ISSN 2319-3670

Journal of Rice Research

Volume 8, No.2

December 2015

Society for Advancement of Rice Research

Society For Advancement of Rice Research

(Regd. No.2175/2004 of A.P. Society Regn. Act. 2001)

The Society for Advancement of Rice Research is a registered society for researchers, research managers extension personnel, institutions, development agencies, trade and industry who practice and promote activities for the advancement of rice science and development. The society has been started with overall objectives of providing a platform for exchange information and knowledge and disseminate the latest developments in rice research and to bring together all persons / institutions working for the cause of rice.

Aims and Objectives

- To advance the cause of rice research and development in the country.
- To disseminate knowledge on latest development in rice research through publications, seminars, lectures and training programs.
- To provide a platform for exchange of knowledge and information on rice research and developments through organizing workshops, symposia, conferences, etc.,
- To provide consultancy in rice production and development.
- To facilitate research and Industry collaboration and public private partnership at national level.
- To honour outstanding achievers in rice research and development.
- To cooperate with other organizations having similar aims and objectives
- To promote any other scientific/professional activities conducive for the advancement of science of rice and rice improvement.

Executive committee 2014-15 to 2015-16

President: Dr. V. Ravindra Babu; Vice President: Dr. A.K. Singh; Secretary: Dr. Vijay Pal Bhadana;
Joint Secretary: Dr. R. Robin; Treasurer: Dr. P. Revathi

Membership: Membership of the society is open to all persons interested in furthering the aims and objectives of the society and in the opinion of the executive committee have the necessary qualification and experience.

Category of the Members: a) Patrons b) Honorary members c) Life members d) Annual members e) Student members f)Corporate/ Institutional members.

Admission fee and Annual subscription fee

Class of Membership	Admission fee	Annual Subscription	
	INR	INR	US $
Ordinary Members	100.00	500.00	100
Life Members	100.00	2200 (one time)	600
Student Members	50	300.00	-
Corporate Members	Nil	10,000 (one time)	-
Library	Nil	2000	400

All membership subscriptions will become due on the 1st of January each year. Membership subscriptions should be paid within four months from the due date

Published by :

Dr. V. Ravindra Babu, President, Society for Advancement of Rice Research, Hyderabad.

Printed at :

Balaji Scan Pvt. Ltd., Hyderabad - 500 004. Ph: 040-23303424 / 25 E-mail: bsplpress@gmail.com

ISSN 2319-3670

Journal of Rice Research

Volume 8, No. 2 December 2015

Society for Advancement of Rice Research

Journal of Rice Research

Volume 8: Issue No. 2 December 2015

Contents

INVITED ARTICLE OPEN ACCESS

Weather Based Forewarning of Rice Yellow Stem Borer, *Scirpophaga incertulas* (Walker) at Raipur (Chhattisgarh, India)

S. Vennila[1]*, D.K. Das[2], J. Singh[2], R.K. Tanwar[1], S. Sharma[3] and C. Chattopadhyay[1]

[1]ICAR-National Research Centre for Integrated Pest Management (NCIPM), New Delhi

[2]ICAR-Indian Agricultural Research Institute (IARI), New Delhi

[3]Indira Gandhi Krishi Vishwa Vidyalaya (IGKVV), Raipur

*Corresponding Author:svennila96@gmail.com

Received: 15th October, 2015

Abstract

Pest forewarning provides lead time for managing impending pest attacks, and optimizes selection of pest control options for minimizing crop loss and reducing cost of plant protection. Light trap catches of rice yellow stem borer, *Scirpophaga incertulas* (Walker) recorded using light trap deployed at IGKVV rice research farm of Raipur were used in conjunction with the weather data of the location for development of weather based prediction through iterative approach between range of each weather variable, and population levels *S. incertulas* categorized as to low, medium and high severity. Validation of the weather based criteria for forewarning the population severity using the prediction rules for seasons between 2011 and 2014 indicated to 96.3% prediction accuracy. The weather based criteria and prediction rules have been integrated online for forewarning *S. incertulas* population levels for the current and future SMWs under the "Pest dynamics *vis a vis* Climate Change" of National Innovations on Climate Resilient Agriculture (NICRA), and made available for use at: http://www.ncipm.org.in/nicra/WeatherPrediction.aspx. Forewarning of *S. incertulas is* specific for Raipur location for *Kharif* season, and is expected to be in use with pest management advisory to the rice growers of the region.

Key words: Rice, *Scirpophaga incertulas*, weather, pest severity, prediction rules,forewarning

Introduction

Rice crop is attacked and damaged by large number of insects from nursery to harvest, but only a few of them are considered to be the pests that cause economic losses by minimizing the attainable yields. Rice stem borer is an important insect pest causing severe damage to rice crop in India (Reji *et. Al.,* 2014). Among them the yellow stem borer, *Scirpophaga incertulas* (Walker) is the most damaging species of rice stem borer in tropical Asia (Cohen *et al.,* 2000). Yellow stem borer is autochthonous and monophagous on rice (*Oryza spp)* (Douglass *et al.,* 2005) and occurs both in *kharif* and *rabi* seasons. It causes yield loss up to 19 per cent in early-planted rice crop, and 38-80 per cent in the late-planted rice. *S. incertulas* infestation in nursery as well as in transplanted crop causes drying of central shoot commonly referred as 'dead heart' (DH) in young plants, and boring at heading stage usually occurs at the peduncle node leading to 'white earhead' (WEH). The initiation of their infestation and spread is greatly influenced by the environment and phenology of the crop. Forewarning on their possible initiation and outbreaks or severity levels is very important for its management (Mandal *et al.,* 2011) based on which the timing of insecticide application as a prophylactic or curative measures can be decided to protect the crop.

Landholders have long used weather and climate information based on experience and intuition for planning and decision making on crop management. Over recent times, the availability of data bases of climatic information and the predictive tools ranging from correlation analysis to computer simulation models have made possible their utility to a much wider range of stakeholders (Coughlan and Huda 2008). A weather-based pest forewarning system is an important component of integrated pest management

(IPM) which can reduce the cost of cultivation by optimizing the timing and frequency of application of pest management measures and ensures operator, consumer and environmental safety by reducing chemical usage. For the purpose of development and use of pest weather models, both meteorological and biological data are required as inputs while the output is the anticipated outbreak of pest or disease. Present study used the meteorological and *S. incertulas* data of Raipur (CG) for development of heuristic rules that have the ability to predict the expected severity for any given week associated with *kharif* season.

Materials and Methods

Standard meteorological week wise data sets of weather and *S. incertulas* moths caught in light trap of the rice research farm at Indira Gandhi Krishi Vishwa Vidyalaya, Raipur (Chhattisgarh) were assembled for the period between 2000 and 2014 (fifteen years) for development and validation of prediction rules. Weather variables *viz.,* mean maximum temperature (°C), mean minimum temperature (°C), mean morning relative humidity (RHI %), total rainfall (mm) and sun shine hours (h/day) from 27 to 48 SMW were considered in conjunction with *S. incertulas* weekly moth catches obtained in light trap as a tool deployed for the pest monitoring for the formulation of weather based criteria predicting the pest severity. The moth catches of *S. incertulas* were categorized to the severity levels of low, moderate and high corresponding to population levels of <100, 100-1000 and high > 1000 moths/trap/week. The data sets of weather variables and S. *incertulas* severity corresponding to years 2000 to 2011 were used for development of weather based criteria for prediction of *S. incertulas* severity. The approach to the formulation of weather based criteria was based on the iterative process wherein the range for individual weather variables and rules of prediction were varied simultaneously testing the match with the observed levels of *S. incertulas* severity. Validation of the developed weather criteria and the rules was made considering the weekly data sets of weather and moth catches of *S. incertulas* of 2011-2014 (four years). Prediction accuracy was calculated based on the number of weeks positively predicting the category of pest severity using the formulated weather criteria and the prediction rules.

Results and Discussion

Weather plays an important role in determining the incidence of crop pests, and hence the models based on weather parameters are useful for forewarning of pest incidence (Agrawal and Mehta, 2007). Many studies also have worked out the relationship between weather parameters and their influence on the abundance and distribution of crop pests to develop weather-based pest forecasting models for use in regional crop protection (Lingappa *et al.,* 2003; Chattopadhyay *et al*., 2011 and Olatinwo *et al*., 2011). Weather based prediction for forewarning of pest is an important component of IPM practices to adopt management of pests according to predicted severity in turn to avoid excess use of pesticides on crops. While the tropical and sub-tropical crop of rice grows well under the temperature regimes of 20° to 40°C with an optimum 30°C during day time and 20°C during night time such warm weather is reported to be the main factor for high population buildup of yellow stem borer *S. incertulas*. Nandihalli *et al.,*1990 reported negative and positive relations of light trap catches of *S. incertulas* at Raichur to maximum temperature and evening relative humidity, and minimum temperature and morning relative humidity, respectively. The lower and upper threshold temperatures for *S. incertulas* reported are 10–15°C and 35–40°C, respectively. Present study attempted to develop simple rules with higher prediction accuracy as the mathematical models are often cumbersome for use with decision support system.

Weather based criteria and prediction rules for *S. incertulas*

Initial fixing of weather criteria considering congenial conditions for development of *S. incertulas* based on reports followed by the iterative approach of varying the range of weather variables for matching the observed severity through the satisfaction of rules using long term historical data has been found to be a logical and highly satisfactory approach. The weather criteria (Table 1) and classification of pest severity (Table 2), and the rules fulfilling more than three, three and less than three criteria predicting high, moderate and low severity levels, respectively of *S. incertulas* were developed for Raipur (CG) based on eleven years (2000-2010) data. While fulfilling all of these weather criteria indicate the high severity of *S. incertulas*, and the converse holds true for the low severity. Das *et al*., (2012) using the similar approach of the present study predicted the severity of *S. incertulas* at Aduthurai with weather criteria of mean maximum temperature (30-32^{o}C), mean minimum temperature (20-22^{o}C), mean morning relative humidity (90-93%), total rainfall (0-10 mm) and mean sunshine hours 8-9 h/day combined with moth catches/week/trap of <100, 100-200 and >200 corresponding to low, moderate and high severity. While the rules of prediction were the same, the prediction accuracy obtained was >90%. It is to be noted that the range of weather parameters favourable for stem borer and severity levels at each site is different. Reji *et al*. (2014) used multiple linear regression analysis to formulate pest-weather models for three sites of Southern India *viz.,* Warangal, Coimbatore and Pattambi wherein positive influence of temperature and relative humidity at Warangal, and negative relations of both weather parameters at other two locations were found for the stem borer damage thus reiterating the differing influence of the same weather variable differently at different places. Hence there is definite need for location specific predictions made available for use in pest forewarning.

Validation of weather based forewarning of *S. incertulas*

The severity of *S. incertulas* depended on the moth abundance in traps on weekly basis categorized as low, moderate and high based on historical data of the pest for that region. Based on the weather criteria and the rules developed, severity of *S. incertulas* was predicted for forewarning during each of the 16 SMWs (27-42) for *Kharif* season of 2011 – 2014. Exact predictions as that of the observed pest severity as well as biologically significant predictions wherein the predictions higher than the observed severity that would not have wrong management implications were used to assess prediction accuracy. The prediction accuracy in respect of *Kharif* seasons *viz.,* 2011, 2012 2013and 2014 were 100, 90 100 and 95%, respectively with a mean of 96.3%. Although overlaps of weather factors are common to a certain extent between locations and cropping systems, there is need for use of location specific relations between weather and *S. incertulas* severity for robust forewarning as well as its management. It is to be noted that the developed weather criteria and the *S. incertulas* severity *vis a vis* prediction rules have been incorporated for use with real time weather data uploaded at weekly interval from Raipur through http://www.ncipm.org.in/nicra/WeatherPrediction.aspx. While the prediction requested for the weeks prior to current SMW present results under validation the current SMW request would give the prediction result that can be disseminated at times of high severity to the farmers.

Conclusions

The criteria of higher severity of yellow stem borer *S. incertulas* were at Raipur (CG) are: maximum temperature (30-34^{o}C), minimum temperature (22 -23^{o}C), morning relative humidity (89- 92%), and total rainfall (up to10 mm) and sunshine hour 8-9 h /day on weekly basis. The application of model available through http://www.ncipm.org.in/nicra/WeatherPrediction.aspx for forewarning of yellow stem borer severity and its integration with in agro-advisory for the region would facilitate timely pest management practices.

Acknowledgements

Research work is an output of the project on " Pest Dynamics in relation to Climate Change (Target crop: Rice)" under the National Innovations on Climate Resilient Agriculture (NICRA) funded by Indian Council of Agricultural Research (ICAR), New Delhi under NCIPM, New Delhi.

References

Agrawal, R. and Mehta, S.C. 2007. Weather-based forecasting of crop yields, pests and diseases – IASRI models. *Journal of Indian Society of Agricultural Statistics* 61 (1):255-263.

Chattopadhyay, N., Samui, R.P., Rathore, L.S. 2011. Strategies for Minimizing Crop Loss due to Pest and Disease Incidences by *Adoption of Weather-Based Plant Protection Techniques Challenges and Opportunities in Agro meteorology* pp ٢٤٣-٢٣٥.

Cohen, M.B., Romena, A.M. and Gould, F. 2000. Dispersal by larvae of the stem borers *Scirpophaga incertulas* (Lepidoptera: Pyralidae) and *Chilo suppressalis* (Lepidoptera: Crambidae) in plots of transplanted rice. *Environmetal Entomology* 29:958-971.

Coughlan, K.J. and Huda, A.K.S. 2008. Use of weather and climate information for agricultural planning and decision making. *Journal of Agrometeorology*:249-260.

Das, D.K., Singh, J., Bentur, J.S., Ramasubramanian, G.V., Vennila, S., Tanwar, R.K., Jhanshilakshmi, V., Sampathkumar, M., Mishra, A. and Shahi, M. 2012. "Weather based prediction of rice yellow stem borer, *Scirophaga incertulas* (Walker) at Aduthurai, Tamil Nadu" in *3rd National symposium on Agriculture Production Protection in Context of Climate Change* (03-05 Nov) at BAU, Jharkhand. 116.

Douglass, E., Stevenson, G., Runjie, Z. and Marvin, K.H.

2005. Physiological time model of *Scirpophaga incertulas* (Lepidoptera: Pyralidae) in Rice in Guandong Province, People's Republic of China. *Journal of Economic Entomology* 98(4):1179-1186.

Lingappa, S., Yelshetty, S. and Venkatesh, H. 2003. Weather Based Forewarning System for the Pest and Disease Management, *Journal of Indian Society of Agricultural Statistics* 56(I):88-99.

Mandal, P., Roy, K. and Saha, G. 2011. Weather based prediction model of *Scirpophaga incertulas* (Walk.). *Annals of Plant Protection Sciences* 19(1):20-24

Nandihalli, B.S., Patil, B.V. and Huger, P. 1990. Influence of weather factors on the light trap catches of yellow rice borer under Tungabhadra project area. *Indian Journal of Ecology* 17(1):90-93.

Oletinwo, R.O., Prabha, T., Paz, J.O., Relay, G.G. and Hoogenboom, G. 2011. The weather research and forecasting (WRF) model: Application in prediction of TSWV – vectors population. *Journal of Applied Biology* 35 (1):81-90.

Reji, G., Chander, S. and Kamble, K. 2014. Predictive zoning of rice stem borer damage in southern India through spatial interpolation of weather-based models. *Journal of Environmental Biology* 35(1):923-928.

Table 1. Weather based criteria for forewarning severity of *S. incertulas*

Weather variables (on weekly basis)	Criteria
Maximum temperature (^{o}C)	30-34
Minimum temperature (^{o}C)	22-23
Morning relative humidity (%)	89-92
Evening relative humidity (%)	40-50
Total rainfall (mm)	up to 10
Sunshine hours (h/day)	6-9

Table 2. Severity levels and prediction rules forewarning of *S. incertulas*

Population of *S. incertulas* numbers (moth catches/ week/ trap)	Level of severity	No. of weather criteria satisfied	Predicted severity
> 1000	High	More than three	High
100 - 1000	Moderate	Three	Moderate
<100	Low	Less than three	Low

ORIGINAL RESEARCH ARTICLE OPEN ACCESS

Characterization of the mutant lines of Akshaya rice variety for blast resistance

B. Anusha[2], B. Krishna Veni[1], M. Sheshu Madhav[3], M. Srinivasa Prasad[3] and M. Lal Ahmed[2]

[1]Rice Research Unit, Bapatla, Guntur, Andhra Pradesh
[2]Agriculture College, Bapatla, Guntur, Andhra Pradesh
[3]ICAR-Indian Institute of Rice Research, Rajendranagar, Hyderabad
*corresponding author: bkv_lam@yahoo.co.in

Received: 17th March, 2015; Accepted: 10th December, 2015

Abstract

The M_4 generation mutant lines of Akshaya rice variety were characterized for blast resistance in 24 mutagenic treatments treated with gamma rays and EMS. The results of phenotypic screening carried out against blast disease by adopting the uniform blast nursery method at two locations revealed that majority of the mutant lines were moderately resistant to blast as that of the parent. The mutant lines derived from the treatments T9 (20kr + 0.25% EMS), T17 (30 kr) and T19 (40 kr+ 0.1% EMS) recorded blast score of 0-1 showing immune reaction whereas mutant lines derived from 7 other treatments (T1, T2, T7, T14, T15, T16 and T22) scored 8-9 and manifested highly susceptible reaction both at Bapatla and Hyderabad. Based on the results of the polymorphism with the markers tested, it was concluded that the mutation might have occurred in the location between 35.1 Mb (RM208) to 37.6 Mb (RM266) on 2nd chromosome and / or 34.5 Mb (RM 567) to 34.9 Mb (RM280) on 4th chromosome. The results of gene profiling studies revealed that these resistant mutant lines do not possess the tested eight major blast resistant genes.

Key words: Resistance, blast, chromosome, mutant lines, polymorphism

Introduction

The use of resistant cultivars is the most economically viable and effective way of controlling rice blast, but the useful life span of many cultivars is only for few years in disease conducive environments because of the breakdown of resistance in the face of high pathogenic variability of *M. oryzae*. Hence, breeding of cultivars with more durable resistance has become a constant challenge in rice breeding programs. Mutations were traditionally identified on the basis of their morphological properties, but the development of new techniques based on DNA information has made this process quicker and more reliable. The present study was undertaken during *kharif* 2012 at Rice Research Unit (RRU), Bapatla and Indian Institute of Rice Research (IIRR), Hyderabad with an objective of identifying blast resistant lines from the M_4 generation mutant population of Akshaya rice variety.

Material and Methods

The material for the present study comprised of 24 mutagenic treatments along with the control variety Akshaya (BPT 2231) treated with gamma rays (10kr, 20kr, 30 kr and 40kr), ethyl methane sulfonate (0.1%, 0.2%, 0.25% and 0.3%) and their combinations. The M_1, M_2 and M_3 generations were raised at RRU, Bapatla. In the M4 generation, ten single plant progenies of each mutant treatment along with the control were grown during *rabi* 2012-13 at two locations *viz.*, RRU, Bapatla and at Indian Institute of Rice Research, Hyderabad. The phenotypic screening of the mutant lines was carried out against blast disease by adopting the uniform blast nursery method. Uniform Blast Nursery was laid out in 10 X 1 m bed and the soil is pre-treated with FYM and recommended dose of fertilizers. Later commercial sulphuric acid is added to the beds before sowing. The susceptible variety for blast HR 12 was sown as border on all sides of the bed and in between the rows after every ten rows for spreading the inoculum under natural conditions. The test material was sown in 50cm rows perpendicular to the border rows. Relative humidity is maintained with water sprinklers. The beds are covered with polythene sheets during night to maintain high humidity and to increase the disease pressure on the entries. All necessary precautionary measures were taken up to increase/develop the disease pressure on mutant lines and the scoring for blast symptoms was done by using Standard Evaluation System, SES, (IRRI,1996) at 30 days after sowing at which the susceptible check HR 12 died. The DNA for genotypic screening was isolated from young leaves harvested after 21 days of sowing using C-TAB method as described by Doyle and Doyle (1990).

The genomic DNA of the selected mutant lines (identified through phenotypic screening) was subjected to PCR amplification as per the procedure described by Chen *et al.* (1997). PCR was carried out using a programmable thermocycler (Corbett Research, Australia). The PCR reaction mixture containing 2µl DNA, 8.5 µl water, 1.5 µl Taq buffer, 1 µl dNTP, 0.5 µl forward primer, 0.5 µl reverse primer and 1 µl Taq polymerase (15 µl reaction mixture) was subjected to the polymerase chain reaction. 36 microsatellite markers distributed over 12 chromosomes were used to reveal the genetic polymorphism between resistant and susceptible mutants.

Gene Profiling

In order to identify the blast resistant gene present in the resistant mutant lines that are screened at field level, gene profiling was carried out using eight major blast resistant gene specific markers *viz*., *Pi1, Pi2, Pi9, Pi33, Pi54, Pib, Pita and Pita2* (Table 1). The positive and negative checks along with the untreated control Akshaya were utilized for each gene separately. The negative checks used were BPT-5204, Co-39 and Swarna which do not contain any gene conferring resistance to blast.

The profile of the PCR (PCR conditions)

94ºC: 5 minutes (Initial denaturation)

94ºC: 30 seconds (denaturation)

55ºC: 1 minute (annealing)

72ºC: 1 minute (extension)

72ºC: 10 minutes (final extension)

Agarose gel electrophoresis

A 3% gel was prepared and the PCR product was loaded to check the amplification of SSR markers.

Gel documentation

After the gel run, the gel was visualized under UV light transmitted gel documentation system. The banding pattern was observed and recorded using gel documentation unit (Alpha Infotech, USA).

Results and Discussion

The results of phenotypic screening revealed that majority of the mutant lines were moderately resistant to blast as that of the parent (Table 2). Mutant lines from the treatments T9 (20kr + 0.25% EMS), T17 (30 kr) and T19 (40 kr+ 0.1% EMS) scored 0-1 showing immune reaction whereas mutant lines from 7 treatments (T1, T2, T7, T14, T15, T16 and T22) scored 8-9 and manifested highly susceptible reaction both at Bapatla and Hyderabad.

The genotypic screening was done using three highly resistant mutant lines *viz.,* T9, T17 and T19 treatments and three susceptible lines from T14, T16 and T22 treatments which were identified through phenotypic screening in the Uniform Blast Nursery in both the locations. The control variety Akshaya was also included to confirm the blast resistance. Among the 36 tested SSR primers, 27 primers showed monomorphic banding pattern indicating that the mutation has not occurred in those loci. Five markers *viz.,* RM266, RM280, RM228, RM72 and RM23946 showed considerable polymorphism and the number of alleles detected per primer ranged from 2 (RM228, RM266 and RM72) to 5 (RM23946). The amount of polymorphism reflects the existence of considerable difference in their loci among resistant and susceptible mutant lines. Abedi *et al.* (2012) reported a significant level of polymorphism with four microsatellite markers *viz.,* RM224, RM277, RM463 and RM179 and tested the association between phenotypic results and the molecular data in rice.

The results of amplification pattern with the marker RM266 on second chromosome showed the significant polymorphism among the mutant lines. The amplicons of the resistant mutant lines have similar amplicon size and it differed with that of all the susceptible lines, the amplification of susceptible mutant lines is similar to that of control (Fig.1). The amplification pattern with the primer RM280 on fourth chromosome manifested a clear polymorphism between resistant mutant lines with its parent (Fig.2). The treatment T9 (R1) is differentiated with the other two resistant mutant lines (T17 and T19) but T17 and T19 (R2 and R3) differed significantly with control as well as with susceptible lines. The banding pattern with the flanking marker RM208 to the primer RM266 manifested clear polymorphism among the resistant and susceptible lines (Fig. 3). Zhou *et al*. (2004) also reported the presence of the blast resistant gene *pi g(t)* by using marker RM208.

Similarly, significant polymorphism between resistant and susceptible lines was also evident from the banding pattern of flanking marker RM567 on chromosome 4 (Fig. 4).

Based on the results of the polymorphism with the arkers tested, it was concluded that the mutation might have occurred in the location between 35.1 Mb (RM208) to 37.6 Mb (RM266) on 2 nd chromosome and / or 34.5 Mb (RM 567) to 34.9 Mb (RM280) on 4th chromosome which might have led to the resistant reaction against blast conferred by the mutant lines isolated from treatments T9, T17 and T19. Madamba *et al*. (2009) isolated a gamma ray induced IR 64 mutant G978 that showed enhanced resistance to blast. The mutation was mapped as a quantitative trait locus to a 3.8-Mb region on chromosome 12.

A molecular profile for the resistant mutant lines was carried out using eight major blast genes (*Pi 1, Pi 9,Pi 2, Pi 54, Pi b, Pi ta, Pi 33 and Pi ta 2*) linked markers to confirm whether the resistant mutant lines have any known blast resistant gene. The DNA of these resistant mutant lines (T9, T17 & T19 treatments) and three susceptible lines identified through phenotyping were used along with the control Akshaya for gene profiling studies. All the amplicons of mutant lines were not similar to that of putative controls. The results of gene profiling studies revealed that these resistant mutant lines do not possess the tested 8 major blast resistant genes (Fig.5).

With the polymorphic survey, it was observed that the mutation might have occurred in the chromosome 2 and 4. But, the gene profiling results indicated that the resistance is not due to the P*i b* gene which was reported from chromosome 2 and also the polymorphic markers *viz.,* RM 266 and RM208 which were reported to be linked with P*i b* gene, so the resistance could be due to the loci which was not earlier reported on chromosome 2. To identify the gene/genes responsible for the resistant reaction in these mutant lines the resistant lines have to be crossed with the control/ any other susceptible variety and the genetics of resistance can be further studied in the F2 generation to unravel the effect of mutation in conferring the resistance.

References

Abedi, F., Babaeiyan, N. and Moumeni, A. 2012. Performance of different rice genotypes against blast pathogen through linked molecular markers. *Journal of Crop Science and Biotechnology*. 15 (2): **79-84.**

Chen, X., Temnykh, S., Xu, Y., Cho, Y.G. and McCouch S.R. 1997. Development of a microsatellite framework map providing genome-wide coverage in rice (*Oryza sativa* L.). *Theoretical and Applied Genetics.* 95 (4): 553-567.

Doyle, J.J and Doyle, J.L. 1990. Isolation of plant DNA from fresh tissue. *Focus.* 12: 13-15.

Madamba, M.R.S., Sugiyama, N., Bordeos, A., Mauleon, R., Satoh, K., Baraoidan,M., Kikuchi, S., Shimamoto, K. and Leung, H. 2009. A recessive mutation in rice conferring non-race-specific resistance to bacterial blight and blast. *Rice.*2 (2/3): 104-114.

International Rice Research Institute. 1996. Standard Evaluation System for Rice. *International Rice Research Institute,Philippines.* 52.

Zhou, J.H., Wang, J.L., Xu, J.C., Lei, C.L. and Ling, Z.Z. 2004. Identification and mapping of a rice blast resistance gene *Pi-g(t)* in the cultivar Guangchangzhan. *Plant Pathology*. 53: 191-196.

Table 1. Major blast resistant gene specific markers

S.No.	Blast resistant gene	Chromosome No.	Positive check	Primer
A	*Pi1*	11	C101LAC	RM 224
B	*Pi9*	6	*O.minuta*,SP48	RM 7103
C	*Pi54*	11	Tetep	RM 206
D	*Pi2*	6	C101A51	RM 56595
E	*Pib*	2	SP 51	RM 166
F	*Pita*	12	Tadukan	RM7 102
G	*Pi33*	8	Bala, IR 64	RM 72
H	*Pita2*	12	IR 64	RM 7102

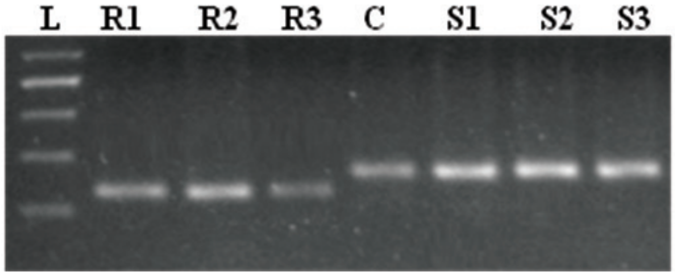
\+ Positive check R1-T9 R2- T17 R3-T19

-Negative check C- T25 (Akshaya) S1- T14 S2- T16 S3 –T22

Table 2. Screening of mutant lines of Akshaya for blast resistance at IIRR, Rajendranagar and at Agriculture College, Bapatla

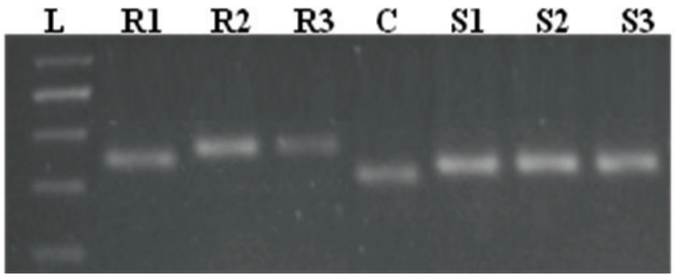
S.No	Treatment	IIRR, Rajendranagar		Bapatla	
		Score	Reaction	Score	Reaction
1	T1 (10kr+0.1%EMS)	8	HS	8	HS
2	T2 (10kr+0.2%EMS)	8	HS	8	HS
3	T3(10kr+0.25%EMS)	4	MR	3	R
4	T4 (10kr+0.3%EMS)	8	HS	7	S
5	T5 (10kr)	7	S	6	MS
6	T6 (0.1% EMS)	6	MS	6	MS
7	T7 (20kr+ 0.1%EMS)	8	HS	8	HS
8	T8 (20kr+ 0.2%EMS)	4	MR	3	R
9	T9 (20kr+ 0.25%EMS)	1	HR	1	HR
10	T10 (20kr+ 0.3%EMS)	4	MR	3	R
11	T11 (20kr)	8	HS	7	S
12	T12 (0.2%EMS)	8	HS	7	S
13	T13 (30kr+0.1%EMS)	5	MR	4	MR
14	T14 (30kr+0.2%EMS)	9	HS	9	HS
15	T15 (30kr+0.25%EMS)	9	HS	9	HS
16	T16 (30kr+0.3%EMS)	9	HS	8	HS
17	T17 (30kr)	1	HR	0	HR
18	T18 (0.1%EMS)	7	S	6	MS
19	T19 (40kr+ 0.1% EMS)	1	HR	1	HR
20	T20 (40kr+ 0.2% EMS)	3	R	3	R
21	T21 (40kr+ 0.25% EMS)	3	R	3	R
22	T22 (40kr+ 0.3% EMS)	9	HS	8	HS
23	T23 (40kr)	5	MR	4	MR
24	T24 (0.3% EMS)	4	MR	3	R
25	T25 (Control variety Akshaya)-	5	MR	5	MR

R: Resistant; MR: Moderately resistant; HR: Highly resistant; S: Susceptible; MS: Moderately susceptible; HS: Highly susceptible



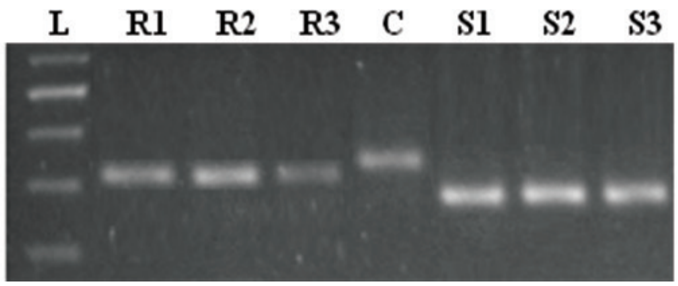
Chromosome 2 RM 266

Fig 1. Banding pattern of PCR amplified product of microsatellite marker RM266 on chromosome 2



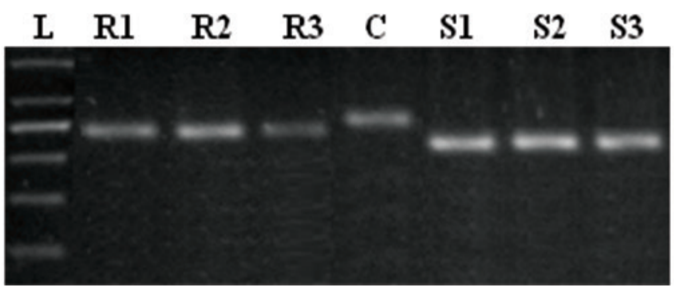
Chromosome 4 RM280

Fig. 2. Banding pattern of PCR amplified product of microsatellite marker RM280 on chromosome 4



Chromosome 2 RM 208

Fig. 3. Banding pattern of PCR amplified product of microsatellite marker RM208 on chromosome



Chromosome 4 RM 567

Fig. 4. Banding pattern of PCR amplified product of microsatellite marker RM567 on chromosome 4

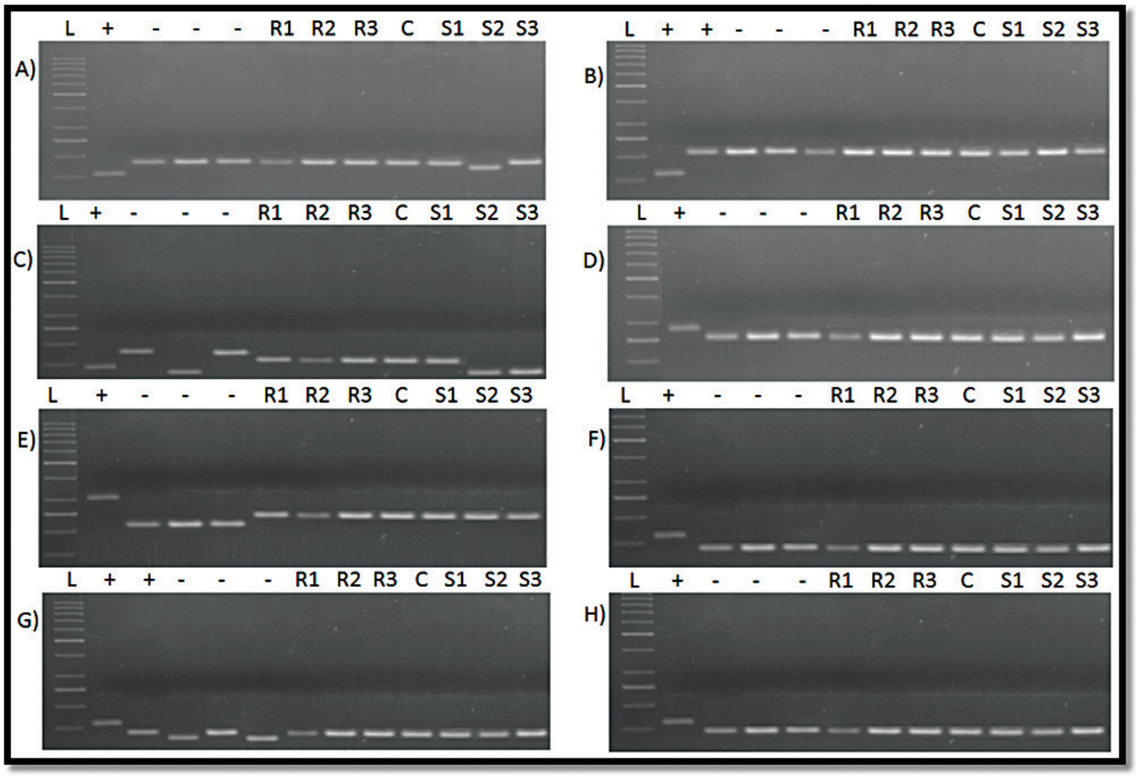


Fig. 5. Gene profiling with the primers specific to blast resistance genes *Pi1, Pi9,Pi54, Pi2,Pib, Pita, Pi33 and Pita2* on chromosomes 6,11, 2, 8 and 12 of rice

ORIGINAL RESEARCH ARTICLE OPEN ACCESS

Molecular Characterization of Aromatic Landraces of Rice (*Oryza sativa* L.) Using Microsatellite Markers

Nirmala Bharti Patel, Neha Agrawal* and Rajeev Shrivastava

Department of Genetics and Plant Breeding, Indira Gandhi Agricultural University, Raipur, Chhattisgarh India

*Corresponding author: pnehaagrawal@gmail.com

Received: 15th July, 2015; Accepted: 20th December, 2015

Abstract

Simple Sequence Repeats (SSR) analysis was performed to assess the genetic diversity in thirty eight aromatic landraces of rice (*Oryza sativa* L.) using 19 SSR primers. The experiment was conducted during *kharif*, 2011 at the Research cum Instructional Farm of Indira Gandhi Krishi Vishwavidyalay, Raipur. 10 SSRs were polymorphic and 3 SSRs were monomorphic while the remaining 6 showed no amplification. The genetic similarity coefficients ranged from 0.40 to 1.00. Cluster analysis was performed using Unweighted Paired Group of Arithmetic Means (UPGMA) using the Jaccard's similarity coefficient. The UPGMA dendrogram resolved the 38 aromatic landraces of rice into two major clusters.

