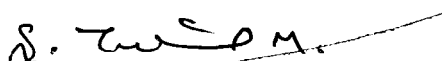
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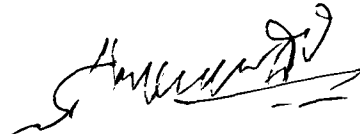
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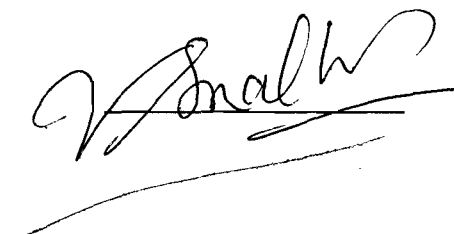
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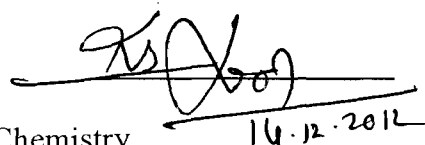
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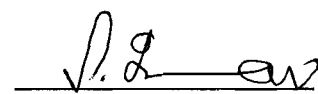
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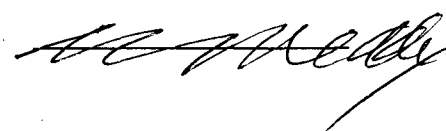
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Acknowledgement

*I deem it as a great privilege to express my profound gratitude and adoration to the Chairman of my Advisory Committee **Dr. D. Srinivasulu Reddy**, Professor and Head, Department of Agronomy, S. V. Agricultural College, Tirupati for his erudite counsel, persistent encouragement, dedicated interest, arduous support, benevolent and genial attitude coupled with compassion, endurance and conviction, which helped me in consummating this study. It is indeed a lifetime memorable learning experience of my academic career to have the prospect of working under his meticulous and exciting guidance.*

*I am immensely grateful to **Dr. V. Sumathi**, Professor, Department of Agronomy, S.V.Agricultural College, Tirupathi, **Dr. K. Sreenivasulu Reddy**, Professor and Head, Department of Soil Science and Agricultural Chemistry, S.V.Agricultural College, Tirupati and **Dr. S. Ismail**, Principle scientist RARS, Tirupati, the members of advisory committee, for their precious guidance and magnificent suggestions, during the period of investigation.*

*It gives me enormous pleasure in extending my sincere thanks to **Dr.V.Sridhar**, Professor, **Dr.G.Prabhakara Reddy**, Professor and **Dr.D.Subramanyam, Dr.Nagavani, Dr. Sunitha, and Dr. Reddi Ramu** Assistant Professors, Department of Agronomy for their valuable, timely suggestions, untiring help and support for successful and pleasant completion of the work for which act of kindness I am highly indebted to them. I extend my sincere thanks to **S. Vishala** Teaching Associate, **Dr.M.Srinivasulu Reddy**, **U.vijayabhaskar Reddy** and **M.S.Rahul** Assistant Professors, Agricultural college, Mahanandi for taking keen interest, sensible support and steady encouragement*

*I express my genuine appreciation to **Dr. B. Ravindranatha Reddy** Associate Dean, Agril. College, Mahanandi for his kind and co-operation during the study.*

*I owe a great debt of gratitude to **Dr.G.Krishna Reddi**, (Agronomy), Senior Scientist RARS Tirupati for his wholehearted support and help. I extend my heartfelt thanks to **Smt Pratima** Scientist, RARS Tirupati, **SmtAdilakshmi**, Scientist, APRRI, Maruteru for their much needed support and encouragement.*

I feel great pleasure and express my earnest thankfulness to farm staff for their sustained help and cooperation during field works.

*I honestly thank **Sri.Kodanda Rami Reddy, Jeevan Babu, Sudhakar** and **Venkataramaiah**, Non-teaching staff, Department of Agronomy for timely cooperation and help during course of the study.*

*I express my heart full affection and submit everything to the lotus feet of my parents **Sri Nadhamuni Reddy and Smt Sivabhushanamma** for their unstinted support and encouragement throughout my academic career, brothers **Dhanumjaya Reddy and Subramanyam Reddy** and my sister-in-law **Shanti and Vani** for their guidance and support during the course of this study.*

*I am in dearth of words to express my love and affection to my spouse **Arunasri** for her untiring support, sustained care and encouragement during this study. I am also thankful to my lovely children **Chaitu, Madhav and Tanish** for their inspiring affection during this period.*

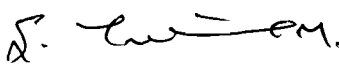
*My sincere thanks are due to my seniors, **Prathap, Kalyani**, classmates **D. Chinnam Naidu, V. Saida Naik** and Ph.D scholar **Ganga Devi**, well wisher **Bhaskar sir, B.V. Srinivasulu sir** and my friends, **Kiran, Narasimhulu, Shiva, Syam, and Swamy** for their cooperation, wonderful and exciting companionship.*

*I am grateful to Acharya N G Ranga Agricultural University, Hyderabad for providing me the study leave to pursue my Ph. D. Programme. I am also enormously thankful to **Dr.K. Veeranjanyulu**, University Librarian for providing excellent library facilities at Tirupathi and Hyderabad.*

*I am also thankful to of **Sri K.Pradeep Kumar, L.S. nagar, Tirupati** for neat typing and execution of my thesis work.*

I pay thanks to all my well wishers, not placed here, who helped me directly or indirectly during course of study.

*I am eternally indebted to **LORD SRI VENKATESWARA** and **Sri Shirdi Sai** for their lavish blessings and it is by their grace, I could bring to light this humble piece of work.*


(S. Tirumala Reddy )

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LIST OF SYMBOLS AND ABBREVIATIONS

%	:	Per cent
@	:	at the rate of
₹	:	Rupees
a.i.	:	Active ingredient
°C	:	Degree Celsius
CD (P=0.05%)	:	Critical Difference at 5 per cent level
cm	:	Centimeter
DAS	:	Days after sowing
dSm ⁻¹	:	Decisiemen per metre
ha ⁻¹	:	Per hectare
EC	:	Electrical Conductivity
<i>et al.</i>	:	and other people
fb	:	followed by
Fig.	:	Figure
g	:	Gram
HW	:	Hand weeding
i.e.	:	that is
K/K ₂ O	:	Potassium
kg ha ⁻¹	:	Kilogram per hectare
g ha ⁻¹	:	Gram per hectare
g l ⁻¹	:	Gram per litre
l	:	litre
LAI	:	Leaf Area Index
L: B ratio	:	Length breadth ratio
m ²	:	Metre square
mm day ⁻¹	:	Millimetre per day
Mt	:	Million tonnes
N	:	Nitrogen
NS	:	Non significant
P/P ₂ O ₅	:	Phosphorous
PE	:	Pre emergence
pH	:	Hydrogen ion concentration
RH	:	Relative humidity
SEm±	:	Standard Error of mean
viz.,	:	Namely
Vs.	:	Against

ABSTRACT

Name of the Author : **S. TIRUMALA REDDY**

Title of the thesis : **NITROGEN AND WEED MANAGEMENT PRACTICES FOR MAXIMIZING THE PRODUCTIVITY AND QUALITY OF AROMATIC RICE UNDER AEROBIC CULTURE IN SOUTHERN AGRO-CLIMATIC ZONE OF ANDHRA PRADESH**

Degree to which it is submitted : **Doctor of Philosophy**

Faculty : **AGRICULTURE**

Department : **AGRONOMY**

Chairperson : **Dr. D. SRINIVASULU REDDY**

University : **Acharya N.G. Ranga Agricultural University**

Year of submission : **2012**

Field experiments were carried out for two consecutive years of *rabi*, 2009, and 2010 on sandy clay loam soils of S.V. Agricultural College, Tirupati to evaluate the nitrogen and weed management practices for maximizing the productivity and quality of aromatic rice under aerobic culture in Southern Agro-climatic Zone of Andhra Pradesh. The experiment was laid out in split plot design, replicated thrice. The treatments consisted of four levels of nitrogen *viz.*, 100 kg ha⁻¹ (N₁), 120 kg ha⁻¹ (N₂), 140 kg ha⁻¹ (N₃) and 160 kg ha⁻¹ (N₄) as main plots, seven weed management practices *viz.*, Un-weeded check (W₁), Pre emergence (PE) application of pretilachlor @ 500 g a.i ha⁻¹ (W₂), PE of oxadiargyl @ 75 g a.i ha⁻¹ (W₃), PE of pyrazosulfuron ethyl @ 20 g a.i ha⁻¹ (W₄), PE of pretilachlor @ 500 g a.i ha⁻¹ followed by (fb) HW at 25 DAS (W₅), PE of oxadiargyl @ 75 g a.i ha⁻¹ fb HW at 25 DAS (W₆) and PE of pyrazosulfuron ethyl @ 20 g a.i ha⁻¹ fb HW at 25 DAS (W₇) as sub plots. The test variety of rice was Sugandha samba (RNR 2465).

Growth parameters of aromatic rice increased with increasing nitrogen levels and recorded the highest values with the application of 160 kg N ha⁻¹, which was comparable to 140 kg N ha⁻¹, while at their lowest with 100 kg N ha⁻¹.

Among weed management practices, pre emergence application of oxadiargyl @ 75 g a.i ha⁻¹ fb HW at 25 DAS, resulted in producing the highest growth parameters, which was statistically on par with PE application of pyrazosulfuron ethyl @ 20 g a.i ha⁻¹ fb HW at 25 DAS, while the lowest was recorded with un-weeded check.

All the yield attributes viz., number of panicles m⁻², panicle length, total number of grains panicle⁻¹, number of filled grains panicle⁻¹ and thousand grain weight recorded the highest values with the application of 140 kg N ha⁻¹, and further increase in nitrogen level 160 kg ha⁻¹, yield attributes decreased slightly. The lowest values of yield attributes observed with 100 kg N ha⁻¹. Pre emergence application of oxadiargyl @ 75 g a.i ha⁻¹ fb HW at 25 DAS was effective and it was at par with pyrazosulfuron ethyl @ 20 g a.i ha⁻¹ fb HW at 25 DAS in producing all the yield attributes. The lowest values of above parameters were found with un-weeded check. With regard to spikelet sterility, the reverse trend was recorded.

The highest grain yield and harvest index was realized with the application of nitrogen 140 kg ha⁻¹, where as the highest straw yield was produced with 160 kg N ha⁻¹. The lowest values of all the above were noticed with 100 kg ha⁻¹. The highest grain and straw yields including harvest index were obtained with pre emergence application of oxadiargyl @ 75 g a.i ha⁻¹ fb HW at 25 DAS, which was comparable with PE application of pyrazosulfuron ethyl @ 20 g a.i ha⁻¹ fb HW at 25 DAS. All the above parameters were recorded at their lowest with un-weeded check.

Grain quality parameters viz., kernel length, breadth, amylose content of grain was influenced only by nitrogen levels and recorded the highest values with the application of 160 kg N ha⁻¹, which was comparable to 140 kg N ha⁻¹, where as milling percent and protein content of grain was significantly influenced by both nitrogen and weed management practices and milling percent followed exactly the similar trend of grain yield and the protein content of grain followed the similar trend as that of straw yield. The head rice recovery, length : breadth ratio and volume expansion of rice were not influenced either by nitrogen or weed management practices during both the years of study.

At all the stages of observation, the highest nitrogen uptake by crop was recorded with highest level of nitrogen 160 kg ha⁻¹, where as phosphorus and potassium uptake was recorded with 140 kg N ha⁻¹ and these were in turn comparable with each other. The highest nitrogen, phosphorus and potassium by crop was recorded with PE application of oxadiargyl @ 75 g a.i ha⁻¹ fb HW at 25 DAS, which was comparable with pyrazosulfuron ethyl @ 20 g a.i ha⁻¹ fb HW at 25 DAS, while the lowest were recorded with un-weeded check (W₁).

Weed species belonging to eight taxonomic families were observed in the experimental field, of which five species were grasses, three species were sedges and twelve species were broad leaved weeds.

At all the stages of observation, density and dry matter production of grasses, sedges, broad leaved weeds and total of all category of weeds recorded

the lowest with 100 kg ha⁻¹ nitrogen application, where as the highest values were associated with 160 kg N ha⁻¹, which was comparable with 140 kg N ha⁻¹. The pre emergence application of oxadiargyl @ 75 g a.i ha⁻¹ fb HW at 25 DAS recorded the lowest density and dry matter production of grasses. PE application of pyrazosulfuron ethyl @ 20 g a.i ha⁻¹ fb HW at 25 DAS recorded lowest density and dry matter production of broad leaved weeds. PE application of oxadiargyl @ 75 g a.i ha⁻¹ or pyrazosulfuron ethyl @ 20 g a.i ha⁻¹ fb HW at 25 DAS were comparable with each other in reducing density and dry matter production of sedges. The pre emergence application of oxadiargyl @ 75 g a.i ha⁻¹ fb HW at 25 DAS recorded the lowest density and dry matter production of total weeds. The highest density and dry matter production of all the categories of weeds were associated with un-weeded check. Nitrogen levels did not exert any significant influence on WCE, where as the influence of different weed management practices on WCE followed exactly the similar trend of total density and dry matter production of weeds.

The lowest uptake of nutrients by weeds was obtained with 100 kg N ha⁻¹, while the highest was noticed with 160 kg ha⁻¹. The lowest nutrient uptake by weeds was recoded with pre emergence application of oxadiargyl @ 75 g a.i ha⁻¹ fb hand weeding at 25 DAS, which was comparable to PE application of pyrazosulfuron ethyl @ 20 g a.i ha⁻¹ fb HW at 25 DAS, where as the highest was recorded with un-weeded check.

The highest gross and net returns including benefit-cost ratio were realized with 140 kg N ha⁻¹, which was comparable to 160 kg N ha⁻¹. Pre emergence application of oxadiargyl @ 75 g a.i ha⁻¹ fb HW at 25 DAS recorded the highest gross and net returns, where as PE application of pyrazosulfuron ethyl @ 20 g a.i ha⁻¹ fb HW at 25 DAS resulted in highest benefit-cost ratio and these were in turn comparable with each other in recording higher economic returns. The lowest gross and net returns with lower benefit - cost ratio were realized with un-weeded check.

Increasing levels of nitrogen supply enhanced the post harvest soil available nitrogen up to the highest level 160 kg ha⁻¹, where as the highest soil available phosphorus and potassium were recorded with 140 kg N ha⁻¹ and these were in turn comparable with each other. Pre emergence application of oxadiargyl @ 75 g a.i ha⁻¹ fb HW at 25 DAS resulted in the highest soil available nitrogen, phosphorus and potassium, which was comparable with PE application of pyrazosulfuron ethyl @ 20 g a.i ha⁻¹ fb HW at 25 DAS, while the lowest values of post harvest soil nutrient status was noticed with un-weeded check.

In conclusion, the study revealed that the higher grain yield and quality of aromatic rice with maximum economic returns were achieved with combination of nitrogen application 140 kg ha⁻¹ and pre emergence application of oxadiargyl @ 75 g a.i ha⁻¹ fb HW at 25 DAS, which was however, comparable with the same level of nitrogen and PE of pyrazosulfuron ethyl @ 20 g ha⁻¹ fb HW at 25 DAS. Quality parameters were not much affected by the weed management practices except milling per cent and protein content of grain under aerobic culture.

Chapter –I

INTRODUCTION

Chapter – I

INTRODUCTION

Rice is the staple food for more than three billion people, and over half the world's population. It provides 27 per cent of dietary energy and 20 per cent of dietary protein in the developing world, and is the primary source of income and employment for more than 100 million households in Asia and Africa (FAO, 2004). Globally, rice has been cultivated in area of 168 M ha, with production of 721.4 Mt with productivity of 4400 kg ha⁻¹ (FAO, 2012). The area grown under rice in India during 2011 is 45.5 M ha with production of 99.1 Mt and it ranks second in production. Andhra Pradesh has an area, production and productivity of 47.52 lakh hectares, 144.20 lakh tonnes and 3035 kg ha⁻¹, respectively (ANGRAU, 2011).

Water is a looming crisis due to competition among agricultural, industrial and domestic users. By 2025, 30 per cent of the human population would be threatened by water scarcity because, worldwide 70 per cent of water withdrawals are used in irrigated agriculture. Rice is the staple food in Asia and is the single biggest user of fresh water. On average, about 2,500 liters of water is needed to produce 1 kg of rough rice and it is 2-3 times those of other major cereals. The declining availability of water due to erratic rainfall pattern threatens the traditional way of growing rice under submerged conditions. Moreover, the lack of rainfall is a major production constraint in rain fed areas. (<http://www.janegoodall.ca/project-blue/FoodProductionandWater.html>)

The increasing shortage of water resources has led to the development and adoption of aerobic rice system. To differentiate it from the traditional upland rice, IRRI (International Rice Research Station) coined the term “aerobic rice”. Rice grown in well-drained, non-puddled and non saturated soils called as aerobic rice (Bouman, 2001). It is growing rice just like any other irrigated dry crops. In China, the new way of growing rice started in the mid-1980s and term “*Ju Dao*” refers to all rice grown under upland or aerobic conditions, whereas the

term “*Han Dao*” specifically indicates the new system of high-yielding aerobic rice. Aerobic rice is the answer to falling water table and to mitigate the effects of climate change.

Aerobic rice saves water input and increases water productivity by reducing water requirement during land preparation and limiting seepage, percolation, and evaporation losses. The soil is maintained aerobic throughout the growing season. Aerobic rice also reduces emission of greenhouse gases from rice field especially methane. Aerobic rice saved 73 per cent of irrigation water for land preparation and 56 per cent during the crop growth stage. On an average, it saves 40-50 per cent of total water requirement of rice under puddled condition. Unlike flooded rice, irrigation given to aerobic rice is not used to flood the soil but to just bring the soil water content in the root zone up to field capacity.

In order to fulfill the ever increasing demand of quality rice, efforts are being made to popularize the cultivation of scented rice in traditional rice cultivation area. Enhanced and stable productivity from those rainfed areas is possible through adoption of scented rice varieties by formulating improved agronomical packages. Among the rice varieties, aromatic rice is popular in Asia and gained wider acceptance in Europe and the United States of America because of their aroma, flavor and texture with premium price. Demand for aromatic rice in recent years has increased to a greater extent for both internal consumption and export (Das and Baqui, 2000). India has exported 2.18 Mt of basmati rice to the world for the worth of ₹10578.68 crores during the year 2010-11. The increase in growth rate of export is about 15 per cent during 2011-12 compared to previous year (APEDA - Agriculture and processed food products export development authority. Ministry of Commerce & Industry. Govt. of India-2012).

Nitrogen plays a key role in rice production and it is required in large quantity and important limiting nutrient in rice production and has a positive influence on the production of effective tillers plant⁻¹, yield and yield attributes (Jashim *et al.* 1984; BRRI, 1990). It is necessary to find out the optimum dose of

nitrogen fertilizer for the aerobic rice with particular reference to location specific and efficient management for better yield of rice. Scented rice varieties are poor competitor for nutrients due to their initial slow growth compared to non-aromatic rice cultures. Severity of competition between scented rice and weeds intensified in light textured soil due to recurrent weed germination from sowing of seed onwards. Poor germination, erratic stand establishment and slow growth of rice seedlings in the early phase of crop life cycle in aerobic rice lead to vigorous growth of weeds resulting in low yields. Yield losses due to weeds are greater in direct-seeded rice up to 73 per cent loss (Milberg and Hallgren, 2004). Early emergence of weeds along with crop seedlings and their rapid growth results in a severe crop-weed competition for light, nutrients, moisture and space. When weed control is optimum and crop establishment is good, the yield of direct - seeded rice under non-puddled condition is equal to those of transplanted rice (Sipaseuth *et al.* 2000). One of the potent means of controlling weeds is use of herbicides. Research results from various locations showed that herbicides alone do not solve the purpose of weed control satisfactorily and they cause environmental pollution and hence environment friendly, low volume herbicides and labour efficient methods of weed control for aerobic rice is essential.

To regulate uninterrupted nitrogen supply and to realize the higher yield potential, it is essential to ascertain how much nitrogen is depleted by weeds and impact of the weed management practices on nitrogen availability to crop at different growth stages. Thus, it is of utmost importance to control the emerging weeds timely to save the loss of applied nitrogen and increased nitrogen use efficiency as well as other nutrients.

Information on competition between scented rice and weeds under aerobic culture for nitrogen is scarce in literature. However, reliable information on the vital agro-techniques for successful aerobic rice culture for scented rice in Southern Agro climatic Zone of Andhra Pradesh is absolutely lacking. In this backdrop, the present study was undertaken with the following objectives.

1. To determine the optimum dose of nitrogen for maximization of yield and quality of aromatic rice, under aerobic culture in the Southern Agro Climatic Zone of Andhra Pradesh.
2. To find out an effective weed management practice for aromatic rice under aerobic culture.
3. To examine the weed flora in aerobic rice, so as to verify the crop weed association phenomenon.
4. To determine the extent of yield reduction of aerobic rice by weed infestation.
5. To evolve the best combination of nitrogen dose and weed management practice for the maximum yield, quality and economics of aromatic rice under aerobic culture in the domain of study.

Chapter –II

REVIEW OF LITERATURE

Chapter - II

REVIEW OF LITERATURE

A brief review of relevant literature on nitrogen and weed management in aromatic rice under aerobic culture is presented in this chapter. However, the information available under aerobic rice is very meager and hence information on rice under the upland conditions and semidry conditions of rice cultivation is also included, to have a comprehensive understanding as these systems have some common management methods as like aerobic rice.

2.1 AEROBIC RICE

Rice grown in non-puddled, aerobic soils under irrigation with high external inputs is called “aerobic rice”. In aerobic rice, the soil is maintained at field capacity throughout the crop growth period and hence the crop rarely experiences moisture stress. A new development in water-saving technologies is the concept of aerobic rice (Bouman, 2001; Bouman *et al.* 2005). Rice has been grown under nonflooded, aerobic soil conditions in uplands for centuries, but the average yields are only 1-2 t ha⁻¹ (Maclean *et al.* 2002). In aerobic rice systems, fields remain unsaturated throughout the crop growing season.

Irrigated aerobic rice is a new system cultivation being developed for lowland areas with water shortage and for favorable upland areas with access to supplementary irrigation. It entails the cultivation of nutrient responsive cultivars in non saturated soil with application of sufficient external inputs to reach the yields of 70–80 per cent of high input flooded rice (Belder *et al.* 2005).

2.2 EFFECT OF NITROGEN ON GROWTH PARAMETERS

Nair *et al.* (1973) recorded that split application of 120 kg N ha⁻¹ to upland rice increased the plant height as compared to single application of the same dose at basal dressing.

Singh *et al.* (1994) inferred that plant height of rice genotypes increased significantly with increased levels of N from 0 to 60 kg ha⁻¹ under upland conditions of Chhotanagpur plateau.

Studies by Kumar *et al.* (1996) revealed that increasing levels of nitrogen up to 120 kg ha⁻¹ significantly increased the leaf area index of rice plants at all stages of growth.

Murali and Setty (2001) concluded that the application of 150-75-75 N, P₂O₅ and K₂O kg ha⁻¹ to scented rice Pusa basmati-1 has recorded significantly higher total dry matter production at all the three stages viz., 35, 70 DAS and at harvest as compared to other two levels.

Jadhav *et al.* (2004) studied effect of nitrogen on scented rice under upland condition and reported that the rate of dry matter accumulation was slow during initial stages upto 30 DAS, fast between 31 to 75 DAS and very fast between 76 to 90 DAS. The dry matter accumulation was continued up to harvest, but the rate of accumulation was relatively slow. The leaf area per plant was influenced significantly due to the application of nitrogen and was improved as nitrogen application increased up to 120 kg ha⁻¹.

Mhaskar *et al.* (2005) stated that increasing the rate of N from 0 to 120 kg ha⁻¹ resulted in a significant increase in leaf area of scented rice. A similar trend was observed for LAI. Leaf area was maximum at 45 days after transplanting and gradually decreased thereafter.

Jadhav *et al.* (2006) reported that the plant height increased continuously up to harvest in upland basmati rice. The number of leaves per plant and mean leaf area per plant increased continuously up to 90 days with the application of nitrogen up to 120 kg N ha⁻¹.

Senthivelu and Prabha (2007) recorded that the application of 150:50:50 N, P₂O₅ and K₂O kg ha⁻¹ registered significantly the higher dry matter production

viz., 2528, 6307, 8369 and 10902 kg ha⁻¹ at tillering, panicle initiation, flowering and at harvest stage respectively.

Application of 175 kg N ha⁻¹ to aerobic rice recorded the highest values in growth parameters *viz.*, plant height, drymatter production, root volume, leaf area index and crop growth rate (Maheswari *et al.*, 2008).

The results of an experiment by Sathiya and Ramesh, (2009) at Tamilnadu Agricultural University, Coimbatore showed that nitrogen management based on LCC value of 4 (150 kg N ha⁻¹) produced the highest plant height of aerobic rice at maturity and drymatter at flowering stage than LCC value of 4 at 100 kg N ha⁻¹.

Devi and Sumathi (2011) stated that the application of N at 100, 125, 150 and 175 kg ha⁻¹ to aerobic rice resulted in increased growth parameters with increased N rate.

2.3 EFFECT OF NITROGEN ON YIELD ATTRIBUTES AND YIELD

Dubey *et al.* (1983) reported that the number of effective tillers and number of grains panicle⁻¹ were significantly increased with higher levels of nitrogen at 120 kg ha⁻¹ under upland conditions

Gangaiah and Rajendra Prasad (1999) reported that the significant increase in plant height, drymatter production, productive tillers hill⁻¹, number of grains panicle⁻¹ of scented rice with each successive increment of N from 0 to 180 kg ha⁻¹.

Neelam Kumar Chopra and Nisha Chopra (2000) reported that the incremental doses of N to scented rice, increased the number of panicles plant⁻¹ up to 120 kg N ha⁻¹. Panicle length and 1000- seed weight remained unaffected due to incremental dose of N. The straw yield also significantly increased with increasing level of N.

Mohammed Ikramullah and Rakesh Kumar (2001) concluded that the grain yield of pre-released scented rice cultivar RNR-18833 increased by 22, 49 and 46 per cent with 50, 100 and 150 kg N ha⁻¹ respectively, over the control.

Murali and Setty (2001) concluded that increased N, P₂O₅ and K₂O application upto 150-75-75 kg ha⁻¹ to scented rice resulted in significant increase in number of panicles hill⁻¹, number of grains panicle⁻¹ and grain yield as compared to other two lower levels.

In a field experiment conducted with upland rice cv. Sugandha the grain yield increased with increase in N levels up to 80 kg ha⁻¹. However, straw yield increased with increase in N application upto 120 kg ha⁻¹ and it was significantly superior over the 40 kg N ha⁻¹ (Jadhav *et al.*, 2003).

Sriramchandrasekaran and Ravichandran (2003) at Coimbatore reported that number of panicles m⁻² was recorded the highest for rice crop when the crop was subjected to application of 150 kg N ha⁻¹.

Rakesh Kumar and Mohammed – Ikrammullah (2004) reported that pre released scented rice variety RNR 18833 recorded higher productive tillers m⁻², filled grains panicle⁻¹, panicle length and grain yield with increased nitrogen rate upto 150 kg/ha.

Field experiment conducted in Maharashtra on four scented rice cultivars (Pusa Basmati 1, Kasturi, Indrayani and Sugandha) found that increasing the rate of N from 0 to 120 kg ha⁻¹ resulted in significantly higher grain and straw yields. (Mhaskar *et al.*, 2005).

Experiments by Belder *et al.* (2005) revealed that the yield under aerobic conditions with 150 kg N ha⁻¹ was 15 to 39 per cent lower compared with flooded conditions.

Manzoor *et al.* (2006) revealed that super basmati rice recorded maximum grain yield with 175 kg ha⁻¹ nitrogen application due to the highest number of

grains panicle⁻¹, number of productive tillers hill⁻¹, panicle length and 1000 grain weight.

According to Sahrawat (2006) unlike rice grown in submerged soil conditions, continuous rice systems under arable conditions show reduction in yield and are unable to sustain productivity even due to decline in soil fertility.

Jadhav *et al.* (2006) reported that in upland basmati rice, tillers plant⁻¹ increased continuously from 45 to 105 DAS and the number of filled grains panicle⁻¹, panicles per m⁻² and test weight increased significantly with the application of nitrogen up to 120 kg N ha⁻¹.

Ramana *et al.* (2007) noticed that increased number of tillers, grains panicle⁻¹ and thousand grain weight of upland non-scented rice varieties increased with increased levels of nitrogen.

Field experiments conducted on wetlands at Agricultural college and Research Institute, Tamilnadu Agricultural University, Coimbatore by Maheswari *et al.* (2007) indicated that among the four levels of nitrogen levels *i.e.*, 100, 125, 150 and 175 kg ha⁻¹, application of 150 kg N ha⁻¹ was found to be optimal dose for the aerobic rice variety PMK-3.

Naw Mar Lar *et al.* (2007a) reported that yield attributes, grain and straw yields of aromatic rice were increased with increased levels of N up to 150 kg ha⁻¹ and recorded highest harvest index.

Gautam *et al.* (2008) stated that the application of 160 kg N ha⁻¹ to aromatic rice recorded 23.7 and 26.1 per cent more grain yield and straw yield over without nitrogen application. Where as, it was 6.4 and 6.1 per cent more over 80 kg N ha⁻¹.

The results of an experiment by Sathiya and Ramesh (2009) at Tamilnadu Agricultural University, Coimbatore showed that nitrogen management in aerobic rice at LCC value of 4 at 150 kg N ha⁻¹ produced significantly higher grain yield than LCC value of 4 at 100 kg N ha⁻¹.

Devi and Sumathi (2011) concluded that increased rates of N (100, 125, 150 and 175 kg ha⁻¹) increased the number of effective tillers, number of filled grains panicle⁻¹, 1000grain weight of vasumati scented rice only up to 150 kg ha⁻¹ under aerobic culture.

2.4 EFFECT OF NITROGEN ON QUALITY PARAMETERS

Rabindra *et al.* (1977) found that the increasing nitrogen rates from 0 to 120 kg ha⁻¹ applied to five high yielding rice cultivars increased the average grain protein content from 5.47 to 6.92 per cent.

Manoj Kumar *et al.* (1996) reported that nitrogen did not affect the grain quality of scented rice markedly. The breadth of the kernel increased marginally, which caused the length breadth ratio to decrease slightly with increase in N rate.

Mohammed- Ikramullah and Kumar (2001) concluded that the quality characters of pre released scented rice culture RNR 18833 were not affected by increased rates of N from 50, 100 and 150 Kg N ha⁻¹.

When application of nitrogen fertilizer increased, amylose content of grain decreased, P fertilizer had no obvious influence on the amylose content and increased rate of K fertilizer lead to increased amylose content, grain taste and quality of rice (Xu DaYong *et al.*, 2005).

Hemant lal sonboir (2009) reported that grain quality parameters like amylose and protein content of aromatic rice were increased with increasing levels of nitrogen from up to 240 kg ha⁻¹ under SRI.

Ramana murthy (2010) concluded that protein and amylose content of rice under aerobic culture increased with nitrogen application from 80-140 kg ha⁻¹.

Devi and Sumathi (2011) stated that grain quality parameters like milling per centage, head rice recovery, and kernel length and breadth were markedly

improved by increased N application and recorded significantly higher values with 150 kg N ha⁻¹ than lower doses in scented rice under aerobic culture.

2.5 EFFECT OF NITROGEN ON NUTRIENT UPTAKE AND SOIL FERTILITY

Pradeep *et al.* (1994) reported that the progressive increase in N uptake by grain and straw individually as well as total uptake by plants was recorded with the increased rates of N application in direct seeded rice .

Prasad and Rafey (1995) reported that the average increase in nutrient uptake by upland rice was 16.6 kg N ha⁻¹, 11.0 kg P ha⁻¹ and 27.0 kg K ha⁻¹ compared to weedy check.

Subhash Chander and Jithendar Pandey (1997) reported that increase in nitrogen level upto 120 kg ha⁻¹ resulted in significant increase in nutrient uptake by rice compared with lower level of N 60 kg ha⁻¹.

Gangaiah and Rajendra Prasad (1999) reported that the N, P, K and Zn uptake in scented rice increased significantly with each successive increment of N from 0 to 180 kg ha⁻¹.

Application of higher dose of N to upland rice at 180 kg ha⁻¹ recorded significantly higher N and K uptake than 120 and 60 kg N ha⁻¹ where as significant increase in N uptake was up to 120 kg N ha⁻¹ (Pandey *et al.*, 2000).

Murali and Setty (2001) concluded that the application of 150-75-75 N, P₂O₅ and K₂O kg ha⁻¹ to scented rice Pusa basmati-1 has resulted in higher total 'N' uptake ha⁻¹.

Mhaskar and Thorat (2005) reported that the different levels of N had significant effect in augmenting the uptake of N, P and K nutrients in grains as well as straw of scented rice. Every increment of 40 kg N ha⁻¹ from 0 to 120 kg N ha⁻¹ increased the total N uptake by 49.55, 34.30 and 27.17 per cent, total P

uptake by 40.33, 27.06 and 20.32 per cent and total K uptake by 32.43, 20.70 and 17.25 per cent respectively over control.

The N, P and K uptake by upland rice crop was found to be the highest when supplied with 90 kg N ha⁻¹ (Ramana *et al.*, 2005).

A drastic reduction in plant uptake of fertilized N was reported in aerobic rice. Hence, aerobic rice is a system that can save water at the cost of nitrogen. Hence adequate N management or slow release of fertilizer is required for sustainable and increased aerobic rice production (Takeshi Horie *et al.*, 2005).

Studies conducted by Sharma (2007) indicated that in direct seeded upland rice, dry matter accumulation and uptake of nitrogen increased with increasing levels of nitrogen at all stages of growth. The differences in nitrogen concentration due to nitrogen levels were greatest at panicle initiation stage and started becoming narrower with the advancement in crop age.

Zhang Hong Yan *et al.* (2007) reported that the apparent use efficiencies of applied N, P and K were 33.4 per cent, 3.0 per cent and 8.5 per cent for rice. Producing one tonne of rice grain required 14.9 to 33.7 kg N, 2.9 to 5.9 kg P and 17.9 to 38.1 kg K and N is the main factor affecting the yield of aerobic rice.

Naw Mar Lar *et al.* (2007b) reported that there was 49.9, 63.9 and 70.4 per cent increase in the N uptake (grain + straw), over the control with 50, 100 and 150 kg N ha⁻¹ respectively. With each successive increase in the level of N, P uptake was increased significantly up to 100 kg N ha⁻¹. Total uptake of K by rice crop was increased with an increase in N levels up to 150 kg ha⁻¹.

Majumdar *et al.* (2007) observed that increased N, P and K uptake by upland rice with increased levels of N from 0 to 60 kg ha⁻¹.

Sikdar *et al.* (2008) reported that organic matter, available phosphorus and exchangeable potassium at post harvest in soil increased with increasing level of nitrogen from 40 to 80 kg ha⁻¹.

2.6 EFFECT OF NITROGEN ON WEED COUNT AND DRY MATTER PRODUCTION

Jayashree Beura Reddy (2003) studied the effects of 0, 60, 120 or 180 kg N ha⁻¹ in direct sown rice and reported that the highest weed count and weed dry weight were associated with 180 kg N ha⁻¹

Shebl (2004) reported that increasing nitrogen levels increased the dry weight of barnyardgrass regardless of its density. In general increasing weed density recorded up to 20 weeds m⁻² under higher level of nitrogen 120 kg ha⁻¹.

Subramanian *et al.* (2005) revealed that increasing levels of nitrogen increases the weed dry weight and recorded highest with application of 150 kg N ha⁻¹.

Sharma *et al.* (2007) concluded that increase in application of nitrogen (120 kg ha⁻¹) significantly increased the weed density and drymatter. However, minimum nutrient uptake by crop and maximum nutrient removal by weeds were noted under weedy check.

2.7 EFFECT OF WEED MANAGEMENT PRACTICES ON THE PERFORMANCE OF AEROBIC RICE

2.7.1 Yield Loss Due to Weeds

Kathirvelan and Vaiyapuri (2004) reported that the grain yield reduced to 69.9 per cent due to uncontrolled weed growth as compared to hand weeding twice.

Singh and Tewari (2005) revealed that reduction in grain yield was upto 40.2 per cent in weedy plots in direct seeded rice.

Mishra and Singh (2008) stated that infestation of weeds reduced the grain yield of dry-seeded rice by 60 per cent compared with hand-weeding twice and removed 10.99 kg N, 2.78 kg P and 7.22 kg ha⁻¹.

Rao *et al.* (2008) reported that weedy check recorded the lowest yield with a yield reduction of 59.4 per cent due to severe weed competition in direct seeded semi dry-rice.

Samar Singh *et al.* (2008) reported loss of grain yield of rice due to weed competition in aerobic rice ranged from 38 to 92 per cent. Both weed density and dry weight were negatively correlated with rice grain yield in aerobic rice.

2.7.2 Weed Flora

The weed flora of the direct seeded upland rice field at Palampur consisted of *Echinochloa colonum*, *Cyperus iria*, *Panicum dichotomiflorum*, *Aeschynomene indica* and *Euphorbia heterophylla* (Angiras and Vinod Sharma, 1998).

The most predominant weed flora of the experimental upland rice plots comprised of *Echinochloa colonum*, *Eleusine indica*, *Digitaria sanguinalis* among grasses; *Cyperus rotundus*, *Cyperus iria*, *Cyperus microiria* among sedges; *Amaranthus viridis*, *Eclipta alba*, *Commelina benghalensis*, *Euphorbia hirta* and *Phyllanthus niruri* among broad leaved weeds (Jena *et al.*, 1999).

Narsimha Reddy *et al.* (1999) concluded that *Ammania baccifera*, *Cyanotis axilaris* and *Chara sp.* were effectively controlled with application of pretilaclor + safener at 0.50 kg ha⁻¹ which was almost similar to that of butachlor at 1.5 kg ha⁻¹ and anilofos at kg ha⁻¹.

Dario and Gallo (1999) revealed that the application of oxadiargyl was found to be highly effective against *Cyperus iria* at all rates tested, and against *Echinochloa colonum* and *Ischaemum rugosum* at 400, 480 and 560 g ha⁻¹. Oxadiargyl caused slight phytotoxicity to rice plants when applied at 480 and 560 g ha⁻¹, but the symptoms disappeared at 60 days after application.

The predominant weeds observed in direct-seeded upland rice were *Cyperus rotundus*, *Echinochloa colonum*, *Setaria glauca*, *Ageratum conyzoides*, *Borreria hispida*, *Mimosa pudica*, *Chenopodium album*, *Cynodon dactylon* and *Amaranthus spinosus* (Sarma *et al.*, 2001).

The dominant weeds in the upland direct seeded rice included *Eleusine indica*, *Digitaria sanguinalis*, *Cynodon dactylon*, *Setaria glauca*, *Imperata cylindrica*, *Cyperus rotundus*, *Borreria hispida*, *Ageratum conyzoides*, *Mikania micrantha*, *Eupatorium odoratum*, *Valeriana alliariifolia*, *Erechtites uderianalfelia*, *Euphorbia hirta*, *Amaranthus viridis* and *Mimosa pudica* (Singh and Tongpong Longkumar, 2002).

Echinochloa colonum among the grasses, *Trianthema monogyna* among the non-grasses, and *Cyperus iria* and *Cyperus rotundus* among the sedges were the dominant weed flora in direct seeded rice (Tomar *et al.*, 2002).

Rajkhowa *et al.* (2005) observed that the major weeds infested the rice field were *Sphenoclea zeylanica*, *Fimbristylis geminata*, *Eleocharis acutangula*, *Sacciolepis interrupta* and *Dicanthium annulatum*.

Halder *et al.* (2005) reported that the predominant weed species were *Echinochloa crusgalli*, *Cyperus iria*, *Fimbristylis miliacea*, *Scripus maritimus*, *Monochoria vaginalis*, *Ludwigia parviflora* and *Ammania baccifera*

Mondal *et al.* (2005) stated that the upland rice field consisted of dominant weeds *Ludwigia perennis*, *Lindernia ciliata*, *Fimbristylis miliacea* and *Echinochloa colonum* and pre-emergence application of pyrazosulfuron-ethyl at 20, 25 and 30 g ha⁻¹ at all doses significantly controlled grasses, broadleaved weeds and sedges and increased the yield of rice than butachlor at 1000 g ha⁻¹.

Angiras and Suresh Kumar (2005) noticed that *Echinochloa colona*, *E. crus-galli*, *Cyperus iria*, *Panicum dichotomiflorum*, *Commelina communis* and *Aeschynomene indica* were the dominant weeds and the application of

pyrazosulfuron-ethyl at 15 g ha⁻¹ mixed with sand at 150 kg ha⁻¹ was effective in controlling the weeds and without any phytotoxic effect.

The dominant weeds in directly sown upland rice fields were *Echinochloa colona*, *E. crus-galli*, *Digitaria sanguinalis*, *Setaria pumila*, *Commelina benghalensis* and *Polygonum* sp (Saini, 2005).

The predominant weed species in aerobic rice were *Digitaria ciliaris*, *Eleusine indica*, *Echinochloa colona*, *Leptochloa chinensis*, *Dactyloctenium aegyptium* and *Portulaca oleracea* and *Rottboellia cochinchinensis* (Zhao, 2006).

Mishra and Singh (2007) revealed that the pre emergence application of pendimethalin 1.0 kg ha⁻¹ or pretilachlor 0.75 kg ha⁻¹ + 1HW at 30 DAS significantly reduced the population of *E. colona* compared with the weedy check. These treatments, however, did not affect the population of *Commelina* spp.

Samar Singh *et al.* (2008) reported that the grassy weeds constituted 78-96 per cent of total weed weight in all systems of rice establishment. Both weed density and dry weight were negatively correlated with rice grain yield in aerobic rice.

Swapan kumar maity and Mukherjee (2009) reported that the common weeds infesting the upland rice includes grasses, like *Cynodon dactylon*, *Echinochloa colona*, *Digitaria sanguinalis*, *Brachiaria ramosa*; sedges, like *Cyperus pilosus*, *Cyperus iria* and broad leaved weeds, like *Amaranthus spinosus*, *Solanum nigrum*, *Euphorbia hirta*, *Commelina diffusa*, *Phyllanthus niruri*, *Chenopodium album*, *Alternanthera* sp., *Physalis minima*, *Polygonum pensylvanicum*.

2.7.3 Effect of Weed Control Methods on Weed Count and Weed Dry matter

Gogoi and Kalith (1992) reported that the bensulfuron methyl 0.4 kg ha^{-1} , pretilachlor $(0.45) + \text{fencloirim } (0.2)$ and pendimethalin $(0.75) \text{ kg ha}^{-1}$ were equally effective and recorded significantly lesser weed-dry weight than butachlor alone in direct seeded rice. Among other herbicides, only bensulfuron methyl emerged to be superior over commonly used butachlor.

Angiras and Rana (1998) revealed that pretilachlor $0.80 \text{ kg a.i. ha}^{-1}$ was found to be the best herbicide for control of all weeds which was being statistically at par with hand-weeding twice in direct seeded upland rice.

Nandal and Hari om (1998) stated that pretilachlor 1.0 kg ha^{-1} in combination with hand weeding at 25 DAS in direct seeded puddled rice reduced weed population and weed dry matter significantly over rest of weed management practices.

Gnanasambandan and Balakrishna Murthy (2001) observed that application of oxadiargyl @ 100 g ai ha^{-1} effectively controlled weeds in wetland rice compared to other herbicides.

Bhattacharya *et al.* (2001) stated that application of pyrazosulfuron-ethyl at $0.07 \text{ kg a.i ha}^{-1} + \text{molinate at } 1.50 \text{ kg a.i. ha}^{-1}$ at 10 DAT was the most effective in controlling weed population and weed dry matter compared with the other herbicide treatments.

Bhowmick (2002) revealed that pretilachlor at 500 g ha^{-1} alone and in combination with one hand weeding at 40 DAT gave results comparable to two hand weedings in minimizing weed density and dry weight in transplanted rice.

Saini (2003) stated that pyrazosulfuron-ethyl at $20 \text{ g a.i. ha}^{-1}$ was effective in reducing the dry weight of grasses, sedges, broadleaved and total weeds and it was on par with hand weeding twice.

In experiments conducted at Haryana by Vinod Kumar *et al.* (2004) among the herbicides, oxadiargyl @ 75 g ha⁻¹ recorded the lowest number and dry weight of *Echinochloa crus-galli*.

Kathirvelan and Vaiyapuri (2004) stated that pretilachlor+ 2,4-D @ 240+240 g ha⁻¹ in transplanted rice has been found effective against grasses and some of broad leaved weeds. There is increase in the density of broad leaved weeds and sedges by continuous use of pretilachlor.

Angiras and Suresh Kumar (2005) revealed that the application of pyrazosulfuron-ethyl at 15 g ha⁻¹ mixed with sand at 150 kg ha⁻¹ was effective in controlling the weeds and increasing the biomass of rice seedlings without any phytotoxic effect.

Halder *et al.* (2005) reported that pyrazosulfuron ethyl at 16 g a.i. ha⁻¹ was the best in reducing weed population and weed dry weight without showing any phytotoxic symptoms in direct seeded rice compared to other herbicides.

Samar Singh *et al.* (2005) recorded that oxadiargyl at 100 g ha⁻¹ resulted in 93 per cent reduction in dry weight of weeds, which was at par with anilofos at 450 g ha⁻¹ and butachlor at 2.0 kg ha⁻¹.

Sanjoy Saha (2006) found that the sulfonylurea herbicides were found superior in reducing total weed density and dry matter production in transplanted rice. Triasulfuron alone (9 g a.i ha⁻¹) and bensulfuron methyl (60 g a.i ha⁻¹) effectively controlled sedges and non grassy weeds with high WCE of 93.7 and 90.1 per cent, respectively.

Experimental results of Natarajan and Arivazhagan (2006) indicated that the application of 0.07 kg oxadiargyl ha⁻¹ resulted in the highest weed control index (75per cent) and least weed biomass and count.

In the investigations made in transplanted rice by Subramanyam *et al.* (2007) revealed that PE application of oxadiargyl at 80 g a.i ha⁻¹ integrated with HW at 40 DAT recorded the highest grain yield due to low dry weight and

nutrient uptake by weeds, which was comparable with HW twice. On an average, uncontrolled weed growth drained 16.06, 6.61 and 17.88 kg N, P and K ha⁻¹, respectively.

Experiments conducted by Arul Chezian and Kathiresan (2008) resulted in pre-emergence application of oxadiargyl @ 70 g ai ha⁻¹ with one hand weeding at 40 DAS recorded lower weed count and biomass lead to higher grain yield.

Ravisankar *et al.* (2008) stated that pretilachlor- plus @ 0.3 kg ha⁻¹ at 2 DAS effectively controlled the germinating weeds at the plumule- initiation stage itself in wet-seeded rice. It reduces the weed density more effectively compared with pretilachlor- plus at 5 DAS.

Ramana *et al.* (2008) reported that application of oxadiargyl @ 80 g ha⁻¹ in rainfed upland rice reduces weed dry matter by 71 per cent over weedy check and oxadiargyl integrated with weeding with star weeder at 40 DAS gave the lowest dry matter of weeds i.e. 93.7 per cent over weedy check.

Gowda *et al.* (2009) revealed that two hand weedings at 20 and 45 DAS resulted in the lowest weed population and dry weight of weeds when compared to butachlor (0.75, 1.00 and 1.25 kg a.i. ha⁻¹), pyrazosulfuron ethyl (20, 25 and 30 g a.i ha⁻¹) and clomazone + 2,4-DEE (0.75, 1.00 and 1.25 litre ha⁻¹) in aerobic rice.

Thimmegowda *et al.* (2010) revealed that in aerobic rice applications of herbicides butachlor (0.75, 1.0 and 1.25 kg a.i ha⁻¹), pyrazosulfuron ethyl (20, 25 and 30 g a.i ha⁻¹), clomozone+2, 4-DEE (0.75, 1.0 and 1.25 lit ha⁻¹) and two intercultivations and hand weeding at 20 and 45 DAS along with weedy check, pyrazosulfuron ethyl at 30 g a.i ha⁻¹ has shown best results in reducing weed population and weed dry matter specially sedges with an efficiency of 90.86 per cent.

Jayadeva *et al.* (2011) reported that the application of pyrazosulfuron at 25 g a.i ha⁻¹ or butachlor at 1.0 kg a.i ha⁻¹ at 5 DAS followed by hand weeding at 20 and 40 DAS resulted in complete control of weeds in aerobic rice during both the seasons at 60 DAS.

Bhandare *et al.* (2011) reported that among herbicidal treatments the lowest dry matter of weeds was recorded with application of oxadiargyl @ 75g ha⁻¹ at 3-4 DAT + one hoeing and one weeding at 40 DAT and weed free check was significantly superior over all treatments.

Sunil *et al.* (2011) noticed that application of bensulfuron methyl + pretilachlor at 0.06+0.60 kg a.i ha⁻¹+ one intercultivation at 40 DAS recorded significantly lower weed population and weed dry weight as compared to control in aerobic rice.

2.7.4 Effect of Weed Control Methods on Weed Control Efficiency

Singh and Tongpong Longkumar (2002) reported that hand weeding at 20 and 40 DAS than pretilachlor 500 g ha⁻¹ alone in direct seeded upland rice resulted in the lowest weed dry matter and highest weed control efficiency.

Kathirvelan and Vaiyapuri (2004) reported that pretilachlor+2,4-D at 300+300 g ha⁻¹ recorded the lowest grassy and non-grassy weed densities (6 and 4 weeds m⁻², respectively) and total weed dry weight (235 kg ha⁻¹) and weed control efficiency (82%) among the herbicide treatments.

Rao (2005) experimental results revealed that all the herbicides significantly controlled *Echinochloa* spp over un-weeded check and application of post emergence herbicides recorded higher weed control efficiency of 85 to 89 per cent and was found to be superior to pre emergence herbicides pretilachlor 500 g ha⁻¹ + safner, pyrazosulfuron ethyl 20 g ha⁻¹ and oxadiargyl 80 g ha⁻¹, which recorded WCE of 66, 68 and 69 per cent respectively at 30 DAS.

Saha Sanjoy (2006) concluded that pyrazosulfuron-ethyl (25 g ha⁻¹) applied at 10 days after sowing of direct sown summer rice recorded 93.7 %

weed control efficiency and this was at par with hand weeding twice at 20 and 40 DAS. Application of pretilachlor + safener (750 g ha^{-1}) applied at 7 DAS and fentrazamide (120 g ha^{-1}) applied at 7 DAS also showed good suppression of weeds with weed control efficiency of 91.4 and 90.5%, respectively.

Suganthi *et al.* (2010) stated that application of pretilachlor (1.0 kg ha^{-1}) recorded higher weed control efficiency as against the anilofos (1.25), butachlor (0.4) and rifit (0.75) kg ha^{-1} in transplanted rice. There was general decrease in weed control efficiency over stages of crop growth in *rabi* season in contrast to summer season where there was increase in weed control efficiency as the crop growth stage progressed.

2.7.5 Effect of Herbicides on Phytotoxicity of Rice

Dario and Gallo (1999) found that oxadiargyl when applied at higher rates of 480 and 560 g ha^{-1} , caused slight phytotoxicity to rice plants but the symptoms disappeared 60 days after application. Due to effective weed control, oxadiargyl resulted in increased rice yields as compared to the un-weeded control.

Fujita (2000) reported that in direct sown rice elongation of leaf blade and sheath was inhibited by pretilachlor, butachlor and mefenaset at 1.5 kg ha^{-1} application, and severely injured rice hills which became dwarf.

Gitsopoulos and Froud-williams (2004) stated that crop sensitivity to oxadiargyl was comparatively greater for wet-seeded (anaerobic) than for dry-seeded rice (aerobic).

Bhattacharya *et al.* (2005) stated that the dominant weed flora in the experimental field were *Echinochloa crusgalli*, *Alternanthera sessilis*, *Fimbristylis miliacea*, *Sphenoclea zeylanica*. It was further evident that oxadiargyl @ $100 \text{ g a.i.ha}^{-1}$ recorded lower weed density and weed dry weight compared to butachlor @ $1250 \text{ g a.i.ha}^{-1}$ without showing any phytotoxicity.

2.7.6 Effect of Weed Control Methods on Growth, Yield Attributes Yield and Quality of Rice

Thakur *et al.* (1993) the results revealed that pyrazosulfuron-ethyl (0.005 and 0.01 kg ha⁻¹), butachlor (1 and 1.5 kg ha⁻¹), butachlor + pyrazosulfuron-ethyl (1 + 0.005 kg ha⁻¹), pretilachlor (0.75 and 1 kg ha⁻¹), pretilachlor (0.75 kg ha⁻¹) followed by the 2,4-D (0.25 kg ha⁻¹) treatment, and 2,4-D (0.6 kg ha⁻¹) alone increased rice grain yield over control under upland conditions.

Kurmi (1993) revealed that the highest grain yield was recorded with pyrazosulfuron ethyl @ 0.005 kg a.i ha⁻¹ + oxadiazon at 0.4 kg a.i ha⁻¹ at 7 DAT compare to other herbicides.

Ajay Pandey and Tiwari (1996) reported that in upland direct seeded rice hand weeding twice at 20 and 45 DAS, was the best weed management practice to increase the rice yield than applications of pyrazosulfuron at 0.005-0.01 kg ha⁻¹, butachlor 1.5 kg ha⁻¹, butachlor + pyrazosulfuron 1.0 + 0.005 kg ha⁻¹, pendimethalin 1.0 kg ha⁻¹ and pretilachlor 1.0 kg ha⁻¹.

Nandal and Hari om (1998) reported that the application of pretilachlor 1.0 kg ha⁻¹ in combination with hand weeding at 25 DAS at reduced rates in combination with hand weeding was found significantly better over herbicides alone in production of number of panicles m⁻², grains panicle⁻¹ and panicle length which were at par with hand weeding twice.

Porwal (1999) concluded that the post-emergence application of pretilachlor with safner (Sofit) at 0.375 kg ha⁻¹ at 10 DAS to direct drilled upland rice gave 13.4 per cent higher yield over its pre- emergence application.

Among the herbicides for semi dry rice at Madurai, pendimethalin 1.5 kg ha⁻¹ recorded the highest grain yield and it was on par with pretilachlor 1.0 kg ha⁻¹. (Selvam *et al.*, 2001).

Bhattacharya *et al.* (2001) stated that application of pyrazosulfuron-ethyl 0.07 kg a.i ha⁻¹ + molinate 1.50 kg a.i ha⁻¹ at 10 DAT resulting in the highest grain and straw yields compared with the other herbicide treatments.

Moorthy (2002) reported that the treatments pyrazosulfuron ethyl at 15 g ha⁻¹ + molinate at 1000 g ha⁻¹ is effective in controlling weeds and to obtain a reasonable yield in direct seeded lowland rice, while PE application of butachlor at 1000g ha⁻¹ gave the lowest yield among the herbicide treatments.

