

Performance of Promising Rice Hybrids for the Superior Yield-Attributing Traits and Productivity Under Kymore Plateau

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By

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2007



CERTIFICATE-I

This is to certify that the thesis entitled, "**Performance of promising rice hybrids for the superior yield-attributing traits and productivity under Kymore plateau**" submitted in partial fulfilment of the requirement for the degree of **MASTER OF SCIENCE** in **AGRICULTURE** of Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur is a record of the bonafide research work carried out by **Mr. Shailendra Pratap Singh** under my guidance and supervision. The subject of the thesis has been approved by the Student's Advisory Committee and the Director of Instructions.

No part of the thesis has been submitted for any other degree or diploma (Certificate awarded etc.) or has been published/published part has been fully acknowledged. All the assistance and help received during the course of the investigation has been duly acknowledged by him.



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CERTIFICATE-II

This is to certify that the thesis entitled "Performance of promising rice hybrids for the superior yield-attributing traits and productivity under Kymore plateau" submitted by Mr. Shailendra Pratap Singh to Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur in partial fulfilment of the requirements for the degree of **MASTER OF SCIENCE** in **AGRICULTURE** in the **Department of Agronomy**, College of Agriculture, Rewa (M.P.) has after evaluation been approved by the Student's Advisory Committee after an oral examination of the same.


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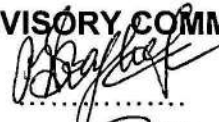


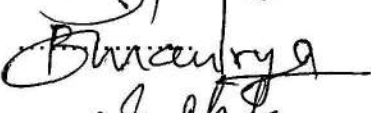

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LIST OF ABBREVIATIONS

Words	Abbreviations
Centimetre	cm
Co-workers	<i>et al.</i>
Critical difference	C.D.
Degree of centigrade	°C
Degree of Freedom	d.f.
Days after transplanting	DAT
Figure	Fig.
Fisher's value	"F" value
Gram(s)	G
Hectare	Ha
Kilogram(s)	Kg
Mean sum of square	M.S.S.
Metre	M
Muriate of Potash	MOP
Nitrogen	N
Non-significant	N.S.
Number	No.
Per	/
Per cent	%
Phosphorus	P ₂ O ₅
Panicle initiation (stage)	P.I.
Potash	K
Potential of hydrogen ions	pH
Quintal	q
Rupees	Rs
Serial No.	S.No.
Significant at 5% level	*
Significant at 1% level	**
Single Super phosphate	SSP
Source of variation	S.V.
Sum of square	S.S.
Square	sq.
Standard error of means	S.Em _±
Standard error of difference	S.Ed
Variety	V

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INTRODUCTION

CHAPTER-I

INTRODUCTION

Rice (*Oryza sativa* L.) is the staple food for nearly half of the world's population, most of whom live in developing nations, particularly in Asia, where 92% of the world's rice is produced and consumed.

In recent years, the development of HY rice hybrids have shown better yield potential than HY inbred varieties mainly due to presence of larger sink. Hybrid rice has unique advantage of better physiological efficiency. Due to this very reason, the hybrid rice has ability of produce about 15-20% higher grain yield than in bred cultivars (Virmani *et al.*, 1991). According to Siddiq (1993), hybrid vigour in rice can be profitably used to increase its productivity by 14 to 28% over the available best varieties in India. All the commercial rice hybrids currently being are based on Cytoplasmic Gene Male Sterility (CGMS) system. Eventhough this system is most stable system, excessive dependence on a single source of cytoplasm and cumbersome process of hybrid seed production and parental line development warrants the development of alternate approaches to exploit hybrid vigour. Two line breeding is one such possibility.

As the result of concerted efforts, 21 hybrids, have been released for commercial cultivation in India. Among these, 18 have been developed by the public sector while the others have developed by the private sector.

The hybrids viz. PHB-71, Pro-agro 6444, PA 6201, KRH-2, Sahyadri and DRRH-1 are being cultivated in large scale. During *kharif* 2005 it is estimated that an area of about 750000 ha is covered under hybrid rice in the country. Hybrid technology has successfully been used to increase the yields. Many high yielding rice hybrids have been developed in India but in most cases quality is not to the desirable extent and therefore, lacked acceptability by consumers and millers. The increasing demand of quality rice in the local and international markets has paid attention on quality breeding. Improving rice quality has now become a prime objective of most of breeding programmes. The quality characteristic of

rice includes the total head rice recovery, physical attributes of kernel like size, shape and appearance, cooking and eating quality, and aroma. In rice, heterosis for various workers, but little information is available on quality characters. Therefore, it is essential to develop quality rice hybrids by using CMS lines and aromatic restores that will be expected to aromatic if aroma is governed by a dominant gene as reported Bijral and Gupta (1998).