Key words: Aromatic rice, Genetic diversity, Cluster analysis, SSR, Polymorphism

Introduction

Rice (*Oryza sativa* L.) feeds more than 50 % of the tropical populace. A class of aromatic, superfine grade premium rice has evolved its own market niches, making rice trade a commercial success internationally. The Indian aromatic rice, often called Basmati is nature's gift to the sub continent and human kind at large (Ahuja *et al.,* 1995). Basmati rice is highly priced in domestic as well as international markets. Indigenous short aromatic grain (ASG) rice, possess outstanding quality characteristics *viz*., aroma, kernel elongation after cooking (KLAC), fluffiness and taste. However, ASG improvement has been somewhat neglected as they lacked export value. Almost every state of the country has its own set of aromatic rice that performs well in native areas.

Scope of improvement of these landraces depends not only on on the conserved use of genetic variability and diversity but also on the use of new biotechnological tools. Molecular characterization can reveal the maximum genetic variation or genetic relatedness found in a population (Xu *et al*., 2000). Chakravarthi and Naravaneni (2006) reported the usefulness of preservation and conservation of genetic resources since genetic diversity provides information to monitor germplasm and prediction of potential genetic gains. Information regarding genetic variability at molecular level could be used to help, identify and develop genetically unique germplasm that compliments existing cultivars (Ni *et al*., 2002; Ravi *et al*., 2003; Chakravarthi and Naravaneni, 2006). DNA based molecular markers have proven to be powerful tools in the assessment of genetic variation and in the elucidation of genetic relationships within and among the species of rice (Ragunathanchari *et al*., 1999, 2000; Shivapriya and Hittalmani, 2006). The present investigation was undertaken for the assessment of genetic diversity among the aromatic rice landraces with the help of SSR markers.

Materials and Methods

Plant materials and genomic DNA isolation

The plant materials selected for the present study were thirty eight different aromatic landraces of rice (Table 1). The experiment was conducted during the *kharif* season of 2011 at the Research cum Instructional Farm of Indira Gandhi Krishi Vishwavidyalay, Raipur.

Healthy seeds of each variety were sown in pots under appropriate growth conditions for collecting fresh leaves. Total genomic DNA from thirty eight landraces was extracted from six weeks old rice seedlings by mini prep method of DNA extraction. 0.1g of leaf sample was put it into 2 ml eppendorf tube. 0.4 ml of extraction buffer and beads were added to it and grinded using a crusher. 0.4 ml of 24:1 Chloroform:-Isoamyl alcohol mixture was added and mixed well by vortexing and centrifuged at 14000 rpm for 4 min. Supernatant was collected and transferred to a new eppendorf tube (this action was repeated twice). 0.8 ml of absolute ethanol was added and mixed properly by the tube inversion and centrifuged at 14000 rpm for 4 min. Supernatant was discarded and pellet was washed with 70% Ethanol and air dried for 15-20 min. Pellets were dissolved in 20-40 µl (based on the size of the pellet) of TE buffer or double distilled sterile water and treated with 3 µl RNase for 20 min to remove RNA.

Quantification of DNA

1. Nanodrop spectrophotometer based quantification

Nucleic acid has maximum absorbance of ultra violet light *i.e.*, about 260 nm. The ratio between the readings at 260 nm and 280 nm (OD 260/ OD 280) provides an estimate for the purity of nucleic acid. Pure preparation of DNA and RNA has a ratio of approximately 1.8 and 2.0 respectively. If there is contamination with protein or phenol the ratio will be significantly less than this value (< 1.8). A ratio greater than 2.0 indicates a high proportion of RNA in the DNA sample.

2. Dilution of DNA

The crude DNA after quantification was diluted suitably for amplification. DNA was diluted in such a way that the diluted samples contained about 50 ng/µl of crude DNA. Dilution was carried out according to the formula:

$$\text{Dilution} = \frac{\text{Required conc. o f DNA (ng/µl) X Total volume required (µl)}}{\text{Available conc. of crude DNA (ng/µl)}}$$

SSR analysis

For the SSR analysis,2 µl diluted template DNA of each entry was dispensed in PCR plates. Separate cocktail PCR master mix was prepared in an eppendorf tube. The quantity of 18 µl cocktail was added to each well of PCR plates having template DNA. The reaction was carried out in 20 µl reaction volume containing 2 µl (10 ng/ µl) genomic DNA, 11 µl nanopure water, 2 µl 10X PCR buffer, 2 µl 1mM dNTPs, 1 µl Taq DNA polymerase and 2 µl primer (Forward and Reverse). All the reaction chemicals except primers were procured from M/s. Genei, Bangalore, India.

SSR amplification procedure

The PCR tubes were kept in a PCR machine model PTC-100 of MJ research. The DNA was amplified by using profile with some modifications of thermal cycler. Amplification was performed in a thermal cycler with an initial denaturation of 94^0C for 4 min followed by 35 cycles which contains denaturation at 94^0C for 1 min followed by annealing in which the annealing temperature was adjusted based on the Tm value of each primers and finally extension at 72^0C for 5 min.

Electrophoresis and visualization of SSR products

13 µl of PCR amplified SSR was mixed with 2 µl of loading dye (bromophenol) and loaded on 5% polyacrylamide gel prepared in 1X TBE buffer. PBR-322 (ladder) molecular marker was also loaded along with the DNA samples. Electrophoresis was done for 1 hr at 199 volts. The gel along with the DNA samples was then stained with Eithidium bromide (10 µg/10ml) for 40-45 mins. Gel was visualized on UV-transilluminator and images were saved in computer. The banding pattern in the landraces for each set of primers was scored separately. For estimating the size of DNA of each sample, the band position was compared with a base pair of standard marker (PBR-322 ladder). Presence of band in a particular base pair position was scored as “1” and absence of band in a particular base pair position was scored as “0”(zero). The 19 SSR primers used for this purpose are presented in table 2.

Results and Discussion

The results of present study indicated a considerable level of genetic diversity among the cultivars selected. Nineteen SSR markers *viz*., RM-9, RM-215, RM-228, RM-245, RM-247, RM-251, RM-288, RM-302, RM-307, RM-323, RM-335, RM-410, RM-411, RM-433, RM-444, RM-484, RM-506, RM-517 and RM-535 present on different rice chromosomes were studied. There was no amplification with six SSRs (RM 228, RM 245, RM 302, RM 307, RM 323 and RM 517). Ten SSR markers (RM 9, RM 247, RM 251, RM 335, RM 410, RM 411, RM 433, RM 484 RM 444 and RM 535) showed polymorphic reaction, where as three SSR markers RM 215, RM 288 and RM 506 exhibited monomorphic reaction (Fig 1). The dendrogram derived from UPGMA cluster analysis based on similarity coefficient matrix of 38 landraces was constructed. The genetic similarity coefficient for all accessions ranged from 0.40 - 1.00. Results (Fig. 2) indicated that two major groups were formed having 40% similarity *i.e.*

Jawaphool with rest of the aromatic landraces. All the aromatic landraces except Jawaphool were grouped into two classes at nearly 50 % genetic similarity level. Seven genotypes *viz*., Dubraj-1, Dubraj-2, Dubraj-3, Maidubraj, Kharigilas, Kasturi and Dujai clustered together into one group while remaining 30 landraces *viz*., Tulsimanjari, Kalikamod, Atmasheetal, Shuklaphool, Kheraghul, Gangabaru, Jaigundi, Tulsiprasad, Kapoorsar, Chinnor-1, Kubrimohar-1, Jeeradhan, Anterved, Jaophool, Londhi, Samudrafan, Chinnor-2, Kubrimohar-2, Tilkasturi, Elaychi, Lalloo-14, Badhshshbhog, Bisni, Shyamjeera, Katarnibhog, Vishnubhog-2, Gopalbhog, Srikamal, Jeeraphool and Vishnubhog-1 clustered together in the second group.

In group I, Kasturi which is not an aromatic landrace of Chhattisgarh exhibited 55 % similarity with Dubraj group, Dujai and Kharigilas. Kharigilas and rest of the races of group I had 70% genetic similarity. Further, 5 landraces of group I formed two classes which indicated that Dubraj-3 and Maidubraj have genetic similarity nearly 82% according to 13 loci under study.

In second group, Vishnubhog-1 exhibited 61 % genetic similarity with rest of the entries of group II. This group was further divided into two sub groups. With 70 % genetic similarity, group II A included Lalloo-14, Badhshshbhog, Bisni, Shyamjeera, Katarnibhog, Vishnubhog-2, Gopalbhog, Srikamal and Jeeraphool. Whereas group II B included Tulsimanjari, Kalikamod, Atmasheetal, Shuklaphool, Kheraghul, Gangabaru, Jaigundi, Tulsiprasad, Kapoorsar, Chinnor-1, Kubrimohar-1, Jeeradhan, Anterved, Jaophool, Londhi, Samudrafan, Chinnor-2, Kubrimohar-2, Tilkasturi and Elaychi. Kapoorsar, Chinnor-1 and Kubrimohar exhibited 100 % genetic similarity for loci under study. Anterved and Jaophool also exhibited 100 % genetic similarity and also exhibited 91 % genetic similarity with Londhi.Chinnor-2 and Kubrimohar-2 showed similarity for all 13 loci whereas with Tilkasturi, they exhibited 91% genetic similarity. Badhshshbhog, Bisni and Shyamjeera were also found similar for all 13 loci but they were 85% similar with Lalloo-14.

The present investigation reveals that SSR is a valuable tool for estimating the extent of genetic diversity as well as to ascertain the genetic relationship between different cultivars of *Oryza sativa*.

References

Ahuja, S.C., D.V.S. Pawar, Ahuja, U. and Gupta K.R. 1995. *Basmati Rice – The Scented Pearl*, *Tech. bulletin*. Haryana Agriculture University, Hisar, India.

Chakravarthi, B.K. and Naravaneni, R. 2006. SSR marker based DNA fingerprinting and diversity study in rice (*Oryza sativa* L.). *African Journal of Biotechnology* 5(9): 684-688.

Ni, J., Colowit, P.M. and Mackill, D.J. 2002. Evaluation of genetic diversity in rice subspecies using microsatellite markers. *Crop Science* 42:601-607.

Ragunathanchari, P., Khanna, V.K., Singh, N.K. and Singh, U.S. 2000. A comparison of agarose RAPD and polyacrylamide RAPD to study genetic variability in *Oryza sativa* L. *Acta Botany Indica*. 27: 41-44.

Ragunathanchari, P., Khanna, V.K., Singh, U.S. and Singh, N.K. 1999. RAPD analysis of genetic variability in Indian scented rice germplasm *Oryza sativa* L. *Current Science* 79: 994-998.

Ravi, M., Geethanjali, S., Sameeyafarheen, F. and Maheswaran, M. 2003. Molecular marker based genetic diversity analysis in rice (*Oryza sativa* L.) using RAPD and SSR markers. *Euphytica* 133:243-252.

Shivapriya, M. and Hittalmani, S. 2006. Detection of genotype specific fingerprints and molecular diversity of selected Indian locals and landraces of rice (*Oryza sativa* L.) using DNA markers. *Indian Journal of Genetics and Plant Breeding* 66:1-5.

Xu, R., Norihiko, T., Vaughan, A.D. and Doi, K. 2000. The *Vigna angularis* complex: Genetic variation and relationships revealed by RAPD analysis and their implications for *In-situ* conservation and domestication. *Genetic Resources and Crop Evolution* 47:123-134.

Table 1. Landraces used in study and places from where they are collected

S. No.	Variety	Source	S. No.	Variety	Source
1	Anterved	Chhuriya/ Rajnandgaon	20.	Londhi	Pendra
2	Atmasheetal	Chhindgarh / Bastar	21.	Mai Dubraj	Bastar
3	Badshahbhog	Jagadalpur	22.	Samudrafan	Pandariya/ Bilaspur
4	Bisni	Surajpur	23.	Shyamjeera	Surajpur
5	Chinnor –I	Balaghat	24.	Srikamal	Raipur Naikin / Sidhi
6	Chinnor-II	Tilda / Raipur	25.	Kalikamod	Aarang/ Raipur
7	Dubraj-I	Nagari	26.	Kapoorsar	Jabera/ Damoh
8	Dubraj-II	Balaodabazar/ Raipur	27.	Kasturi	Bakawand/ Bastar
9	Dubraj-III	Nagri	28.	Kharigilas	Charama/ Bastar
10	Dujai	Pendra	29.	Katarnibhog	Sabour (Bihar)
11	Elaychi	Phingeshwar/ Raipur	30.	Kheraghul	Gharghoda/ Raigarh
12	Gopalbhog	Bagicha, Sarguja	31.	Kubrimohar-I	Bemetra
13	Gangabaru	Chhindgarh/Bastar	32.	Kubrimohar-II	Magarload/ Raipur
14	Jaigundi	Saraypali / Raipur	33.	Sukalaphool	Jaijepur/ Bilaspur
15	Javaphool	Raigarh	34.	Tilkasturi	Pithora/ Raipur
16	Jeeradhan	Tilda / Raipur	35.	Tulasiprasad	Aarang/ Raipur
17	Jeeraphool	Bageecha, Sarguja	36.	Tulsimanjari	Sabour / Bihar
18	Jaophool	Lallunga / Raigarh	37.	Vishnubhog-I	Pendra
19	Lalloo-14	Mandla	38.	Vishnubhog-II	Badrafnagar/ Sarguja

Table 2. Microsatellite markers used for genetic diversification among 38 rice landraces

	SSR Primers	PRIMER SEQUENCES	
		FORWARD 5’ → 3’	REVERSE 5’ → 3’
1	RM 9	GGTGCCATTGTCGTCCTC	ACGGCCCTCATCACCTTC
9	RM 215	CAAAATGGAGCAGCAAGAGC	TGAGCACCTCCTTCTCTGTAG
10	RM 228	CTGGCCATTAGTCCTTGG	GCTTGCGGCTCTGCTTAC
9	RM 245	ATGCCGCCAGTGAATAGC	CTGAGAATCCAATTATCTGGGG
12	RM 247	TAGTGCCGATCGATGTAACG	CATATGGTTTTGACAAAGCG
3	RM 251	GAATGGCAATGGCGCTAG	ATGCGGTTCAAGATTCGATC
9	RM 288	CCGGTCAGTTCAAGCTCTG	ACGTACGGACGTGACGAC
1	RM 302	TCATGTCATCTACCATCACAC	ATGGAGAAGATGGAATACTTGC
4	RM 307	GTACTACCGACCTACCGTTCAC	CTGCTATGCATGAACTGCTC
1	RM 323	CAACGAGCAAATCAGGTCAG	GTTTTGATCCTAAGGCTGCTG
4	RM 335	GTACACACCCACATCGAGAAG	GCTCTATGCGAGTATCCATGG
9	RM 410	GCTCAACGTTTCGTTCCTG	GAAGATGCGTAAAGTGAACGG
3	RM 411	ACACCAACTCTTGCCTGCAT	TGAAGCAAAAACATGGCTAGG
8	RM 433	TGCGCTGAACTAAACACAGC	AGACAAACCTGGCCATTCAC
9	RM 444	GCTCCACCTGCTTAAGCATC	TGAAGACCATGTTCTGCAGG
10	RM 484	TCTCCCTCCTCACCATTGTC	TGCTGCCCTCTCTCTCTCTC
8	RM 506	CGAGCTAACTTCCGTTCTGG	GCTACTTGGGTAGCTGACCG

3	RM 517	GGCTTACTGGCTTCGATTTG	CGTCTCCTTTGGTTAGTGCC
2	RM 535	ACTACATACACGGCCCTTGC	CTACGTGGACACCGTCACAC

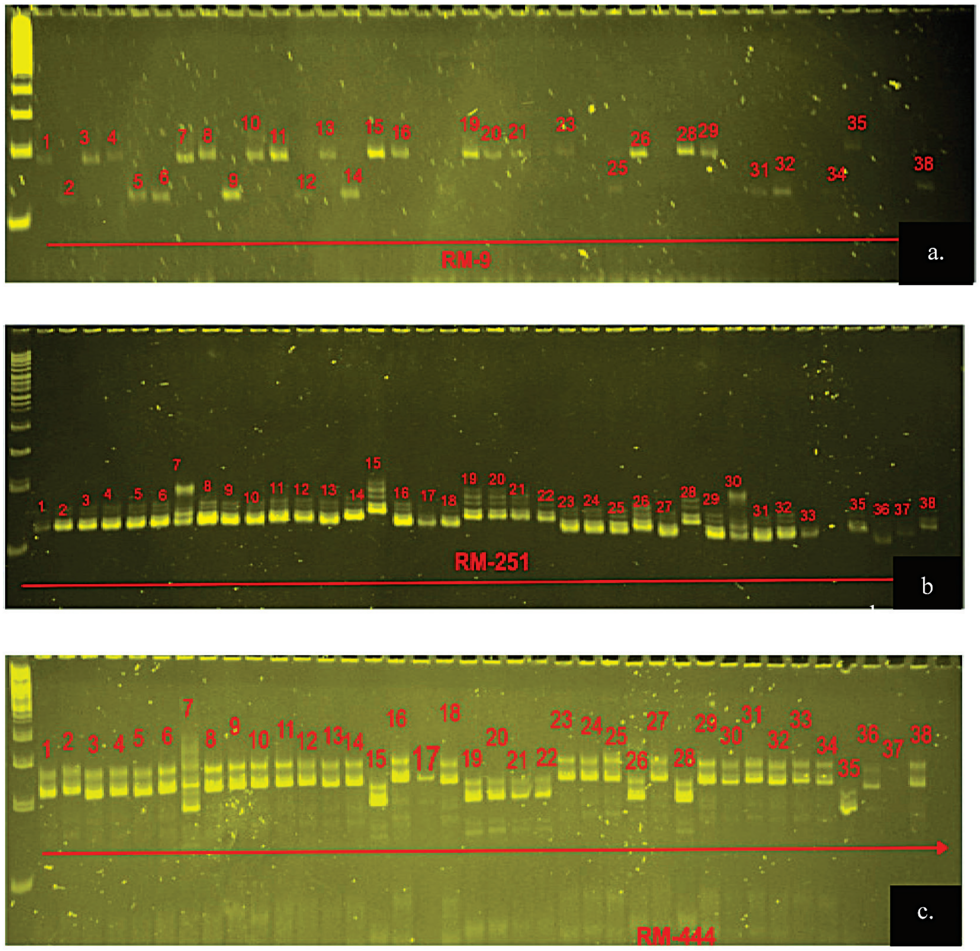


Fig. 1. SSR primers banding pattern of thirty eight aromatic rice landraces using primers a) RM 9 b) RM 251 and c) RM 444

Sequence of 38 rice landraces in gel pictures

1= Tulsimanjari	2= Kapoorsar	3= Kalikamod	4= Atmasheetal	5= Jiradhan	6= Chinnor-1
7= Chinnor-2	8= Shukulaphool	9= Elaychi	10= Gangabaru	11= Jaigundhi	12= Anterved
13= Tulsiprasad	14= Kubrimohar-1	15= ubrimohar-2	16= Keraghul	17= Samudrafan	18= Jouphool
19= Dubraj-1	20= Dubraj-2	21= Dubraj-3	22= Maidubraj	23= Lallu-14	24= Katarnibhog
25= Badshahbhog	26= Karigilas	27= Shrikamal	28= Tilkasturi	29= Vishnubhog-1	30= Vishnubhog-2
31= Shyamjeera	32= Bisni	33= Jeeraphool	34= Londhi	35= Dujai	36= Gopalbhog
37= Jawaphool	38=Kasturi				

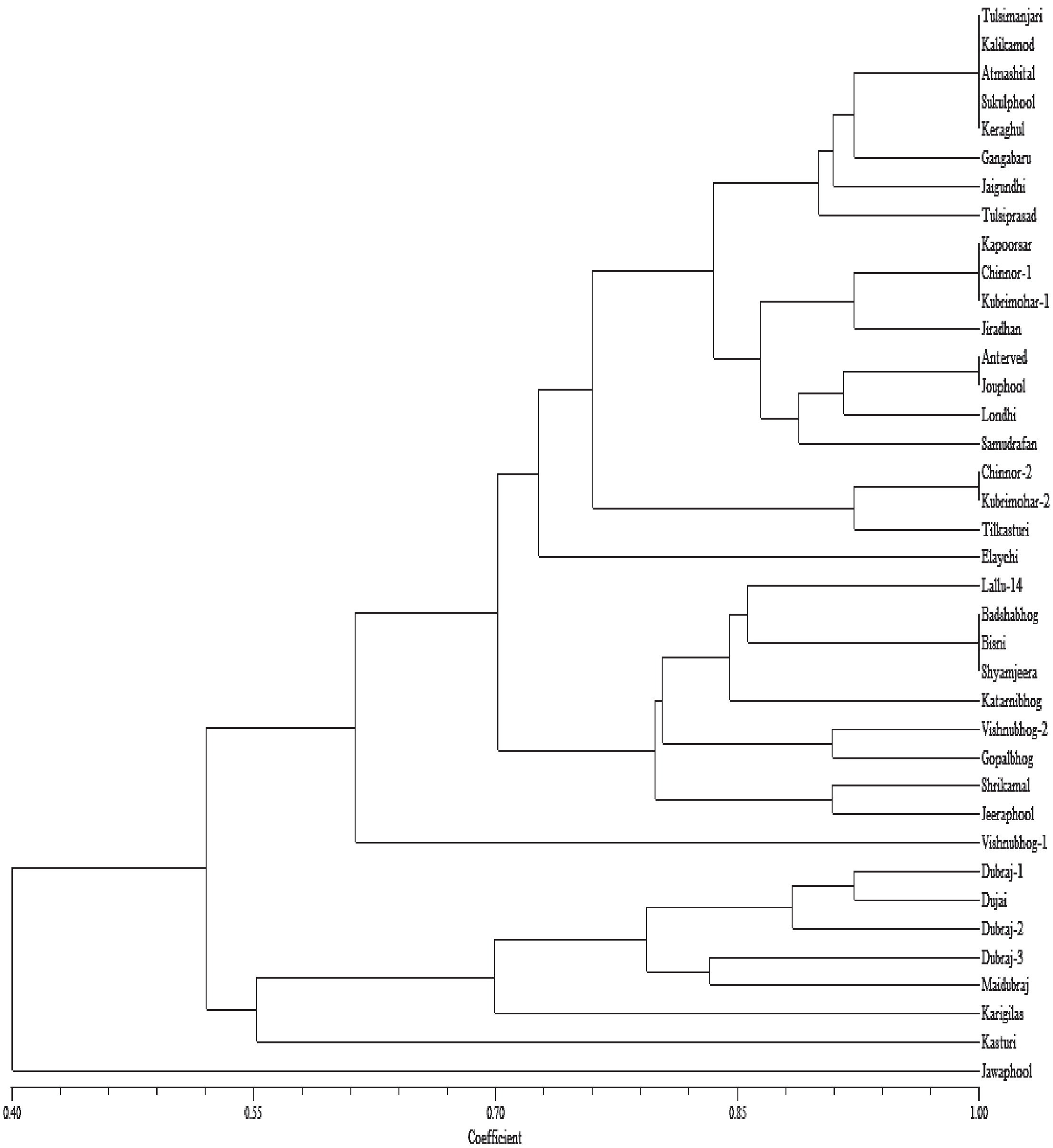


Fig. 2. Dendrogram showing clustering pattern of thirty eight rice cultivars based on 19 SSR primers using UPGMA method

ORIGINAL RESEARCH ARTICLE OPEN ACCESS

Genotype X Environment Interaction and Stability Parameters in New Rice Hybrids *(Oryza sativa L.)*

Narendra Kulkarni*, Zakir Hussain, Amit Kumar and Syed Saleem

Research and Development farm, RJ Biotech Limited, Aushapur, Ranga Reddy

*Corresponding author: nm_kulkarni@hotmail.com

Received: 18th March, 2015; Accepted: 20th November, 2015

Abstract

G x E interaction and stability parameters were estimated in ten newly developed rice hybrids along with four checks. They were grown in *Kharif* 2013, 2014 and *Rabi* 2013-14 at RJ Biotech R&D centre Aushapur. Mean squares due to varieties and environment linear were significant for grain yield, yield components and physical grain quality characters. Environment linear was very high for flowering, plant height, panicle length, grain yield, milling percent and kernel length. G x E (linear) interaction was significant for flowering, plant height, grain yield and milling percent. Pooled deviations were significant for all characters except panicle length and kernel length. Simultaneous consideration of stability parameters for grain yield indicated that among test hybrids IR 58025A/RJ-2, IR 58025A/R-19 with long slender grains were stable with non-significant bi and S2 di Estimates. IR 58025A/OVT-89 was also stable hybrid with short slender grains and well adapted to *Rabi* season. These three hybrids recorded 7240 to 7760 kg/ha grain yield and were superior to all checks including PA 6444 hybrid. They are recommended for multi-location testing before commercially released. The milling percent of hybrids ranged from 68-72 percent with goodhead rice recovery.

Key words: Regression coefficient, Environment (linear), pooled deviations, stability

Introduction

In India rice production was increased almost four times due to adaption of high yielding semi-dwarf varieties. But, from last one decade plateauing of yield and decline in natural resources necessitated to break these yield barriers. Hybrid rice has potential technology to enhance the rice production and China has successfully exploited it. In India also it has been tested and beginning has been made by ushering in to an era of hybrid rice. Many hybrids have been developed and released by public and private sector. Since advent of hybrid rice technology the rate of adaption is steadily increasing but study on the stability of hybrid performance is limited. Panwar *et al* (2008) have stressed the need to evaluate hybrids over environments to identify stable hybrid. It is difficult to establish superiority of any particular hybrid in absence of information on adaption and stability performance. Consistency of a hybrid over wide range of environments is primary consideration in breeding programmes. Identification of hybrids with stable performance is important before it is recommended for cultivation. Stability analysis provides good measure of adaptability of different crop varieties (Morales *et al*., 1991). Therefore, Present study with promising new hybrids was attempted to understand the G x E interaction and consistency in performance through stability analysis

Materials and Methods

The popular CMS line IR 58025A was crossed with several restorers with good agronomic background identified by RJ Biotech limited. These hybrids were evaluated initially for two years. Ten hybrids involving RJ-2, R-18, R-19, RJ-35, RR-46, R-9, R-15, R-18, R-78 and OVT-89 as restorer lines were found promising. These hybrids with PA 6444, Maruti-115 as hybrid checks and MTU-1010, Samba Mahsuri as varietal checks were grown in three seasons *viz*. 2013 and 2014 *Kharif*, and 2013-14 *Rabi* at research and development centre Aushapur. The design was randomised block with three repeats. The plot size was 10.8 m^2 for each hybrid and all the package of practices for hybrid rice cultivation were followed. The data was collected on days to 50% flowering, plant height, number of productive tillers /hill, panicle length and grain yield/plot in each replication and season. The data was also collected on physical quality characters *Viz.,* milling percent, head rice recovery, kernel length, kernel breadth and L/B ratio. The g x e interaction and stability analysis was done following Eberhart and Russell (1966).

Results and Discussion

The genotypic differences were significant for grain yield; yield components and physical grain quality characters (table-1) indicating presence of genetic variability among the hybrids tested. Environment (linear) was also significant and proportionately higher and significant mean squares due to environment (linear) indicated the difference between seasons and their considerable influence on these characters .Proportion of environment (linear) was15 to 87times higher to g x e (linear) interaction for flowering, plant height, panicle length, grain yield, milling percent, kernel length, and kernel breadth. For other characters also it was higher but with lower magnitude. Number of productive tillers per plant is known to directly contribute to grain yield and environment (linear) was non-significant for this character and also for L/B ratio and head rice recovery. Arumugam *et al* (2007) and Ramya and Senthil Kumar (2008) reported interaction of grain yield and important yield components. Since panicle length and kernel length did not exhibit g x e interaction in pooled analysis the stability analysis was not carried out. Non-existence of g x e interaction for these characters was also reported by Sreedhar *et al* (2011). Pooled deviations were significant for all characters except panicle length and kernel length indicating that the hybrids differed considerably for their stability. Thus the seasons used in the study differed in physical parameters resulting in differential response of hybrids to different environmental conditions. Environmental indexes and means are presented in table-2. The comparative study of means among seasons indicated that flowering duration increased in *Rabi* season by about 13 days, but plant height decreased by 15-21cms.Number of productive tillers and panicle length almost remained same over seasons. The grain yield was higher in *Rabi* season but milling percent was less. L/B ratio remained same across seasons but kernel length and kernel breadth was reduced in *Rabi* compared to *Kharif*. Kernel length and breadth forms the core of the physical grain quality characters. Lesser length and breadth gives slender appearance and will have superior cooking quality. Grading of rice was also done on L/B ratio only. For this important character IR 58025A/OVT-89 and IR 58025A/ RJ-35 have appearance akin to Samba Mahsuri and possess slender grains. Among these former hybrid has high yield and is stable for grain yield. Flowering duration of hybrids ranged from 96 to 108 days (table-3). The hybrid IR 58025A/ RJ-35 and IR 58025A/GP-78 were stable over seasons with unit regression coefficient (bi) and non-significant deviation from regression (S^2di), while other hybrids were not stable. For plant height among the test hybrids IR 58025A/ R-18, IR 58025A/ RJ-46 and IR 58025A/ RJ-35 were considered as stable with unit regression and least S^2di estimates. Number of productive tillers had non-significant bi and only two hybrids viz. IR 58025A/ R-33 and IR 58025A/ RJ-2 deviated significantly from regression. The hybrids recorded grain yield of 6355 to 7761 kg/ha, while checks 5972 to 7317 kg/ha. Both linear and non-linear components of g x e interactions were accountable for grain yield. Five hybrids exhibited stable performance with unit bi and least S^2di estimates. Sinha and Biswas (1986) regarded a variety well buffered which produces high mean and stable under fluctuations of the environment. This property in adapted genotype is result of balanced combination of different traits which helps to function co-ordinately in complex conditions. In the present study IR 58025A/ RJ-2 (7761 kg/ha) and IR 58025A/ R-9 (7003 kg/ha) with higher mean grain yield and non-significant bi and S^2di and thus were stable across seasons. Their grain yield and grain type is better than check hybrid PA 6444 which is popular commercial hybrid and also stable. Panwar *et al* (2008) also stressed the need for evolving stable hybrids across environments that shows least interaction with environment. Hariprasad *et al* (2011) have pointed out that hybrid in south India have not been adapted on large scale due to grain quality requirement i.e. farmers like medium slender grains like Samba Mahsuri. In the present study the hybrid IR 58025A/OVT-89 is equally a good hybrid with comparable yield with check hybrid and 16.8 percent higher to Samba Mahsuri has significant bi indicating only linear component of g x e interaction was accountable and its suitability to higher environment in the present case it is *Rabi* season. This hybrid was also stable for plant height and number of productive tillers and possesses short slender grains which are preferred by farmers and consumers. There is need of medium/ short slender grain hybrids particularly in south India and because of this hybrids are not popular in these states. Further the restorer parent OVT-89is high yielding variety with good grain quality which will fetch extra income to hybrid seed producer. Most of the hybrids were stable for milling out turn and ranged from 68-71 percent (table-3). Among checks MTU-1010 was not stable. Head rice recovery in hybrids is an important character as hybrids have generally lower recovery. All hybrids were superior to check hybrid PA 6444 for head rice recovery and ranged from 37 to 63 percent. Three hybrids *viz*. IR 58025A/R-18, IR 58025A/RJ-35, and IR58025A/ RJ-19 were stable for head rice recovery. For kernel breadth except three hybrids all test hybrids exhibited stability. Most of the hybrids were stable for L/B ratio. Based on L/B ratio two hybrids IR 58025A/RJ-35, IR 58025A/ OVT-89 belong to short slender grain types. The hybrid IR 58025A/ RJ-2 has long bold grains and higher head rice recovery of 55.8 percent. Thus, considering grain yield and physical grain quality characters three hybrids viz. IR 58025A/RJ-2, IR 58025A/ RJ-19and IR 58025A/ OVT-89 can be recommended for multi-location testing before their release for commercial cultivation.