Khanna *et al.* (2002) reported that herbicide application and weeding increased the amylose and protein content in rice grains relative to the un-weeded control. Application of benthocarb and butachlor (1.5 kg ha⁻¹) resulted in the highest amylose and protein content in rice grains, than control.

Saini and Angiras (2002) stated that pretilachlor at 0.8 kg ha⁻¹ resulted in higher yield attributes and grain yield of direct seeded puddle rice compared to other herbicides.

Saini (2003) stated that pyrazosulfuron-ethyl at 20 g a.i ha⁻¹ was effective in enhancing almost all the yield attributes and yield of transplanted rice and it was on par with hand weeding twice.

Sanjoy Saha Moorthy and Jayashree Beura (2003) results showed that in direct sown rice under puddle conditions pyrazosulfuron ethyl at 15 g ha⁻¹, anilofos+ethoxysulfuron at 312+12 g ha⁻¹ and butachlor+safener at 1000 g ha⁻¹ controlled the weeds effectively and increased the rice grain yield compared to two hand-weedings.

Sharma *et al.* (2004) concluded that pyrazosulfuron, applied at 24-40 g ha⁻¹ after 3 and 6 DAT resulted in higher number of tillers m⁻² and grain yield of rice.

Kathirvelan and Vaiyapuri (2004) revealed that among the herbicide treatments pretilachlor + 2,4-D (ready mix) at 240 + 240 g ha⁻¹ produced significantly higher number of panicles hill⁻¹, number of filled grains panicle⁻¹, grain and straw yield of transplanted rice.

In experiments conducted by Vinod Kumar *et al.* (2004) concluded that among the herbicides, oxadiargyl @ 75 g ha⁻¹ recorded the lowest number and dry weight of *E. crus-galli* and the highest panicle number m⁻², 1000-grain weight and grain yield of rice.

Samar Singh *et al.* (2005) reported that application of oxadiargyl at 100 g ha⁻¹ to transplanted rice resulted in highest grain yield, which was comparable with application of anilofos at 450 g ha⁻¹ and butachlor at 2.0 kg ha⁻¹.

Mondal *et al.* (2005) stated that the yield increases due to pyrazosulfuron-ethyl dose ranged from 19.9 to 28.9 per cent compared with the traditional practice of hand weeding.

Rajkhowa *et al.* (2005) reported that application of oxadiargyl at 100 g ha⁻¹ resulted in the lowest weed density and the highest rice grain yield when compared to other herbicides.

Mishra and Singh (2007) stated that the pre emergence application of pendimethalin 1.0 kg ha⁻¹ or pretilachlor 0.75 kg ha⁻¹ + 1HW at 30 DAS, being on par with hand weeding twice, produced significantly higher grain yield than the weedy check in direct seeded rice. Grain yield of rice was negatively correlated ($r = -0.85$) with dry matter of weeds.

Field experiments conducted at Naira, Andhra Pradesh by Ramana *et al.* (2007) proved that in rainfed upland rice application of oxadiargyl at 80 g ai ha⁻¹ + working with star weeder at 40 DAS, followed by pre-emergence application of oxadiargyl at 80 g ha⁻¹ alone resulted in improved weed-control efficiency, better growth parameters, yield attributes, and higher grain and straw yields, besides fetching higher net returns and benefit cost ratio compared with un-weed control.

Experiments done by Arul Chezian and Kathiresan (2008) resulted in pre-emergence application of oxadiargyl at 70 g a.i ha⁻¹ with one hand weeding at 40 DAS recorded least weed count, biomass lead to higher grain yield.

Mishra and Singh (2008) stated that integration of pendimethalin 1.0 kg ha⁻¹ or pretilachlor 0.75 kg ha⁻¹ with one hand-weeding at 30 DAS proved quite effective against weeds and gave significantly higher grain yields and net benefit than weedy check.

Gowda *et al.* (2009) revealed that the number of effective tillers hill⁻¹, panicle length, filled grains panicle⁻¹ and 1000-grain weight were found significantly higher with two hand weeding at 20 and 45 DAS over butachlor (0.75, 1.00 and 1.25 kg a.i ha⁻¹), pyrazosulfuron ethyl (20, 25 and 30 g a.i ha⁻¹) and clomazone + 2,4-DEE (0.75, 1.00 and 1.25 litre ha⁻¹).

Thimmegowda *et al.* (2009) reported that application of pyrazosulfuron ethyl at 30 g a.i. ha⁻¹ was recorded significantly higher number of effective tillers hill⁻¹, panicle length, filled grains panicle⁻¹ and 1000 grain weight in aerobic rice.

Thimmegowda *et al.* (2010) reported that the application of pre-emergence herbicides pyrazosulfuron ethyl (20, 25 and 30 g a.i ha⁻¹), butachlor (0.75, 1.0 and 1.25 kg a.i ha⁻¹) and hand weeding at 20 and 45 DAS recorded comparatively higher yield attributes and grain yield in aerobic rice and significant over weedy check.

Bhandare *et al.* (2011) revealed that various growth characters such as plant height, LAI, drymatter plant⁻¹, number of tillers m⁻², number of effective tillers plant⁻¹ recorded maximum values which lead to higher grain yield with application of oxadiargyl at 75 g ha⁻¹ at 3-4 DAT + one hoeing and one weeding at 40 DAT.

Jayadeva *et al.* (2011) revealed that the application of pyrazosulfuron at 25 g a.i ha⁻¹ at 5 DAS and one hand weeding at 20 DAS recorded significantly higher grain and straw yield.

Sunil *et al.* (2011) reported that pre-emergence application of bensulfuron methyl+pretilachlor at 0.06+0.60 kg a. i ha⁻¹ + one intercultivation at 40 DAS recorded higher grain and straw yield.

2.7.7 Effect of Weed Control Methods on Nutrient Uptake

Results of a field investigation carried out at Coimbatore, Tamil Nadu by Ramamoorthy (1989) showed that the weeds when allowed to compete with the upland rice depleted 25.8, 3.65 and 21.3 of N, P_2O_5 and K_2O kg ha⁻¹.

K uptake by weeds was the lowest and K uptake by rice was the highest with two hand weeding at 21 and 42 DAS in direct seeded upland rice (Singh and Sharma, 1995).

Thimmegowda *et al.* (2009) reported that application of pyrazosulfuron ethyl at 30 g a.i. ha⁻¹ was had significantly higher nutrient uptake by aerobic rice.

Gowda *et al.* (2009a) concluded that application of pyrazosulfuron ethyl (30 g ha⁻¹) to aerobic rice recorded highest nutrient uptake than clomazone + 2,4-DEE (0.75 + 1.00 l ha⁻¹) and comparable to two hand weeding at 20 and 45 DAS.

Sunil *et al.* (2011) noticed that the uptake of major nutrients by rice was higher in bensulfuron methyl+pretilachlor at 0.06+0.60 kg a.i ha⁻¹+one intercultivation at 40 DAS and was at par with bensulfuron methyl+pretilachlor at 0.06+0.60 kg a.i ha⁻¹. Higher nutrient uptake by weeds was recorded in unweeded check.

2.8 INTERACTION EFFECT OF NITROGEN AND WEED MANAGEMENT PRACTICES

Prasad and Rafey (1995) reported that the average increase in nutrient uptake by upland rice was 16.6 kg N ha⁻¹, 11.0 kg P ha⁻¹ and 27.0 kg K ha⁻¹ and nutrient depletion by weeds was 44.4 kg N ha⁻¹, 10.5 kg P ha⁻¹ and 20 kg K ha⁻¹ compared to the weedy check.

Subhash Chander and Jithendra Pandey (2001) stated that the dry matter accumulation and nitrogen depletion by weeds were higher with 120 kg N ha⁻¹ compared with 60 kg N ha⁻¹.

Subhash Chander and Jithendra Pandey (2002) stated that the unchecked weed growth (weedy check) depleted K to the extent of 11.3, 37.0 and 63.1 kg ha⁻¹ respectively at maximum tillering, flowering and maturity stages in rice. Relative potassium uptake by weeds increased with advance in crop growth stages, whereas reverse in uptake by crop. Nitrogen at 120 kg ha⁻¹ effected marked increase in K uptake than to 60 kg N ha⁻¹.

Singh and Namdeo (2004) reported that the seed protein and nutrient uptake were increased significantly with increasing fertility levels and the herbicides over their respective control.

Subhash chander *et al.* (2005) stated that the grain and straw yield and protein yield were significantly more under higher nitrogen level of 120 kg ha⁻¹ than lower levels 60 kg ha⁻¹, however hulling, milling and head rice recovery, grain length, breadth and length/breadth ratio before and after cooking were remained statistically unchanged by increased nitrogen application. Herbicide treatments were also significantly superior to weedy check treatment in improving grain and straw yield and protein yield, but statistically grain quality characters remained statically identical under different weed control treatments.

Weeds which had high dry matter production at high N application rates in monoculture were most competitive at low N and least sensitive to low applied N. Nitrogen application levels sub-optimal to rice reduced the competitive ability of rice when in mixture with weeds (Ampong-Nyarko and De Datta, 2006).

Sharma *et al.* (2007) trials conducted during the rainy season of 2002 and 2003 to study the effect of nitrogen and weed management in direct-seeded upland rice resulted in the grain and straw yields of rice and N, P and K uptake by rice crop and weeds increased significantly with successive increase in nitrogen up to 120 kg ha⁻¹. Two hand-weedings at 20 and 40 DAS significantly

increased the nutrient uptake by the crop at 120 kg N ha⁻¹ and significantly reduced the density and dry weight of weeds and nutrient depletion by weeds with higher weed-control efficiency, N-use efficiency and production efficiency.

Parmeet Singh *et al.* (2008) reported that the growth and yield attributes increased with the increasing fertility levels 120:60:60 kg ha⁻¹ of N: P: K. Weed intensity (monocot and dicot) and total weed dry weight also significantly increased. The reduction in yield due to presence of weeds was observed more in weedy check plots with weed index of 67 -69 per cent. The maximum net returns and benefit: cost ratio obtained with application of 120: 60: 60 kg ha⁻¹ N: P: K and two hand weedings.

2.9 ECONOMICS

Singh *et al.* (2000) stated that each incremental dose of nitrogen applied up to 120 kg ha⁻¹ to scented rice significantly increased the grain and straw yields, net returns, benefit: cost ratio as well as physical and monetary productivity over 100 kg N ha⁻¹.

Rakesh Kumar and Mohammed –Ikrammullah (2004) reported that pre released scented rice variety RNR 18833 recorded the highest returns and benefit cost ratio with 100 kg N ha⁻¹ closely followed by 150 kg N ha⁻¹.

Halder *et al.* (2005) showed that the highest benefit: cost ratio was obtained with application of pyrazosulfuron ethyl at 15 g a.i ha⁻¹ and it is the right herbicide to replace the hand weeding in direct seeded rice.

Experimental results of Natarajan and Arivazhagan (2006) indicated that the application of oxadiargyl 0.07 kg ha⁻¹ resulted in the highest grain yield, net income and benefit: cost ratio.

Samar Singh *et al.* (2008) recorded that aerobic direct seeded rice treatment produced yield and net economic returns similar to conventionally puddled transplanted rice treatment when weeds were controlled. The aerobic

direct seeded rice was as effective as conventionally puddle-transplanted rice in attaining higher rice grain yield and net returns when weeds were kept under control.

Studies conducted during the *kharif* season of 2005 in Karnataka on the efficacy of some pre emergence herbicides on aerobic rice by Gowda *et al.* (2009) revealed that the maximum gross returns was realized with hand weeding, which was closely followed by pyrazosulfuron ethyl at 30 g a.i.ha⁻¹. The net returns and benefit cost ratio were maximum with pyrazosulfuron ethyl at 30 g a.i.ha⁻¹ and quite lower under two hand weeding at 20 and 45 DAS.

Ramana murthy (2010) reported that highest gross, net returns and B:C ratio of rice under aerobic culture was obtained with application of 140 kg N ha⁻¹.

Jayadeva *et al.* (2011) revealed that the application of pyrazosulfuron at 25 g a.i ha⁻¹ at 5 DAS and one hand weeding at 20 and 40 DAS recorded higher average gross income, net income and benefit cost ratio.

Bhandare *et al.* (2011) concluded that the highest gross returns, net returns and B:C ratio were recorded in weed free plot followed by oxadiargyl at 75 g ha⁻¹ at 3-4 DAT + one hoeing and one weeding at 40 DAT and two hoeings and two weeding at 20 and 40 DAT.

Chapter –III

MATERIAL AND METHODS

Chapter – III

MATERIAL AND METHODS

Field experiments were conducted at S.V. Agricultural College Farm, Tirupati Campus of Acharya N. G. Ranga Agricultural University, Andhra Pradesh to evaluate the nitrogen and weed management for maximizing the productivity and quality of aromatic rice under aerobic culture in Southern Agro Climatic Zone of Andhra Pradesh for the two consecutive *rabi* seasons of 2009 and 2010. The material used and methods employed for the investigations are described here under.

3.1 LOCATION OF THE EXPERIMENTAL SITE

Field experiments were conducted at the College Farm of S. V. Agricultural College, Tirupati, which is geographically situated at 13.5°N latitude, 79.5°E longitude and at an altitude of 182.9 m above the mean sea level in the Southern Agro-Climatic Zone of Andhra Pradesh.

3.2 WEATHER DURING THE CROP PERIOD

Weather during the crop period of rice recorded at the meteorological observatory, S. V. Agricultural College, Tirupati is depicted in Fig. 3.1 and 3.2. and presented in Appendix - A and B.

3.2.1 Crop Season, 2009-10

The weekly mean maximum temperature during the crop period ranged from 27.5 to 39.7°C, with an average of 32.2°C, while the decennial mean maximum temperature for the corresponding period ranged from 27.9 to 36.7°C, with an average of 31.4°C. The weekly mean minimum temperature during the crop period ranged from 15.7 to 25.6°C, with an average of 20.3°C, while the decennial mean minimum temperature for the corresponding period ranged from 15.9 to 24.0°C, with an average of 19.1°C.

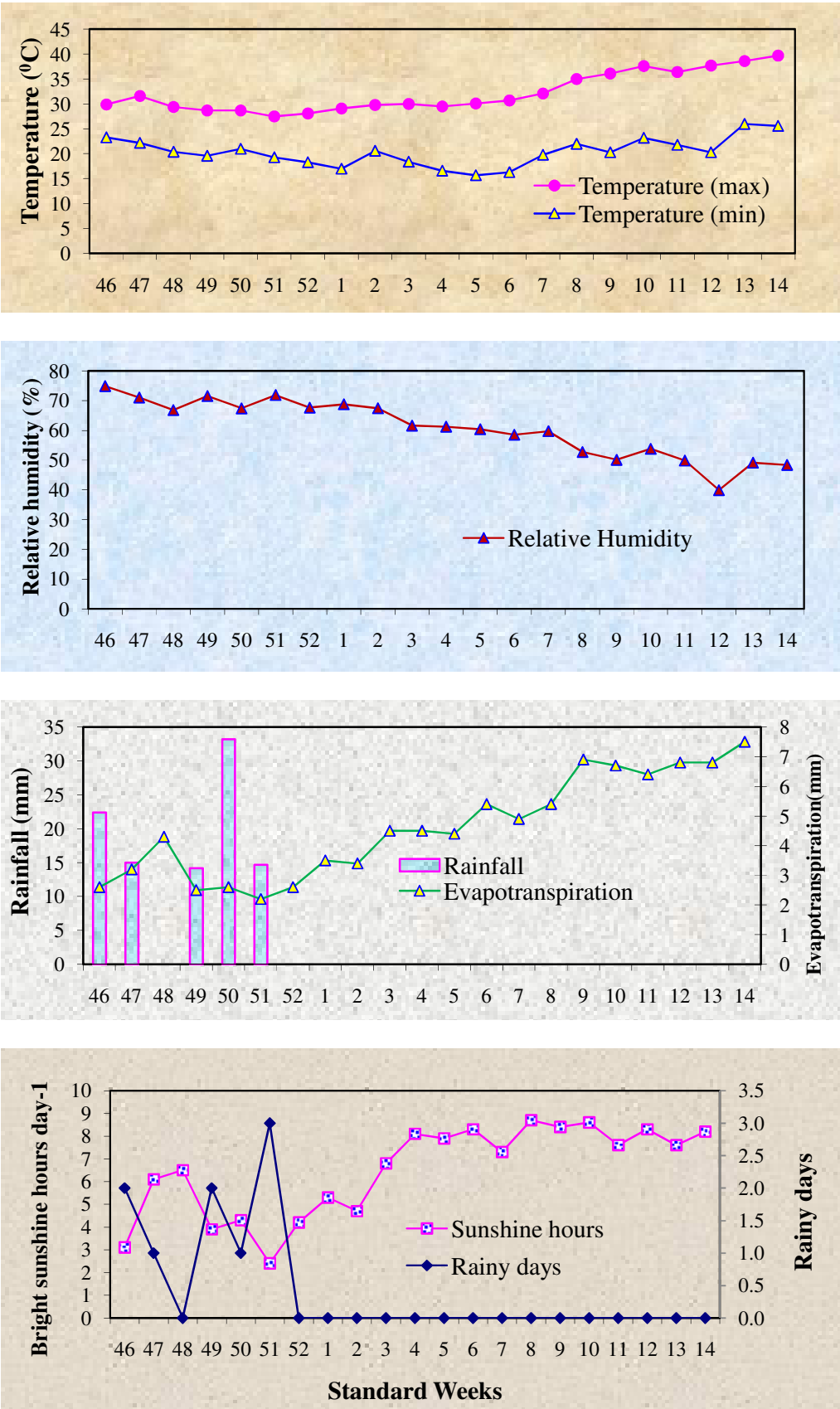


Fig. 3.1. Standard week wise meteorological data during the crop period of aromatic rice during 2009-2010

The weekly mean relative humidity during the crop period ranged from 39.9 to 74.9 per cent, with an average of 60.6 per cent, while the decennial mean relative humidity for the corresponding period ranged from 52.2 per cent to 73.0 per cent, with an average of 62.8 per cent.

A total amount of 99.5 mm rainfall was received during the crop period in 9 rainy days, as against the decennial average of 200.2 mm received in 9.3 rainy days for the corresponding period.

During the crop period, the evaporation (measured from USWB class A open pan evaporimeter) ranged from 2.2 to 7.5 mm day⁻¹, with an average of 4.6 mm day⁻¹ while the decennial mean evaporation for the corresponding period ranged from 3.5 to 7.1 mm day⁻¹, with an average of 5.1 mm day⁻¹.

Mean bright sunshine hours day⁻¹ during crop period ranged from 2.4 to 8.6, with an average of 6.4. The decennial mean bright sunshine hours day⁻¹ for the corresponding period ranged from 5.4 to 9.0 with an average of 7.6.

3.2.2 Crop Season, 2010-11

The weekly mean maximum temperature during the crop period ranged from 22.8 to 37.9°C, with an average of 31.2°C, while the decennial mean maximum temperature for the corresponding period ranged from 28.3 to 37.0°C, with an average of 31.5°C. The weekly mean minimum temperature during the crop period ranged from 13.9 to 23.7°C, with an average of 18.5°C, while the decennial mean minimum temperature for the corresponding period ranged from 16.1 to 24.2°C, with an average of 19.1°C.

The weekly mean relative humidity during the crop period ranged from 89.9 to 52.0 per cent, with an average of 67.6 per cent, while the decennial mean relative humidity for the corresponding period ranged from 50.6 per cent to 71.4 per cent, with an average of 62.4 per cent.

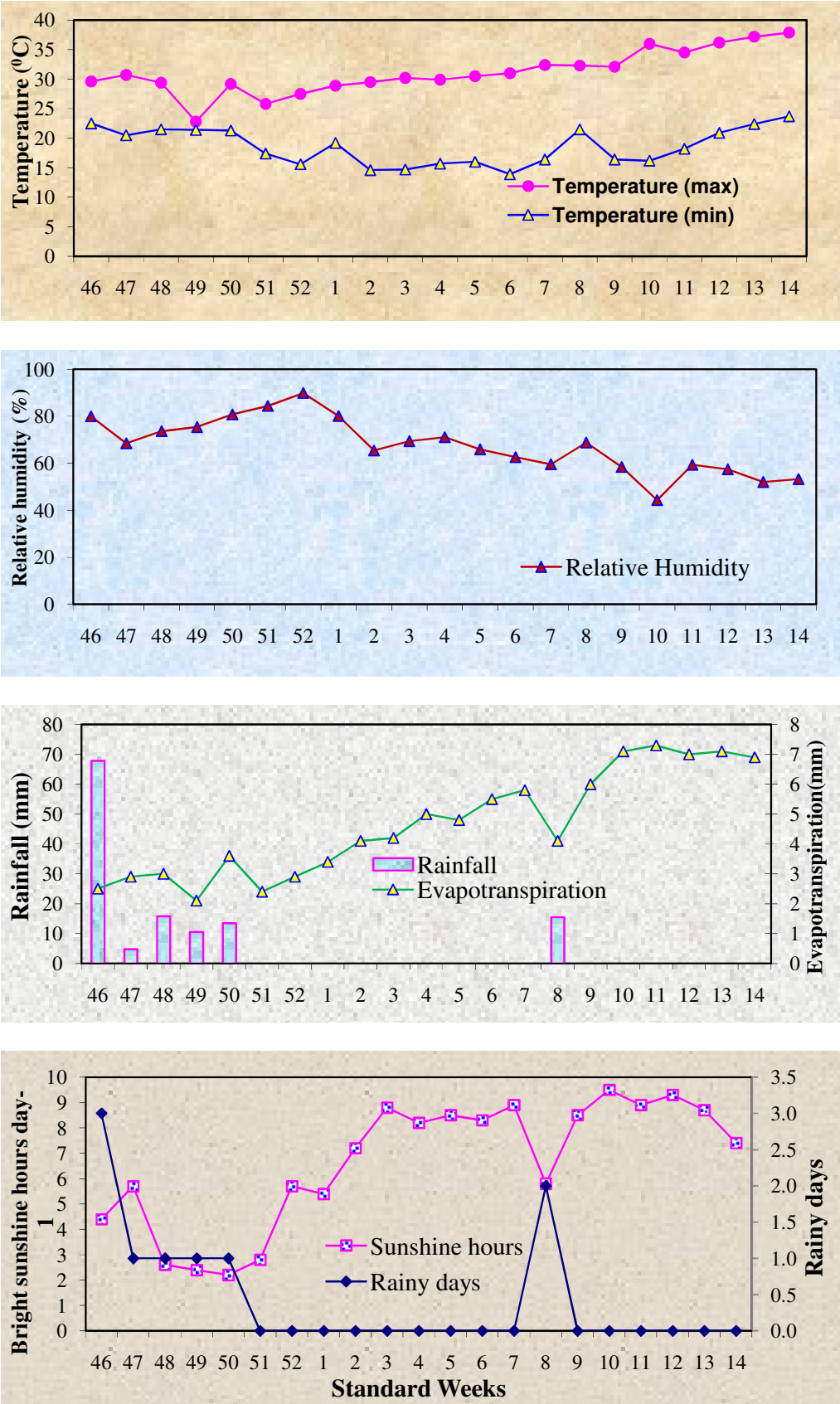


Fig.3.2: Standard week wise meteorological data during the crop period of aromatic rice during 2010-2011

a total amount of 128.1 mm rainfall was received during the crop period in 9 rainy days, as against the decennial average of 187.6mm received in 8.9 rainy days for the corresponding period.

During the crop period, the evaporation (measured from USWB class A open pan evaporimeter) ranged from 2.1 to 7.3 mm day⁻¹, with an average of 4.6 mm day⁻¹, while the decennial mean evaporation for the corresponding period ranged from 3.5 to 7.1 mm day⁻¹, with an average of 5.1 mm day⁻¹.

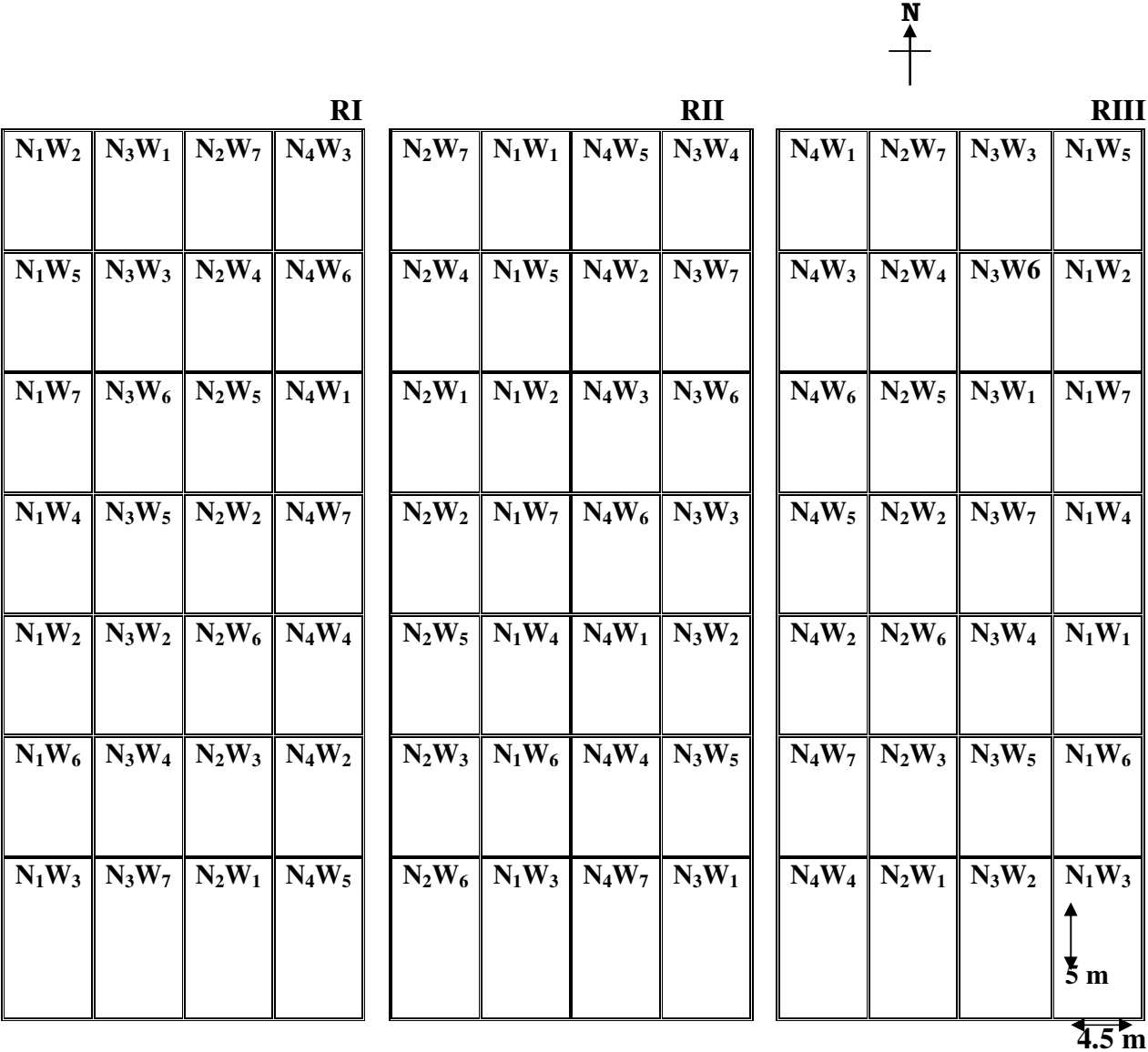
Mean bright sunshine hours day⁻¹ during crop period ranged from 2.2 to 9.5, with an average of 6.6. The decennial mean bright sunshine hours day⁻¹ for the corresponding period ranged from 5.6 to 9.1 with an average of 7.5.

3.3 SOILS

The study was conducted on different fields during two consecutive years (Field No. 138 during 2009-10 and Field No. 139 during 2010-11) at S. V. Agricultural College farm, Tirupati. Soil analysis was done initially prior to the start of the experiment from the samples drawn at random from a depth of 30 cm. The physico-chemical properties of soil revealed that the soils were sandy clay loam in texture, neutral in reaction, low in organic carbon and available nitrogen, medium in available phosphorus and potassium (Table 3.1)

Table 3.1 Physico-chemical properties of the soils of the experimental fields

S. No.	Particulars	Field No. 138	Field No. 139	Method
I. Mechanical analysis				
	Sand (%)	70.7	70.6	Bouyoucos hydrometer method (Piper, 1950)
	Silt (%)	6.5	6.5	
	Clay (%)	22.8	22.9	
	Texture	Sandy clay loam		
II. Chemical analysis				
	Organic carbon (%)	0.24	0.23	Wet digestion method (Walkley and Black, 1934)
	Available nitrogen (kg ha ⁻¹)	207	210	Alkaline permanganate method (Subbiah and Asija, 1956)
	Available P ₂ O ₅ (kg ha ⁻¹)	21.7	21.5	Olsen's method (Olsen <i>et al.</i> , 1954)
	Available K ₂ O (kg ha ⁻¹)	221	219	Flame photometry (Jackson, 1973)
	pH (1:2 soil water suspension)	7.2	7.4	Glass electrode pH meter (Jackson, 1973)
	EC (dS m ⁻¹)	0.16	0.16	Conductivity bridge (Jackson, 1973)



Design

Plot size

: Split plot design

Gross: 4.5 m × 5.0 m

Net: 3.9 m × 4.6 m

Fig. 3.3: Layout plan of experimental field

CROPPING HISTORY OF THE EXPERIMENTAL FIELDS

Year	Field No. 138		Field No. 139	
	<i>Kharif</i>	<i>Rabi</i>	<i>Kharif</i>	<i>Rabi</i>
2006-07	Groundnut	Groundnut	Groundnut	Groundnut
2007-08	Bajra	Groundnut	Bajra	Groundnut
2008-09	Bajra	Groundnut	Bajra	Groundnut
2009-10	Groundnut	Rice (Present experiment)	Groundnut	Horsegram
2010-11	-	-	Groundnut	Rice (Present experiment)

3.5 EXPERIMENTAL DETAILS

3.5.1 Design and Layout

The experiment was laid-out in a split plot design with three replications. The layout plan of the experimental field is furnished in the Fig. 3.3. The same pattern of layout was followed during both the years of study.

3.5.2 Treatments

There were four main plot treatments and seven sub plot treatments.

TREATMENTS

Main Plots: Nitrogen levels (N)

N₁: 100 kg ha⁻¹

N₂: 120 kg ha⁻¹

N₃: 140 kg ha⁻¹

N₄: 160 kg ha⁻¹

Sub Plots: Weed management practices (W)

W₁- Un-weeded check (Control)

W₂. Pre emergence (PE) of pretilachlor @ 500 g a.i ha⁻¹

W₃. PE of oxadiargyl @ 75 g a.i ha⁻¹

W₄. PE of pyrazosulfuron ethyl @ 20 g a.i ha⁻¹

W₅. PE of pretilachlor @ 500 g a.i ha⁻¹ fb hand weeding at 25 DAS

W₆. PE of oxadiargyl @ 75 g a.i ha⁻¹ fb hand weeding at 25 DAS

W₇. PE of pyrazosulfuron ethyl @ 20 g a.i ha⁻¹ fb hand weeding at 25 DAS

3.6 VARIETY

The test variety of rice was Sugandha samba (RNR 2465) developed by crossing between RNR M-7 X RNR 19994 at Agricultural Research Institute, Acharya N .G. Ranga Agricultural University, Rajendranagar, Hyderabad and was released by State Varietal Release Committee during 2011. It is a semi dwarf plant type, strongly scented, fine and short grain type with good cooking quality. It can be suited for both seasons *i.e.* *khariif* (August planting) and *rabi* (November 2nd fortnight) planting. The length of kernel is 5.5-5.8 mm with breadth of 2 mm and length: breadth ratio of 2.8. The head rice recovery is 70 per cent and tolerant to panicle mite. It matures in 130 days with yielding ability of 6.0-6.5 t ha⁻¹.

3.7 DETAILS OF HERBICIDES

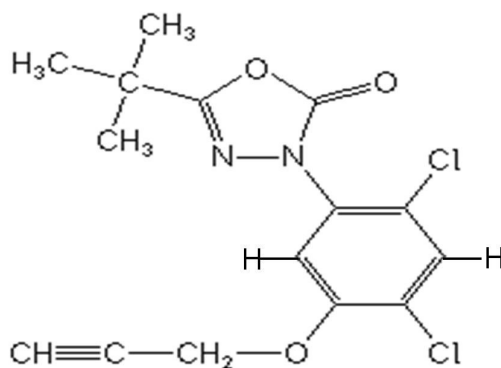
3.7.1 Oxadiargyl

Chemical group	:	Oxadiazoles
Chemical Name	:	5-Tert-butyl-3-[2,4-dichloro-5-(prop-ynyl)phenyl] 1,3,4-oxadiazole-2(3H)-one
Trade Name	:	Topstar
Formulation	:	Wettable Powder (WP)
Active ingredient	:	80%

Molecular formula : $C_{15}H_{14}Cl_2N_2O_3$

Mode of action : Inhibition of protoporphyrinogen oxidase

Chemical Structure :



3.7.2 Pyrazosulfuron-ethyl

Chemical group : Sulfonylurea

Chemical Name : Ethyl 5-[(4,6-dimethoxypyrimidin-2-yl)carbonyl]sulfamoyl]-1-methylpyrazole-4-carboxylate

Trade Name : Saathi

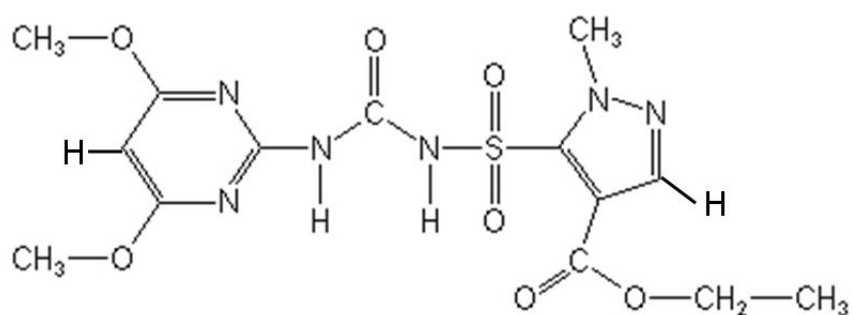
Formulation : Wettable Powder (WP)

Active ingredient : 10%

Molecular formula : $C_{14}H_{18}N_6O_7S$

Mode of action : Inhibition of aceto lactate synthase (ALS), Aceto hydroxyacid synthase (AHAS)

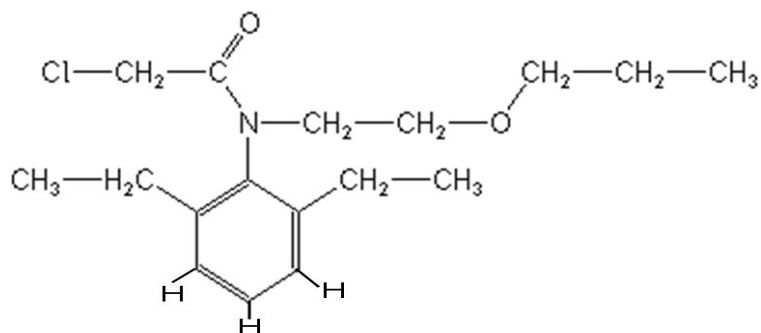
Chemical Structure:



3.7.3 Pretilachlor

- Chemical group : Chloroacetanilide
- Chemical Name : 2-chloro-2',6'-diethyl-N-(2-propoxyethyl)acetanilide
- Trade Name : Chek
- Formulation : Emulsifiable Concentrate
- Active ingredient : 50%
- Molecular formula : $C_{17}H_{26}ClNO_2$
- Mode of action : Inhibition of cell division

Chemical Structure :



3.8 SEASON

The crop was planted during *rabi* season purposefully to ensure coincidence of cooler period of the year with grain filling stage as it is essential for enhancing quality of scented rice. The crop was sown during 25th November 2009 and 24th November 2010, *i.e.* 47th standard meteorological week, during both the years of study.

3.9 CULTIVATION DETAILS OF CULTURAL OPERATIONS

3.9.1 Main Field Preparation

The experimental area was ploughed twice with tractor drawn cultivator and levelled with levelling blade to obtain the required tilth for direct sowing of rice seeds. The field was laid out into different experimental plots with provision for irrigation channels according to the layout plan presented in Fig.3.3.

3.9.2 Sowing

The seed of rice was directly sown in lines under non puddled and non flooded soil. The seed was treated with fungicide carbendazim @ 1g kg⁻¹ seed and then dibbled at two to three seeds hill⁻¹ with a spacing of 15 x 10 cm. Thinning and gap filling were done at 10 DAS to maintain the uniform plant stand in all the plots. Seed rate was estimated at three seeds hill⁻¹ was 40 kg ha⁻¹.

3.9.3 Fertilizers

The graded levels of nitrogen (100,120,140 and 160 kg ha⁻¹) were applied in the main plots as per the treatments and the recommended fertilizer dose of 60 kg P₂O₅ and 50 kg K₂O ha⁻¹ was applied uniformly as common basal dose for all main plots. As usual, nitrogen was applied in four equal splits, one each at basal, active tillering, panicle initiation and heading stages during both the years of experimentation.

3.9.4 Herbicides and Weeding

Pre emergence application of pretilachlor @ 500 g a.i ha⁻¹, oxadiargyl @ 75 g a.i ha⁻¹ and pyrazosulfuron ethyl @ 20 g a.i ha⁻¹ were applied to the respective plots on the next day after sowing with a spray solution of 500 l ha⁻¹ at optimum soil moisture condition. The herbicides were sprayed by using a knapsack sprayer fitted with flat fan nozzle. Manual weeding was done at 25 DAS as per the weed management treatments. Weeding was carried out by using hand hoes.

3.9.5 Irrigation

Both the seasons, the crop was received good amount of rainfall at vegetative stages. However, during 2009-10 the crop was encountered continuous dry spell, where as in 2010-11 only 15.5 mm of rainfall was received with 2 rainy days at reproductive stage. A total of 10 irrigations were given to the crop, when the crop has not received sufficient rainfall.

3.9.6 Plant Protection

Blast and brown spot incidence was observed during *rabi*, 2009 and the crop was protected by spraying with tricyclazole @ 0.6 g l⁻¹ for two times at 1 week interval. Spraying of copper oxy chloride 3 g l⁻¹ + streptomycin sulphate (0.1g l⁻¹) against bacterial leaf blight and spraying of monochrotophos (2.2ml l⁻¹) to arrest the spread of sucking pest in the second season experiment i.e. during *rabi*, 2010. Both the seasons, crop was suffered due to iron deficiency at early stages and it was corrected by spraying of ferrous sulphate (5 g l⁻¹) twice at seven days interval.

3.9.7 Harvesting and Threshing

The crop was harvested when the grain and straw turned yellow. The border rows were harvested first and later the net plots were harvested separately. The harvested crop was allowed to dry for two days in the plots itself and then threshed for separation of grain. The separated grain was then sun dried on open

threshing floor to a moisture level of about 14 per cent, while the straw was allowed to sun dry to a constant weight in the plot itself. Grain and straw yields were then recorded treatment wise and expressed as kg ha⁻¹.

3.10 COLLECTION OF EXPERIMENTAL DATA ON CROP

For recording observations which involved destructive sampling, five plants were sampled each time from the second outermost row in the border, while for recording other observations, 10 hills were randomly selected and labelled with tags from each net plot.

3.10.1 Growth Parameters

3.10.1.1 Plant height

Plant height was measured in cm at active tillering, panicle initiation, and flowering stages. The height was measured from base of the plant to tip of the largest leaf stretched at active tillering and panicle initiation stages; and from base of the plant to the tip of the panicle at flowering stage and expressed as cm.

3.10.1.2 Tiller number

Numbers of total tillers m⁻² were counted at active tillering, panicle initiation, flowering and at harvest from marked one square meter area within each net plot.

3.10.1.3 Leaf area index

Leaf area from five destructively sampled plants from border rows excluding extreme rows was measured using LICOR model, LT-300 portable leaf area meter. The leaf area index was calculated taking into account the area occupied by each plant as per the following formula (Watson, 1952). The leaf area index was worked out at active tillering, maximum tillering, panicle initiation, flowering and at harvest.

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

3.10.1.4 Dry matter production

Five plants from the border rows leaving the extreme rows were destructively sampled at active tillering, maximum tillering, panicle initiation, flowering and at harvest. These plant samples were air-dried and then oven-dried at 60°C to a constant weight and expressed as kg ha⁻¹.

3.10.2 Yield Attributes and Yield

3.10.2.1 Productive tillers (panicles)

The numbers of panicle bearing tillers were counted from the marked one square meter area within each net plot.

3.10.2.2 Panicle length

The length of panicle from the last node to the tip was recorded from randomly selected ten panicles and the mean length was expressed in cm.

3.10.2.3 Number of total grains panicle⁻¹

Number of total grains from ten randomly selected panicles were counted, averaged and expressed as number of grains panicle⁻¹.

3.10.2.4 Number of filled grains panicle⁻¹

Filled grains from the above ten randomly selected panicles were counted, averaged and expressed as number of filled grains panicle⁻¹.

3.10.2.5 Spikelet sterility

From the above ten randomly selected panicles, ill filled grains were counted and averaged. Spikelet sterility was worked out using following formula and expressed in per cent.

$$\text{Spikelet sterility (\%)} = \frac{\text{Number of ill filled grains panicle}^{-1}}{\text{Number of total grains panicle}^{-1}} \times 100$$

3.10.2.6 Test weight

Thousand grains were randomly drawn from the composite sample (dried to 14 per cent moisture content) of grain yield obtained from net plot in each treatment, weighed and expressed in grams.

3.10.2.7 Grain yield

Grain from the net plot was thoroughly sun dried to 14 per cent moisture content, weighed and expressed in kg ha⁻¹.

3.10.2.8 Straw yield

Straw obtained from the net plot was thoroughly sun dried in the field itself until a constant weight and expressed in kg ha⁻¹.

3.10.2.9 Harvest index

The relationship of economic yield to the total biological yield was expressed as harvest index and expressed in percentage.

$$\text{Harvest index} = \frac{\text{Grain yield}}{\text{Total biological yield}} \times 100$$

3.10.3 Quality Parameters

3.10.3.1 Kernel length

Length of ten randomly selected unbroken shelled rice (brown rice) was measured by using grain vernier (Mitutoyo micrometer), averaged and expressed in mm.

3.10.3.2 Kernel breadth

Breadth of the same ten randomly selected shelled rice (brown rice) was measured using grain vernier (Mitutoyo micrometer), averaged and expressed as mm.

3.10.3.3 Kernel length breadth ratio (L: B ratio)

From the above length and breadth of shelled rice, length: breadth ratio was worked out.

3.10.3.4 Milling per cent

The harvested rice grains were allowed for three months of curing period and then used for milling. Duplicate samples of 250 g rice grain was taken from the composite sample of net plot in each treatment and shelled using experimental rice dehusker (sheller). The samples were further polished with rice polisher (Indosaw laboratory miller) for 4 minutes and milling per cent was worked out using following formula.

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

3.10.3.5 Head rice recovery

From the milled rice, head rice (length equal or more than 3/4) were separated and weighed. Head rice recovery was calculated using following formula and expressed as per cent.

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

3.10.3.6 Protein content

The kernel nitrogen content estimated by Microkjeldhal method (Jackson, 1973) was multiplied by the factor 5.95 and expressed as protein content of the grain in percentage.

$$\text{Protein content (\%)} = \text{Total N content of rice kernels (\%)} \times 5.95$$

3.10.3.7 Amylose content

Grain amylose content was estimated as per the procedure described by Sadasivam and Manickam (1992) and expressed as percentage.

3.10.3.8 Volume expansion

One hundred ml of water was poured into a 250 ml measuring cylinder. A sample of 10 grams of milled rice was poured in the cylinder. The rise of water level was recorded. Then the rice was cooked. After cooling, the cooked rice was poured into the water of cylinder. Replacement of water volume was recorded. Finally, the ratio was calculated by using the formulae of Shahidullah *et al.* (2009)

$$\text{Volume expansion ratio} = \frac{\text{Volume of cooked rice (ml)}}{\text{Volume of milled rice (ml)}}$$

3.10.4 Observations on Weeds

The observations on weed growth at different stages were recorded from two randomly selected quadrant areas (0.5 m²) in each plot.

3.10.4.1 Weed flora

Weed flora of the experimental site was identified and categorized as grasses, sedges and broad leaved weeds in un-weeded check at all the stages of crop growth with out any deviation of the weed flora observed.

3.10.4.2 Weed density

Weed counts are taken category wise at 25, 50, 75,100 DAS and at harvest. At these stages, the three categories of weeds viz., grasses, sedges and BLWs expressed as number m⁻². All categories of weed count was taken at 25 DAS and later on hand weeding was imposed as per treatments.

3.10.4.3 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 60⁰ 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 25, 50, 75,100 DAS and at harvest. All categories of weed dry matter was taken at 25 DAS and later on hand weeding was done as per treatments.

3.10.4.4 Weed control efficiency (WCE)

Weed control efficiency in terms of weed dry weight was worked out based on the following formula (Mani *et al.*, 1973).

$$WCE = \frac{DM_C - DM_T}{DM_C} \times 100$$

Where,

DM_C = Dry matter of weeds in the un-weeded check

DM_T = Dry matter of weeds in the treatment imposed plot

3.10.5 Plant analysis and nutrient uptake

Plant samples collected for dry matter estimation at active tillering, panicle initiation and flowering were dried, ground into fine powder. Grains and straw from the net plot area were ground separately. These powdered plant samples were analysed for N, P and K contents by the standard procedures outlined by Jackson (1973).

The uptake of N, P and K at different stages of crop growth was calculated by multiplying the nutrient content with the respective dry matter weights and expressed as kg ha⁻¹. The total N, P and K uptake at harvest was arrived by summing up the grain and straw uptake.

3.10.6 Soil Analysis

After harvesting of rice, soil samples were collected from the individual plots of the treatments. The soil samples were analysed for organic carbon (Walkley and Black, 1934), available nitrogen (Subbiah and Asija, 1956), available phosphorus (Olsen *et al.* 1954) and available potassium (Jackson, 1973).

3.10.7 Economics

Total cost of cultivation of rice was calculated for each treatment on the basis of cost of inputs used. Gross returns were calculated based on the prevailing market price of the output. Net returns were arrived at by subtracting the cost of cultivation of respective treatments from gross returns for corresponding treatments. Benefit cost ratio was worked out for different treatments by dividing the gross returns with the cost of cultivation of the corresponding treatments.

3.10.8 Statistical Analysis

The data recorded on various growth and yield parameters of rice crop were analyzed following standard statistical analysis of variance procedure as suggested by Panse and Sukhatme (1985). Significance of the treatments was tested by 'F' test at 0.05 level of probability and critical differences were worked out, wherever treatment differences were found significant. The treatment differences wherever found not significant were denoted as 'NS'. Due to larger variation in density and dry weight of weeds, the corresponding data were transformed by using square root transformation ($\sqrt{x+0.5}$) before subjecting to statistical analysis as suggested by Gomez and Gomez (1984).

Chapter –IV

RESULTS AND DISCUSSION

Chapter IV

RESULTS AND DISCUSSION

Investigations were carried out at S. V. Agricultural College of Acharya N. G. Ranga Agricultural University, Tirupati on “**Nitrogen and weed management for maximizing the productivity and quality of aromatic rice under aerobic culture in Southern Agro-climatic Zone of Andhra Pradesh**” for two consecutive *rabi* seasons of 2009 and 2010.

Response of rice to the time of application of nitrogen with an optimal dose, is an important agronomic practice for realizing the yield potential of the crop. For growing rice under aerobic culture, one of the key management practices is the optimal rate of application of nitrogen to enable the realization of potential yield. The higher nitrogen requirement for aerobic rice may be due to the fact that more quantity of nitrate is expected to leached down due to increased soil aeration (either with growing rice under non flooded conditions, or with the shift to upland conditions) than under flooded conditions. Accordingly, four levels of nitrogen have been tried in the present investigation, to identify the optimum dose of nitrogen for rice under aerobic culture. Weeds are known to compete with the crop for basic resources both the above and below ground surfaces are known to affect the dry matter production and its effective partitioning to rice grain. Effective weed management during critical stages of crop weed competition increases the dry matter accumulation and is very much essential for effective partitioning of accumulated dry matter to rice grain. Therefore, the timely and effective management of all three groups of weeds (grasses, broad leaved weeds and sedges) should be the ultimate aim to elevate the yield levels without deteriorating the crop environment. Keeping this in view, seven weed management practices were tried, three of which are low volume herbicides (Oxadiargyl, Pyrazosulfuron and Pretilachlor) without hand weeding and other three are low volume herbicides integrated with hand weeding and another one is weedy check in the present investigation. The experimental results pertaining to growth, yield attributes, yield, quality parameters of rice, weed

density, weed dry matter, nutrient uptake, economics and post harvest soil fertility status as influenced by nitrogen and weed management practices are presented in this chapter.

4.1 WEATHER

Weather during the crop period was congenial for optimum performance of scented rice under aerobic culture. During 2009-10 crop encountered continuous dry spell, where as in 2010-11 only 15.5 mm of rainfall was received with 2 rainy days at reproductive stage, which was not sufficient to produce aerobic rice. Hence, the crop was given supplemental irrigations at 10 days interval. All the weather variables were within the cardinal range so as to enable the crop to reasonably express the effect of imposed treatments (Appendix A and B, Fig 3.1 and 3.2).

4.2 GROWTH PARAMETERS

Graded levels of nitrogen application and different weed management practices significantly influenced the growth parameters *viz.*, plant height, leaf area index, number of tillers m^{-2} and dry matter production. The interaction effect of graded levels and weed management practices were statistically measurable for dry matter production at different stages of crop growth, while none of the interaction was found for plant height, leaf area index and number of tillers m^{-2} (Table 4.1 to 4.8 and Fig 4.1 to 4.4).

4.2.1 Plant Height

Nitrogen and weed management practices significantly influenced the plant height of aromatic rice at different stages *viz.*, active tillering (AT), maximum tillering (MT), panicle initiation (PI) and at flowering (FL). The interaction effect of nitrogen and weed management was not statistically traceable, at any of the growth stages, with unaltered trend during both the years of study. The plant height tends to increase with advance in the age of crop up to flowering (Table 4.1 and Fig 4.1).

The tallest plants were obtained with the highest level of nitrogen application 160 kg ha^{-1} (N_4), which was at par with 140 kg N ha^{-1} (N_3) at all the stages during both the years of study. The next best nitrogen application for producing highest plant height of aromatic rice was with application of nitrogen 120 kg ha^{-1} (N_2) and it was significantly superior to 100 kg ha^{-1} (N_1). The shortest plants were recorded with application of nitrogen 100 kg ha^{-1} (N_1) at all the stages of crop growth during both the years of instances. The increase in plant height with increased levels of nitrogen might be attributed to the fact that higher nitrogen levels induce cell division and maintain higher auxin levels, which in turn stimulate cell elongation along the main axis leading to better elongation of internodes and finally resulted in conspicuous increase in plant height. Similar results of increase in plant height with increasing nitrogen levels have been amply documented by Jadhav *et al.* (2006), Maheswari *et al.* (2008) and Sathiya and Ramesh (2009).

Among different weed management practices, the tallest plants were noticed with pre-emergence (PE) application of oxadiargyl @ 75 g ha^{-1} supplemented with HW at 25 DAS (W_6), which was at par with PE application of pyrazosulfuron ethyl @ 20 g ha^{-1} supplemented with HW at 25 DAS (W_7) and both of them were significantly higher than rest of the weed management practices. This might be due to effective control of weeds by oxadiargyl or pyrazosulfuron lead to elimination of weed competition during critical stages of crop, resulted in increased plant height. The next best weed management practice in recording the plant height was with the PE application of pretilachlor @ 500 g ha^{-1} supplemented with HW at 25 DAS (W_5) which was significantly higher than with PE application of oxadiargyl @ 75 g ha^{-1} (W_3) and pyrazosulfuron ethyl @ 20 g ha^{-1} alone (W_4) and these two weed management practices were comparable with each other and significantly higher than with pretilachlor $500 @ \text{ g ha}^{-1}$ (W_2) alone. The lowest plant height recorded was with un-weeded check (W_1) at all the stages of crop growth during both the years. The shortest plants were recorded with un-weeded check (W_1) at all the stages of crop growth during both the years of experimentation due to heavy weed infestation, which resulted in increased competition for growth resources between crop and weeds which in

Table 4.1. Plant height (cm) of aromatic rice at different growth stages as influenced by nitrogen and weed management practices under aerobic culture

Treatments	<i>rabi,2009</i>				<i>rabi, 2010</i>			
	AT	MT	PI	FL	AT	MT	PI	FL
Nitrogen								
N ₁	15.0	38.5	48.3	55.0	15.2	39.0	50.3	55.3
N ₂	15.8	40.2	53.0	57.9	16.1	41.0	54.3	58.5
N ₃	16.5	43.0	54.9	62.0	16.8	43.4	56.7	62.2
N ₄	16.6	43.7	55.1	62.3	17.0	43.6	57.2	63.2
SEm $\pm$	0.16	0.30	0.3	0.47	0.15	0.34	0.5	0.56
CD (P=0.05)	0.6	1.0	1.2	1.6	0.6	1.2	1.7	1.9
Weed management								
W ₁	10.6	30.4	39.6	47.1	10.6	31.0	43.5	47.7
W ₂	15.7	39.5	50.8	53.0	15.3	40.2	51.0	57.8
W ₃	16.5	41.8	53.1	59.2	16.6	42.1	54.4	60.3
W ₄	16.3	41.5	53.0	58.7	16.3	42.1	54.1	59.9
W ₅	17.1	43.8	56.3	63.2	17.6	44.0	57.3	62.4
W ₆	17.8	46.7	58.5	67.2	18.7	46.5	61.2	65.7
W ₇	17.7	45.9	58.4	66.7	18.6	46.2	60.8	64.6
SEm $\pm$	0.17	0.52	0.6	0.98	0.30	0.50	1.0	0.70
CD (P=0.05)	0.5	1.5	1.7	2.8	0.9	1.4	2.7	2.0



Fig. 4.1: Plant height (cm) of aromatic rice at different growth stages as influenced by nitrogen and weed management practices under aerobic culture.

turn reduced the plant height. These results corroborate the documented evidence by Ramana *et al.* (2007) and Bhandare *et al.* (2011).

4.2.2 Leaf Area Index

Leaf area index of aromatic rice computed at different growth stages *viz.*, active tillering (AT), maximum tillering (MT), panicle initiation (PI), flowering (FL) and at harvest was significantly influenced by nitrogen and weed management practices, whereas the interaction effect was not statistically traceable, at any of the growth stages, with unaltered trend during both the years of study. Leaf area index of aromatic rice increased progressively with the advance in the age of the crop up to flowering and then declined at harvest due to senescence of older leaves (Table 4.2 and Fig 4.2).