In M.P. rice is grown in the area of about 1.64 million hectare with production of 1.34 million tones and productivity 12.05q/ha which is below than the national level 20.8 q/ha. The productivity of high yielding inbred varieties of rice has almost reaches to a plateau with the present level of management in rice growing areas of Madhya Pradesh. Introduction of hybrids in rice has opened a door of opportunity to break the barriers of low productivity in rice growing areas.

In recent years farmers are growing rice hybrids in lowland and banded upland under irrigated ecosystem in M.P. and Rewa division particularly and drastic changes in rice scenario appeared due to adoption of rice hybrid. Several rice hybrids of different origins possessing desirable characters have come forward for different agro-climatic condition.

Keeping these facts in view, the present investigation is therefore proposed to study on performance of promising rice hybrids in Rewa condition with the following objectives-

- To evaluate the rice hybrid varieties for yield attributing characters and grain yield and their suitability in Rewa division.
- To study the correlation between yield and yield attributing traits of rice hybrids.
- To work out the economics of different treatments.

REVIEW OF LITERATURE

CHAPTER-II

REVIEW OF LITERATURE

Considerable progress in yield improvement over the traditional varieties was made in rice through crop breeding programmes. The yield level has almost reached a plateau. In order to meet the food demand of the increasing population and to increase the efficiency of other limited resources like land, water and fertilizers, continuous effort for yield improvement is essential. It is believed that the plateau in yield levels in recent day rice cultivars can be overcome by identifying and alleviating some of the constraints, which have not been hitherto paid much attention. In general, the scope for further improvement in the yield of rice varieties lies in the genetic manipulations of physiological efficiency of both sources and sink. A lot of commercial rice hybrids currently available are mostly based on cytoplasmic gene male sterility (CGMS) system. The literature available on the performance of such rice hybrids under different agro-climatic conditions of India has been reviewed in this chapter.

A brief review of the results of the experiments conducted at different locations under All India Co-ordinated Rice Improvement Programme (Anonymous, 1995) indicated that interaction of Pro Agro 6201 x 200 kg N/ha at Hyderabad, Hybrid 4 x 200 kg N/ha at Mandya, CRH 1 x 150 kg N/ha at Cuttack, Pro Agro 6201 x 150 kg N/ha at Faizabad and interaction of Pro Agro 6201 x 100 kg N/ha at Chinsurah produced the grain yields 7.65 t/ha, 4.93 t/ha, 4.30 t/ha, 5.6 t/ha and 5.50 t/ha, respectively which were superior to all possible interactions of different hybrids and local checks with graded nitrogen levels of 0, 50, 100, 150 and 200 kg/ha.

Mehta and Panwar (1998) reported that hybrid (PHB 71) at 150 kg N/ha and 180 kg N/ha level produced 11 % and 16 % extra grain yield than variety HKR 126 and 17 % and 20 % extra grain yield than PR 106. Also hybrid HKRH gave about 10 % (5.4 q/ha) extra grain yield than IR 64 at 120 kg N/ha level. It was also reported that hybrid UPRH-27 produced 33 % (17.3 q/ha) and 7 %

(4.8 q/ha) extra grain yield than IR 64 and HKR 126, respectively at 120 kg N level.

Singh *et al.* (1998) compared the rice hybrids and local checks (Rasi and Jaya) at 0, 60, 120 and 180 kg N/ha. They observed that yield differed significantly between cultivars. Hybrid Pro Agro 103 produced 14 % more grain yield than check (Rasi) Hybrid responded up to 120 kg N/ha application.

Srivastava and Tripathi (1999) conducted an experiment at Raipur (M.P.) with the hybrid Pro Agro 6201 and high yielding cultivar Kranti and R 320-300 at 60, 120 and 180 kg N/ha levels. Grain yield averaged 5.5, 5.1 and 5.9 t/ha of hybrid Pro Agro 6201, Kranti and R 320-300, respectively. Highest grain yield (6.1 t/ha) was recorded up to 120 kg N/ha, after it at 150 kg N/ha yield decreased (5.6 t/ha) due to low fertility percentage.

Bhowmick and Nayak (2000) conducted an experiment with four varieties CNHR 2 and CNHR 3 (hybrids), IR 36 and IR 64 (high-yielding varieties) with five nutrition levels and reported that highest grain yield (8.56 t/ha) was recorded in case of CNHR 2 when applied $N_{180}+P_{90}+K_{90}$ kg/ha. Highest straw yield (8.35 t/ha) was recorded in case of rice hybrid CNHR 2 when applied $N_{180}+P_{90}+K_{90}+Zn_{30}$ kg/ha.