References

Arumugam, M., Rajanna, M.P. and Vidhachandra. Stability of rice genotypes for yield and yield components over extended dates of sowing under Cauvery command area in Karnataka. *Oryza* 44: 104-107

Eberhart, S.A. and Russell, W.L. 1966. Stability parameters for comparing varieties. *Crop science* : 36-40

Hariprasad, A.S., Senguttuvel, P., Revathi, P., Kemparaju, K.B., Shobha Rani, N. and Virkatmath, B.C. 2011. Hybrid rice in India Technical Bulletin no.56/2011. Directorate of Rice Research (ICAR), Hyderabad-30 A.P. India

Morales, A.C., Paragas, A.A. and Carangal, V.R. 1991. Phenotypic stability for grain yield in Mung bean (*Vigna radiata* L.) *FLCG Newsletter* 16: 12-15

Panwar, L.L., Joshi, N. and Ali, M. 2008. Genotype x environment inter actions in scented rice. *Oryza* 45:103-108

Ramya, K. and Kumar, S.N. 2008. Genotype x environment interactions for yield and its component traits in rice (*Oryza sativa* L.) *Crop improvement* 35: 11-15

Sinha, S.K. and Biswas, S. 1986. Adaptability of some rice varieties in unilocational testing programmes during Aus season. *Oryza* 23:166-172

Sreedhar, S., Dayakarreddy, T. and Ramesha, M.S. 2011. Genotype x environment interaction and stability for yield and its components in hybrid rice cultivars (*Oryza sativa* L.). *International Journal of Plant Breeding and Genetics* 5(3): 194-208

Table 1. Pooled analysis of variance across three seasons for yield, its contributing characters and physical quality characters in rice hybrids

Source	D.F.	Days to 50% flowering	Plant height (cm)	No. of Productive Tillers /plant	Panicle Length (cm)	Grain Yield/ plot Kg/plot	Milling (%)	Head Rice Recovery (%)	Kernel Length (mm)	Kernel Breadth (mm)	L/B ratio
Genotypes	13	193.08**	139.59**	1.64**	3.13**	3.68**	4.87**	256.46**	1.27**	0.050**	0.266**
Environment (Linear)	1	2083.35**	3202.5**	1.23	5.59**	247.44**	80.91**	68.99	0.860**	0.118**	0.003
G x E	26	27.92**	24.49**	0.70**	0.59	0.85**	1.67**	15.34**	0.003	0.046**	0.024**
G x E (linear)	13	47.03**	36.47**	0.57	0.37	1.07*	2.42*	12.37	0.058	0.003	0.017
Pooled deviations	14	6.01**	10.36**	0.65*	0.78	0.60**	0.86**	16.99**	0.032	0.004*	0.029*
Pooled error	84	0.21	2.47	0.29	0.55	0.20	0.28	0.31	0.004	0.002	0.009

*,**= Significant at 5 and 1% respectively

Table 2. Means of seasons (M) and environmental indexes (I) for grain yield, yield Components and physical grain quality characters

S.No.	Character		2013 *Kharif*	2013-14 *Rabi*	2014 *Kharif*
1	Days to 50% flowering	M	100.8	112.7	95.9
		I	-2.355	9.559	-7.204
2	Plant height (cm)	M	108.2	87.5	102.4
		I	8.858	-11.881	3.023
3	Number of productive	M	12.8	12.4	12.4
	Tillers /plant	I	0.285	-0.167	-0.118
4	Panicle length (cm)	M	25.0	24.8	24.9
		I	0.1	-0.1	0.0
5	Grain yield (kg/plot)	M	4.05	9.48	8.69
		I	-3.41	1.99	1.424
6	Milling (%)	M	70.9	67.9	70.9
		I	0.99	-1.96	0.97
7	Head rice recovery (%)	M	51.1	48.9	48.0
		I	1.74	-0.44	-1.30
8	Kernel length (mm)	M	6.53	6.22	6.51
		I	0.108	-0.202	0.094
9	Kernel breadth (mm)	M	1.96	1.87	1.99
		I	0.021	-0.073	0.052
10	L / B ratio	M	3.31	3.33	3.32
		I	-0.009	0.012	-0.003

Table 3. Mean and stability parameters for grain yield and its components in rice hybrids and checks

S. NO.	Hybrids	Days to 50% flowering			Plant height (cm)			No. of productive tillers/plant			Grain yield (kg/plot)			Milling (%)		
		Mean	Bi	S^2 di	Mean	bi	S^2 di	Mean	Bi	S^2di	Mean	bi	S^2 di	Mean	bi	S^2 di
1	IR 58025A/ R-18	95.7	0.85	5.07**	94.4	1.04	5.95	13.0	2.03	0.75	7.11	0.90	-0.03	72.1	-0.52**	-.018
2	IR 58025A / RJ-2	113.7	1.79**	0.93*	117.4	1.05	8.35*	13.1	1.59	1.23*	8.39	1.13	0.02	71.1	0.45	1.71*
3	IR 58025A / R-15	95.5	0.47	17.45**	103.3	0.57*	3.57	12.9	-2.00	-0.25	7.44	1.08	0.26	69.1	0.24*	0.64
4	IR 58025A / RJ-46	98.4	1.02	8.43**	97.9	1.09	4.82	12.6	1.55	-0.29	6.87	0.62*	-0.16	70.8	0.93	0.37
5	IR 58025A / R-33	103.3	0.93	5.27**	103.7	1.75**	0.06	12.1	-3.99*	3.73**	8.22	1.02	0.89*	67.8	1.37	-0.21
6	IR 58025A / RJ-35	107.8	0.78	-0.08	100.0	1.39	3.18	12.3	4.89	0.34	7.23	1.01	-0.13	71.1	1.39	-0.07
7	IR 58025A / OVT-89	104.8	0.56*	15.44**	95.9	0.81	3.18	13.3	0.89	-0.10	7.82	1.33	-0.08	70.3	0.93	-0.31
8	IR 58025A / R-19	105.1	0.64	0.62**	102.1	1.25	7.46*	12.6	-0.64	0.04	7.99	0.45**	-0.01	70.7	1.67	-0.07
9	IR 58025A / R-9	104.2	2.22**	6.34**	89.1	0.43**	53.48**	13.4	0.77	-0.29	7.57	1.03	0.10	69.6	0.98	-9.08
10	IR 58025A / GP-78	100.3	1.75	-0.20	97.7	1.419*	20.56**	13.1	0.64	-0.04	7.79	1.35	1.49**	69.2	0.48	0.26
11	PA-6444 (check)	103.8	0.52*	16.30**	102.9	0.92	0.45	12.7	0.15	-0.07	7.91	0.92	0.37	68.8	1.74	0.51
12	RJ-115	95.0	0.42**	2.60**	99.7	1.18	-1.32	11.1	1.99	-0.26	7.33	1.24	1.27**	67.8	1.30	0.79
13	Samba Mahsuri	122.9	1.33**	3.12**	94.9	0.23**	-2.23	12.7	0.25	0.58	6.69	1.02	1.42**	69.6	1.33	-0.23
14	MTU-1010	93.3	0.72	-0.21	91.8	0.86	3.04	11.0	5.86*	-0.29	6.45	0.49**	0.54*	70.4	1.70	4.17**
	S.E. +/-	0.27	0.20	-	0.91	0.21	-	0.31	2.29	-	0.26	0.18	-	0.65	0.38	-

*,**=Significant at 5% and 1% respectively

Table 4. Mean and stability parameters for physical grain quality characters in rice hybrids and checks

S. No.	Hybrids	Milling (%)			Head rice recovery (%)			Kernel Length (mm)	Kernel breadth (mm)			L / B Raito		
		Mean	bi	S^2 di	Mean	bi	S^2 di	Mean	Mean	bi	S^2 di	Mean	bi	S^2 di
1	IR 58025A/ R-18	72.1	-0.52	-.018	39.1	2.71	0.48	7.18	1.94	1.42	0.012*	3.72	-0.37	-0.007
2	IR 58025A / RJ-2	71.1	0.45	1.71*	55.8	0.56	2.08*	6.08	2.09	0.89	-0.001	2.92	7.65	-0.002
3	IR 58025A / R-15	69.1	0.24*	0.64	42.8	2.44	39.64**	7.23	2.00	0.57	0.001	3.61	4.35	-0.005
4	IR 58025A / RJ-46	70.8	0.93	0.37	63.4	-1.03	13.26**	6.83	1.85	1.46	0.001	3.70	12.46	0.036*
5	IR 58025A / R-33	67.8	1.37	-0.21	53.2	-0.61	8.51**	6.23	2.09	0.95	0.003	2.97	-3.44	-0.003
6	IR 58025A / RJ-35	71.1	1.39	-0.07	48.6	0.68	0.09	5.42	1.77	0.89	-0.002	3.08	-6.71	-0.007
7	IR 58025A / OVT-89	70.3	0.93	-0.31	53.6	0.53	3.68**	5.77	1.76	0.50	0.008*	3.29	4.93	0.035*
8	IR 58025A / R-19	70.7	1.67	-0.07	37.9	1.45	-0.22	7.06	1.94	1.75	0.006*	3.73	-2.63	-0.007
9	IR 58025A / R-9	69.6	0.98	-9.08	44.6	-0.06	11.05**	6.56	1.88	1.09	-0.002	3.45	-6.10	0.038*
10	IR 58025A / GP-78	69.2	0.48	0.26	43.2	4.63	31.25**	6.87	1.96	0.29	0.000	3.51	-8.77	-0.003
11	PA-6444 (hybrid check)	68.8	1.74	0.51	36.8	2.15	44.89**	6.22	2.10	1.49	-0.002	2.94	14.47	-0.001
12	RJ-115	67.8	1.30	0.79	57.4	0.14	3.56**	6.52	2.03	2.06	-0.001	3.23	12.99	-0.008
13	Samba Mahsuri (check)	69.6	1.33	-0.23	48.6	1.34	71.44**	5.09	1.73	0.58	-0.001	3.10	-10.61	0.225**
14	MTU-1010	70.4	1.70	4.17**	65.9	-0.93	3.51*	6.74	2.06	0.06	0.008*	3.27	-4.36	-0.008
	S.E. +/-	0.65	0.38	-	2.91	1.86	-	0.13	0.044	0.68	-	0.12	11.2	-

*,**=Significant at 5 and 1% respectively.

ORIGINAL RESEARCH ARTICLE OPEN ACCESS

Effect of Desiccant (Zeolite) beads on Storage Life and Quality of Rice Seed *(Oryza sativa L.)*

M. Sudha Rani, M. Rajasri* and P.S. Rao

Seed Research and Technology Centre, Professor Jayashankar Telangana State Agricultural University, Rajendranagar, Hyderabad

*Coressponding author: nihariraj@yahoo.co.in

Received: 12th April, 2015; Accepted: 21st October, 2015

Abstract

The present study was conducted on storage of rice seed using desiccant (Zeolite) beads made of aluminum silicate to study the effect of the beads on seed longevity and quality of rice (BPT-5204) during July, 2013 to November, 2014 at Seed Research and Technology Centre, Rajendranagar. The treatments included storing the seed in air tight container; storing the seed in air tight container with silica gel (1:0.17); storing the seed in air tight container with zeolite beads (1:0.35); seed in cloth bag and seed stored in gunny bag (Control) under ambient storage conditions. The experiment was conducted using completely randomized design with three replications. Data was collected on seed quality parameters in alternate months during the storage period and statistically analyzed. The study revealed that rice seed lots stored in air tight container along with zeolite beads was significantly superior compared to other treatments with respect to germination per cent (80), field emergence (81%), seedling vigour index (8.19) based on seedling dry weight and seedling vigour index (1828) based on seedling length after a period of 16 months storage followed by seed lots stored in airtight containers along with silica gel. However, the seed lots stored in gunny bag was inferior as it recorded a lower germination per cent of 24, field emergence (43%), seedling vigour index (SVI I) based on seedling dry weight (2.65) and seedling vigour index (SVI II) based on seedling length (180) at the end of storage period of 16 months.

Key words: Seed, storage, zeolite, moisture

Introduction

Seeds are hygroscopic in nature and the moisture content of the seed changes in accordance to the relative humidity of the surrounding environment in which they are stored. In tropical climate, high temperature and humidity cause rapid deteoration of seed in open storage resulting in loss of viability, poor stand establishment, lower productivity and disincentive to invest in improved seeds. In general, seed longevity is reduced by approximately half for every one per cent increase in seed moisture content or five degrees increase in temperature and effects are additive (Miller and Lawrence, 1998). Thus, combination of temperature and moisture content results in rapid loss of viability.

Generally, the moisture content of the seeds harvested at physiological maturity is high (15-18%). For safe seed storage the moisture content need to be brought down to 6-13%. However, if seeds are dried to low moisture content, these are much better able to survive in storage even at high temperatures (Sastry *et al.*, 2007). Majority of crop seeds in India are locally produced, stored and utilized. Improved varieties can enhance productivity and quality and expand the market opportunities. Therefore, there is need to develop low cost drying methods as alternative to expensive seed drying equipments in order to lower the moisture content and to maintain safe moisture level for longer storage life. Drying beads are modified ceramic materials (Aluminum silicates or Zeolites) that absorb and hold water molecules very tightly in their microscopic pores. The beads will continue to absorb water until all their pores are filled up to 20 per cent of their initial weight (Nassari *et al.*, 2014). Seeds placed in to a container with beads will lose water due to low air humidity and will continue to do so until they come to equilibrium. Thus, it has been proposed that in lieu of humidity controlled and air conditioned storage facilities, which require expensive and reliable energy sources to run and maintain. Seeds can be dried to low moisture levels and sealed in hermetic containers without temperature control. Zeolite beads are used in the present study due to their micro pores and strong affinity to absorb and hold water very tightly. Thus, seeds can be used for longer period without losing viability and vigour. The current investigation was carried out to study the effect of zeolite beads on storability and seed viability.

Materials and Methods

Freshly harvested seed material of rice variety (BPT-5204) was obtained from Seed Research and Technology Centre, Rajendranagar. The seed material was measured for moisture content and reduced to ten per cent by spreading in a thin layer on ground at a temperature ranging from 29^0C to 34 ^{0}C for 30 hours with duration of five hours a day. Then the treatments were imposed *viz*., seed stored in air tight container; seed stored in air tight container with silica gel (1:0.17); seed stored in air tight container with zeolite beads (1:0.35); seed stored in cloth bag and seed stored in gunny bag under ambient conditions. Seeds with 10 per cent moisture content were utilized for testing the longevity during storage. The experiment was laid out in CRD replicated thrice. The containers were kept under ambient storage conditions. Bimonthly observations on germination per cent (ISTA, 2004), moisture percent (ISTA 2004), field emergence and seedling vigour index (SVI) (Abdul-Baki and Anderson, 1973) were recorded. The data were statistically analyzed using Anova technique (Panse and Sukhatme. 1985). Standard error of difference was calculated at 5 per cent probability level to compare the mean difference among the treatments.

Results and Discussion

Mean initial germination per cent of seed lots stored in different containers was 95.3 and there was no significant difference among the treatments. After a storage period of 16 months, the germination per cent was reduced drastically in all the treatments. However, germination per cent in the seed lot stored in air tight container along with drying beads (80 %) was significantly superior followed by seed lot stored in air tight container along with silica gel (53%) (Tables 1 and 2). The seed lots stored in gunny bag recorded the lowest germination per cent of 24% at the end of storage period. Similar findings were reported by Kong and Zhang (1998) by storing the asparagus beans along with silica gel with a ratio of 4:1. Further, Eklou *et al.,* (2006) also found that rice seed stored with silica gel at the ratio of 1:1 could reduce the moisture content to five per cent and improved the seed longevity.

The fluctuations in moisture content were more in seed stored in cloth bag and the moisture content was higher at the end of storage period (14%). The seed lot stored in air tight container along with drying beads recorded significantly lower moisture content (5.6 %) followed by seed lot stored in air tight container along with silica gel (7.2%). The moisture trend showed that rice seed (1kg) stored with 350 g of zeolite beads had reduced the moisture to 6.8 per cent at the end of few hours of mixing with beads and this was maintained during the entire storage period (Table 1 and 2). The current findings are in accordance with the work of Ejeromedoghene (2010) who reported that seeds stored with desiccant beads had significantly reduced the moisture content throughout the storage period and also had their viability and vigour better maintained than those stored with other means like silica gel. Therefore, the storage life of the seeds stored under moisture controlled environment usually longer than seeds stored under ambient storage conditions and seed deteoration is faster than the later (Oyekale, 2010). Sastry *et al*. (2007) stated that groundnut seed survived for 20 weeks when seed moisture content decreased from 10.1% to 3.4 %. Seed stored at moisture content of 10.1% deteorated faster and lost viability within a short period. Significant and lower qualitative seed quality parameters were observed in gunny bag during entire storing period may be due to its permeable nature which might have favored the longer fluctuations in moisture content leading to metabolic and respiratory activity of the seeds compared to airtight containers, where in seed quality parameters were comparatively superior with slow rate of seed deteoration. Similar beneficial effects were documented by Venkatasalam (2001) in Tomato and Veena (2007) in Onion.

The superiority of seed lot stored in air tight container along with drying beads also continued for seedling vigour index (Based on seedling length) at the end of the storage period (1828) followed by seed lot stored in air tight container along with silica gel (1808) (Table 1 and 2). Similarly, seedling vigour index based on seedling dry weight recorded highest (11.19%) in the seed lots stored with silica gel. However, the seedling vigour index and field emergence were also higher for seed lot stored with zeolite beads (8.19% and 81.0%) while the seed lot stored in gunny bag recorded the lowest (180) seedling vigour index based on seedling length and 2.65 based on dry weight. However, field emergence recorded by the seed lot stored in gunny bag was 43 per cent after 16 months of storage. The results are in line with the reports of (Gupta *et al.,* 1989). The seed lot stored in air tight container along with drying beads was found to be superior during storage with respect to all seed quality parameters. Singh and Dadlani (2003) and Usha *et al.,* (1990) also reported significantly superior performance for seed quality parameters for Sesame and Soybean seeds stored along with charcoal.

References

Abdul-Baki, A.A. and Anderson, J.D. 1973. Vigour determination in Soybean by multiple criteria. Crop Science. 13: 630-633.

Ejeromedoghene, E.T. 2010. Physiological quality of soybean seeds during containerized dry storage using dry charcoal. B. Agric. Product Report. Department of Agronomy and Landscape design, Babcock University, Ilishan-Remo Nigeria, 52.

Eklou, A.S., Sanchez. I.M., Nwilene, F., Sié M, Ogunbayo, A.A., Sanni K. and Daniel, D. 2006. Comparative studies of drying methods on the seed quality of inter specific NERICA rice varieties (*Oryza glaberrima x Oryza sativa)* and their parents. *African Journal of Biotechnology*. 5 (18): 1618-1624.

Gupta, R.P, Mehra, U., Pandey, U.B. and Mehra, U. 1989. Effect of various chemicals on viability of onion seed in storage. *Seed Research*. 17 (1) 99-101.

Kong, X.H. and Zhang, H.Y. 1998. The effect of ultra drying methods and storage on vegetable seeds. *Seed science research*. 8 (1): 41-45.

Miller, B.M. and Lawrence, C. 1998. Seed production principles and practices. CBS publishers and distributors. 132-133.

Nassari, P.J., Keshavulu, K., Rao, M., Chandra Shehar Reddy, K. and Raheem A. 2014. Post harvest drying of Tomato (*Lycopersicon esculentum* Mill) seeds to ultra low moisture safe for storage using desiccant (Zeolite beads) and their effects on seed quality. *American Journal of Research Communication*. 2 (4) 74-83.

Oyekale, K.O. 2010 Modeling seed deteoration of maize under moisture-conditioned and open storage in humid tropical seed stores. Ph.D Thesis. Department of Plant Breeding and Seed Technology, University of Agriculture, Abeokuta Nigeria. 110.

Panse, V.G. and Sukhatme, P.V. 1985. Statistical methods for Agricultural workers, ICAR, New Delhi, pp.327-340.

Sastry, D.V.S.S.R., Upadhaya, H.D. and Gowda, C.L.L. 2007. Survival of groundnut seeds under different storage conditions. *SAT e-journal*. 5 (1): 1-3.

Singh, K.K., Dadlani, M. 2003. Effect of packaging on vigour and viability of soybean (*Glycine max* (i) Merrill) seed during ambient storage. *Seed Research* 31 (1): 27-32.

Usha, H., Javaregowda, S., Ramaiah, H. 1990. Influence of containers, chemicals and byproduct treatments on storability of cowpea (*Vigna unguiculata*) and horsegram (*Dolichos biflora*) seeds. *Legume Research*. 13 (1): 13-16.

Veena, M.G. 2007. Studies on seed pelleting in onion M.Sc. (Agri) Thesis, Univ. Agric. Sci., Dharwad (India).

Venkatasalam, E.P. 2001. Investigations on certain aspects of seed production, processing, storage and storage and varietal identification in tomato hybrid COTMI and its parental lines. Ph.D. Thesis, Tamil Nadu Agricultural University, Coimbatore, India.

Table 1. Effect of drying beads in air tight containers on seed quality parameters of Rice after 2 months of storage

Treatment	Germination (%)	Moisture (%)	Seedling length (cm)	Seedling dry weight (mg)	VI-I	VI-II	FE (%)
T_1- Seed stored in polythene 700 guage ba)	94.3	10.67	32.6	1.53	3074	144.3	83.0
T_2- Seed stored in air tight container	97.0	11.30	32.1	1.52	3113	147.4	89.6
T_3- Seed stored in polythene bag + silica gel	96.0	5.07	31.8	1.6	3052	153.6	91.3
T_4- Seed stored in air tight container + drying beads	94.3	7.00	32.5	1.51	3064	142.4	88.3
T_5- Seed stored in gunny bag	94.7	11.17	30.2	1.54	2859	145.9	86.6
T_6- Seed stored in cloth bag	95.3	15.07	53.0	2.312	3076	146.7	79.0
Mean	0.76	0.183	0.742	0.023	3074	144.3	86.3
S.Em±	2.478	0.596	2.422	0.077	1.35	1.01	3.11
CD at 5%	94.3	10.67	32.6	1.53	427.5	3.19	9.81

Table 2. Effect of drying beads in air tight containers on seed quality parameters of rice after 16 months of storage

Treatment	Germination (%)	Moisture (%)	Seedling length (cm)	Seedling dry weight (mg)	VI-I	VI-II	FE (%)
T2 (Seed stored in air tight container)	51	13.1	15.9	0.112	824	5.83	51.0
T3 (Seed stored in polythene bag + silica gel)	56	12.8	19.5	0.129	1094	7.31	67.0
T4 (Seed stored in air tight container + drying beads)	53	7.2	22.8	0.139	1808	11.2	75.0
T5(Seed stored in gunny bag)	80	5.6	34.5	0.154	1828	8.19	81.0
T6 (Seed stored in cloth bag)	24	13.8	7.5	0.111	180	2.65	43.0
Mean	37	14	9.9	0.12	376	4.48	48.0
S.Em±	50.2	11.1	18.4	0.1	1018	6.62	60.8
CD at 5%	11.5	0.67	5.46	0.015	241.5	2.20	10.2

VI-I: Seedling vigour index based on dry weight;

VI-II: Seedling vigour index based on seedling length

F.E: Field emergence

ORIGINAL RESEARCH ARTICLE OPEN ACCESS

Grain Quality Parameters of Cultivars as Influenced by SRI *Vs* Normal Method of Rice Cultivation

R. Mahender Kumar*[1], V. Ravindra Babu[1], L.V. Subba Rao[1], K. Surekha[1], Ch. Padmavathi[1], M.S. Prasad [1], N. Somasekhar [1], A.S. Rama Prasad[1] and V. Vinod Goud[2]

ICAR-Indian Institute of Rice Research, Rajendranagar, Hyderabad; [2]WWF and ICRISAT, Hyderabad

*Corresponding author: kumarrm213@gmail.com

Received: 18th March, 2015; Accepted: 20th August, 2015

Abstract

Experiments were carried out at Directorate of Rice Research, ICRISAT farm- Ramachandrapuram, during wet (*kharif*) and dry (*rabi*) seasons which included 3 cultivars (MTU 1010, Shanthi, DRRH2 during dry season and BPT 5204, DRRH 2, Swarna in Wet season) to study the performance of cultivars managed under System of Rice Intensification (SRI) compared with Normal Transplanting (NTP) method. During both the seasons, three methods of crop establishment tested were (i) Eco-SRI where 100% organic manure was applied (ii) SRI where both organic + inorganic fertilizers were applied in 50:50 ratio and (iii) Normal transplanting where 28-30 day old and 2-3 seedlings were planted in normal spacing of 20 x 15 cm with fertilizers doses similar to SRI method. In addition to grain yield, the quality characters studied includes hulling, milling, head rice recovery, kernel length, kernel breadth, L/B ratio, volume expansion ratio, water uptake, alkali spreading value, amylose content and gel consistency were recorded. During wet season grain yield was significantly higher in SRI method than Normal transplanting and Eco-SRI by 10.3 and 33.4%, respectively. Whereas, SRI and normal transplanting were on par and superior to Eco-SRI in dry season. The quality parameters showed that there was significant influence due to methods of crop establishment especially on hulling, milling, head rice recovery, and gel consistency in *rabi* season and K.L, K.B, L.B and water uptake in wet season. The traits *viz.,* alkali spread value (ASV), amylose content (AC), kernel length(KL), kernel breadth (KB) and L/B ratio were not influenced by the cultivation methods. Varietal differences were observed in hulling , milling, head rice recovery ASV, AC and GC. Interaction effect of Genotype and cultivation method was significant with hulling, milling, head rice recovery, AC and GC in dry season and KL and L.B ratio in wet season. SRI method recorded higher milling, head rice recovery values as compared to Normal transplanting method. Among the varieties, DRRH2 hybrid showed highest significant values in all the traits as compared to rest of the cultivars. Eco-SRI had very high and significant effect on gel consistency. In general, Eco-SRI and SRI reduced the water uptake in different varieties tested during *kharif* season. The better quality parameters of grain in SRI method was due to delayed senescence with enhanced photosynthesis in the lower leaves was also responsible for supply of more assimilates towards roots for maintaining higher activity and better grain filling and quality.

Key words: System of Rice Intensification, Rice Cultivars, Quality parameters

Introduction

Rice is staple food of more than half the people in the world and demand is increasing due to the growing population there by leading to the imminent shortfall with plateauing of rice yield levels in the recent decades and also increases in food prices. Despite intense efforts on varietal improvement front through conventional and also through other options like heterosis breeding, development of New Plant Type (NPT), utilization of frontier technologies like molecular breeding and genetic engineering; immediate stepping up of yields is not forthcoming to increase the rice production to the comfortable levels. In view of such a grave situation, a simple management method System of Rice Intensification (SRI) developed in Madagascar, has brought hope to many rice farmers as it claims to accomplish more rice crop per drop of water (Laulanei, 1993 and WWF- ICRISAT, 2007). It is a combination of plant, soil, water and nutrient management practices that are employed in SRI which enhances robust root growth, corresponding increase in tillering and greater grain filling resulting in higher grain yield. Under SRI cultivation, it is well established that the root exudates to enrich large and varied microbial growth and when the soils are flooded and drained (alternate wetting and drying) it entails both aerobic and anaerobic bacteria and mycorrhizal fungi a chance to enhance plant growth (Uphoff *et al.,* 2002). Generally, long duration varieties perform better with wider spacing than short duration because of extended growth (Baloch *et al.*, 2002). However, very limited studies were carried out on comparative performance of different cultivars under SRI and Normal transplanting method with regard to grain quality aspects. Besides increasing grain yield, improving the grain quality is also important (Ravindra Babu *et al.,* 2006) in view of consumer as well as to farmers for getting high commercial value. Grain quality is complex phenomena and concentrated efforts are needed to enhance the quality of the rice. With this view an attempt is made in the present study to evaluate different cultivation methods and cultivars influence on grain yield and quality parameters.

Materials and Methods

The field experiment was conducted in *wet* (*Kharif*) and *dry* (*Rabi*) seasons at the Directorate of Rice Research-Ramachandrapuram farm in ICRISAT campus in a sandy clay loam soil. Initial soil samples were collected from three depths and were analysed for important properties using standard procedures. The soil was alkaline [pH 8.5 and 9.45 in surface (0-15 cm) and sub surface (30-60 cm) depths, respectively]; non-saline (EC- 0.47,0.67dS/m in surface and sub surface depths, respectively; with high organic carbon (0.76-1.27%) content. Available N was medium (291kg/ha); available P_2O was high (26.8 kg/ha) and available K_2O was also high (527 kg/ha) in surface layer.

The experiment was laid out in a split-plot design with cultivars as main plots (BPT 5204, Swarna & DRRH 2 in *wet;* MTU 1010, Shanti & DRRH 2 in *dry season*) and methods of crop establishment (ECO-SRI, SRI and Normal transplanting) as sub-plot treatments in four replications. In SRI and Normal transplanting, the recommended dose of N @ 100 kg/ha during *wet season* and 120 kg/ha during *dry season* was applied through 50% organics (FYM) + 50% inorganics (urea). P_2O_5 and K_2O @ 60 and 40 kg/ha were given through single super phosphate and muriate of potash, respectively, in both seasons. Whereas, in ECO-SRI method, total nutrients were supplied through organic source, FYM only. Twelve days old seedlings in Eco-SRI and SRI at a spacing of 25 x 25 cm and 30 day old seedlings in Normal transplanting at 20 x15 cm spacing were transplanted. Water management in the first two treatments was done as recommended for SRI method i.e. depending on the soil moisture content once in 3-4 days, just to keep the soil moist, while it was irrigated regularly in normal transplanted method to maintain submergence of 5 ± 2 cm. Weeding was done with the help of cono weeders once in 10 days starting from 10^{th} day after transplanting. Experiment plots were bunded with polythene sheet to a depth of 1 m for preventing the lateral seepage of water from one to other treatments. Water applied to each treatment through hose pipe is measured periodically with water meters installed at source point. The paddy samples were collected for recording quality parameters and were analysed at DRR quality laboratory. The characters studied were hulling, milling, head rice recovery (HRR), kernel length, kernel breadth, L/B ratio, alkali spreading value, amylose content and gel consistency. All the data were analysed using standard statistical methods (Gomez and Gomez, 1984) and compared by LSD tests between method of cultivation and cultivar and their interactions at 5% level of significance.

Results and Discussion

Grain yield (t/ha)

There was significant effect of cultivars and method of crop establishment on grain yield in both the seasons. Grain yield data presented in Table 1 indicated the superiority of SRI (5.27 t/ha) over normal transplanting (4.78 t/ha) and Eco-SRI (3.95 t/ha) during *wet season* by 10.3 and 33.4%, respectively. Whereas, during *dry season*, SRI (3.34 t/ha) and Normal transplanting (3.46 t/ha) were on par and both were significantly superior to Eco-SRI (1.66 t/ha). Among the varieties/hybrid tested , grain yield differences were significant with Swarna (5.33 t/ha) during *wet season* and hybrid DRRH 2 (4.12 t/ha) during *dry season* and found superior to other varieties recording maximum grain yield. The expected higher yields in SRI could not be attained especially, during *dry season* due to sub-soil alkalinity and delayed planting. Plant growth on saline and alkaline soils is mainly affected by high levels of soluble salts causing ion toxicity, ionic imbalance and impaired water balance and rice is very sensitive during early growth stage. Eco-SRI with 100% organics did not perform well during initial years of organic farming, yield reduction is expected due to slower release of nutrients and mismatch of nutrient release from organics and crop demand. Various individual practices associated with

SRI method of crop management have already identified as conducive for increasing the rice yields under irrigated production system *i.e.,* single seedling /hill (San-oh *et al.*, 2006), young seedlings (Menete *et al.*, 2008) and moderate wetting and drying soil condition (Yang *et al.*, 2004).

Quality parameters

The quality of the rice grain is an important aspect for consumer acceptability and market price and its demand for seed. The cultivation methods had significant influence during dry season on quality parameters such as hulling, milling, head rice recovery and gel consistency. However, cultivation methods had no influence on variables such as hulling, milling, head rice recovery, gel consistency, volume expansion ratio and alkali spread value in wet season. The Normal transplanting was better over SRI and Eco SRI for hulling was noticed. In milling, head rice recovery and gel consistency, SRI method was significantly better in quality parameters over the other two methods. (Table 2-3).

The varietal differences are significant in all parameters except in kernel length, kernel breadth and L/B ratio. DRRH2 was significantly superior in hulling, milling, head rice recovery in dry season. MTU 1010 had significantly high value of gel consistency over other cultivars tested in dry season. DRRH-2 was significantly superior in hulling, volume expansion ratio, water uptake and gel consistency during wet season. BPT 5204 cultivar was superior in alkali spread value gel consistency during wet season.

The interaction of varieties and methodologies was significant in hulling (Fig. 1), milling (Fig. 2), head rice recovery (Fig. 3), and GC (Fig. 4) in dry season. DRRH2 with Normal transplanting of cultivation recorded significantly highest milling, hulling, AC values while with SRI cultivation method showed significantly higher head rice recovery. ASV, KL, KB, L/B ratio were unaffected by cultivation methods in dry season. With respect to hulling, DRRH2 with - SRI method recorded highest value (80.6) and BPT-5204 with Eco-SR method recorded highest milling percent of 72.2.during wet season. The hybrid DRRH2 with normal transplanting yielded lowest value of milling (69.46%). Water uptake was very low (210) in BPT 5204 in Eco- SRI method and SRI, but highest (305) in DRRH2 with Normal method of transplanting. Gel consistency was increased phenomenally (67.7) in DRRH2 by adopting SRI method over the other two cultivars. Whereas with cultivar Swarna, SRI method increased the gel consistency significantly (63.3) over Normal transplanting (45.7) . The results indicated that there is significant interactions with cultivation methodologies with genotype with respect to quality parameters (Fig. 5-9) in wet season also. The components under SRI cultivation produced seeds with better quality due to the better filling of seeds which indicates the better food reserves in the seeds produced with these treatments might have resulted in better quality parameter. These results are in agreement with the observations of Nandisha and Mahadevappa (1984) and Uday Kumar (2005).

Conclusions

The results showed that there was significant influence of cultivation methods on some of the quality characters *viz.,* hulling, milling, head rice recovery and gel consistency. The traits *viz.,* alkali spread value (ASV), amylose content (AC), kernal length (KL), kernel breadth (KB) and L/B ratio were not influenced by the cultivation methods. Varietal differences were observed in Hulling, Milling, Head Rice recovery ASV, AC and GC. Genotype and cultivation method interactions were recorded in hulling, milling, head rice recovery, AC and GC. SRI had very high and significant effect on Milling, Head rice recovery. There was no influence of cultivation methods on grain chalkiness. Among the varieties DRRH2 showed highest significant values in all the traits. Gel consistency showed significant differences for methods and varieties. Eco-SRI had very high and significant effect on Gel consistency. In general Eco-SRI and SRI reduced the water uptake in different varieties which is desirable and better quality grain can be produced by adopting SRI method.

Acknowledgement

The authors are highly thankful to Dr. N Shobha Rani, PS, DRR for her help in the analysis of quality parameters.

References

Baloch, A.W., Soomro, A.M., Javed, M.A., Ahmed, M., Bughio, H.R., Bughio, M.S. and Mastoi, N.N. 2002. Optimum plant density for high yield in rice (*Oryza sativa* L.). *Asian Journal of Plant Science* 1(1):25–27.

Gomez, K.A. and Gomez A.A. 1984. Statistical procedure for agricultural research. 2nd ed. NewYork: John Wiley and Sons.

Laulanei, H., 1993. Le systeme de rigiculture intensive malagache. Tropicultura (Brussels), 11: 104-114.

Menete, M.Z.L., Van Es., H.M., Brito R.M.L., De Gloria. and S.D, Famba, S. 2008. Evaluation of system of rice intensification (SRI)component practices and their synergies on salt-affected soils. *Field Crops Research* 109:34–44.

Nandisha., B. S and Mahadevappa, M., 1984.Influence of mother plant and nutrition and spacing in planting value of rice seeds. Seed. Res., 12(2): 52-32.

Ravindra Babu, V., R. Mahendra Kumar, L.V.Subba Rao, K. Surekha, Ch. Padmavathi, P.C Latha, M.S. Prasad,Vinod Goud ,O.P. Rupela and B.C.Viraktamath. Evaluation of quality parameters under SRI and Normal transplanting of cultivation- Abstracts of National Symposium on present and future prospect of SRI cultivation" held in ANGRAU – Rajendranagar from 17 – 18th November 2006. p108

San-oh Y, Sugiyama T, Yoshita D, Ookawa T, Hirasawa T. 2006. Missing in the bodyhe effect of planting pattern on the rate of photosynthesis and related processes during ripening in rice plants.

Uday Kumar. 2005, Studies on System of Rice Intensification (SRI) for seed yield and seed quality. M.Sc. (Agri.) Thesis, Acharya N.G. Ranga Agric. University

Uphoff, N., E.C.F. Fernandes., Yuan L.P., Peng J., S. Rafaralahy and J. Rabenandrasana., 2002. *Assessments of the System of Rice Intensification: Proceedings of an International Conference, Sanya, China, April 1-4, 2002.* Ithaca, NY: Cornell International Institute for Food, Agriculture and Development.

WWF- ICRISAT. 2007. More rice with less water . SRI- System of Rice Intensification. Available from website:/http//www. Wassan.org/sri/documents/ wwf_rice_report _2007.pdf

Yang C., Yang L., Yang Y. and Ouyang, Z. 2004. Rice root growth and nutrient uptake as influenced by organic manure in continuously and alternately flooded paddy soils. *Agricultural Water Management* 70:67–81.