The highest leaf area index was recorded with the highest level of application of nitrogen 160 kg ha^{-1} (N_4), which was comparable with 140 kg ha^{-1} (N_3), at all the stages during both the years. The next best level of nitrogen application was recorded with application of 120 kg ha^{-1} (N_2) and it was significantly higher than with N_1 in producing higher leaf area index. The lowest leaf area index was recorded with application of nitrogen 100 kg ha^{-1} (N_1), at all the stages of crop growth during both the years. The increase in leaf area index with increased levels of nitrogen might be attributed to the fact that higher nitrogen levels increases the availability of vital nutrients, there by production of more number of leaves per unit area and finally resulted in conspicuous increase in leaf area index. The present findings are in conformity with those of Jadhav *et al.* (2004) and Mhaskar *et al.* (2005).

With regard to different weed management practices tried, the highest leaf area index was observed with PE application of oxadiargyl @ 75 g ha^{-1} supplemented with HW at 25 DAS (W_6), which was comparable with PE application of pyrazosulfuron ethyl @ 20 g ha^{-1} supplemented with HW at 25 DAS (W_7) and both of them were significantly higher than rest of the weed management practices might be due to maintenance of weed free environment, lead to better utilization of growth resources, production of more number of

Table 4.2. Leaf area index of aromatic rice at different growth stages as influenced by nitrogen and weed management practices under aerobic culture

Treatments	<i>rabi,2009</i>					<i>rabi,2010</i>				
	AT	MT	PI	FL	At harvest	AT	MT	PI	FL	At harvest
Nitrogen										
N ₁	0.46	1.26	2.70	3.28	1.15	0.51	1.42	2.91	3.91	1.28
N ₂	0.53	1.36	2.89	3.63	1.21	0.58	1.55	3.09	4.02	1.35
N ₃	0.58	1.57	3.16	3.81	1.29	0.64	1.77	3.34	4.34	1.43
N ₄	0.60	1.62	3.19	3.89	1.33	0.66	1.84	3.49	4.41	1.46
SEm $\pm$	0.01	0.01	0.01	0.03	0.02	0.01	0.02	0.05	0.02	0.01
CD (P=0.05)	0.03	0.06	0.04	0.09	0.07	0.03	0.08	0.16	0.08	0.04
Weed management										
W ₁	0.27	1.13	1.26	1.82	0.58	0.33	1.19	1.36	1.94	0.63
W ₂	0.50	1.33	3.06	3.67	1.23	0.55	1.51	3.17	4.21	1.37
W ₃	0.56	1.44	3.19	3.85	1.33	0.61	1.65	3.38	4.40	1.46
W ₄	0.54	1.43	3.15	3.82	1.30	0.59	1.62	3.36	4.34	1.44
W ₅	0.61	1.54	3.33	4.02	1.38	0.66	1.75	3.58	4.64	1.54
W ₆	0.67	1.68	3.50	4.21	1.46	0.73	1.91	3.84	4.87	1.62
W ₇	0.65	1.63	3.46	4.18	1.43	0.71	1.86	3.77	4.81	1.61
SEm $\pm$	0.01	0.02	0.02	0.05	0.01	0.01	0.04	0.06	0.04	0.02
CD (P=0.05)	0.03	0.08	0.05	0.15	0.04	0.03	0.10	0.18	0.10	0.05

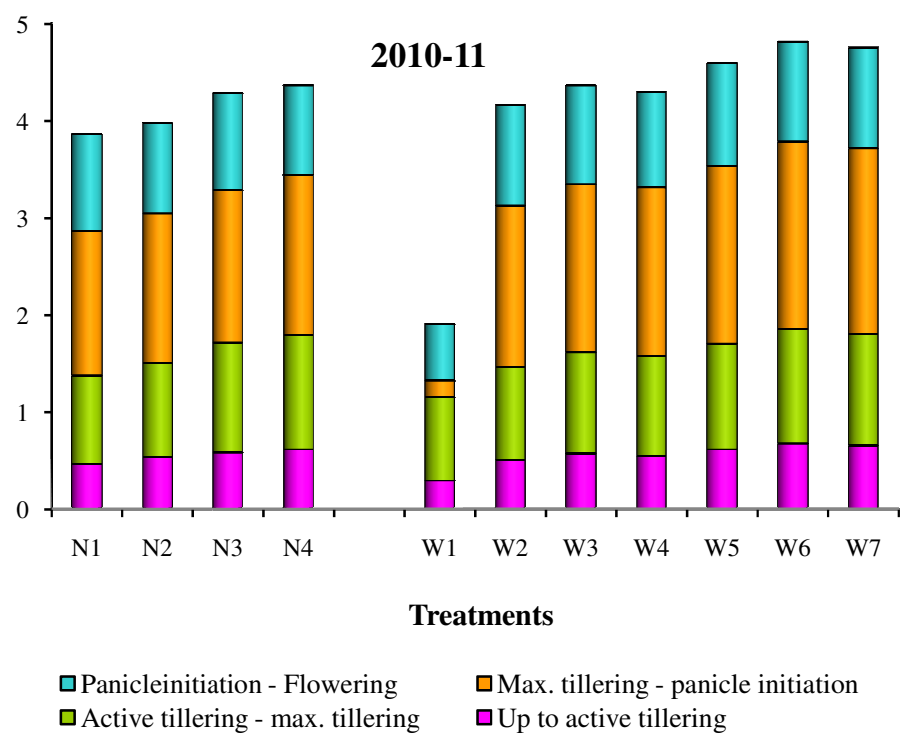
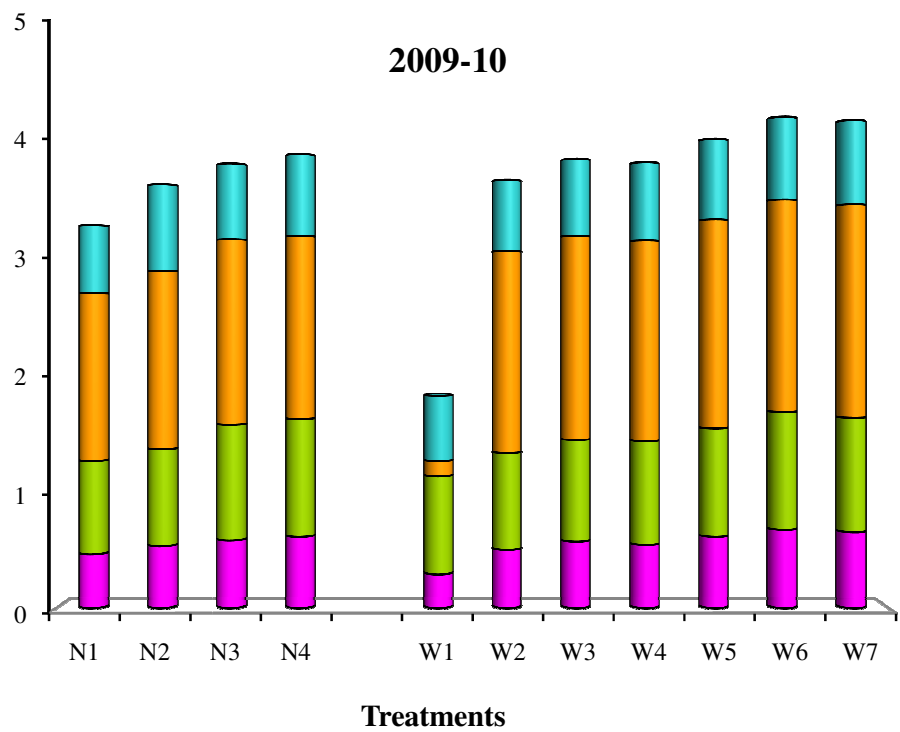


Fig.4.2. LAI of aromatic rice at different growth stages as influenced by nitrogen and weed management practices under aerobic culture

leaves, their rapid expansion and increased size of successive leaves. PE application of pretilachlor @ 500g ha⁻¹ supplemented with HW at 25 DAS (W₅) was next best in producing higher leaf area index and it was significantly higher than with PE application of oxadiargyl @ 75 g ha⁻¹ (W₃) and pyrazosulfuron ethyl @ 20g ha⁻¹ alone (W₄) and these two weed management practices were comparable with each other, at all the stages during both the years. Significantly higher leaf area index was computed with PE application of pretilachlor @ 500g ha⁻¹ alone (W₂) which is significantly higher than with un-weeded check (W₁). The lowest leaf area index was recorded with un-weeded check (W₁), at all the stages of crop growth during both the years of study. The lowest LAI with un-weeded check (W₁) due to heavy weed infestation lead to poor availability of ground resources resulted in reduced expansion of leaves and number of photosynthetically active leaves plant⁻¹. Similar results have been reported by Bhandare *et al.* (2011).

4.2.3 Number of Tillers m⁻²

Total number of tillers m⁻² counted at active tillering, maximum tillering, panicle initiation, flowering and at harvest was significantly affected by the graded levels of nitrogen and weed management practices tried, while the interaction effect was not statistically traceable at any of the stages of observation, during both the years of study. At all the stages of observation, effect of graded levels of nitrogen and weed management practices on the tiller number m⁻² of aromatic rice under aerobic culture followed similar trend, without any deviation, during both the years of study. Total number of tillers m⁻² of rice tended to increase up to flowering, beyond which declined towards harvest (Table 4.3 and Fig 4.3).

Increasing levels of nitrogen progressively enhanced the total number of tillers m⁻² up to flowering and then declined to harvest. The highest number of tillers m⁻² were obtained with the application of nitrogen 160 kg ha⁻¹ (N₄), which was comparable with the application of nitrogen at 140 kg ha⁻¹ (N₃). Application of nitrogen 120 kg ha⁻¹ (N₂) was the next best level in producing higher number of tillers m⁻² than 100 kg N ha⁻¹ (N₁). The lowest number of tillers m⁻² were

Table 4.3. No. of tillers (m⁻²) of aromatic rice at different growth stages as influenced by nitrogen and weed management practices under aerobic culture

Treatments	<i>rabi,2009</i>					<i>rabi,2010</i>				
	AT	MT	PI	FL	At harvest	AT	MT	PI	FL	At harvest
Nitrogen										
N ₁	133	296	334	353	232	139	310	348	356	235
N ₂	138	310	343	361	245	143	319	356	364	251
N ₃	144	323	352	368	259	149	329	367	372	262
N ₄	146	329	354	369	262	150	334	373	376	265
SEm ±	1.22	3.22	1.99	1.67	1.41	0.58	2.31	2.05	1.93	1.11
CD (P=0.05)	4	12	7	6	5	2	7	7	7	4
Weed management										
W ₁	80	247	275	307	218	82	238	305	313	228
W ₂	135	303	336	358	237	141	316	352	360	247
W ₃	144	319	354	367	250	153	331	366	371	254
W ₄	142	316	349	365	248	150	326	362	368	252
W ₅	156	331	362	374	256	159	341	374	379	259
W ₆	162	347	376	387	270	167	357	386	390	268
W ₇	160	344	372	382	266	165	352	382	387	265
SEm ±	1.22	3.74	2.44	2.06	1.66	1.51	3.13	1.98	2.36	1.58
CD (P=0.05)	3	10	7	6	5	4	9	6	7	4

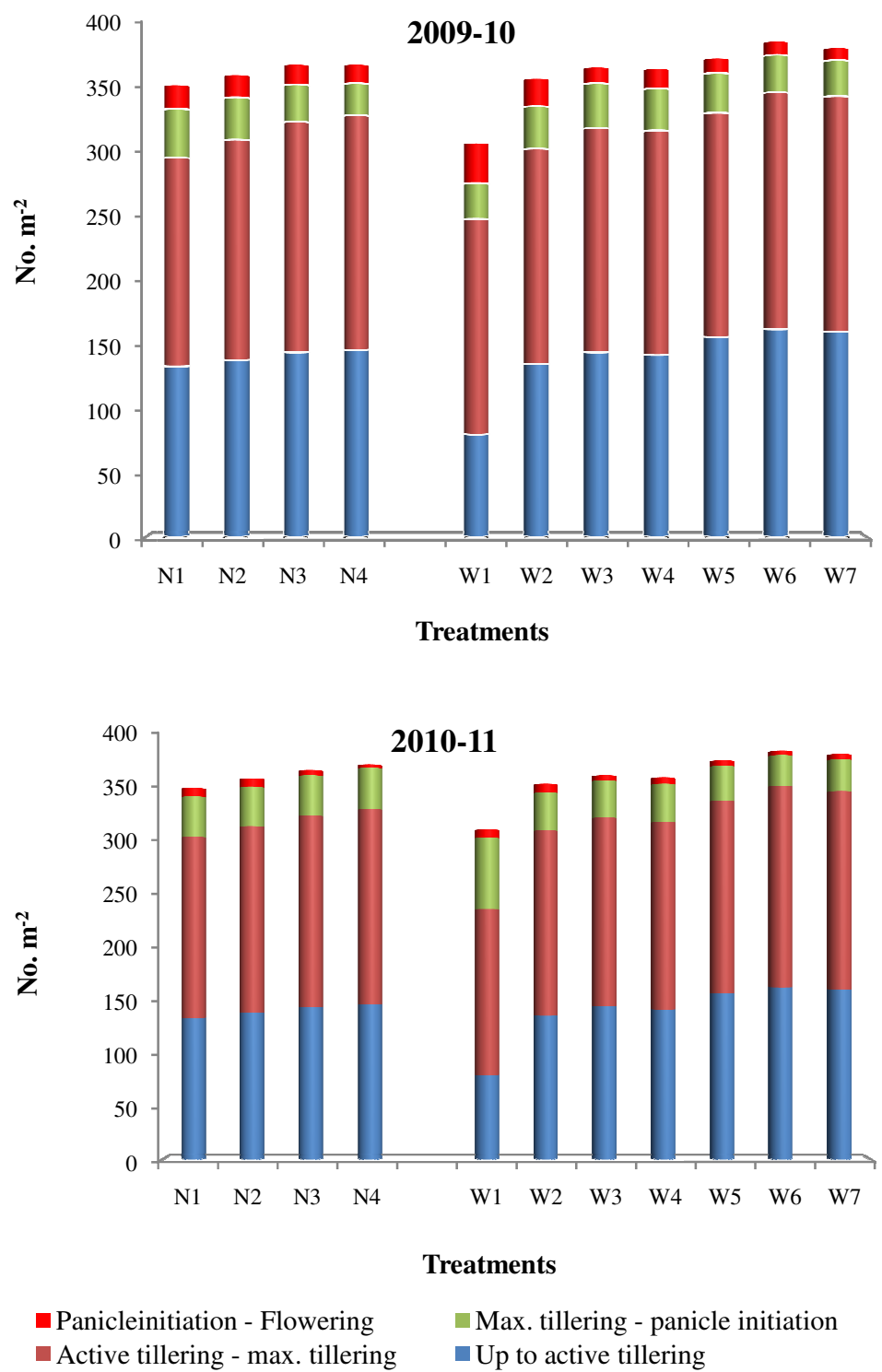


Fig.4.3. Total tillers (m^{-2}) of aromatic rice at different growth stages as influenced by nitrogen and weed management practices under aerobic culture

noticed with 100 kg ha⁻¹ (N₁) nitrogen application, which was significantly lower than with rest of the nitrogen levels, at all the stages during both the years. The increase in number of tillers m⁻² with increased levels of nitrogen due to more nitrogen supply at active tillering stage. These results are in conformity with the findings of Jadhav *et al.* (2006) and Ramana *et al.* (2007).

Among the weed management practices tried, the highest number of tillers unit area⁻¹ were produced with PE application of oxadiargyl @ 75 g ha⁻¹ supplemented with HW at 25 DAS (W₆), which was however, comparable with PE application of pyrazosulfuron ethyl @ 20g ha⁻¹ supplemented with HW at 25 DAS (W₇) and both of them were significantly higher than with PE application of pretilachlor @ 500g ha⁻¹ supplemented HW at 25 DAS (W₅) during both the years of experimentation was due to better control of dominant weeds with out any phyto-toxicity on rice crop provide better environment for production on more number of tillers. The next best weed management practice in producing total number of tillers m⁻² were with PE application of oxadiargyl @ 75 g ha⁻¹ alone (W₃) which was comparable with PE application of pyrazosulfuron ethyl @ 20g ha⁻¹ alone (W₄) and these weed management practices in turn were significantly superior to PE application of pretilachlor @ 500g ha⁻¹ alone (W₂). The lowest number of tillers m⁻² were produced with un-weeded check (W₁), which were significantly lesser than with rest of the weed management practices, during both the years of investigation might be due to severe competition of rice plant with weeds for available nutrients which in turn reduced the tiller production capacity of rice. These results are in agreement with those of Sharma *et al.* (2004).

4.2.4 Dry matter Production

Dry matter production of aromatic rice differed significantly due to nitrogen and weed management practices, as well as their interaction effect during both the instances of investigation, at all the stages of crop growth. Dry matter production of aromatic rice tended to increase progressively with an advance in the age of the crop up to harvest (Table 4.4. to 4.8 and Fig 4.4).

4.2.4.1 Dry matter production at active tillering

Dry matter production of aromatic rice at active tillering was significantly influenced by graded levels of nitrogen and weed management practices, as well as their interaction (Table 4.4).

Among the nitrogen levels tried the highest dry matter production of aromatic rice was produced with the application of nitrogen 160 kg ha^{-1} (N_4) which was however, comparable with 140 kg N ha^{-1} (N_3) and both of them were significantly higher in producing higher dry matter production, in both the years . Application of 120 kg N ha^{-1} (N_2) proved to be the next best level, in producing higher dry matter production which was significantly higher than with 100 kg ha^{-1} nitrogen (N_1) application. The lowest quantity of dry matter production was recorded with 100 kg ha^{-1} nitrogen application (N_1), which was significantly lower than rest of the nitrogen levels applied during both the instances of experimentation.

Among the weed management practices tried, the highest quantity of dry matter production recorded with PE application of oxadiargyl @ 75 g ha^{-1} supplemented with HW at 25 DAS (W_6), which was however, comparable with PE application of pyrazosulfuron ethyl @ 20 g ha^{-1} supplemented with HW at 25 DAS (W_7). Pre emergence application of pretilachlor @ 500 g ha^{-1} supplemented with HW at 25 DAS (W_5) was the next best weed management practice in producing higher dry matter production followed by PE application of oxadiargyl @ 75 g ha^{-1} alone (W_3) and pyrazosulfuron ethyl @ 20 g ha^{-1} alone (W_4). The later two weed management practices were comparable with each other and significantly higher than with PE application of pretilachlor @ 500 g ha^{-1} alone (W_2). The lowest quantity of dry matter production was recorded with un-weeded check (W_1), which was significantly lesser than with rest of the weed management practices tried, during both the years of investigation.

Irrespective of weed management practices tried, the highest dry matter production was recorded with 140 kg N ha^{-1} (N_3) which was significantly higher than 160 kg N ha^{-1} (N_4) except at W_2 , W_3 and W_4 , where N_4 recorded significantly

Table 4.4. Drymatter production of aromatic rice (kg ha⁻¹) at active tillering as influenced by nitrogen and weed management practices under aerobic culture

Treatments	<i>rabi, 2009</i>					<i>rabi, 2010</i>				
	N1	N2	N3	N4	Mean	N1	N2	N3	N4	Mean
W1	346	514	838	677	594	772	797	958	830	839
W2	1631	1702	2038	2254	1906	1699	1758	2050	2314	1955
W3	1800	1818	1976	2418	2003	1694	1789	2239	2387	2027
W4	1762	1794	1943	2409	1977	1671	1775	2218	2404	2017
W5	1973	2237	2514	2286	2253	1878	2221	2478	2346	2230
W6	2100	2322	2606	2412	2360	2013	2233	2590	2560	2349
W7	2066	2308	2572	2390	2334	1990	2224	2578	2530	2330
	1668	1814	2070	2121		1674	1828	2158	2196	

	SEm ±	CD (P=0.05)	SEm ±	CD (P=0.05)
N	16.30	57	11.98	42
W	23.77	67	19.60	56
N at W	43.78	122	32.87	90
W at N	47.53	135	39.20	111

higher dry matter production than N_3 . During 2010-11, these two N levels were comparable with each other at W_6 and W_7 . Significantly the lowest dry matter production of aromatic rice was recorded with 100 kg N ha^{-1} (N_1).

Disregarding N levels, PE application of oxadiargyl 75 g ha^{-1} supplemented with HW at 25 DAS (W_6) produced the highest quantity of dry matter production, which was comparable with PE application of pyrazosulfuron ethyl supplemented with HW at 25 DAS (W_7), while the lowest dry matter production was registered with un-weeded check during both the years .

Among all the treatmental combinations the highest quantity of dry matter production was recorded with application of 140 kg N ha^{-1} in combination with PE application of oxadiargyl @ 75 g ha^{-1} supplemented with HW at 25 DAS (N_3W_6), which was comparable with same level of N application with PE application of pyrazosulfuron ethyl @ 20 g ha^{-1} supplemented HW at 25 DAS (N_3W_7) during both the years. The lowest quantity of dry matter production of aromatic rice was recorded with application of 100 kg N ha^{-1} coupled with un-weeded check (N_1W_1).

4.2.4.2 Dry matter production at maximum tillering

Dry matter production of aromatic rice at maximum tillering was significantly influenced by graded levels of nitrogen and weed management practices, as well as their interaction and followed exactly similar trend to that of dry matter production at active tillering (Table 4.5).

4.2.4.3 Dry matter production at panicle initiation

Dry matter production of aromatic rice at panicle initiation was significantly influenced by graded levels of nitrogen and weed management practices, as well as their interaction and followed exactly similar trend to that of dry matter production at active tillering (Table 4.6).

Table 4.5. Drymatter production of aromatic rice (kg ha⁻¹) at maximum tillering as influenced by nitrogen and weed management practices under aerobic culture

Treatments	<i>rabi, 2009</i>					<i>rabi, 2010</i>				
	N1	N2	N3	N4	Mean	N1	N2	N3	N4	Mean
W1	1812	2092	2728	2436	2267	1685	1896	2868	2556	2251
W2	4198	4268	4517	5337	4580	4321	4402	4952	5441	4779
W3	4268	4342	5069	5535	4804	4328	4508	5275	5564	4919
W4	4248	4322	4981	5499	4763	4300	4407	5240	5580	4882
W5	4736	5276	5800	5383	5299	4597	5254	5742	5471	5266
W6	5063	5483	5980	5667	5548	4890	5282	5917	5885	5493
W7	5006	5436	5946	5594	5495	4850	5251	5880	5846	5457
	4190	4460	5003	5064		4139	4429	5125	5192	

	SEm ±	CD (P=0.05)	SEm ±	CD (P=0.05)
N	18.80	65	22.24	77
W	24.68	70	27.39	78
N at W	49.68	140	58.27	166
W at N	49.36	140	54.78	156

Table 4.6. Drymatter production of aromatic rice (kg ha⁻¹) at panicle initiation as influenced by nitrogen and weed management practices under aerobic culture

Treatments	<i>rabi, 2009</i>					<i>rabi, 2010</i>				
	N1	N2	N3	N4	Mean	N1	N2	N3	N4	Mean
W1	3023	3321	3998	3722	3516	2901	3201	4333	4017	3613
W2	5799	5879	6674	7077	6358	5972	6138	6823	7322	6564
W3	5966	6019	6776	7283	6511	6059	6180	7132	7546	6729
W4	5959	5969	6663	7246	6460	6029	6153	7028	7566	6694
W5	6485	7098	7684	7092	7090	6424	7183	7792	7467	7217
W6	6880	7323	7827	7456	7371	6644	7219	7917	7831	7403
W7	6799	7338	7705	7440	7321	6597	7170	7877	7769	7353
	5844	6135	6759	6761		5804	6178	6986	7074	

	SEm ±	CD (P=0.05)	SEm ±	CD (P=0.05)
N	26.00	90	27.25	95
W	19.14	55	34.19	98
N at W	65.31	197	71.56	204
W at N	38.28	109	68.38	194

4.2.4.4 Dry matter production at flowering

Dry matter production of aromatic rice at flowering was significantly influenced by graded levels of nitrogen and weed management practices, as well as their interaction and followed exactly similar trend to that of dry matter production at active tillering (Table 4.7).

4.2.4.5 Dry matter production at harvest

Dry matter production of aromatic rice at harvest was significantly influenced by graded levels of nitrogen and weed management practices, as well as their interaction and followed exactly similar trend to that of dry matter production at active tillering (Table 4.8).

At all the stages of crop growth, dry matter production of aromatic rice increased progressively with increasing levels of N and recorded the highest quantity with 160 kg N ha⁻¹ (N₄). This might be due to cumulative effect of photosynthesis due to taller plants with more number of tillers and larger leaf area because of increased availability of vital nutrients lead to increased dry matter production. The positive effect of nitrogen on dry matter production of aromatic rice has been documented earlier by Murali and Setty (2001), Senthivelu and Prabha (2007) and Devi and Sumathi (2011).

Among all weed management practices, PE application of oxadiargyl @ 75 g ha⁻¹ supplemented with HW at 25 DAS (W₆) recorded the highest dry matter production owing to effective control of all category of weeds during active crop growth period and reduced the nutrient uptake by weeds and gave better environment for development of growth attributing characters. The lowest dry matter production was recorded with un-weeded check (W₁) due to severe competition of rice plant with weeds for available nutrients which in turn reduced the plant height, number of tillers resulted in reduced dry matter production. These results are in concurrence with findings of Ramana *et al.* (2007) and Bhandare *et al.* (2011).

Table 4.7. Drymatter production of aromatic rice (kg ha⁻¹) at flowering as influenced by nitrogen and weed management practices under aerobic culture

Treatments	<i>rabi, 2009</i>					<i>rabi, 2010</i>				
	N1	N2	N3	N4	Mean	N1	N2	N3	N4	Mean
W1	3642	3927	4545	4207	4080	3543	3748	4868	4561	4180
W2	6244	6328	6940	7516	6757	6449	6563	7164	7759	6984
W3	6388	6458	7067	7695	6902	6476	6650	7593	7952	7168
W4	6320	6394	7013	7642	6842	6417	6582	7540	7976	7129
W5	6856	7428	8014	7560	7464	6842	7549	8076	7895	7591
W6	7187	7667	8152	7859	7716	7125	7583	8352	8201	7815
W7	7083	7619	8091	7812	7651	7050	7533	8286	8176	7761
	6246	6546	7117	7184		6272	6601	7411	7503	

	SEm ±	CD (P=0.05)	SEm ±	CD (P=0.05)
N	28.29	98	28.00	97
W	26.89	76	35.90	102
N at W	72.21	153	73.77	209
W at N	53.78	212	71.80	204

Table 4.8. Drymatter production of aromatic rice (kg ha⁻¹) at harvest as influenced by nitrogen and weed management practices under aerobic culture

Treatments	<i>rabi, 2009</i>					<i>rabi, 2010</i>				
	N1	N2	N3	N4	Mean	N1	N2	N3	N4	Mean
W1	3975	4292	4769	4644	4420	3987	4138	5233	4885	4561
W2	7462	7477	8414	8670	8006	7637	7747	8435	8922	8185
W3	7539	7608	8618	8891	8164	7680	7855	8815	9106	8364
W4	7517	7569	8499	8838	8106	7671	7804	8723	9075	8318
W5	8072	8576	9072	8971	8673	8037	8766	9277	9013	8773
W6	8339	8803	9319	9235	8924	8342	8786	9458	9470	9014
W7	8263	8809	9288	9232	8898	8263	8757	9453	9425	8975
	7310	7591	8283	8354		7374	7693	8485	8557	

	SEm ±	CD (P=0.05)	SEm ±	CD (P=0.05)
N	34.82	121	22.48	78
W	26.52	75	43.40	123
N at W	87.63	151	64.10	173
W at N	53.03	264	86.81	247

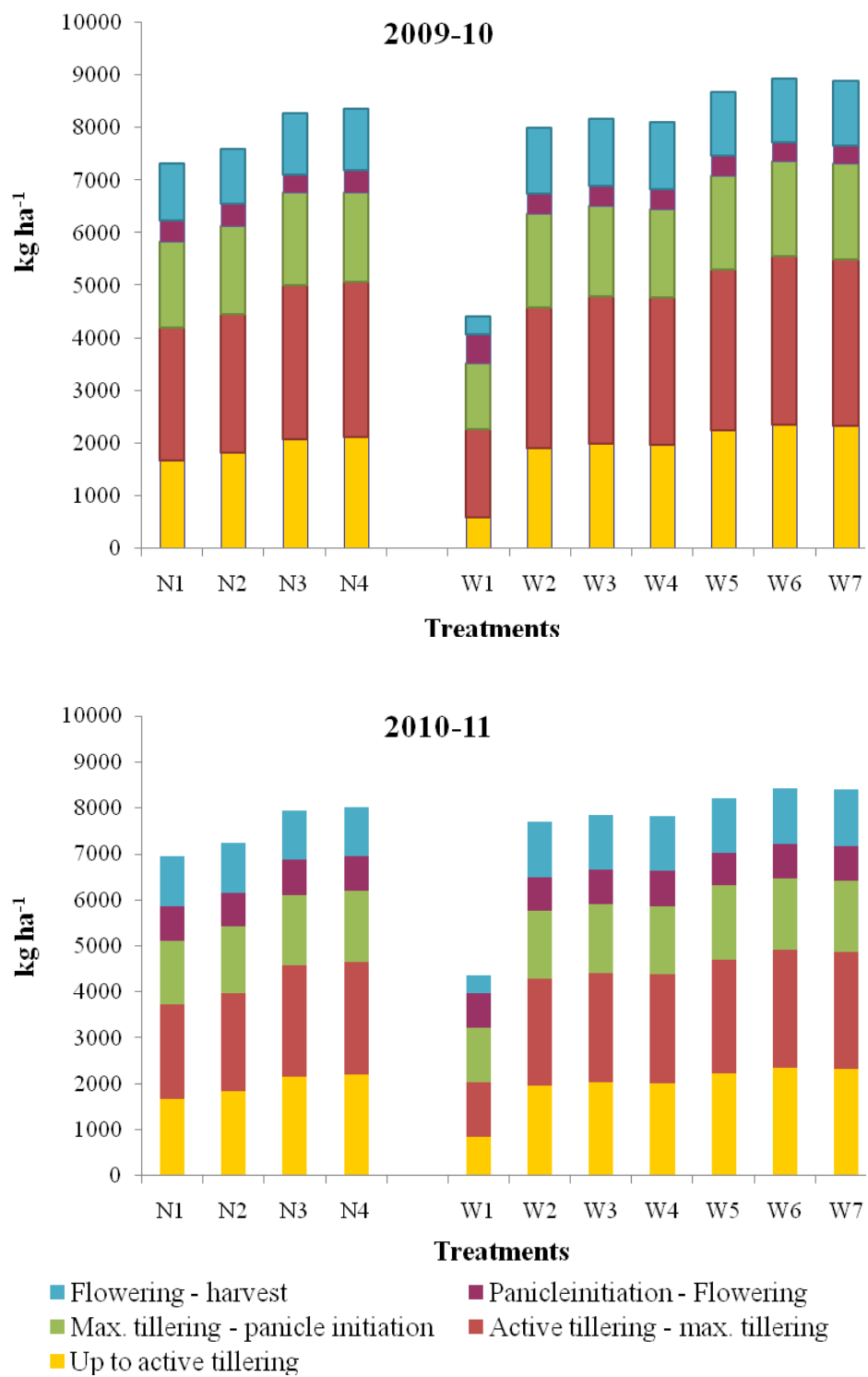


Fig. 4.4. Drymatter production (kg ha⁻¹) of aromatic rice at different growth stages as influenced by nitrogen and weed management practices under aerobic culture

4.3 YIELD ATTRIBUTES

Graded levels of nitrogen application and different weed management practices significantly influenced the yield attributes *viz.*, number of panicles m^{-2} , panicle length, total number of grains panicle $^{-1}$, filled grains panicle $^{-1}$, spikelet sterility and thousand grain weight. The interaction effect of graded levels and weed management practices were statistically measurable for total number of grains panicle $^{-1}$, filled grains panicle $^{-1}$ and spikelet sterility while none of the interaction was found for number of panicles m^{-2} , panicle length and thousand grain weight (Table 4.9 to 4.13 and Fig 4.5 to 4.6).

4.3.1 Number of Panicles m^{-2}

Panicle production m^{-2} of aromatic rice under aerobic culture was significantly influenced by nitrogen as well as weed management practices, however their interaction effects were not found significant during both the instances of experimentation (Table 4.9 and Fig 4.5).

Increasing levels of nitrogen progressively enhanced the number of panicles m^{-2} up to 140 kg N ha^{-1} (N_3), beyond which the number of panicles m^{-2} declined. The highest number of panicles m^{-2} was recorded with the application of nitrogen 140 kg ha^{-1} (N_3), which was however, comparable with 160 kg ha^{-1} (N_4) and both of them significantly higher in producing more number of panicles m^{-2} than rest of the nitrogen levels tried during both the years of study. Application of 120 kg ha^{-1} (N_2) nitrogen was the next best level in producing higher number of panicles m^{-2} , which was significantly higher than with 100 kg N ha^{-1} (N_1). The lowest number of panicles m^{-2} was recorded with the application of nitrogen 100 kg ha^{-1} (N_1) during both the years of study. The highest number of panicles m^{-2} with 140 kg N ha^{-1} (N_3) might be attributed to the fact that favourable growing environment would have converted larger proportion of tillers in to effective tillers due to better translocation of photosynthates and thereby producing higher number of panicles m^{-2} . Similar findings also reported by Murali and Setty (2001) and Sriramchandrasekaran and Ravichandran (2003).

With regard to weed management practices tried, the highest number of panicles m^{-2} were produced with PE application of oxadiargyl @ 75 g ha^{-1} supplemented with HW at 25 DAS (W_6), which was statistically similar to PE application of pyrazosulfuron ethyl @ 20 g ha^{-1} supplemented with HW at 25 DAS (W_7) and these two weed management practices were significantly superior to rest of the weed management practices in producing higher number of panicles m^{-2} . This might be due to effective control of weeds through out the crop growth period, which resulted in better translocation of photosynthates from source to sink. The next best weed management practice was PE application of pretilachlor @ 500 g ha^{-1} supplemented with HW at 25 DAS (W_5), which was significantly higher than PE application of oxadiargyl @ 75 g ha^{-1} alone (W_3), which in turn at par with PE application pyrazosulfuron ethyl @ 20 g ha^{-1} alone (W_4). PE application of pretilachlor @ 500 g ha^{-1} alone (W_2) recorded significantly higher number of panicles m^{-2} than unweeded check (W_1). The lowest number of panicles m^{-2} were noticed with unweeded check (W_1) during both the years of study owing to severe crop weed competition at critical stages for growth resources have detrimental effect on growth and development of crop. These results are in accordance with those of Saini and Angiras (2002) and Thimmegowda *et al.* (2009).

4.3.2 Panicle Length

Nitrogen as well as weed management practices were significantly influenced the panicle length of aromatic rice under aerobic culture, while the interactions effects were not statistically traceable during both the years of study (Table 4.9).

The longest panicle measured was with the application of nitrogen at 140 kg ha^{-1} (N_3), which was at par with 160 kg N ha^{-1} (N_4) and these two nitrogen levels were significantly higher than rest of the nitrogen levels tried during both the years of study. The next best nitrogen level in recording higher panicle length was application of nitrogen at 120 kg ha^{-1} (N_2), which was significantly higher than with 100 kg N ha^{-1} (N_1), which produced the shortest panicles during both the years of experimentation. The longest panicle with 140 kg N ha^{-1} might be

Table 4.9. No. of panicles (m⁻²) and panicle length (cm) of aromatic rice as influenced by nitrogen and weed management practices under aerobic culture

Treatments	<i>rabi, 2009</i>		<i>rabi, 2010</i>	
	No. of panicles (m ⁻²)	Panicle length (cm)	No. of panicles (m ⁻²)	Panicle length (cm)
Nitrogen				
N1	112	17.9	112	17.8
N2	118	19.1	119	18.9
N3	124	20.9	127	20.8
N4	123	20.5	125	20.3
SEm ±	0.65	0.17	0.82	0.17
CD (P=0.05)	2	0.6	3	0.6
Weed management				
W1	55	15.4	59	15.6
W2	113	17.9	119	18.1
W3	127	19.4	127	19.5
W4	125	19.0	125	19.3
W5	131	20.4	134	20.4
W6	143	22.9	144	22.0
W7	141	22.3	140	21.3
SEm ±	1.08	0.31	1.52	0.27
CD (P=0.05)	3	0.9	5	0.8

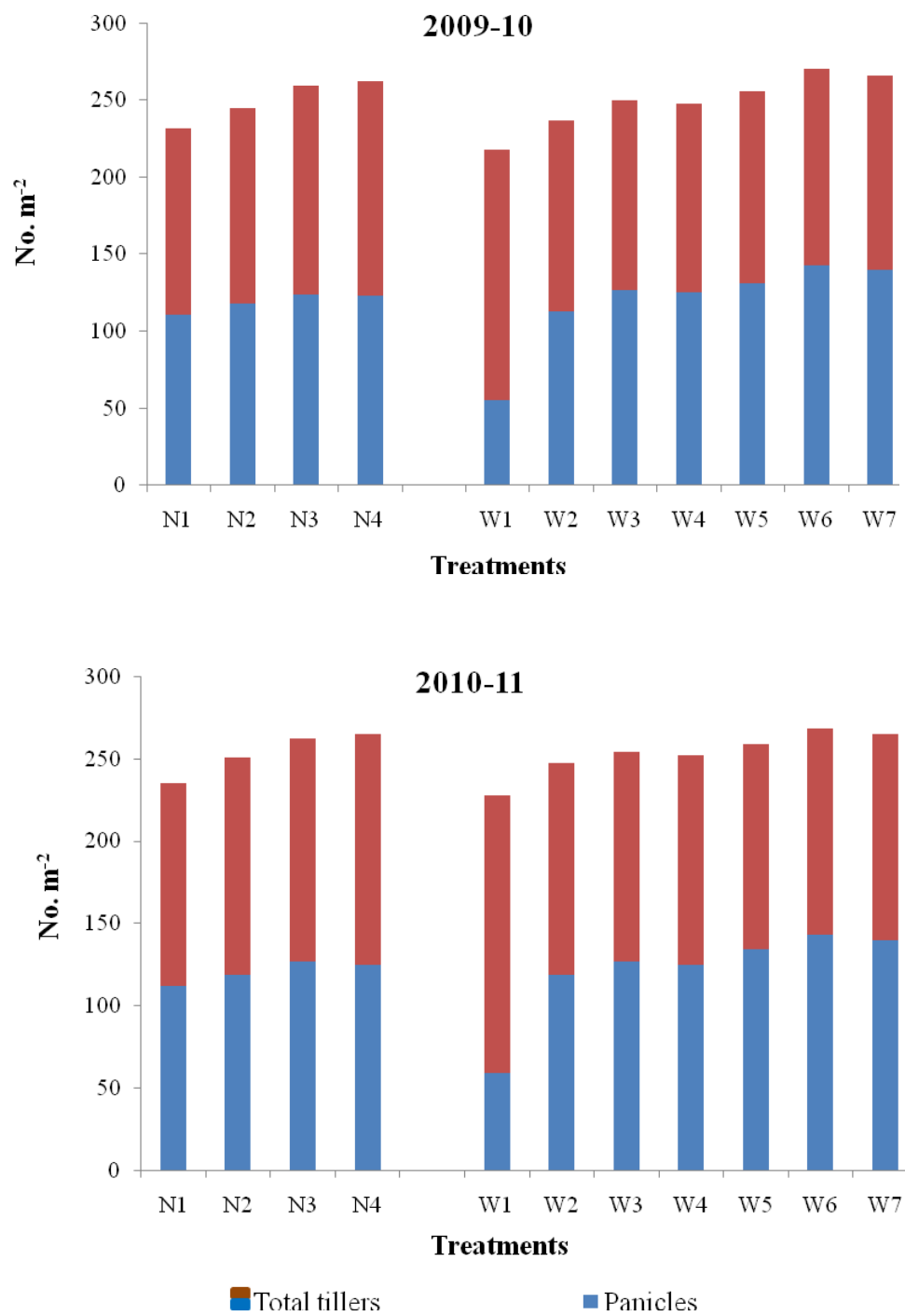


Fig.4.5. Total tillers Vs panicles (m⁻²) of aromatic rice as influenced by nitrogen and weed management practices under aerobic culture

attributed to maintain better nitrogen balance of rice plant during panicle growth period. The present findings are in accordance with those of Rakesh Kumar and Mohammed –Ikrammullah (2004) and Manzoor *et al.* (2006).

Among weed management practices, the longest panicle was associated with PE application of @ oxadiargyl 75 g ha⁻¹ supplemented with HW at 25 DAS (W₆), which was at par with PE application of pyrazosulfuron ethyl @ 20g ha⁻¹ supplemented with HW at 25 DAS (W₇) and both of them were significantly higher than rest of the weed management practices, due to weed free environment at the time of panicle production. Similar results reported by Nandal and Hari om (1998). PE application of pretilachlor@ 500g ha⁻¹ supplemented with HW at 25 DAS (W₅), proved to be the next best weed management practice followed by PE application of oxadiargyl @ 75 g ha⁻¹ (W₃) and pyrazosulfuron ethyl @ 20g ha⁻¹ alone (W₄) and the later two weed management practices were comparable with each other. PE application of pretilachlor @ 500g ha⁻¹ alone (W₂) recorded significantly longer panicles than un-weeded check (W₁), which resulted in shortest panicles.

4.3.3 Total Number of Grains Panicle⁻¹

Total number of grains panicle⁻¹ of aromatic rice under aerobic culture varied significantly with graded levels of nitrogen and weed management practices, as well as their interaction effect with unaltered trend during both the instances of experimentation (Table 4.10 and Fig 4.6).

The highest number of total grains panicle⁻¹ was recorded with the application of nitrogen 140 kg ha⁻¹ (N₃) which was however, comparable with 160 kg ha⁻¹ (N₄) and these two nitrogen levels were significantly superior to rest of the nitrogen levels tried during both the years of study might be attributed to the fact that increased production and partitioning of photosynthates to seed, owing to adequate availability of growth resources. Similar findings also reported by Murali and Setty (2001) and Manzoor *et al.* (2006). Application of 120 kg N ha⁻¹ (N₂) was the next best N level and recorded significantly higher number of total grains panicle⁻¹ than with 100 kg N ha⁻¹ (N₁). The lowest number

of total grains panicle⁻¹ was recorded with the application of nitrogen 100 kg ha⁻¹ (N₁) during both the years of experimentation.

As regards weed management practices, the highest number of total grains panicle⁻¹ were produced with PE application of oxadiargyl @ 75 g ha⁻¹ supplemented with HW at 25 DAS (W₆) which was however, comparable with PE application of pyrazosulfuron ethyl @ 20g ha⁻¹ supplemented with HW at 25 DAS (W₇) and both of them were significantly superior to rest of the weed management practices. This might be due to increased production and partitioning of photosynthates to seed, owing to adequate availability of growth resources as a result of less competition offered by weeds. The next best weed management practice in producing higher number of total grains panicle⁻¹ was PE application of pretilachlor @ 500g ha⁻¹ supplemented with HW at 25 DAS (W₅), which was significantly higher than PE application of oxadiargyl @ 75 g ha⁻¹ alone (W₃) which in turn comparable with pyrazosulfuron ethyl @ 20g ha⁻¹ alone (W₄). Pre-emergence application of pretilachlor @ 500g ha⁻¹ alone (W₂) recorded significantly higher number of total grains panicle⁻¹ than un-weeded check (W₁). The lowest number of total grains panicle⁻¹ was noticed with un-weeded check (W₁) during both the years of study due to reduction in post flowering dry matter accumulation, which in turn resulted in poor translocation of photosynthates from source to sink. The present findings are in accordance with those of Nandal and Hari om (1998) and Thimmegowda *et al.* (2010).

Disregarding of the weed management practices tried, the highest total number of grains panicle⁻¹ was recorded with 160 kg ha⁻¹ (N₄) which was comparable with 140 kg N ha⁻¹ (N₃) during both the years, except at W₄ where N₃ comparable with N₂ and at W₅ and W₃ where N₃ significantly differed with rest of the N levels tried. The lowest total number of g rains panicle⁻¹ was recorded with N₁ at all the weed management practices tried during both the years.

Table 4.10. Total no. of grains panicle⁻¹ of aromatic rice as influenced by nitrogen and weed management practices under aerobic culture

Treatments	<i>rabi, 2009</i>					<i>rabi, 2010</i>				
	N1	N2	N3	N4	Mean	N1	N2	N3	N4	Mean
W1	59	62	65	66	63	60	63	70	66	65
W2	106	110	116	112	111	109	110	120	121	115
W3	109	116	119	125	117	115	119	122	126	120
W4	107	119	120	116	116	111	120	123	123	119
W5	107	120	136	123	121	119	126	133	126	126
W6	120	126	133	136	129	124	129	138	138	132
W7	120	123	132	133	127	125	128	133	134	130
	104	111	117	116		109	114	120	119	

	SEm ±	CD (P=0.05)	SEm ±	CD (P=0.05)
N	0.74	2	0.68	2
W	1.19	4	0.94	3
N at W	2.03	5	1.80	5
W at N	2.38	7	1.88	5

Regardless of the nitrogen levels tried, during both the years, PE application of oxadiargyl @ 75 g ha⁻¹ supplemented with HW at 25 DAS (W₆) resulted in higher number of total grains panicle⁻¹, which was comparable with PE application of pyrazosulfuron ethyl @ 20g ha⁻¹ supplemented with HW at 25 DAS (W₇). The lowest total number of grains panicle⁻¹ of aromatic rice was registered with un-weeded check (W₁).

Among the treatment combinations tried, the highest number of total grains panicle⁻¹ were recorded with application of 160 kg N ha⁻¹ in combination with PE application of oxadiargyl @ 75 g ha⁻¹ supplemented with HW at 25 DAS (N₄W₆) which was comparable with same level of N with PE application of pyrazosulfuron ethyl @ 20g ha⁻¹ supplemented with HW at 25 DAS (N₄W₇). The lowest number of total grains panicle⁻¹ of aromatic rice under aerobic culture was recorded with the application of nitrogen at 100 kg N ha⁻¹ coupled with un-weeded check (N₁W₁).

4.3.4 Number of Filled Grains Panicle

Nitrogen and weed management practices, as well as their interaction effects significantly influenced the number of filled grains panicle⁻¹ of aromatic rice under aerobic culture during both the years of investigation (Table 4.11 and Fig 4.6).

The highest number of filled grains panicle⁻¹ was noticed with the application of nitrogen at 140 kg ha⁻¹ (N₃) and it was comparable with 160 kg N ha⁻¹ (N₄) might be primarily due to increase in chlorophyll content of leaves and maintenance of optimum nitrogen balance between source and sink which in turn better translocation of photosynthates to grain development. The present findings are in accordance with those of Rakesh Kumar and Mohammed – Ikramullah (2004) and Jadhav *et al.* (2006). The next best N level in recording higher number of filled grains panicle⁻¹ was the application of nitrogen at 120 kg ha⁻¹ (N₂), which was significantly higher than with 100 kg N ha⁻¹ (N₁), which produced the lowest number of filled grains panicle⁻¹ during both the years of experimentation.

Among weed management practices, the highest number of filled grains panicle⁻¹ was associated with PE application of oxadiargyl @ 75 g ha⁻¹ supplemented with HW at 25 DAS (W₆), which was comparable with PE application of pyrazosulfuron ethyl @ 20g ha⁻¹ supplemented with HW at 25 DAS (W₇) and both of them were significantly better than rest of the weed management practices due to adequate availability of growth resources as a result of less competition offered by weeds and better translocation of photosynthates resulted in lower number of ill-filled grains. These results corroborate the documented evidence by Ramana *et al.* (2007) and Thimmegowda *et al.* (2010). Pre-emergence application of pretilachlor @ 500g ha⁻¹ supplemented with HW at 25 DAS (W₅), proved to be the next best weed management practice in promoting more number of filled grains panicle⁻¹. Pre-emergence application of oxadiargyl @ 75 g ha⁻¹ alone (W₃) and pyrazosulfuron ethyl @ 20g ha⁻¹ alone (W₄) were comparable with each other. Pre-emergence application of pretilachlor @ 500g ha⁻¹ alone (W₂) recorded significantly higher number of filled grains panicle⁻¹ than un-weeded check (W₁) which resulted in lowest number of filled grains panicle⁻¹.

Irrespective of the weed management practices tried, the highest number of filled grains panicle⁻¹ were recorded with 140 kg ha⁻¹ (N₃), which was comparable with 140 kg ha⁻¹ (N₄) during both the years except at W₆ and W₁ during both 2009-10 these two N levels differed significantly. The lowest number of filled grains panicle⁻¹ was recorded with 140 kg ha⁻¹ (N₁) during both the years.

Regardless of the nitrogen levels tried, during both the years, PE application of oxadiargyl @ 75 g ha⁻¹ supplemented with HW at 25 DAS (W₆) resulted in higher number of filled grains panicle⁻¹, which was comparable with PE application of pyrazosulfuron ethyl @ 20g ha⁻¹ supplemented with HW at 25 DAS (W₇) except at N₃ where W₅ also at par with above two weed management

Table 4.11. Filled grains panicle⁻¹ of aromatic rice as influenced by nitrogen and weed management practices under aerobic culture

Treatments	<i>rabi, 2009</i>					<i>rabi, 2010</i>				
	N1	N2	N3	N4	Mean	N1	N2	N3	N4	Mean
W1	42	44	51	45	46	44	47	49	47	47
W2	89	95	98	96	95	86	98	103	106	98
W3	95	99	113	110	104	95	102	115	114	107
W4	91	93	116	112	103	94	101	114	113	106
W5	95	113	118	115	110	107	116	120	118	115
W6	110	119	121	126	119	114	122	128	126	122
W7	109	113	122	123	117	115	117	125	122	120
	90	97	105	104		94	100	108	107	

	SEm ±	CD (P=0.05)	SEm ±	CD (P=0.05)
N	0.74	2	0.70	2
W	1.13	3	1.04	3
N at W	1.99	5	1.89	5
W at N	2.25	7	2.09	6

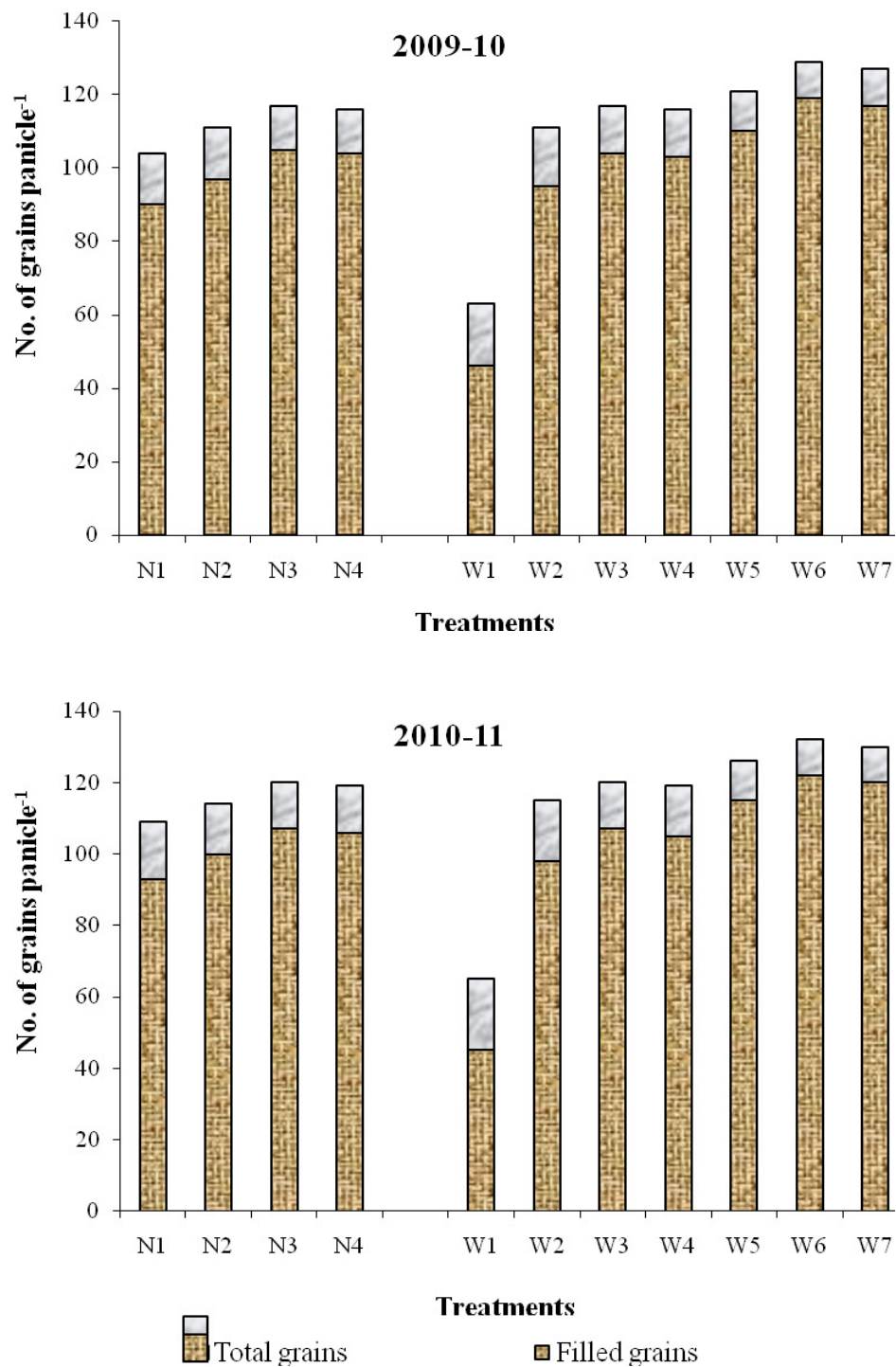


Fig. 4.6. Total grains Vs filled grains panicle⁻¹ of aromatic rice as influenced by nitrogen and weed management practices under aerobic culture

practices during I year and W₆ during II year. The lowest number of filled grains panicle⁻¹ was registered with un-weeded check (W₁).

Among the treatment combinations tried, the highest number of filled grains panicle⁻¹ was recorded with application of 160 kg N ha⁻¹ in combination with PE application of oxadiargyl @ 75 g ha⁻¹ supplemented with HW at 25 DAS (N₄W₆) which was comparable with same level of N with PE application of pyrazosulfuron ethyl @ 20g ha⁻¹ supplemented with HW at 25 DAS (N₄W₇). The lowest number of filled grains panicle⁻¹ of aromatic rice recorded with the application of nitrogen at 100 kg N ha⁻¹ coupled with un-weeded check (N₁W₁), which was comparable with N₂W₁ during both the years.

4.3.5 Spikelet Sterility

Spikelet sterility of aromatic rice under aerobic culture was significantly affected by the graded levels of nitrogen and weed management practices, as well as their interaction effect during both the years of experimentation (Table 4.12).