Hariom *et al.* (2000) conducted experiments in 1993 and 1994 to study the effect of nitrogen level (0, 50, 100, 150 and 200 kg/ha) on rice hybrid PHB 71 and PMS 2A / IR 31802. They recorded significant increase in grain yield with each additional application of nitrogen up to 200 kg/ha in 1993 and up to 150 kg/ha in 1994. The highest yields of 9.25 and 8.24 t/ha were given by PHB 71 at 200 kg N/ha in 1993 and 1994, respectively. Yield attributes showed improvement with the increase in nitrogen levels.

Shivani and Sree Rama Reddy (2000) conducted investigation involving ten hybrids and two varieties of rice to study the nature and extent of relationship of yield components and physiological traits. Grain yield showed positive correlation with plant height, days to 50 % flowering and leaf area per plant at genotypic level and panicle length, spikelets per panicle, filled grains

per panicle, biological yield at harvest and harvest index both at genotypic and phenotypic levels. Days to 50 % flowering showed positive significant correlation with filled grains per panicle indicating the importance of vegetative phase for grain filling. Positive non-significant association of NAR with many characters was observed indicating its independent inheritance. Results of path analysis indicated negative direct effects of plant height with grain yield. Days to 50 % flowering showed positive direct effect and positive indirect effects through filled grains per panicle, harvest index, DMP and NAR. Spikelet sterility recorded positive direct effect and negative correlation with grain yield while filled grains per panicle showed positive direct effect and positive correlation. DMP recorded negative direct effect while LA and NAR showed positive direct effect on grain yield per plant.

Selvi *et al.* (2001) tested forty two hybrids and seven parents for combining ability of grain yield and physiological characters viz., plant height, leaf temperature, transpiration rate, stomatal conductance, flag leaf area, leaf area index (LAI), panicles per plant, dry matter production, harvest index (HI) and filled grains per panicle. Among the parents, CO 43 was the best general combiner for leaf temperature, flag leaf area, dry matter production and harvest index. The hybrid IR 20/ACM 44 was the best specific combiner for transpiration rate, stomatal conductance, flag leaf area, dry matter production and harvest index. The hybrid IR 20/ACM 44 was the best specific combiner for transpiration rate, stomatal conductance, flag leaf area, leaf area index, dry matter production and filled grains/panicle. Eight combinations viz., ADS 16/IR 50, CO 43/IR 50, CO 43/ADT 36, CO 43/ACM 44, MDU 4/IR 50, MDU 4/ ACM 44, IR 20/ADT 36 and IR 20/ACM 44 were regarded as the best combiners for more than one character besides grain yield.

Chen-Jin Hong *et al.* (2001) reported the better performance of high-yielding japonica hybrid rice as compared with those of the high-yielding varieties.

Subbaiah *et al.* (2002) conducted coordinated trials at different locations under AICRIP and found that hybrid rice KRH-2 recorded higher grain yield (5.92 t/ha) than high yielding variety (4.6 t/ha).

Naik *et al.* (2002) carried out trial at Krishi Nagar Farm, JNKVV, Jabalpur (M.P.) and found that amongst the three hybrids, PHB 71 produced higher number of panicles/hill (16.1) and weight per panicle (3.08 g) over other hybrids. The hybrid PHB-71 also-registered higher grain yields (20.7 and 10.3 %) and straw (12.8 and 14.2 %) over Pro-agro-6201 and PAC-801, respectively.

Anna Durai (2002) evaluated the 35 hybrids obtained in a line x tester mating fashion in RBD for the nature and magnitude of heterosis for four physiological traits including leaf area index (LAI), total chlorophyll content (TCC) at maximum tillering stage, total dry matter accumulation (TDMA) and harvest index (HI) after maturity along with grain yield per plant.

Variable response for yield was recorded for hybrids showing high heterosis for TDMA. These results showed that hybrids with higher TDMA would not necessarily result in higher yield. This confirms the earlier reports of moderated and lack of correlation at higher level of dry matter production and spikelet fertility, which determined the yield (Balasubramanian *et al.*, 1999). All the hybrids showing positive SH for HI showed higher heterosis for yield. Among the components of TDMA and HI yield determining traits, the study revealed greater role of HI to contribute higher yield.

Chellamuthu *et al.* (2002) reported that at Karaihal region of Pondicherry, 120 kg N/ha is sufficient to get economic yield of rice hybrids and there was no need for K application. However, considering the sustainability of soil health as well as rice yields in the long run, a starter dose of K (<40 kg/ha) may be applied.