Table 1. Grain and straw yields (t/ha) as influenced by different methods of crop establishment

Treatments	Grain yield (t/ha)							
	Wet - Wet season				*Dry- Dry season*			
	BPT 5204	**Swarna**	**DRRH 2**	**Mean**	**MTU 1010**	**Shanti**	**DRRH 2**	**Mean**
Eco-SRI	3.38	4.83	3.63	3.95	1.30	0.87	2.90	1.69
SRI	5.05	6.00	4.75	5.27	3.32	1.75	4.96	3.34
Conventional	4.52	5.17	4.65	4.78	3.39	2.53	4.45	3.46
Mean	4.32	5.33	4.34		2.67	1.69	4.12	
C.D (0.05)								
Main	0.32	Sub	0.15		Main	٠,٥٨	Sub	0.60

** Interaction effects were not significant*

Table 2. Quality parameters as influenced by different methods of crop establishment in wet season

Cultivars	Methods	Hulling	Milling	HRR	ASV	AC	GC	KL	KB	L/B	Volume expansion ratio	Water Uptake
		(%)	(%)	(%)								
BPT-5204	Eco-SRI	78.83	72.2	70.4	5	24.17	77.0	5.11	1.76	2.90	4.66	210.0
	SRI	77.6	70.06	68.16	5	24.4	77.3	5.15	1.82	2.83	4.96	226.7
	Con	78.3	71.2	67.26	5	25.25	73.7	5.07	1.79	2.83	4.60	251.7
DRRH-2	Eco-SRI	80.36	69.86	46.46	4	24.7	51.0	6.75	1.99	3.39	5.30	276.0
	SRI	80.6	71.83	51.73	4.16	22.69	67.7	6.43	1.89	3.40	5.30	305.0
	Con	79.63	69.46	54.43	4	26.04	51.0	6.15	2.05	3.00	5.30	330.0
Swarna	Eco-SRI	78.2	71.03	65.06	4.66	25.87	55.0	5.15	2.09	2.46	5.46	223.3
	SRI	77.8	70.16	67.4	4.66	25.26	63.3	4.84	2.14	2.26	5.10	240.0
	Con	78.46	71.53	69.1	4.5	26.16	45.7	5.01	2.11	2.37	4.86	248.3
CD(.05) Interaction	*VXM*	*0.84*	*1.28*	*NS*	*NS*	*0.47*	*5.2*	*0.14*	*0.52*	*0.10*	*NS*	*23.6*
	MXV	*0.84*	*1.28*	*NS*	*NS*	*0.47*	*5.2*	*0.16*	*0.53*	*0.11*	*NS*	*23.6*
Mean of Methods	*Eco-SRI*	*79.1*	*71.0*	*60.6*	*4.6*	*24.9*	*61.0*	*5.7*	*1.9*	*2.91*	*5.1*	*236.4*
	SRI	*78.7*	*70.7*	*62.4*	*4.6*	*24.1*	*69.4*	*5.5*	*2.0*	*2.81*	*5.1*	*257.2*
	Conventional	*78.8*	*70.7*	*63.6*	*4.5*	*25.8*	*56.8*	*5.4*	*2.0*	*2.73*	*4.9*	*276.7*
C.D (%0.05)	*Methods*	*NS*	*NS*	*NS*	*NS*	*0.27*	*3.0*	*0.13*	*0.03*	*0.09*	*NS*	*13.6*
Mean of cultivars	*BPT 5204*	*78.24*	*71.15*	*68.61*	*5.00*	*24.61*	*76.0*	*5.11*	*1.79*	*2.85*	*4.74*	*229.4*
	DRRH2	*80.20*	*70.38*	*50.87*	*4.05*	*24.48*	*56.6*	*6.44*	*1.98*	*3.26*	*5.30*	*303.7*
	Swarna	*78.15*	*70.91*	*67.19*	*4.61*	*25.76*	*54.7*	*5.00*	*2.11*	*2.37*	*5.14*	*237.2*
C.D (0.05%)	*Cultivars*	*0.39*	*NS*	*3.59*	*0.28*	*0.27*	*3.0*	*0.07*	*0.27*	*0.05*	*0.28*	*13.64*

Table 3. Quality parameters as influenced by different methods of crop establishment in dry season

Cultivars	Methods	Hulling (%)	Milling (%)	HRR (%)	ASV	AC	GC	KL	KB	L/B
MTU 1010	Eco-SRI	75	61.5	57	3.00	21.69	80	5.92	2.01	2.95
	SRI	75	65.5	61	3.00	22.8	78	5.72	2.06	2.78
	Con	76.5	60.8	56.6	3.00	22.65	82	5.95	1.99	2.99
Shanthi	Eco-SRI	69	58	55.3	4.00	24.72	44	6.38	2.01	3.17
	SRI	77.3	66	62	4.00	24.63	43	6.55	1.94	3.38
	Con	78	64.5	60.5	4.00	24.66	50	6.32	1.92	3.29
DRRH2	Eco-SRI	78	68.6	63.2	4.00	24.54	44	6.51	1.87	3.48
	SRI	76.5	66.8	64.5	4.00	25.7	46	6.43	1.93	3.33
	Con	79.5	68.9	62.5	5.00	26.13	42	6.32	1.92	3.29
CD(.05) Interaction	VXM	1.0	1.3	1.1	NS	0.52	4.3	NS	NS	NS
	MXV	1.0	1.3	1.1	NS	0.52	4.3	NS	NS	NS
Mean of Methods	Eco-SRI	74.00	62.70	58.50	3.67	23.65	56.00	6.27	1.96	3.19
	SRI	76.27	66.10	62.50	3.67	24.38	55.67	6.23	1.98	3.15
	Conventional	78.00	64.73	59.87	4.00	24.48	58.00	6.20	1.94	3.19
C.D (٪۰,۰۵)	Methods	2.1	1.89	1.51	NS	NS	1.5	NS	NS	NS
Mean of Cultivars	MTU 1010	75.50	62.60	58.20	3.00	22.38	80.00	5.86	2.02	2.90
	Shanthi	74.77	62.83	59.27	4.00	24.67	45.67	6.42	1.96	3.28
	DRRH2	77.50	66.63	62.73	4.00	24.97	46.67	6.42	1.91	3.37
C.D (0.05%)	Cultivars	1.3	2.2	4.2	0.30	1.4	4.28	NS	NS	NS

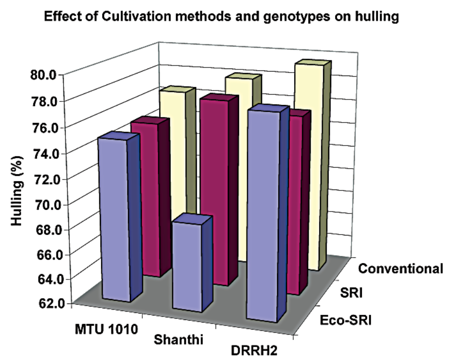


Fig. 1. Hulling

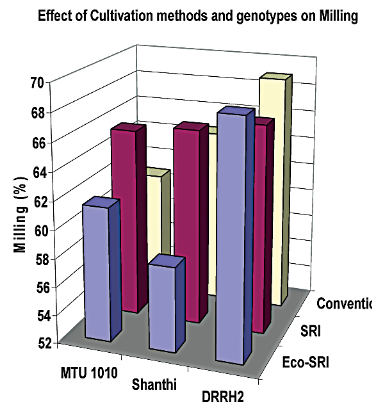


Fig. 2. Milling

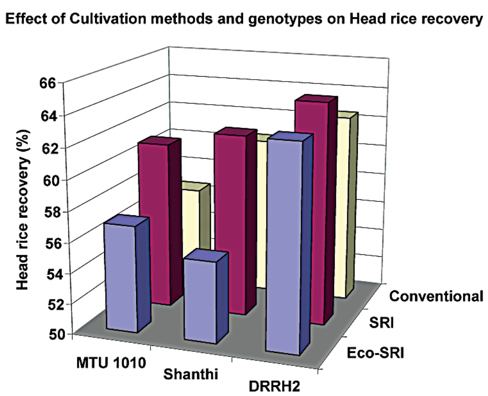


Fig. 3. Head rice recovery

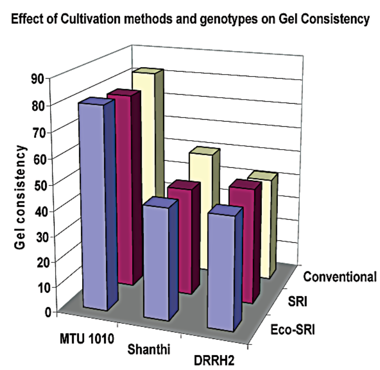


Fig. 4. Gel consistency

Fig1-4. Quality parameters as influenced significantly by methods and cultivars in dry season.

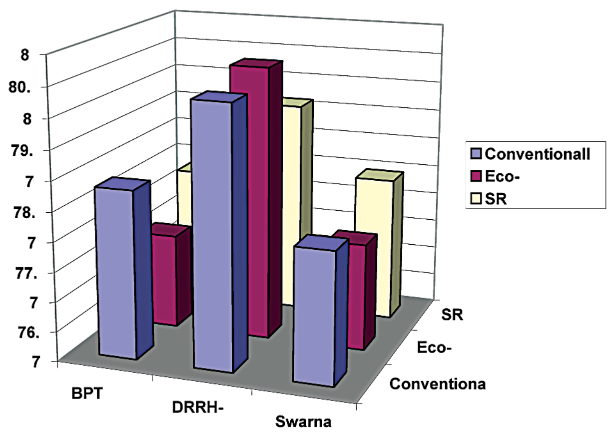


Fig. 5. Hulling

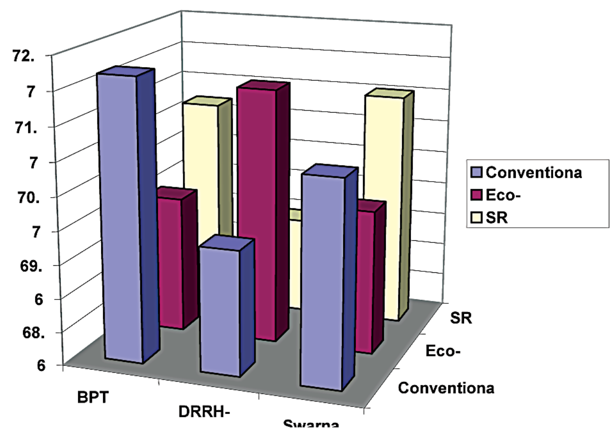


Fig. 6. Milling

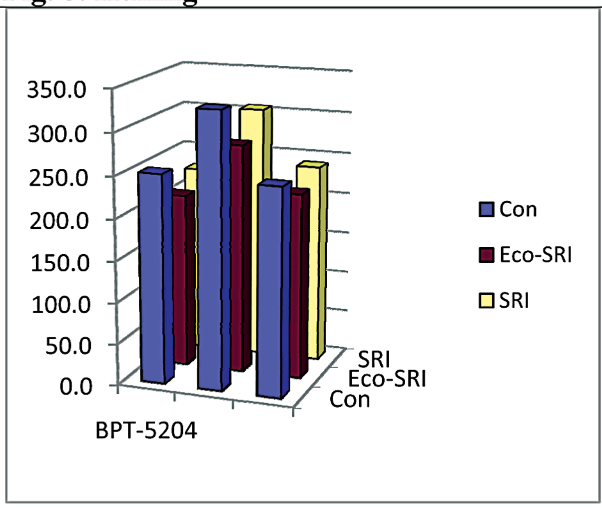


Fig. 7. Water uptake

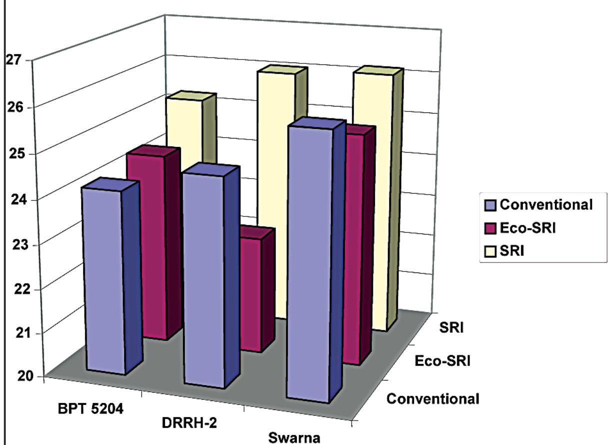


Fig. 8. Amylose content

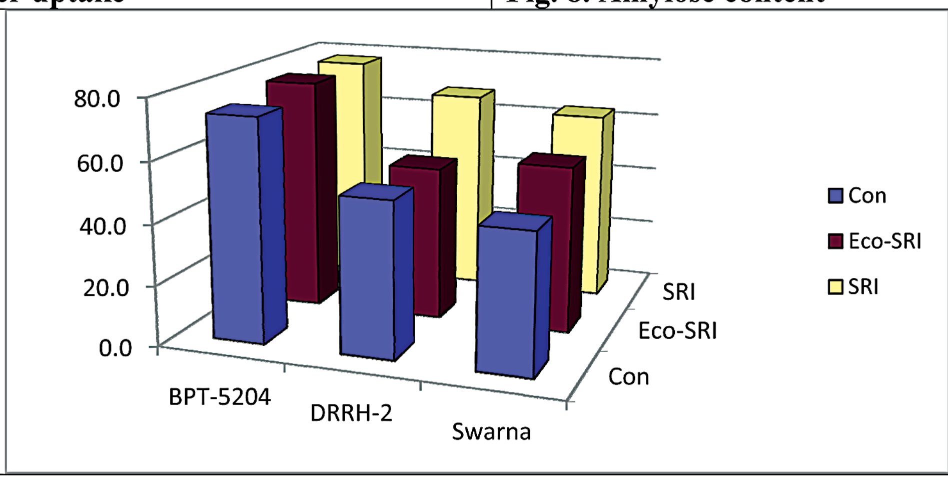


Fig. 9. Gel consistency

Fig. 5-9. Quality parameters as influenced significantly by methods and cultivars in wet season.

ORIGINAL RESEARCH ARTICLE OPEN ACCESS

Time of Start of Irrigation and Weed Management Practices on Performance of Dry Seeded Irrigated (Semi Dry) Rice

G. Sreenivas*, D. Raji Reddy and P. Leela Rani

Department of Agronomy, College of Agriculture, Professor Jayashankar Telangana State Agricultural University, Rajendranagar, Hyderabad

*Corresponding author: gsreenivas2002@gmai.com

Received: 29th May, 2015; Accepted: 26th December, 2015

Abstract

Experiments was conducted at College farm, College of Agriculture, Rajendranagar, Hyderabad to find out ideal time of irrigation and best weed management practice under dry seeded irrigated condition. Experiment was laid out with three irrigation schedules (starting of irrigation from 45, 60 and 75 DAE) as main plots and five weed management treatments (pre-emergence application of butachlor @ 1 kg ha-1 fb 2, 4-D Na salt @ 1 kg ha-1 at 30 DAE, pre-em application of pretilachlor @ 0.75 kg ha-1 fb 2, 4-D Na salt @ 1 kg ha-1 at 30 DAE, interculture at 20 DAE fb HW at 40 DAE, interculture at 20 DAE fb HW at 40 and 60 DAE and unweeded check) as sub plots in split plot design replicated thrice.Scheduling of irrigation from 45 DAE resulted in significantly higher grain yield than irrigation started from 60 DAE which inturn resulted in significantly higher yield than that of irrigation scheduled from 75 DAE. The total water input (effective rainfall + irrigation) was higher in irrigation scheduled from 45 DAE, while the water productivity was higher in irrigation scheduled from 60 DAE. Higher B:C ratio was obtained with irrigation scheduled from 45 DAE than that of irrigation started from 60 and 75 DAE. Among the weed management treatments, interculture at 20 DAE fb HW at 40 and 60 DAE recorded significantly lower weed DMP, higher WCE, number of panicles and grain yield than that of pre-em application of pretilachlor @ 0.75 kg ha-1 fb 2, 4-D Na salt @ 1 kg ha-1. Number of panicles and yield were comparable with pre-em application of pretilachlor @ 0.75 kg ha-1 fb 2, 4-D Na salt @ 1 kg ha-1 and butachlor @ 1 kg ha-1 fb 2, 4-D Na salt @ 1 kg ha-1 at 30 DAE. Higher water productivity and B:C ratio were obtained with interculture at 20 DAE fb HW at 40 and 60 DAE.

Key words: Dry seeded irrigated rice, Weed drymatter, WCE, Effective rainfall, Grain yield and Water productivity

Introduction

Rice, in India, is cultivated under varied ecosystems - rainfed upland and low land and irrigated. The rainfed lowland and upland rice is usually direct seeded into dry soil. On the other hand, the irrigated rice is established either by transplanting or direct seeding under puddled condition or dry seeding. Irrigated rice requires about 3,000 – 5,000 L of water to produce 1 kg of grain (IRRI, 2001). Because of this high water requirement, the increasing water shortage threatens the sustainability of the irrigated rice system (Tuong and Bouman, 2002). Considering the future population growth, competition from non-agricultural uses of water and increasing demand for agricultural products, available water needs to be used efficiently. To reduce the share of water in rice cultivation, it is imperative to develop new way of growing rice that uses less water, while maintaining high yields. Dry seeded irrigated (Semi-dry) rice culture is a system associated with upland condition in the early and low land situation at later stages of crop growth. The semi-dry rice is characterized by sowing of dry seed with the help of monsoon rains and subsequently converting it into wet condition by using tank, canal or ground water. Dry seeded rice offers scope to advance crop establishment and to increase the effective use of early season rainfall (Tuong, 1999). The time of starting of conversion of dry rice to wet land or irrigated dry rice plays major role in obtaining higher yields. It has been reported that similar yields as that of transplanted rice can be obtained by scheduling irrigation as that of irrigated dry crop. Further, irrigation of semi-dry rice with 5 cm at weekly intervals upto 45-60 DAE significantly improved the yield over that at fortnightly irrigations (Thyagarajan and Selvaraju, 2001). These results indicated that there is greater scope for scheduling the irrigation water for rice crop production. Further, providing need-based irrigation by taking rainfall into consideration, considerable quantity of water can be saved. Hence, an experiment with scheduling of irrigation was carried. In dry seeded rice ecosystems, weeds and rice emerge simultaneously, and weeds compete with rice plant for light, nutrients and moisture resulting in reduction of grain yield upto 80 per cent (Sinha Babu *et al.,* 1992). Manual weeding of dry seeded rice fields is labour oriented and expensive. The traditional hand weeding practice needs to be substituted by herbicides to control weeds timely and economically. There is a need to develop integrated weed management for effective weed control in irrigated dry seeded rice. Keeping in view the investigation was carried out with aim to identify optimum time for starting of irrigation and weed management practices for higher grain yield of rice under dry seeded irrigated conditions

Material and Methods

The investigation was carried out during *kharif*, 2003 at College farm, College of Agriculture, Rajendranagar, Hyderabad situated at an altitude of 542.6 m above mean sea level on 17°19' N latitude and 78°23' E longitude. The mean weekly maximum temperature during cropping period ranged from 27.5 to 35.2°C. The weekly mean minimum temperature varied between 9.5 to 24.0°C. The mean relative humidity fluctuated between 26.3 to 93.9 per cent.Rainfall of 810.2 mm was received in 45 rainy days. The weekly mean bright sunshine hours per day varied from 2.0 to 9.3 hours and mean evaporation ranged from 2.2 to 8.4 mm day^{-1}during crop growing season.

The experiment was conducted in sandy clay loam soil having pH 7.7with available nitrogen 279.5 kg ha^{-1}, phosphorous 10.9 kg ha^{-1} and available potassium of 128.95 kg ha^{-1}. three times of start of irrigation *viz.,* 45 DAE, 60 DAE and 75 DAE in main plots and five weed management treatments *viz.,* pre-em application of butachlor @ 1 kg ha^{-1} fb 2, 4-D Na salt @ 1 kg ha^{-1} at 30 DAE, pre-em application of pretilachlor @ 0.75 kg ha^{-1} fb 2, 4-D Na salt @ 1 kg ha^{-1} at 30 DAE, IC at 20 DAE fb HW at 40 DAE, IC at 20 DAE fb HW at 40 and 60 DAE and unweeded check in sub plots in a split-plot design. The treatments were replicated thrice in both the experiments. The experiment was sown on 16 July, 2003 using medium duration cultivar Polasa Prabha (JGL 384) and harvested on 30 November 2003. Sowing was done with dry seed in solid rows at 20 cm spacing between two rows. A seed rate of 400 seeds m^{-2} was used. A uniform level of 140 kg ha^{-1} N as urea, 60 kg ha^{-1} P_2O_5 as single super phosphate, 40 kg ha^{-1} K_2O as muriate of potash was applied to all the treatments. The entire P_2O_5, K_2O and $ZnSO_4$ @ 50 kg ha^{-1} were applied at sowing . The nitrogen was applied in three splits -1/3 each at sowing, active tillering and panicle initiation stages. Irrigation was applied as per the treatments with a depth of irrigation was 5 cm. An area of one m^2 was earmarked in each net plot randomly for recording the observations on weed density. Weeds were removed from 0.25 m^2 area using the quadrat from outside the net plot at 30, 60, 90 DAE and harvest. The samples were shade dried and then oven dried at 75°C to a constant weight.

Results and Discussion

During crop growth period, ten weed species comprising five monocots *viz.Echinochloa colona* L, *Dinebra retroflexa* L, *Cynodon dactylon* pers., *Dactyloctenium aegyptium* Beauv *and Cyperus rotundus* L. and five dicots were *Eclipta alba* Hassk, *Caesulia axillaris* Rozb, *Parthenium hysterophorus* L, *Trianthema portulacastrum* L and *Amaranthus viridis* L were observed.

Time of starting of irrigation

Time of start of irrigation did not affect the weed density, weed dry matter and weed control efficiency at any stage of the crop growth (Table 1). Significantly higher grain yield was obtained with irrigation started from 45 DAE than that from 60 and 75 DAE and it was 8.98 and 38.8 per cent higher in the former irrigation treatment than that of latter treatments (Table 2). Irrigation given from 60 DAE recorded 27.4 per cent higher grain yield than that of irrigation from 75 DAE. Irrigation started from 75 DAE recorded significantly lower grain yield.

The higher grain yield with irrigation scheduled from 45 DAE was mainly due to higher amount of total water input (effective rainfall + irrigation) during crop growth period than with irrigation scheduled from 60 DAE (Table 4). The water deficit through effective rainfall before start of irrigation was 23 per cent in the irrigation scheduled from 45 DAE. Further with delay in schedule of irrigation 60 and 75 DAE, there was 40.2 and 37.2 per cent deficit water (effective rainfall) respectively than that of water requirement in respective irrigation treatments (Table 3).

Greater quantity of required water could be met through the rainfall before start of irrigation in irrigation scheduled from 45 DAE (77%) than that of irrigation scheduled from 60 DAE (60%) and 75 DAE (63%), which might have resulted in higher grain yield in the former treatment than that of the latter irrigation treatments.

Greater amount of water was received during its growth period in the irrigation treatment at 45 DAE that might have resulted in higher number of panicles and less spikelet sterility (Table 2) as compared to irrigation scheduled 60 and 75 DAE. This might be due to higher water input in irrigation scheduled from 45 DAE might have resulted in higher grain yield than that of irrigation scheduled from 60 DAE. There are reports that in dry seeded rice, submergence at 30 or 45 DAE recorded higher grain yield and further delay in irrigation reduced grain yield (Govindasamy *et al.,* 1992). The results obtained in the present study corroborate this.

Higher gross and net income and B:C ratio was obtained with irrigation scheduled from 45 DAE than that of 60 and 75 DAE (Table 5). Higher initial growth due to lower deficit (23%) rainfall helped in increased grain yield in irrigation scheduled from 45 DAE as compared to irrigation scheduled from 60 and 75 DAE.

Weed Management

There was lower weed density and DMP, and higher WCE at 90 DAE in the crop with interculture at 20 DAE fb HW at 40 and 60 DAE than that of interculture at 20 DAE fb HW at 40 DAE (Table 1). At 30 and 60 DAE, weed dry weight was comparable between intercultureat 20 DAE fb HW at 40 and 60 DAE and interculture at 20 DAE fb HW at 40 DAE. The total removal of weeds at 60 DAE in interculture at 20 DAE fb HW at 40 and 60 DAE caused lower crop-weed competition, thereby lower weed dry weight at 90 DAE and harvest than interculture at 20 DAE fb HW at 40 DAE. The critical period of weed competition for upland rice was upto 60 DAS (Ali and Sankaran, 1984). The variation of critical period of weed competition was due to variation in crop growth rate during 60-90 days (Bhargavi and Reddy, 1990).

An increase in panicle number might be contributed to higher grain yield in interculture at 20 DAE fb HW at 40 and 60 DAE (Table 2). On the other hand, interculture at 20 DAE fb HW 40 DAE recorded 52.4 and 32.0 per cent higher weed dry matter at 90 DAE and harvest, respectively than interculture at 20 DAE fb HW at 40 and 60 DAE thereby lower grain yield in former treatment.

Significantly higher grain yield and water productivity was obtained with interculture at 20 DAE fb HW at 40 and 60 DAE than that at 20 DAE fb HW at 40 DAE, which in turn recorded significantly higher grain yield over pre-em application of pretilachlor @ 0.75 kg ha^{-1} fb 2,4-D Na salt @ 1 kg ha^{-1} at 30 DAE and butachlor @ 1 kg ha^{-1} fb 2,4-D Na salt @ 1 kg ha^{-1} at 30 DAE. The grain yield in the latter two treatments was comparable and significantly higher than that of unweeded check (Table 2).

Interculture at 20 DAE fb HW at 40 DAE recorded 19.7 per cent higher grain yield than pre-em application of pretilachlor @ 0.7 kg ha^{-1} fb 2,4-D Na Salt @ 1 kg ha^{-1} at 30 DAE. The former treatment recorded 28.9, 18.3 and 16.7 per cent higher crop dry matter accumulation at PI, heading and harvest, respectively than the latter treatment. In interculture at 20 DAE fb HW at 40 DAE, the total removal of weeds due to HW at 40 DAE resulted in lower weed dry weight and higher WCE at 60 and 90 DAE, resulting in the higher panicle number per unit area thereby increased grain yield. It has been reported that in drilled rice, mechanical weeding at 35 DAE fb HW at 40 DAE resulted in higher Weed Control Efficiency (Prusty*et al.,* 1990). At 30 DAE, pre-em application of pretilachlor @ 0.75 kg ha^{-1} fb 2,4-D Na salt @ 1 kg ha^{-1} at 30 DAE resulted in lower weed density, weed weight and WCE than interculture at 20 DAE fb HW at 40 DAE. Though pre-em application of pretilachlor @ 0.75 kg ha^{-1} effectively reduced the weed dry weight at 30 DAE, it could not give higher grain yield due to severe crop weed competition in later crop growth stages. Pre-em application of pretilachlor @ 0.75 kg ha^{-1} fb 2, 4-D Na salt @ 1 kg ha^{-1}at 30 DAE resulted in reduced density of broad leaved weeds, resulting in dominance of monocots, which led to higher weed dry weight at 60 DAE. On the other hand, the weeds were effectively removed at 40 DAE by HW in the treatment IC at 20 DAE fb HW at 40 DAE, which resulted in lower crop weed competition thereby improved grain yield.

Pre-em application of pretilachlor @ 0.75 kg ha^{-1} fb 2,4-D Na salt @ 1 kg ha^{-1} at 30 DAE and butachlor @ 1 kg ha^{-1} fb 2, 4-D Na salt @ 1 kg ha^{-1} at 30 DAE recorded comparable grain yield and significantly higher than that of unweeded check. Pre-em application of butachlor @ 1 kg ha^{-1} fb 2,4-D Na salt @1 kg ha^{-1} at 30 DAE effectively reduced the weed dry weight, which resulted in higher WCE due to low crop weed competition throughout the crop growth period. Better control of weeds with application of butachlor in semi-dry rice led to higher panicles, yield attributes and grain yield than that of unweeded check (Nair *et al.,* 1979). The severe crop weed competition throughout the crop growth period reduced panicles and grain yield of rice.

Higher gross and net income and B:C ratio were obtained with IC at 20 DAE fb HW at 40 and 60 DAE followed by IC at 20 DAE fb HW at 40 DAE because of increased yield, reduced weed dry weight at 60 and 90 DAE and harvest. Lower B:C ratio was recorded in pre-em application of butachlor @ 1 kg ha^{-1} fb 2, 4-D Na salt @ 1 kg ha^{-1} at 30 DAE and pretilachlor @ 0.75 kg ha^{-1} fb 2, 4-D Na salt @ 1 kg ha^{-1} at 30 DAE as a result of low yield as compared to IC at 20 DAE and HW at 40 and 60 DAE because of the weed control was less effective in this treatment.

From these results, it can be concluded that, scheduling irrigation from 45 DAE with adoption of IC at 20 DAE fb HW at 40 and 60 DAE will improve the yield and net returns of dry seeded irrigated rice in south Telangana agro climatic zone of Telangana.

References

Ali, A.M. and Sankaran, S. 1984. Crop-weed competition in direct seeded lowland and upland rice. *Indian Journal of Weed Science* 16 : 90-96.

Bhargavi, K. and Reddy, Y.T. 1990 Effect of time and method of application of herbicides on weed control in semi-dry rice (*Oryza sativa* L.). *Indian Journal of Agricultural Sciences* 60(2): 147-150.

Govindasamy, K.N., Lakshminarayana, T. and Subramanian, S. 1992. Effect of submergence timing and application of *Azospirillum* and K on direct seeded rice. *International Rice Research Newsletter* 17 (4): 18.

IRRI 2001 Annual report 2000-2001 : Rice research : the way forward : Los Banos ,Philippines. International Rice Research Institute. pp.71.

Sinha Babu, D.P., Moorthy, B.T.S., Rajamani, S. and Manna, G.B. Integrated weed management benefits direct seeded upland rice. *Indian Farming* 42:7-8.

Thyagarajan, T.M. and Selvaraju, R. 2001. Water-saving rice cultivation in India. In: Proceedings of International workshop, Water-saving rice production systems, Nanjing University, China, April 2-4, 2001. Plant Research International, Wageningen, report 33, pp 15-45.

Tuong, T.P. 1999. Productive water use in rice production: Opportunities and limitations. *Journal of Crop Production* 2: 241-264.

Tuong, T.P. and Bouman, B.A.M. 2002. Rice production in water scarce environments. To be published in proceedings of the water productivity workshop, 12-14 Nov.2001, International Water Management Institute, Sri Lanka.

Table 1. Weed density, weed dry matter and weed control efficiency as affected by time of start of irrigation and weed management practices in dry seeded irrigated rice

Treatment	Weed density (number m^{-2})				Weed dry matter (g m^{-2})				Weed control efficiency (%)			
	30 DAE	60 DAE	90 DAE	Harvest	30DAE	60DAE	90DAE	Harvest	30DAE	60DAE	90DAE	Harvest
Time of irrigation (I)												
45 DAE	10.21 (106)	9.74 (100.8)	8.19 (71)	6.59 (50)	39.5	77.4	92.6	67.5	42.6	58.4	65.2	69.8
60 DAE	9.95 (102)	9.13 (89)	8.14 (71)	6.81 (52)	34.6	68.6	97.7	73.1	56.5	63.4	65	71
75 DAE	10.09 (103)	9.18 (90)	7.89 (67)	6.55 (50)	42.1	70.2	105.9	83.5	55.5	63.9	64.5	73
SEm±	0.28	0.35	0.25	0.15	3.6	2.4	4.5	4.4	-	-	-	-
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	-	-	-	-
Weed management (W)												
W_1	8.71 (76)	9.32 (87)	8.24 (68)	6.10 (37)	16.9	82.4	103.7	68.4	72.9	44.5	49.6	60.4
W_2	8.38 (71)	9.14 (84)	8.03 (65)	6.01 (36)	15.1	82	102	62.1	74.6	44.7	50	63.6
W_3	10.67 (114)	7.45 (56)	6.78 (47)	5.29 (28)	49	32.6	55.1	40	31.7	78.5	72.9	76.7
W_4	10.39 (109)	7.19 (52)	5.39 (29)	4.37 (19)	49.7	30.2	26.2	27.2	27	79.9	87.1	84.4
W_5	12.12 (148)	13.66 (187)	11.92 (142)	11.48 (132)	62.9	133.4	206.8	175.8	0	0	0	0
SEm±	0.36	0.29	0.34	0.29	3.8	4.6	5.4	6.1	-	-	-	-
CD (P=0.05)	1.05	0.86	0.99	0.85	11.1	13.5	15.8	17.8	-	-	-	-
Interaction (IxW)												
SEm±	0.62	0.51	0.59	0.5	6.6	8	9.4	10.5	-	-	-	-
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	-	-	-	-

W_1 - Pre-em butachlor @ 1 kg ha^{-1} fb 2, 4-D Na salt @ 1 kg ha^{-1} at 30 DAE.

W_2 - Pre-em pretilachlor @ 0.75 kg ha^{-1} fb 2, 4-D Na salt @ 1 kg ha^{-1} at 30 DAE.

W_3 - IC at 20 DAE fb HW at 40 DAE

W_4 - IC at 20 DAE fb HW at 40 and 60 DAE

W_5 - Unweeded check

Table 2. Yield attributes and grain yield of rice as affected by time of start of irrigation and weed management practices in dry seed irrigated rice

Treatment	Panicles m^{-2}	Spikelets $Panicle^{-1}$	Filled spikelets $panicle^{-1}$	Spikelet sterility (%)	Test weight (g)	Grain yield ($t\ ha^{-1}$)	Straw yield ($t\ ha^{-1}$)	Harvest index (%)
Time of irrigation (I)								
45 DAE	230	104	80.4	24.4	13.7	2.79	5.06	35
60 DAE	217	105.3	78	28	13.6	2.56	4.84	34.2
75 DAE	193	102.5	74.2	29.6	13.5	2.01	4.05	31.7
SEm±	4	2	1.5	0.4	0.1	0.06	0.05	-
CD (P=0.05)	16	NS	NS	1.4	NS	0.23	0.21	-
Weed management (W)								
W_1	216	110	84.7	23	13.7	2.21	4.48	32.8
W_2	221	111.6	85.3	23.5	13.7	2.32	4.67	33.2
W_3	247	116	89.7	22.6	13.8	2.89	5.58	34
W_4	276	120.8	94	22.1	13.9	3.66	6.04	37.6
W_5	105	61.2	34	44.4	13	1.19	2.47	30.8
SEm±	8	2.1	1.7	0.6	0.1	0.12	0.1	-
CD (P=0.05)	23	6.1	5.1	1.5	0.2	0.35	0.29	-
Interaction (IxW)								
SEm±	14	3.6	3	1	0.1	0.21	0.17	-
CD (P=0.05)	NS	NS	NS	NS	NS	NS	0.6	-

W_1 - Pre-em butachlor @ 1 kg ha^{-1} fb 2, 4-D Na salt @ 1 kg ha^{-1} at 30 DAE.

W_2 - Pre-em pretilachlor @ 0.75 kg ha^{-1} fb 2, 4-D Na salt @ 1 kg ha^{-1} at 30 DAE.

W_3 - IC at 20 DAE fb HW at 40 DAE

W_4 - IC at 20 DAE fb HW at 40 and 60 DAE

W_5 - Unweeded check

Table 3. Effective rainfall and water requirement in different irrigation treatments before start of irrigation of dry seeded irrigated rice

Time of irrigation	Effective rainfall(mm)	Water requirement (mm)	Deficit (%)
45 DAE	160.0	207.7	23.0
60 DAE	163.2	272.9	40.2
75 DAE	210.8	335.4	37.2

Table 4. Effective rainfall, irrigation water, total water and water productivity as influenced by time of start of irrigation and weed management treatments in dry seeded irrigated rice

Treatment	Effective rainfall(mm)	Irrigation water (mm)	Total water (mm)	Water productivity (kg m^{-3})
Starting of irrigation at 45 DAE	226.5	730.0	956.5	0.29
Starting of irrigation at 60 DAE	244.3	580.0	824.3	0.31
Starting of irrigation at 75 DAE	248.3	440.0	688.3	0.29

Table 5. Gross income, cost of cultivation, net income and B:C ratio as influenced by time of irrigation and weed management practices in dry seeded irrigated rice

Treatment	Gross income (Rs ha^{-1})	Cost of cultivation (Rs ha^{-1})	Net income (Rs ha^{-1})	B:C
Time of irrigation (I)				
45DAE	17700	12425	5275	1.42
60DAE	16300	12316	3984	1.32
75DAE	12873	12196	677	1.06
Weed management (W)				
W_1	14162	12278	1884	1.15
W_2	14860	12491	2369	1.19
W_3	18436	12392	6044	1.49
W_4	23040	12842	10198	1.79
W_5	7643	11642	-3999	0.66

W_1 - Pre-em butachlor @ 1 kg ha^{-1} fb 2, 4-D Na salt @ 1 kg ha^{-1} at 30 DAE.

W_2 - Pre-em pretilachlor @ 0.75 kg ha^{-1} fb 2, 4-D Na salt @ 1 kg ha^{-1} at 30 DAE.

W_3 - IC at 20 DAE fb HW at 40 DAE

W_4 - IC at 20 DAE fb HW at 40 and 60 DA+E

W_5 - Unweeded check

ORIGINAL RESEARCH ARTICLE OPEN ACCESS

Influence of Plant Densities and Age of Seedlings on Radiation Use efficiency of *Kharif* Transplanted Rice (*Oryza sativa* L.) in Southern Telangana

G. Vijayalaxmi*[1], G. Sreenivas[1]* and P. Leela Rani[2]

[1]Agro Climate Research Centre and Agriculture Research Institute;
[2]College of Agriculture, Prof. Jayashankar Telangana State Agricultural University, Rajendranagar, Hyderabad
*Corresponding author: gsreenivas2002@gmail.com

Received: 28th July, 2015; Accepted: 30th September, 2015

Abstract

Field experiment was conducted during *kharif*, 2013 at college farm, Prof. Jayashankar Telangana State Agricultural university, Rajendranagar, Hyderabad in randomized block design (Factorial) with three plant densities (1, 3 and 5 seedlings hill-1) and four age of seedlings (15, 25, 35 and 45 days old seedlings). The study revealed that the 5 seedlings hill-1 and 25 days old seedlings intercepted higher PAR at panicle initiation, heading and physiological maturity stages. But single seedling per hill obtained higher radiation use efficiency over 25, 35 and 45 days old seedlings. The estimated RUE of *kharif* transplanted rice under Southern Telangana zone was 1.12 g MJ-1.