The lowest spikelet sterility was recorded with the application of nitrogen at 140 kg ha⁻¹ (N₃) and it was comparable with 160 kg N ha⁻¹ (N₄) during both the years of study. The next best level of nitrogen was 120 kg ha⁻¹ (N₂), which was comparable with 100 kg ha⁻¹ (N₁) during 2009-10 and differed significantly with N₁ during 2010-11. The highest spikelet sterility was observed with the application of nitrogen @ 100 kg ha⁻¹ (N₁) during both the instances of study. The highest spikelet sterility with lower level of nitrogen might be due to lower availability of vital nutrients at lower levels of nitrogen resulted in more ill filled grains and same was reported by Jadhav *et al.* (2006) and Devi and Sumathi (2011).

Among weed management practices, the lowest spikelet sterility was associated with PE application of oxadiargyl @ 75 g ha⁻¹ supplemented with HW at 25 DAS (W₆), which was comparable with PE application of pyrazosulfuron ethyl @ 20g ha⁻¹ supplemented with HW at 25 DAS (W₇) and both of them were

significantly better than rest of the weed management practices due to lowest crop weed competition for resources at the grain filling because of weed free environment. Similar results were reported by Thimmegowda *et al.* (2010). Pre-emergence application of pretilachlor @ 500g ha⁻¹ supplemented with HW at 25 DAS (W₅), proved to be the next best weed management practice in recording lower spikelet sterility. Pre-emergence application of oxadiargyl @ 75 g ha⁻¹ alone (W₃) and pyrazosulfuron ethyl @ 20g ha⁻¹ alone (W₄) were comparable with each other. Pre-emergence application of pretilachlor @ 500g ha⁻¹ alone (W₂) recorded significantly lower spikelet sterility than un-weeded check (W₁) which resulted in the highest spikelet sterility.

Disregarding of weed management practices tried, the lowest spikelet sterility was recorded with 140 kg N ha⁻¹ (N₃), except at W₂, W₅ and W₆ where 120 kg N ha⁻¹ (N₂) recorded the lowest. The highest spikelet sterility was recorded with 100 kg N ha⁻¹ (N₁), except at W₁, where 160 kg N ha⁻¹ (N₄) recorded the highest.

Irrespective of nitrogen levels tried, the lowest spikelet sterility was recorded with PE application of oxadiargyl @ 75 g ha⁻¹ supplemented with HW at 25 DAS (W₆) except at N₃ and N₄ where PE application of pretilachlor @ 500g ha⁻¹ supplemented with HW at 25 DAS (W₅) recorded the lowest spikelet sterility. The highest spikelet sterility of aromatic rice was registered with W₁ during both the years of experimentation.

Among the treatment combinations tried, the lowest spikelet sterility was recorded with application of 120 kg N ha⁻¹ in combination with PE application of oxadiargyl @ 75 g ha⁻¹ supplemented with HW at 25 DAS (N₂W₆), which was comparable with 160 kg N ha⁻¹ in combination with PE application of pretilachlor @ 500 g ha⁻¹ supplemented with HW at 25 DAS (N₄W₅). The highest spikelet sterility of aromatic rice under aerobic culture was recorded with 160 kg N ha⁻¹ in combination with un-weeded check (N₄W₁).

Table 4.12. Spikelet sterility (%) of aromatic rice as influenced by nitrogen and weed management practices under aerobic culture

Treatments	<i>rabi, 2009</i>					<i>rabi, 2010</i>				
	N1	N2	N3	N4	Mean	N1	N2	N3	N4	Mean
W1	28.81	29.03	21.54	31.82	27.80	26.67	25.40	30.00	28.79	27.71
W2	16.04	13.64	15.52	14.29	14.87	21.10	10.91	14.17	12.40	14.64
W3	12.84	14.66	5.04	12.00	11.14	17.39	14.29	5.74	9.52	11.73
W4	14.95	21.85	3.33	3.45	10.90	15.32	15.83	7.32	8.13	11.65
W5	11.21	5.83	13.24	6.50	9.20	10.08	7.94	9.77	6.35	8.54
W6	8.33	5.56	9.02	7.35	7.57	8.06	5.43	7.25	8.70	7.36
W7	9.17	8.13	7.58	7.52	8.10	8.00	8.59	6.02	8.96	7.89
	14.48	14.10	10.75	11.85		15.23	12.63	11.47	11.83	

	SEm ±	CD (P=0.05)	SEm ±	CD (P=0.05)
N	0.34	1.19	0.22	0.78
W	0.36	1.01	0.23	0.63
N at W	0.88	2.56	0.58	1.68
W at N	0.71	2.01	0.46	1.31

4.3.6 Test Weight

Nitrogen and weed management practices exerted significant influence on test weight of aromatic rice under aerobic culture. None of the interactions were found statistically traceable, during both the instances of study (Table 4.13).

The highest test weight of aromatic rice was noticed with the application of nitrogen at 140 kg ha^{-1} (N_3), which was comparable with 160 kg N ha^{-1} (N_4) and these two nitrogen levels were significantly higher than rest of the nitrogen levels tried during both the years of study due to more production and translocation of photosynthates at optimum level of nitrogen fulfill the sink needs. These results are in agreement with those of Jadhav *et al.* (2006) and Ramana *et al.* (2007). The next best N level in recording higher test weight was the application of nitrogen at 120 kg ha^{-1} (N_2), which was significantly higher than with 100 kg N ha^{-1} (N_1), which produced the lowest test weight during both the years of experimentation.

With regard to weed management practices tried, the highest thousand grain weight was registered with PE application of oxadiargyl @ 75 g ha^{-1} supplemented with HW at 25 DAS (W_6) which was however, comparable with PE application of pyrazosulfuron ethyl @ 20 g ha^{-1} supplemented with HW at 25 DAS (W_7) and both of them were significantly superior to rest of the weed management practices tried due to weed free environment especially at critical stages of crop growth, which might have resulted in production and translocation of photosynthtes sufficient to supply the sink needs. Similar results also been reported by Vinod Kumar *et al.* (2004). Pre-emergence application of pretilachlor @ 500 g ha^{-1} supplemented with HW at 25 DAS (W_5), proved to be the next best weed management practice and it was significantly higher than with PE application of oxadiargyl @ 75 g ha^{-1} alone (W_3) and pyrazosulfuron ethyl @ 20 g ha^{-1} alone (W_4). The later two weed management practices were comparable with each other in recording test weight. PE application of pretilachlor @ 500 g ha^{-1} alone (W_2) recorded significantly higher thousand grain weight than un-weeded check (W_1). The lowest test weight was associated with un-weeded check (W_1) during both the instances of study.

Table 4.13. Test weight (g) of aromatic rice as influenced by nitrogen and weed management practices under aerobic culture

Treatments	<i>rabi, 2009</i>	<i>rabi, 2010</i>
Nitrogen		
N1	19.35	19.33
N2	19.71	19.79
N3	20.16	20.22
N4	20.06	20.16
SEm ±	0.10	0.11
CD (P=0.05)	0.31	0.33
Weed management		
W1	18.99	19.02
W2	19.4	19.49
W3	19.77	19.83
W4	19.73	19.8
W5	20.06	20.12
W6	20.44	20.48
W7	20.34	20.42
SEm ±	0.08	0.09
CD (P=0.05)	0.23	0.26

4.4 YIELD

Graded levels of nitrogen application and different weed management practices were significantly influenced the grain yield, straw yield and harvest index. The interaction effect of graded levels and weed management practices were statistically measurable for grain yield, while none of the interaction was found for straw yield and harvest index (Table 4.14 to 4.15 and Fig 4.7 to 4.8).

4.4.1 Grain Yield

Grain yield of aromatic rice under aerobic culture differed significantly with nitrogen and weed management practices as well as their interaction with unaltered trend during both the years of study (Table 4.14 and Fig 4.7 to 4.8).

Increasing levels of nitrogen supply progressively enhanced the grain yield up to 140 kg N ha⁻¹ (N₃), thereafter the grain yield declined. The highest grain yield was recorded with application of nitrogen 140 kg ha⁻¹ (N₃), which was in turn comparable with 160 kg N ha⁻¹ (N₄) and both of them were significantly higher over rest of nitrogen levels. This might be due to increased nitrogen supply would have improved the metabolic activity and cell division resulting in increased growth and yield components coupled with higher metabolic activity lead to increased yield components and yield of aerobic rice. Higher levels of nitrogen application at 160 kg N ha⁻¹ recorded lesser grain yield than 140 kg N ha⁻¹ due to the reason that over dose of nitrogen application produced profuse tillering which led to competition among them resulting in conversion of lesser number of tillers into effective tillers and reduced the quantity of transfer of photosynthates from source to sink would have resulted with more number of ill filled grains. These results are in accordance with the findings of Gangaiah and Rajendra Prasad (1999), Gautam *et al.* (2008) and Sathiya and Ramesh (2009). The next best level of nitrogen application was the 120 kg ha⁻¹ (N₂) followed by 100 kg N ha⁻¹ (N₁), with significant disparity between them. The lowest grain yield of aromatic rice under aerobic condition was recorded with application of 100 kg N ha⁻¹ (N₁), which was significantly lower than rest of the nitrogen levels tried during both the years of study.

Among weed management practices, the highest grain yield was recorded with PE application of oxadiargyl @ 75 g ha⁻¹ supplemented with HW at 25 DAS (W₆) which was comparable with PE application of pyrazosulfuron ethyl @ 20g ha⁻¹ supplemented with HW at 25 DAS (W₇) and both of them were significantly higher than rest of the weed management practices. This might be due to higher weed control efficiency during early growth stages of crop, there by minimizing competition between crop and weeds for nutrients and the crop plants able to utilize available nutrients more efficiently through out crop growth period ,which in turn positively influenced the yield components *viz.*, number of panicles m⁻², filled grains panicle⁻¹ and 1000 grain weight led to higher grain yield. The next best treatment was the PE application of pretilachlor @ 500g ha⁻¹ supplemented with HW at 25 DAS (W₅). Pre-emergence application of oxadiargyl @ 75 g ha⁻¹ alone (W₃) and pyrazosulfuron ethyl @ 20g ha⁻¹ alone (W₄) were comparable with each other in producing higher grain yield than PE application of pretilachlor @ 500g ha⁻¹ (W₂). The lowest grain yield of aromatic rice under aerobic cultivation was registered with un-weeded check (W₁). The lowest grain yield of aerobic rice recorded with un-weeded check (W₁) due to severe competition offered by weeds for available growth resources through out crop growth period suppressed the crop, severely affecting dry matter production per hill led to poor yield components and thus lower grain yield. The reduction in grain yield of aerobic rice due to un-weeded check was 83.6 and 83.2 per cent, respectively compared to the best weed management practice *i.e* PE application of oxadiargyl 75 g ha⁻¹ or pyrazosulfuron ethyl 20g ha⁻¹ supplemented with HW at 25 DAS (W₆ and W₇) respectively. These results are in confirmity with the findings of Rajkhowa *et al.* (2005) and Arul Chezhan and Kathiresan (2008).

Irrespective of the weed management practices tried, the highest grain yield was recorded with 140 kg N ha⁻¹ (N₃), which was comparable with 160 kg N ha⁻¹ (N₄), during both the years except at W₂, W₅ and W₇ during 2009-10, where N₃ significantly higher than with N₄ and these two N levels were significantly superior to rest of nitrogen levels tried. The lowest grain yield was associated with 100 kg N ha⁻¹ (N₁) during both the years.

Table 4.14. Grain yield (kg ha⁻¹) of aromatic rice as influenced by nitrogen and weed management practices under aerobic culture

Treatments	<i>rabi, 2009</i>					<i>rabi, 2010</i>				
	N1	N2	N3	N4	Mean	N1	N2	N3	N4	Mean
W1	358	427	548	518	463	389	427	608	574	500
W2	1534	1707	2073	1956	1818	1613	1765	2166	2156	1925
W3	1905	2086	2372	2482	2211	1977	2151	2496	2475	2275
W4	1881	2063	2349	2465	2189	1907	2068	2421	2407	2201
W5	2088	2452	2824	2701	2517	2162	2515	2895	2791	2591
W6	2458	2852	3223	3135	2917	2477	2849	3249	3171	2936
W7	2387	2847	3161	3014	2852	2381	2846	3178	3085	2872
	1802	2062	2364	2324		1844	2089	2431	2380	

	SEm ±	CD (P=0.05)	SEm ±	CD (P=0.05)
N	15.25	53	19.75	68
W	27.62	79	26.71	76
N at W	42.80	116	52.41	148
W at N	55.25	157	53.41	152

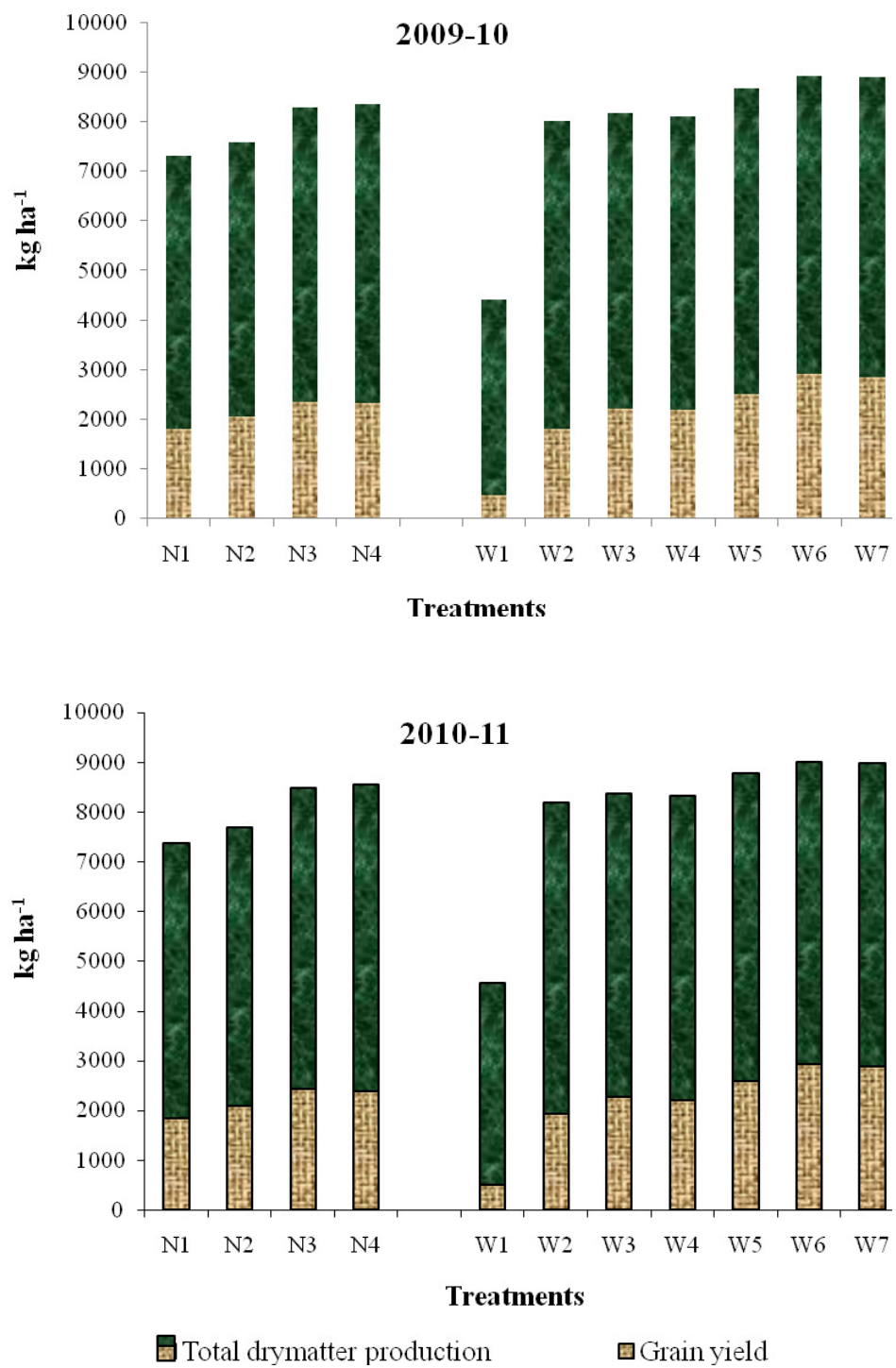


Fig.4.7. Total drymatter production Vs grain yield (kg ha⁻¹) of aromatic rice as influenced by nitrogen and weed management practices under aerobic culture

Regardless of the nitrogen levels tried, PE application of oxadiargyl @ 75 g ha⁻¹ supplemented with HW at 25 DAS (W₆) resulted in higher grain yield, which was comparable with PE application of pyrazosulfuron ethyl @ 20g ha⁻¹ supplemented with HW at 25 DAS (W₇) and both of them were significantly higher than rest of the weed management practices. The lowest grain yield of aromatic rice under aerobic culture was registered with un-weeded check (W₁)

Among the treatment combinations tried, the highest grain yield was recorded with application of 140 kg N ha⁻¹ in combination with PE application of oxadiargyl @ 75 g ha⁻¹ supplemented with HW at 25 DAS (N₃W₆), which was comparable with same level of N along with PE application of pyrazosulfuron ethyl @ 20g ha⁻¹ supplemented with HW at 25 DAS (N₃W₇) and 160 kg N ha⁻¹ combined with PE application of oxadiargyl @ 75 g ha⁻¹ supplemented with HW at 25 DAS (N₄W₆) during both the years of study. The lowest grain yield of aromatic rice under aerobic culture was recorded with the application of nitrogen 100 kg ha⁻¹ coupled with un-weeded check (N₁W₁) which was comparable with 120 kg ha⁻¹ coupled with un-weeded check (N₂W₁).

4.4.2 Straw Yield

Nitrogen and weed management practices exerted significant influence on straw yield of aromatic rice under aerobic culture, while none of the interactions were found statistically traceable during both the instances of study (Table 4.15 and Fig 4.8).

Increasing levels of nitrogen supply progressively enhanced the straw yield. The highest straw yield was recorded with the application of nitrogen 160 kg ha⁻¹ (N₄), which was however, comparable with 140 kg N ha⁻¹ (N₃) and both of them were significantly higher than with rest of nitrogen levels tried during both the years. The next best level of nitrogen application was with 120 kg ha⁻¹ (N₂) followed by 100 kg N ha⁻¹ (N₁), with significant disparity between them. The lowest straw yield was recorded with application of 100 kg N ha⁻¹ (N₁), which was significantly lower than rest of the nitrogen levels tried during both the years of study. Increased N supply would have improved the metabolic activity and

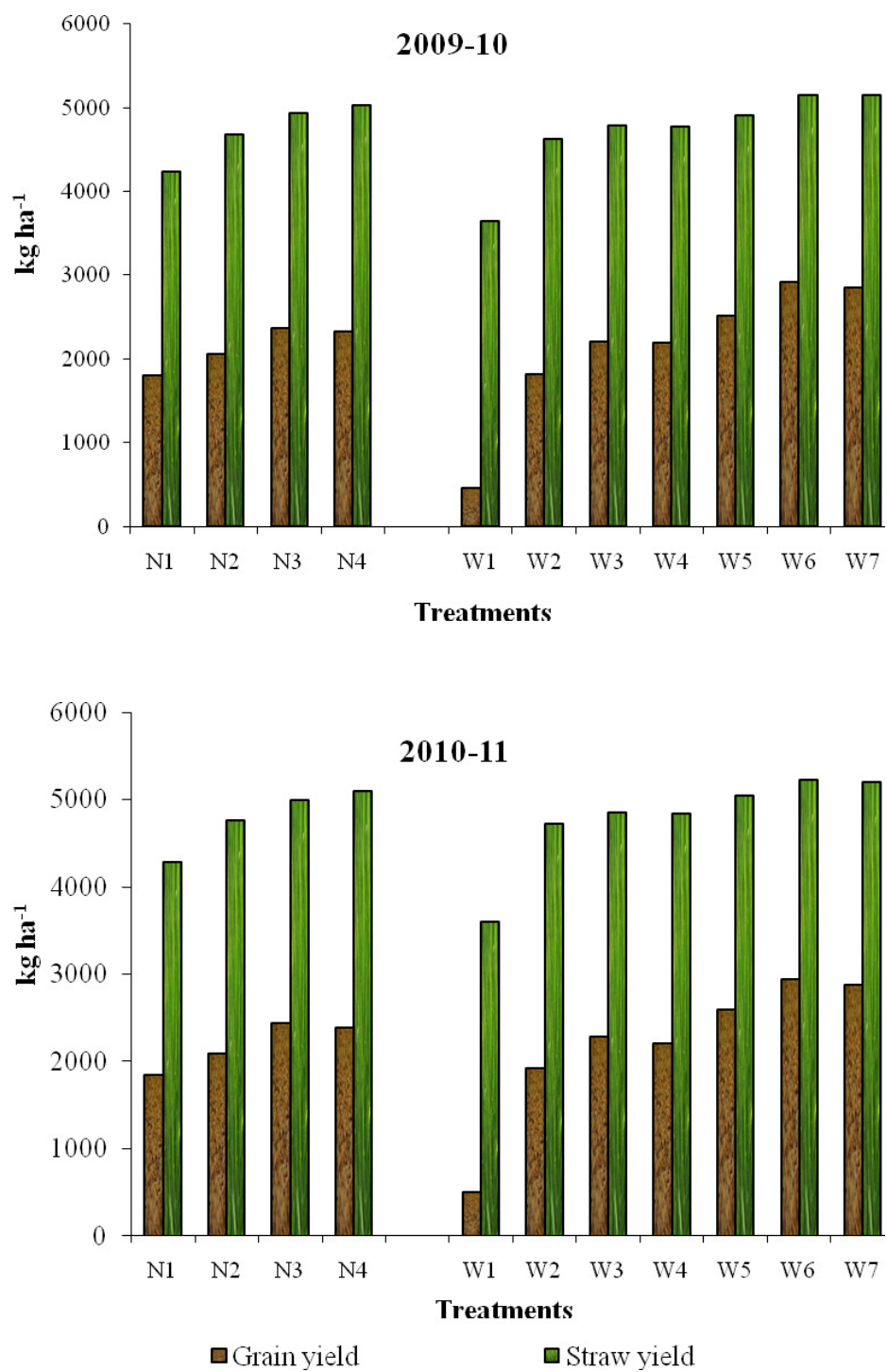


Fig.4.8. Grain yield and straw yield (kg ha⁻¹) of aromatic rice as influenced by nitrogen and weed management practices under aerobic culture

cell division resulting in increased growth parameters viz., plant height, leaf area, number of tillers and higher dry matter production led to higher straw yield of aerobic rice. These results are in accordance with the findings of Mhaskar *et al.* (2005) and Gautam *et al.* (2008).

With regard to weed management practices tried, the highest straw yield was recorded with PE application of oxadiargyl @ 75 g ha⁻¹ supplemented with HW at 25 DAS (W₆) which was comparable with PE application of pyrazosulfuron ethyl @ 20g ha⁻¹ supplemented with HW at 25 DAS (W₇) and both of them were significantly superior to rest of the weed management practices tried might be due to luxurious growth of crop with increased stature of growth parameters viz., plant height, leaf area, number of tillers and higher dry matter production and lesser crop weed competition at critical stages leading to higher straw yield. The next best weed management practice was the PE application of pretilachlor @ 500g ha⁻¹ supplemented with HW at 25 DAS (W₅) followed by PE application of oxadiargyl @ 75 g ha⁻¹ alone (W₃) and pyrazosulfuron ethyl @ 20g ha⁻¹ alone (W₄) and the later two weed management practices were comparable with each other in producing higher straw yield. Pre emergence application of pretilachlor @ 500g ha⁻¹ alone (W₂) resulted in significantly higher straw yield than un-weeded check (W₁). The lowest straw yield of aerobic rice recorded with un-weeded check (W₁) during both the instances of study. The lowest straw yield of aerobic rice recorded with un-weeded check (W₁) due to severe competition offered by weeds for growth resources which in turn reduced the growth parameters. The present findings are in agreement with those of and Jayadeva *et al.* (2011) and Sunil *et al.* (2011).

4.4.3 Harvest Index

Harvest index was significantly influenced by nitrogen as well as weed management practices, where as the interaction effect was not statistically traceable during both the years of study (Table 4.15).

The highest harvest index was registered with application of nitrogen 140 kg ha⁻¹ (N₃), which was significantly superior to rest of the weed management

practices tried due to better partitioning of photosynthates at flowering period from source to sink and increased grain yield in these treatments but excessive vegetative growth and biomass accrual decreases the harvest index. The next best N level in recording higher harvest index was the application of nitrogen at 160 kg N ha⁻¹ (N₄), followed by 120 kg N ha⁻¹ (N₂) and 100 kg N ha⁻¹ (N₁) with significant disparity between any two of the nitrogen levels tried. The lowest straw yield was recorded with application of 100 kg N ha⁻¹ (N₁), which was significantly lower than rest of the nitrogen levels tried during both the years of study.

All the weed management practices show significant disparity with each other in recording harvest index, with similar trend during both the years of study. PE application of oxadiargyl @ 75 g ha⁻¹ supplemented with HW at 25 DAS (W₆) was most efficient and statistically superior to the rest of weed management practices tried, in recording harvest index due to better control of weed population which reduces competition for nutrients, space and water resulted in higher dry matter accumulation ultimately higher grain yield of rice. These results are in accordance with those of Sunil *et al.* (2011). PE application of pyrazosulfuron ethyl @ 20g ha⁻¹ supplemented with HW at 25 DAS (W₇) proved to be the next best treatment in recording harvest index followed by PE application of pretilachlor @ 500g ha⁻¹ supplemented with HW at 25 DAS (W₅) with significant difference between them. The next best weed management practice was the PE application of oxadiargyl @ 75 g ha⁻¹ alone (W₃), followed by PE application of pyrazosulfuron ethyl @ 20g ha⁻¹ alone (W₄) and PE application of pretilachlor @ 500g ha⁻¹ alone (W₂) with significant disparity between any two of them in recording harvest index. The lowest harvest index was recorded with un-weeded check (W₁), which was significantly lower than rest of weed management practices during both the instances of investigation.

Table 4.15. Straw yield (kg ha⁻¹) and harvest index of aromatic rice as influenced by nitrogen and weed management practices under aerobic culture

Treatments	<i>rabi, 2009</i>		<i>rabi, 2010</i>	
	Straw yield (kg ha ⁻¹)	Harvest index	Straw yield (kg ha ⁻¹)	Harvest index
Nitrogen				
N1	4231	0.28	4281	0.28
N2	4682	0.29	4759	0.29
N3	4940	0.31	4995	0.31
N4	5023	0.30	5093	0.30
SEm ±	24.40	0.002	29.55	0.002
CD (P=0.05)	84	0.01	102	0.01
Weed management				
W1	3643	0.11	3594	0.12
W2	4630	0.28	4719	0.28
W3	4783	0.32	4856	0.32
W4	4769	0.31	4841	0.31
W5	4910	0.34	5042	0.34
W6	5154	0.36	5227	0.36
W7	5144	0.35	5196	0.35
SEm ±	31.72	0.003	41.65	0.003
CD (P=0.05)	90	0.01	118	0.01

4.5 QUALITY PARAMETERS

Graded levels of nitrogen application and different weed management practices were significantly influenced the milling per cent and protein content of grain, where as kernel length, breadth, amylose content of grain was influenced only by nitrogen levels and head rice recovery, L: B ratio, volume expansion of rice were not influenced either by nitrogen or weed management practices. The interaction effect was not statistically traceable for any quality parameter (Table 4.16 to 4.17 and Fig 4.9 to 4.10).

4.5.1 Milling Per cent

Milling per cent of aromatic rice under aerobic culture differed significantly with nitrogen and weed management practices, while none of the interaction effect was found with unaltered trend during both the years of study (Table 4.16 and Fig 4.9).

Increasing levels of nitrogen supply progressively enhanced the milling per cent up to 140 kg N ha⁻¹ (N₃), thereafter the milling per cent declined. The highest milling per cent was recorded with application of nitrogen 140 kg ha⁻¹ (N₃), which was comparable with 160 kg N ha⁻¹ (N₄) and both of them were significantly higher than with rest of nitrogen levels tried. The next best level of nitrogen application was 120 kg ha⁻¹ (N₂) followed by 100 kg N ha⁻¹ (N₁) with significant disparity between them, and N₁ resulted in lowest milling per cent during both the years of study. These results are in accordance with the findings of Devi and Sumathi (2011).

With regard to weed management practices, the highest milling per cent was recorded with PE application of oxadiargyl @ 75 g ha⁻¹ supplemented with HW at 25 DAS (W₆) which was comparable with PE application of pyrazosulfuron ethyl @ 20g ha⁻¹ supplemented with HW at 25 DAS (W₇) and both of them were significantly higher than rest of the weed management practices tried. The next best treatment was the PE application of pretilachlor @ 500g ha⁻¹ supplemented with HW at 25 DAS (W₅), and it recorded significantly

higher milling per cent than with PE application of oxadiargyl @ 75 g ha⁻¹ alone (W₃), which in turn at par with PE application of pyrazosulfuron ethyl @ 20g ha⁻¹ alone (W₄). PE application of pretilachlor @ 500g ha⁻¹ (W₂) resulted in significantly higher milling per cent than un-weeded check (W₁). The lowest milling per cent of aerobic rice recorded with un-weeded check (W₁). Similar results were reported by Khanna *et al.* (2002).

4.5.2 Head Rice Recovery

Head rice recovery of aromatic rice under aerobic culture was not significantly influenced either by the graded levels of nitrogen application or weed management practices during both the years of study (Table 4.16).

4.5.3 Kernel Length

Graded levels of nitrogen application exerted significant influence on the length of kernel of aromatic rice under aerobic culture, where as weed management practices and their interaction was not shown any significant effect on kernel length during both the years of study (Table 4.16).

Increasing levels of nitrogen supply progressively enhanced the kernel length. The longest kernels were recorded with application of 160 kg N ha⁻¹ (N₄), which was however, comparable with 140 kg N ha⁻¹ (N₃) and both of them were significantly higher than with rest of nitrogen levels tried. The next best kernel length of rice was recorded with 120 kg N ha⁻¹ (N₂), which was significantly superior to 100 kg N ha⁻¹ (N₁). Significantly the shortest kernels were recorded with the lowest level of N application (N₁) during both the years of experimentation. The results confirm the findings of Manoj Kumar *et al.* (1996) and Devi and Sumathi (2011).

4.5.4 Kernel Breadth

Breadth of kernel of aromatic rice under aerobic culture was significantly influenced only by graded levels of nitrogen application, where as weed

Table 4.16. Quality parameters of aromatic rice (milling per cent, head rice recovery, kernel length and breadth) as influenced by nitrogen and weed management practices under aerobic culture

Treatments	<i>rabi,2009</i>				<i>rabi,2010</i>			
	Milling percent	Head rice recovery (%)	Kernel length (mm)	Kernel breadth (mm)	Milling percent	Head rice recovery (%)	Kernel length (mm)	Kernel breadth (mm)
Nitrogen								
N ₁	74.2	67.4	5.47	1.74	74.3	67.6	5.45	1.73
N ₂	75.4	68.2	5.59	1.82	75.6	68.3	5.58	1.79
N ₃	77.4	68.6	5.79	1.90	77.7	68.8	5.80	1.89
N ₄	76.7	68.4	5.84	1.92	77.1	68.6	5.83	1.90
SEm $\pm$	0.31	0.3	0.02	0.01	0.27	0.57	0.03	0.01
CD (P=0.05)	1.1	NS	0.07	0.05	0.9	NS	0.09	0.05
Weed management								
W ₁	74.4	67.2	5.65	1.82	74.5	67.4	5.66	1.80
W ₂	75.0	67.7	5.66	1.84	75.2	67.9	5.65	1.81
W ₃	75.8	68.2	5.67	1.85	76.1	68.4	5.67	1.82
W ₄	75.6	67.9	5.65	1.83	75.9	68.1	5.66	1.81
W ₅	76.4	68.4	5.68	1.86	76.7	68.6	5.68	1.84
W ₆	77.2	68.8	5.70	1.88	77.5	69.0	5.67	1.85
W ₇	77.0	68.5	5.69	1.86	77.3	68.7	5.68	1.83
SEm $\pm$	0.16	0.4	0.02	0.02	0.19	0.51	0.02	0.01
CD (P=0.05)	0.5	NS	NS	NS	0.5	NS	NS	NS

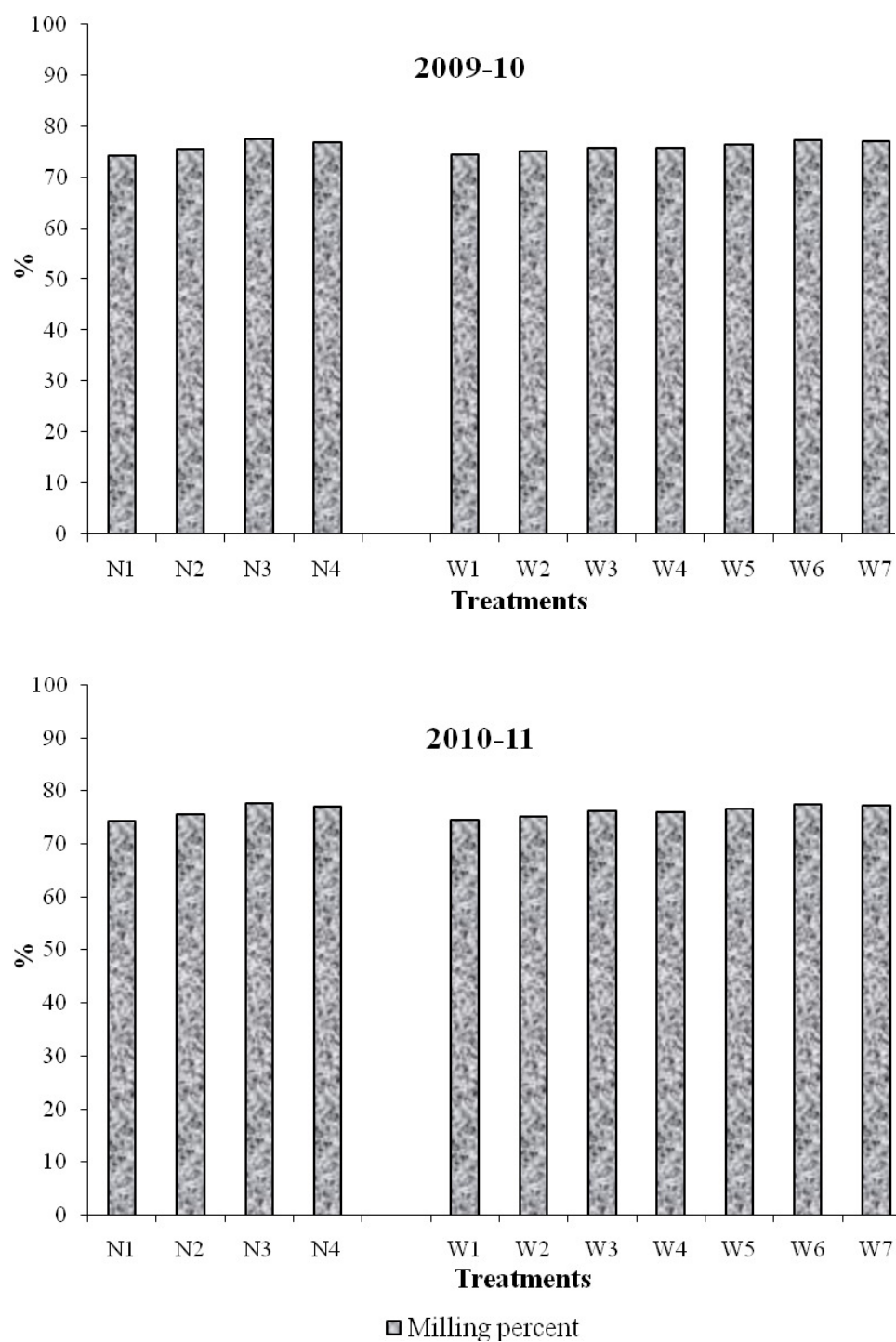


Fig. 4.9. Milling per cent (%) of aromatic rice as influenced by nitrogen and weed management practices under aerobic culture

management practices and their interaction was not shown any significant effect on kernel breadth during both the years of study (Table 4.16).

The trend with graded levels of nitrogen application on kernel breadth of aromatic rice under aerobic culture was exactly similar to that of kernel length.

4.5.5 Length Breadth Ratio

Length breadth ratio of aromatic rice under aerobic culture was not significantly influenced either by the graded levels of nitrogen application or weed management practices during both the years of study (Table 4.17).

4.5.6 Amylose Content

Amylose content of aromatic rice under aerobic culture was significantly influenced by nitrogen application, where as the weed management practices and their interaction was not statistically traceable during both the years of study (Table 4.17).

Increasing levels of nitrogen supply progressively enhanced the amylose content. The highest amylose content was recorded with application of nitrogen 160 kg ha^{-1} (N_4), which was however, comparable with 140 kg N ha^{-1} (N_3) and both of them were significantly higher than with rest of nitrogen levels tried. The next best treatment was 120 kg N ha^{-1} (N_2), followed by 100 kg N ha^{-1} (N_1) with disparity between them. Significantly the lowest amylose content was recorded with lowest level of N application (N_1) during both the years of experimentation. Similar results were reported by Hemant lal sonboir (2009) and Ramana murthy (2010).

4.5.7 Protein Content

Protein content of aromatic rice under aerobic culture was significantly influenced by nitrogen and weed management practices, while none of the interaction effect was found with unaltered trend during both the years of study (Table 4.17 and Fig 4.10).

Increasing levels of nitrogen supply progressively enhanced the protein content of grain and the highest was recorded with application of nitrogen 160 kg ha⁻¹ (N₄), which was comparable with 140 kg N ha⁻¹ (N₃) and both of them were significantly higher than with rest of nitrogen levels tried. The next best level of nitrogen application was 120 kg ha⁻¹ (N₂) followed by 100 kg N ha⁻¹ (N₁) which resulted in significantly lowest protein content of grain than rest of the nitrogen levels tried during both the years of study. Higher protein content of grain with higher levels of nitrogen due to increased absorption of nitrogen by crop in presence of adequate availability of nitrogen and protein content of grain is directly proportional to nitrogen uptake by grain. Increased grain protein makes brown rice more resistant to cracking and breakage during abrasive milling. These results are in conformity with those of Hemant lal sonboir (2009) and Ramana murthy (2010).

With regard to weed management practices, the highest protein content of grain was recorded with PE application of oxadiargyl @ 75 g ha⁻¹ supplemented with HW at 25 DAS (W₆) which was comparable with PE application of pyrazosulfuron ethyl @ 20g ha⁻¹ supplemented with HW at 25 DAS (W₇) due to effective control of weeds which in turn reduced the competition for nutrients, there by higher uptake of nitrogen by crop and both of them were significantly higher than rest of the weed management practices tried. These results confirm the findings of Khanna *et al.* (2002). The next best weed management practice in producing higher protein content was the PE application of pretilachlor @ 500g ha⁻¹ supplemented with HW at 25 DAS (W₅). Pre emergence application of oxadiargyl @ 75 g ha⁻¹ alone (W₃) and pyrazosulfuron ethyl @ 20g ha⁻¹ alone (W₄) which were comparable with one other. Pre emergence application of pretilachlor @ 500g ha⁻¹ (W₂) resulted in significantly higher protein content than un-weeded check (W₁). The lowest protein content of grain was recorded with un-weeded check (W₁) which was significantly lower than rest of the weed management practices tried might be due to heavy weed infestation reduced the nitrogen uptake by crop.

Table 4.17. Quality parameters of aromatic rice (L: B ratio, amylose, protein content and volume expansion ratio) as influenced by nitrogen and weed management practices under aerobic culture

Treatments	<i>rabi,2009</i>				<i>rabi,2010</i>			
	L:B ratio	Amylose content (%)	Protein content (%)	Volume expansion ratio	L:B ratio	Amylose content (%)	Protein content (%)	Volume expansion ratio
Nitrogen								
N ₁	3.14	31.67	7.61	1.20	3.16	31.51	7.66	1.19
N ₂	3.07	31.99	8.00	1.26	3.12	32.08	8.04	1.24
N ₃	3.05	32.83	8.37	1.28	3.08	33.07	8.38	1.26
N ₄	3.04	32.62	8.41	1.33	3.08	32.71	8.42	1.30
SEm $\pm$	0.03	0.08	0.09	0.02	0.03	0.14	0.09	0.02
CD (P=0.05)	NS	0.28	0.33	NS	NS	0.48	0.32	NS
Weed management								
W ₁	3.11	32.09	7.49	1.24	3.14	32.16	7.43	1.23
W ₂	3.08	32.16	7.79	1.26	3.12	32.23	7.78	1.24
W ₃	3.08	32.26	8.05	1.27	3.12	32.33	8.07	1.25
W ₄	3.09	32.21	8.03	1.27	3.13	32.28	8.04	1.25
W ₅	3.06	32.36	8.29	1.29	3.08	32.42	8.33	1.26
W ₆	3.04	32.44	8.55	1.28	3.06	32.51	8.63	1.26
W ₇	3.06	32.41	8.52	1.27	3.10	32.48	8.6	1.25
SEm $\pm$	0.03	0.09	0.07	0.02	0.02	0.14	0.08	0.01
CD (P=0.05)	NS	NS	0.21	NS	NS	NS	0.23	NS



Fig.4.10. Protein content (%) of aromatic rice grain as influenced by nitrogen and weed management practices under aerobic culture

4.5.8 Volume Expansion Ratio

Volume expansion ratio of aromatic rice under aerobic culture was not significantly influenced either by the graded levels of nitrogen application or weed management practices during both the years of study (Table 4.17).

4.6 NUTRIENT UPTAKE

Uptake of nitrogen, phosphorous and potassium by aromatic rice under aerobic culture at active tillering, maximum tillering, panicle initiation, flowering and at harvest (grain and straw) was estimated. The nutrient uptake by crop was significantly influenced by nitrogen and weed management practices, while none of the interaction effect was found for phosphorous and potassium uptake except for nitrogen at all the stages of observation during both the years of study (Table 4.18 to 4.25 and Fig 4.11 to Fig 4.13). The discussion pertaining to nutrient uptake by crop was explained at 4.7.3.

4.6.1 Nitrogen Uptake by Crop

Uptake of nitrogen by aromatic rice under aerobic culture was estimated at active tillering, maximum tillering, panicle initiation, flowering and at harvest (grain and straw). The uptake of nitrogen was found to increase progressively up to harvest of the crop during both the years of study (Table 4.18 to 4.23 and Fig 4.11).

4.6.1.1 Nitrogen uptake by crop at active tillering

Uptake of nitrogen by aromatic rice under aerobic culture at active tillering was significantly influenced by graded levels of nitrogen and weed management practices, as well as their interaction during both the years of study (Table 4.18).

The nitrogen uptake at active tillering tended to increase progressively with increasing levels of N. The highest N uptake was recorded with 160 kg N

ha⁻¹ (N₄), which was however, comparable with 140 kg ha⁻¹ (N₃) during both the years of study. Application of 120 kg N ha⁻¹ (N₂) proved to be the next best level in recording higher nitrogen uptake than 100 kg ha⁻¹ nitrogen (N₁) application. The lowest nitrogen uptake was recorded with 100 kg ha⁻¹ nitrogen application (N₁), which was significantly lower than rest of the N levels tried, during both the instances of experimentation.

Among the weed management practices tried, the highest nitrogen was recorded with application of oxadiargyl @ 75 g ha⁻¹ supplemented with HW at 25 DAS (W₆), which was however, comparable with pyrazosulfuron ethyl @ 20g ha⁻¹ with HW at 25 DAS (W₇) and both of them were significantly superior to PE application of pretilachlor @ 500g ha⁻¹ with HW at 25 DAS (W₅). The next best weed management practice was with application of oxadiargyl @ 75 g ha⁻¹ alone (W₃) which was comparable with pyrazosulfuron ethyl @ 20g ha⁻¹ alone (W₄) and both of them were significantly superior to PE application of pretilachlor @ 500g ha⁻¹ alone (W₂). The lowest nitrogen uptake was recorded with un-weeded check (W₁), which was significantly lesser than with rest of the weed management practices tried, during both the years of investigation.

Irrespective of weed management practices, the highest nitrogen uptake was recorded with 140 kg ha⁻¹ (N₃) which was at par with 160 kg ha⁻¹ (N₄) during both the years except at W₂, W₃, W₄ and W₆ where N₃ significantly differed with N₄ during first year of experiment. The lowest N uptake was estimated with application of 100 kg ha⁻¹ (N₁), which was significantly lower than rest of rest of n levels tried except at W₁, where it was at par with rest of the N levels tried during both the years of study.

Disregarding N levels, the highest N uptake was registered with PE application of oxadiargyl @ 75 g ha⁻¹ supplemented with HW at 25 DAS (W₆) which in turn parity with PE application of pyrazosulfuron ethyl @ 20g ha⁻¹ or pretilachlor @ 500g ha⁻¹ supplemented with HW at 25 DAS (W₇, W₅) during both the years of experiment, while the lowest N uptake was associated with un-weeded check (W₁).

Table 4.18. Nitrogen uptake of aromatic rice (kg ha⁻¹) at active tillering as influenced by nitrogen and weed management practices under aerobic culture

Treatments	<i>rabi, 2009</i>					<i>rabi, 2010</i>				
	N1	N2	N3	N4	Mean	N1	N2	N3	N4	Mean
W1	2.97	4.72	6.96	5.74	5.10	6.77	7.51	6.82	7.90	7.26
W2	16.02	18.56	21.41	23.74	19.93	16.27	18.44	23.62	22.12	20.11
W3	18.29	20.68	21.42	26.20	21.65	16.86	19.64	25.18	24.50	21.54
W4	17.87	20.62	21.24	26.14	21.47	16.55	19.77	25.34	24.34	21.50
W5	20.48	23.79	26.68	25.98	24.23	19.50	23.04	26.48	26.30	23.83
W6	21.51	25.30	29.04	26.65	25.62	20.54	24.30	27.54	29.07	25.37
W7	21.24	24.86	28.50	26.70	25.33	20.43	24.04	27.63	28.70	25.21
	16.91	19.79	22.18	23.02		16.70	19.54	23.23	23.28	

	SEm ±	CD (P=0.05)	SEm ±	CD (P=0.05)
N	0.34	0.98	0.26	0.90
W	0.28	0.97	0.36	1.02
N at W	0.74	2.10	0.70	1.96
W at N	0.68	1.94	0.72	2.04

Among all the combinations the highest nitrogen uptake was recorded with application of 140 kg N ha⁻¹ in combination with PE application of oxadiargyl @ 75 g ha⁻¹ supplemented with HW at 25 DAS (N₃W₆), which was comparable with same level of N with PE application of pyrazosulfuron ethyl @ 20g ha⁻¹ + HW at 25 DAS (N₃W₇) during 2009-10 and in addition to these two, application of 160 kg N ha⁻¹ with above two weed management practices also comparable during 2010-11. The lowest nitrogen uptake was recorded at 100 kg N ha⁻¹ with unweeded check (N₁W₁), which was comparable with N₂W₁ during 2009-10, N₂W₁, N₃W₁ and N₄W₁ during 2010-11.

4.6.1.2 Nitrogen uptake by crop at maximum tillering

Graded levels of nitrogen and different weed management practices, as well as their interactions were significantly influenced the uptake of nitrogen by aromatic rice under aerobic culture at maximum tillering, during both the instances of experimentation (Table 4.19).

The trend with graded levels of nitrogen application and weed management practices on nitrogen uptake by aromatic rice at maximum tillering was exactly similar to that of nitrogen uptake by aromatic rice crop at active tillering differing only in their magnitude.

Regardless of weed management practices, the highest nitrogen uptake was recorded with 140 kg ha⁻¹ (N₃) which was comparable with 160 kg ha⁻¹ (N₄) at W₁ and W₅ and significantly superior to N₄ at W₆ and W₇. At W₂ and W₃ significantly the highest N uptake was registered with N₄ than rest of N levels tried, while the lowest uptake was recorded with 100 kg ha⁻¹ (N₁) during both the years of study.

Irrespective of N levels, the highest N uptake was registered with PE application of oxadiargyl @ 75 g ha⁻¹ + HW at 25 DAS (W₆), which was comparable with PE application of pyrazosulfuron ethyl @ 20g ha⁻¹ or pretilachlor @ 500g ha⁻¹ supplemented with HW at 25 DAS (W₇ and W₅), while significantly the lowest nitrogen uptake was recorded with un-weeded check (W₁) during both the years of study.

Table 4.19. Nitrogen uptake of aromatic rice (kg ha⁻¹) at maximum tillering as influenced by nitrogen and weed management practices under aerobic culture

Treatments	<i>rabi, 2009</i>					<i>rabi, 2010</i>				
	N1	N2	N3	N4	Mean	N1	N2	N3	N4	Mean
W1	15.53	19.19	24.09	22.67	20.37	14.37	17.88	23.31	22.74	19.57
W2	41.26	46.54	48.44	57.55	48.45	41.37	46.18	53.74	56.83	49.53
W3	43.37	49.37	56.23	61.28	52.56	43.04	49.43	58.02	59.96	52.61
W4	43.13	49.82	55.72	60.96	52.41	42.55	49.10	58.16	60.76	52.64
W5	49.16	56.12	62.61	62.50	57.60	48.17	54.83	61.24	63.35	56.90
W6	51.84	59.74	67.75	63.93	60.81	49.91	58.50	67.73	63.95	60.02
W7	51.47	58.57	66.99	63.84	60.22	49.48	56.75	65.78	64.49	59.12
	42.25	48.48	54.55	56.10		41.27	47.52	55.42	56.01	

	SEm ±	CD (P=0.05)	SEm ±	CD (P=0.05)
N	0.53	1.83	0.40	1.38
W	0.66	1.87	0.49	1.39
N at W	1.39	3.94	1.04	2.97
W at N	1.31	3.74	0.98	2.78

Among all the combinations, the highest nitrogen uptake was recorded with application of 140 kg N ha⁻¹ in combination with PE application of oxadiargyl @ 75 g ha⁻¹ supplemented with HW at 25 DAS (N₃W₆), which was comparable with same level of N with pyrazosulfuron ethyl @ 20g ha⁻¹ supplemented with HW at 25 DAS (N₃W₇) during both the years of study. The lowest nitrogen uptake was recorded with 100 kg N ha⁻¹ in combination with un-weeded check (N₁W₁), which was comparable with N₂W₁ during 2009-10.

4.6.1.3 Nitrogen uptake by crop at panicle initiation

Uptake of nitrogen by aromatic rice under aerobic culture at panicle initiation was significantly influenced by graded levels of nitrogen and weed management practices, as well as their interaction during both the years of study (Table 4.20).

The trend with graded levels of nitrogen application and weed management practices on nitrogen uptake by aromatic rice at panicle initiation was exactly similar to that of nitrogen uptake by aromatic rice crop at active tillering differing only in their magnitude.

Irrespective of weed management practices, the highest nitrogen uptake was recorded with 140 kg ha⁻¹ (N₃) which was comparable with 160 kg ha⁻¹ (N₄) at W₁, W₅ and W₇ and significantly superior to N₄ at W₆. At W₂, W₃ and W₄ significantly the highest N uptake was registered with N₄ which was superior to rest of N levels tried. The lowest uptake was recorded with 100 kg ha⁻¹ (N₁) during both the years of study.

Disregarding N levels, the highest N uptake was registered with PE application of oxadiargyl @ 75 g ha⁻¹ supplemented with HW at 25 DAS (W₆), which was comparable with PE application of pyrazosulfuron ethyl @ 20g ha⁻¹ and pretilachlor @ 500g ha⁻¹ supplemented with HW at 25 DAS (W₇ and W₅), while significantly the lowest nitrogen uptake was recorded with un-weeded check (W₁) during both the years of study.

Table 4.20. Nitrogen uptake of aromatic rice (kg ha⁻¹) at panicle initiation as influenced by nitrogen and weed management practices under aerobic culture

Treatments	<i>rabi, 2009</i>					<i>rabi, 2010</i>				
	N1	N2	N3	N4	Mean	N1	N2	N3	N4	Mean
W1	25.55	31.16	35.54	34.67	31.73	22.56	31.24	36.20	34.69	31.17
W2	56.28	63.40	71.15	77.72	67.14	59.65	61.96	74.37	77.21	68.30
W3	61.32	68.45	75.35	80.98	71.53	59.69	68.62	77.57	82.52	72.10
W4	59.87	67.75	74.41	79.65	70.42	60.26	67.76	78.33	81.29	71.90
W5	67.34	75.50	83.12	81.67	76.90	66.80	74.52	83.10	86.77	77.79
W6	70.80	80.14	89.54	82.02	80.63	68.47	77.84	89.87	85.54	80.43
W7	69.83	78.61	87.21	83.72	79.84	66.08	79.62	89.28	85.31	80.07
	58.72	66.43	73.76	74.35		57.65	65.94	75.54	76.19	

	SEm ±	CD (P=0.05)	SEm ±	CD (P=0.05)
N	0.54	1.84	0.18	0.60
W	0.68	1.93	0.37	1.04
N at W	1.40	3.98	0.50	1.35
W at N	1.35	3.85	0.73	2.07

Among all the combinations, the highest nitrogen uptake was recorded with application of 140 kg N ha⁻¹ in combination with PE application of oxadiargyl @ 75 g ha⁻¹ supplemented with HW at 25 DAS (N₃W₆), which was comparable with same level of N with pyrazosulfuron ethyl @ 20g ha⁻¹ supplemented with HW at 25 DAS (N₃W₇), while the lowest nitrogen uptake was recorded with 100 kg N ha⁻¹ with un-weeded check (N₁W₁) during both the years of study.

4.6.1.4 Nitrogen uptake by crop at flowering

Graded levels of nitrogen and different weed management practices, as well as their interactions were significantly effect the uptake of nitrogen by aromatic rice under aerobic culture at flowering, during both the instances of experimentation (Table 4.21).

The trend with graded levels of nitrogen application and weed management practices on nitrogen uptake by aromatic rice at flowering was exactly similar to that of nitrogen uptake by aromatic rice crop at active tillering differing only in their magnitude.

Regardless of weed management practices, the highest nitrogen uptake was recorded with 160 kg ha⁻¹ (N₄) which was comparable with 140 kg ha⁻¹ (N₃) at W₂, W₃, W₄ and W₅ except at W₂, W₅ and W₆ during 2010-11, which showed significant disparity among them. The lowest uptake was recorded with 100 kg ha⁻¹ (N₁) during both the years of study.

Irrespective of N levels, highest N uptake was registered with PE application of oxadiargyl @ 75 g ha⁻¹ supplemented with HW at 25 DAS (W₆), which was comparable with PE application of pyrazosulfuron ethyl @ 20g ha⁻¹ and pretilachlor @ 500g ha⁻¹ supplemented with HW at 25 DAS (W₇ and W₅) except at N₃, where W₆ and W₇ were comparable with each other and significantly superior to W₅. Significantly lowest nitrogen uptake was recorded with un-weeded check (W₁) during both the years of study.