Key words: Photosynthetically Active Radiation, Radiation Use Efficiency

Introduction

Rice is the staple food for more than half of the world's population and plays a pivotal role in food security of many countries. More than 90% of the global production and consumption of rice is in Asia (IRRI, 1997). As for India, rice is not only a food commodity but also a source of foreign exchange earning about 11,000 cores annually. At the current rate of population growth (1.5%), the rice requirement by the year 2025 would be about 120 million tons by 2025 as against 104.32 million tons to feed its one and a half billion plus population by then (RKMP, 2013). Although the productivity of rice is higher than India but it is less than the world. This is because of the late onset of monsoon, uneven distribution of rainfall and late release of water into canals forced the farmers to use over aged seedlings from the nursery and transplanting of more number of seedlings hill^{-1}. So it is necessary to use properly managed seedbeds with adequate nutrition and optimum seedling densities at appropriate age are important factors to get vigorous plant stands after transplanting. Plant densities (no. of seedlings hill^{-1}) are an important factor for rice production because it influences the radiation interception, photosynthetic rate, tiller production, nutrient uptake and other physiological phenomena and ultimately the growth and development of rice plant. The correct age of seedlings used for transplanting is of primary importance for uniform stand and seedling establishment as half of the success of rice cultivation depends on the seedling (Khakwani *et al*., 2005). Keeping these facts in view, the present investigation was carried out with better utilization of resources.

Material and Methods

The experiment was carried out during *kharif*, 2013 at college farm, Rajendranagar, Hyderabad situated at an altitude of 542.3 m above mean sea level at 17°19' N latitude and 78°23' E longitude. The experiment was laid out in a randomized block design (factorial) with 12 treatments comprised of four levels of different age seedlings (15, 25, 35 and 45 days old seedlings) as one factor and three levels of plant densities (1, 3 and 5 seedlings hill^{-1}) as another factor. The soil of the experiment site was sandy loam in texture, alkaline in reaction (^{pH} - 8.02), low in available nitrogen (210 kg ha^{-1}), available phosphorus (14.14 kg ha^{-1}) and available potassium (249.76 kg ha^{-1}). The other cultivation practices were recommended for raising the crop.

Intercepted PAR (Photosynthetically Active Radiation)

Sun Scan Plant Canopy Analyser was used to measure the incident and transmitted PAR through canopies during the crop growth period at panicle initiation, heading and physiological maturity stages. The intercepted PAR and transmitted PAR were expressed in percentage.

Radiation Use Efficiency (RUE)

The radiation use efficiency was calculated as the ratio of dry matter to radiant energy intercepted (Intercepted photosynthetically active radiation) by the crop (Gallagher and Biscoe, 1978).

$$\text{RUE} = \frac{\text{Amount of dry matter produced (g m}^{-2}\text{)}}{\text{Amount of cumulative intercepted PAR (MJ m}^{-2}\text{)}}$$

Results and Discussion

Intercepted PAR (Photosynthetically Active Radiation) (%)

Experimental results revealed that, light interception increased consistently up to heading and reached maximum at heading stage, thereafter it declined towards physiological maturity (Fig.1). This was due to senescence of leaves and tiller mortality. percent light interception was increased from 1 seedling hill^{-1} to 5 seedlings hill^{-1}. The highest interception was recorded with 5 seedlings hill^{-1} (54.6, 66.3 an 63.3) at panicle initiation, heading and physiological maturity respectively and was significantly superior to 3 seedlings hill^{-1} and 1 seedling hill^{-1}, in turn the lowest values were observed with 1 seedling hill^{-1} at panicle initiation (41.7), heading (50.8) and physiological maturity stages (48.5). The increased light interception might be due to increased leaf area index at higher plant densities over low plant densities (Baloch *et al*., 2006).

In similar way percent light interception was increased with different age of seedlings during crop growth (Fig.2). Significantly the highest radiation interception was observed with 25 days old seedlings (61.7, 71.8 and 68.5) over 15 (48.6, 63.0 and 60.8), 35 (42.8, 53.7 and 50.2) and 45 days old seedlings (37.0, 47.1 and 44.4) at panicle initiation, heading and physiological maturity stages respectively. This might be due to the lower leaf area index with old age seedlings, which reduced the intercepted light (Salem *et al*., 2011).

Radiation Use Efficiency (g MJ^{-1})

The radiation use efficiency was increased with progress of the crop growth (Table.1). The highest radiation use efficiency was observed with 1 seedling hill^{-1} at at panicle initiation, heading and physiological maturity stage and was followed by 3 and 5 seedlings hill^{-1}. With advancement of crop age the radiation use efficiency was increased up to physiological maturity stage. The lowest radiation use efficiency was recorded with 45 days old seedlings. This might be due to early harvesting of 45 days old seedlings, lead to less radiation accumulation compared to younger seedlings, where younger seedlings retained for the longer period under field condition.

A linear relationship was observed between biomass and intercepted PAR. Overall the RUE of rice for Southern Telangana zone was estimated to be 1.12 g MJ^{-1} (Fig. 3). In similar way Kiniry *et al*., (1989) noticed the RUE of 2.2 g MJ^{-1} of intercepted PAR from a non-stressed rice crop. The estimated RUE of *kharif* transplanted rice under Southern Telangana zone was 1.12gMJ^{-1}.

References

Baloch, M.S., Awan, I.U. and Hassan, G. 2006. Growth and yield of rice as affected by transplanting dates and seedlings hill^{-1} under high temperature of Dera Ismail Khan, Pakisthan. *Journal of Zhejiang University and Science.* 7(7): 572–579.

Gallagher, J.N. and Biscoe, P.V. 1978. Radiation absorption, growth and yield of cereals. *Journal* of *Agricultural Science, Cambridge.* 19: 47-60.

IRRI, (International Rice Research Institute) 1997. Annual report 1996-97. Rice research: the way forward. Los Banos. *International Rice Research Institute,* Philippines.

Khakwani, A.A., Shiraishi, M., Zubair, M., Baloch, M.S., Naveed, K. and Awan, I. 2005. Effect of seedling age and water depth on morphological and physiological aspects of transplanted rice under high temperature. *Journal of Zhejiang University*. 68(5): 389-395.

Kiniry, J.R., Jones, C.A., O'Toole, J.C., Blanchet, R., Cabelguenne, M. and Spanel, D.A. 1989. Radiation-use-efficiency in biomass accumulation prior to grain filling for five grain crop species. *Field Crops Research*. 20: 51-64.

Rice Knowledge Management Portal (RKMP) 2013. Directorate of Rice Research, Rajendranagar, Hyderabad. http://www.rkmp.co.in

Salem, A.K.M., ElKhoby, W.M., Khalifa, A.B.A. and Ceesay, M. 2011. Effect of nitrogen fertilizer and seedling age on inbred and hybrid rice varieties. *American-Eurasian Journal of Agricultural & Environmental Science.* 11(5): 640-646.

Table 1. Radiation use efficiency (g MJ^{-1}) of rice at different growth stages under varied plant densities and age of seedlings

Treatments	Panicle initiation	Heading	Physiological maturity
Plant densities			
1 seedling $hill^{-1}$	1.05	1.28	1.54
3 seedlings $hill^{-1}$	1.15	1.20	1.41
5 seedlings $hill^{-1}$	1.04	1.13	1.31
Age of seedlings			
15 days	0.82	0.98	1.24
25 days	0.81	0.97	1.26
35 days	1.18	1.43	1.63
45 days	1.51	1.43	1.56

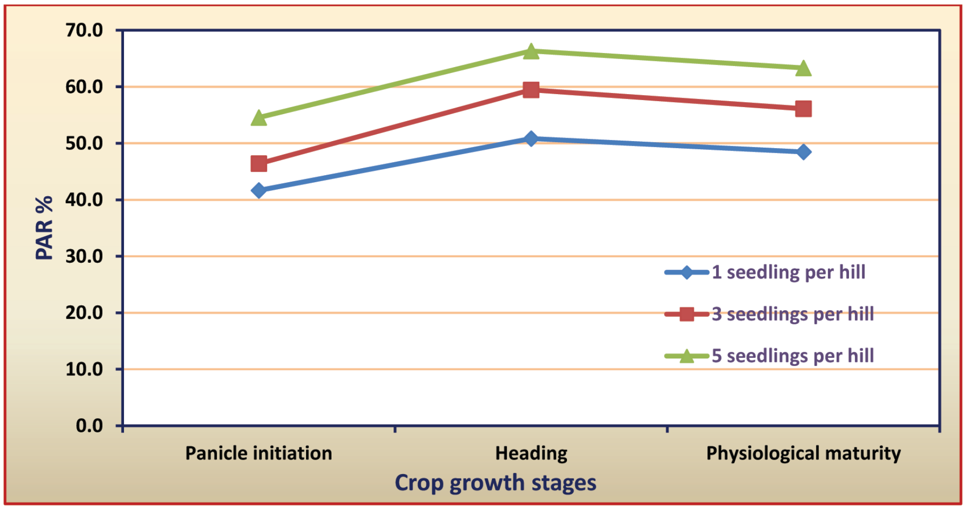


Fig. 1. Per cent intercepted PAR at different phenophases of rice under variable plant densities

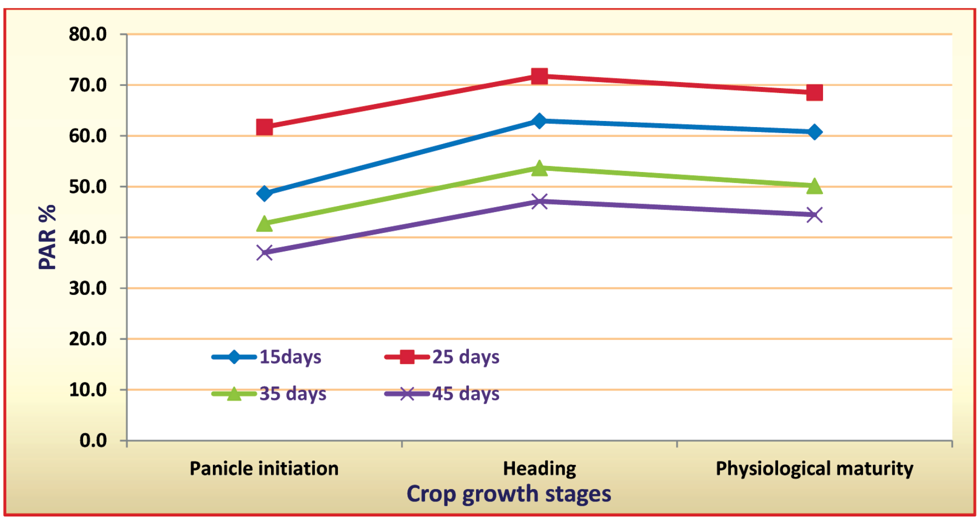


Fig. 2. Per cent intercepted PAR at different phenophases of rice under variable age of seedlings

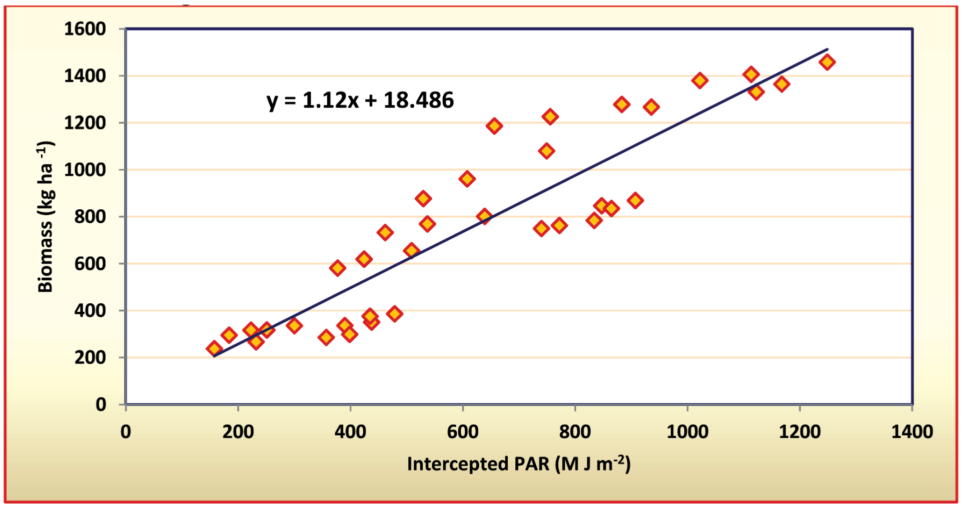


Fig. 3. Relationship between intercepted PAR and biomass of rice under variable plant densities and age of seedlings

ORIGINAL RESEARCH ARTICLE OPEN ACCESS

Time of Start of Irrigation and Weed Management Practices on Nutrient Uptake of Crop and Weed in Dry Seeded Irrigated (Semi Dry) Rice

G. Sreenivas*, D. Raji Reddy, N. Mahesh and P. Leela Rani

Agro Climate Research Centre, Prof. JayashankarTelangana State Agricultural University, Telangana
*Corresponding author: gsreenivas2002@gmail.com

Received: 28th August, 2015; Accepted: 20th November, 2015

Abstract

An experiment was conducted at College farm, College of Agriculture, Rajendranagar, Hyderabad to find out ideal time for start of irrigation and best weed management practice under dry seeded irrigated condition. Scheduling of irrigation from 45 DAE resulted in significantly higher crop drymatter production, nutrient uptake and grain yield than irrigating from 60 DAE which inturn resulted in significantly higher yield than that of irrigation scheduled from 75 DAE. Among the weed management treatments, interculture at 20 DAE fb HW at 40 and 60 DAE recorded significantly lower weed drymatter production, and higher crop dry matter, nutrient uptake and grain yield than rest of the weed management practices.

Key words: Dry seeded irrigated rice, Time of start of irrigation, Drymatter, Nutrient uptake, Grain yield

Introduction

Weeds are endemic in crops and a constant problem in crop production because of their dynamic nature (Blackshaw *et al.*, 2005). Despite modern control practices aimed at weed elimination, weed continues to be a ubiquitous and recurrent threat for crop production due to its ability to shift in response to management practices and environmental conditions (Buhler *et al.*, 2000). Aerobic rice systems, wherein the crop is established via direct-seeding in non-puddled, non-flooded fields, are among the most promising approaches for saving water. Aerobic rice systems can substitute the conventional rice cultivation system in the wake of water shortage and energy crises. However, aerobic systems are subject to much higher weed pressure than conventionally puddled transplanted rice. The major constraint in the success of aerobic rice is high weed infestation. Weed management continues to be a huge challenge in aerobic rice which is highly vulnerable to weed infestation because of dry ploughing and aerobic soil conditions (Balasubramanian and Hill, 2002). Proper weed management is considered to be one of the most important prerequisites to ensure satisfactory yield of rice. High weed pressure in direct seeded rice lowers the economic return, and in extreme cases rice cultivation results in a losing concern

In dry seeded rice ecosystems, weeds and rice emerge simultaneously, and weeds compete with rice plant for light, nutrients and moisture resulting in reduction of grain yield upto 80 per cent (Sinha Babu *et al.,* 1992). Manual weeding of dry seeded rice fields is labour oriented and expensive. The traditional hand weeding practice needs to be substituted by herbicides to control weeds timely and economically. There is a need to develop integrated weed management for effective weed control in irrigated dry seeded rice.

Considering the above facts, the present investigation was carried out to identify ideal time for start of irrigation and best weed management practice under dry seeded irrigated condition to realize higher nutrient uptake and yield.

Material and Methods

An experiment was carried out during *Kharif* season 2003 at College farm, College of Agriculture, Rajendranagar, Hyderabad situated at an altitude of 542.6 m above mean sea level on 17°19’ N latitude and 78°23’ E longitude. During the crop growth season, the mean weekly maximum temperature during cropping period ranged from 27.5 to 35.2°C. The weekly mean minimum temperature varied between 9.5 to 24.0°C during the same period. The mean relative humidity fluctuated between 26.3 to 93.9 per cent. Rainfall of 810.2 mm was received in 45 rainy days during cropping period.The experimental soils are clayey with pH 7.7, low in organic carbon (0.72%), available nitrogen (275.9 kg/ha) and available phosphorus (10.8 kg/ha) and low in available potassium (128.9 kg/ ha). The experiment was conducted with three irrigation schedules (starting of irrigation from 45 DAE, 60 DAE and 75 DAE) as main plots and five weed management treatments (pre-em application of butachlor @ 1 kg ha^{-1} fb 2, 4-D Na salt @ 1 kg ha^{-1} at 30 DAE, pre-em application of pretilachlor @ 0.75 kg ha^{-1} fb 2, 4-D Na salt @ 1 kg ha^{-1} at 30 DAE, interculture at 20 DAE fb HW at 40 DAE, interculture at 20 DAE fb HW at 40 and 60 DAE and unweeded check) as sub plots in split plot design replicated thrice. Sowing was done with dry seed in solid rows at 20 cm spacing between two rows.A uniform level of 140 kg ha^{-1} N as urea, 60 kg ha^{-1} P_2O_5 as single super phosphate, 40 kg ha^{-1} K_2O as muriate of potash was applied to all the treatments. The entire P_2O_5, K_2O and $ZnSO_4$ @ 50 kg ha^{-1} were applied at sowing. The nitrogen was applied in three splits -1/3 each at sowing, active tillering and panicle initiation stages. Irrigation was applied as per the treatment details. The depth of irrigation was 5 cm till 01.10.2003 and later 4 cm depth of irrigation was given.

Results and Discussion

Weed drymatter production

At all the growth stages, time of start of irrigation did not influence the weed DMP (Figure 1) while it was significantly influenced by weed management treatments. At harvest, weed DMP recorded in interculture at 20 DAE fb HW at 40 and 60 DAE and interculture at 20 DAE fb HW at 40 DAE was comparable with each other and significantly lower than that observed with pre-em application of pretilachlor @ 0.75 kg ha^{-1} fb 2, 4-D Na salt @ 1 kg ha^{-1} at 30 DAE and pre-em application of butachlor @ 1 kg ha^{-1} fb 2, 4-D Na salt @ 1 kg ha^{-1} at 30 DAE. The weed DMP in latter two weed management treatments was comparable with each other and significantly lower than that of unweeded check (Figure 2).

Crop drymatter production

Time of start of irrigation and weed management treatments significantly influenced the DMP of rice. At maturity, the irrigation started at 45 DAE resulted in significantly higher DMP over that of 60 and 75 DAE. The DMP recorded with start of irrigation at 60 DAE was significantly higher than that observed with 75 DAE (Figure 3).

Significantly higher DMP was recorded in interculture at 20 DAE fb HW at 40 and 60 DAE than that of interculture at 20 DAE fb HW at 40 DAE. The DMP recorded in latter treatment was significantly higher than that observed with pre-em application of pretilachlor @ 0.75 kg ha^{-1} fb 2, 4-D Na salt @ 1 kg ha^{-1} at 30 DAE and pre-em application of butachlor @ 1 kg ha^{-1} fb 2, 4-D Na salt @ 1 kg ha^{-1} at 30 DAE. The DMP noticed in latter two treatments was comparable with each other and significantly higher than that of unweeded check (Figure 4).

Nutrient uptake by weeds

Time of starting irrigation significantly influenced the phosphorus uptake by weeds. The phosphorus uptake at harvest in former irrigation treatment 45 DAE was significantly higher than that of irrigation scheduled from 75 DAE. Phosphorus uptake of weeds recorded in irrigation scheduled from 60 and 75 DAE was comparable with each other. However nitrogen and potassium uptake by weeds was not influenced by time of start of irrigation.

Nitrogen, phosphorus and potassium uptake at harvest recorded in interculture at 20 DAE fb HW at 40 and 60 DAE and interculture at 20 DAE fb HW at 40 DAE was comparable with each other and significantly lower than that of pre-em application of pretilachlor @ 0.75 kg ha^{-1} fb 2, 4-D Na salt @ 1 kg ha^{-1} at 30 DAE. Nitrogen uptake recorded in pre-em application of pretilachlor @ 0.75 kg ha^{-1} fb 2, 4-D Na salt @ 1 kg ha^{-1} at 30 DAE and pre-em application of butachlor @ 1 kg ha^{-1} fb 2, 4-D Na salt @ 1 kg ha^{-1} at 30 DAE was comparable with each other and significantly lower than that of unweeded check (Table 2).

Nutrient uptake by crop

Time of starting of irrigation and weed management practices significantly influenced the nutrient uptake by rice. Significantly higher nitrogen, phosphorus and potassium uptakeat harvest was recorded in the crop that received irrigation from 45 DAE than that of irrigation from 60 DAE which inturn recorded comparable nitrogen uptake as that of irrigation from 75 DAE.

Nitrogen, phosphorous and potassium uptake at harvest recorded with interculture at 20 DAE fb HW at 40 and 60 DAE and interculture at 20 DAE fb HW at 40 DAE was comparable with each other and significantly higher than that of pre-em pretilachlor @ 0.75 kg ha^{-1} fb 2, 4-D Na salt @ 1 kg ha^{-1} at 30 DAE. The nitrogen uptake recorded in latter weed management treatment was significantly higher than that of pre-em application of butachlor @ 1 kg ha^{-1} fb 2, 4-D Na salt @ 1 kg ha^{-1} at 30 DAE (Table 2).

Grain and straw yield

Significantly higher grainyieldand straw yield was observed by starting of irrigation at 45 DAE than irrigation started at 60 DAE. The grain yield obtained in latter treatment was significantly higher than that of 75 DAE. The higher grain yield and straw yield with irrigation scheduled from 45 DAE was mainly due to higher amount of total water input (effective rainfall + irrigation) during crop growth period than with irrigation scheduled from 60 DAE and 75 DAE.

Among weed management treatments, interculture at 20 DAE fb HW at 40 and 60 DAE recorded significantly higher grainyield and straw yield than that of interculture at 20 DAE fb HW at 40 DAE. Grainyieldand straw yield noticed in the latter treatment was significantly higher than that of pre-em application of pretilachlor @ 0.75 kg ha^{-1} fb 2, 4-D Na salt @ 1 kg ha^{-1} at 30 DAE and pre-em application of butachlor @ 1 kg ha^{-1} fb 2, 4-D Na salt @ 1 kg ha^{-1} at 30 DAE. The grain yield and strawyieldobserved in latter two treatments was comparable with each other and significantly higher than that of unweeded check (Table 2).

Conclusion

From these results, it is concluded that, higher nutrient uptake and grain yield and straw yield can be obtained by scheduling irrigation from 45 DAE with adoption of IC at 20 DAE fb HW at 40 and 60 DAE.

References

Balasubramanian, V. and Hill, J.E. 2002. Direct seeding of rice in Asia: emerging issues and strategic research needs for the 21st century. in Direct Seeding: Research Strategies and Opportunities, S. Pandey and International Rice Research Institute, Eds., pp. 15–39, IRRI, Los Banos, Philippines, 2002.

Blackshaw, R.E., Moyer, J.R., Harker, K.N. and Clayton, G.W. 2005. Integration of agronomic practices and herbicides for sustainable weed management in a zero-till barley field pea rotation. *Weed Technology* 19(1): 190–196.

Buhler, D.D., Liebman, M. and Obrycki, J.J. 2000. Theoretical and practical challenges to an IPM approach to weed management. *Weed Science* 48(3): 274–280.

Sinha Babu, D.P., Moorthy, B.T.S., Rajamani, S. and Manna, G.B. 1992. Integrated weed management benefits direct seeded upland rice. *Indian Farming* 42:7-8.

Table 1. Nutrient uptake (kg ha^{-1}) by weeds and rice at harvest as influenced by time of start of irrigation and weed management treatments in dry seeded irrigated rice

Treatment	Nutrient uptake by weeds			Nutrient uptake by rice		
	Nitrogen	Phosphorus	Potassium	Nitrogen	Phosphorus	Potassium
Time of irrigation (I)						
45 DAE	12.7	3.5	12.5	81.6	13.1	74.0
60 DAE	10.4	3.2	12.5	68.5	12.3	69.6
75 DAE	9.2	2.8	12.2	64.5	10.9	60.4
SEm±	0.9	0.2	0.1	2.3	0.5	0.4
CD (P=0.05)	NS	0.7	NS	9.0	1.8	1.5
Weed management (W)						
W_1	12.4	3.3	11.8	60.1	10.9	70.5
W_2	10.4	3.1	12.3	70.0	12.1	73.5
W_3	7.1	1.8	11.2	100.1	16.3	86.4
W_4	5.3	1.4	10.9	105.8	18.3	97.0
W_5	18.5	6.3	15.9	21.5	3.0	12.6
SEm±	1.0	0.3	0.3	3.0	0.4	0.6
CD (P=0.05)	2.9	0.9	0.6	8.6	1.0	1.7
Interaction (IxW)						
SEm±	1.8	0.5	0.5	5.1	0.6	1.0
CD (P=0.05)	NS	NS	NS	NS	NS	NS

Table 2. Grain and straw yield and harvest index as influenced by time of start of irrigation and weed management treatments in dry seeded irrigated rice

Treatment	Grain yield (t ha $^{-1}$)	Straw yield (t ha $^{-1}$)
Time of irrigation (I)		
45 DAE	2.79	5.06
60 DAE	2.56	4.84
75 DAE	2.01	4.05
SEm±	0.06	0.05
CD (P=0.05)	0.23	0.21
Weed management (W)		
W_1	2.21	4.48
W_2	2.32	4.67
W_3	2.89	5.58
W_4	3.66	6.04
W_5	1.19	2.47
SEm±	0.12	0.10
CD (P=0.05)	0.35	0.29
Interaction (IxW)		
SEm±	0.21	0.17
CD (P=0.05)	NS	0.6

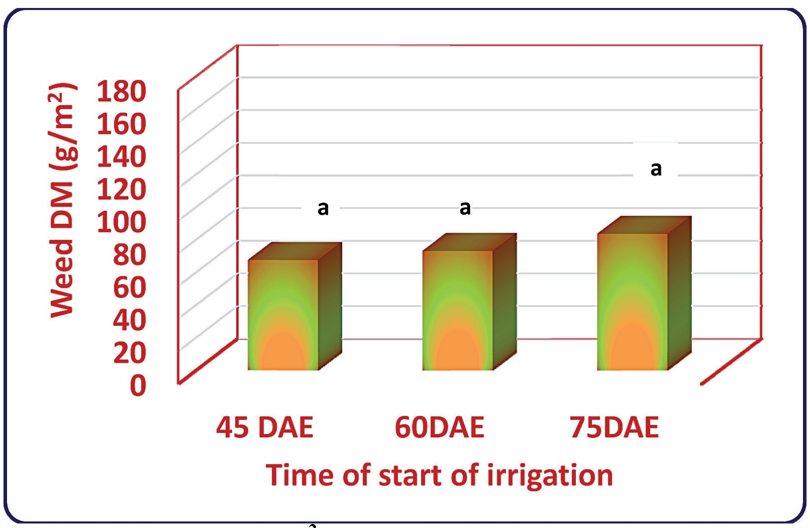


Fig. 1.Weed dry matter (g m-2) at crop physiological maturity as influenced by time of start of irrigation in dry seeded irrigated rice

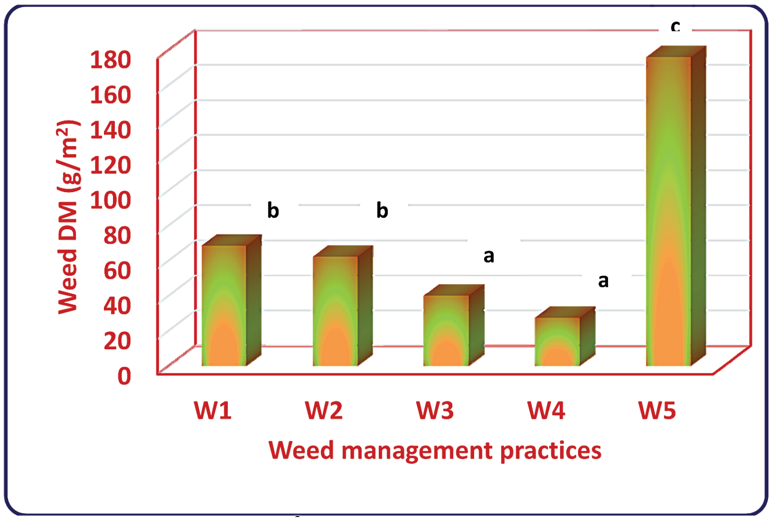


Fig. 2. Weed dry matter (g m^{-2}) at crop physiological maturity as influenced by weed management treatments in dry seeded irrigated rice

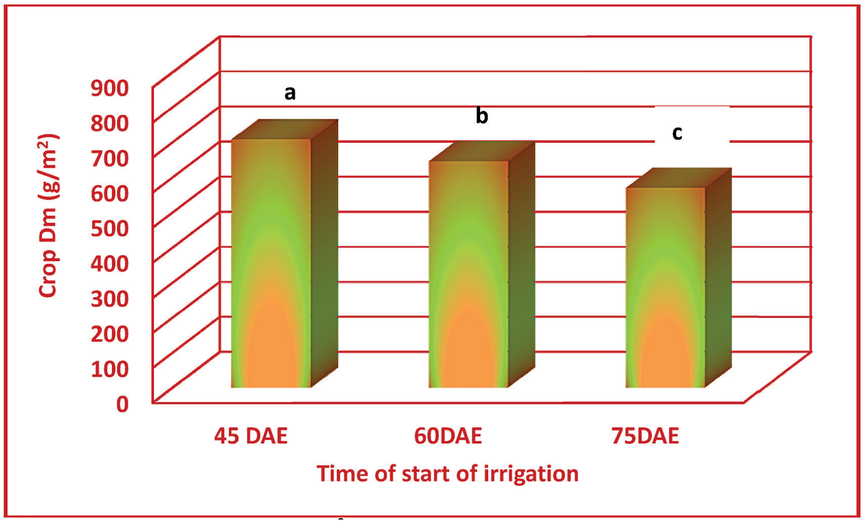


Fig. 3. Crop dry matter (g m-2) crop physiological maturity as influenced by time of start of irrigation in dryseeded irrigated rice

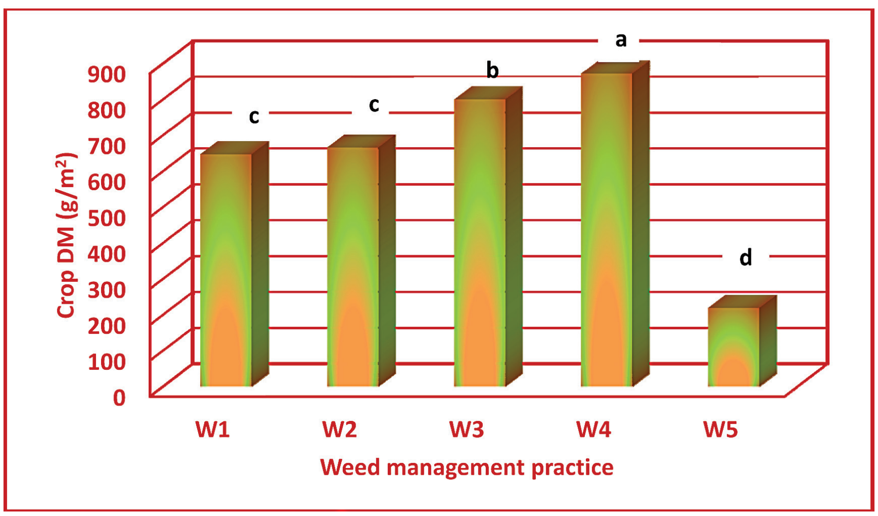


Fig. 4. Crop dry matter (g m-2) crop physiological maturity as influenced by weed management treatments in dry seeded irrigated rice

ORIGINAL RESEARCH ARTICLE OPEN ACCESS

Production Potential of Rice-Zero till Maize Cropping System under Various Weed Management Practices

P. Leela Rani* and M. Yakadri

AICRP on Weed Management, College of Agriculture, Rajendra Nagar, Hyderabad
*Corresponding author: leelagro@gmail.com

Received: 2nd December, 2014; Accepted: 22nd August, 2015

Abstract

A field experiment was conducted to evaluate the efficacy of different herbicide treatments on *kharif* rice and *rabi* maize in rice-maize sequence during 2014-15 season. *Kharif* rice research results revealed that significantly higher rice grain yield (6378 kg ha^{-1}) was obtained with pre emergence application of pretilachlor @ 750 g ha^{-1} at 3-5 DAT followed by hand weedingat 25-30 DAT and was onpar with hand weeding twice at 20 DAT and 40 DAT (5924 kg ha^{-1}) was found to be more economical with B.C ratio of 2.19 and 1.88 respectively. In similar way higher weed control efficiency (91.01 and 92.66) and lower weed index values (0.0 and 8.8) were noticed in vice versa. In *rabi* zero tillage maize higher grain yield (5631 kg ha^{-1}) was obtained with hand weeding twice at 20 and 40 DAS and was on a par with either pre-emergence application of atrazine @ 1000 g ha^{-1}+paraquat @.600 g ha^{-1} (4886 kg ha^{-1}) or pre-emergence application of oxyfluorfen 150 g ha^{-1}+paraquat @.600 g ha^{-1} (4869 kg ha^{-1}) with B.C ratio of 2.35, 2.43 and 2.41 respectively. In similar way higher WCE and lower WI values were observed with similar treatments. Higher system productivity (12555 kg ha^{-1}) was noticed with farmers practice twice both for *kharif* rice and *rabi* maize and was followed by pre emergence application of pretilachlor @ 750 g ha^{-1} at 3-5 DAT followed by hand weeding at 25-30 DAT for *kharif* rice and in sequence pre emrgence application of atrazine 1000 g+paraquat @ 600 g ha-1 for *rabi* maize recorded higher rice grain equivalent yields (12341 kg ha^{-1}). Economic analysis of system productivity indicates that higher economic returns were obtained with pre emergence application of pretilachlor @ 750 g ha^{-1} at 3-5 DAT followed by hand weeding at 25-30 DAT for *kharif* rice and in sequence PE application of atrazine 1000 g+paraquat @ 600 g ha-1 for *rabi* maize.

Key Words: Rice-maize, system productivity, weed management practices

Introduction

Weeds constitute a major component among the bottlenecks for successful crop production. Intense weed competition is one of the major constraints in productivity of crops. In Krishna delta of Andhra Pradesh, due to late release of water, transplanting of rice is much delayed and ultimately timely sowing of blackgram as relay crop is not possible since 2003. Therefore, farmers are switching over to non-traditional crop like maize in rice fallows as an alternative to blackgram due to yellow vein mosaic and *Cuscuta* problem. Under the emerging and potential crop sequence (rice-maize) in coastal region of Andhra Pradesh, the conventional tillage for planting maize under heavy textured soil of rice needs 25-30% higher energy for field preparation that not only limits the farm profitability but also delays planting of maize which in turn leads to lower productivity. Generally rice is harvested during second fortnight of November. In case of zero tillage under rice-maize rotation the farmers can plant maize in time. Further the no till maize in rice fallow demonstrated a potential benefit of saving on cost of production changing from Rs 3800-5500 ha^{-1} (Mukundam *et al*., 2011). Conventional tillage has a long been contributing negatively to soil quality in fracturing the soil, disrupting the soil structuring, accelerating surface runoff and soil erosion. Intense tillage system reduced the soil organic carbon (SOC) content 20% less after 20 year (Mann, 1986). Introduction of crop residue in the soil offers the best means to restore carbon in agriculture soils (Regmi *et al*., 2002). Timsina *et al*. (2010) hypothesized that the establishment of maize after rice with reduced or no tillage, and retaining of crop residues, could help to conserve soil organic matter (SOM) and maintain soil fertility if improved nutrient management is practiced. Similarly, weed infestation is one of the major causes that leads to 20 to 80% maize yield reduction (Chikoye and Ekeleme, 2003). Conservation agriculture like zero tillage, residue management along with proper nutrient management strategy and effective weed management practice helps to conserve the soil properties, reduce the cost of production, reduce the yield losses due to weed infestation and produce the sustainable yield in longer run, which lead to the sustainability of rice-maize cropping system. Mukundam *et al*. (2011) also observed superior productivity of the rice-zero till maize system with herbicide treatments over no-herbicide. Therefore, an attempt was made in order to evaluate the impact of different weed management practices in sequence for *kharif* rice and *rabi* maize under zero till sown condition with an objective, to identify the good production system with higher productivity, weed control efficiency and total water use efficiency.

Materials and Methods

The experiment was carried out at college farm, Professor Jayashankar Telangana State Agricultural university, Rajendranagar, Hyderabad situated at an altitude of 542.3 m above mean sea level at 17^{o}19' N latitude and 78^{o}23' E longitude. The experiment was laid out in complete randomized block design with 4 replications having 5 weed management treatments viz.. T_1: Pretilachlor @ 750 g ha^{-1} as PE at 3-5 DAT followed by hand weeding at 25-30 DAT, T_2; Bispyribac sodium as PoE at 20-25 DAT @ 25 g ha^{-1} followed by hand weeding at 40-45 DAT, T_3; Pretilachlor followed by ethoxysulfuron @750/18.75 at 25 DAT (3-4 leaf stage), T_4; Farmers practice (20, 40 DAT hand weeding), T_5; Unweeded check with MTU -1010 as test variety. Nursery was raised on 07-07-2014. Twenty two days old seedlings were transplanted on 29-07-2014. Entire dose of P, half of the potash and one third of N was applied just before planting. The remaining nitrogen was applied in two equal splits 20 and 40 DAT (180-60-40 NPK k g ha^{-1}). *Rabi* maize was sown under zero till condition on 19-11-2014 with 5 weed management treatments viz.. T_1: Atrazine 1000 g + paraquat @600g ha^{-1} as PE, T_2; Oxyfluorfen 150 g ha-1 + paraquat @.600 g ha^{-1} as PE, T_3; Atrazine EPoE @1000 g ha^{-1} at 15-20 DAS, T_4; Farmers practice (20, 40 DAT hand weeding), T_5; Unweeded check in sequence with dekalb 900M as test hybrid. The herbicide treatments were imposed as per the technical programme of the work and the remaining package of practices was fallowed as per the recommendations of PJTSAU for both the crops. Data on growth and yield attributes of transplanted rice and maize was taken at 30, 60 and 120 DAS (Harvest). Weed density and dry matter were recorded at various stages with the help of quadrate and then converted in per square metre. The data on weed density and dry weight were subjected to square root transformation $\sqrt{x+0.5}$ before statistical analysis to normalise their distribution (Panse and Sukhatme, 1978).

The yield of maize crop, rice straw and maize stover was converted into rice equivalent yield (REY). Sale price of crop commodities for calculating equivalent yield were: rice grains = Rs. 14/ kg; ricece straw = Rs. 1.50/kg; Maize grain = Rs. 13.1/ kg; maize straw = Rs.1.50/kg.

System productivity was calculated after converting *rabi* maize grain yields, rice straw yield and maize stover yield into rice equivalent yields using following formulae.

$$\text{REY (kg ha}^{-1}\text{)} = \frac{\text{Rice yield (k g ha-1) + Maize yield (k g ha-1) x Price (Rs./kg)}}{\text{Rice Price (Rs/ha)}}$$

Results and Discussion

Kharif rice

Weed flora

Transplanted rice was infested with a less number of weeds owing to flooding and puddle conditions. Prominent weed species recorded were *Cyprus rotundus, Cyperus difformis, E.crusgulli, E.colonum, Eclipta alba, Fimbristilis dichotoma* and *paspalum distichum.*

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

Hand weeding twice at 20 and 40 DAT recorded significantly the lowest weed dry matter at all the crop growth stages (Fig.1) and was on a par with pre emergence application of pretilachlor @ 750 g ha-1 at 3-5 DAT followed by hand weeding at 25-30 DAT treatment at 30 DAT and 60 DAT but inturn this was on a par with bispyribac sodium as PoE at 20-25 DAT @25 g ha^{-1} followed by hand weeding at 40-45 DAT and Pretilachlor followed by ethoxysulfuron @750/18.75 at 25 DAT (3-4 leaf stage) treatment at 60 DAT. At harvest hand weeding twice did not differ significantly in weed dry matter production with bispyribac sodium as PoE at 20-25 DAT @ 25 g ha^{-1} followed by hand weeding at 40-45 DAT and pretilachlor @ 750 g ha^{-1} as PE at 3-5

DAT followed by hand weeding at 25-30 DAT treatment respectively.

Weed Density (no/m^2)

Significantly less weed density was observed with pre emergence application of pretilachlor @ 750 g ha^{-1} at 3-5 DAT followed by hand weeding at 25-30 DAT and was significantly superior over all other treatments (Fig.2). But at 60 DAT and at harvest significantly the lowest weed density was observed with farmers practice and was onpar with bispyribac sodium as PoE at 20-25 DAT @ 25 g ha^{-1} followed by hand weeding at 40-45 DAT, pre emergence application of pretilachlor @ 750 g ha^{-1} as PE at 3-5 DAT followed by hand weeding at 25-30 DAT and pre emergence application of pretilachlor followed by ethoxysulfuron @ 750/18.75 at 25 DAT (3-4 leaf stage).

Yield, weed control efficiency and weed index

Pre emergence application of pretilachlor @ 750 g ha^{-1} at 3-5 DAT followed by hand weeding at 25-30 DAT recorded more grain (6378 kg ha^{-1}) and straw yield (6966 kg ha^{-1}) and was significantly superior over bispyribac sodium as PoE at 20-25 DAT @ 25 g ha^{-1} followed by hand weeding at 40-45 DAT and pre emergence application of pretilachlor followed by ethoxysulfuron @750/18.75 at 25 DAT but it was not differed significantly with hand weeding twice. Significantly the lowest grain yield and straw yield was recorded with unweede check treatment (Fig.3).

Rabi zero till maize

Weed flora

The predominant weed flora observed in maize during crop growing season at 30 DAS was *Cyprus rotundus, E.crusgulli, Paspalum distichum, Trianthema portula castrum, Parthenium hysterophotus, Sonchus sp, Acalypha indica and Eclipta alba.* At 60 DAS *Fimbristylis dichotoma, E. crusgulli, Paspalum distichum, Alternanthera* and *Dinebra retroflexa.* At 90 DAS in addition to 60 days weed spp *Grangea maderaspatana, Ageratum conyzoides, Amaranthus polygamous, Melilotus alba, Digera muricata* and *Cleome viscosa.*

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

Hand weeding twice at 20 and 40 DAS recorded significantly the lowest weed dry matter at 30, 60, 90 and 120 DAS, however it was on par with pre-emergence application of oxyfluorfen 150 g ha^{-1} + paraquat @.600 g ha^{-1} treatment at 30, 60 and 120 DAS but inturn this was onpar with pre-emergence application of atrazine @ 1000 g ha^{-1} + paraquat @.600 g ha^{-1} and early post-emergence application of atrazine @ 1000 g ha^{-1} treatment at 30 DAS (Fig.4).

Weed Density (no/m$^{2)}$

Significantly lower weed density was recorded with farmers practice at 60 and 90 DAS and was onpar with pre-emergence application of atrazine @ 1000 g ha^{-1} + paraquat @.600 g ha^{-1} and early post-emergence application of atrazine @ 1000 g ha^{-1} treatment at 60 and 90 DAS. But at 30 DAS pre-emergence application of oxyfluorfen @ 150 g ha^{-1} + paraquat @.600 g ha^{-1} recorded the lowest density. The highest weed density was recorded with weedy check (Fig.5).

Yield, weed control efficiency and weed index

Significantly higher grain yield (5631k g ha^{-1}) and stover yield (6111 k g ha^{-1}) was obtained with hand weeding twice (Fig.6) and was on a par with pre-emergence application of atrazine @ 1000 g ha^{-1} + paraquat @.600 g ha^{-1} and pre-emergence application of oxyfluorfen 150 g ha^{-1} + paraquat @.600 g ha-^{1}, inturn this was showed on a par yield with early post-emergence application of atrazine @ 1000 g ha.$^{-1}$ Higher WCE values at 60, 90 and at physiological maturity stages and lower weed index values at physiological maturity stage were noticed with hand weeding twice and it was followed by T_2, T_1 and T_3 treatments up to harvest stage.

Rice–zero till maize system productivity

Economic analysis of system productivity showed higher rice grain equivalent yields (12533 kg ha^{-1}) with hand weeding twice at 20 and 40 DAS both for *kharif* rice and *rabi* maize and it was followed by pre emergence application of pretilachlor @ 750 g ha^{-1} at 3-5 DAT followed by hand weeding at 25-30 DAT for *kharif* rice and in sequence PE application of atrazine 1000 g+paraquat @ 600 g ha^{-1} for *rabi* maize recorded higher rice grain equivalent yields (12341 kg ha^{-1}). In terms of economic returns higher net returns of Rs 104421 were obtained with pre emergence application of pretilachlor @ 750 g ha^{-1} at 3-5 DAT followed by hand weeding at 25-30 DAT for *kharif* rice and in sequence PE application of atrazine 1000 g+paraquat @ 600 g ha^{-1} for *rabi* maize and there after hand weeding twice for *kharif* rice as well as for *rabi* maize with net returns of Rs 93713. This reduced net returns was due to increased cost of cultivation (Rs 81750) as human labour engaged in hand weeding operation. Total rainfall use efficiency of 18.94 kg ha^{-1} mm^{-1} and 18.66 kg ha^{-1} mm^{-1} for *kharif* rice and *rabi* maize respectively was obtained with hand weeding twice in rice-zero till maize sequence (Table.1).

Conclusions

Pre-emergence applicaton of pretilachlor @ 750 g ha^{-1} at 3-5 DAT followed by hand weeding at 25-30 DAT for *kharif* rice and was followed by PE application of atrazine 1000 g+paraquat @ 600 g ha^{-1} for *rabi* maize recorded higher system net returns. But hand weeding twice for *kharif* rice followed by *rabi* zero till sown maize obtained more system productivity and higher total water use efficiency of cropping system due to higher weed control efficiency.

References

Chikoye, D. and Ekeleme, F. 2003. Cover crops forcogongrass management and effects on subsequent yield. *Weed Sci*ence 51:792-797.

Mann, L.K. 1986. Changes in soil carbon storage after cultivation. *Soil Science*. 142(5):419-425.

Mukundam, B., Srividya, S. and Raja, V. 2011. Productivity and economics of rice-zero till maize as influenced by weed management practices in Southern Telangana region of Andhra Pradesh. *Indian Journal of Weed Science* 43 (3&4) : 163-168.

Panse, V.G. and Sukhatme, P.V. 1978. Statistical Methods for Agricultural Workers. I.C.A.R., New Delhi, India.

Regmi, A.P., Ladha, J.K., Pathak, H., Pashuquine, E., Dawani, D., Hobbs, P.R., Joshi, D,, Maskey, S.L. and Pandey, S.P. 2002. Yield and soil fertility trends in a 20 years rice wheat experiment in Nepal. *Soil Science Society of America Journal* 66:857–867.

Timsina, J., Buresh, R.J., Dobermann, A., Dixon, J., Tabali, J. 2010. Strategic assessment of rice-maize systems in Asia. IRRICIMMYT Alliance Project "Intensified Production Systems in Asia (IPSA)", IRRI-CIMMYT Joint Report, IRRI, Los Banos, Philippines.

Table 1. System productivity of rice-maize cropping system under different weed management practices

Treatment	REY of *Kharif* rice (kg/ha)	REY of *Rabi* Maize (kg/ha)	Rice CC Rs/ha	Maize CC Rs/ha	Total CC Rs/ha	System productivity	Gross return	Net returns	Total water use efficiency
T_1	7124	5217	40720	27635	68355	12341	172776	104421	18.66
T_2	5268	5206	40650	32612	73262	10473	146627	73365	15.83
T_3	5928	5003	41432	30970	72402	10931	153030	80628	16.52
T_4	6609	5924	44000	37750	81750	12533	175463	93713	18.94
T_5	2585	5217	36000	30250	66250	5699	79785	13535	8.61

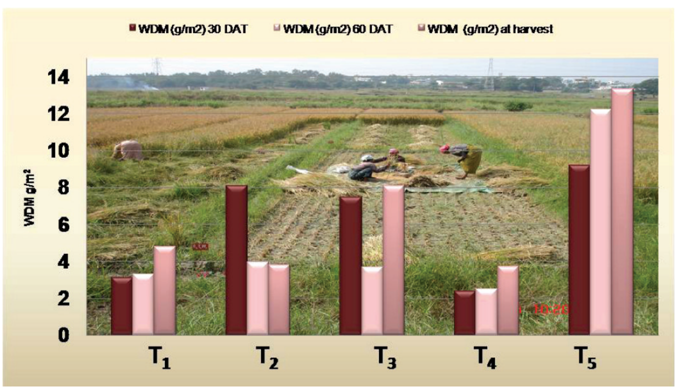


Fig.1. Effect of weed management practices on weed dry matter of rice in rice -maize cropping system (*Kharif*, 2014-15)

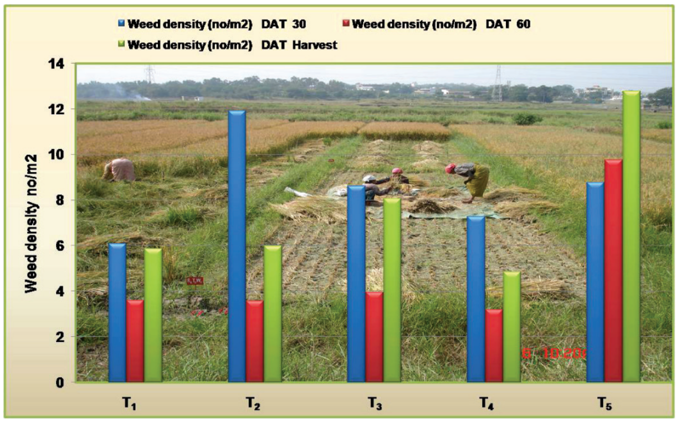


Fig. 2. Influnce of weed management practices on weed density of rice in rice -maize cropping system (*Kharif*, 2014-15)

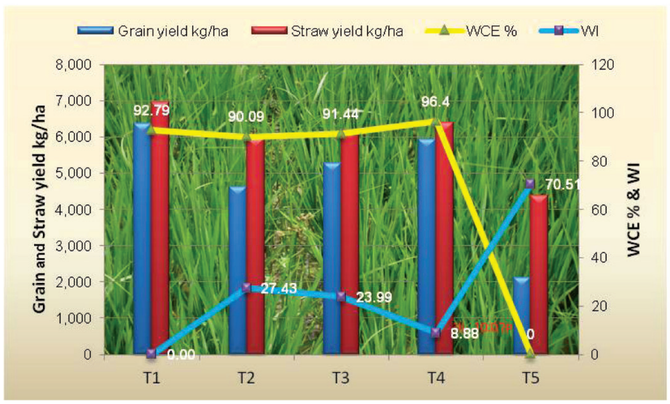


Fig. 3. Influence of weed management practices on WCE, WI and grain and straw yield of rice in rice -maize cropping system (*Kharif*, 2014-15)

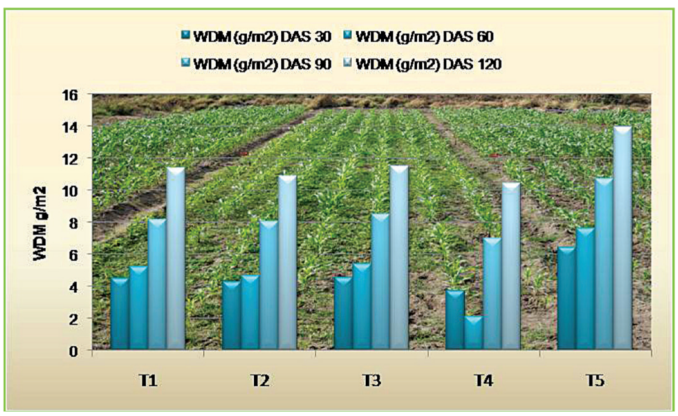


Fig. 4. Influnce of weed management practices on weed dry matter of zero till sown maize in rice -maize cropping system (*rabi*, 2014-15)

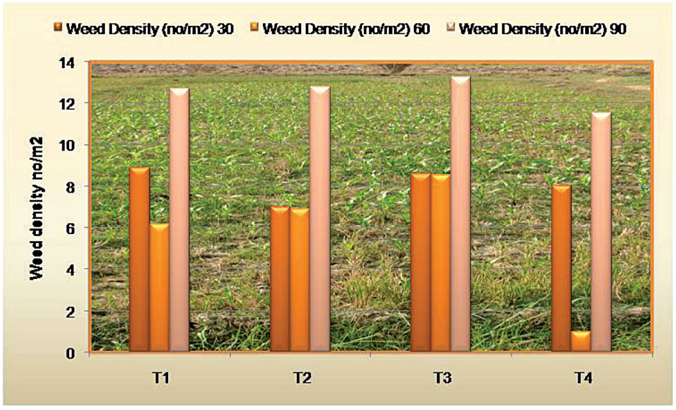


Fig. 5. Influence of weed management practices on weed density of zero till sown maize in rice -maize cropping system (*rabi*, 2014-15)

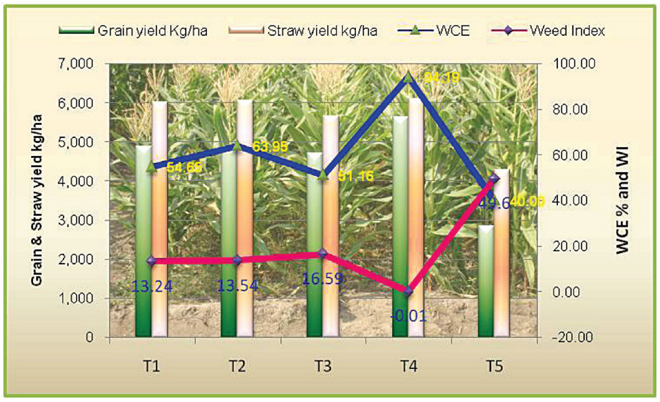


Fig. 6. Influence of weed management practices on WCE, WI and grain yield of maize in rice -maize cropping system (*Rabi*, 2014-15)

ORIGINAL RESEARCH ARTICLE OPEN ACCESS

Effectiveness of Chemical Fertilizers with and without Bio-organic Materials in Transplanted Rice

Malay K. Bhowmick[1]*, M. C. Dhara[1], S. K. Bardhan Roy[2], K. Surekha[3] and R. Mahender Kumar[3]

[1]Rice Research Station, Chinsurah, Hooghly, West Bengal

[2]Centre for Strategic Studies, AE 607, Salt Lake, Kolkata, West Bengal

[3]ICAR-Indian Institute of Rice Research, Rajendranagar, Hyderabad, Telangana

*Corresponding author: bhowmick_malay@rediffmail.com

Received: 11th March, 2015; Accepted: 20th September, 2015

Abstract

A field experiment was conducted during wet *(kharif)* season of 2012 and 2013 at Rice Research Station, Chinsurah to evaluate different nutrient management options, each of which was inclusive of recommended fertilizer dose (RFD) applied at 80:40:40 kg N:P2O5:K2O/ha in transplanted rice. There were six treatment combinations of chemical fertilizers viz. urea, di-ammonium phosphate (DAP), single super phosphate (SSP) and muriate of potash (MOP), and bio-organic materials viz. biologically-active phosphate (BioAgPhos), BioAg Soil Amendment + Seed Inoculant (BioAgSS) and vermicompost. Maximum grain yield (5.87 t/ha) was achieved under RFD (urea + SSP + MOP) + BioAgSS (10 l/ha) + BioAgPhos (0.1 t/ha) + vermicompost (1.5 t/ha). Next in order of grain yield performance were RFD application (urea + DAP + MOP), when combined with BioAgSS at 10 l/ha + BioAgPhos at 0.2 t/ha (5.45 t/ha) and only BioAgPhos at 0.2 t/ha (5.36 t/ha). Significantly higher yields under these treatments were due to higher values of growth and yield attributes, compared with sole use of chemical fertilizers (urea + DAP + MOP) which registered the lowest grain yield of 4.83 t/ha. Inclusion of bio-organic materials in nutrient management practice might enhance soil microbial activity, widening the scope for efficient utilization of soil moisture and nutrients by rice crop plants, besides providing different secondary and micronutrients, leading to 7.66-21.53% higher grain yields.

Key words: Bio-organic materials, Chemical fertilizers, Integrated nutrient management, Productivity, Transplanted rice

Introduction

Rice is life for millions of people in the world, particularly in developing countries. It is the main staple food for most of the people in India. Intensive cropping along with extensive use of chemical fertilizers in rice farming not only results in nutrient imbalances including emerging deficiencies of secondary and micronutrients, decreasing organic carbon content, soil health deterioration etc., but also leads to plateauing productivity. Though chemical fertilizers are a major source of nutrients, their sole use for a long period of time leaves unfavorable effects on soil physical, chemical and biological properties, and environment. Use of organic manures and/or bio-organic materials plays an important role to enhance fertilizer use efficiency, improve soil health and ensure sustainable production. Conjunctive use of chemical fertilizers and bio-organic materials is very much imperative towards ensuring soil sustainability *vis-a-vis* higher rice production and productivity. Considering all these, an integrated nutrient management (INM) practice is of utmost importance (Bhowmick *et al*., 2011). With this perspective in view, the present study was undertaken to evaluate the effectiveness of chemical fertilizers with and without using bio-organic materials for improving growth and yield of transplanted rice.

Materials and Methods

A field experiment was conducted during wet (*kharif*) season of 2012 and 2013 at the Rice Research Station, Chinsurah, Hooghly, West Bengal, located at $22^0 52'$ N latitude and $88^0 24'$ E longitude with an altitude of 8.62 m above mean sea level. The experimental soil was clay loam having pH 7.1, EC 0.5 dS/m, organic carbon 1.17%, available N 358 kg/ha, available P_2O_5 130 kg/ha and available K_2O 411 kg/ha.

The experiment comprising of six treatments was laid out in a randomized complete block design with four replications, keeping individual plots of 5 m × 4 m in size. The recommended fertilizer dose (RFD) of 80:40:40 kg $N:P_2O_5:K_2O$/ha was applied through different chemical fertilizers *viz*. urea (46.0% N), di-ammonium phosphate (DAP: 18.0% N and 46.0% P_2O_5), single super phosphate (SSP: 16.0% P_2O_5 and 12.5% S) and muriate of potash (MOP: 60.0% K_2O) as per treatments. Besides, different bio-organic materials *viz.* biologically-active phosphate (Bio*Ag*Phos: P_2O_5 13%, S 1% and Ca 36%), Bio*Ag* Soil Amendment + Seed Inoculant (Bio*Ag*SS: P_2O_5 2.09%) and vermicompost (1.00% N, 1.86% P_2O_5 and 1.13% K_2O) were applied as per treatment schedule. The treatments taken for the study included RFD (urea + DAP + MOP); RFD (urea + DAP + MOP) + Bio*Ag*SS (10 l/ha); RFD (urea + DAP + MOP) + Bio*Ag*Phos (0.2 t/ha); RFD (urea + DAP + MOP) + Bio*Ag*SS (10 l/ha) + Bio*Ag*Phos (0.2 t/ha); RFD (urea + SSP + MOP) + Bio*Ag*SS (10 l/ha) + vermicompost (3.0 t/ha); and RFD (urea + SSP + MOP) + Bio*Ag*SS (10 l/ha) + Bio*Ag*Phos (0.1 t/ha) + vermicompost (1.5 t/ha). Full doses of P_2O_5 and K_2O along with one-fourth of total N were applied as basal at the time of transplanting whereas the remaining half and one-fourth of total N were applied at active tillering and panicle initiation stages, respectively. Bio*Ag*Phos was applied 15 days ahead of transplanting whereas Bio*Ag*SS and vermicompost were applied on the surface of puddle soil and mixed into the soil at final land preparation. Besides, a common dose of $ZnSO_4.7H_2O$ was applied as basal at 25 kg/ha in all the treatment plots uniformly.

Rice variety Swarna (MTU 7029) was sown in 26th and 25th June, transplanted at a spacing of 20 cm × 20 cm on 3rd and 1st August, and harvested on 19th and 11th November in 2012 and 2013, respectively. The crop was raised with recommended package of practices.

Twelve hills were randomly sampled from each plot for recording biometric observations on growth and yield attributes. Plant height (cm) was measured from the base of stem up to the apex of the plant (tip of the longest leaf or the panicle if longer) at 45 days after transplanting (DAT) and harvest. Number of tillers/hill under each treatment was noted similarly on 12 random hills at 45 DAT and harvest by visual counting and their average values were multiplied by the number of hills/m^2. Likewise, number of effective tillers (panicles)/m^2, panicle length (cm) and panicle weight (g) were recorded for each plot at harvest. Each panicle was hand threshed separately, and the filled and partially-filled spikelets were separated by submerging threshed grains in tap water. All floating grains were considered as partially-filled spikelets. After drying them thoroughly under the sun, the empty and half-filled spikelets were separated from partially-filled spikelets by using a blower and then the number of filled, half-filled and empty spikelets was recorded for each panicle. These were then oven dried at 70 ^{0}C to constant weight for determining individual grain weight. Percentage filled grains and 1000-grain weight (g) were then computed from the collected observations. Grain and straw yields were recorded for each plot separately at harvest and converted in t/ha. Grains were harvested, dried and weighed, and grain weight was adjusted to a moisture content of 0.14 g H_2O/g fresh weight. Collected data were subjected to statistical analysis as per the procedures outlined by Gomez and Gomez (1984).

Results and Discussion

Effect of treatments on crop growth and yield attributes

The treatment including RFD (urea + SSP + MOP), Bio*Ag*SS, Bio*Ag*Phos and vermicompost recorded the highest values of plant height (89.00 cm at 45 DAT and 108.59 cm at harvest), number of tillers (306.50/m^2 at 45 DAT and 436.00/m^2 at harvest) and yield attributes (358.13 panicles/m^2, panicle weight 3.59 g, 87.74% filled grains/panicle and test weight 18.09 g) in both the years of study. SSP contained water-soluble phosphoric acid (monocalcium phosphate), being absorbed quickly by rice plants at the young stage when the root system was not fully developed (Yawalkar *et al*., 2011). Unlike conventional acidified fertilisers, Bio*Ag*Phos containing reactive phosphate rock treated with a proprietary fermented culture was not water soluble and therefore did not leach or become "locked up". As reported, about one-third of total P_2O_5 content in Bio*Ag*Phos was immediately available (i.e. citrate-soluble) for plant use and the remainder was slowly digested by microorganisms over a sustained period of time and added to the nutrient reservoir in the soil. Besides, Bio*Ag*SS (fermented liquid microbial culture) was reported to be a rich source of vitamins, minerals, proteins, enzymes, amino acids, carbohydrates, growth promoters and dormant beneficial organisms (Anonymous, 2015). Vermicompost was also known to contribute all the major nutrients along with certain other nutrients. All these nutrient sources combined together made the INM treatment (urea + SSP + MOP + Bio*Ag*SS + Bio*Ag*Phos + vermicompost) possible to maintain its superiority over the others. However, next in descending order of performance were RFD (urea + DAP + MOP) in combination with Bio*Ag*SS + Bio*Ag*Phos and Bio*Ag*Phos alone, indicating that the treatments inclusive of Bio*Ag*Phos were better than those devoid of it. Bio*Ag*Phos was reported to influence root architecture in producing high root biomass associated with the stimulation of mycorrhizae, improving the efficiency of phosphorus uptake (Anonymous, 2015). Application of RFD through chemical fertilizers without using any bio-organic materials remained inferior in terms of growth (Table 1) and yield attributes (Table 2), registering the lowest number of panicles (304.50/m^2) with their minimum length (21.84 cm) and weight (3.15 g) as per mean of two-year data. Conjunctive use of chemical fertilizers and bio-organic materials were found superior to sole use of chemical fertilizers, possibly due to the release of micronutrients, growth regulators and/or humic substances coupled with improved soil microbial activity with the addition of bio-organic materials. This might further be substantiated with the fact that the nutrients contained in chemical fertilizers were used rapidly but incompletely, and the nutrients supplied with organic matter were used slowly and stored for a long time in the soil (Kumazawa, 1984). Moreover, bio-organic materials would be more useful as because, fertilizer efficiency in rice was reported to be the lowest, hardly exceeding 40-50% even under well-managed conditions (Yawalkar *et al*., 2011). According to Surekha *et al*. (2015), any easily available organic sources might be efficiently utilized rather than using scarce organic manures at higher price.

Effect of treatments on crop productivity

In the first year, application of RFD (urea + SSP + MOP) along with Bio*Ag*SS, Bio*Ag*Phos and vermicompost recorded the highest grain yield (5.59 t/ha) and straw yield (6.54 t/ha), which was as good as that obtained with RFD (urea + DAP + MOP) + Bio*Ag*SS + Bio*Ag*Phos (5.54 t/ha). In the second year too, conjunctive use of RFD (urea + SSP + MOP), Bio*Ag*SS, Bio*Ag*Phos and vermicompost recorded the highest grain yield (6.15 t/ha), which was, however, followed by RFD (urea + SSP + MOP) + Bio*Ag*SS + vermicompost (5.50 t/ha). Based on two-year mean data (Table 3), it was found that maximum grain yield (5.87 t/ha) was achieved under RFD (urea + SSP + MOP) + Bio*Ag*SS (10 l/ha) + Bio*Ag*Phos (0.1 t/ha) + vermicompost (1.5 t/ha), followed by RFD (urea + DAP + MOP) + Bio*Ag*SS + Bio*Ag*Phos (5.45 t/ha) and RFD (urea + DAP + MOP) + Bio*Ag*Phos (5.36 t/ha). Significantly higher yields (Table 3) under these treatments were due to higher values of growth (Table 1) and yield attributes (Table 2), compared with the sole use of chemical fertilizers (4.83 t/ha). Dhara and Bhowmick (2015) reported higher grain yields of summer rice with the use of 75% RFD + vermicompost (3.0 t/ha) + soil conditioner (50 kg/ha) and 100% RFD + vermicompost (3.0 t/ha) owing to higher values of panicle number and weight, which was attributed to effective absorption of nutrients and their supply in presence of useable moisture to crop plants. Improved microbial activity after application of Bio*Ag*Phos in soil might help in unlocking previously-applied phosphate, calcium and other nutrients, whereas Bio*Ag*SS as a soil inoculant might encourage early crop establishment with better root development. Moreover, Bio*Ag*SS was reported to be effective in delivering essential nutrients and metabolites directly to crop plants as well as stimulating microbial activities in soil, thereby improving natural soil fertility and moisture and nutrient utilization (Anon., 2015). It was found from the present study that inclusion of bio-organic materials in nutrient management practice resulted in grain yield enhancement to the extent of 7.66-21.53%. Adhikary and Majumdar (2002) suggested combined application of chemical fertilizers and organic manure for attaining higher grain yields. Supply of nutrients in required quantities through the combinations of organic and inorganic sources facilitated balanced nutrition of rice crop, which resulted in enhanced grain yields due to higher values of yield attributes. Bhowmick and Ghosh (2001 and 2002) were of similar opinion. Comparatively lower levels of grain and straw yields in the plots of RFD applied through chemical fertilizers (urea + DAP + MOP) without applying any bio-organic materials might be ascribed to poor utilization of fertilizer nutrients in absence of organic nutrient sources

Conclusion

The study indicated that judicious use of chemical fertilizers along with application of bio-organic materials in balanced proportion would be an effective tool of integrated nutrient management for rejuvenating natural soil fertility and enhancing rice productivity.

Acknowledgement

Thanks are due to BioAg Pty Ltd., 22-26 Twynam Street, Narrandera, NSW 2700, Australia for providing necessary bio-organic materials under investigation and technical support on their usage.

References

Anonymous. 2015. Bio*Ag*. Better Soils. Better Crops. Better Stock. Available at: http://www.bioag.com.au/ (Accessed on October 25, 2015).

Adhikary, J. and Majumdar, D. K. 2002. Effect of combinations of organic manures and chemical fertilizers on rice. *Proceedings.* National Seminar on "Development and use of biofertilizers, biopesticides and organic manures", Nov. 10-12, 2000, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal, India. pp. 288-293.

Bhowmick, M.K., Dhara, M.C., Bag, M. K., Adhikari, B. and Kundu, C. 2011. Integrated nutrient management for aromatic rice in West Bengal. *Oryza* 48(3): 276-277.

Bhowmick, M.K. and Ghosh, R.K. 2001. Effect of kri-kelp on growth and yield of transplanted paddy. *Advances in Plant Sciences* 14(2): 501-506.

Bhowmick, M.K. and Ghosh, R. K. 2002. Role of bio-organic materials in yield maximization of summer paddy. *Proceedings.* National Seminar on "Development and use of biofertilizers, biopesticides and organic manures", Nov. 10-12, 2000, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal, India. pp. 310-312.

Dhara, M.C. and Bhowmick, M.K. 2015. Methods of crop establishment and nutrient management with and without soil conditioner in summer rice. *SATSA Mukhapatra-Annual Technical Issue* **19**: 130-134.

Gomez, K.A. and Gomez, A.A. 1984. *Statistical Procedures for Agricultural Research* (2nd ed.). An International Rice Research Institute Book. Wiley-Interscience Publication, John Wiley and Sons, New York. p. 20-30.

Kumazawa, K. 1984. Beneficial effects of organic matter on rice growth and yield in Japan. (in) *Organic Matter and Rice*. International Rice Research Institute, Philippines. p. 431-444.

Surekha, K., Mahender Kumar, R. and Viraktamath, B.C. 2015. Organic rice farming: Opportunities for quality seed production and soil health improvement. *SATSA Mukhapatra-Annual Technical Issue* **19**: 1-18.

Yawalkar, K.S., Agarwal, J.P. and Bokde, S. 2011. *Manures and Fertilizers*. Agri-Horticultural Publishing House, Nagpur, India. 366 p.