Among all the combinations, the highest nitrogen uptake was recorded with application of 140 kg N ha⁻¹ in combination with PE application of

Table 4.21. Nitrogen uptake of aromatic rice (kg ha⁻¹) at flowering as influenced by nitrogen and weed management practices under aerobic culture

Treatments	<i>rabi, 2009</i>					<i>rabi, 2010</i>				
	N1	N2	N3	N4	Mean	N1	N2	N3	N4	Mean
W1	29.10	36.70	41.72	37.83	36.34	26.40	37.01	40.01	40.88	36.08
W2	61.99	68.34	76.10	83.06	72.37	62.42	69.19	77.08	83.07	72.94
W3	64.91	73.43	79.32	86.17	75.96	64.43	72.93	83.85	88.04	77.31
W4	64.20	73.70	79.40	85.40	75.68	63.50	73.32	83.55	87.56	76.98
W5	71.16	78.99	87.40	87.81	81.34	72.22	78.30	86.14	92.11	82.19
W6	75.26	84.14	94.63	87.34	85.34	73.35	84.21	95.53	89.69	85.70
W7	73.83	83.09	94.08	87.48	84.62	73.41	81.39	94.36	92.45	85.40
	62.92	71.20	78.95	79.30		62.25	70.91	80.07	81.97	

	SEm ±	CD (P=0.05)	SEm ±	CD (P=0.05)
N	1.03	3.58	0.72	2.51
W	1.06	3.02	0.94	2.66
N at W	2.66	7.72	1.91	5.41
W at N	2.12	6.03	1.87	5.32

oxadiargyl @ 75 g ha⁻¹ supplemented with HW at 25 DAS (N₃W₆), which was comparable with same level of N with pyrazosulfuron ethyl @ 20g ha⁻¹ supplemented with HW at 25 DAS (N₃W₇) during 2009-10, and 160 kg N ha⁻¹ in combination with pyrazosulfuron ethyl @ 20g ha⁻¹ + HW at 25 DAS (N₄W₇) during 2010-11. The lowest nitrogen uptake was recorded with 100 kg N ha⁻¹ with un-weeded check (N₁W₁) during both the years of study.

4.6.1.5 Nitrogen uptake by grain

Uptake of nitrogen by grain of aromatic rice under aerobic culture was significantly influenced by graded levels of nitrogen and weed management practices, as well as their interaction during both the years of study (Table 4.22).

The nitrogen uptake by grain tended to increase progressively with increasing levels of N and recorded highest with 140 kg N ha⁻¹ (N₃), which was however, comparable with 160 kg ha⁻¹ (N₄) during both the years of study. Application of 120 kg N ha⁻¹ (N₂) proved to be the next best level, which recorded significantly higher nitrogen uptake than 100 kg N ha⁻¹ application. The lowest nitrogen uptake was recorded with 100 kg ha⁻¹ nitrogen application (N₁), during both the instances of experimentation.

Among the weed management practices tried, the highest nitrogen was recorded with application of oxadiargyl @ 75 g ha⁻¹ supplemented with HW at 25 DAS (W₆), which was however, comparable with pyrazosulfuron ethyl @ 20g ha⁻¹ with HW at 25 DAS (W₇) and both of them were significantly superior to PE application of pretilachlor @ 500g ha⁻¹ with HW at 25 DAS (W₅). The next best weed management practice was with application of oxadiargyl @ 75 g ha⁻¹ alone (W₃) which was comparable with pyrazosulfuron ethyl @ 20g ha⁻¹ alone (W₄) and both of them were significantly superior to PE application of pretilachlor @ 500g ha⁻¹ alone (W₂). The lowest nitrogen uptake was recorded with un-weeded check (W₁), which was significantly lesser than with rest of the weed management practices tried, during both the years of investigation.

Table 4.22. Nitrogen uptake of aromatic rice by grain (kg ha⁻¹) as influenced by nitrogen and weed management practices under aerobic culture

Treatments	<i>rabi, 2009</i>					<i>rabi, 2010</i>				
	N1	N2	N3	N4	Mean	N1	N2	N3	N4	Mean
W1	4.24	4.94	6.16	5.92	5.32	4.79	5.17	6.77	6.48	5.80
W2	19.95	22.06	27.28	26.47	23.94	20.35	22.10	28.06	27.79	24.57
W3	23.75	26.21	31.01	32.28	28.31	24.30	26.35	31.70	31.80	28.54
W4	23.72	26.35	30.56	31.86	28.12	23.82	26.04	30.82	30.95	27.91
W5	26.20	31.37	35.65	35.08	32.07	26.64	30.39	35.39	35.71	32.03
W6	29.30	34.08	40.05	38.32	35.44	29.29	33.81	40.11	38.17	35.35
W7	28.70	33.78	39.27	37.75	34.88	28.42	33.48	39.07	37.92	34.72
	22.26	25.54	30.00	29.67		22.52	25.33	30.27	29.83	

	SEm ±	CD (P=0.05)	SEm ±	CD (P=0.05)
N	0.15	0.51	0.16	0.57
W	0.34	0.97	0.25	0.71
N at W	0.45	1.17	0.44	1.23
W at N	0.69	1.95	0.50	1.42

Irrespective of weed management practices, the highest nitrogen uptake was recorded with 140 kg ha⁻¹ (N₃) which was at par with 160 kg ha⁻¹ (N₄) at W₁, W₂ and W₅ and significantly superior to N₄ at W₆ and W₇. At W₃ and W₄ highest N uptake was recorded with N₄ which was significantly higher than N₃ during first year of experiment. The lowest N uptake was estimated with application of 100 kg ha⁻¹ (N₁), which was significantly lower than rest of rest of N levels tried except at W₁, where it was at par with N₂ during both the years of study.

Disregarding N levels, the highest N uptake was registered with PE application of oxadiargyl @ 75 g ha⁻¹ supplemented with HW at 25 DAS (W₆) which was at par with PE application of pyrazosulfuron ethyl @ 20g ha⁻¹ supplemented with HW at 25 DAS (W₇) and significantly superior to rest of the weed management practices, while the lowest N uptake was associated with unweeded check (W₁).

Among all the combinations the highest nitrogen uptake by grain was recorded with application of 140 kg N ha⁻¹ in combination with PE application of oxadiargyl @ 75 g ha⁻¹ supplemented with HW at 25 DAS (N₃W₆), which was comparable with same level of N with PE application of pyrazosulfuron ethyl @ 20g ha⁻¹ supplemented with HW at 25 DAS (N₃W₇) and 160 kg N ha⁻¹ with PE application of oxadiargyl @ 75 g ha⁻¹ supplemented with HW at 25 DAS (N₄W₆). The lowest nitrogen uptake was recorded with 100 kg N ha⁻¹ with unweeded check (N₁W₁), which was comparable with N₂W₁, N₃W₁ and N₄W₁ during 2010-11 and N₂W₁ during 2010-11.

4.6.1.6 Nitrogen uptake by straw

Uptake of nitrogen by straw of aromatic rice under aerobic culture was significantly influenced by graded levels of nitrogen and weed management practices, while none of the interaction was found during both the years of study (Table 4.23).

The trend with graded levels of nitrogen application and weed management practices on nitrogen uptake by straw of aromatic rice was exactly

Table 4.23. Nitrogen uptake of aromatic rice by straw (kg ha⁻¹) as influenced by nitrogen and weed management practices under aerobic culture

Treatments	<i>rabi,2009</i>	<i>rabi,2010</i>
Nitrogen		
N ₁	34.79	34.39
N ₂	38.84	38.51
N ₃	41.76	41.10
N ₄	42.77	42.18
SEm ±	0.41	0.41
CD (P=0.05)	1.44	1.43
Weed management		
W ₁	27.06	26.90
W ₂	37.94	37.87
W ₃	41.00	40.11
W ₄	39.89	39.39
W ₅	42.55	41.67
W ₆	44.18	44.09
W ₇	44.13	43.34
SEm ±	0.52	0.48
CD (P=0.05)	1.49	1.38

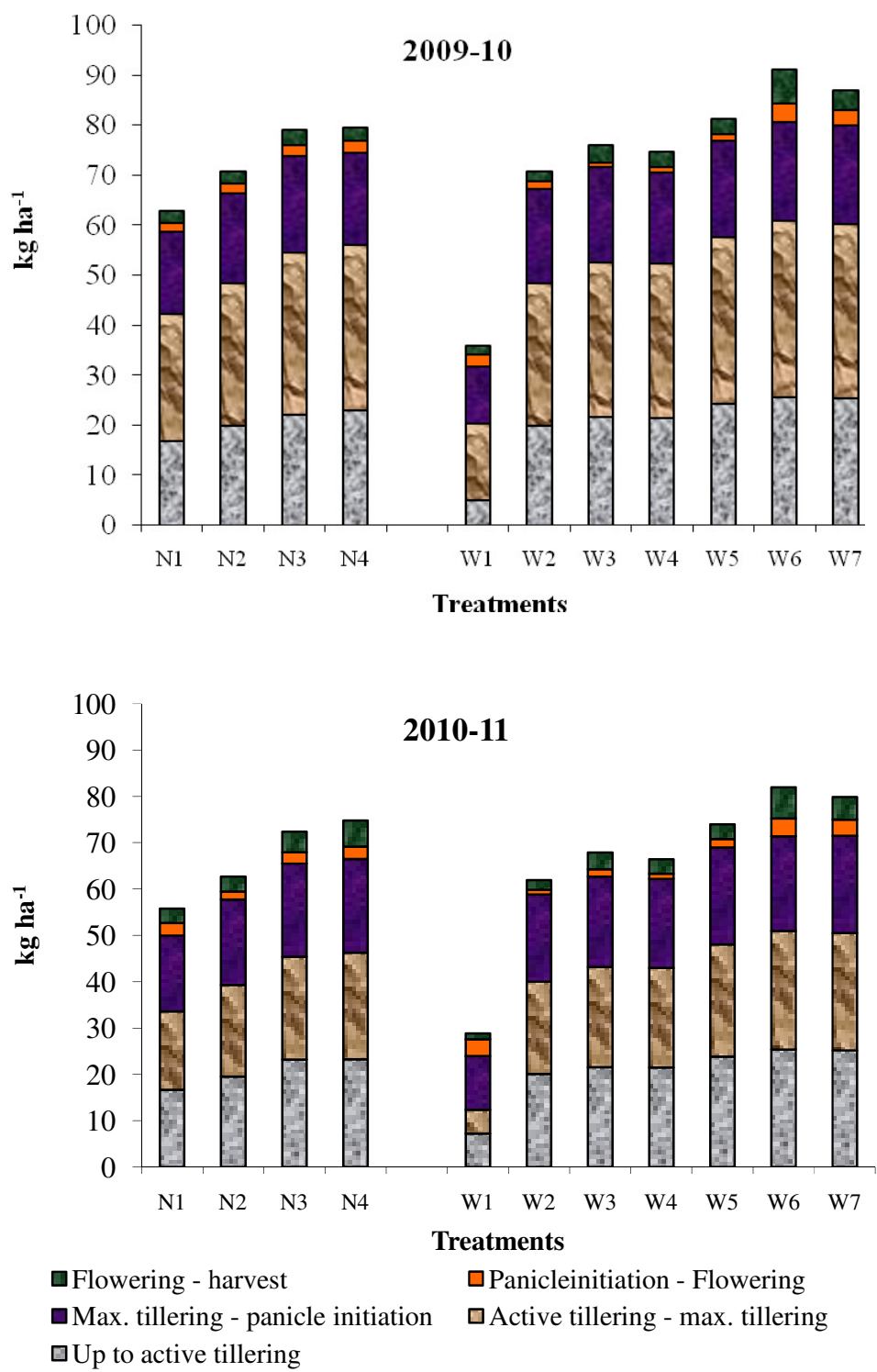


Fig.4.11. Nitrogen uptake (kg ha^{-1}) of aromatic rice at different growth stages as influenced by nitrogen and weed management practices under aerobic culture

similar to that of nitrogen uptake by aromatic rice crop at active tillering differing only in their magnitude.

4.6.2 Phosphorous Uptake by Crop

The phosphorus uptake of aromatic rice under aerobic culture recorded at different growth stages of the crop *viz.*, active tillering, maximum tillering, panicle initiation, flowering and at harvest differed significantly due to application of graded levels of nitrogen and weed management practices followed similar trend, without any deviation. While none of the interaction was statistically measurable at any of the growth stages during both the years of study. The phosphorus uptake of rice tended to increase progressively with advance in the age of the crop up to maturity (Table 4.24 and Fig 4.12).

The highest phosphorus uptake was recorded with the application of nitrogen 140 kg ha⁻¹ (N₃), which was comparable with 160 kg ha⁻¹ (N₄), at all the stages of crop growth during both the years of study. Application of 120 kg N ha⁻¹ (N₂) proved to be the next best level, in registering higher phosphorus uptake than 100 kg ha⁻¹ nitrogen (N₁) application which registered the lowest phosphorus uptake at all the stages of observation during both the instances of experimentation.

With different weed management practices tried, the highest phosphorus uptake was recorded with PE application of oxadiargyl @ 75 g ha⁻¹ supplemented with HW at 25 DAS (W₆), which was statistically similar to PE application of pyrazosulfuron ethyl @ 20g ha⁻¹ supplemented with HW at 25 DAS (W₇) and both of them were higher than with PE application of pretilachlor @ 500g ha⁻¹ supplemented with HW at 25 DAS (W₅), at all the stages of observation during both the years of experimentation. The next best weed management practice was the application of oxadiargyl @ 75 g ha⁻¹ alone (W₃) and it was comparable with PE application of pyrazosulfuron ethyl @ 20g ha⁻¹ alone (W₄). PE application of pretilachlor @ 500g ha⁻¹ alone (W₂) recorded significantly higher phosphorous uptake than un-weeded check. The lowest phosphorus uptake was recorded with un-weeded check (W₁), which was

Table 4.24. Phosphorous uptake of aromatic rice (kg ha⁻¹) at different growth stages as influenced by nitrogen and weed management practices under aerobic culture

Treatments	<i>rabi,2009</i>					<i>rabi,2010</i>				
	AT	MT	PI	FL	At harvest	AT	MT	PI	FL	At harvest
Nitrogen										
N ₁	2.80	7.06	9.84	10.40	12.24	2.82	6.94	9.74	10.41	12.16
N ₂	3.39	8.35	11.47	12.11	14.14	3.40	8.23	11.49	12.19	14.16
N ₃	3.90	9.62	13.02	13.63	16.04	4.13	9.84	13.41	14.07	16.10
N ₄	3.89	9.29	12.80	13.26	15.48	3.97	9.39	13.00	13.62	15.37
SEm ±	0.06	0.11	0.16	0.19	0.18	0.06	0.18	0.16	0.18	0.27
CD (P=0.05)	0.19	0.37	0.55	0.64	0.61	0.20	0.62	0.56	0.63	0.94
Weed management										
W ₁	1.11	4.36	6.86	6.86	8.18	1.58	4.24	6.88	7.05	7.61
W ₂	3.05	7.34	10.31	10.92	12.94	3.10	7.59	10.48	11.14	12.98
W ₃	3.62	8.75	11.97	12.66	14.97	3.65	8.86	12.16	12.95	15.03
W ₄	3.48	8.45	11.49	12.23	14.47	3.53	8.55	11.75	12.53	14.53
W ₅	4.06	9.60	12.95	13.60	15.79	4.04	9.53	13.11	13.78	15.85
W ₆	4.64	10.95	14.66	15.32	17.70	4.64	10.86	14.68	15.49	17.78
W ₇	4.49	10.62	14.20	14.87	17.28	4.51	10.57	14.29	15.08	17.35
SEm ±	0.07	0.13	0.20	0.22	0.24	0.07	0.15	0.22	0.26	0.26
CD (P=0.05)	0.22	0.38	0.58	0.62	0.68	0.20	0.43	0.62	0.74	0.74

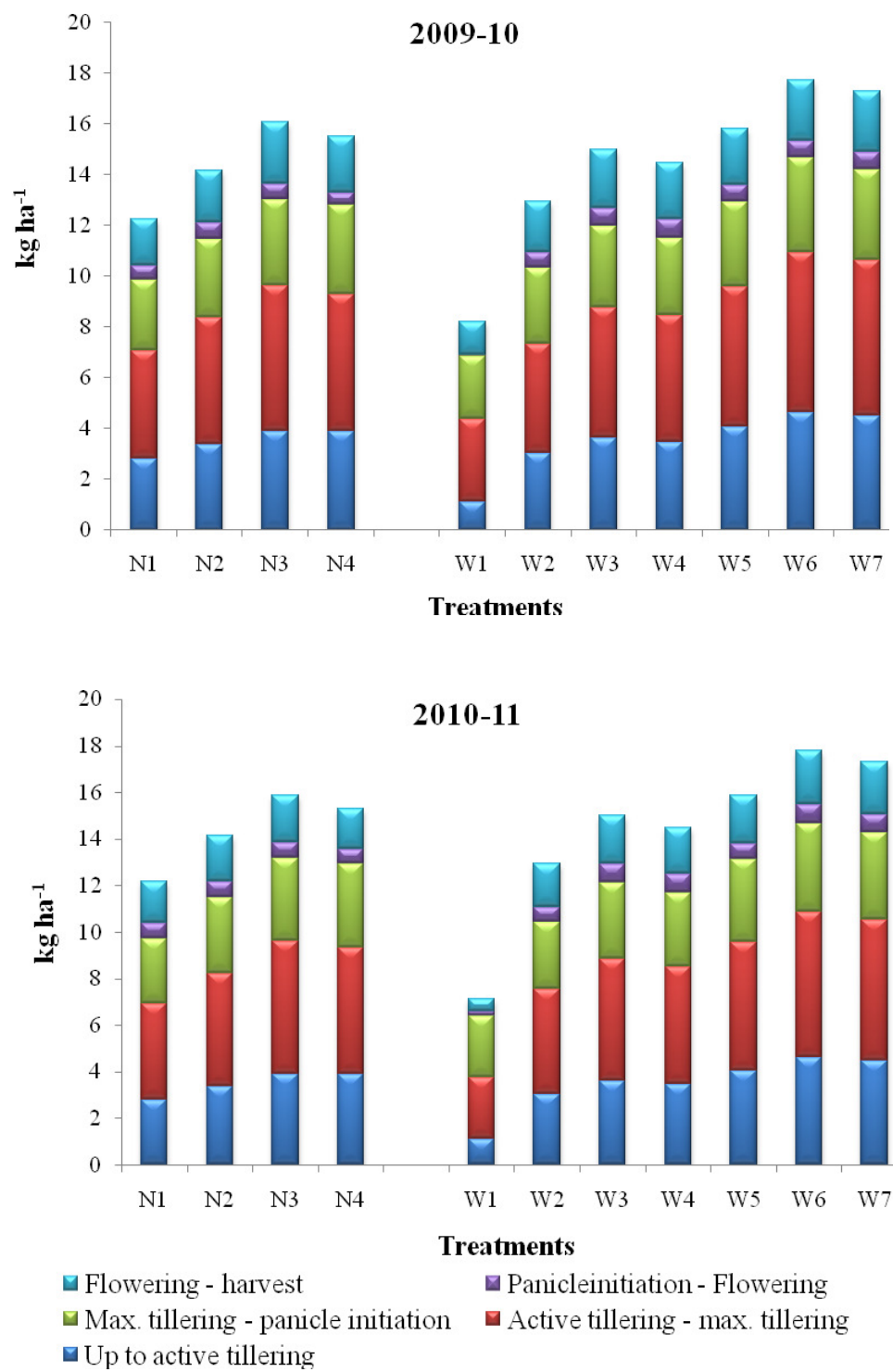


Fig.4.12. Phosphorus uptake (kg ha^{-1}) of aromatic rice at different growth stages as influenced by nitrogen and weed management practices under aerobic culture

significantly lesser than with rest of the weed management practices tried, during both the years of investigation.

4.6.3 Potassium Uptake by Crop

Graded levels of nitrogen and weed management practices were significantly influenced the uptake of potassium, at all the growth stages of the aromatic rice crop *viz.*, active tillering, maximum tillering, panicle initiation, flowering and at harvest, where as the interaction was not statistically traceable at any of the growth stages, with unaltered trend during both the years of experimentation. The potassium uptake of rice tended to increase progressively with advance in the age of the crop up to maturity (Table 4.25 and Fig 4.13).

Potassium uptake by aromatic rice crop at all the stages of crop growth with graded levels of nitrogen application and weed management practices, followed exactly similar trend to that of phosphorus uptake by aromatic rice crop.

The highest nitrogen uptake by crop at all the stages of observation was recorded with 160 kg N ha⁻¹ (N₄) due to increased availability of vital nutrients resulted in higher dry matter production per unit area led to higher nitrogen uptake. The highest phosphorus and potassium uptake by crop was recorded with 140 kg N ha⁻¹ (N₃). The response at the highest level of nitrogen 160 kg ha⁻¹ (N₄) was lesser, as this level was above the optimal dose required for the potential crop performance. The lowest nutrient uptake by crop was associated with 100 kg N ha⁻¹ (N₁) due to reduced growth under limited soil available nutrients. The present findings are in confirmity with those Mhaskar and Thorat (2005), Takeshi Horie *et al.* (2005), Naw Mar Lar OO *et al.* (2007b) and Zhang Hong Yan *et al.* (2007).

Among the weed management practices, highest nitrogen, phosphorus and potassium uptake by aromatic rice at all the stages of observation was recorded with PE application of oxadiargyl @ 75 g ha⁻¹, supplemented with HW at 25 DAS (W₆) due to higher dry matter production of crop at all stages because of effective control of all categories of weeds which helps in minimizing the crop

Table 4.25. Potassium uptake of aromatic rice (kg ha⁻¹) at different growth stages as influenced by nitrogen and weed management practices under aerobic culture

Treatments	<i>rabi,2009</i>					<i>rabi,2010</i>				
	AT	MT	PI	FL	At harvest	AT	MT	PI	FL	At harvest
Nitrogen										
N ₁	21.70	55.36	77.41	83.28	100.18	21.96	53.99	76.91	83.51	100.48
N ₂	23.94	59.52	81.99	87.98	104.74	24.02	58.08	82.22	88.2	105.07
N ₃	26.75	64.63	87.79	93.42	111.22	27.44	65.67	90.41	96.1	111.61
N ₄	25.97	64.50	86.21	91.97	109.60	27.18	64.53	89.00	94.65	109.96
SEm $\pm$	0.52	0.90	0.77	1.02	0.82	0.16	0.37	0.53	0.54	0.58
CD (P=0.05)	1.81	3.10	2.64	3.54	2.84	0.57	1.29	1.82	1.87	2.00
Weed management										
W ₁	10.22	40.06	62.42	72.79	93.21	14.69	39.14	63.07	73.12	93.88
W ₂	23.10	57.75	80.96	86.52	102.90	23.19	59.7	82.69	88.21	103.66
W ₃	25.89	62.42	84.75	90.06	106.53	25.95	63.13	86.35	92.04	107.3
W ₄	25.61	62.12	83.78	89.61	106.16	25.86	62.74	86.06	91.68	106.92
W ₅	27.78	65.62	87.89	92.74	109.75	27.57	65.18	89.34	94.49	110.03
W ₆	29.96	69.91	92.38	96.68	113.49	29.52	67.27	92.76	97.72	112.98
W ₇	29.58	69.15	91.28	95.74	113.01	29.29	66.81	92.15	97.05	112.7
SEm $\pm$	0.55	0.87	0.86	0.71	1.07	0.53	0.46	0.77	0.75	0.82
CD (P=0.05)	1.56	2.47	2.45	2.01	3.05	1.49	1.31	2.17	2.13	2.34

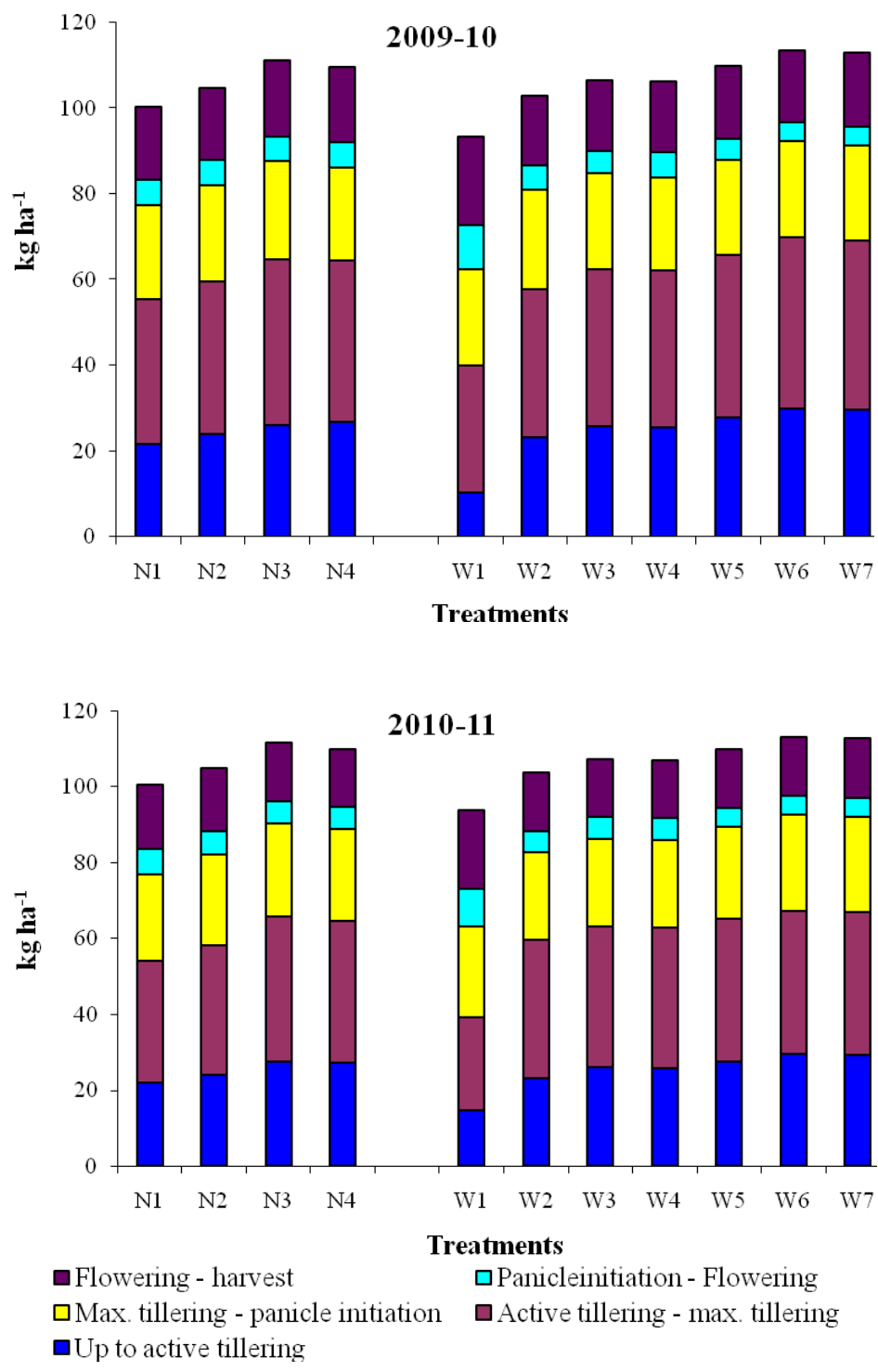


Fig.4.13. Potassium uptake (kg ha^{-1}) of aromatic rice at different growth stages as influenced by nitrogen and weed management practices under aerobic culture

weed competitions and helps the crop to utilize available nutrients to the maximum extent. It was evident that wherever effective control of weeds was observed, significant loss of nutrients could be avoided and increased availability of nutrient to the crop. Crop and weeds growing together in a community, nutrient uptake by crop and weeds follow an inverse relationship and it was an evident in the present investigation also. The lowest nutrient uptake by crop was noticed with un-weeded check (W_1), might be due to poor control of weeds and greater competitions offered by weeds for available nutrients through out crop growth period suppressed the crop and severely affecting the plant growth led to lower dry matter production by crop, resulted in lower nutrient uptake. These results corroborate the documented evidence by Thimmegowda *et al.* (2009), Gowda *et al.* (2009a) and Sunil *et al.* (2011).

4.7 WEED PARAMETERS

Weed parameters like weed flora of different taxonomic category, density and dry matter production of grasses, sedges, broad leaved weeds, weed control efficiency at different intervals of crop period *viz.*, 25, 50, 75, 100 DAS, at harvest of crop and nutrient uptake by weeds at harvest of crop were computed and tabulated (Table 4.26 to 4.38 and Fig 4.14 to 4.23).

4.7.1 Weed Flora

During crop growth period, weed flora belonging to eight taxonomic families was observed in the un-weeded check of the experimental field, of which seven species were grasses, two species were sedges and seven species were broad leaved weeds (Table 4.26). Among the grasses, *Echinochloa crus-galli* was the predominant species followed by *Dactyloctenium aegypticum* and *Cynodon dactylon*. Among the sedges, the predominant species was *Cyperus rotundus* followed by *Cyperus iria*. Among the broad leaved weeds, *Commelina benghalensis*, *Cyanotis cucullata* and *Physalis minima* were predominant during both the years of study.

Table 4.26. Weed flora of the experimental field at different stages of crop growth

S. No.	Botanical name	Common name	Family
I	Grasses		
1	<i>Echinochloa crus-galli</i> (L.)Beauv.	Barnyard grass	Poaceae
2	<i>Dactyloctenium aegypticum</i> (L.) Beauv.	Crow foot grass	Poaceae
3	<i>Cynodon dactylon</i> (L.) Pers.	Bermuda grass	Poaceae
4	<i>Chloris barbata</i> Sw.	Swollen finger grass	Poaceae
5	<i>Digitaria sanguinalis</i> (L) Scop.	Large crab grass	Poaceae
II	Sedges		
1	<i>Cyperus rotundus</i> L.	Purple nut sedge	Cyperaceae
2	<i>Cyperus iria</i> L.	Flat sedge	Cyperaceae
3	<i>Cyperus difformis</i> L.	Umbrella sedge	Cyperaceae
III	Broad Leaved weeds		
1	<i>Commelina benghalensis</i> L.	Day flower	Commelinaceae
2	<i>Cyanotis cucullata</i> (Roth) Kunth	Cyanotis	Commelinaceae
3	<i>Physalis minima</i> L.	Sunberry	Solanaceae
4	<i>Euphorbia hirta</i> L	Asthma herb	Euphorbiaceae
5	<i>Celosia argentea</i> L.	White cock’s comb	Amaranthaceae
6	<i>Digera avensis</i> Forssk	False Amaranth	Amaranthaceae
7	<i>Vernonia cineria</i> L.	Little Iron weed	Asteraceae
8	<i>Phyllanthus niruri</i> L.	Niruri	Euphorbiaceae
9	<i>Eclipta alba</i> (L) Hassk.	False daisy	Compositae
10	<i>Cleome viscosa</i> L.	Wild mustard	Capparidaceae
11	<i>Tridax procumbens</i>	Tridax	Compositae
12	<i>Vernonia cineria</i> L.	Little Iron weed	Asteraceae

4.7.2 Weed Density

Density of all categories of weeds was computed at different stages of crop growth *viz.*, 25, 50, 75, 100 DAS and at harvest was significantly influenced by graded levels of nitrogen and weed management practices while the interaction effect was not traceable at stage of observation for all categories of weeds. Hand weeding was not imposed by the time of sampling at 25DAS. The discussion pertaining to density and dry matter production of weeds was explained at 4.6.3.4.

4.7.2.1 Density of grasses

Different nitrogen and weed management practices significantly influenced the density of grasses in aromatic rice under aerobic culture at different stages of crop growth *viz.*, 25, 50, 75, 100 DAS and at harvest, whereas the interaction effect was not statistically measurable at any of crop growth stages studied, with unaltered trend during both the years of study (Table 4.27 and Fig 4.14).

The lowest density of grasses was recorded with the application of nitrogen 100 kg ha⁻¹ (N₁), which was significantly lesser than with all other nitrogen levels tried. The next best N level in reducing the density of grasses was with the application of 120 kg N ha⁻¹ (N₂), which was significantly lesser than the rest of the N levels tried. The highest density of grasses was associated with higher level of N application 160 kg ha⁻¹ (N₄) which was however, on par with 140 kg N ha⁻¹ (N₃), at all the stages of observation during both the years of experimentation.

With respect to weed management practices tried, the lowest count of grasses was associated with PE application of oxadiargyl 75 g ha⁻¹ supplemented with HW at 25 DAS (W₆), which was significantly lower than rest of the weed management practices. The next best weed management practice in reducing grass density was the PE application of pretilachlor 500g ha⁻¹ supplemented with HW at 25 DAS (W₅) followed by PE application of pyrazosulfuron ethyl 20g ha⁻¹ supplemented with HW at 25 DAS (W₇) with significant disparity between any

Table 4.27. Density of grasses (No. m⁻²) at different stages of observation as influenced by nitrogen and weed management practices under aerobic culture

Treatments	<i>rabi,2009</i>					<i>rabi,2010</i>				
	25DAS	50DAS	75DAS	100DAS	At harvest	25DAS	50DAS	75DAS	100DAS	At harvest
Nitrogen										
N ₁	24.33 (4.65)	27.76 (4.74)	33.98 (5.33)	38.48 (5.77)	37.09 (5.67)	24.32 (4.69)	27.38 (4.73)	33.21 (5.27)	37.60 (5.70)	36.24 (5.60)
N ₂	29.31 (5.18)	30.94 (5.03)	39.05 (5.78)	43.46 (6.17)	41.41 (6.03)	29.15 (5.19)	30.04 (4.94)	38.14 (5.71)	42.43 (6.10)	40.43 (5.96)
N ₃	32.75 (5.50)	34.33 (5.30)	42.65 (6.04)	46.98 (6.41)	45.29 (6.30)	33.86 (5.62)	33.86 (5.28)	41.74 (5.98)	45.98 (6.34)	44.28 (6.23)
N ₄	35.20 (5.72)	35.89 (5.42)	44.45 (6.18)	48.60 (6.55)	46.65 (6.41)	34.81 (5.71)	35.22 (5.39)	43.30 (6.10)	47.34 (6.46)	45.44 (6.32)
SEm +	0.08	0.04	0.05	0.04	0.04	0.03	0.03	0.04	0.04	0.04
CD (P=0.05)	0.26	0.13	0.16	0.15	0.13	0.10	0.12	0.13	0.13	0.12
Weed management										
W ₁	87.18 (9.35)	110.47 (10.52)	126.22 (11.25)	133.82 (11.58)	127.78 (11.32)	85.53 (9.27)	107.99 (10.41)	123.38 (11.12)	130.81 (11.45)	124.91 (11.19)
W ₂	24.63 (4.99)	30.46 (5.55)	38.50 (6.24)	41.82 (6.50)	40.59 (6.41)	24.38 (4.97)	29.77 (5.49)	37.63 (6.17)	40.88 (6.43)	39.68 (6.33)
W ₃	21.75 (4.69)	25.54 (5.09)	31.38 (5.64)	34.79 (5.94)	33.87 (5.86)	21.58 (4.68)	24.96 (5.04)	30.68 (5.58)	34.01 (5.87)	33.10 (5.79)
W ₄	27.86 (5.30)	34.68 (5.93)	44.94 (6.72)	48.65 (7.00)	47.27 (6.90)	27.54 (5.28)	33.90 (5.86)	43.93 (6.65)	47.56 (6.92)	46.12 (6.82)
W ₅	17.07 (4.16)	8.01 (2.91)	12.79 (3.63)	17.04 (4.18)	16.07 (4.06)	18.18 (4.30)	8.29 (2.95)	12.43 (3.58)	16.55 (4.12)	15.62 (4.01)
W ₆	15.14 (3.93)	7.07 (2.74)	11.24 (3.41)	14.93 (3.92)	14.13 (3.81)	16.82 (4.14)	6.87 (2.70)	10.92 (3.37)	14.50 (3.86)	13.73 (3.76)
W ₇	19.16 (4.41)	9.37 (3.14)	15.14 (3.94)	19.61 (4.48)	18.56 (4.36)	19.70 (4.47)	9.61 (3.14)	14.71 (3.89)	19.05 (4.41)	18.03 (4.30)
SEm ±	0.08	0.05	0.06	0.04	0.04	0.03	0.06	0.04	0.04	0.04
CD (P=0.05)	0.22	0.14	0.16	0.11	0.11	0.09	0.18	0.11	0.12	0.11

Figures in parenthesis indicate square root transformed ($\sqrt{x+0.5}$) values

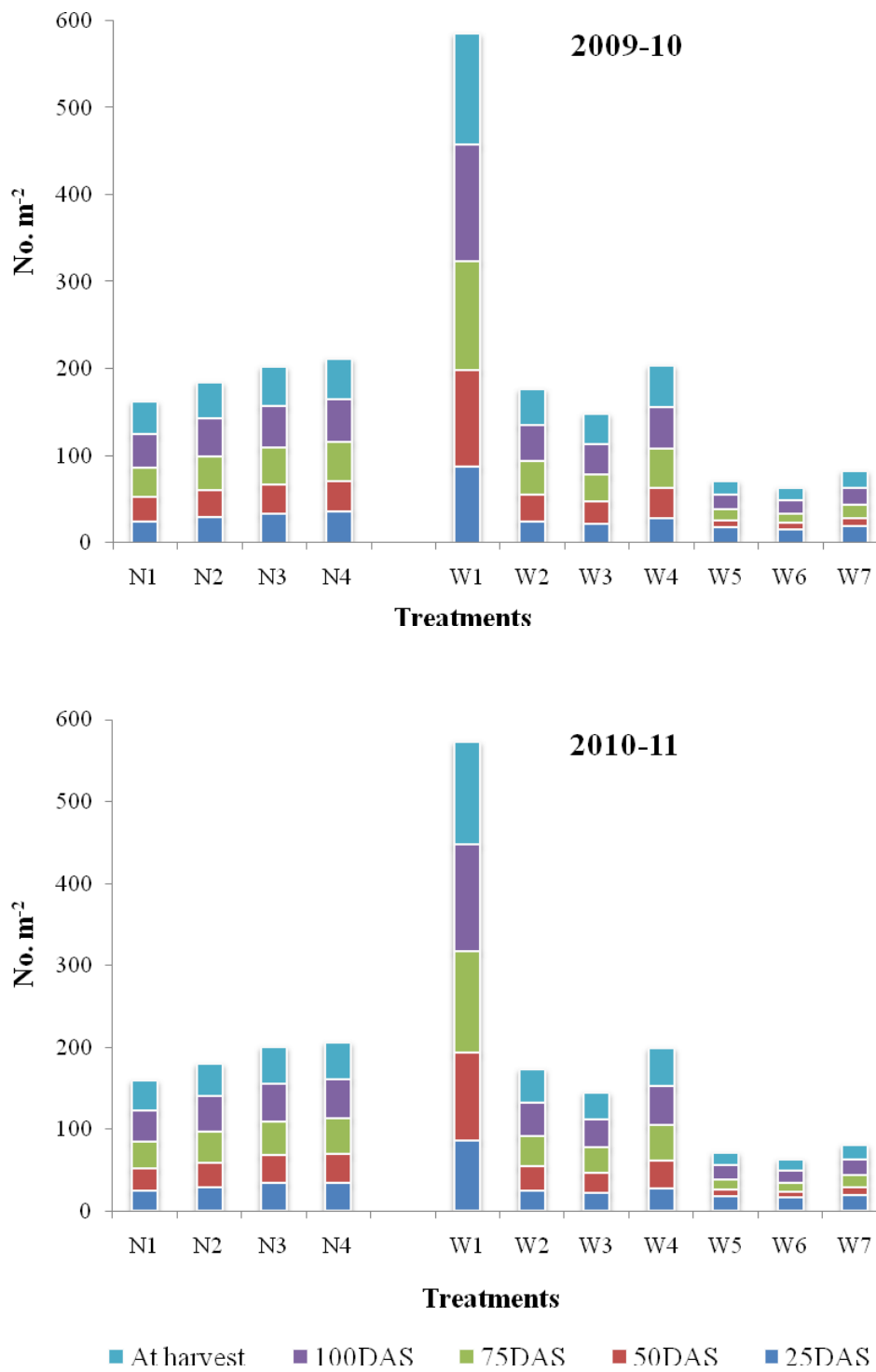


Fig.4.14. Density of grasses (No. m⁻²) at different stages of observation as influenced by nitrogen and weed management practices under aerobic culture

two of them at all the stages of observation during both the years of study. The next best weed management practice was the PE application of oxadiargyl 75 g ha⁻¹ alone (W₃), followed by PE application of pretilachlor 500g ha⁻¹ alone (W₂) and PE application of pyrazosulfuron ethyl 20g ha⁻¹ alone (W₄) and these treatments were significantly differed with each other in reducing the density of grasses. The highest density of grasses was noticed with un-weeded check (W₁), which was significantly higher than rest of weed management practices tried, at all the stages of crop growth during both the instances of study.

4.7.2.2 Density of sedges

Density of sedges were significantly influenced by varied nitrogen levels and weed management practices, in aromatic rice under aerobic culture at different stages of crop growth viz., 25, 50, 75, 100 DAS and at harvest, whereas the interaction effect was not statistically traceable at any of crop growth stages studied, with unaltered trend during both the years of study (Table 4.28 and Fig 4.15).

The lowest density of sedges was associated with the application of nitrogen 100 kg ha⁻¹ (N₁) followed by 120 kg N ha⁻¹ with significant disparity between them and both of them were significantly lower than with rest of N levels tried. The next best N level in reducing the density of sedges was the application of 140 kg N ha⁻¹ (N₃) which was however, at par with application of N 160 kg ha⁻¹ (N₄) and both of them were significantly recorded higher density of sedges than rest of the N levels tried.

With regard to weed management practices tried, the lowest density of sedges was associated with PE application of oxadiargyl @ 75 g ha⁻¹ supplemented with HW at 25 DAS (W₆), which was however, on par with PE application of pyrazosulfuron ethyl @ 20g ha⁻¹ supplemented with HW at 25 DAS (W₇) and both of them were significantly recorded lower density of sedges than rest of the weed management practices. The next best weed management practice in reducing density of sedges was with PE application of pretilachlor @ 500g ha⁻¹ + HW at 25 DAS (W₅) and it was followed by the PE application of

Table 4.28. Density of sedges (No. m⁻²) at different stages of observation as influenced by nitrogen and weed management practices under aerobic culture

Treatments	<i>rabi,2009</i>					<i>rabi,2010</i>				
	25DAS	50DAS	75DAS	100DAS	At harvest	25DAS	50DAS	75DAS	100DAS	At harvest
Nitrogen										
N ₁	17.10 (4.05)	17.03 (3.71)	25.23 (4.86)	29.71 (5.30)	26.76 (4.98)	16.65 (4.00)	17.32 (3.87)	24.54 (4.78)	28.92 (5.22)	26.16 (4.92)
N ₂	19.74 (4.38)	20.36 (4.21)	28.00 (5.16)	32.98 (5.61)	30.05 (5.32)	19.20 (4.32)	20.54 (4.30)	27.21 (5.08)	32.08 (5.53)	29.34 (5.26)
N ₃	24.10 (4.86)	23.84 (4.63)	31.63 (5.50)	36.21 (5.89)	33.03 (5.59)	23.53 (4.80)	23.99 (4.70)	30.83 (5.42)	35.30 (5.81)	32.30 (5.53)
N ₄	24.95 (4.95)	24.57 (4.71)	32.67 (5.59)	36.98 (5.95)	33.55 (5.63)	24.51 (4.91)	24.59 (4.76)	31.70 (5.50)	35.91 (5.86)	32.68 (5.56)
SEm ±	0.04	0.05	0.04	0.04	0.05	0.03	0.04	0.05	0.04	0.05
CD (P=0.05)	0.12	0.17	0.15	0.15	0.18	0.12	0.14	0.16	0.15	0.16
Weed management										
W ₁	46.04 (6.81)	56.58 (7.54)	65.29 (8.10)	73.49 (8.59)	71.23 (8.46)	45.09 (6.74)	55.32 (7.45)	63.84 (8.01)	71.86 (8.49)	69.65 (8.36)
W ₂	23.55 (4.90)	27.99 (5.33)	35.78 (6.01)	40.49 (6.40)	36.95 (6.12)	23.10 (4.85)	27.37 (5.27)	34.99 (5.95)	39.60 (6.33)	36.13 (6.05)
W ₃	18.25 (4.31)	22.35 (4.77)	27.35 (5.27)	31.94 (5.69)	28.85 (5.41)	17.94 (4.27)	21.87 (4.72)	26.74 (5.21)	31.23 (5.63)	28.21 (5.35)
W ₄	19.27 (4.43)	23.82 (4.92)	28.46 (5.37)	33.04 (5.79)	29.70 (5.49)	18.96 (4.39)	23.29 (4.87)	28.01 (5.33)	32.49 (5.74)	29.03 (5.43)
W ₅	15.89 (4.04)	9.50 (3.14)	21.47 (4.68)	26.12 (5.15)	23.06 (4.85)	15.29 (3.96)	9.01 (3.07)	20.87 (4.62)	25.39 (5.08)	22.42 (4.78)
W ₆	13.38 (3.70)	4.73 (2.21)	13.45 (3.72)	16.17 (4.07)	12.62 (3.61)	12.97 (3.64)	6.85 (2.67)	12.46 (3.58)	14.93 (3.91)	12.25 (3.56)
W ₇	13.92 (3.76)	5.19 (2.30)	13.87 (3.78)	16.55 (4.12)	13.52 (3.73)	13.47 (3.70)	7.56 (2.81)	13.08 (3.67)	15.89 (4.04)	13.14 (3.68)
SEm ±	0.05	0.07	0.05	0.05	0.05	0.05	0.07	0.05	0.05	0.05
CD (P=0.05)	0.13	0.19	0.15	0.14	0.15	0.13	0.19	0.15	0.15	0.14

Figures in parenthesis indicate square root transformed ($\sqrt{x + 0.5}$) values

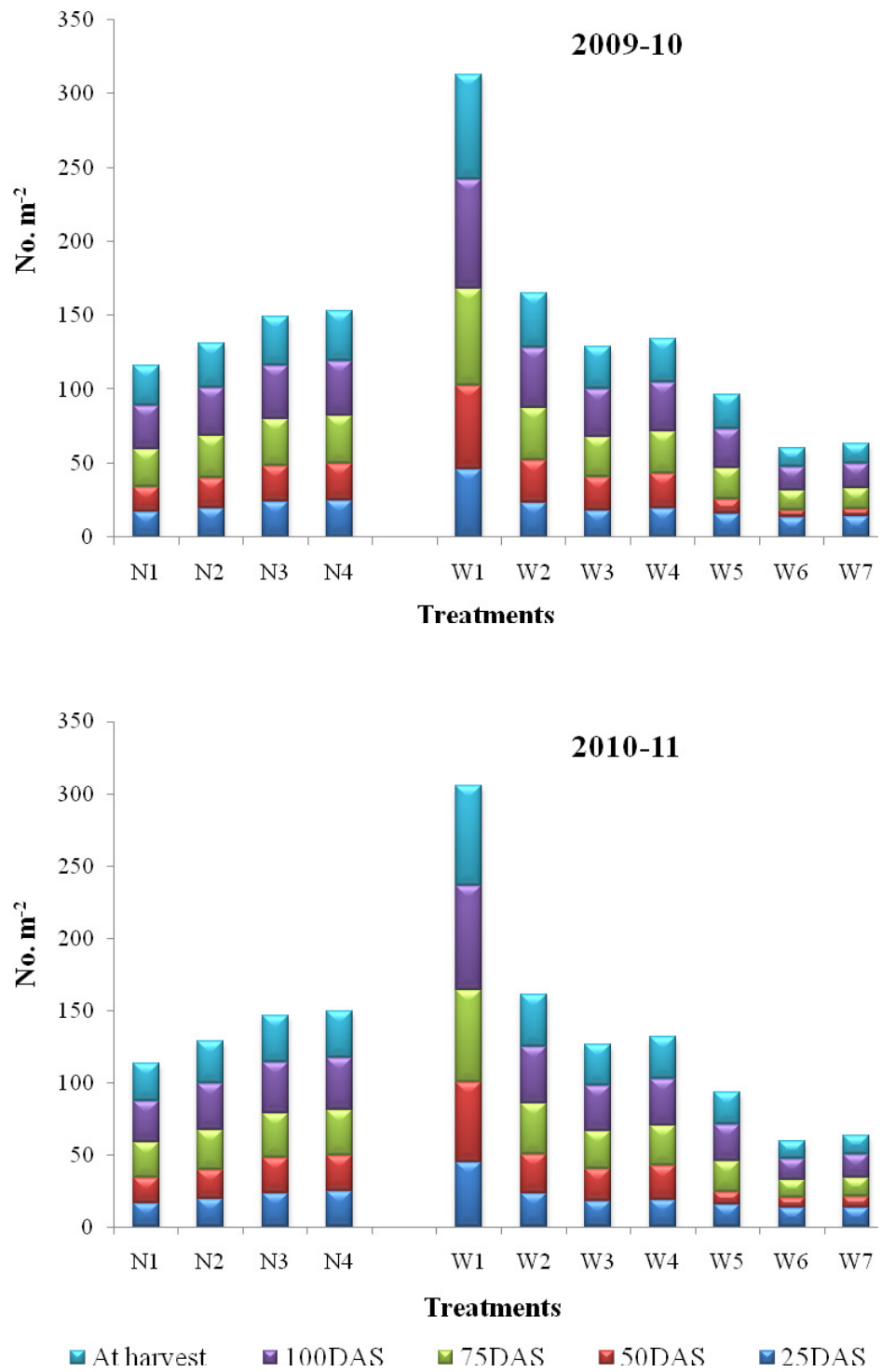


Fig.4.15. Density of sedges (No. m⁻²) at different stages of observation as influenced by nitrogen and weed management practices under aerobic culture

oxadiargyl 75 g ha⁻¹ alone (W₃) followed by PE application of pyrazosulfuron ethyl 20g ha⁻¹ alone (W₄) and both of them were comparable with each other in reducing sedges density. Pre emergence application of pretilachlor 500 g ha⁻¹ alone (W₂) recorded significantly lower number of sedges m⁻² than un- weeded control. The highest density of sedges was registered with un- weeded control which was significantly higher than rest of the weed management practices during both the years at all the stags of observations.

4.7.2.3 Density of broad leaved weeds

Different nitrogen and weed management practices significantly influenced the density of broad leaved weeds in aromatic rice under aerobic culture at different stages of crop growth *viz.*, 25, 50, 75, 100 DAS and at harvest, while none of the interaction effect was statistically traceable, at any of crop growth stages studied, with unaltered trend during both the years of study (Table 4.29 and Fig 4.16).

The lowest density of broad leaved weeds was recorded with the application of nitrogen 100 kg ha⁻¹ (N₁), which was significantly lesser than with all other nitrogen levels tried. The next best N level in reducing the density of broad leaved weeds was the application of 120 kg N ha⁻¹ (N₂). Application of Nitrogen 140 kg ha⁻¹ (N₃) and 160 kg ha⁻¹ (N₄) were comparable with each other in recording the density of broad leaved weeds. The highest density of broad leaved weeds was associated with application of 160 kg N ha⁻¹ (N₄), at all the stages of observation during both the years of experimentation.