Table 1. Effect of treatments on crop growth of transplanted rice during wet season of 2012 and 2013

Treatment	Plant height (cm)				Tillers/m^2			
	45 DAT		Harvest		45 DAT		Harvest	
	2012	2013	2012	2013	2012	2013	2012	2013
Urea + DAP + MOP	78.25	81.33	96.31	98.36	254.75	272.00	330.00	320.50
Urea + DAP + MOP + Bio*Ag*SS (10 l/ha)	85.43	84.19	101.50	103.55	273.50	281.25	386.00	366.25
Urea + DAP + MOP + Bio*Ag*Phos (0.2 t/ha)	85.58	84.55	102.75	104.33	289.50	288.75	393.25	369.75
Urea + DAP + MOP + Bio*Ag*SS (10 l/ha) + Bio*Ag*Phos (0.2 t/ha)	88.50	85.78	104.19	106.23	295.25	290.25	435.25	385.50
Urea + SSP + MOP + Bio*Ag*SS (10 l/ha) + Vermicompost (3.0 t/ha)	80.63	86.52	101.25	106.32	261.25	299.50	351.75	393.25
Urea + SSP + MOP + Bio*Ag*SS (10 l/ha) + Bio*Ag*Phos (0.1 t/ha) + Vermicompost (1.5 t/ha)	88.55	89.45	109.13	108.05	304.75	308.25	455.75	416.25
SEm±	0.43	0.41	2.41	2.45	7.99	6.63	7.57	8.01
LSD (P=0.05)	1.29	1.24	7.27	7.38	24.07	19.98	22.80	24.14
C.V. (%)	1.02	8.20	4.71	5.22	5.71	6.54	3.86	7.85

Table 2. Effect of treatments on yield attributes of transplanted rice during wet season of 2012 and 2013

Treatment	Panicles/m^2		Panicle length (cm)		Panicle weight (g)		% filled grains		1000-grain weight (g)	
	2012	2013	2012	2013	2012	2013	2012	2013	2012	2013
Urea + DAP + MOP	300.75	308.25	21.58	22.09	3.16	3.14	82.93	83.45	16.45	16.39
Urea + DAP + MOP + Bio*Ag*SS (10 l/ha)	323.25	319.75	24.35	23.15	3.45	3.15	85.54	85.33	17.85	16.88
Urea + DAP + MOP + Bio*Ag*Phos (0.2 t/ha)	325.75	329.75	24.55	23.18	3.50	3.23	85.81	85.92	18.03	17.10
Urea + DAP + MOP + Bio*Ag*SS (10 l/ha) + Bio*Ag*Phos (0.2 t/ha)	339.75	331.25	24.78	23.30	3.60	3.35	86.74	86.14	18.13	17.11
Urea + SSP + MOP + Bio*Ag*SS (10 l/ha) + Vermicompost (3.0 t/ha)	320.75	342.75	23.80	24.39	3.31	3.39	85.30	86.28	16.80	17.18
Urea + SSP + MOP + Bio*Ag*SS (10 l/ha) + Bio*Ag*Phos (0.1 t/ha) + Vermicompost (1.5 t/ha)	352.75	363.50	25.55	24.51	3.66	3.51	87.25	88.22	18.93	17.25
SEm±	10.04	7.65	0.69	0.56	0.17	0.16	1.38	1.29	0.37	0.40
LSD (P=0.05)	30.26	23.05	2.09	1.69	NS	NS	NS	3.89	1.10	NS
C.V. (%)	6.14	7.22	5.75	6.35	9.59	10.05	3.23	4.59	4.14	5.53

NS: Not significant

Table 3. Effect of treatments on productivity of transplanted rice during wet season of 2012 and 2013

Treatment	Grain yield (t/ha)			Straw yield (t/ha)		
	2012	2013	Mean	2012	2013	Mean
Urea + DAP + MOP	4.81	4.85	4.83	6.25	6.46	6.36
Urea + DAP + MOP + Bio*Ag*SS (10 l/ha)	5.20	5.20	5.20	6.41	6.64	6.53
Urea + DAP + MOP + Bio*Ag*Phos (0.2 t/ha)	5.41	5.30	5.36	6.53	6.62	6.58
Urea + DAP + MOP + Bio*Ag*SS (10 l/ha) + Bio*Ag*Phos (0.2 t/ha)	5.54	5.35	5.45	6.53	6.64	6.59
Urea + SSP + MOP + Bio*Ag*SS (10 l/ha) + Vermicompost (3.0 t/ha)	5.05	5.50	5.28	6.35	6.71	6.53
Urea + SSP + MOP + Bio*Ag*SS (10 l/ha) + Bio*Ag*Phos (0.1 t/ha) + Vermicompost (1.5 t/ha)	5.59	6.15	5.87	6.54	7.10	6.82
SEm±	0.17	0.19	-	0.21	0.48	-
LSD (P=0.05)	0.52	0.57	-	0.64	1.45	-
C.V. (%)	6.53	10.58	-	11.37	12.49	-

ORIGINAL RESEARCH ARTICLE OPEN ACCESS

Bio-efficacy of Pymetrozine 50 WG against Brown Planthopper, *Nilaparvata lugens* and White Backed Planthopper, *Sogatella furcifera* in Rice

K. Vasanta Bhanu

Department of Entomology, A.P. Rice Research Institute and Regional Agricultural Research Station, Maruteru
Corresponding author: vasanta99@yahoo.com

Received: 15th October, 2015; Accepted: 1st December 2015

Abstract

Pymetrozine 50 WG was field evaluated for its bio-efficacy against brown planthopper (BPH) and white backed planthopper (WBPH) in rice during *Kharif* 2007 and *Rabi* 2007-08 with five dosages *viz.,* 100, 125, 150, 175 and 200 g a.i./ha in *Kharif* and four dosages in *Rabi*. The results revealed that all the dosages of pymetozine 50 WG recorded more than 90 per cent reduction in the population of both BPH and WBPH over the untreated control and superior to neonicotinoids like imidacloprid and thiamethoxam 25 g a.i./ha and chitin bio-synthesis inhibitor like buprofezin 25 SC @ 125 g a.i./ha. Whereas more or less equal to buprofezin 25 SC @ 250 g a.i./ha. The highest grain yield of 5256 kg/ha was recorded in pymetrozine 50 WG @ 175 g a.i./ha treated plots during *Kharif* 2007 and 6842 kg/ha in buprofezin 25 SC @ 250 g a.i./ha treated plots during *Rabi* 2007-08 and was on par with in pymetrozine 50 WG @ 200 g a.i./ha (6481 kg/ha).

Key words: Rice, Pymetrozine 50 WG, brown and white backed planthoppers

Introduction

Rice (*Oryza sativa* L.) is an important staple food crop for more than half of the world population and accounts for more than 50 per cent of the daily calorie intake (Khush, 2005). Approximately 21 per cent of the global production losses of rice are attributed to the attack of insect pests (Yarasi *et al*., 2008). Among the 20 serious insect pests of rice, brown planthopper (BPH), *Nilaparvata lugens* Stal° and white backed planthopper (WBPH), *Sogatella furcifera* Horvarth (Homoptera: Delphacidae), are considered to be most destructive insect pests in Asian countries (Park *et al*., 2008) also causing significant yield loss in wet and dry seasons of Godavari delta. In recent years major out breaks of BPH were recorded in several rice growing countries like China, Korea, Japan, India, Indonesia, Malaysia, the Philippines, Thailand and Vietnam (Heong and Hardy, 2009). Insecticides are the major dependable tools in managing these insect pests and several insecticides belonging to different classes were reported to be effective (Krishnaiah *et al*., 2008). The insecticides though effective, their large scale and continuous use either causes pest resurgence (Tanaka *et al*., 2000) or the insect developed resistance to insecticides (Matsumura *et al*., 2008 and Lakshmi *et al*., 2010) and thus aggravating the BPH problem. Hence, there is a regular need to evaluate new groups of insecticides with different modes of action. Pymetrozine is one of the new insecticide molecules, belonging to pyridine azomethine class with unique mode of action. It is reported to effective against aphids and white flies in vegetables, potatoes, tobacco, deciduous citrus and ornamentals (Chandela, 2003). Physiologically, it appears to act by preventing these insects from inserting their stylus into the plant tissue. In order to generate information on the bio-efficacy of pymetrozine 50 WG against planthoppers in rice, the present experiment was conducted with five different doses of pymetrozine and compared with standard insecticide checks like thiamethoxam 25 WG, imidacloprid 17.8 SL @ 25 g a.i./ha and buprofezin 25 SC @ 125 g and 250 a.i./ha.

Material and Methods

A field experiment was conducted at A.P. Rice Research Institute and Regional Agricultural Research Station, Maruteru, West Godavari district during *Kharif* 2007 and *Rabi* 2007-08 in irrigated rice. The experiment was laid out in a randomized block design using susceptible rice variety, Prabhat (MTU 3626) with nine treatments in *Kharif* and eight treatments in *Rabi* and each was replicated thrice. The plot size was 24 m^2 during *Kharif* and 19.68 m^2 during

Rabi were separated from each other so as to prevent water movement from one plot to another. The treatments includes pymetrozine 50 WG @ 100, 125, 150, 175 and 200 g a.i./ha, thiamethoxam 25 WG, imidacloprid 17.8 SL @ 25 g a.i./ha, buprofezin 25 SC @ 125 g and 250 g a.i./ha and untreated check. Two to three seedlings were planted per hill with a spacing of 20x15cm during *Kharif* and 15x15cm during *Rabi*. The fertilizers, N: P: K was used at 60:40:30 kg/ha during *Kharif* and 120:60:40 during *Rabi*. The test insecticides were applied twice as foliar spray with a knapsack sprayer @ 500 litres spray fluid / hectare at appropriate stage based on the planthoppers build-up. Care was taken to avoid drift of spray solution to adjacent plots.

The data on planthoppers (BPH and WBPH) were collected from 20 randomly selected hills from each plot at one day before and five and ten days after the treatment. Before harvest of the crop, the hopperburn hills and healthy hills were counted separately in each plot and per cent hopperburn area was computed. The data on planthopper numbers were transformed to square root values and the data on percentages of hopperburn area was transformed to Arc Sine values. Similarly, grain yields were recorded from net plot area of 15.81 m^2 during *Kharif* and 14.65 m^2 during *Rabi* and converted to Kg/ha. The data was statistically analyzed and means were separated by L.S.D method (Cochran and Cox, 1957). The results were presented in tables 1, 2 and 3.

Results and Discussion

Pretreatment data on planthopper (both BPH and WBPH) numbers during *Kharif* from the table 1 indicated that the differences in planthopper numbers per 20 hills among the different treatments were not significant indicating the uniform distribution of the insect. During *Kharif* both the planthoppers (BPH and WBPH) and during *Rabi* only BPH were observed.

White backed planthopper

The results (table 1) showed that all the treatments were significantly superior in reducing the buildup of WBPH than untreated control at all the observation recorded after each spray. At five days after first spray, among the treatments, imidacloprid 17.8 SL @ 25 g a.i./ha recorded lowest population of WBPH (29.70 numbers/20 hills) was on par with pymetrozine 50 WG @ 200 (69.00 numbers/20 hills), 175 (79.0 numbers/20 hills), 125 (90.70 numbers/20 hills), 150 g a.i./ha (124.00 numbers/20 hills) and thiamethoxam 25 WG (73.70 numbers/20 hills). These were followed by pymetrozine 50 WG @ 100 g a.i./ha (162.30 numbers/20 hills) and buprofezin 25 SC @ 125 g a.i/ha (203.70 numbers/20 hills). Significantly highest population of WBPH was recorded in untreated control (1178.30/20 hills). At ten days after the first spray also pymetrozine at all the dosages were equal in managing the population of WBPH ranging from 33.00 to 51.30 numbers/20 hills and on par with the check insecticides, imidacloprid (57.3 numbers/20 hills) and thiamethoxam @ 25 g a.i./ha (67.00 numbers/20 hills). These were followed by buprofezin 25 SC @ 125 g a.i/ha (475.70 numbers/20 hills). Significantly highest population of WBPH was recorded in untreated control (2368.00/20 hills).

At five days after the second spray, pymetrozine at all the dosages tested recorded significantly lower number of WBPH per 20 hills ranged from 23.70 to 49.30 numbers and were followed by the check insecticides *viz.,* buprofezin 25 SC @ 125 g a.i/ha (214.30 numbers), imidacloprid @ 25 g a.i./ha (312.00 numbers) and thiamethoxam @ 25 g a.i./ha (394.20 numbers). Significantly highest population of WBPH was recorded in untreated control (1192.70 numbers/20 hills). At ten days after the second spray, except thiamethoxam 25 WG all the other treatments recorded lower number of WBPH than the untreated control. Among the treatments, all the dosages of pymetrozine resulted equal in managing WBPH population ranging from 11.00 to 19.00 numbers per 20 hills and were followed by buprofezin 25 SC @ 125 g a.i/ha (90.00 numbers/20 hills) and imidacloprid @ 25 g a.i./ha (102.00 numbers/20 hills). Thiamethoxam 25 WG @ 25 g a.i./ha (183.70 numbers) and untreated control (203.00 numbers) recorded significantly higher number of WBPH population per 20 hills.

The cumulative mean of all the observations also indicated that all the dosages of pymetrozine 50 WG was equally effective in managing WBPH population (36.58 to 60.33 numbers/20 hills) with mean per cent reduction of 95.12 to 97.04 per cent reduction of WBPH population over untreated control. The next best insecticides were imidaclprid @ 25 g a.i./ha with a population of 125.25 numbers per 20 hills and thiamethoxam 25 WG @ 25 g a.i./ha (179.67 numbers) with mean per cent population reduction of 89.86 and 85.46 per cent mean reduction of population over untreated control. These were followed by buprofezin 25 SC @ 125 g a.i/ha (245.92 numbers/20 hills) with 80.10 per cent mean reduction of population over untreated control.

Brown planthopper

Kharif 2007: The data on BPH population per 20 hills at five and ten days after the first spray (table 2) indicated that all the treatments significantly reduced the BPH population over the untreated control. At five days after the first spray, among the treatments, imidacloprid 17.8 SL @ 25 g a.i./ha recorded significantly lower number of BPH per 20 hills (33.30 numbers) and was on par with pymetrozine 50 WG @ 200 g a.i/ha (49.30 numbers), thiamethoxam25 WG @ 25 g a.i./ha (49.70 numbers), pymetrozine 50 WG @ 125 g a.i/ha (55.70 numbers), pymetrozine 50 WG @ 175 g a.i/ha (61.70 numbers), pymetrozine 50 WG @ 150 g a.i/ha (66.67 numbers) and these were followed by buprofezin 25 SC @ 125 g a.i./ha (131.30 numbers) . Significantly highest population of WBPH was recorded in untreated control (634.30 numbers/20 hills). At ten days after the first spray, pymetrozine 50 WG at all the five dosages tested were equally effective in managing BPH and recorded a population ranged from 15.30 to 33.00 numbers per 20 hills and was on par thiamethoxam @ 25 g a.i./ha (47.30 numbers). These were followed by imidacloprid @ 25 g a.i./ha (52.30 numbers) and buprofezin 25 SC @ 125 g a.i./ha (270.70 numbers).

At five days after the second spray also, among the treatments, pymetrozine 50 WG at all the five dosages tested were equally effective in managing BPH and recorded a population ranged from 19.30 to 28.00 numbers per 20 hills and on par with buprofezin 25 SC @ 125 g a.i./ha(159.70 numbers) and imidacloprid @ 25 g a.i./ha (161.00 numbers). These were followed by thiamethoxam @ 25 g a.i./ha (236.00 numbers). At ten days after the second spray all the insecticides except thiamethoxam (515.00 numbers) were significantly superior in controlling the BPH. All the dosages of pymetrozine 50 WG recorded significantly lowest population of BPH (31.70 to 52.00 numbers/20 hills) and were followed by buprofezin (249.70 numbers) and imidacloprid (273.00 numbers).

The cumulative mean of all the observations also indicated that all the dosages of pymetrozine 50 WG was equally effective in managing BPH population (34.67 to 43.25 numbers/20 hills) with mean per cent reduction of 94.57 to 95.65 per cent reduction of BPH population over untreated control. The next best insecticide was imidaclprid @ 25 g a.i./ha with a population of 129.92 numbers per 20 hills and mean per cent population reduction of 83.69. These were followed by buprofezin 25 SC @ 125 g a.i/ha (202.83 numbers/20 hills) and thiamethoxam 25 WG @ 25 g a.i./ha (212.00 numbers) with 74.54 and 73.39 per cent mean reduction of population over untreated control.

Rabi 2007-08

The distribution of BPH population was not uniform among different plots before the imposition of the insecticide treatments (table 3). At five days after the first spray, all the treatments recorded significantly low build up of BPH than untreated control. Among the treatments, pymetrozine 50 WG @ 100 g a.i. /ha (60.33 numbers/20 hills) was significantly superior in reducing the buildup of BPH and was on par with pymetrozine 50 WG @ 150 g a.i./ha (77.00 numbers/20 hills). These were followed by buprofezin 25 SC @ 250 g a.i./ha (83.00 numbers/20 hills) and pymetrozine @ 125 g a.i./ha (99.67 numbers/20 hills). These were also superior to the neonicotenoids *viz*., thiamethoxam 25 WG @ 25 g a.i./ha (169.33 numbers) and imidacloprid 17.8 SL @ 25 g a.i./ha (192.67 numbers). At ten days after the first spray, pymetrozine 50 WG @ 100 g a.i. /ha (84.67 numbers) and buprofezin 25 SC @ 250 g a.i/ha (97.00 numbers) significantly superior in reducing the buildup of BPH and were followed by the other three dosages of pymetrozine 50 WG. The other treatments recorded significantly higher build up of BPH.

At five days after the second spray, all the dosages of pymetrozine 50 WG (98.33 to 111.67 numbers) and buprofezin 25 SC @ 250 g a.i/ha (117.67 numbers) except pymetrozine 50 WG @ 150 g a.i. /ha (203.33 numbers) significantly reduced the buildup of BPH. These were followed by thiamethoxam 25 WG @ 25 g a.i./ha (408.00 numbers) and imidacloprid 17.8 SL @ 25 g a.i./ha (498.00 numbers). While at ten days after the second spray, all the dosages of pymetrozine 50 WG tested and buprofezin 25 SC @ 250 g a.i/ha significantly reduced the buildup of BPH compared to other treatments. Similar trend was observed at ten days after second spray.

The cumulative mean of all the observations also indicated that all the dosages of pymetrozine 50 WG except @ 150 g a.i./ha was equally effective in managing BPH population (49.67 to 65.17 numbers/20 hills) with mean per cent reduction of 92.28 to 94.34 per cent reduction of BPH population over untreated control. The next best insecticide was buprofezin 25 SC @ 250 g a.i/ha (69.42 numbers per 20 hills) with mean per cent population reduction of 92.08. These were followed by thiamethoxam 25 WG @ 25 g a.i./ha (166.25 numbers) and imidacloprid 17.8 SL @ 25 g a.i./ha (259.42 numbers) with 81.04 and 70.41 per cent mean reduction of population over untreated control.

The untreated control plots only recorded hopperburn of 61.74 and 20.25% during *Kharif* 2007 and *Rabi* 2007-08 respectively.

Grain yield

During *Kharif* 2007 **a**ll the treatments recorded significantly higher grain yields over the untreated control

(849 kg/ha). Among the treatments, pymetrozine @ 175 g a.i./ha recorded significantly superior grain yields (5256 kg/ha) and was followed by imidacloprid 17.8 SL @ 25 g a.i./ha (4650 kg/ha). During *Rabi* 2007-08 also all the treatments recorded significantly higher grain yields over the untreated control. Among the treatments, buprofezin 25 SC @ 250 g a.i/ha recorded significantly superior grain yields (6842 kg/ha) and was on par with pymetrozine @ 200 g (6481 Kg/ha) and 125 g a.i./ha (6239 Kg/ha).

From the present study it was observed that all the dosages of pymetrozine 50 WG was equally effective in managing the planthoppers population in rice and superior to neonicotinoid insecticides *viz*., imidacloprid @ 25 g a.i./ha, thiamethoxam @ 25 g a.i./ha and chitin bio-synthesis inhibitor like buprofezin 25 SC @ 125 g a.i./ha and more or less equal to buprofezin 25 SC @ 250 g a.i./ha. Similar results on the efficacy of pymetrozine 50 WG against BPH and WBPH was earlier reported by Murali Bhaskaran *et al*. (2009a and 2009b).

References

Chandela, A.G. 2003. Pesticides-Past, Present and Future. *Pestology* 27 (12): 13-16.

Cochran, W.G. and Cox, G.M. 1957. *Experimental designs*, 2nd Edn, Jhon Wiley, New York, 611pp.

Heong, K. L and Hardy, B. 2009. *Planthoppers: New Threats to the Sustainability of Intensive Rice Production Systems in Asia*. International Rice Research Institute, Los Baños, Philippines. 470.

Khush, G.S. 2005. What it will take to feed five billion rice consumers by 2030. *Plant Molecular Biology* 59: 1–6.

Krishnaiah, N.V., Jhansi Lakshmi, V., Pasalu, I.C., Katti, G.R. and Padmavathi, Ch. 2008. Insecticides in Rice IPM past, present and Future. *Technical Bulletin No.30*, Directorate of Rice Reseach, Hyderabad, A.P. India: 146pp

Lakshmi, V.J., Krishnaiah, N.V., Katti, G., Pasalu, I.C. and Vasanta Bhanu, K. 2010. Development of insecticide resistance in rice brown planthopper and whitebacked planthopper in Godavari delta of Andhra Pradesh. *Indian Journal of Plant Protection* 38(1): 35-40.

Matsumura, M., Takeuchi, H., Satoh, M., Morimura, S.S., Otuka, A., Watanabe, T. and Thanh, D.V. 2008. Species-specific insecticide resistance to imidacloprid and fipronil in the rice planthoppers *Nilaparvata lugens* and *Sogatella furcifera* in East and South East Asia. *Pest Management Science* 64 (11): 1115-1121.

Murali Bhaskaran, R.K., Suresh, K., Rajavel, D.S. and Palanisamy, N. 2009a. Field efficacy of pymetrozine 50 WG against rice brown planthopper, *Nilaparvata lugens* (Homoptera: Delphacidae). *Pestology* 33 (5): 20-21.

Murali Bhaskaran, R.K., Suresh, K., Rajavel, D.S. and Palanisamy, N. 2009b. Bio-efficacy of Chess 50 WG against rice green leafhopper, *Nephotettix virescens* and white backed planthopper, *Sogatella furcifera*. *Pestology* 33 (5): 37-39.

Park, D.S., Song, M.Y., Park, S.K., Lee, S.K. and Lee, J.H. 2008. Molecular tagging of the *Bph* 1 locus for resistance to brown planthopper (*Nilaparvata lugens* Stal.) through representational divergence analysis. *Molecular Genetics and Genomics* 280: 163-172.

Tanaka, K, Endo, S., Kazano, H. 2000. Toxicity of insecticides to predators of rice planthoppers: spiders, the mirid bug and the drynid wasp. *Applied Entomology and Zoology* 35: 177-187.

Yarasi, B., Sadumpati, V., Immanni, C. P., Vudem, D.R. and Khareedu, V.R. 2008. Transgenic rice expressing *Allium sativum* leaf agglutinin (ASAL) exhibits high-level resistance against major sap-sucking pests. *BMC Plant Biology* 8: 102–115.

Table 1. Comparative efficacy of Pymetrozine 50 WG against WBPH in rice during *Kharif* 2007

S. No	Particulars	Dose g (a.i./ ha)	White backed Planthopper (no.s/ 20 hills) *				Mean	% reduction over control	Hopper Burn area (%) **	Yield (Kg/ ha)
			1st Spray		2nd Spray					
			5 DAS	10 DAS	5 DAS	10 DAS				
1	Untreated Control	-	1178.3 (34.3)	2368.0 (48.4)	1192.7 (34.2)	203.0 (14.0)	1235.50 (32.94)	---	61.74 (51.9)	849
2	Pymetrozine 50 WG	100 g	162.3 (11.3)	34.0 (5.8)	31.3 (5.2)	13.7 (3.6)	60.33 (6.97)	95.12	0.1 (1.8)	3327
3	Pymetrozine 50 WG	125 g	90.7 (9.5)	33.0 (5.7)	38.0 (6.1)	18.7 (4.2)	45.08 (6.44)	96.35	0.1 (1.8)	4042
4	Pymetrozine 50 WG	150 g	124.0 (10.7)	36.0 (5.9)	28.3 (5.3)	12.0 (3.4)	50.08 (6.48)	95.95	0.1 (1.8)	4167
5	Pymetrozine 50 WG	175 g	79.0 (8.6)	51.3 (7.1)	49.3 (6.8)	11.0 (3.3)	47.67 (6.60)	96.14	0.1 (1.8)	5256
6	Pymetrozine 50 WG	200 g	69.0 (8.2)	34.7 (5.8)	23.7 (4.8)	19.0 (3.9)	36.58 (5.85)	97.04	0.1 (1.8)	4191
7	Thiamethoxam 25 WG	25 g	73.7 (8.6)	67.0 (8.1)	394.3 (19.5)	183.7 (13.5)	179.67 (12.54)	85.46	0.1 (1.8)	3764
8	Imidacloprid 17.8 SL	25 g	29.7 (5.4)	57.3 (7.5)	312.0 (17.2)	102.0 (10.0)	125.25 (10.20)	89.86	0.1 (1.8)	4650
9	Buprofezin 25 SC	125 g	203.7 (14.1)	475.7 (21.8)	214.3 (14.5)	90.0 (9.2)	245.92 (15.05)	80.10	0.1 (1.8)	3176
	F test		Sig	Sig	Sig	Sig	Sig		Sig	Sig
	CD		5.51	4.26	5.62	3.25	8.27		3.59	604
	CV (%)		25.91	19.10	25.70	25.97	49.59		28.09	9.40

* Figures in parenthesis are Square root transformed values

** Figures in parenthesis are arc sine transformed values

DAS – Days after spray

Table 2. Comparative efficacy of Pymetrozine 50 WG against BPH in rice during *Kharif* 2007

S. No	Particulars	Dose g (a.i./ ha)	Before spray	Brown Planthopper (no.s/ 20 hills)				Mean	% reduction over control
				1st Spray		2nd Spray			
				5 DAS	10 DAS	5 DAS	10 DAS		
1	Untreated Control	-	258.0 (16.0)	634.3 (25.1)	1306.7 (35.9)	704.0 (26.1)	542.0 (23.0)	796.75 (27.79)	---
2	Pymetrozine 50 WG	100 g	239.3 (15.3)	93.0 (8.8)	15.3 (3.8)	26.0 (5.3)	38.7 (6.2)	43.25 (6.22)	94.57
3	Pymetrozine 50 WG	125 g	294.3 (17.0)	55.7 (7.4)	18.7 (4.3)	20.7 (4.7)	52.0 (7.0)	36.75 (5.88)	95.39
4	Pymetrozine 50 WG	150 g	270.3 (16.4)	66.7 (7.9)	27.0 (5.2)	19.3 (4.7)	33.0 (5.7)	36.50 (5.88)	95.42
5	Pymetrozine 50 WG	175 g	393.7 (19.7)	61.7 (7.7)	33.0 (5.7)	28.0 (5.4)	31.7 (5.5)	38.58 (6.13)	95.16
6	Pymetrozine 50 WG	200 g	429.0 (20.5)	49.3 (7.0)	22.3 (4.7)	20.3 (4.8)	46.7 (6.5)	34.67 (5.77)	95.65
7	Thiamethoxam 25 WG	25 g	385.3 (19.6)	49.7 (7.0)	47.3 (6.9)	236.0 (15.3)	515.0 (22.6)	212.00 (13.00)	73.39
8	Imidacloprid 17.8 SL	25 g	350.0 (18.5)	33.3 (5.8)	52.3 (7.2)	161.0 (12.8)	273.0 (16.4)	129.92 (10.55)	83.69
9	Buprofezin 25 SC	125 g	267.7 (16.3)	131.3 (11.3)	270.7 (16.4)	159.7 (12.9)	249.7 (15.2)	202.83 (14.09)	74.54
	F test		NS	Sig	Sig	Sig	Sig	Sig	
	CD		-	3.84	3.35	10.10	4.38	5.75	
	CV (%)		15.65	22.70	19.35	57.09	21.08	37.32	

* Figures in parenthesis are Square root transformed values

** Figures in parenthesis are arc sine transformed values, DAS – Days after spray

Table 3. Comparative efficacy of Pymetrozine 50 WG against BPH in rice during *Rabi* 2007-08

S. No	Particulars	Dose g (a.i./ha)	Brown Planthopper (no.s/ 20 hills) *						% population reduction over control	Hopper Burn area (%) **	Yield (Kg/ ha)
			Before spray	1st Spray		2nd Spray		Mean			
				5 DAS	10 DAS	5 DAS	10 DAS				
1	Untreated Control	-	606.33 (24.69)	924.00 (30.37)	407.00 (20.15)	1117.33 (33.42)	1389.00 (37.23)	876.83 (27.47)	---	20.25 (26.44)	5027
2	Pymetrozine 50 WG	100 g	126.67 (11.21)	60.33 (7.76)	84.67 (9.20)	100.67 (10.62)	20.00 (4.46)	49.67 (6.62)	94.34	0.1 (1.81)	5917
3	Pymetrozine 50 WG	125 g	287.33 (16.95)	99.67 (9.95)	104.67 (10.23)	111.67 (10.56)	34.33 (5.86)	67.67 (7.85)	92.28	0.1 (1.81)	6239
4	Pymetrozine 50 WG	150 g	517.33 (22.73)	77.00 (8.77)	98.00 (9.89)	203.33 (14.07)	28.00 (5.28)	82.00 (8.19)	90.65	0.1 (1.81)	6029
5	Pymetrozine 50 WG	200 g	472.67 (21.70)	113.00 (10.63)	94.33 (9.70)	98.33 (9.90)	19.00 (4.35)	65.17 (7.60)	92.57	0.1 (1.81)	6481
6	Thiamethoxam 25 WG	25 g	451.33 (21.21)	169.33 (13.01)	114.00 (10.66)	408.00 (20.17)	68.00 (8.22)	166.25 (11.47)	81.04	0.1 (1.81)	5708
7	Imidacloprid 17.8 SL	25 g	292.67 (16.99)	192.67 (13.88)	201.67 (14.16)	498.00 (22.27)	334.00 (18.20)	259.42 (14.52)	70.41	0.1 (1.81)	5770
8	Buprofezin 25 SC	250 g	296.00 (17.10)	83.00 (9.10)	97.00 (9.84)	117.67 (10.82)	24.00 (4.73)	69.42 (8.03)	92.08	0.1 (1.81)	6842
	F test		Sig	Sig	Sig	Sig	Sig	Sig	---	Sig	Sig
	CD		2.94	1.02	1.31	2.52	2.24	6.94	---	3.56	603
	CV (%)		9.92	5.06	7.19	9.88	13.04	41.14	---	46.84	6.47

* Figures in parenthesis are Square root transformed values

** Figures in parenthesis are arc sine transformed values, DAS – Days after spray

ORIGINAL RESEARCH ARTICLE OPEN ACCESS

Prospects for Direct Sown Rice, a Low Cost Technology for Sustainable Livelihood in Godavari Delta of Andhra Pradesh

P.L.R.J. Praveena[1]* and T. V. Sridhar[2]

[1]District Agricultural Advisory and Transfer of Technology Centre

[2]Acharya N.G.Ranga Agricultural University, Kakinada, East Godavari, Andhra Pradesh

*Corresponding author: nayanipraveena@gmail.com

Received: 16th January, 2015; Accepted: 20th July, 2015

Abstract

Rice is the major food crop grown in Andhra Pradesh, cultivated in an area of 28.03 lakh ha in *kharif* and 15.84 lakh ha in *rabi* seasons. East Godavari district contributes about 10% of the total production predominantly from Central and Eastern Delta. Of late, high cost of cultivation has been considered as a major hurdle for paddy farmers to realize sustainable economic returns. Increased labour wages, indiscriminate application of fertilizers and plant protection chemicals and labour scarcity are the factors responsible for high cost of cultivation. In this paper, we report the outcome of the on farm trials conducted during *rabi* 2012-2013 season with the main objective of improving productivity per unit area, reduced cost of cultivation and conservation of natural resources. Low cost technologies like direct sown method by broadcast on puddled field, timely weed management, soil test based fertilizer application and need based plant protection measures were demonstrated in the trial plots and were compared with farmer's practice. MTU 3626, a locally popular *rabi* variety was selected for the trial and also control plots. The data collected from the trials established the superior performance of direct sown method with higher grain yield of 8529 Kg/ha over conventional method (7930Kg/ha) and CB ratio of 1:2.01. Further, in direct sown method, the water requirement could be minimized due to alternate wetting and drying of the field in the initial stages of crop growth. Moreover, crop duration was reduced by 8 to 10 days in direct sown rice than transplanted rice. On an average, the difference in cost of cultivation varied between Rs. 6,000/ to Rs. 7,000/- among different on farm trial plots. The on-farm trials helped to convince not only the host farmers of the trail plots but also the other farmers of the same village as well as from nearby villages on the benefits of the low cost technologies interms of reduced cost of cultivation coupled with sustainable production. The overwhelming response towards adoption of the technologies was highlighted.

Key words: East Godavari, rice based cropping system, direct seeded rice

Introduction

Godavari District is one of the agriculturally prosperous districts in the state to Andhra Pradesh contributing about 10% of the total food production of the state. Popularly known as Rice Bowl of Andhra Pradesh, the district is geographically divided into four agro climatic groups namely eastern delta, central delta, uplands and agency. The major irrigation source is the river Godavari covering an area of 5,06,409 acres through canal irrigation, followed by medium irrigation projects with an ayacut area of 4870 acres and minor irrigation projects covering 53,414 acres.

Rice based cropping system is highly intensive in the district and rice is cultivated both in *kharif* and *rabi* seasons in about 2.23 lakh ha and 1.50 lakh ha respectively with an average productivity of 3.85 tonnes/ha. Traditionally, rice is grown by transplanting of one month old nursery seedlings in puddle field under flooded soil condition which is a labour intensive process. Studies conducted on economics of rice cultivation revealed that the cost of inputs and cost on different operations has increased substantially. It has been reported that the labour cost has increased by 100%, chemical fertilizers and pesticides by 45%, cost on seed by 33% and tillage operations by 35-40% (Chandrasekhar *et al.*, 2013). High cost of cultivation has been viewed as a major hurdle for paddy farmers to transform the farming activity into profitable enterprise. Added to these components, labour scarcity is also posing a great threat for the farmers affecting timely cultural operations. To overcome these constraints so as to achieve sustainable income, the scientists of District Agricultural Advisory and Transfer of Technology Centre, East Godavari District conducted on farm trials (OFTs) during *rabi* 2012-2013 season with the main objective of improving productivity per unit area, reduced cost of cultivation and conservation of natural resources. Low cost technologies like direct sown method by broadcast on puddled field, timely weed management, soil test based fertilizer application and need based plant protection measures were demonstrated in the trial plots and compared with farmer's practice of traditional transplanting method and indiscriminate use of fertilizers and plant protection measures. Besides the demonstration of the potential of low cost technologies, the study also highlighted the accomplishment in successful transfer of cost effective technology among the farmers. Further, the prospects for large scale adoption of the low cost technologies in farmer's fields to transform rice cultivation as a sustainable livelihood enterprise in Godavari delta region of Andhra Pradesh are detailed and discussed.

Materials and Methods

On farm trials were conducted by the scientists of the District Agricultural Advisory and Transfer of Technology Centre (DAATTC), East Godavari District during *Rabi* 2012-2103. Three low cost technologies *viz.,* direct sown rice; soil test based fertilizer application and need based application of plant protection chemicals were selected for the study. In all, trials were conducted in 12 locations covering the delta area and the extent of the trail plot was one acre each. The treatments imposed were common to all the 12 trial plots. Correspondingly, 12 plots raised following the farmer's practice of conventional transplanting method in similar extent of area (1 Acre) at each location, were used as check plots for comparison with direct sown method. MTU 3626, the locally popular variety in *rabi* was sown both in trial plot and check plots. In the trial plots, recommended seed rate, timely weed management, soil test based fertilizer application and need based plant protection measures were the treatments imposed. In the check plots, the farmer's practices for conventional transplanting method were adopted. The operations wise treatments imposed in the trial plots are as follows. The data collected with respect to yield and other related parameters was subjected to the test of significance.

i) **Sowing method and seed rate in trial plots and farmer's practice**: In transplanting method which is a commonly followed practice in the district, the farmers used 25 to 30 kg of seed for raising nursery which is sufficient for transplanting in one acre field. In the OFT plots, direct sowing was followed with 12 kg of seed for one acre area. Further, dry seed treatment with Carbendazim was followed for trial plots and sprouted seed was sown in puddled condition. Thin film of water was maintained at the time of sowing.

ii) **Weed management in trial plots and farmer's practice:** In farmer's practice of transplanted paddy, farmers have resorted to application of pretilachlor @ 400ml/acre, pre emergence weedicide at 3 days after planting (DAP) followed by one hand weeding. In the trial plots, both pre emergence weedicide, pyrazosulfuran ethyl @100g/acre at 3days of sowing (DOS) and post emergence weedicide, bis pryi bac sodium @ 80ml/acre at 20 DOS were applied as weeds are the major problem in direct sown rice.

iii) **Soil test based fertilizer application in trial plots and farmer's practice:** Analysis of soil samples collected from trial plots of the selected farmers revealed that available 'P' was medium to high, 'N' was low to medium and available 'K' was also medium to high. As per the zonal recommendation, 72 +36 + 24 kg NPK per acre has to be applied during *rabi* for soils with medium level of NPK. Thus, in the trial plots, only recommended doses of fertilizers were applied but in the farmers practice, the farmers applied as high as 100 kg N and 45 kg 'P' per acre irrespective of soil analysis and moreover, the time of fertilizer application was also not scrupulously followed by the farmers as the 'P' fertilizer which needs to be applied during last puddle was applied at 10 DAP and at tillering stage.

iv) **Plant protection in trial plots and farmers practice** In the trial plots, need based plant protection measures were adopted. Carbofuran 3G granules were applied at panicle initiation stage to protect the crop from stem borer and BPH. Additionally, two sprays in crop season, one at tillering stage for control of blast and the other at milky stage for the control of BPH were taken up in the trial plots. On the other hand, in check plots, the farmers have resorted to calendar based sprayings even though the pest and disease incidence was low during the corresponding *rabi*. On an average, six sprays with combination of different chemicals were given by the farmers in the control plots.