Among different weed management practices tried, at all the stages during both the years of experimentation, the lowest count of broad leaved weeds was associated with PE application of pyrazosulfuron ethyl 20g ha⁻¹ supplemented with HW at 25 DAS (W₇), followed by PE application of pretilachlor 500g ha⁻¹ supplemented with HW at 25 DAS (W₅) and PE application of oxadiargyl 75 g ha⁻¹ supplemented with HW at 25 DAS (W₆) with significant disparity between any two of them. The next best weed management practice was the PE application of pyrazosulfuron ethyl 20g ha⁻¹ alone (W₄), in reducing the density

Table 4.29. Density of broad leaved weeds (No. m⁻²) at different stages of observation as influenced by nitrogen and weed management practices under aerobic culture

Treatments	<i>rabi,2009</i>					<i>rabi,2010</i>				
	25DAS	50DAS	75DAS	100DAS	At harvest	25DAS	50DAS	75DAS	100DAS	At harvest
Nitrogen										
N ₁	20.38 (4.48)	18.57 (4.01)	22.00 (4.46)	23.33 (4.61)	22.32 (4.52)	19.89 (4.43)	18.13 (3.97)	21.51 (4.41)	22.81 (4.56)	21.83 (4.47)
N ₂	24.14 (4.89)	20.60 (4.29)	24.19 (4.68)	25.45 (4.81)	24.41 (4.72)	23.52 (4.83)	20.12 (4.23)	23.62 (4.62)	24.85 (4.75)	23.84 (4.67)
N ₃	27.39 (5.21)	23.78 (4.61)	26.71 (4.93)	27.97 (5.06)	26.60 (4.93)	26.70 (5.15)	23.21 (4.56)	26.07 (4.87)	27.30 (4.99)	25.96 (4.87)
N ₄	27.78 (5.25)	24.22 (4.66)	26.97 (4.95)	28.16 (5.07)	26.88 (4.96)	27.05 (5.18)	23.63 (4.60)	26.31 (4.89)	27.47 (5.01)	26.22 (4.90)
SEm $\pm$	0.04	0.07	0.04	0.03	0.04	0.02	0.05	0.04	0.04	0.04
CD (P=0.05)	0.13	0.25	0.14	0.11	0.14	0.07	0.16	0.13	0.13	0.14
Weed management										
W ₁	48.41 (6.99)	56.34 (7.53)	62.02 (7.90)	64.80 (8.08)	60.56 (7.81)	47.26 (6.91)	54.99 (7.44)	60.55 (7.81)	63.27 (7.98)	59.12 (7.72)
W ₂	23.04 (4.84)	25.46 (5.08)	28.83 (5.41)	29.92 (5.51)	29.21 (5.44)	22.56 (4.79)	24.88 (5.03)	28.19 (5.35)	29.25 (5.45)	28.56 (5.38)
W ₃	24.57 (5.00)	27.14 (5.24)	30.43 (5.56)	31.47 (5.65)	30.89 (5.60)	24.04 (4.94)	26.53 (5.19)	29.75 (5.49)	30.76 (5.59)	30.20 (5.54)
W ₄	21.76 (4.71)	23.53 (4.89)	26.26 (5.16)	27.27 (5.26)	26.18 (5.16)	21.32 (4.66)	23.00 (4.84)	25.67 (5.11)	26.66 (5.21)	25.59 (5.10)
W ₅	18.84 (4.38)	6.43 (2.62)	9.10 (3.10)	10.19 (3.27)	9.62 (3.18)	18.23 (4.32)	6.24 (2.58)	8.86 (3.06)	9.92 (3.23)	9.36 (3.14)
W ₆	20.65 (4.59)	8.06 (2.91)	10.19 (3.27)	11.15 (3.41)	10.69 (3.34)	19.98 (4.51)	7.82 (2.87)	9.91 (3.22)	10.84 (3.36)	10.39 (3.30)
W ₇	17.18 (4.19)	5.61 (2.46)	7.93 (2.90)	8.79 (3.04)	8.23 (2.95)	16.64 (4.13)	5.43 (2.43)	7.71 (2.86)	8.54 (3.00)	8.00 (2.91)
SEm $\pm$	0.04	0.04	0.04	0.04	0.05	0.02	0.04	0.04	0.04	0.05
CD (P=0.05)	0.11	0.11	0.11	0.12	0.13	0.05	0.10	0.12	0.12	0.13

Figures in parenthesis indicate square root transformed ($\sqrt{x + 0.5}$) values

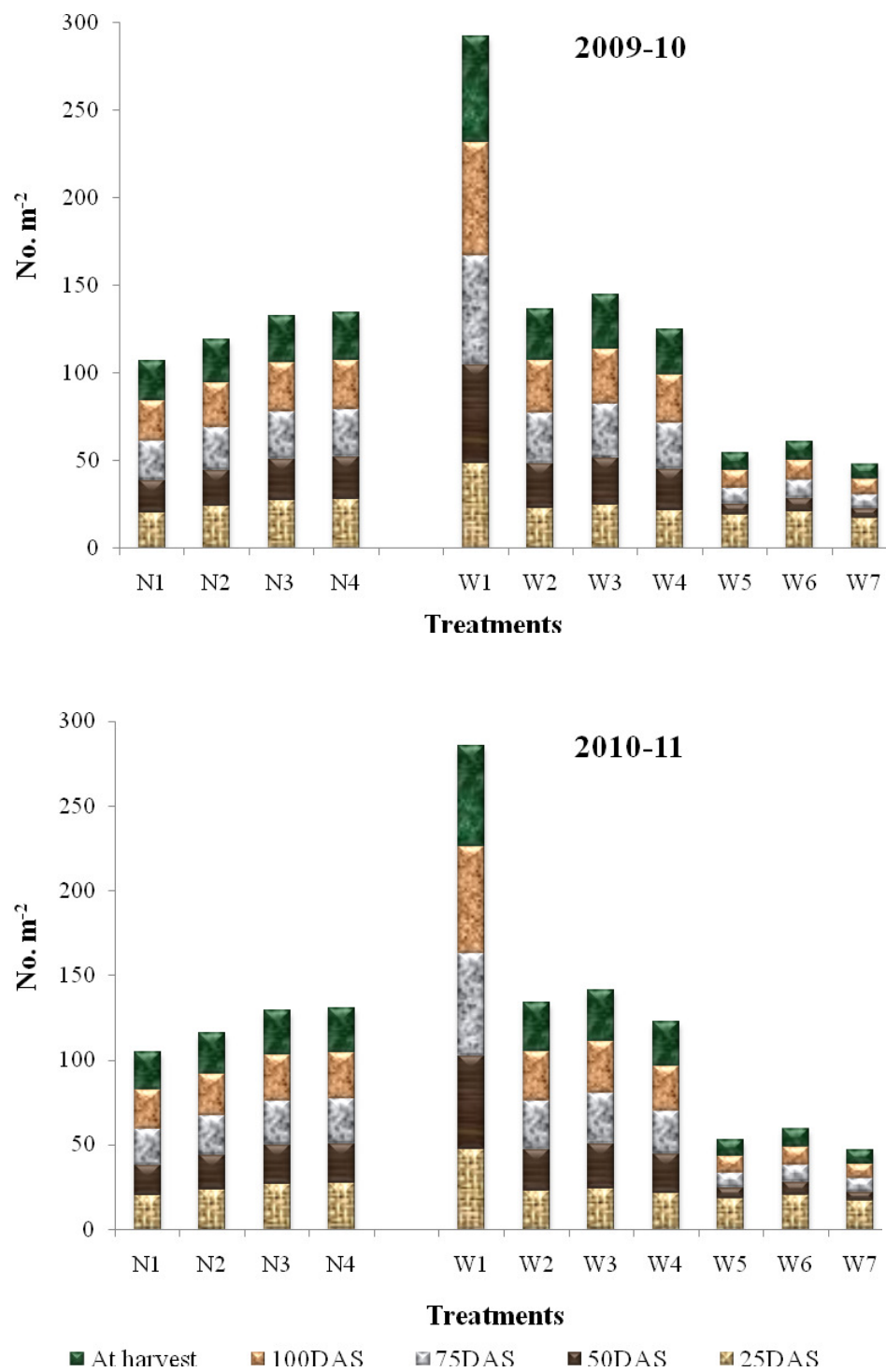


Fig.4.16. Density of broad leaved weeds (No. m⁻²) at different stages of observation as influenced by nitrogen and weed management practices under aerobic culture

of broad leaved weeds at all the stages of crop growth followed by PE application of pretilachlor 500g ha⁻¹ alone (W₂) and PE application of oxadiargyl 75 g ha⁻¹ alone (W₃) with significant disparity between any two of them. The highest density of broad leaved weeds was noticed with un-weeded check (W₁), which was significantly higher than rest of weed management practices, at all the stages of crop growth during both the years of study.

4.7.2.4 Total weed density

Different nitrogen and weed management practices significantly influenced the total weed density in aromatic rice under aerobic culture at different stages of crop growth viz., 25, 50, 75, 100 DAS and at harvest, while none of the interaction effect was statistically traceable, at any of crop growth stages studied, with unaltered trend during both the years of study (Table 4.30 and Fig 4.17).

The lowest total weed density was registered with the application of nitrogen 100 kg ha⁻¹ (N₁), which was significantly lesser than with all other nitrogen levels tried. Application of 120 kg N ha⁻¹ (N₂) proved to be the next best N level in reducing the total weed density followed by 140 kg N ha⁻¹ (N₃). The highest total density of weeds was associated with 160 kg N ha⁻¹ (N₄), which was at par with N₃ at all the stage of observation during both the years of experimentation.

Pre emergence application of oxadiargyl @ 75 g ha⁻¹ supplemented with HW at 25 DAS (W₆) was most efficient and statistically superior to the rest of weed management practices tried in reducing total density of weeds. Pre emergence application of pyrazosulfuron ethyl @ 20g ha⁻¹ supplemented with HW at 25 DAS (W₇) was the next best treatment in reducing total density of weeds followed by PE application of pretilachlor @ 500g ha⁻¹ supplemented with HW at 25 DAS (W₅) and PE application of oxadiargyl @ 75 g ha⁻¹ alone (W₃) with significant disparity between any two of them. Pre emergence application of pyrazosulfuron ethyl @ 20g ha⁻¹ (W₄) and pretilachlor @ 500g ha⁻¹ alone (W₂) recorded significantly lower total density of weeds than un-weeded check at all

Table 4.30. *Total weed density (No. m⁻²) at different stages of observation as influenced by nitrogen and weed management practices under aerobic culture

Treatments	<i>rabi,2009</i>					<i>rabi,2010</i>				
	25DAS	50DAS	75DAS	100DAS	At harvest	25DAS	50DAS	75DAS	100DAS	At harvest
Nitrogen										
N ₁	62.38 (7.63)	63.08 (7.15)	81.21 (8.45)	91.52 (9.06)	86.17 (8.76)	60.72 (7.53)	62.97 (7.24)	79.26 (8.34)	89.40 (8.95)	84.23 (8.66)
N ₂	73.76 (8.36)	71.62 (7.75)	91.24 (9.03)	101.89 (9.61)	95.88 (9.29)	71.72 (8.24)	70.85 (7.76)	88.97 (8.91)	99.43 (9.48)	93.61 (9.18)
N ₃	84.82 (9.00)	81.67 (8.34)	100.98 (9.52)	111.16 (10.05)	104.93 (9.74)	83.94 (8.96)	80.20 (8.31)	98.64 (9.41)	109.50 (9.98)	102.54 (9.62)
N ₄	88.49 (9.21)	84.39 (8.47)	104.09 (9.66)	113.75 (10.18)	107.08 (9.84)	86.23 (9.05)	83.58 (8.45)	101.31 (9.52)	110.79 (10.04)	104.34 (9.71)
SEm $\pm$	0.07	0.04	0.05	0.05	0.06	0.03	0.04	0.04	0.03	0.04
CD (P=0.05)	0.24	0.14	0.16	0.18	0.19	0.10	0.15	0.13	0.09	0.13
Weed management										
W ₁	181.63 (13.48)	223.39 (14.95)	253.53 (15.93)	272.12 (16.50)	259.58 (16.12)	177.88 (13.34)	218.05 (14.77)	247.77 (15.74)	266.19 (16.32)	253.68 (15.93)
W ₂	72.21 (8.51)	83.91 (9.19)	103.11 (10.17)	112.24 (10.61)	106.76 (10.35)	70.04 (8.38)	81.78 (9.08)	100.81 (10.05)	110.23 (10.51)	104.37 (10.23)
W ₃	64.57 (8.04)	75.03 (8.67)	89.17 (9.46)	98.19 (9.92)	93.61 (9.69)	63.55 (7.98)	73.12 (8.56)	87.17 (9.35)	96.25 (9.83)	91.52 (9.58)
W ₄	68.89 (8.31)	82.03 (9.04)	99.66 (9.99)	108.96 (10.45)	103.15 (10.17)	67.83 (8.24)	79.94 (8.94)	97.61 (9.89)	106.96 (10.35)	100.74 (10.05)
W ₅	54.80 (7.41)	23.94 (4.92)	43.37 (6.61)	53.34 (7.33)	48.75 (7.01)	51.71 (7.20)	25.29 (5.06)	42.16 (6.52)	52.11 (7.24)	47.40 (6.91)
W ₆	49.16 (7.00)	17.86 (4.24)	34.88 (5.93)	42.24 (6.52)	37.44 (6.14)	48.77 (6.96)	20.29 (4.52)	33.29 (5.79)	40.52 (6.39)	36.37 (6.06)
W ₇	50.27 (7.11)	20.16 (4.52)	36.95 (6.10)	44.95 (6.73)	40.31 (6.37)	49.82 (7.07)	22.35 (4.75)	35.51 (5.98)	43.73 (6.64)	39.18 (6.28)
SEm $\pm$	0.03	0.05	0.05	0.04	0.04	0.03	0.05	0.05	0.05	0.05
CD (P=0.05)	0.10	0.14	0.14	0.10	0.13	0.10	0.13	0.13	0.15	0.13

Figures in parenthesis indicate square root transformed ($\sqrt{x + 0.5}$) values

* Of all the three categories of weeds

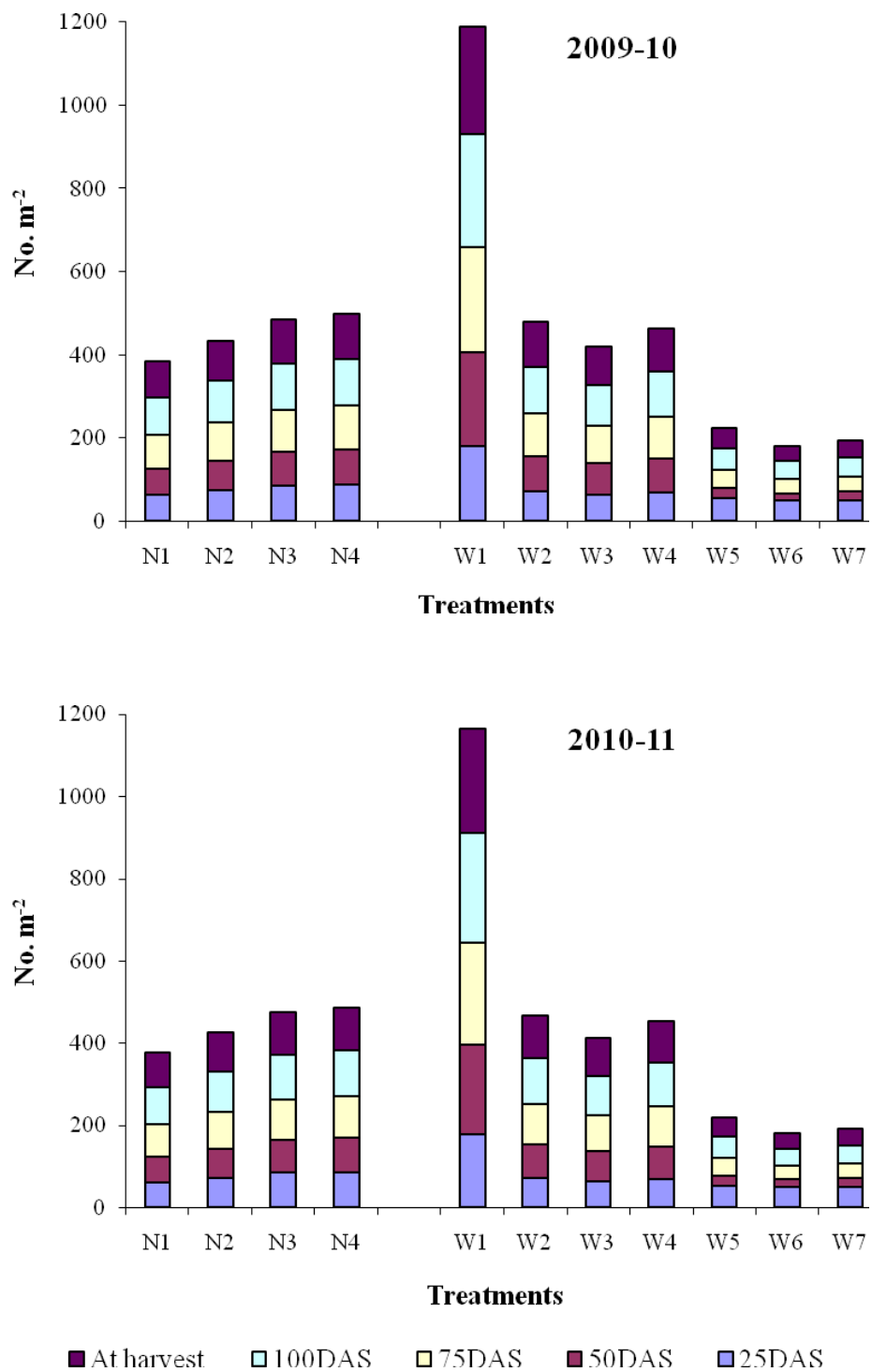


Fig. 4.17. Total weed density (No. m⁻²) at different stages of observation as influenced by nitrogen and weed management practices under aerobic culture

the stages of crop growth. The highest density of all category of weeds was associated with un-weeded check (W_1), which was significantly higher than rest of weed management practices at all the stages of crop growth during both the instances of study.

4.7.3 Dry matter Production of Weeds

Dry matter production of all categories of weeds was computed at different stages of crop growth viz., 25, 50, 75, 100 DAS and at harvest was significantly influenced by graded levels of nitrogen and weed management practices. Hand weeding was not imposed by the time of sampling at 25DAS.

4.7.3.1 Dry matter production of grasses

Different nitrogen and weed management practices significantly influenced the dry weight of grasses in aromatic rice under aerobic culture at different stages of crop growth viz., 25, 50, 75, 100 DAS and at harvest, while none of the interaction effect was statistically traceable at any of crop growth stages studied, during both the instances of study (Table 4.31 and Fig 4.18).

The trend with graded levels of nitrogen application and weed management practices on dry matter production of grasses was exactly similar to that of density of grasses.

4.7.3.2 Dry matter production of sedges

At all the stages of sampling (25, 50, 75, 100 DAS and at harvest of rice) dry weight of sedges in aromatic rice under aerobic culture, were significantly influenced by the varied nitrogen and weed management practices, whereas, the interaction effect was not statistically measurable at any of crop growth stages studied, during both the years of study (Table 4.32 and Fig 4.19).

The trend with graded levels of nitrogen application and weed management practices on dry matter production of sedges was exactly similar to that of density of sedges.

Table 4.31. Dry matter production of grasses (g m⁻²) at different stages of observation as influenced by nitrogen and weed management practices under aerobic culture

Treatments	<i>rabi,2009</i>					<i>rabi,2010</i>				
	25DAS	50DAS	75DAS	100DAS	At harvest	25DAS	50DAS	75DAS	100DAS	At harvest
Nitrogen										
N ₁	14.29 (3.26)	22.34 (3.79)	34.13 (4.87)	43.27 (5.66)	39.60 (5.43)	14.26 (3.30)	21.84 (3.75)	33.37 (4.81)	42.30 (5.60)	38.71 (5.36)
N ₂	16.74 (3.61)	24.71 (4.01)	38.50 (5.24)	48.40 (6.03)	43.75 (5.75)	16.64 (3.62)	24.14 (3.96)	37.61 (5.18)	47.29 (5.96)	42.74 (5.68)
N ₃	18.53 (3.83)	27.34 (4.22)	41.95 (5.47)	52.26 (6.27)	47.84 (6.00)	18.44 (3.84)	26.77 (4.17)	41.07 (5.42)	51.16 (6.20)	46.84 (5.94)
N ₄	19.52 (3.95)	28.58 (4.31)	43.57 (5.59)	53.80 (6.38)	49.13 (6.10)	19.49 (3.98)	27.86 (4.25)	42.47 (5.52)	52.43 (6.30)	47.89 (6.02)
SEm $\pm$	0.04	0.03	0.04	0.05	0.04	0.04	0.03	0.05	0.05	0.04
CD (P=0.05)	0.14	0.10	0.14	0.17	0.13	0.15	0.10	0.16	0.17	0.13
Weed management										
W ₁	74.32 (8.64)	119.54 (10.94)	166.80 (12.92)	194.32 (13.95)	176.61 (13.30)	72.70 (8.54)	116.85 (10.82)	163.04 (12.77)	189.95 (13.79)	172.64 (13.14)
W ₂	9.30 (3.12)	17.88 (4.28)	30.50 (5.56)	39.92 (6.35)	36.62 (6.09)	9.14 (3.10)	17.47 (4.23)	29.81 (5.50)	39.03 (6.28)	35.80 (6.02)
W ₃	8.39 (2.97)	14.36 (3.85)	23.67 (4.90)	32.11 (5.70)	30.29 (5.54)	8.26 (2.95)	14.04 (3.81)	23.14 (4.85)	31.39 (5.64)	29.60 (5.48)
W ₄	11.99 (3.52)	22.31 (4.77)	38.76 (6.26)	51.24 (7.18)	46.44 (6.84)	11.77 (3.49)	21.80 (4.71)	37.89 (6.18)	50.08 (7.11)	45.40 (6.77)
W ₅	5.54 (2.45)	2.01 (1.58)	5.42 (2.43)	9.08 (3.09)	8.11 (2.93)	6.05 (2.55)	1.96 (1.56)	5.27 (2.39)	8.82 (3.05)	7.88 (2.89)
W ₆	5.08 (2.34)	1.22 (1.31)	4.59 (2.25)	7.73 (2.86)	6.96 (2.72)	5.43 (2.42)	1.17 (1.29)	4.46 (2.22)	7.51 (2.82)	6.76 (2.69)
W ₇	6.26 (2.59)	2.87 (1.83)	7.02 (2.73)	11.63 (3.48)	10.53 (3.31)	7.11 (2.74)	2.79 (1.81)	6.82 (2.70)	11.30 (3.43)	10.23 (3.27)
SEm $\pm$	0.03	0.06	0.05	0.05	0.05	0.04	0.06	0.05	0.05	0.05
CD (P=0.05)	0.10	0.17	0.15	0.14	0.14	0.11	0.17	0.15	0.15	0.14

Figures in parenthesis indicate square root transformed ($\sqrt{x+0.5}$) values

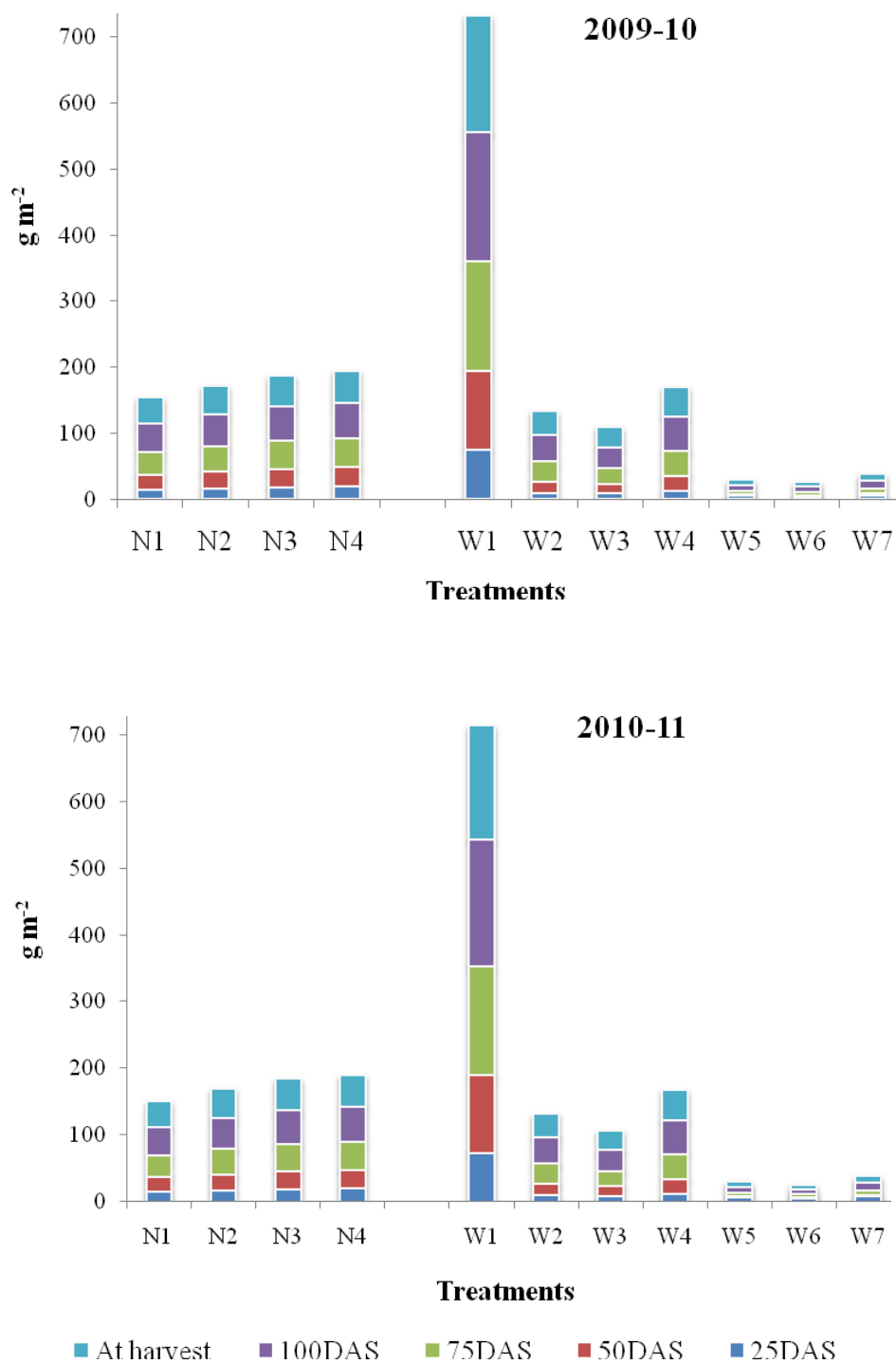


Fig.4.18. Drymatter production of grasses (g m^{-2}) at different stages of observation as influenced by nitrogen and weed management practices under aerobic culture

Table 4.32. Dry matter production of sedges (g m⁻²) at different stages of observation as influenced by nitrogen and weed management practices under aerobic culture

Treatments	<i>rabi,2009</i>					<i>rabi,2010</i>				
	25DAS	50DAS	75DAS	100DAS	At harvest	25DAS	50DAS	75DAS	100DAS	At harvest
Nitrogen										
N ₁	7.75 (2.51)	12.64 (3.14)	20.70 (4.19)	28.68 (4.97)	25.70 (4.65)	7.54 (2.47)	12.36 (3.11)	20.25 (4.15)	28.05 (4.91)	25.14 (4.60)
N ₂	8.85 (2.73)	14.41 (3.40)	22.61 (4.43)	31.52 (5.24)	28.51 (4.94)	8.59 (2.68)	14.08 (3.36)	22.08 (4.37)	30.79 (5.18)	27.85 (4.88)
N ₃	10.69 (3.05)	16.39 (3.64)	25.35 (4.71)	34.46 (5.49)	31.19 (5.17)	10.43 (3.01)	16.05 (3.60)	24.81 (4.66)	33.73 (5.43)	30.53 (5.12)
N ₄	11.14 (3.12)	16.79 (3.69)	25.86 (4.77)	34.90 (5.54)	31.38 (5.20)	10.81 (3.08)	16.36 (3.64)	25.19 (4.70)	34.00 (5.46)	30.58 (5.14)
SEm ±	0.04	0.02	0.03	0.05	0.05	0.03	0.03	0.03	0.03	0.05
CD (P=0.05)	0.12	0.08	0.10	0.17	0.18	0.10	0.11	0.09	0.11	0.17
Weed management										
W ₁	36.57 (6.07)	57.31 (7.59)	74.16 (8.64)	100.14 (10.03)	94.56 (9.74)	35.76 (6.01)	56.03 (7.51)	72.51 (8.54)	97.91 (9.91)	92.45 (9.63)
W ₂	9.16 (3.10)	15.91 (4.04)	27.67 (5.30)	36.15 (6.05)	31.91 (5.69)	8.96 (3.07)	15.56 (4.00)	27.06 (5.24)	35.34 (5.98)	31.20 (5.63)
W ₃	5.42 (2.41)	10.54 (3.31)	18.59 (4.36)	25.98 (5.14)	23.01 (4.84)	5.30 (2.39)	10.31 (3.28)	18.17 (4.31)	25.40 (5.08)	22.50 (4.79)
W ₄	5.76 (2.48)	11.06 (3.39)	19.39 (4.45)	27.03 (5.24)	24.13 (4.96)	5.62 (2.46)	10.79 (3.35)	18.94 (4.40)	26.41 (5.18)	23.59 (4.90)
W ₅	4.28 (2.17)	5.30 (2.40)	11.89 (3.52)	17.35 (4.22)	14.81 (3.91)	4.02 (2.11)	5.15 (2.37)	11.56 (3.47)	16.87 (4.16)	14.40 (3.86)
W ₆	2.85 (1.81)	2.54 (1.73)	6.61 (2.66)	9.80 (3.20)	7.71 (2.86)	2.69 (1.77)	2.48 (1.72)	6.45 (2.63)	9.55 (3.16)	7.52 (2.82)
W ₇	3.22 (1.90)	2.76 (1.79)	7.09 (2.75)	10.29 (3.28)	8.24 (2.95)	3.05 (1.85)	2.68 (1.77)	6.89 (2.71)	10.01 (3.23)	8.01 (2.91)
SEm ±	0.06	0.04	0.04	0.04	0.05	0.05	0.04	0.04	0.04	0.05
CD (P=0.05)	0.17	0.10	0.11	0.11	0.14	0.13	0.12	0.11	0.12	0.15

Figures in parenthesis indicate square root transformed ($\sqrt{x + 0.5}$) values

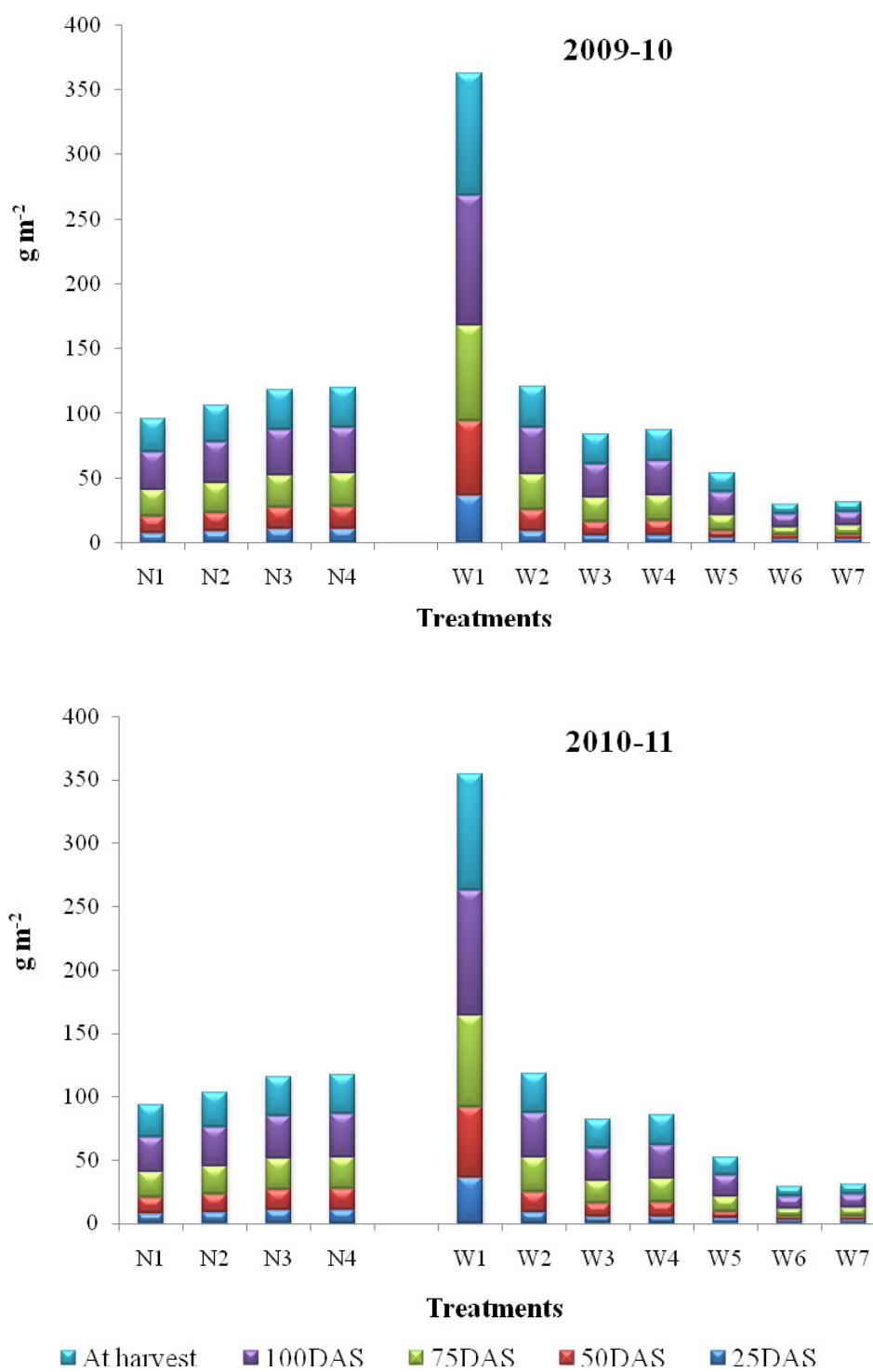


Fig. 4.19. Drymatter production of sedges (g m^{-2}) at different stages of observation as influenced by nitrogen and weed management practices under aerobic culture

4.7.3.3 Dry matter production of broad leaved weeds

All the nitrogen and weed management practices significantly influenced the dry weight of broad leaved weeds in aromatic rice under aerobic culture at different stages of crop growth *viz.*, 25, 50, 75, 100 DAS and at harvest, while the interaction effect was not statistically declarable at any of crop growth stages studied, during both the years of study (Table 4.33 and Fig 4.20).

The trend with graded levels of nitrogen application and weed management practices on dry matter production of broad leaved weeds was exactly similar to that of density of broad leaved weeds.

4.7.3.4 Total dry matter production of weeds

At all the stages of sampling (25, 50, 75, 100 DAS and at harvest of rice) total dry matter production of all category of weeds in aromatic rice under aerobic culture, were significantly influenced by the different nitrogen and weed management practices, while none of the interaction effect was statistically measurable at any of crop growth stages studied, during both the years of study (Table 4.34 and Fig 4.21).

The trend with graded levels of nitrogen application and weed management practices on total dry matter production of all categories of weeds was exactly similar to that of total density of all categories of weeds.

Among graded levels of nitrogen application all the category of weeds *viz.*, grasses, sedges, broad leaved weeds and total weed density and dry matter at all the stages of observation was recorded lowest with application of nitrogen 100 kg ha^{-1} (N_1) due to more competition between crop and weeds for available limited nutrients. The highest values for the above parameters was associated with 160 kg N ha^{-1} (N_4) might be due to fact that higher levels of nitrogen application might have improved the availability of vital nutrients in soil which not only helpful in germination of all category of weeds and also play major role in better growth and development of weeds resulted in higher weed dry matter.

Table 4.33. Dry matter production of broad leaved weeds (g m⁻²) at different stages of observation as influenced by nitrogen and weed management practices under aerobic culture

Treatments	<i>rabi,2009</i>					<i>rabi,2010</i>				
	25DAS	50DAS	75DAS	100DAS	At harvest	25DAS	50DAS	75DAS	100DAS	At harvest
Nitrogen										
N ₁	8.00 (2.65)	12.10 (3.01)	18.23 (3.80)	22.80 (4.30)	20.97 (4.15)	7.80 (2.62)	11.84 (2.98)	17.83 (3.76)	22.30 (4.25)	20.65 (4.11)
N ₂	9.41 (2.90)	13.34 (3.17)	19.93 (3.98)	24.76 (4.48)	23.02 (4.34)	9.16 (2.86)	13.03 (3.13)	19.48 (3.94)	24.19 (4.43)	22.49 (4.29)
N ₃	10.61 (3.09)	14.73 (3.34)	21.82 (4.18)	26.99 (4.69)	24.91 (4.52)	10.36 (3.05)	14.42 (3.30)	21.35 (4.13)	26.42 (4.64)	24.36 (4.47)
N ₄	10.80 (3.12)	15.03 (3.38)	22.14 (4.21)	27.32 (4.72)	25.33 (4.56)	10.47 (3.07)	14.61 (3.33)	21.52 (4.15)	26.56 (4.66)	24.62 (4.50)
SEm ±	0.02	0.03	0.03	0.04	0.03	0.02	0.03	0.03	0.04	0.04
CD (P=0.05)	0.08	0.09	0.11	0.12	0.11	0.06	0.11	0.11	0.13	0.14
Weed management										
W ₁	34.50 (5.91)	53.65 (7.35)	72.10 (8.51)	87.21 (9.36)	78.82 (8.90)	33.69 (5.84)	52.38 (7.26)	70.39 (8.41)	85.14 (9.25)	77.15 (8.80)
W ₂	6.58 (2.66)	12.70 (3.63)	20.57 (4.59)	25.36 (5.07)	24.09 (4.95)	6.43 (2.63)	12.41 (3.59)	20.11 (4.54)	24.79 (5.02)	23.54 (4.90)
W ₃	7.49 (2.82)	14.19 (3.83)	22.21 (4.76)	27.28 (5.26)	26.18 (5.16)	7.32 (2.79)	13.87 (3.79)	21.71 (4.71)	26.67 (5.21)	25.59 (5.10)
W ₄	5.56 (2.46)	11.19 (3.41)	17.27 (4.21)	21.13 (4.65)	19.79 (4.50)	5.43 (2.43)	10.94 (3.38)	16.88 (4.16)	20.66 (4.59)	19.35 (4.45)
W ₅	4.66 (2.26)	1.61 (1.45)	3.69 (2.05)	5.56 (2.46)	5.12 (2.37)	4.48 (2.22)	1.56 (1.43)	3.59 (2.02)	5.40 (2.43)	4.97 (2.34)
W ₆	5.11 (2.36)	2.17 (1.63)	4.77 (2.29)	6.98 (2.73)	6.52 (2.65)	4.90 (2.31)	2.11 (1.61)	4.63 (2.26)	6.78 (2.70)	6.34 (2.61)
W ₇	4.02 (2.12)	1.10 (1.26)	3.09 (1.89)	4.77 (2.29)	4.38 (2.21)	3.87 (2.08)	1.06 (1.25)	3.00 (1.87)	4.64 (2.26)	4.26 (2.18)
SEm ±	0.03	0.03	0.05	0.05	0.04	0.03	0.04	0.05	0.05	0.05
CD (P=0.05)	0.08	0.10	0.14	0.13	0.12	0.08	0.10	0.13	0.14	0.13

Figures in parenthesis indicate square root transformed ($\sqrt{x + 0.5}$) values

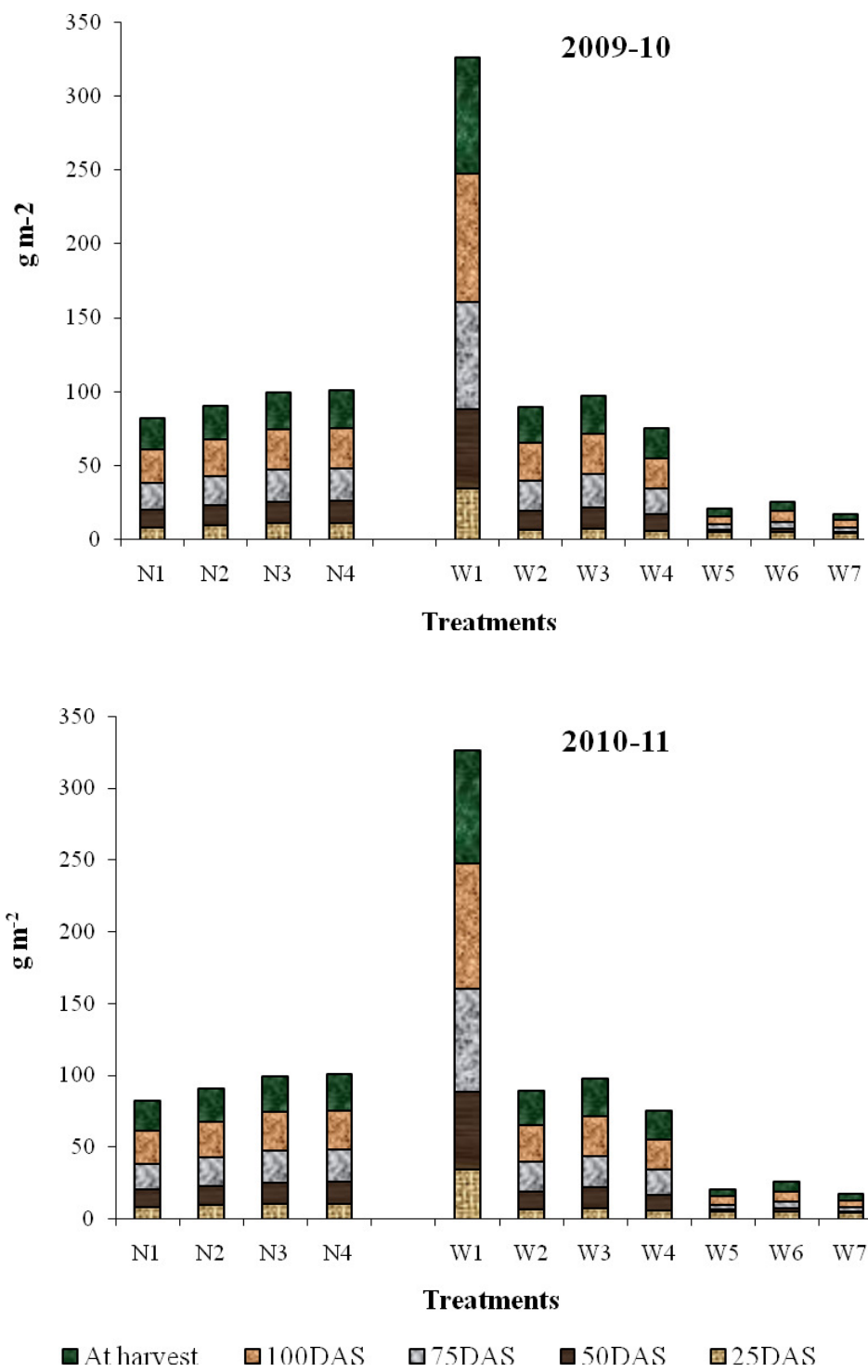


Fig. 4.20. Drymatter production of broad leaved weeds (g m^{-2}) at different stages of observation as influenced by nitrogen and weed management practices under aerobic culture

The present findings are in accordance with those of Jayashree Beura Reddy (2003), Shebl (2004), Subramanian *et al.* (2005) and Sharma *et al.* (2007).

With different weed management practices tried, at all the stages of observations, all the category of weeds viz., grasses, sedges, broad leaved weeds and total weed density and dry matter production was recorded lowest with PE application of oxadiargyl @ 75 g ha⁻¹ supplemented with HW at 25 DAS (W₆) could be attributed to the fact that, it is a potent inhibitor of protoporphyrinogen oxidase in protoporphyrin pathway, a key enzyme responsible for synthesis of chlorophyll. It produces higher levels of singlet oxygen in the presence of molecular oxygen and light which is very toxic and reduced emergence of weeds and death of weeds. These results are in agreement with those of Vinod Kumar *et al.* (2004), Samar Singh *et al.* (2005), Subramanyam *et al.* (2007), Ramana *et al.* (2008) and Bhandare *et al.* (2011). This was followed by pyrazosulfuron ethyl 20g ha⁻¹ supplemented with HW at 25 DAS (W₇) in reducing the density of broad leaved weeds and sedges could be attributed to the fact that, it inhibit specific plant enzymes involved in the synthesis of amino acids, which are the building blocks of all proteins. The amino acid synthesis inhibitors are readily translocated to areas of high metabolic activity and bind with the enzyme and the resulting deficiency of critical amino acids leads in turn to a gradual depletion of proteins vital for normal plant growth and development. Similar results have been reported by Saini (2003), Halder *et al.* (2005) and Thimmegowda *et al.* (2010). Next best weed management practice was PE application of pretilachlor @ 500g ha⁻¹ supplemented with HW at 25 DAS (W₅) which effectively control the grassy weeds due to inhibition of cell division at germination stage itself there by effectively reduces the density and dry weight of grassy weeds. The present findings are in accordance with those of Bhowmick (2002) and Ravisankar *et al.* (2008). Though the pretilachlor was most effective on grassy weeds, it shows some phytotoxicity on rice crop, which gives the opportunity to grow more sedges and broad leaved weeds and their by recorded highest dry weight among all herbicide combinations tried.

Table 4.34. *Total dry matter production of weeds (g m⁻²) at different stages of observation as influenced by nitrogen and weed management practices under aerobic culture

Treatments	<i>rabi,2009</i>					<i>rabi,2010</i>				
	25DAS	50DAS	75DAS	100DAS	At harvest	25DAS	50DAS	75DAS	100DAS	At harvest
Nitrogen										
N ₁	30.04 (4.77)	47.16 (5.68)	72.92 (7.41)	94.94 (8.66)	86.42 (8.23)	29.59 (4.78)	46.04 (5.62)	71.45 (7.35)	92.87 (8.56)	84.64 (8.14)
N ₂	35.00 (5.27)	52.53 (6.06)	80.89 (7.89)	104.86 (9.15)	95.42 (8.71)	34.39 (5.25)	51.26 (5.99)	79.17 (7.81)	102.48 (9.04)	93.23 (8.60)
N ₃	39.78 (5.69)	58.53 (6.43)	88.97 (8.31)	113.89 (9.55)	104.08 (9.11)	39.22 (5.67)	57.23 (6.36)	87.24 (8.24)	111.53 (9.46)	101.86 (9.01)
N ₄	41.42 (5.78)	60.47 (6.51)	91.42 (8.44)	116.20 (9.67)	105.98 (9.21)	40.77 (5.80)	58.84 (6.44)	89.19 (8.34)	113.22 (9.55)	103.23 (9.08)
SEm $\pm$	0.03	0.03	0.04	0.06	0.05	0.04	0.03	0.03	0.04	0.03
CD (P=0.05)	0.10	0.09	0.15	0.19	0.17	0.14	0.09	0.11	0.13	0.09
Weed management										
W ₁	145.39 (12.07)	230.50 (15.18)	313.06 (17.69)	381.67 (19.54)	349.99 (18.71)	142.15 (11.93)	225.27 (15.01)	305.94 (17.49)	373.00 (19.31)	342.24 (18.50)
W ₂	25.04 (5.14)	47.49 (6.91)	78.74 (8.89)	102.68 (10.15)	93.62 (9.69)	24.53 (4.99)	45.44 (6.77)	76.98 (8.79)	100.66 (10.05)	91.54 (9.59)
W ₃	21.30 (4.48)	39.10 (6.28)	64.46 (8.05)	85.37 (9.26)	79.48 (8.93)	20.88 (4.61)	38.22 (6.21)	63.02 (7.96)	83.46 (9.15)	77.70 (8.83)
W ₄	23.31 (5.02)	44.55 (6.70)	75.43 (8.70)	99.40 (9.98)	90.36 (9.52)	22.82 (4.81)	43.52 (6.62)	73.71 (8.60)	97.15 (9.87)	88.34 (9.42)
W ₅	14.46 (3.94)	8.91 (3.06)	21.01 (4.63)	31.99 (5.69)	28.04 (5.34)	14.54 (3.90)	8.67 (3.02)	20.42 (4.57)	31.09 (5.61)	27.25 (5.26)
W ₆	13.03 (3.46)	5.42 (2.42)	14.95 (3.92)	24.51 (4.99)	21.19 (4.65)	13.02 (3.65)	5.76 (2.49)	15.54 (3.99)	23.84 (4.92)	20.62 (4.59)
W ₇	13.50 (3.62)	6.73 (2.68)	17.20 (4.20)	26.70 (5.20)	23.15 (4.85)	14.03 (3.78)	6.53 (2.64)	16.71 (4.14)	25.94 (5.13)	22.50 (4.78)
SEm $\pm$	0.04	0.06	0.06	0.05	0.05	0.04	0.05	0.05	0.05	0.05
CD (P=0.05)	0.11	0.16	0.18	0.15	0.14	0.12	0.14	0.14	0.15	0.15

Figures in parenthesis indicate square root transformed ($\sqrt{x + 0.5}$) values

* Of all the three categories of weeds

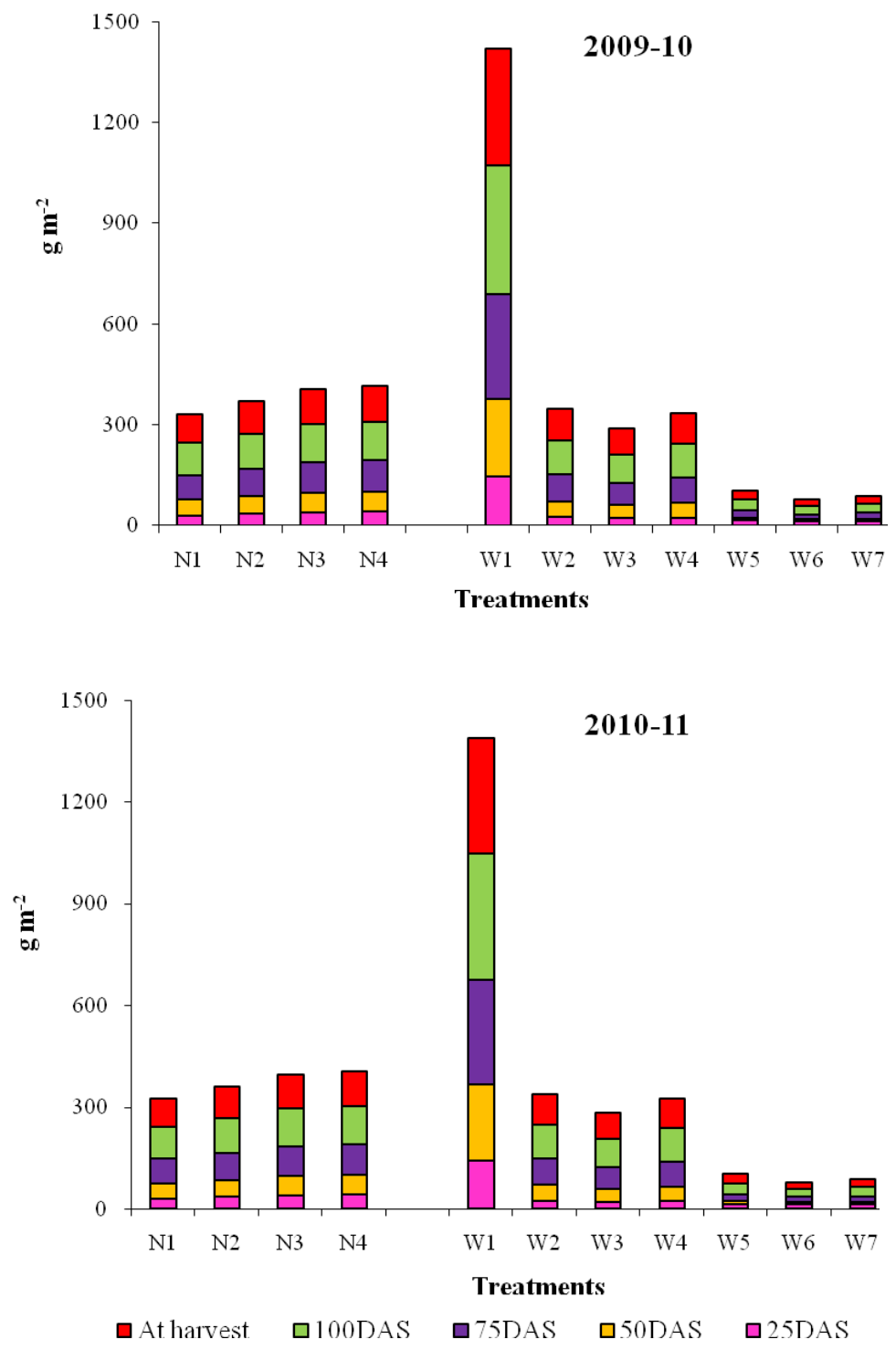


Fig. 4.21. Total drymatter production of weeds (g m^{-2}) at different stages of observation as influenced by nitrogen and weed management practices under aerobic culture

Among all the herbicides oxadiargyl @ 75 g ha⁻¹ was very effective on grassy weeds followed by pretilachlor @ 500g ha⁻¹, where as oxadiargyl @ 75 g ha⁻¹ and pyrazosulfuron ethyl 20g ha⁻¹ are comparable in controlling sedges. Pyrazosulfuron ethyl 20g ha⁻¹ was very effective in controlling broad leaved weeds followed by pretilachlor @ 500g ha⁻¹. Among the herbicides, pretilachlor @ 500g ha⁻¹ (W₂) recorded significantly higher density and dry weight of total weeds due to poor control of sedges and broad leaved weeds. The reduction in total dry weight of weeds at harvest was 86, 84 and 81 per cent with oxadiargyl @ 75 g ha⁻¹, pyrazosulfuron ethyl 20g ha⁻¹ and pretilachlor @ 500g ha⁻¹ supplemented with HW at 25 DAS (W₆, W₇ and W₅) and 64, 60 and 58 per cent with their alone application (W₃, W₄ and W₂) over un-weeded check (W₁).

In the present experiment hand weeding at 25DAS in combination with above herbicides maintained weed density and dry weight at their lowest at all the stages of observation. Hand weeding was the oldest method of weed management practice and it is still being considered as most effective in controlling all categories of weeds. The superiority of hand weeding to control the weeds was continued up to harvest of the crop. Hence application of all herbicides supplemented with hand weeding at 25 DAS recorded lowest density and dry weight of weeds compared to their alone application. These findings are in accordance with those of Arul Chezhian and Kathiresan (2008) and Sunil *et al.* (2011).

The highest density and dry weight of all categories of weeds were registered with un-weeded check (W₁) due to heavy weed infestation, right from the sowing to harvest of the crop. These results are in conformity with findings of Sanjoy Saha (2006), Natarajan and Arivazhagan (2006) and Bhandare *et al.* (2011).

4.7.4 Weed Control Efficiency

The weed control efficiency computed at 25, 50, 75, 100 DAS and at harvest of aromatic rice under aerobic culture was not significantly influenced by the graded levels of nitrogen application except at 25 DAS. Different weed

management practices were significantly influenced the weed control efficiency at all the stages of observation and the weed control efficiency was increased up to 50 DAS and there after it was marginally declined towards harvest due to increased dry weight of weeds in respective treatments and hand weeding was not imposed by the time of sampling at 25 DAS (Table 4.35 to 4.36 and Fig 4.22).

4.7.4.1 Weed control efficiency at 25 das

The weed control efficiency computed at 25 DAS of aromatic rice under aerobic culture was significantly influenced by levels of nitrogen application and weed management practices, as well as their interaction during both the years of study (Table 4.35).

The highest WCE was recorded with application of nitrogen 100 kg ha^{-1} (N_1), which was significantly higher than the rest of nitrogen levels tried. Application of 120 kg N ha^{-1} (N_2) proved to be the next best N level in recording higher WCE and significantly superior to rest of the N levels 160 and 140 kg N ha^{-1} . The lowest WCE was associated with 140 kg N ha^{-1} (N_3) which was however, comparable with 160 kg N ha^{-1} (N_4) during both the years of experimentation. Higher WCE with 100 kg ha^{-1} might be attributed due to lower availability of vital nutrients under sub optimal nitrogen application to all category of the weeds resulted in reduced weed dry weight led to higher WCE. Quite opposite results were recorded with higher level of nitrogen application 160 kg ha^{-1} (N_4). These findings corroborate the documented evidence by Subramanian *et al.* (2005) and Sharma *et al.* (2007).

With regard to weed management practices tried, all the herbicides alone or in combination with hand weeding shows significant disparity with each other in recording WCE with similar trend during both the years of study. PE application of oxadiargyl @ 75 g ha^{-1} supplemented with HW at 25 DAS (W_6) was most efficient and statistically superior to the rest of weed management practices tried in recording WCE. Pre emergence application of pyrazosulfuron ethyl @ 20 g ha^{-1} supplemented with HW at 25 DAS (W_7) proved to be the next

Table 4.35. Weed control efficiency (%) at 25 DAS of aromatic rice as influenced by nitrogen and weed management practices under aerobic culture

Treatments	<i>rabi,2009</i>					<i>rabi,2010</i>				
	N ₁	N ₂	N ₃	N ₄	Mean	N ₁	N ₂	N ₃	N ₄	Mean
W ₁	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)
W ₂	83.38 (8.15)	82.38 (8.10)	81.26 (8.05)	81.49 (8.06)	82.13 (8.09)	84.16 (8.19)	83.03 (8.14)	81.78 (8.08)	82.18 (8.10)	82.79 (8.12)
W ₃	88.17 (8.39)	87.03 (8.33)	85.14 (8.24)	85.76 (8.27)	86.53 (8.31)	87.22 (8.34)	85.67 (8.26)	83.90 (8.18)	84.70 (8.21)	85.37 (8.25)
W ₄	85.02 (8.23)	82.69 (8.12)	81.90 (8.08)	82.21 (8.10)	82.95 (8.13)	85.94 (8.28)	83.87 (8.18)	82.91 (8.13)	83.29 (8.15)	84.00 (8.18)
W ₅	91.65 (8.59)	90.01 (8.49)	88.23 (8.39)	88.65 (8.42)	89.64 (8.47)	91.91 (8.60)	90.24 (8.50)	88.41 (8.40)	88.88 (8.43)	89.86 (8.48)
W ₆	94.92 (8.80)	92.14 (8.62)	90.26 (8.50)	90.89 (8.54)	92.05 (8.62)	93.21 (8.68)	91.41 (8.57)	89.24 (8.45)	89.95 (8.49)	90.95 (8.55)
W ₇	93.63 (8.71)	91.75 (8.59)	89.74 (8.47)	90.13 (8.50)	91.31 (8.57)	92.92 (8.66)	90.40 (8.51)	88.69 (8.42)	89.05 (8.44)	90.26 (8.51)
Mean	76.68 (7.37)	75.14 (7.28)	73.79 (7.21)	74.16 (7.23)		76.48 (7.35)	74.95 (7.28)	73.56 (7.19)	74.01 (7.22)	

	SEm ±	CD (P=0.05)	SEm ±	CD (P=0.05)
N	0.01	0.04	0.02	0.06
W	0.01	0.02	0.01	0.03
N at W	0.03	0.10	0.04	0.13
W at N	0.02	0.04	0.02	0.05

The figures in the parenthesis indicate arcsine transformed values

best treatment followed by PE application of pretilachlor @ 500g ha⁻¹ supplemented with HW at 25 DAS (W₅) followed by PE application of oxadiargyl @ 75 g ha⁻¹ alone (W₃), and PE application of pyrazosulfuron ethyl @ 20g ha⁻¹ alone (W₄) with significant disparity between any two of them in recording WCE. PE application of pretilachlor @ 500g ha⁻¹ alone (W₂) recorded significantly lower weed control efficiency than rest of weed management practices tried, during both the instances of study.