Results and Discussion

i) Yield parameters

The investigators performed five field visits at regular intervals to monitor the crop condition and observations were recorded from both the trial and control plots. Data pertaining to yield parameters was recorded at 30, 45 and 90 days of sowing and BC ratio was also worked out. The data pertaining to yield parameters is furnished in Table 1. It is apparent from the data that the average number of hills/sqm in direct sown rice was 64 as against 34 hills/sq m in the transplanted plots. In general, the optimum number of hills per sq m required for realizing good yields during *rabi* is 44 hills per sq m. In the direct sown method, the sprouted seeds are broadcast uniformly on the puddled field while in transplanted rice, 3 to 4 seedlings were planted per hill at an approximate spacing of 15 x 15 to 16 cm. With regard to maximum number of tillers per sq m recorded at 45 days, it was observed that the direct sown plots on an average recorded 844 tillers per sq m while the transplanted plots recorded 712 tillers per sqm. On the other hand, the direct sown plots on an average recorded 623 productive tillers per sq m and transplanted pots recorded 581 tillers per sqm. Similar findings were reported by Shekar and Singh (1991) where direct seeding of sprouted seed under puddle conditions resulted in significant improvement in yield attributes like number of effective tillers and grain yield. The differences among various parameters were found statistical significant at 5% level.

ii) Crop duration and Yield

It was noticed that the direct sown plots came to harvest 8 to 10 days earlier than check plots of transplanted rice. Generally, the crop duration of the MTU3626 variety chosen for the trials is 130 days. It was observed that the crop duration in the trial plots of direct sown method ranged from 120-122 days while in control plots the crop was ready for harvest by 130 days. The findings are in agreement with the study of Wang and Sun (1990) who reported that the duration can be shortened by 7-15 days in direct seeded rice compared to transplanted rice. Due to early harvest, water requirement was also less in direct sown rice compared to transplanted rice. As regards to plot yields, the trial plots of direct sown rice recorded higher yield (8529 kg/ha) over conventional method (7930 kg/ha). Bhushan *et al.* (2007) also reported similar findings with regard to direct sown rice which demonstrated an added advantage of minimizing the water requirement in addition to the realizing of higher yields compared to transplanted rice.

iii) Labour and cost reduction

The cost incurred towards nursery raising, quantity of seed and transplanting cost was remarkably reduced in direct sown rice. The input costs like fertilizer, plant protection chemicals were also minimized in the on farm trials as these inputs were used rationally based on soil test values and ETL of pests and diseases, respectively. In direct sown rice, the cost of cultivation could be brought down by Rs. 6,000/- to Rs.7,000/- per acre. A comparison on cost of cultivation between direct sown rice and transplanted rice is presented in Table 2. Transplanted rice is a labour intensive method which requires additional labour for nursery raising (sowing & pulling) and transplanting, compared to direct sown method. Based on studies conducted on direct sown rice in Pakistan, Akther Ali *et al*. (2014) concluded that direct sown rice requires less labour and also recorded higher yields compared to transplanted rice.

Conclusions

The direct sown rice method was established to be superior with respect to total crop yield and minimizing the labour input. However, this method is still considered as a novel method for the farmers who have been traditionally practicing the transplanting method for decades. Nevertheless, the onfarm trials conducted on low cost technologies demonstrated the potential of these technologies in bringing down the cost of production and in realizing better economic returns, to the farmers. The trials provided an opportunity not only to the farmers who hosted the trial plots but also to the farmers of respective villages and also from nearby villages to observe the efficiency and positive benefits of the low cost technologies, in the trial plots. As a result, the response towards adoption of these technologies in the succeeding season was overwhelming. Rice based system being predominant in the delta area of the East Godavari District, the farmers are left with no other option than rice in both the seasons unlike the upland farmers who can take up irrigated dry (ID) crops in place of paddy during *rabi*. Moreover, the delta areas are low lying and more suitable for paddy cultivation. Hence, in the light of labour shortage, increasing labour wages, and growing input costs, any new technologies that ensure reduced labour requirement and rational input use with improved production naturally attracts the attention of the farmers and such technologies are adopted at a faster rate. Hence, in order to popularize these proven technologies and to create awareness among farming community, large scale field demonstrations and capacity building programmes need to be organized by the extension personnel.

Acknowledgements

The authors are indebted to the Associate Director of Research, Regional Agricultural Research Station, Maruteru, Andhra Pradesh for the technical support and guidance extended throughout the study.

References

Akther, Ali., Olaf E. and Rahut D.B. 2014. Impact of direct rice sowing technology on rice producers earnings: empirical evidence from Pakistan. *Development Studies Research: An open Access Journal* 1(1): 244-254.

Bhusahan, L., Landha, J.K., Gupta, R.K., Singh, S., Padre, A.T., Saharwat, Y.S., Gathala, M. and Pathak, H. 2007. Saving of water and labor in a rice-wheat system with no tillage and direct seeding technologies. *Agronomy Journal* 99(5): 1288-1296.

Chandrasekhar Rao, C., Jitendranath S., and Murthy T.G.K., 2013. Resource optimization in rice through direct seeding by drum seeder *International Journal of Agriculture and Food Science Technology* 4(3): 239-246.

Sekhar, J. and Singh, C.M. 1991. Influence of methods and dates of stand establishment on growth and yield of rice. *Oryza* 28:45-48.

Table 1. Comparison of yield parameters between direct sown rice and transplanted rice

Yield parameters	Direct sown rice	Transplanted rice
Hills /sq m	64	34
Maximum tillers/sq m	844	712
Productive tillers/sq m	623	581
Duration in days	120-122	130
Yield Kg/ha	8529	7930
CB Ratio	1: 2.1	1: 1.57
t value	1.91*	

* significant at 5% level

Table 2. Comparison of cost of cultivation between trial plot and farmer's practice of transplanted Rice

Inputs/operations	Cost of Cultivation in Rs./acre	
	Trial plot (Direct sown)	Farmers practice (transplanted rice)
Seed	600-00	1000-00
Land preparation	4000-00	4000-00
Nursery	--	1000-00
Sowing/planting	1200-00	2500-00
Weeding	1200-00	2000-00
Fertilizer	3200-00	
	4200-00	
Irrigation (labour cost)	1000-00	1000-00
PP measures	1800-00	2,500-00
Harvesting, threshing	5000-00	5000-00
Total	18,500-00	23,200-00
Gross returns	39,000-00	36,500-00
Net profit	20,500-00	13,300-00

Productivity of Research Publications of Indian Institute of Rice Research Published during 1990-2014 - A Bibliometric Study

M. Ezra[1]* and D. Ravinder[2]

[1]ICAR-Indian Institute of Rice Research, Rajendranagar, Hyderabad, Telangana.
[2]Department of Library and Information Science, Sri Krishnadevaraya University, Anantapur, Andhra Pradesh.
*Corresponding author: ezradrr@gmail.com

Received: 15th August, 2015; Accepted: 20th October, 2015

Abstract

A bibliometric analysis of publications of the research workers of Indian Institute of Rice Research was done for the period from 1990 to 2014 to assess the publication productivity in various subjects. The classification and analysis of publications indicated various proportions in terms of nature of articles published in peer reviewed journals, newsletters, popular articles, in-house publication as well as those presented in conferences etc. An interesting trend surfaced over time was gradual increase in multi-authored contributions highlighting the increased belief in multi-disciplinary research cutting across institutions.

Keywords: Publication productivity, bibliometric analysis, multi-authorship

Introduction

Agriculture is closely linked with production of the fundamental elements of Man's food, shelter and clothing. Agriculture has dominant role in Indian economy contributing nearly half of the national income. Indian Council of Agricultural Research (ICAR), since its inception in 1929, with its network of research institutes, research centers and research stations, plays a dominant role in the research activities on various crops. Rice research is one of the most important crop based research in India as rice is a staple food for more than half of the population and is the focus of research across the globe.

Research output analysis is a kind of SWOT (strengths, weaknesses, opportunities and threats) analysis that provides a stimulus in furthering the research effort in any discipline. Hence an attempt was made to assess the productivity of publications in research conducted by Indian Institute of Rice Research during the period between 1990 and 2014.

Objectives

The major purpose of the present investigation was to examine the trend in the research conducted during the twenty five years on various aspects of rice with the objectives;

- To the identify the authors 'productivity
- To identify the predominant type of publications
- To measure the growth and development of research publication productivity of IIRR and
- To find out the single author vs. multi authored papers.

Review of Literature

Reports many similar studies have been reviewed in this part. Ramesh and Mahapatra (2012) used 2001-2010 Scopus database related to agricultural science; Rathinasabapathy (2012) analysed the publications on goat research utilizing the CAB direct online data pertaining to 1960-2012; Gupta et al. (2012) assessed the database on material science from 2001 to 2010; Gupta et al. (2011) on diabetes (1999-2008); Kshiting and Gupta (2011) on semantic web using Scopus database; Gupta and Bala (2011b) on Science and Technology (1996-2010); Varaprasad and Ramesh (2011) on Indian chemical research (1987-2007). Karpagam et al. (2010) on Nanoscience and Nanotechnology pertaining to period between 1938 and 2009. Jain and Kumar (2010)[9] on soya bean research using International crop CD database; Krishnamurthy et al. (2010) on Meteorology using publication data of period from 2006 to 2009. Mohan (2010) on Indian research in Nanoscience using science citation index (1982-2008);

Methodology

The present study has analysed the contributions made by IIRR Scientists / Research workers. The publication data were collected from the Annual Reports of IIRR for the study period from 1990 to 2014. All the bibliographic details were imported to MS-Excel for data manipulation and statistical analysis.

Results and Discussion

Table 1. Indicated the classification of various publications of research workers of IIRR appeared during the period 1990-2014 was shown. The total numbers of publications were 2485. It was observed that the highest number of papers i.e., 259 (10.49 %) had been published in 2014. In 1994there were only 11 articles (0.44%)i.e., least productivity. On an average 3.99 papers had been published every year since 1990.

Table 2 showed the five yearly distributions of publications. The highest number of contribution in Indian journals had been 581 (23.35 %) and 306 (12.30 %) papers had been published in foreign journals. The papers in Conferences and Seminars were 1000 out of which 860 (34.69 %) papers have been contributed in National Conferences and 140 (5.63 %) in conferences and seminars at Internal level. The highest number of contributions was during 2010-2014. Rests of 36.30 % contributions were as Book Chapters, Popular Articles and Newsletters.

Table: 3 showed that 887 (35.73 %) papers had been contributed in National and International journals. Indian Journal of Plant Protection had the highest number with 74 (8.34 %) papers, followed by Oryza 63 (7.10 %) papers. The scientists used 262 journals for 887 contributions. 145 (16.1 %) journals received only one contribution each while 34 % articles had been published in 7 journals. Rest of 50 % articles had been published by 110 journals.

Table 4 showed that 658 (26.48 %) research articles were in Plant Breeding followed by 398 (16.02 %) research articles in Entomology. It was apparent from the table that that almost all the major branches of agriculture had been covered by the scientists of IIRR.

Table 5 showed the authorship pattern. It differed in every research article. Generally articles have two or three authors but at the same time there are as many as four, five or even more than 10 authors. The authorship in each research article was shown in Table5. It revealed that there were 472 (18.97 %) papers had four authors, 342 (13.75 %) papers had have two authors, 32 (12.10 %), 187 (7.52 %), 145 (5.83 %), 109 (4.38 %) while 244 (9.81 %) papers had only one authors papers with five authors to ten authors and more. It showed that there were multiple authorship trends among the scientist of IIRR. Thus there were 2485 articles with 2488 authorship as shown in Table.5.

The Indian Institute of Rice Research (IIRR) is a major institute of research in Rice under ICAR. The scientists of IIRR had contributed significant research papers, the scientists had contributed 2485 papers in leading Indian and International Journals and Conferences. The study revealed that rice research was well coordinated research. The trend indicated the increase in the contribution by multiple authors with time indicating the concept of team work in multi-disciplinary and multi-institutional research.

References

Ramesh, D.B., and Mahapatra, R.K. 2012. Scientific Research output in agriculture and Biosciences in India: *A Bibliometric analysis National Conference of Agriculture Libraries and user Community (NCALUC). Bhubaneswar*: 162-171.

Rathinasabapathy, G. 2012. Scientometrics analysis of publication on goat research: A profile based on CAB direct online. *Indian Journal of Agricultural Library and Information Services (IJALIS)* 28: 35-39.

Gupta, B.M., Bala, A. and Kshiting, A. 2012. Contribution and citation impact of Materials Science research in India, 2001-10. *DESIDOC Journal of Library & Information Technology (DJLIT)* 32: 477- 481.

Gupta, B.M., Kaur, H. and Bala, A. 2011. Mapping of Indian Diabetes research during 1999-2008: *A Scientometrics analysis of publication output. DJLIT* 31:143-152.

Kshiting, A. and Gupta, B.M. 2011. Semantic web: A quantitative analysis of world publications output, 2001-2010 *(DJLIT)* 31: 253-261

Gupta, B. M. and Bala, A. 2011b. Indian science and Technology during fifteen years (1996- 2010): A quantitative assessment using publications data. *DJLIT* 31:359-370.

Varaprasad, S.J.D. and Ramesh, D.B. 2011. Activity and growth of chemical research in India during 1987-2007. *DJLIT* 31:387-394.

Karpagam, R, Gopalakrishnan, S. and Ramesh Babu, B. 2010. Publication trend on Nanotechnology among G15 countries: A bibliometric study. In proceeding, *ICWISE, Mysore. http://www.collnet.de.*

Jain, K.B. and Kumar, S. 2010. The evaluation of collaboration pattern of Indian contribution to world Soybean research. *In proceeding ICWISE, Mysore. http://www.collnet.de.*

Krishnamurthy, C; Jodalli, S. and Hadagali, G.S. 2010. Meteorology: A bibliometric analysis. *In Proceeding ICWISE, Mysore. http://www.collnet.de.*

Mohan, L. 2010. Research trends in Nanoscience and Nanotechnology in India *DJLIT* 30: 40-58.

Table 1. Year wise distribution of contributions and communications

S. No.	Year	Nat./Int. Journals	Popular Articles	Nat. /Int. Symposium	Nat. /Int. Newsletters	Book Chapters	In-house publications	Total	%
1	1990	10	0	3	1	1	0	15	0.60
2	1991	14	0	2	0	0	0	16	0.64
3	1992	14	0	1	1	2	0	18	0.72
4	1993	8	0	3	7	1	0	19	0.76
5	1994	9	0	0	2	0	0	11	0.44
6	1995	23	14	20	4	9	0	70	2.82
7	1996	17	15	60	0	8	0	100	4.02
8	1997	20	0	20	2	2	0	44	1.77
9	1998	24	4	27	28	13	0	96	3.86
10	1999	34	8	21	3	3	0	69	2.78
11	2000	28	4	46	8	8	1	95	3.82
12	2001	43	0	47	5	7	2	104	4.19
13	2002	36	20	71	15	9	3	154	6.20
14	2003	39	12	43	11	37	1	143	5.75
15	2004	36	3	27	0	4	4	74	2.98
16	2005	40	0	53	3	5	3	104	4.19
17	2006	43	0	84	3	1	5	136	5.47
18	2007	39	1	51	3	7	6	107	4.31
19	2008	40	10	57	7	6	4	124	4.99
20	2009	42	8	60	4	10	10	134	5.39
21	2010	48	10	62	22	9	4	155	6.24
22	2011	53	2	27	0	4	10	96	3.86
23	2012	64	7	94	6	24	8	203	8.17
24	2013	70	6	20	12	22	9	139	5.59
25	2014	93	11	104	12	31	8	259	10.42
	Total	887	135	1003	159	223	78	2485	100

Table 2. IIRR five yearly distribution of contributions

S. No	Name	1990-94	1995-99	2000-04	2005-09	2010-14	Total	%
1	Indian Journals	46	98	143	132	162	581	23.38
2	Foreign Journals	10	20	39	72	166	307	12.35
3	National Conferences/ Seminars / Symposiums	7	120	180	281	274	862	34.69
4	International Conferences / Seminars / Symposiums	2	27	54	24	33	140	5.63
5	In-house Publications	0	0	11	28	39	78	3.14
6	News letters	11	37	39	20	52	159	6.40
7	Book chapters	4	35	65	29	90	223	8.97
8	Popular Articles	0	41	39	19	36	135	5.43
10	Total	80	378	570	605	852	2485	100

Table 3. Distribution of most productive journals during 1990-2014

S.No.	Indian Journals	1990-94	1995-99	2000-04	2005-09	2010-14	Total	%
1	Indian Journal of Plant Protection	9	14	24	16	11	74	8.34
2	Oryza	7	12	11	22	11	63	7.10
3	Journal of Mycology and Plant Pathology	1	2	17	16	2	38	4.28
4	Indian Journal of Agricultural Science	9	5	8	6	7	35	3.95
5	Journal of Research ANGRAU	-	6	16	4	9	35	3.95
6	Indian Journal of Genetics and Plant Breeding	1	12	3	7	6	29	3.27
7	Progressive Research International Journal	-	-	-	2	26	28	3.16
8	Journal of Biological Control	1	4	7	6	4	22	2.48
9	Indian Journal of Plant Physiology	7	4	1		6	18	2.03
10	Current Science		7	5	3	1	16	1.80
11	1 journal with 15 articles	0	0	3	5	7	15	1.69
12	1 journal with 9 articles	0	0	0	1	8	9	1.01
13	4 journals with 8 articles each	1	5	11	5	10	32	3.61
14	7 journals with 7 articles each	2	6	12	11	18	49	5.52

S.No.	Indian Journals	1990-94	1995-99	2000-04	2005-09	2010-14	Total	%
15	6 journals with 6 articles each	8	4	5	12	7	36	4.06
16	7 journals with 5 articles each	1	3	5	7	19	35	3.95
17	13 journals with 4 articles each	1	7	8	12	24	52	5.86
18	20 journals with 3 articles each	4	4	11	16	25	60	6.76
19	48journals with 2 articles each	1	11	12	19	53	96	10.82
20	145journals with 1 articles each	2	12	23	34	74	145	16.35
Total	262	55	118	182	204	328	887	100

Table 4. Subject Analysis of Contributions

S. No.	Subjects	1990-94	1995-99	2000-04	2005-09	2010-14	Total	%	Rank
1	Plant Breeding	20	118	159	132	229	658	26.48	I
2	Entomology	20	61	93	117	107	398	16.02	II
3	Agronomy	7	49	73	73	66	268	10.78	III
4	Plant Biotechnology	3	25	36	65	108	237	9.54	IV
5	Plant Pathology	14	38	41	63	58	214	8.61	V
6	Crop Physiology	7	20	23	24	68	142	5.71	VI
7	General	10	32	39	28	32	141	5.67	VII
8	Agricultural Extension	0	8	25	14	66	113	4.55	VIII
9	Soil Science and Soil Chemistry	4	25	20	15	31	95	3.82	IX
10	Nematology	1	1	23	21	27	73	2.94	X
11	Agricultural Economics	2	6	6	12	11	37	1.49	XI
12	Computer Science and Statistical Applications	0	1	11	11	14	37	1.49	XII
13	Agricultural Engineering	1	3	13	3	0	20	0.80	XIII
14	Soil Science	0	3	1	1	9	14	0.56	XIV
15	Soil Science and Microbiology	0	3	2	3	5	13	0.52	XV
16	Agricultural Microbiology	0	0	0	0	7	7	0.28	XVI
17	Seed Technology	1	0	2	4	0	7	0.28	XVII
18	Post Harvest Technology	0	0	4	1	1	6	0.24	XVIII

S. No.	Subjects	1990-94	1995-99	2000-04	2005-09	2010-14	Total	%	Rank
19	Agricultural Chemistry	0	0	0	0	5	**5**	0.20	XIX
	Total	90	393	571	587	844	2485	100	
	%	3.62	15.81	22.98	23.62	33.96	100		

Table 5: Authorship Pattern in 5 yearly contributions

S. No	Name	1990-94	1995-99	2000-04	2005-09	2010-14	Total	%
1	Single author	15	46	57	53	73	244	9.81
2	Two Authors	32	95	94	56	65	342	13.75
3	Three Authors	25	97	158	118	74	472	18.97
4	Four Authors	4	66	107	120	135	432	17.36
5	Five Authors	3	51	78	94	95	321	12.90
6	Six Authors	0	12	26	58	91	187	7.52
7	Seven Authors	0	9	20	30	86	145	5.83
8	Eight Authors	0	1	9	30	69	109	4.38
9	Nine Authors	0	2	10	14	35	61	2.45
10	Ten Authors	0	0	6	11	27	44	1.77
11	More than ten Authors	0	0	5	22	104	131	5.27
	Total	79	379	570	606	854	2488	100

SHORT COMMUNICATION OPEN ACCESS

Evaluation of Gene Pyramided Rice Cultures Against Bacterial Leaf Blight Disease of Rice

K. Rajappan* and V. Ravi

Tamil Nadu Rice Research Institute, Aduthurai, Tamil Nadu
*rajappankasilingam@yahoo.co.in

Received: 18th April, 2015; Accepted: 15th September, 2015

Bacterial leaf blight (BLB) caused by *Xanthomonas oryzae* pv. *oryzae* is becoming a major disease on rice throughout the country. In Tamil Nadu, severe incidence of BLB has been observed both in *kharif* (June – Sep.) and *rabi* (Sep. – Dec.) seasons in the recent years. Most of the ruling rice varieties are found to be susceptible to the disease. Under ICAR – All India Coordinated Rice Improvement Project, gene pyramided rice cultures were screened for their resistance against BLB disease in the field conditions at Tamil Nadu Rice Research Institute, Aduthurai from 2012-13 to 2014-15. Rice cultures with one, two and three gene pyramids in the background of IR 64 were developed at CRRI, Cuttack (Anonymous, 2009). The rice cultures consisted lines with resistant genes *Xa4, Xa5, Xa13* and *Xa21* individually as well as in combination of *Xa5* + *Xa13*, *Xa5* + *Xa21*, *Xa13* + *Xa21* and *Xa5* + *Xa13* + *Xa21*. Screening trial was conducted during 2012-2015 in *rabi* season along with checks and two local check varieties ADT 38 and CR 1009.

The gene pyramided cultures were artificially screened against bacterial leaf blight pathogen *Xanthomonas oryzae pv. oryzae* by clip inoculation method with pure culture. The disease grade / reaction was assessed as per the IRRI-SES scale (1996) for bacterial leaf blight as given below.

Disease score chart

Score	Description (affected lesion area)
1	1-5%
3	6-12%
5	13-25%
7	26-50%
9	51-100%

The results revealed that the cultures IRRB 53 (*Xa5* + *Xa13*), IRBB 56 (*Xa4* + *Xa5* + *Xa13*) and IRBB – 60 (*Xa4* + *Xa5* + *Xa13* + *Xa21*) were found to be resistant to the disease with grade 3 (Table 1). Similar results were reported by Karthikeyan and Chandrasekaran (2005).

References

Anonymous 2009. ICAR – AICRIP Progress Report, Directorate of Rice Research, Hyderabad . p 350.

Karthikeyan, A. and B. Chandrasekaran, 2005. Field testing of gene pyramided rice cultures for resistance against bacterial leaf blight disease of rice**.** Paper presented in "National Seminar on Emerging Trends in Plant Pathology and their social relevance" held at Annamalai University, Annamalai Nagar on 7th - 8th, March, 2005. P. 8

Table 1. Evaluation of gene pyramided cultures against BLB pathogen under field conditions

Sl. No.	Lines / Differential	Gene Combination	Reaction (SES 0-9 scale)		
			2012-13	2013-14	2014-15
1	IRBB - 1	*Xa1*	5	5	9
2	IRBB - 3	*Xa3*	7	8	9
3	IRBB - 4	*Xa4*	7	7	9
4	IRBB - 5	*Xa5*	7	7	9
5	IRBB - 7	*Xa7*	5	5	9
6	IRBB - 8	*Xa8*	5	5	9

Sl. No.	Lines / Differential	Gene Combination	Reaction (SES 0-9 scale)		
			2012-13	2013-14	2014-15
7	IRBB - 10	*Xa10*	7	5	8
8	IRBB - 11	*Xa11*	7	7	8
9	IRBB - 13	*Xa13*	5	5	9
10	IRBB - 14	*Xa14*	7	5	9
11	IRBB - 21	*Xa21*	5	5	9
12	IRBB - 50	*Xa4 + Xa5*	4	4	9
13	IRBB - 51	*Xa4 + Xa13*	5	5	9
14	IRBB - 52	*Xa4 + Xa21*	4	4	9
15	IRBB – 53	*Xa5 + Xa13*	3	3	9
16	IRBB - 54	*Xa5 + Xa21*	4	4	9
17	IRBB - 55	*Xa13 + Xa21*	5	5	9
18	IRBB - 56	*Xa4 + Xa5 + Xa13*	3	3	9
19	IRBB - 57	*Xa4 + Xa5 + Xa21*	4	4	9
20	IRBB - 58	*Xa4 + Xa13 + Xa21*	3	3	8
21	IRBB - 59	*Xa5 + Xa13 + Xa21*	3	--	9
22	IRBB - 60	*Xa4 + Xa5 + Xa13 + Xa21*	3	--	9
23	DV - 85		7	--	9
24	Ajaya		5	--	8
25	TN - 1		9	--	8

SHORT COMMUNICATION OPEN ACCESS

New Report of *Chrysonotomyia* species (Hymenoptera:Eulophidae: Entedoninae), Larval Parasitoid on the Rice Hispa, *Dicladispa armigera* (Oliver) (Coleoptera: Chrysomelidae) in Himachal Pradesh

Ajai Srivastava[1]*, Urvi Sharma[1] and Chitra Shanker[2]

[1]CSK HPKV Rice and Wheat Research Centre, Malan, Kangra H.P.

[2]ICAR-Indian Institute of Rice Research, Rajendranagar, Hyderabad

*Corresponding author: ajai_mustard@rediffmail.com

Received: 15th June, 2015; Accepted: 3rd November, 2015

Rice (*Oryza sativa* L.) is one of the world's most important sources of food among cereals and ranks first position in acreage and total production. In Himachal Pradesh, rice occupies third position in acreage after wheat and maize with 75.20 thousand ha area under its cultivation and total production of 128.92 thousand metric tonnes (Anonymous, 2011). Rice crop has relatively a large number of insect pests which limits its production. More than 100 species of insects attack and feed on rice crop from nursery to maturity stage and also in storage. The rice hispa, *Dicladispa armigera* (Oliver) (Coleoptera: Chrysomelidae) which was earlier known to be a sporadic pest of paddy is now emerging as an important pest of grave concern. It is now a major pest of rice in southern Asia and Australia, more particularly in Bangladesh, India and Nepal (Polaszek *et al.,* 2002). Yield loss caused due to *D. armigera* attack has been estimated as 28 per cent in India (Nath and Dutta, 1997), 20 -30 per cent in Nepal (Dhaliwal *et al*.,1998) and up to 52 per cent in deepwater rice in Bangladesh (Islam, 1989). In India, in the past few years, it has also gained major pest status, particularly in states of Assam, Bihar, Uttar Pradesh, Himachal Pradesh and Odisha causing considerable economic loss to the farmers. Scant information is available on the native parasitoids of *D. armigera*. Despite the promising results of some recent studies in Bangladesh (Islam and Rabbi,1998; Polaszek *et al*., 2002; Polaszek, 2004) no work has been initiated on the biological control of this pest. Survey for natural enemies in Assam revealed the presence of *Trichogramma* and *Oligosita* sp. on eggs of hispa.

Hispa damage was observed at the Rice and Wheat Research centre, Malan in Kangra District of Himachal Pradesh during 2015. A maximum of 68 per cent leaf damage was observed during September, 2015 with a mean of 37.36 % leaves being damaged. Natural parasitisation of grubs was observed during this period in the field. The parasitoids were reared to adults in the laboratory and were tentatively identified based on keys described by Hansson (1990) and Gumovsky (2001). The key identification features were forewing with one hairline, ascending from stigma vein, body extensively dark and metallic green body. The eulophid, *Chrysonotomyia* species has been reported as larval parasitoid on the rice hispa, *D. armigera* in Himachal Pradesh for the first time. It was earlier reported from Bangladesh and West Bengal along with another species *Bracon hispae* (Bhattacharyya *et al*., 2000).

References

Anonymous. 2011. Economic Survey of Himachal Pradesh. Economics and Statistical Department, Government of Himachal Pradesh, India p46-47.

Bhattacharyya, B., Basit, A. and Kanchan, S. 2000. Parasitoids of rice hispa in Assam. *Insect Environment* 5:159.

Gumovsky, A.V. 2001. The status of some genera allied to *Chrysonotomyia* Ashmead and *Closterocerus* Westwood (Hymenoptera, Eulophidae, Entedoninae), with description of a new species from Dominican Amber *Phegea* 29 (4):125-141

Hansson, C. 1990. A taxonomic study on the paleartic species of *Chrysonotomyia* Ashmead and *Neochrysocharis Kurdjumov* (Hymenoptera: Eulopidae). *Ent. Scandinavia* 21:29-52.

Islam, Z. 1989. Crop losses due to hispa beetle damage in deep water rice (DWR). *International Rice Research Newsletter* 14:53.

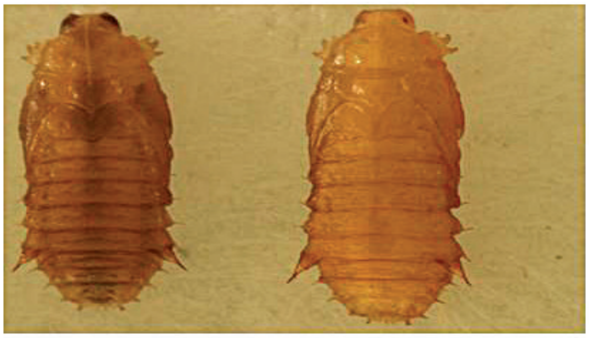
Islam, Z. and Rabbi, M.F. 1998. Parasitism of rice hispa. *Dicladispa armigera*

(Oliver) grubs in Bangladesh. *Bangladesh Journal of Entomology* 8:127-129.

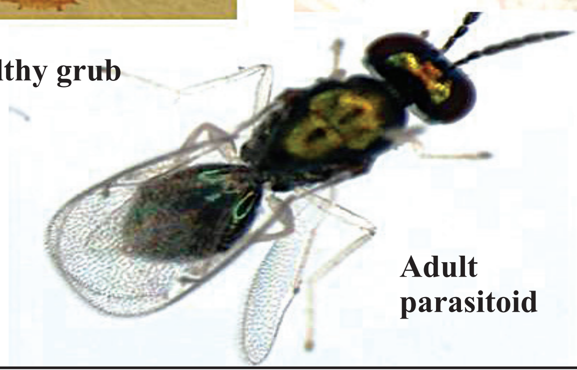
Nath, R.K. and Dutta, B.C. 1997. Assessment of yield loss due to due to rice hispa, *Dicladispa armigera* (Oliv.) *Journal of the Agriculural Science Society of North India* 10:268-270.

Polaszek, A., Rabbi, M.F., Islam, Z. and Buckley, Y.M. 2002. *Trichogramma zahiri*, an egg parasitoid of the rice *Dicladispa armigera* in Bangladesh (Hymenoptera: Trichogrammatidae, Coleoptera :Chromelidae:Hispinae). *Bulletin of Entomogical Research* 92:529-537.

Polaszek, A. 2004. Identification guide to the common insect-pest parasitoids of the rice hispa beetle, *Dicladispa armigera* (Oliver) in Bangladesh. Report, CABI Bioscience/ Bangladesh Rice Research Institute, 1-8.



Parasitized and healthy grub



Adult parasitoid

Journal of Rice Research - Authors Guidelines

Scope: Journal of Rice Research is a channel for publication of full length papers covering results of original research, invited critical reviews or interpretative articles related to all areas of rice science, rice based crop systems and rice crop management. The journal also publishes occasional short communications, book reviews and letters to the editor.

Articles reporting experimentation or research in any field involving rice or rice based cropping systems will be accepted as original articles while critical reviews are generally invited. Short articles concerned with experimental techniques or observation of unique nature will be accepted as short communication. Letters to the editor concerning previous articles are welcome and are published subject to review and approval by the editorial board. The original authors will be invited to reply to the points raised in these letter for their response which are also published together.

General Requirement:

Submission to the journal must be reports of original research of at least two crop seasons and must not be previously published or simultaneously submitted to any other scientific or technical journal. At least one of the authors (in case of joint authorship) should be member of the Society for Advancement of Rice Research and not in arrears of subscription. Authors of invited articles are exempted from this.

Submission of manuscript:

Manuscripts should be sent online to the Journal office at sarr_drr@yahoo.com; surekhakuchi@gmail.com, jyothi_rishik@yahoo.com, ento_sam@yahoo.co.in as an attachment. All the enclosed figures (as ppt files), graphs (as MS Excel worksheet with original data) and photographs (as jpg or ppt files with high resolution) may be submitted as separate files. Avoid using more than one font. The manuscript should be typed in double spaced with margins of at least 2.5 cm. On the first page give the title, a byline with the names of authors, their affiliation and corresponding author's e-mail ID. Abstract should be followed by a list of key words, and abbreviations used in the paper. The usual order of sections to be included after title and abstract pages are: Introduction which includes literature review; materials and methods; results and discussion; conclusion (optional), acknowledgements and references followed by figures and tables.

Title and byline should give a clear idea what the articles is about. It should be brief and informative (12-15 words).

References: References are quoted in author-year notation system only. Arrange all the references alphabetically by author. All single author entries precede multiple author entries for the same first authors. Use chronological order within entries with identical authorship and add a low case letter a, b, c, etc., to year for same year entries of the same author. References should be typed as follows:

Research papers

1. Mukherjee JN. 1953. The need for delineating the basic oil and climatic regions of importance to the plant industry. *Journal of Indian Society of Soil Science* 1:1-6.
2. Shin YS, Kim ES, Watson JE and Stokstad EL. 1975. Studies on folic acid compounds in nature. IV. Folic acid compounds in soybeans and cow milk. *Canadian Journal of Biochemistry* 53:338-343.
3. Paul M and Keegstra K. 2008. Cell-wall carbohydrates and their modification as a resource for biofuels. *Plant Journal* 54:559-568.

Thesis

Bhuiyan MDAR. 2010. Phenotypic and genotypic evaluation of selected transgressive variants derived from *Oryza rufipogon* Griff. x *Oryza sativa* L. cv. MR219. Ph D. Thesis. University Kebaangsaan Malaysia, Malaysia, 150 p.

Book chapter

Scott JM. 1984. Catabolism of folates. P. 307-327. In R.L. Blackley and S.J. Benkovic (ed.) Folates and Pterims Vol.1. John Wiley & Sons, New York.

Book

Subba Rao LV, Shobha Rani N, Chiranjeevi M, Chaitanya U, Sudharshan I, Suneetha K, Jyothi Badri and Choudhary DR. 2013. DUS Characterization of Rice Varieties. Directorate of Rice Research, Rajendranagar, Hyderabad-500 030, AP, India. 524 pp.

Figures: Photographs and drawings for graphs and charts should be prepared with good contract of dark and light. Figure caption should be brief specifying the crop or soil, major variables presented, place and year. Give careful attention to the width of lines and size, and clarity of type and symbols.

Tables: Tables are used for reporting extensive numerical data in an organized manner and statistically analyzed. They should be self explanatory. Prepare tables with the word-processing tables feature and tabs or graphics boxes should not be used. Table head should be brief but complete and self contained. Define all variables and spellout all the abbreviations. An exponenetial expression (eg. x 103) in the units line is often needed to keep length of the data reasonably short, and referenced with an explanatory note. Unless otherwise required, two decimal place values are suggested. Follow the articles published in recent journal for table format.

Society for Advancement of Rice Research

ICAR-Indian Institute of Rice Research (ICAR-IIRR)
Rajendranagar
Hyderabad – 500 030 (India), Phone No: 091 40 24591221, 24591216
Fax: +9140 24591217, email: sarr_drr@yahoo.com