Irrespective of weed management practices, the highest WCE recorded with 100 kg ha⁻¹ (N₁), which was at par with rest of the N levels tried during both the years of experimentation except at W₄, W₅, W₆ and W₇ during 2009-10 where N₁ recorded significantly higher WCE than rest of N levels.

Disregarding the N levels, the highest WCE was recorded with PE application of oxadiargyl @ 75 g ha⁻¹ supplemented with HW at 25 DAS (W₆), which was significantly higher than rest of the weed management practices tried during both the years except at N₂, N₃ during 2009-10 and N₁, N₃ during 2010-11, where it was at par with PE application of pyrazosulfuron ethyl @ 20g ha⁻¹ supplemented with HW at 25 DAS (W₇). Among the herbicides tried, PE application of pretilachlor @ 500g ha⁻¹ alone (W₂) recorded the lower WCE.

Among the treatment combinations tried, the highest WCE was recorded with application of 100 kg N ha⁻¹ in combination with PE application of oxadiargyl @ 75 g ha⁻¹ supplemented with HW at 25 DAS (N₁W₆) and significantly superior to rest of treatmental combinations. The lowest WCE under aerobic culture was recorded with the application of any level of nitrogen coupled with pretilachlor @ 500g ha⁻¹ alone (N₂W₂, N₃W₂ and N₄W₂).

4.7.4.2 Weed control efficiency at 50, 75, 100 das and at harvest

The weed control efficiency computed at different stages of crop growth viz., 50, 75, 100 DAS and at harvest of aromatic rice under aerobic culture was not significantly influenced by the levels of nitrogen application. However, all the weed management practices were significantly influenced the WCE at all the

Table 4.36. Weed control efficiency (%) at 50, 75, 100 DAS and at harvest of aromatic rice as influenced by nitrogen and weed management practices under aerobic culture

Treatments	<i>rabi,2009</i>				<i>rabi,2010</i>			
	50DAS	75DAS	100DAS	At harvest	50DAS	75DAS	100DAS	At harvest
Nitrogen								
N ₁	76.84 (7.43)	74.20 (7.27)	72.47 (7.18)	72.36 (7.17)	76.86 (7.43)	74.16 (7.27)	72.53 (7.18)	72.37 (7.17)
N ₂	76.33 (7.40)	73.30 (7.22)	71.92 (7.15)	71.81 (7.14)	76.38 (7.40)	73.30 (7.22)	71.93 (7.15)	71.81 (7.14)
N ₃	75.97 (7.38)	72.79 (7.19)	71.74 (7.14)	71.51 (7.12)	75.98 (7.37)	72.77 (7.19)	71.74 (7.14)	71.50 (7.12)
N ₄	76.04 (7.38)	72.99 (7.20)	71.91 (7.15)	71.73 (7.14)	76.04 (7.38)	72.98 (7.20)	71.91 (7.15)	71.73 (7.14)
SEm +	0.01	0.02	0.02	0.02	0.01	0.02	0.02	0.01
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS
Weed management								
W ₁	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)
W ₂	79.44 (7.97)	74.85 (7.77)	73.24 (7.70)	73.10 (7.70)	79.64 (7.98)	74.88 (7.77)	73.24 (7.70)	73.00 (7.69)
W ₃	83.05 (8.14)	79.40 (7.97)	77.79 (7.88)	77.64 (7.88)	83.07 (8.14)	79.42 (7.97)	77.84 (7.88)	77.64 (7.88)
W ₄	80.66 (8.03)	75.92 (7.82)	74.18 (7.74)	73.98 (7.74)	80.69 (8.03)	75.95 (7.82)	74.20 (7.74)	73.96 (7.73)
W ₅	96.14 (8.90)	93.30 (8.69)	91.99 (8.61)	91.63 (8.58)	96.16 (8.90)	93.35 (8.69)	92.04 (8.61)	91.68 (8.59)
W ₆	97.67 (9.04)	95.25 (8.83)	93.97 (8.73)	93.60 (8.71)	97.53 (9.03)	94.95 (8.81)	93.99 (8.74)	93.63 (8.71)
W ₇	97.10 (8.98)	94.53 (8.77)	93.41 (8.70)	93.03 (8.67)	97.12 (8.99)	94.57 (8.78)	93.45 (8.70)	93.07 (8.67)
SEm +	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
CD (P=0.05)	0.03	0.03	0.02	0.03	0.03	0.03	0.03	0.02

The figures in the parenthesis indicate arcsine transformed values

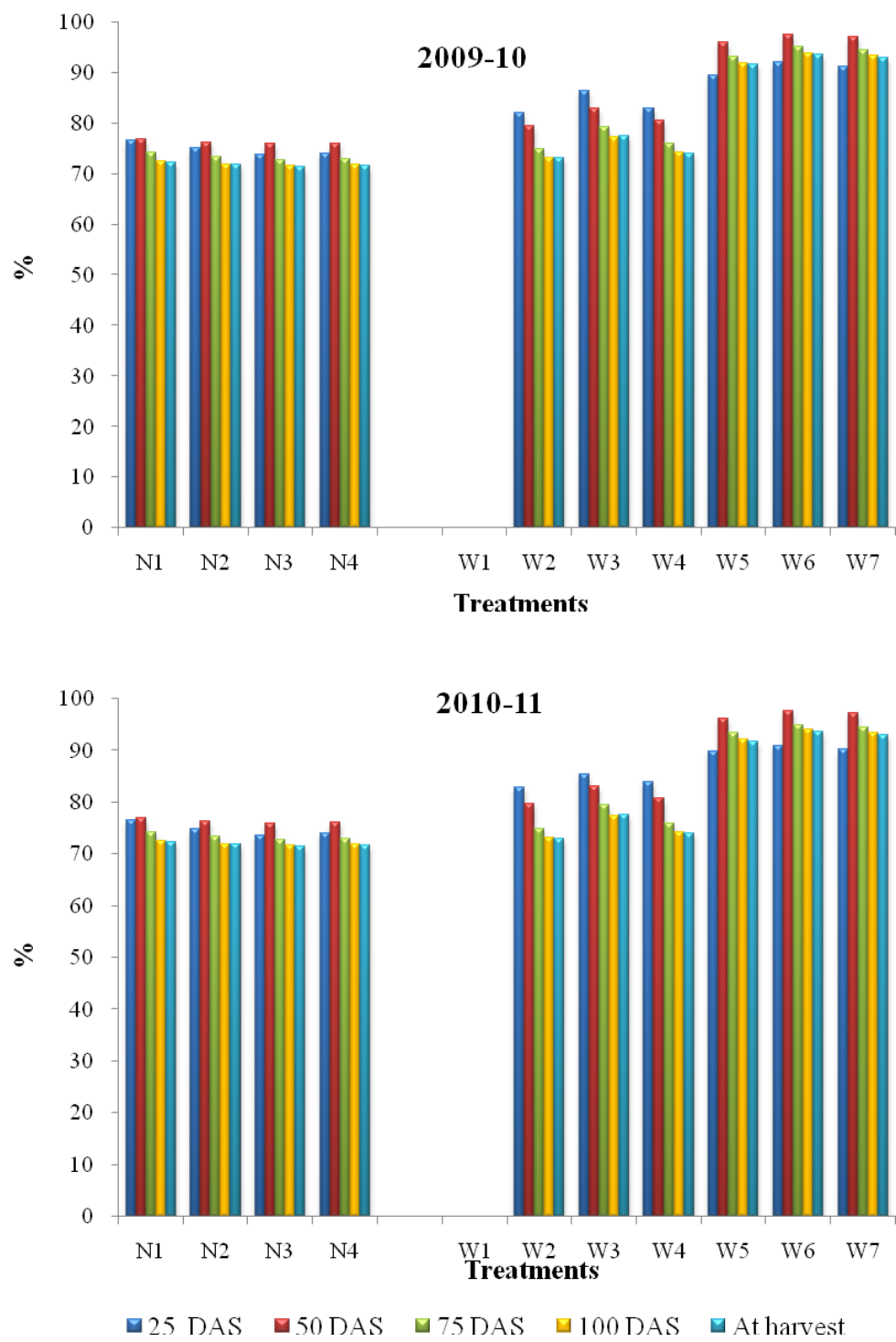


Fig. 4.22. Weed control efficiency (%) at different stages of observation as influenced by nitrogen and weed management practices under aerobic culture

stages of observation with similar trend during both the years of study (Table 4.36).

With different weed management practices tried at all stages of observation, the highest weed control efficiency was recorded with PE application of oxadiargyl @ 75 g ha⁻¹ supplemented with HW at 25 DAS (W₆) was most efficient and statistically superior to the rest of weed management practices tried in recording WCE due to effective control of all categories of weeds resulted in reduced dry weights. Pre emergence application of pyrazosulfuron ethyl @ 20g ha⁻¹ supplemented with HW at 25 DAS (W₇) proved to be the next best treatment followed by PE application of pretilachlor @ 500g ha⁻¹ supplemented with HW at 25 DAS (W₅) followed by PE application of oxadiargyl @ 75 g ha⁻¹ alone (W₃), and PE application of pyrazosulfuron ethyl @ 20g ha⁻¹ alone (W₄) with significant disparity between any two of them in recording WCE. PE application of pretilachlor @ 500g ha⁻¹ alone (W₂) recorded significantly lower weed control efficiency than rest of weed management practices tried, during both the instances of study because of poor weed control resulted in higher dry weight of weeds led to lower WCE. The WCE of 97 per cent was registered with W₆ and W₇ where as, it was 77 and 74 per cent with W₃ and W₄ over W₁. These results are in concurrence with findings of Rao (2005), Saha Sanjoy (2006) and Suganthi *et al.* (2010).

4.7.5 Nutrient Uptake by Weeds

Uptake of nitrogen, phosphorous and potassium by weeds (composite sample) at harvest of aromatic rice crop under aerobic culture was estimated. The nutrient uptake by weeds was significantly influenced by nitrogen and weed management practices, while none of the interaction effect was found for phosphorous and potassium except for nitrogen during both the years of study (Table 4.37 to 4.38 and Fig 4.23).

4.7.5.1 Nitrogen uptake by weeds at harvest

Uptake of nitrogen by weeds was significantly influenced by graded levels of nitrogen and weed management practices, as well as their interaction with unaltered trend during both the years of experimentation (Table 4.37 and Fig 4.23).

The nitrogen uptake by weeds tended to increase progressively with increasing levels of nitrogen. The lowest nitrogen uptake by weeds was recorded with 100 kg ha⁻¹ nitrogen application (N₁), which was significantly lower than rest of N levels tried during both the instances of experimentation. The next best level of nitrogen was 120 kg N ha⁻¹ (N₂) followed by 140 kg N ha⁻¹ (N₃) with significant disparity with each other. The highest nitrogen uptake by weeds was recorded with 160 kg ha⁻¹ (N₄) nitrogen application, which was statistically comparable with 140 kg N ha⁻¹ (N₃).

With different weed management practices tried, the lowest N uptake by weeds was associated with PE application of oxadiargyl @ 75 g ha⁻¹ supplemented with HW at 25 DAS (W₆), which was comparable with PE application of pyrazosulfuron ethyl @ 20g ha⁻¹ supplemented with HW at 25 DAS (W₇) during both the years of study. Pre emergence application of pretilachlor @ 500g ha⁻¹ with HW at 25 DAS (W₅) proved to be the next best weed management practice, followed by PE application of oxadiargyl @ 75 g ha⁻¹ alone (W₃) and pyrazosulfuron ethyl @ 20g ha⁻¹ alone (W₄) in recording lower nitrogen uptake by weeds. The later two weed management practices were comparable with each other. PE application of pretilachlor @ 500g ha⁻¹ alone (W₂) proved to be the next best weed management practice, which was recorded significantly lower nitrogen uptake than un-weeded check (W₁). The highest nitrogen uptake by weeds at harvest was recorded with un-weeded check (W₁), which was significantly higher than rest of the weed management practices during both the years of investigation.

Irrespective of weed management practices tried, significantly the lowest nitrogen uptake was recorded with 100 kg ha⁻¹ nitrogen application (N₁). Application of 120 kg N ha⁻¹ (N₂) was next best level and significantly lower

Table 4.37. Nitrogen uptake by weeds (kg ha⁻¹) at harvest of aromatic rice as influenced by nitrogen and weed management practices under aerobic culture

Treatments	<i>rabi, 2009</i>					<i>rabi, 2010</i>				
	N1	N2	N3	N4	Mean	N1	N2	N3	N4	Mean
W1	33.55	35.06	37.18	37.51	35.83	33.68	35.21	37.35	37.68	35.98
W2	9.08	10.44	10.23	10.5	10.06	9.01	10.15	10.28	10.55	10.00
W3	7.17	8.35	9.25	9.44	8.55	7.35	8.39	9.29	9.48	8.63
W4	7.28	8.38	9.34	9.56	8.64	7.31	8.42	9.38	9.61	8.68
W5	6.31	7.38	8.34	8.51	7.64	6.33	7.41	8.38	8.55	7.67
W6	5.24	6.29	7.29	7.60	6.6	5.25	6.32	7.33	7.64	6.63
W7	5.50	6.48	7.48	7.71	6.79	5.52	6.51	7.52	7.75	6.83
	10.59	11.77	12.73	12.97		10.63	11.77	12.79	13.04	

	SEm ±	CD (P=0.05)	SEm ±	CD (P=0.05)
N	0.10	0.35	0.10	0.36
W	0.10	0.29	0.09	0.25
N at W	0.26	0.75	0.26	0.78
W at N	0.21	0.59	0.18	0.51

than 140 kg N ha⁻¹ (N₃) and 160 kg N ha⁻¹ (N₄) except at W₂ where all these three N levels were comparable among them. The highest nitrogen uptake by weeds was recorded with 160 kg ha⁻¹ (N₄), which was however, comparable with 140 kg ha⁻¹ (N₃) during both the instances of experimentation.

Regardless of N levels, the lowest nitrogen uptake was recorded with PE application of oxadiargyl @ 75 g ha⁻¹ supplemented with HW at 25 DAS (W₆), which was however, comparable with PE application of pyrazosulfuron ethyl @ 20g ha⁻¹ with HW at 25 DAS (W₇) during both the years of study. The highest nitrogen uptake by weeds was recorded with un-weeded check (W₁) during both the years of study.

The interaction effect of nitrogen and weed management practices revealed that the lowest nitrogen uptake was recorded with application of 100 kg N ha⁻¹ in combination with PE application of oxadiargyl @ 75 g ha⁻¹ supplemented with HW at 25 DAS (N₁W₆), which was however, comparable to same level of N with PE application of pyrazosulfuron ethyl @ 20g ha⁻¹ supplemented with HW at 25 DAS (N₁W₇). The highest N uptake by weeds was recorded with application of 160 kg ha⁻¹ in combination with un-weeded check (N₄W₁), which was at parity with 140 kg N ha⁻¹ along with un-weeded check (N₃W₁) and these treatments were significantly superior to rest of the combinations during both the years of study.

4.7.5.2 Phosphorous uptake by weeds at harvest

The phosphorus uptake by weeds recorded at harvest of aromatic rice under aerobic culture differed significantly due to application of graded levels of nitrogen and weed management practices, while none of the interaction was statistically measurable with unaltered trend during both the years of study (Table 4.38 and Fig 4.23).

Phosphorus uptake by weeds tended to increase progressively with increasing levels of nitrogen. The lowest phosphorus uptake by weeds was recorded with 100 kg ha⁻¹ nitrogen application (N₁), which was significantly

lower than rest of N levels tried during both the instances of experimentation. The next best level of nitrogen was 120 kg N ha⁻¹ (N₂) followed by 140 kg N ha⁻¹ (N₃) with significant disparity with each other. The highest phosphorus uptake by weeds was recorded with 160 kg ha⁻¹ (N₄) nitrogen application, which was statistically comparable with 140 kg N ha⁻¹ (N₃).

With different weed management practices tried, the lowest phosphorus uptake by weeds was associated with PE application of oxadiargyl @ 75 g ha⁻¹ supplemented with HW at 25 DAS (W₆), which was comparable with PE application of pyrazosulfuron ethyl @ 20g ha⁻¹ supplemented with HW at 25 DAS (W₇) during both the years of study. Pre emergence application of pretilachlor @ 500g ha⁻¹ with HW at 25 DAS (W₅) proved to be the next best weed management practice followed by PE application of oxadiargyl @ 75 g ha⁻¹ alone (W₃) and pyrazosulfuron ethyl @ 20g ha⁻¹ alone (W₄) in recording lower phosphorus uptake by weeds. The later two weed management practices were comparable with each other. PE application of pretilachlor @ 500g ha⁻¹ alone (W₂) proved to be the next best weed management practice, which was recorded significantly lower phosphorus uptake than un-weeded check (W₁). The highest phosphorus uptake by weeds at harvest was recorded with un-weeded check (W₁), which was significantly higher than rest of the weed management practices during both the years of study.

4.7.5.3 Potassium uptake by weeds at harvest

Graded levels of nitrogen application and different weed management practices were significantly influenced the uptake of potassium by weeds at harvest of aromatic rice under aerobic culture, where as the interaction effect was not statistically traceable, with unaltered trend during both the years of experimentation (Table 4.38 and Fig 4.23).

The trend with graded levels of nitrogen application and weed management practices for potassium uptake by weeds was exactly similar to that of phosphorus uptake by weeds.

The lowest nitrogen, phosphorus and potassium uptake by weeds was recorded with 100 kg N ha⁻¹ (N₁) due to reduced growth and dry matter production under limited soil available nutrients. The highest nutrient uptake by weeds at harvest was associated with 160 kg N ha⁻¹ (N₄) due to increased availability of vital nutrients resulted in higher dry matter production per unit area led to higher nutrient uptake. The present findings are in conformity with those Takeshi Horie *et al.* (2005) and Zhang Hong Yan *et al.* (2007).

Among the weed management practices, lowest N, P and K uptake by weeds at harvest was observed with PE application of oxadiargyl @ 75 g ha⁻¹, supplemented with HW at 25 DAS (W₆) due to lower dry weight of weeds during active crop growth period because of effective control of all categories of weeds which helps in minimizing the crop weed competitions and helps the crop to utilize available nutrients to the maximum extent. It was evident that wherever effective control of weeds was observed, significant loss of nutrients could be avoided and increased availability of nutrient to the crop. Crop and weeds growing together in a community, nutrient uptake by crop and weeds follow an inverse relationship and it was an evident in the present investigation also. The highest nutrient uptake by weeds with un-weeded check (W₁), might be due to poor control of weeds and greater competitions offered by weeds for available nutrients through out crop growth period suppressed the crop and severely affecting the plant growth led to higher dry matter production by weeds, their by utilizing available nutrients to the maximum extent resulted in higher nutrient uptake. The uptake of N, P and K by weeds was 36, 9 and 32 kg ha⁻¹ respectively in un-weeded check and these N, P and K loss by weeds could be arrested to the extent of 82,73 and 80 per cent by imposition of best treatment PE application of oxadiargyl @ 75 g ha⁻¹, supplemented with HW at 25 DAS (W₆). These results corroborate the documented evidence by Thimmegowda *et al.* (2009) and Sunil *et al.* (2011).

Table 4.38. Phosphorous and potassium uptake by weeds (kg ha⁻¹) at harvest of aromatic rice as influenced by nitrogen and weed management practices under aerobic culture

Treatments	<i>rabi,2009</i>		<i>rabi,2010</i>	
	Phosphorous (kg ha ⁻¹)	Potassium (kg ha ⁻¹)	Phosphorous (kg ha ⁻¹)	Potassium (kg ha ⁻¹)
Nitrogen				
N ₁	2.99	9.94	3.03	10.31
N ₂	3.42	10.42	3.46	10.89
N ₃	3.97	10.95	3.93	11.43
N ₄	3.98	11.22	4.02	11.60
SEm $\pm$	0.05	0.13	0.03	0.14
CD (P=0.05)	0.17	0.44	0.11	0.49
Weed management				
W ₁	8.92	32.29	8.98	32.25
W ₂	3.12	8.24	3.14	8.75
W ₃	2.83	7.45	2.84	7.85
W ₄	2.90	7.52	2.89	7.93
W ₅	2.61	6.79	2.62	7.29
W ₆	2.35	6.02	2.39	6.63
W ₇	2.41	6.12	2.43	6.7
SEm $\pm$	0.06	0.21	0.02	0.18
CD (P=0.05)	0.18	0.61	0.06	0.52

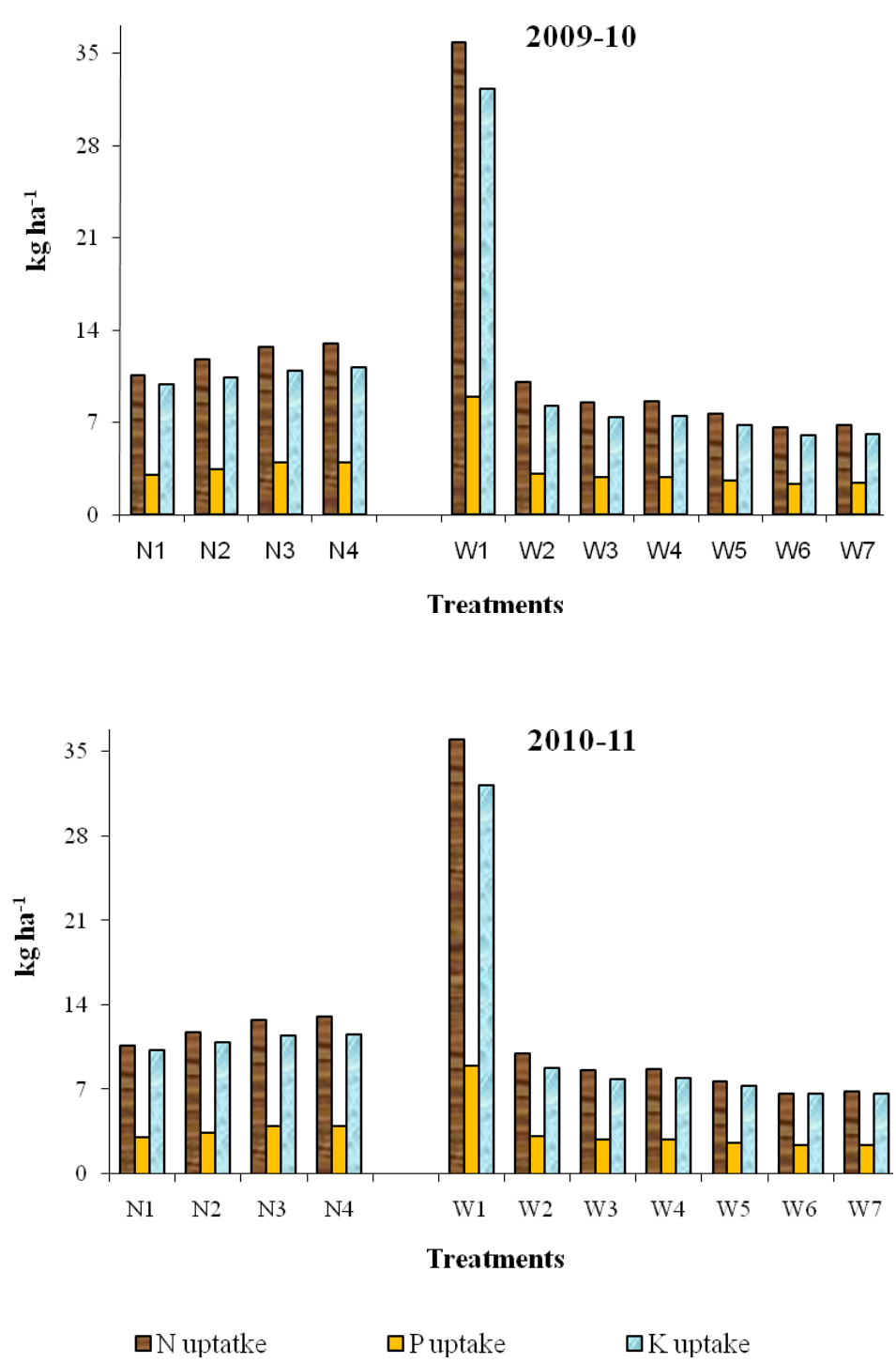


Fig. 4.23. N, P and K uptake (kg ha⁻¹) by weeds at harvest of aromatic rice crop as influenced by nitrogen and weed management practices under aerobic culture

4.8 ECONOMICS

4.8.1 Gross Returns

Gross returns of aromatic rice under aerobic culture differed significantly with nitrogen and weed management practices as well as their interaction, with unaltered trend during both the years of study (Table 4.39 and Fig 4.24).

Increasing levels of nitrogen supply progressively enhanced the gross returns up to 140 kg N ha⁻¹ (N₃), thereafter the gross returns declined. The highest gross returns were realized with application of nitrogen 140 kg ha⁻¹ (N₃), which was however, comparable with 160 kg N ha⁻¹ (N₄) and both of them were significantly higher than with rest of nitrogen levels tried during both the years. The next best level of nitrogen application in realizing gross returns was the application of 120 kg N ha⁻¹ (N₂) followed by 100 kg N ha⁻¹ (N₁), with significant disparity between them. The lowest gross returns were recorded with application of 100 kg N ha⁻¹ (N₁), which was significantly lower than rest of the nitrogen levels tried during both the years of study.

Among different weed management practices tried, the highest gross returns were realized with PE application of oxadiargyl @ 75 g ha⁻¹ supplemented with HW at 25 DAS (W₆) which was however, comparable with PE application of pyrazosulfuron ethyl @ 20g ha⁻¹ supplemented with HW at 25 DAS (W₇) and both of them were significantly higher than rest of the weed management practices tried. Pre emergence application of pretilachlor @ 500g ha⁻¹ supplemented with HW at 25 DAS (W₅), was the next best weed management practice in realizing higher gross returns. Pre emergence application of oxadiargyl @ 75 g ha⁻¹ alone (W₃) and pyrazosulfuron ethyl @ 20g ha⁻¹ alone (W₄) were comparable with each other in realizing higher gross returns and significant higher than with pre emergence application of pretilachlor @ 500g ha⁻¹ alone (W₂). The lowest gross returns of aerobic rice recorded with unweeded check (W₁) during both the years of study.

Disregarding of the weed management practices tried, both the years of study, the highest gross returns were realized with 140 kg N ha⁻¹ (N₃) which was however, comparable with 160 kg N ha⁻¹ during both the years of study except at W₇ during 2009-10, where N₃ significantly higher than N₄ in realizing maximum gross returns. The next best level of nitrogen application in realizing gross returns was with 120 kg N ha⁻¹ (N₂) which was significantly higher than with 100 kg N ha⁻¹ except at W₁ where both of them were at par with each other during both the years of study.

Irrespective of the nitrogen levels tried, the highest gross returns were realized with PE application of oxadiargyl @ 75 g ha⁻¹ supplemented with HW at 25 DAS (W₆) which was at par with PE application of pyrazosulfuron ethyl @ 20g ha⁻¹ supplemented with HW at 25 DAS (W₇) and both of them were significantly higher than rest of the weed management practices tried. The next best weed management practice for realizing higher gross returns were the PE application of pretilachlor @ 500g ha⁻¹ supplemented with HW at 25 DAS (W₅). Pre emergence application of oxadiargyl @ 75 g ha⁻¹ alone (W₃) and pyrazosulfuron ethyl @ 20g ha⁻¹ alone (W₄) were comparable with each other in realizing gross returns. The lowest gross returns of aerobic rice recorded with un-weeded check (W₁), which was significantly lower than rest of the weed management practices during both the years of study.

The interaction effect of nitrogen and weed management practices revealed that the highest gross returns were realized with the application of 140 kg N ha⁻¹ along with PE application of oxadiargyl @ 75 g ha⁻¹ supplemented with HW at 25 DAS (N₃ W₆) which was however, comparable with same level of nitrogen with PE application of pyrazosulfuron ethyl @ 20g ha⁻¹ supplemented with HW at 25 DAS (N₃ W₇) and 160 kg N ha⁻¹ with same weed management practice (N₄ W₆) and these treatments were significantly superior to rest of the treatment combinations during both the years of study. The lowest gross returns were realized with application of N either at 100 or 120 kg ha⁻¹ in combination with un-weeded check (N₁ W₁ and N₂ W₁).

Table 4.39. Gross returns (₹ ha⁻¹) of aromatic rice as influenced by nitrogen and weed management practices under aerobic culture

Treatments	<i>rabi, 2009</i>					<i>rabi, 2010</i>				
	N1	N2	N3	N4	Mean	N1	N2	N3	N4	Mean
W1	11301	12623	16644	15886	14114	12036	12511	18139	17297	14996
W2	41401	46097	55456	52589	48886	43458	47643	57778	57681	51640
W3	50789	55724	63053	65850	58854	52636	57433	66225	65750	60511
W4	50126	55133	62496	65443	58299	50835	55324	64369	64071	58650
W5	55655	64838	74363	71518	66594	57550	66632	76247	73771	68550
W6	64977	75174	84588	82413	76788	65494	75128	85247	83368	77309
W7	63182	75036	83031	79395	75161	63091	75068	83520	81250	75732
	48205	54947	62805	61871		49300	55677	64504	63313	

	SEm ±	CD (P=0.05)	SEm ±	CD (P=0.05)
N	394	1365	499	1727
W	689	1958	674	1916
N at W	1098	2996	1324	3732
W at N	1378	3917	1348	3832

4.8.2 Net Returns

Net returns of aromatic rice under aerobic culture differed significantly with nitrogen and weed management practices as well as their interaction, with unaltered trend during both the years of study (Table 4.40 and Fig 4.24).

The trend of net returns with nitrogen and weed management practices, as well as their interaction effect was exactly similar to that of gross returns during both the years of experimentation with minor deviation at irrespective of the weed management practices, at W_2 , W_5 and W_7 significantly higher net returns were realized with N_3 than N_4 . At W_1 all the levels of nitrogen application shows non-significance during 2009-10.

4.8.3 Benefit Cost Ratio

Benefit cost ratio of aromatic rice under aerobic culture differed significantly with nitrogen and weed management practices as well as their interaction, during both the years of study (Table 4.41 and Fig 4.24).

The highest benefit cost ratio was recorded with application of nitrogen 140 kg ha^{-1} (N_3) which was significantly higher than with rest of nitrogen levels tried during both the years. The next best level of nitrogen was 160 kg N ha^{-1} (N_4) in obtaining higher benefit cost ratio followed by 120 kg N ha^{-1} (N_2) and 100 kg N ha^{-1} (N_1) with significant disparity between any two of the N levels tried. The lowest benefit cost ratio was recorded with application of 100 kg N ha^{-1} (N_1), which was significantly lower than rest of the nitrogen levels tried during both the years of study.

As regards weed management practices, the highest benefit cost ratio was realized with PE application of pyrazosulfuron ethyl @ 20 g ha^{-1} supplemented with HW at 25 DAS (W_7) which was however, at par with PE application of oxadiargyl @ 75 g ha^{-1} supplemented with HW at 25 DAS (W_6) and both of them were significantly higher than rest of the weed management practices tried. The next best benefit cost ratio was recorded with the PE application of pretilachlor @ 500 g ha^{-1} supplemented with HW at 25 DAS (W_5) followed by PE application

Table 4.40. Net returns (₹ ha⁻¹) of aromatic rice as influenced by nitrogen and weed management practices under aerobic culture

Treatments	<i>rabi, 2009</i>					<i>rabi, 2010</i>				
	N1	N2	N3	N4	Mean	N1	N2	N3	N4	Mean
W1	743	1829	5614	4620	3202	1096	1335	6727	5649	3702
W2	30303	34763	43886	40783	37434	31978	35927	45826	45493	39806
W3	39460	44159	51252	53813	47171	40925	45486	54042	53331	48446
W4	39212	43983	51110	53821	47031	39539	43792	52601	52067	47000
W5	43557	52504	61793	58712	54142	45070	53916	63295	60583	55716
W6	52648	62609	71787	69376	64105	52783	62181	72064	69949	64244
W7	51268	62886	70645	66773	62893	50795	62536	70752	68246	63082
	36742	43248	50870	49700		37455	43596	52187	50760	

	SEm ±	CD (P=0.05)	SEm ±	CD (P=0.05)
N	394	1365	499	1727
W	689	1958	674	1916
N at W	1098	2996	1324	3732
W at N	1378	3917	1348	3832

of pyrazosulfuron ethyl @ 20g ha⁻¹ alone (W₄) and PE application of oxadiargyl @ 75 g ha⁻¹ alone (W₃) and these three weed management practices were in turn comparable with each other. Pre emergence application of oxadiargyl @ 75 g ha⁻¹ alone (W₃) recorded significantly higher benefit cost ratio than PE application of pretilachlor @ 500g ha⁻¹ alone (W₂) during 2009-10, where as during 2010-11 it was (W₃) comparable with W₂. Pre emergence application of pretilachlor @ 500g ha⁻¹ alone (W₂) recorded significantly higher benefit cost ratio than un-weeded check (W₁). The lowest B: C ratio was recoded with un-weeded check (W₁), which was significantly lower than with rest of the weed management practices tried during both the years of study.

Regardless of the weed management practices tried the highest benefit cost ratio was realized with 140 kg N ha⁻¹ (N₃) which was however, comparable with 160 kg N ha⁻¹ (N₄) except at W₂, W₅, W₆ and W₇ during 2009-10 and at W₅ during 2010-11, where N₃ significantly higher than N₄. The lowest B: C ratio was registered with N₁ which was significantly lesser than rest of the nitrogen levels tried except at W₁ where it was on par with N₂ during both the years of study.

Disregarding of the nitrogen levels tried, highest benefit cost ratio were realized with PE application of pyrazosulfuron ethyl @ 20g ha⁻¹ supplemented with HW at 25 DAS (W₇) which was however, comparable with PE application of oxadiargyl @ 75 g ha⁻¹ supplemented with HW at 25 DAS (W₆). The lowest benefit cost ratio of aerobic rice recorded with un-weeded check (W₁) during both the years of study

Among the treatmental combinations the highest benefit cost ratio was recorded at 140 kg N ha⁻¹ with PE pyrazosulfuron ethyl @ 20g ha⁻¹ supplemented with HW at 25 DAS (N₃W₇), which was however, comparable with same level of nitrogen with PE application oxadiargyl @ 75 g ha⁻¹ supplemented with HW at 25 DAS (N₃W₆). The lowest benefit cost ratio being registered with application of N either at 100 or 120 kg ha⁻¹ in combination with un-weeded check (N₁W₁ and N₂W₁).

With the different levels of nitrogen application, the highest gross, net returns and B: C ratio was recorded with application of 140 kg N ha⁻¹ (N₃) might be due to fact that, increased nitrogen supply have improved the yield components *viz.*, number of tillers and panicles m⁻², filled grains panicle⁻¹ and test weight and produced higher grain and straw yield of aerobic rice resulted in higher gross, net returns and B: C ratio during both the years of study. The economic returns at 160 kg N ha⁻¹ (N₄) were comparably lower than N₃ because, more than optimal dose of nitrogen could not helpful in increasing yield components and yield of aromatic rice and association of higher cost of production with N₄, reduced the returns. The lowest economic returns were recorded with application of 100 kg N ha⁻¹ (N₁), due to lower stature of yield components and yield of rice because of limited resources. These results are in accordance with the findings of Singh *et al.* (2000), Rakesh Kumar and Mohammed –Ikramullah (2004) and Ramana murthy (2010).

Among the weed management practices, the highest gross and net returns were realized with PE application of oxadiargyl @ 75 g ha⁻¹ supplemented with HW at 25 DAS (W₆) might be due to effective control of all category weeds with improved weed control efficiency resulted in lesser competition offered by weeds at critical stages leading to higher increased stature of yield components *viz.*, number of panicles m⁻², filled grains panicle⁻¹ and test weight and higher yields resulted in higher gross and net returns. Where as the highest B: C ratio was realized with PE application of pyrazosulfuron ethyl @ 20g ha⁻¹ supplemented with HW at 25 DAS (W₇) might be due to comparable returns associated with low cost of weed management practice. The lowest economic returns were recoded with un-weeded check (W₁), due to severe competition offered by weeds for growth resources which in turn reduced the yield components and yield of aromatic rice, which led to lower gross, net returns and B: C ratio. These results are in confirmity with the findings of Natarajan and Arivazhagan (2006), Gowda *et al.* (2009) and Bhandare *et al.* (2011).

Table 4.41. Benefit cost ratio of aromatic rice as influenced by nitrogen and weed management practices under aerobic culture

Treatments	<i>rabi, 2009</i>					<i>rabi, 2010</i>				
	N1	N2	N3	N4	Mean	N1	N2	N3	N4	Mean
W1	1.07	1.17	1.51	1.41	1.29	1.10	1.12	1.59	1.48	1.32
W2	4.73	5.07	5.79	5.45	5.26	4.79	5.07	5.83	5.73	5.35
W3	4.88	5.22	5.74	5.87	5.43	4.89	5.21	5.84	5.69	5.41
W4	4.99	5.34	5.89	6.03	5.54	4.90	5.20	5.87	5.74	5.43
W5	4.80	5.46	6.12	5.78	5.56	4.81	5.44	6.09	5.79	5.53
W6	5.17	5.88	6.51	6.22	5.95	5.05	5.70	6.37	6.11	5.81
W7	5.18	6.06	6.58	6.17	5.99	5.01	5.87	6.42	6.13	5.86
	4.40	4.88	5.45	5.28		4.37	4.80	5.43	5.24	

	SEm ±	CD (P=0.05)	SEm ±	CD (P=0.05)
N	0.03	0.12	0.04	0.14
W	0.06	0.16	0.05	0.16
N at W	0.10	0.26	0.11	0.30
W at N	0.12	0.33	0.11	0.31



Fig.4.24. Gross returns, net returns (₹ ha⁻¹) and B:C ratio of aromatic rice as influenced by nitrogen and weed management practices under aerobic culture

4.9 POST HARVEST SOIL FERTILITY

Post harvest soil fertility status estimated in terms of available nitrogen, available P_2O_5 and available K_2O , immediately after the harvest of rice crop was significantly affected by the graded levels of nitrogen and weed management practices tried, during both the years of study (Table 4.42 to 4.43 and Fig 4.25 to 4.27).

4.9.1 Soil Available Nitrogen

Available nitrogen content of the soil after harvest of the rice crop was influenced by graded levels of nitrogen and weed management practices, as well as their interaction, with unaltered trend during both the years of study (Table 4.42 and Fig 4.25).

The highest value of soil available N was associated with application of nitrogen 160 kg ha^{-1} (N_4), which was however, comparable with 140 kg N ha^{-1} (N_3) and both of them were significantly higher than with rest of nitrogen levels tried during both the years. The next best level of nitrogen application was with 120 kg ha^{-1} (N_2) followed by 100 kg N ha^{-1} (N_1), with significant disparity between them. The lowest value of soil available N was recorded with application of 100 kg N ha^{-1} (N_1), which was significantly lower than rest of the nitrogen levels.

Among the weed management practices tried, the highest value of soil available N was recorded with PE application of oxadiargyl @ 75 g ha^{-1} supplemented with HW at 25 DAS (W_6) which was comparable with PE application of pyrazosulfuron ethyl @ 20 g ha^{-1} supplemented with HW at 25 DAS (W_7) and both of them were significantly superior to rest of the weed management practices tried. The next best weed management practice was the PE application of pretilachlor @ 500 g ha^{-1} supplemented with HW at 25 DAS (W_5), and it recorded significantly higher soil available N, than with PE application of oxadiargyl @ 75 g ha^{-1} alone (W_3) and pyrazosulfuron ethyl @ 20 g ha^{-1} alone (W_4). The later two weed management practices were comparable

Table 4.42. Post harvest soil status of nitrogen (kg ha⁻¹) as influenced by nitrogen and weed management practices under aerobic culture

Treatments	<i>rabi, 2009</i>					<i>rabi, 2010</i>				
	N1	N2	N3	N4	Mean	N1	N2	N3	N4	Mean
W1	177.00	177.72	179.30	180.40	178.61	175.47	174.14	179.70	180.48	177.45
W2	185.18	186.23	187.18	187.11	186.42	183.53	186.57	187.56	188.48	186.54
W3	187.77	189.54	191.77	192.66	190.43	185.92	189.69	191.96	192.85	190.11
W4	187.44	189.16	190.95	191.63	189.80	185.80	186.18	191.33	192.68	189.00
W5	191.67	194.97	195.52	196.30	194.61	190.06	195.35	195.91	196.69	194.50
W6	194.09	197.24	200.14	200.51	198.00	192.69	197.83	200.74	201.12	198.09
W7	193.84	196.78	198.69	200.24	197.39	192.24	197.17	199.09	200.64	197.28
	188.14	190.23	191.94	192.69		186.53	189.56	192.33	193.28	

	SEm ±	CD (P=0.05)	SEm ±	CD (P=0.05)
N	0.25	0.87	0.51	1.76
W	0.24	0.70	0.42	1.20
N at W	0.64	1.88	1.28	3.83
W at N	0.49	1.39	0.84	2.39

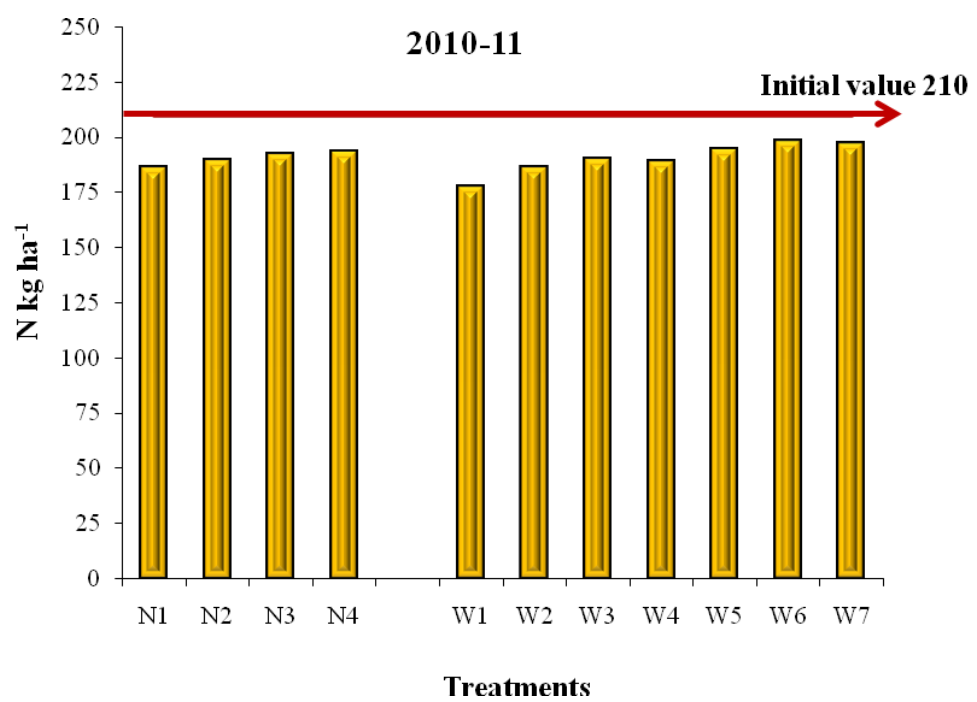
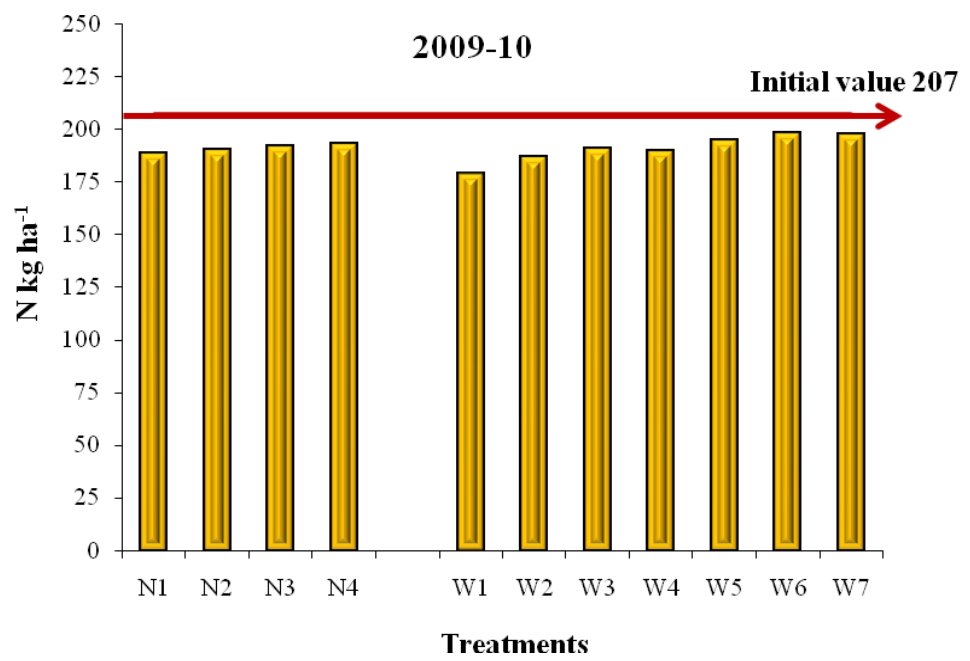


Fig. 4.25. Post harvest soil status of nitrogen (kg ha⁻¹) as influenced by nitrogen and weed management practices under aerobic culture

with each other. PE application of pretilachlor @ 500g ha⁻¹ alone (W₂) resulted in significantly higher value of soil available N than un-weeded check (W₁). The lowest value of soil available N was associated with un-weeded check (W₁) during both the instances of study.

Disregarding of the weed management practices tried, the highest value of soil available N recorded with 160 kg N ha⁻¹ (N₄) which in turn comparable with 140 kg N ha⁻¹ (N₃) and 120 kg N ha⁻¹ (N₂). Application of 100 kg N ha⁻¹ (N₁), resulted in the lowest soil available N during both the years of study.

Irrespective of the nitrogen levels tried, the highest value of soil available N recorded with PE application of oxadiargyl @ 75 g ha⁻¹ supplemented with HW at 25 DAS (W₆) which was however, comparable with PE application of pyrazosulfuron ethyl @ 20g ha⁻¹ supplemented with HW at 25 DAS (W₇) and both of them were significantly higher than with rest of the weed management practices during both the years however, these weed management practices were at par with W₅ during second year of experiment. The lowest value of soil available N recorded with un-weeded check (W₁) during both the years of study.

Among all the combinations the highest value of soil available N was recorded with the application of 160 kg N ha⁻¹ and PE application of oxadiargyl @ 75 g ha⁻¹ supplemented with HW at 25 DAS (N₄W₆), which was however, comparable with same level of nitrogen with pyrazosulfuron ethyl @ 20g ha⁻¹ supplemented with HW at 25 DAS (N₄W₇) or 140 kg N ha⁻¹ with oxadiargyl @ 75 g ha⁻¹ supplemented with HW at 25 DAS (N₃W₆) and these treatment combinations were significantly superior to rest of them. The lowest soil available N was noticed with application of N either at 100 or 120 kg ha⁻¹ in combination with un-weeded check (N₁W₁ and N₂W₁).

4.9.2. Soil Available Phosphorous

Available phosphorous content of the soil after harvest of the rice crop was influenced by graded levels of nitrogen and weed management practices, while none of the interaction was found, during both the years of study with unaltered trend (Table 4.43 and Fig 4.26).

The trend with graded levels of nitrogen application and weed management practices on soil available phosphorous content was exactly similar to that of soil available nitrogen content.

4.9.3. Soil Available Potassium

Available potassium content of the soil after harvest of the rice crop was influenced by graded levels of nitrogen and weed management practices, where as interaction was not shown any significant effect on soil available potassium content during both the years of study (Table 4.43 and Fig 4.27).

The trend with graded levels of nitrogen application and weed management practices on soil available potassium content was exactly similar to that of soil available nitrogen content.

Among the different nitrogen levels tried, the highest post harvest soil available nitrogen up to the highest level of nitrogen tried (160 kg N ha^{-1}) where as phosphorus and potassium were noticed with application of nitrogen at 140 kg ha^{-1} . Relatively higher soil available nitrogen, phosphorus and potassium status with higher nitrogen supply might be due to unutilized nutrients tapped in the soil. Similar results are in agreement with Sikdar *et al.* (2008).

With different weed management practices tried, the highest post harvest soil available nutrients were recorded with PE application of oxadiargyl @ 75 g ha^{-1} supplemented with HW at 25 DAS (W_6) due to optimum removal of nutrients by crop, where as un-weeded check (W_1) recorded lowest post harvest nutrients due to over exploitation of all major nutrients by heavy weed infestation.

4.10. CORRELATION STUDIES

Correlation coefficients were worked out between growth parameters at harvest, yield attributes, nitrogen uptake (grain and straw) and yield of rice to study their relation (Table 4.44 and 4.45).

Table 4.43. Post harvest soil status of phosphorous and potassium (kg ha⁻¹) as influenced by nitrogen and weed management practices under aerobic culture

Treatments	<i>rabi,2009</i>		<i>rabi,2010</i>	
	Available P ₂ O ₅ (kg ha ⁻¹)	Available K ₂ O (kg ha ⁻¹)	Available P ₂ O ₅ (kg ha ⁻¹)	Available K ₂ O (kg ha ⁻¹)
Nitrogen				
N ₁	15.52	192.63	17.31	193.15
N ₂	16.86	195.46	18.15	195.98
N ₃	18.38	199.71	19.14	200.25
N ₄	17.90	198.85	18.79	199.38
SEm ±	0.19	0.77	0.14	0.60
CD (P=0.05)	0.65	2.67	0.48	2.08
Weed management				
W ₁	12.58	180.74	15.99	181.08
W ₂	14.12	193.70	17.20	194.08
W ₃	17.36	197.46	18.22	197.84
W ₄	17.33	197.07	18.18	197.45
W ₅	18.64	200.61	19.15	201.01
W ₆	20.09	203.74	19.96	204.64
W ₇	20.03	203.32	19.73	204.22
SEm ±	0.25	0.83	0.16	0.97
CD (P=0.05)	0.71	2.35	0.45	2.76

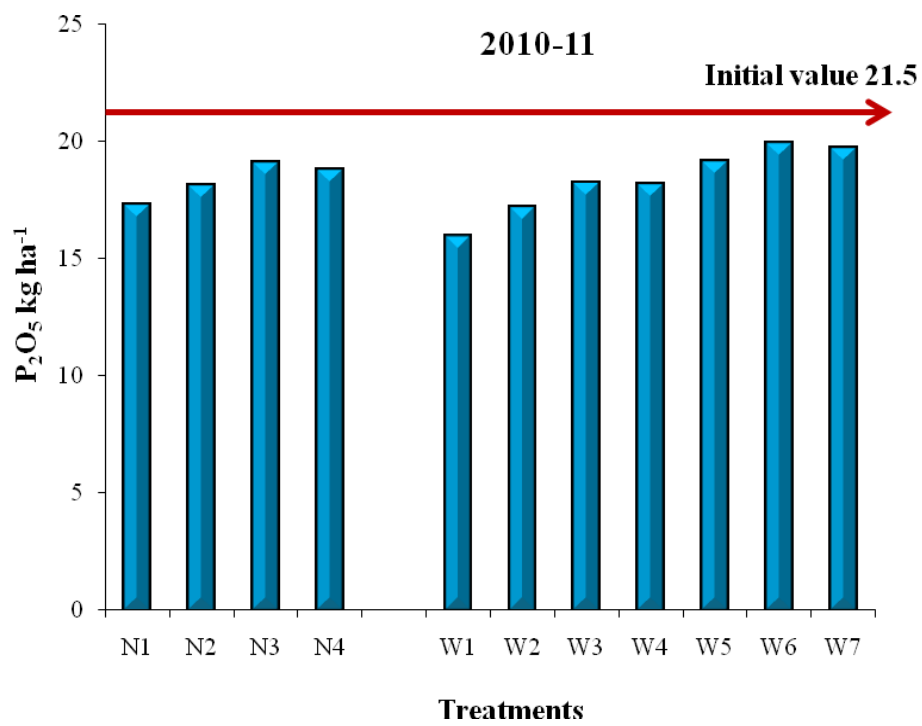
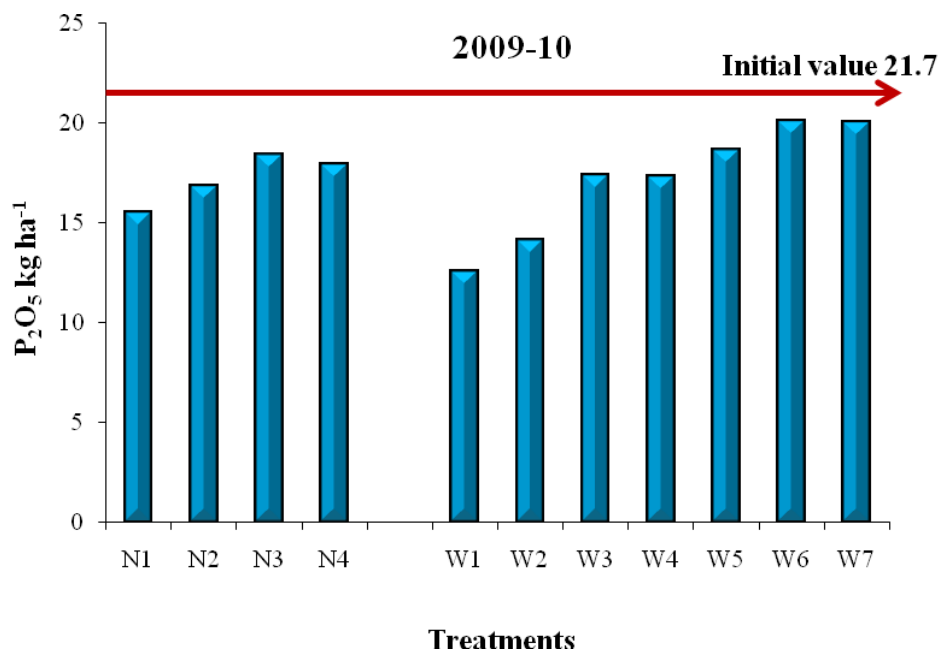


Fig. 4.26. Post harvest soil status of phosphorus (kg ha^{-1}) as influenced by nitrogen and weed management practices under aerobic culture

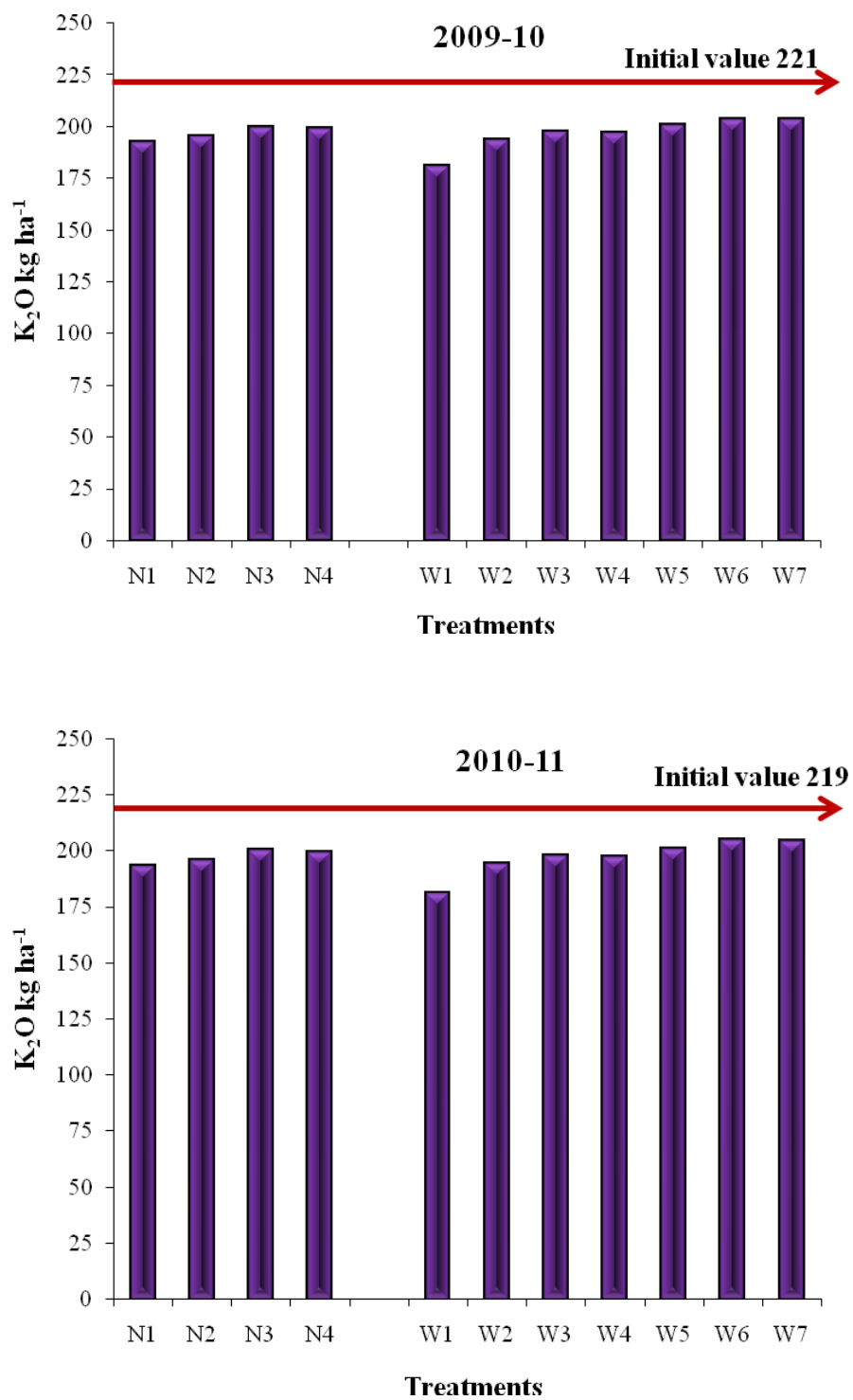


Fig. 4.27. Post harvest soil status of potassium ($kg\ ha^{-1}$) as influenced by nitrogen and weed management practices under aerobic culture

The distinguishable positive correlation was observed between plant height and grain yield; number of tillers m^{-2} , plant height or grain yield; quantity of dry matter at harvest, grain yield or number of tillers m^{-2} and leaf area; number of panicles m^{-2} and quantity of dry matter at harvest or grain yield; test weight and filled grains panicle $^{-1}$ or number of panicles m^{-2} and quantity of dry matter at harvest or grain yield; nitrogen uptake by grain and quantity of dry matter at harvest or number of panicles m^{-2} , filled grains panicle $^{-1}$, thousand grain weight, grain yield; potassium uptake by crop and quantity of dry matter at harvest or number of panicles m^{-2} , filled grains panicle $^{-1}$, nitrogen uptake by grain and straw and quantity of dry matter at harvest or number of panicles m^{-2} , thousand grain weight, phosphorous uptake by crop. Weed dry matter production and weed density; nitrogen uptake by weeds and density, dry matter production of weeds; potassium uptake and phosphorous uptake by weeds or nitrogen uptake, dry matter production, density of weeds.

The distinguishable negative correlation was observed between weed density at harvest and plant height or tillers, dry matter production, filled grains, test weight, grain yield; dry matter production of weeds at harvest and growth parameters or yield attributes, grain yield, nutrient uptake by crop; nitrogen, phosphorous, potassium uptake by weeds at harvest and nitrogen uptake by grain or straw, phosphorous, potassium uptake by crop, filled grains, test weight, growth parameters, grain yield.

Table 4. 44. Correlation coefficient (r) between growth parameters, yield attributes, nutrient uptake, weed parameters and grain yield of aromatic rice under aerobic culture during 2009

	Grain yield (Y)	Plant height (X1)	Leaf area index (X2)	No. of tillers (X3)	Dry matter production (X4)	No. of panicles (X5)	Filled grains (X6)	Test weight (X7)	Weed density (X8)	Weed dry matter (X9)	Nitrogen uptake by weeds (X10)	Phosphorus uptake by weeds (X11)	Potassium uptake by weeds (X12)	Nitrogen uptake by grain (X13)	Nitrogen uptake by straw (X14)	Phosphorus uptake by crop (X15)	Potassium uptake by crop (X16)
Y	1.0000	0.9608**	0.9732**	0.9408**	0.9681**	0.9851**	0.9900**	0.9300**	-0.9406**	-0.9347**	-0.8921**	-0.8714**	-0.8896**	0.9962**	0.9755**	0.9882**	0.9641**
X1		1.0000	0.8809**	0.9785**	0.8744**	0.9032**	0.9154**	0.9850**	-0.8440**	-0.8156**	-0.7394**	-0.7125*	-0.7331*	0.9437**	0.9395**	0.9743**	0.9740**
X2			1.0000	0.8740**	0.9957**	0.9930**	0.9949**	0.8388**	-0.9478**	-0.9660**	-0.9562**	-0.9370**	-0.9586**	0.9861**	0.9672**	0.9471**	0.9099**
X3				1.0000	0.8743**	0.8801**	0.9030**	0.9896**	-0.7795**	-0.7655**	-0.7019*	-0.6646*	-0.7037*	0.9324**	0.9573**	0.9749**	0.9883**
X4					1.0000	0.9837**	0.9910**	0.8410**	-0.9392**	-0.9592**	-0.9462**	-0.9243**	-0.9509**	0.9839**	0.9688**	0.9449**	0.9166**
X5						1.0000	0.9970**	0.8568**	-0.9622**	-0.9706**	-0.9537**	-0.9381**	-0.9522**	0.9893**	0.9589**	0.9573**	0.9154**
X6							1.0000	0.8795**	-0.9510**	-0.9604**	-0.9388**	-0.9189**	-0.9396**	0.9963**	0.9751**	0.9701**	0.9376**
X7								1.0000	-0.7735**	-0.7466**	-0.6662*	-0.6315*	-0.6648*	0.9139**	0.9280**	0.9659**	0.9832**
X8									1.0000	0.9925**	0.9563**	0.9572**	0.9480**	-0.9375**	-0.8754**	-0.8826**	-0.8269**
X9										1.0000	0.9831**	0.9808**	0.9788**	-0.9414**	-0.8862**	-0.8769**	-0.8194**
X10											1.0000	0.9974**	0.9990**	-0.9087**	-0.8542**	-0.8295**	-0.7623**
X11												1.0000	0.9944**	-0.8855**	-0.8219**	-0.8004**	-0.7263*
X12													1.0000	-0.9091**	-0.8599**	-0.8302**	-0.7656**
X13														1.0000	0.9849**	0.9843**	0.9612**
X14															1.0000	0.9843**	0.9748**
X15																1.0000	0.9904**
X16																	1.0000

** : Significant at 1% level

* : Significant at 5% level

Table 4.45. Correlation coefficient (r) between growth parameters, yield attributes, nutrient uptake, weed parameters and grain yield of aromatic rice under aerobic culture during 2010

	Grain yield (Y)	Plant height (X1)	Leaf area index (X2)	No. of tillers (X3)	Dry matter production (X4)	No. of panicles (X5)	Filled grains (X6)	Test weight (X7)	Weed density (X8)	Weed dry matter (X9)	Nitrogen uptake by weeds (X10)	Phosphorus uptake by weeds (X11)	Potassium uptake by weeds (X12)	Nitrogen uptake by grain (X13)	Nitrogen uptake by straw (X14)	Phosphorus uptake by crop (X15)	Potassium uptake by crop (X16)
Y	1.0000	0.9824**	0.9800**	0.9133**	0.9694**	0.9865**	0.9911**	0.9236**	-0.9430**	-0.9398**	-0.8969**	-0.8777**	-0.8944**	0.9974**	0.9802**	0.9906**	0.9619**
X1		1.0000	0.9516**	0.9696**	0.9558**	0.9565**	0.9634**	0.9598**	-0.8712**	-0.8722**	-0.8273**	-0.7981**	-0.8297**	0.9834**	0.9949**	0.9901**	0.9875**
X2			1.0000	0.8563**	0.9929**	0.9977**	0.9969**	0.8409**	-0.9563**	-0.9726**	-0.9592**	-0.9431**	-0.9604**	0.9879**	0.9652**	0.9557**	0.9135**
X3				1.0000	0.8736**	0.8641**	0.8747**	0.9789**	-0.7362**	-0.7351**	-0.6783*	-0.6387*	-0.6849*	0.9133**	0.9609**	0.9497**	0.9799**
X4					1.0000	0.9886**	0.9876**	0.8428**	-0.9236**	-0.9483**	-0.9402**	-0.9186**	-0.9457**	0.9833**	0.9708**	0.9506**	0.9243**
X5						1.0000	0.9987**	0.8568**	-0.9595**	-0.9713**	-0.9527**	-0.9370**	-0.9527**	0.9914**	0.9671**	0.9661**	0.9231**
X6							1.0000	0.8711**	-0.9579**	-0.9673**	-0.9442**	-0.9275**	-0.9438**	0.9953**	0.9716**	0.9720**	0.9332**
X7								1.0000	-0.7636**	-0.7415**	-0.6629*	-0.6295*	-0.6618*	0.9119**	0.9374**	0.9573**	0.9791**
X8									1.0000	0.9924**	0.9557**	0.9559**	0.9463**	-0.9369**	-0.8777**	-0.8934**	-0.8201**
X9										1.0000	0.9828**	0.9805**	0.9777**	-0.9420**	-0.8880**	-0.8904**	-0.8190**
X10											1.0000	0.9980**	0.9991**	-0.9090**	-0.8547**	-0.8460**	-0.7678**
X11												1.0000	0.9953**	-0.8880**	-0.8258**	-0.8210**	-0.7344*
X12													1.0000	-0.9090**	-0.8594**	-0.8456**	-0.7714**
X13														1.0000	0.9854**	0.9876**	0.9622**
X14															1.0000	0.9861**	0.9785**
X15																1.0000	0.9853**
X16																	1.0000

** : Significant at 1% level

* : Significant at 5% level

Chapter – V

SUMMARY AND CONCLUSIONS

CHAPTER –V

SUMMARY AND CONCLUSION

Field experiments were carried out for two consecutive years of *rabi*, 2009, and 2010 on sandy clay loam soils of S.V. Agricultural College farm, Tirupati to evaluate the nitrogen and weed management practices for maximizing the productivity and quality of aromatic rice under aerobic culture in Southern Agro-climatic Zone of Andhra Pradesh. The experiment was laid out in split plot design, replicated thrice. The treatments consisted of four levels of nitrogen *viz.*, 100 kg ha⁻¹ (N₁), 120 kg ha⁻¹(N₂), 140 kg ha⁻¹(N₃) and 160 kg ha⁻¹ (N₄) allotted to main plots and seven weed management practices *viz.*, Un-weeded check (W₁), PE of pretilachlor @ 500 g a.i ha⁻¹ (W₂), PE of oxadiargyl @ 75 g a.i ha⁻¹ (W₃), PE of pyrazosulfuron ethyl @ 20g a.i ha⁻¹(W₄), PE of pretilachlor @ 500 g a.i ha⁻¹ fb hand weeding at 25 DAS(W₅), PE of oxadiargyl @ 75 g a.i ha⁻¹ fb hand weeding at 25 DAS(W₆) and PE of pyrazosulfuron ethyl @ 20 g a.i ha⁻¹ fb hand weeding at 25 DAS(W₇) were allotted to sub plots. The test variety of rice was sugandha samba (RNR 2465).

The salient findings of the influence of different levels of nitrogen and weed management practices and their interactions wherever existed on aromatic rice under aerobic culture are summarized below.

The trend of influence of graded levels of nitrogen and weed management practices, as well as the interaction effect, wherever figured in respect of different parameters studied, followed similar trend, without any deviation, during both the years of study.

Graded levels of nitrogen and weed management practices significantly influenced the growth parameters. The interaction effect was not statistically traceable between nitrogen and weed management practices with respect to all the growth parameters except for dry matter production, at all the stages of observation during both the years.

Among the nitrogen levels tried, the highest stature of growth parameters *viz.*, plant height, leaf area index, number of tillers m^{-2} and dry matter production were associated with the application of the highest level of nitrogen application 160 kg ha^{-1} (N_4), which was comparable with 140 kg N ha^{-1} (N_3) at all the stages of observation during both the years of study. The lowest values of the above growth parameters were registered with 100 kg ha^{-1} (N_1).

Among the weed management practices tried, the highest values of the growth parameters *viz.*, plant height, leaf area index, number of tillers m^{-2} and dry matter production were recorded with PE application of oxadiargyl @ 75 g ha^{-1} supplemented with hand weeding at 25 DAS (W_6), which was at par with PE application of pyrazosulfuron ethyl @ 20 g ha^{-1} supplemented with hand weeding at 25 DAS (W_7), at all stages of observation during both the years of study. All the growth parameters were recorded lowest values with un-weeded check (W_1).

The interaction effect of graded levels of nitrogen and weed management practices was significant in producing dry matter production. Disregarding weed management practices, the highest dry matter production was produced with 160 kg N ha^{-1} . Irrespective of N levels, the highest quantity of dry matter production was recorded with PE application of oxadiargyl @ 75 g ha^{-1} supplemented with hand weeding at 25 DAS. Among the different treatment combinations, application of 140 kg N ha^{-1} with PE application of oxadiargyl @ 75 g ha^{-1} supplemented with hand weeding at 25 DAS (N_3W_6) produced the highest quantity of dry matter production, which was however comparable with 140 kg N ha^{-1} with PE application of pyrazosulfuron ethyl @ 20 g ha^{-1} supplemented with hand weeding at 25 DAS (N_3W_7) at all the stages, while they were at their lowest with 100 kg N ha^{-1} with un-weeded check (N_1W_1) during both the years of study.

All the yield attributes *viz.*, number of panicles m^{-2} , panicle length, total number of grains panicle^{-1} , number of filled grains panicle^{-1} , spikelet sterility and thousand grain weight were significantly influenced by graded levels of nitrogen and different weed management practices. The interaction effect of nitrogen and weed management practices was not statistically traceable with all

the yield attributes except for total number of grains panicle⁻¹, number of filled grains panicle⁻¹ and spikelet sterility during both the years.

Increasing levels of nitrogen progressively enhanced the yield attributes and the highest values of yield attributes viz., number of panicles m⁻², panicle length, total number of grains panicle⁻¹, number of filled grains panicle⁻¹ and thousand grain weight along with the lowest spikelet sterility were associated with 140 kg N ha⁻¹ (N₃) which was at par with 160 kg N ha⁻¹ (N₄). Significantly the lowest values of all the yield components along with higher spikelet sterility were registered with 100 kg N ha⁻¹ (N₁).

With to regard to weed management practices, The highest stature of all the yield attributes along with lower spikelet sterility were obtained with PE application of oxadiargyl @ 75 g ha⁻¹ supplemented with HW at 25 DAS (W₆), which was however, comparable with PE application of pyrazosulfuron ethyl @ 20g ha⁻¹ supplemented with HW at 25 DAS (W₇). The lowest values of yield components with higher spikelet sterility were registered with un-weeded check (W₁) during both years of experimentation.

The interaction effect of graded levels of nitrogen and weed management practices was significant incase of total number of grains panicle⁻¹, number of filled grains panicle⁻¹ and spikelet sterility. Regardless of weed management practices, the highest total number of grains panicle⁻¹ were produced with 160 kg N ha⁻¹, number of filled grains panicle⁻¹ produced with 140 kg N ha⁻¹, and lower spikelet sterility associated with 120 kg N ha⁻¹. Irrespective of N levels, the highest total and filled grains panicle⁻¹ along with lower spikelet sterility was associated with PE application of oxadiargyl @ 75 g ha⁻¹ supplemented with HW at 25 DAS. Among the different combinations, 160 kg N ha⁻¹ with PE application of oxadiargyl @ 75 g ha⁻¹ supplemented with hand weeding at 25 DAS (N₄W₆) produced the highest total and filled grains panicle⁻¹ which was however, comparable with 140 kg N ha⁻¹ with PE application of either oxadiargyl @ 75 g ha⁻¹ or pyrazosulfuron ethyl @ 20g ha⁻¹ supplemented with hand weeding at 25 DAS (N₃W₆, N₃W₇) and the lowest spikelet sterility was associated with

120 kg N ha⁻¹ along with PE application of oxadiargyl @ 75 g ha⁻¹ supplemented with hand weeding at 25 DAS (N₂W₆). The lowest total and filled grains panicle⁻¹ were produced with 100 kg N ha⁻¹ with un-weeded check (N₁W₁) and higher spikelet sterility with 160 kg N ha⁻¹ along with un-weeded check (N₄W₁) during both the years of study.

Graded levels of nitrogen and weed management practices significantly influenced the grain yield, straw yield and harvest index. The interaction effect was not statistically measurable between nitrogen and weeds management practices with respect to straw yield and harvest index except for grain yield during both the years.

The highest grain yield was produced with the application of 140 kg N ha⁻¹ (N₃) and straw yield was produced with 160 kg N ha⁻¹ (N₄) and both of the N levels were comparable with each other in recording either grain or straw yield and significantly higher than with rest of nitrogen levels tried. The lowest grain and straw yield were recorded with the application of 100 kg N ha⁻¹ (N₁).

Among the weed management practices tried, the highest grain yield and straw yields were recorded with PE application of oxadiargyl @ 75 g ha⁻¹ supplemented with HW at 25 DAS (W₆), which was at par with PE application of pyrazosulfuron ethyl @ 20g ha⁻¹ supplemented with HW at 25 DAS (W₇), while the lowest grain and straw yields were recorded with un-weeded check (W₁).

The highest harvest index was recorded with the application of 140 kg N ha⁻¹ (N₃) and the lowest was recorded with 100 kg N ha⁻¹ (N₁) with significant disparity among all the N levels tried. With regard to weed management practices, the highest harvest index was recorded with PE application of oxadiargyl @ 75 g ha⁻¹ fb hand weeding at 25 DAS (W₆), while the lowest was recorded with un-weeded check (W₁) with significant disparity among all the weed management practices tried during both the years of experimentation.

The interaction effect of graded levels of nitrogen and weed management practices was significant for grain yield. Irrespective of weed management

practices, the highest grain yield was realized with 140 kg N ha⁻¹. Disregarding weed management practices, the highest grain yield was produced with PE application of oxadiargyl @ 75 g ha⁻¹ supplemented with HW at 25 DAS. Among the treatment combinations, 140 kg N ha⁻¹ along with PE application of oxadiargyl @ 75 g ha⁻¹ supplemented with HW at 25 DAS (N₃W₆) produced the highest grain yield, which was at par with 140 kg N ha⁻¹ along with PE application of pyrazosulfuron ethyl @ 20g ha⁻¹ supplemented with HW at 25 DAS (N₃W₇). The lowest grain yield was produced with 100 kg N ha⁻¹ with un-weeded check (N₁W₁) during both the years of study.

Grain quality parameters *viz.*, milling per cent and protein content of grain was significantly influenced by nitrogen and weed management practices, where as kernel length, breadth, amylose content of grain was influenced only by nitrogen levels and head rice recovery, L: B ratio, volume expansion of rice were not influenced either by nitrogen or weed management practices during both the years of study. The interaction effect was not statistically traceable for any of the quality parameter.

The highest milling per cent was recorded with 140 kg N ha⁻¹ (N₃) and the highest kernel length, breadth, amylose content, protein content of grain was recorded with 160 kg N ha⁻¹ (N₄) and both of the N levels were comparable with each other and significantly higher than with rest of nitrogen levels tried. The lowest above all quality parameters were recorded with 100 kg N ha⁻¹ (N₁).

Among the weed management practices the highest milling per cent and protein content of grain was recorded with PE application of oxadiargyl @ 75 g ha⁻¹ supplemented with HW at 25 DAS (W₆), which was statistically comparable with PE application of pyrazosulfuron ethyl @ 20g ha⁻¹ supplemented with HW at 25 DAS (W₇), while the lowest values were recorded with un-weeded check (W₁).

Graded levels of nitrogen and weed management practices significantly influenced the nitrogen, phosphorus and potassium uptake by the crop, at all the stages of observation during both the years. The interaction effect was not

statistically measurable with respect to phosphorus and potassium uptake, where as nitrogen uptake by crop was significantly influenced by the interaction effect of nitrogen and weed management practices, at all the stages of crop growth.

The highest uptake of nitrogen(including by grain and straw at harvest) was recorded with 160 kg N ha⁻¹(N₄), where as the highest phosphorus and potassium was recorded with 140 kg N ha⁻¹(N₃) and both of them were comparable with each other and significantly higher than with rest of nitrogen levels tried. The lowest nitrogen, phosphorus and potassium uptake by the crop was associated with the application of 100 kg N ha⁻¹(N₁) during both the years of study.

As regards weed management, the highest nitrogen, phosphorus and potassium by the crop at all the stages of observation recorded with PE application of oxadiargyl @ 75 g ha⁻¹ supplemented with HW at 25 DAS (W₆), which was comparable with PE application of pyrazosulfuron ethyl @ 20g ha⁻¹ supplemented with HW at 25 DAS (W₇), while the lowest nutrient uptake by crop was observed with un-weeded check (W₁).

The interaction effect of nitrogen and weed management practices was found for nitrogen uptake. Irrespective of weed management practices, the highest uptake of nitrogen was recorded with application of nitrogen 140 kg ha⁻¹. Irrespective of N levels, the highest nitrogen uptake was registered with PE application of oxadiargyl @ 75 g ha⁻¹ supplemented with HW at 25 DAS. Among the treatment combinations, 140 kg N ha⁻¹ along with PE application of oxadiargyl @ 75 g ha⁻¹ supplemented with HW at 25 DAS (N₃W₆) recorded the highest N uptake, which was at par with 140 kg N ha⁻¹ along with PE application of pyrazosulfuron ethyl @ 20g ha⁻¹ supplemented with HW at 25 DAS (N₃W₇). The lowest N uptake was recorded with 100 kg N ha⁻¹ with un-weeded check (N₁W₁) during both the years of study.

During crop growth period, weed flora belonging to eight taxonomic families were observed, eight taxonomic families were observed in the experimental field, of which five species were grasses, three species were sedges

and twelve species were broad leaved weeds. The predominant weed species observed in the experimental field were *Echinochloa crus-galli*, *Cyperus rotundus*, *Cyperus iria*, *Commelina benghalensis*, *Cyanotis cucullata* and *Physalis minima*.

Density and dry matter production of grasses, sedges, broad leaved weeds and total density, dry matter production of all category of weeds was significantly influenced by graded levels of nitrogen and weed management practices, while none of the interaction effect was found for the above weed parameters, at all the stages of observation during both the years of experimentation.

With different levels of nitrogen tried, at all the stages of observation viz., 25, 50, 75, 100 DAS and at harvest, the lowest density and dry matter production of grasses, sedges, broad leaved weeds and total density; dry matter production of weeds were recorded with lower level of nitrogen application 100 kg N ha^{-1} (N_1) and the highest values of above weed parameters were recorded with 160 kg N ha^{-1} (N_4), which was however, statistically comparable with 140 kg N ha^{-1} (N_3) during both the years of study.

Among the weed management practices, at all the stages of observation, the lowest density and dry matter production of grasses was recorded with PE application of oxadiargyl @ 75 g ha^{-1} supplemented with HW at 25 DAS (W_6), which was significantly lower than rest of weed management practices. This was followed by PE application of pretilachlor @ 500 g ha^{-1} supplemented with HW at 25 DAS (W_5), while the highest values were recorded with un-weeded check (W_1) during both the instances of study.

With regard to different weed management practices tried, at all the stages of observation the lowest density and dry matter production of sedges was recorded with PE application of oxadiargyl @ 75 g ha^{-1} supplemented with HW at 25 DAS (W_6), which was however comparable with PE application of pyrazosulfuron ethyl @ 20 g ha^{-1} supplemented with HW at 25 DAS (W_7). The highest values were recorded with un-weeded check (W_1).

The lowest density and dry matter production of broad leaved weeds was recorded with PE application of pyrazosulfuron ethyl @ 20g ha⁻¹ supplemented with HW at 25 DAS (W₇), which was significantly lower than rest of weed management practices tried. This was followed by PE application of pretilachlor @ 500 g ha⁻¹ supplemented with HW at 25 DAS (W₅), while the highest values were recorded with un-weeded check (W₁) at all the stages of observation ,during both the instances of study.

Among the weed management practices, the total density and dry matter production of all categories of weeds was recorded the lowest values with PE application of oxadiargyl @ 75 g ha⁻¹ supplemented with HW at 25 DAS (W₆). PE application of pyrazosulfuron ethyl @ 20g ha⁻¹ supplemented with HW at 25 DAS (W₇) was the next best weed management practice followed by PE application of pretilachlor @ 500 g ha⁻¹ supplemented with HW at 25 DAS (W₅), followed by alone application of above herbicides (W₃, W₄ and W₂) with significant disparity between any two of them in reducing density and dry matter production. The highest density and dry matter production of all categories of weeds were recorded with un-weeded check (W₁) during both the instances of study.

WCE was not significantly influenced by the graded levels of nitrogen application at any stage of crop growth, except at 25 DAS. Different weed management practices were significantly influenced the WCE at all the stages of crop growth, while the interaction effect was not traceable at any of crop growth stage, except at 25 DAS.

The highest WCE at 25 DAS was noticed with the application of 100 kg N ha⁻¹ (N₁). The lowest WCE was noticed with 140 kg N ha⁻¹ (N₃), which was comparable with 160 kg N ha⁻¹ (N₄).

With the different weed management practices tried, at all the stages of crop growth the highest WCE was noticed with PE application of oxadiargyl @ 75 g ha⁻¹ supplemented with HW at 25 DAS (W₆). This was followed by PE application of pyrazosulfuron ethyl @ 20g ha⁻¹ supplemented with HW at 25

DAS (W_7). The lowest WCE was recorded with PE application of pretilachlor @ 500g ha⁻¹ alone (W_2) during both the instances of study.

Irrespective of weed management practices, the highest WCE was noticed with 100 kg N ha⁻¹. Disregarding graded levels of nitrogen, the highest WCE was noticed with PE application of oxadiargyl @ 75 g ha⁻¹ supplemented with HW at 25 DAS. Among the combinations, the highest WCE was recorded with 100 kg N ha⁻¹ along with PE application of oxadiargyl @ 75 g ha⁻¹ supplemented with HW at 25 DAS (N_1W_6), while the lowest was recorded with 140 kg N ha⁻¹ along with PE application of pretilachlor @ 500g ha⁻¹ (N_3W_2) during both the years of study.

Nutrient (nitrogen, phosphorus and potassium) uptake by weeds estimated at harvest of the crop was significantly influenced by graded levels of nitrogen and weed management practices. The interaction effect was not statistically measurable with respect to phosphorus and potassium uptake by weeds except for nitrogen.

The lowest nitrogen, phosphorus and potassium by weeds was associated with 100 kg N ha⁻¹ (N_1), while the highest was recorded with 160 kg N ha⁻¹ (N_4), which was at par with 140 kg N ha⁻¹ (N_3), during both the years of study.

Among weed management practices, the lowest nitrogen, phosphorus and potassium uptake by weeds was noticed with PE application of oxadiargyl @ 75 g ha⁻¹ supplemented with HW at 25 DAS (W_6), which was comparable with PE application of pyrazosulfuron ethyl @ 20g ha⁻¹ supplemented with HW at 25 DAS (W_7). The highest nutrient by weeds was observed with un-weeded check (W_1), which was significantly higher than rest of weed management practices tried, during both the instances of experimentation.

Disregarding weed management practices, the lowest nitrogen uptake by weeds at harvest was recorded with 100 kg N ha⁻¹. Irrespective of N levels, the lowest nitrogen uptake was recorded with PE application of oxadiargyl @ 75 g ha⁻¹ supplemented with HW at 25 DAS. Among treatment combinations the

lowest uptake was noticed with 100 kg N ha⁻¹ along with PE application of oxadiargyl @ 75 g ha⁻¹ supplemented with HW at 25 DAS (N₁W₆), while the highest nitrogen uptake was recorded with 160 kg N ha⁻¹ along with un-weeded check (N₄W₁) during both the years of study.

Graded levels of nitrogen and weed management practices, as well as their interaction significantly influenced the gross returns, net returns and B: C ratio during both the years of study.

The highest gross and net returns as well as benefit cost ratio was realized with 140 kg N ha⁻¹(N₃), which was comparable with 160 kg N ha⁻¹(N₄) in case of gross and net returns, where as these two N levels showed significant disparity with respect to B: C ratio. The lowest economic returns were realized with the application of 100 kg N ha⁻¹(N₁) during both the years of study.

Among the weed management practices, the highest gross and net returns were recorded with PE application of oxadiargyl @ 75 g ha⁻¹ supplemented with HW at 25 DAS (W₆), where as the highest B: C ratio was obtained with PE application of pyrazosulfuron ethyl @ 20g ha⁻¹ supplemented with HW at 25 DAS (W₇) and these two treatments were in turn comparable with each other in recording higher economic returns. The lowest gross and net returns including B:C ratio were realized with un-weeded check (W₁) during both the instances of experimentation.

Irrespective of weed management practices, the highest economic returns were realized with 140 kg N ha⁻¹. Disregarding of N levels, the highest gross and net returns were realized with PE application of oxadiargyl @ 75 g ha⁻¹ supplemented with HW at 25 DAS and higher B: C ratio was recorded with PE application of pyrazosulfuron ethyl @ 20g ha⁻¹ supplemented with HW at 25 DAS (W₇). Among the different combinations, the highest economics were realized with 140 kg N ha⁻¹ along with PE application of oxadiargyl @ 75 g ha⁻¹ supplemented with HW at 25 DAS (N₃W₆), which was at par with 140 kg N ha⁻¹ along with PE application of pyrazosulfuron ethyl @ 20g ha⁻¹ supplemented with HW at 25 DAS (N₃W₇). The lowest economics realized with 100 kg N ha⁻¹ along with un-weeded check (N₁W₁) during both the years of study.

The status of soil available nitrogen, available phosphorus and available potassium after harvest of the rice crop was significantly influenced by different nitrogen and weed management practices tried, while the interaction effect was statistically measurable with respect to soil available nitrogen only.

The highest status of soil available nitrogen was recorded with 160 kg N ha⁻¹(N₄), where as soil available phosphorus and potassium was recorded with 140 kg N ha⁻¹(N₃), and these two N levels were comparable with each other in recording soil available nutrients. The lowest post harvest soil available nitrogen, phosphorus and potassium were estimated with 100 kg N ha⁻¹(N₁) during both the years of study.

Among the weed management practices, the highest status of soil available nitrogen, phosphorus and potassium were obtained with PE application of oxadiargyl @ 75 g ha⁻¹ supplemented with HW at 25 DAS (W₆), which was at par with PE application of pyrazosulfuron ethyl @ 20g ha⁻¹ supplemented with HW at 25 DAS (W₇), while the lowest post harvest soil nutrient status was noticed with un- weeded check (W₁).

Disregarding weed management practices, the highest soil available nitrogen was recorded with 160 kg N ha⁻¹. Irrespective of N levels the highest soil available nitrogen was recorded with PE application of oxadiargyl @ 75 g ha⁻¹ supplemented with HW at 25 DAS. Among the treatment combinations, the highest post harvest soil available nitrogen was noticed with 160 kg N ha⁻¹ along with PE application of oxadiargyl @ 75 g ha⁻¹ supplemented with HW at 25 DAS (N₄W₆), which was at par with 160 kg N ha⁻¹ along with PE application of pyrazosulfuron ethyl @ 20g ha⁻¹ supplemented with HW at 25 DAS (N₄W₇). The lowest soil available nitrogen was observed with 100 kg N ha⁻¹ along with un-weeded check (N₁W₁) during both the years of study.

Based on the foregoing, the following broad conclusions could be drawn from the present investigation:

- For higher productivity of aromatic rice under aerobic culture in Southern Agro-climatic Zone of Andhra Pradesh, the application of nitrogen at 140 kg N ha^{-1} was found optimum than other levels of nitrogen tried.
- Pre emergence application of oxadiargyl @ 75 g ha^{-1} supplemented with hand weeding at 25 DAS was found to be effective in broad spectrum control of weeds and it was comparable with pre emergence application of pyrazosulfuron ethyl @ 20 g ha^{-1} supplemented with HW at 25 DAS for higher grain yield and economic returns of aromatic rice under aerobic culture. The quality parameters of aromatic rice except milling per cent and protein content of grain were not much influenced by different weed management practices.
- Application of 140 kg N ha^{-1} either with pre emergence application of oxadiargyl @ 75 g ha^{-1} or pyrazosulfuron ethyl @ 20 g ha^{-1} supplemented with hand weeding at 25 DAS resulted in the best performance of aromatic rice under aerobic culture in terms of productivity and profitability.

In conclusion, the present study revealed that aromatic rice variety sugandha samba can be successfully grown under aerobic culture in Southern Agro-climatic Zone of Andhra Pradesh, with a package of agro techniques, *i.e.* application of nitrogen @ 140 kg ha^{-1} in combination with either pre emergence application of oxadiargyl @ 75 g ha^{-1} or pyrazosulfuron ethyl @ 20 g ha^{-1} supplemented with hand weeding at 25 DAS for higher productivity, quality and monetary returns without disturbing the soil fertility status.

FUTURE LINE OF RESEARCH

1. Time of sowing must be evaluated for coincidence of grain development period with low temperatures in order to improve aroma of scented rice.
2. Investigations on response of aromatic rice under aerobic culture for micro nutrients have to be made (with special emphasis on iron nutrition).
3. The principles of site-specific nutrient management (SSNM) for aerobic rice should be evolved.
4. Prospects of combinations of pre and post emergence herbicides for effective weed control in aerobic rice needs further research.
5. Selection of high yielding drought resistant rice varieties for tropical aerobic rice systems is essential.
6. Studies on organic farming of aromatic rice under aerobic culture have to be initiated; keeping in view of future prospects for organic foods.

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*** Original not seen**

APPENDICES

Appendix – A
Standard week wise meteorological data during the crop period - rabi, 2009 (12.11.2009 to 08.04.2010)

Standard week	Date and month	Temperature (°C)				Mean R.H (%)		Rainfall (mm)		No.of rainy days		Mean evaporation (mm day ⁻¹)		Mean bright sunshine hours day ⁻¹	
		Maximum		Minimum											
		A	DN	A	DN	A	DN	A	DN	A	DN	A	DN	A	DN
46	12Nov.- 18Nov.	29.9	0.02	23.3	3.52	74.9	6.595	22.4	8.81	2	0.9	2.6	-1.55	3.1	-3.78
47	19Nov.- 25Nov.	31.6	3.58	22.2	2.03	71.05	-2.035	15	-29.91	1	-0.9	3.2	-0.31	6.1	0.67
48	26Nov.- 02Dec.	29.4	1.44	20.4	1.33	66.85	-4.825	0	-49.19	0	-1.6	4.3	0.65	6.5	0.46
49	03 Dec.-09 Dec.	28.7	0.37	19.6	1.6	71.55	1.42	14.2	-8.75	2	1	2.5	-1.24	3.9	-3.34
50	10 Dec.-16 Dec.	28.7	0.37	21	3.16	67.4	-1.315	33.2	29.8	1	0.6	2.6	-1.29	4.3	-2.28
51	17 Dec.-23 Dec.	27.5	-0.78	19.3	1.78	71.9	1.995	14.7	-16.26	3	2.2	2.2	-1.52	2.4	-3.92
52	24 Dec.-31 Dec.	28.1	-0.84	18.3	0.88	67.65	-2.035	0	-4.54	0	-0.5	2.6	-1.28	4.2	-2.56
1	01 Jan.-07 Jan.	29.1	0.68	17	-0.5	68.8	0.795	0	-4.16	0	-0.2	3.5	-0.81	5.3	-2.11
2	08 Jan.-14 Jan.	29.8	0.98	20.6	4.01	67.45	-0.615	0	-0.25	0	0	3.4	-0.92	4.7	-2.75
3	15 Jan.-21 Jan.	30	0.33	18.4	2.42	61.6	-4.315	0	-0.04	0	0	4.5	-0.24	6.8	-1.47
4	22 Jan.-28 Jan.	29.5	-1.38	16.6	-1.26	61.25	-2.08	0	0	0	0	4.5	-0.33	8.1	0.16
5	29 Jan.-04 Feb.	30.1	-0.76	15.7	-2.49	60.4	-4.855	0	-0.56	0	-0.2	4.4	-0.34	7.9	0.19
6	05 Feb.-11 Feb.	30.7	-0.92	16.3	-1.73	58.55	-2.1	0	-1.48	0	-0.1	5.4	-0.09	8.3	0.05
7	12 Feb.-18 Feb.	32.1	-0.41	19.8	1.6	59.75	-0.01	0	0	0	0	4.9	-0.91	7.3	-1.59
8	19 Feb.-25 Feb.	35	1.82	22	3.8	52.75	-3.925	0	-2.94	0	-0.1	5.4	-0.89	8.7	0.03
9	26 Feb.-04 Mar.	36.1	0.99	20.3	1.15	50.1	-3.345	0	-2.05	0	-0.3	6.9	0.15	8.4	-0.65
10	05 Mar.-11 Mar.	37.6	2.82	23.2	2.89	53.8	-0.015	0	-0.17	0	0	6.7	-0.3	8.6	0.14
11	12 Mar.-18 Mar.	36.4	1.44	21.8	0.65	49.85	-4.495	0	-6.28	0	-0.2	6.4	-0.19	7.6	-0.67
12	19 Mar.-25 Mar.	37.7	1.47	20.3	-2.1	39.9	-12.365	0	-3.76	0	-0.3	6.8	-0.22	8.3	-0.09
13	26 Mar.-01 Apr.	38.6	1.91	26	2.47	49.15	-3.79	0	-3.5	0	-0.2	6.8	-0.32	7.6	-0.62
14	02 Apr.-08 Apr.	39.7	2.98	25.6	1.52	48.4	-5.415	0	-5.5	0	-0.4	7.5	0.73	8.2	0.24

*A- Actual

**DN- Deviation from decennial mean

Appendix - B

Standard week wise meteorological data during the crop period - *rabi*, 2010 (12.11.2010 to 08.04.2011)

Standard week	Date and month	Temperature (°C)				Mean R.H (%)		Rainfall (mm)		No.of rainy days		Mean evaporation (mm day ⁻¹)		Mean bright sunshine hours day ⁻¹	
		Maximum		Minimum											
		A	DN	A	DN	A	DN	A	DN	A	DN	A	DN	A	DN
46	12Nov.- 18Nov.	29.6	-0.27	22.5	2.14	80	9.655	67.9	52.07	3	1.7	2.5	-1.38	4.4	-1.93
47	19Nov.- 25Nov.	30.7	2.19	20.5	0.21	68.5	-2.94	4.8	-33.37	1	-0.5	2.9	-0.64	5.7	0.01
48	26Nov.- 02Dec.	29.4	1.34	21.5	2.44	73.7	2.94	15.8	-26.5	1	-0.3	3	-0.75	2.6	-3.4
49	03 Dec.-09 Dec.	22.8	-5.53	21.4	3.16	75.45	5.01	10.6	-13.77	1	-0.2	2.1	-1.43	2.4	-4.32
50	10 Dec.-16 Dec.	29.2	0.85	21.3	3.27	80.8	11.74	13.5	6.78	1	0.5	3.6	-0.12	2.2	-4.15
51	17 Dec.-23 Dec.	25.8	-2.53	17.4	-0.24	84.4	14.45	0	-29.41	0	-0.9	2.4	-1.2	2.8	-3.22
52	24 Dec.-31 Dec.	27.5	-1.48	15.6	-1.79	89.95	20.95	0	-4.39	0	-0.5	2.9	-0.92	5.7	-0.88
1	01 Jan.-07 Jan.	28.9	0.39	19.2	1.72	80.1	12.26	0	-4.16	0	-0.2	3.4	-0.83	5.4	-1.75
2	08 Jan.-14 Jan.	29.5	0.64	14.6	-2.27	65.45	-2.26	0	-0.25	0	0	4.1	-0.16	7.2	0.08
3	15 Jan.-21 Jan.	30.2	0.69	14.7	-1.48	69.45	3.97	0	-0.04	0	0	4.2	-0.6	8.8	0.8
4	22 Jan.-28 Jan.	29.9	-0.9	15.7	-2.23	71.1	8.24	0	0	0	0	5	0.13	8.2	0.36
5	29 Jan.-04 Feb.	30.5	-0.28	16	-2.18	65.95	0.85	0	-0.56	0	-0.2	4.8	0	8.5	0.9
6	05 Feb.-11 Feb.	31	-0.4	13.9	-3.42	62.6	2.49	0	-1.48	0	-0.1	5.5	-0.02	8.3	-0.09
7	12 Feb.-18 Feb.	32.4	-0.05	16.4	-1.75	59.6	-0.03	0	0	0	0	5.8	0	8.9	0.15
8	19 Feb.-25 Feb.	32.3	-1.32	21.5	3.32	68.8	14	15.5	15.5	2	2	4.1	-2.21	5.8	-3.28
9	26 Feb.-04 Mar.	32.1	-3.11	16.4	-2.72	58.4	7.79	0	-0.72	0	-0.1	6	-0.99	8.5	-0.67
10	05 Mar.-11 Mar.	36	0.95	16.2	-4.42	44.35	-9.49	0	-0.17	0	0	7.1	0.06	9.5	1.07
11	12 Mar.-18 Mar.	34.5	-0.46	18.2	-2.88	59.35	4.97	0	-6.28	0	-0.2	7.3	0.71	8.9	0.78
12	19 Mar.-25 Mar.	36.2	-0.24	20.9	-1.33	57.45	5.94	0	-3.76	0	-0.3	7	-0.06	9.3	1.02
13	26 Mar.-01 Apr.	37.2	0.12	22.4	-1.64	52.05	-0.45	0	-3.5	0	-0.2	7.1	-0.07	8.7	0.49
14	02 Apr.-08 Apr.	37.9	0.9	23.7	-0.52	53.25	-0.65	0	-5.5	0	-0.4	6.9	0.06	7.4	-0.42

*A- Actual **DN- Deviation from decennial mean

Appendix –C

Calendar of operations

Operation	<i>rabi, 2009</i>	<i>rabi, 2010</i>
Preparatory tillage of the field	15-11-2009	13-11-2010
Secondary tillage of the field	19-11-2009	18-11-2010
Field layout	22-11-2009	22-11-2010
Pre sowing irrigation	24-11-2009	23-11-2010
Basal application of N, P and K fertilizers	25-11-2009	24-11-2010
Sowing	25-11-2009	24-11-2010
Spraying of Pre emergence herbicides in treatment plots	26-11-2009	25-11-2010
Thinning	09-12-2009	08-12-2010
Hand weeding in all treatments except W ₁ treatment	21-12-2009	20-12-2010
Ferrous sulphate application	23-12-2009	22-12-2010
Top dressing of Nitrogen at Active tillering stage	27-12-2009	24-12-2010
Ferrous sulphate application	29-12-2009	28-12-2010
Top dressing of Nitrogen at Maximum tillering stage	19-01-2010	17-01-2011
Spraying of Tricyclazole	11-01-2010	-
Irrigations	Appendex -D	Appendex -D
Spraying of Tricyclazole	30-01-2010	-
Spraying of COC + streptomycin sulphate	-	29-01-2011
Spraying of Monochrotophos	-	31-01-2011
Top dressing of Nitrogen at Panicle initiation stage	14-02-2010	13-02-2011
Top dressing of Nitrogen at Flowering stage	01-03-2010	28-02-2011
Harvesting and threshing	07-04-2010 to 09-04-2010	06-04-2011 to 08-04-2011
Drying, winnowing and bagging	08-04-2010 to 10-04-2010	07-04-2011 to 12-04-2011

Appendix- D

Scheduling of irrigations

Irrigation no.	Date of irrigation	
	<i>rabi, 2009</i>	<i>rabi, 2010</i>
1	08-01-10	27-12-10
2	19-01-10	07-01-11
3	30-01-10	18-01-11
4	10-02-10	30-01-11
5	19-02-10	10-02-11
6	25-02-10	16-02-11
7	05-03-10	03-03-11
8	12-03-10	10-03-11
9	19-03-10	17-03-11
10	26-03-10	24-03-11

Appendix- E

**Cost of cultivation of aerobic rice
(Excluding the cost of nitrogen and weed management
during 2009 and 2010)**

S.No.	Item of expenditure	Cost (₹ ha ⁻¹)	
		2009	2010
1.	Land preparation	950	950
2.	Seeds	1200	1200
3.	Sowing	850	850
4.	Fertilizers (Phosphorus and Potassium fertilizers)	1742	1742
5.	Irrigation	800	800
6.	Plant protection	1546	1928
7.	Harvesting, threshing and cleaning	2300	2300
	Total	9388	9770

Appendix-F
**Cost of nitrogen management under graded levels of
nitrogen application during 2009 and 2010**

Treatment	Cost of Nitrogen fertilizer (₹ ha ⁻¹)	Cost of application (₹ ha ⁻¹)	Total cost of Nitrogen management and its application (₹ ha ⁻¹)
N ₁	1130	40	1170
N ₂	1356	50	1406
N ₃	1582	60	1642
N ₄	1808	70	1878

Appendix-G
**Cost of weed management under different levels of
weed management practices 2009 and 2010**

Treatment	Cost of herbicide (₹ ha ⁻¹)	Cost of application and hand weeding (₹ ha ⁻¹)	Total cost of herbicide and its application (₹ ha ⁻¹)
W ₁	-	-	-
W ₂	240	300	540
W ₃	471	300	771
W ₄	56	300	356
W ₅	240	1300	1540
W ₆	471	1300	1771
W ₇	56	1300	1356

Appendix-H

Cost of nitrogen and weed management under different levels of nitrogen and weed management practices during 2009 and 2010

Treatment	Cost of nitrogen (₹ ha⁻¹)	Cost of Weed management (₹ ha⁻¹)	Total cost (₹ ha⁻¹)
N ₁ W ₁	1170	-	1170
N ₁ W ₂	1170	540	1710
N ₁ W ₃	1170	771	1941
N ₁ W ₄	1170	356	1526
N ₁ W ₅	1170	1540	2710
N ₁ W ₆	1170	1771	2941
N ₁ W ₇	1170	1356	2526
N ₂ W ₁	1406	-	1406
N ₂ W ₂	1406	540	1946
N ₂ W ₃	1406	771	2177
N ₂ W ₄	1406	356	1762
N ₂ W ₅	1406	1540	2946
N ₂ W ₆	1406	1771	3177
N ₂ W ₇	1406	1356	2762
N ₃ W ₁	1642	-	1642
N ₃ W ₂	1642	540	2182
N ₃ W ₃	1642	771	2413
N ₃ W ₄	1642	356	1998
N ₃ W ₅	1642	1540	3182
N ₃ W ₆	1642	1771	3413
N ₃ W ₇	1642	1356	2998
N ₄ W ₁	1878	-	1878
N ₄ W ₂	1878	540	2418
N ₄ W ₃	1878	771	2649
N ₄ W ₄	1878	356	2234
N ₄ W ₅	1878	1540	3418
N ₄ W ₆	1878	1771	3649
N ₄ W ₇	1878	1356	3234

Appendix - I
Total cost of cultivation of aerobic rice under different levels of nitrogen and weed management practices during 2009 and 2010

Treatment	Cost of cultivation excluding nitrogen and weed management (₹ ha ⁻¹)		Cost of nitrogen and Weed management (₹ ha ⁻¹)	Total cost (₹ ha ⁻¹)	
	2009	2010		2009	2010
N ₁ W ₁	9388	9770	1170	10558	10940
N ₁ W ₂	9388	9770	1710	11098	11480
N ₁ W ₃	9388	9770	1941	11329	11711
N ₁ W ₄	9388	9770	1526	10914	11296
N ₁ W ₅	9388	9770	2710	12098	12480
N ₁ W ₆	9388	9770	2941	12329	12711
N ₁ W ₇	9388	9770	2526	11914	12296
N ₂ W ₁	9388	9770	1406	10794	11176
N ₂ W ₂	9388	9770	1946	11334	11716
N ₂ W ₃	9388	9770	2177	11565	11947
N ₂ W ₄	9388	9770	1762	11150	11532
N ₂ W ₅	9388	9770	2946	12334	12716
N ₂ W ₆	9388	9770	3177	12565	12947
N ₂ W ₇	9388	9770	2762	12150	12532
N ₃ W ₁	9388	9770	1642	11030	11412
N ₃ W ₂	9388	9770	2182	11570	11952
N ₃ W ₃	9388	9770	2413	11801	12183
N ₃ W ₄	9388	9770	1998	11386	11768
N ₃ W ₅	9388	9770	3182	12570	12952
N ₃ W ₆	9388	9770	3413	12801	13183
N ₃ W ₇	9388	9770	2998	12386	12768
N ₄ W ₁	9388	9770	1878	11266	11648
N ₄ W ₂	9388	9770	2418	11806	12188
N ₄ W ₃	9388	9770	2649	12037	12419
N ₄ W ₄	9388	9770	2234	11622	12004
N ₄ W ₅	9388	9770	3418	12806	13188
N ₄ W ₆	9388	9770	3649	13037	13419
N ₄ W ₇	9388	9770	3234	12622	13004

Appendix - J

Cost /Price (₹ kg⁻¹) of inputs and output of the experiment

Input/Output	Cost /Price (₹ kg ⁻¹)
Urea	5.20
SSP	3.60
MOP	4.70
Ferrous sulphate	20.00
Rice seed	40.00
Rice grain	25.00
Rice straw	0.75
	Cost /Price (₹ g⁻¹)
pretilachlor	0.48
Oxadiargyl	6.28
pyrazosulfuron ethyl	2.80
Monocrotophos	0.45
Tricyclazole	2.41
Copper oxy chloride (Blitox)	1.00
Streptomycin sulphate	6.66
Carbendizam	0.45

* Cost/Price of inputs and output were same during both the years of experimentation.

PLATES





Plate 1: Overall view of experimental field



Plate 2: Field view of treatmental combinations



Plate 3: Efficacy of treatmental combinations at harvest



Plate 4: Recording of different observations

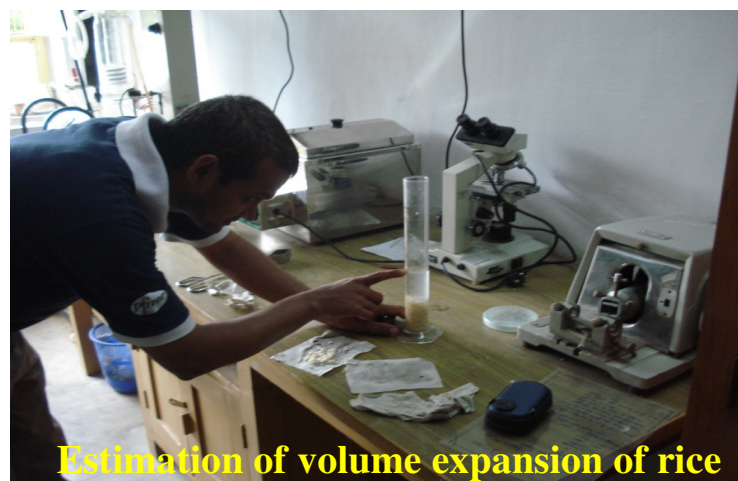
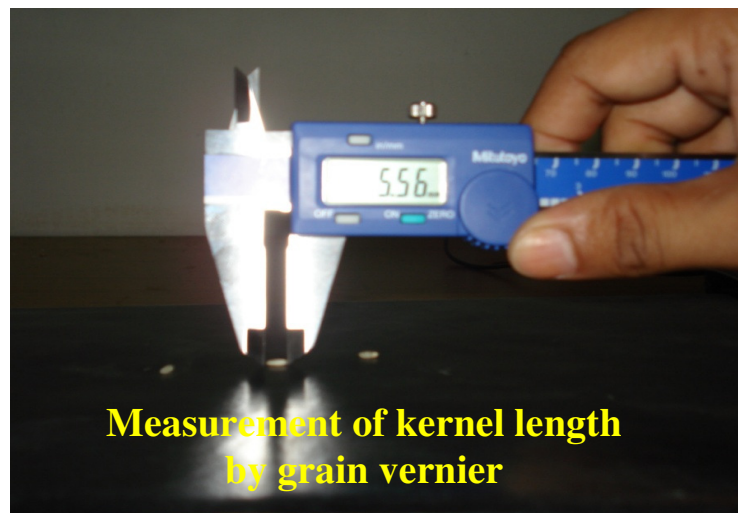


Plate 5: Estimation of quality parameters of grain