Krishna Kumar (2002) conducted experiment with two rice hybrids (KRH 2 and PHB 71) and one high yielding variety (IR 36) as local check with different combination of N and K and reported that the hybrid KRH 2 produced maximum

number of tillers per hill and highest grain and straw yield while hybrid PHB 71 produced maximum panicle length and conventional variety IR 36 produced maximum test weight than both the hybrids, maximum plant height and tillers per hill was recorded under the treatment combination $N_{150}+K_0$. Yield attributes like number of sound grains per panicle and test weight performed better under the treatment $N_{120} + K_{80}$. Highest grain and straw yield (94 % and 81.2 % more than the control) was also observed under the nutrient combination $N_{50} + K_0$ kg/ha.

Narayana Reddy *et al.* (2002) found that K supply for hybrid rice is more than HYV's as reflected in grain yield and K uptake. The superiority of split application of K also varied with soil type. The K needs of hybrid rice was more over the check (conventional) varieties.

Rao and Moorthy (2002) revealed from CRRI, Cuttack, Orissa that "Pro Agro 6201" rice hybrid was found significantly superior to all other hybrids and conventional varieties. The hybrids "DRH-1" and "PAC 831" were only comparable to it in two different years. The hybrids responded up to 120 kg N/ha and N response was quadratic in nature. N-use efficiency showed a decreasing trend at higher N-levels.

Tripathi and Jaiswal (2002) concluded experiment at Faizabad (U.P.) and found that amongst the six hybrids and three N levels, HRI-120 may be sown with 180 kg N/ha for obtaining economically highest grain yield of rice hybrid.

Mahadevappa (2004) reported that as a result of concerted and coordinated efforts, for the first time in country the states released four rice hybrids for commercial cultivation during 1994. Since then a total of 20 rice hybrids have been released both from public and private sectors. The trial of commercial hybrids tested during *kharif* of 1999 and 2000 in 64 and 46 locations in different rice growing locations of 14 states of the country revealed KRH-2 as the best performer besides being highly stable. Among the public bred one PHB-71 and Sahyadri are the other promising hybrids. These trials

convincingly showed that rice hybrids were definitely superior to semi dwarf varieties across all the locations. Another salient feature of the India hybrid rice programme is the successful development of Pusa BH-10, a scented hybrid that has all the qualities of the scented varieties yielding 39.9 % more than the check variety Pusa Basmati-1.

Singh (2004) conducted experiment at Agriculture College, Rewa (M.P.) and found that in comparison to high-yielding variety "Jaya" and the local check "IR-36", the rice hybrid KRH-2 proved the most suitable with respect to growth and yield-attributing characters as well as grain yield and net return up to Rs.39,648/ha.

Panwar (2005) conducted experiment at Agricultural Research Station, Kofa, Rajasthan and revealed that the line IET 13846 and the testers Kasturi, Basmati 370, Pusa Basmati-1, Taraori Basmati and IR 64 were good general combiners for grain yield /plant. The superiority of Basmati 370 and Pusa Basmati-1 as good general combiners for grain characters has been reported earlier (Armugachamy *et al.*, 1992). It may be suggested that multiple crossing programme involving Kasturi, Basmati 370, Pusa Basmati-1, Taraori Basmati, IET 13846 and IR 64 as parents may be taken up to generate desirable segregants for selection. Phenotypic stability in respect of important agronomic traits influencing hybrid seed yield in the cytoplasmic male sterile (cms) lines is highly desirable over a range of sowing dates to ensure commercially feasible and economically viable hybrid seed production. Among the large number of cms lines developed over the years, only few possess traits suitable for developing commercial hybrids. Keeping this in view, Sharma *et al.* (2005) evaluated ten cms lines with varying sowing dates at IARI, New Delhi. Environment-wise analysis of variance revealed significant differences among the cms lines for all traits in all environments with the exception of number of tillers per plant in E₃ and E₄ and number of spikelets per panicle in E₄. This suggested that the differences in performance of cms lines may disappear for these two traits due to the influence of sowing dates. Pooled analysis of variance reflected the significance of differences among the cms lines and

environments for all traits. However, the interaction component was significant for number of tillers per plant, panicle length, number of spikelets per panicle and panicle exertion indicating that the cms lines markedly interacted with the environments for these traits.

Satyanarayana *et al.* (2005) evaluated for the development of high-yielding heterotic rice hybrids under Maruteru, West Godavari district, Andhra Pradesh conditions. The lines viz., Bunan and Daringan possessing sturdy culms and high grain number were identified and utilized in inter sub-specific hybridization programme with the established indica restorers viz., Vajram, Swarna, BPT-5204, IR-64 and II 103-5-3-1, possessing good grain quality and resistance to insects and diseases. Study of the resultant hybrids resulted in identification of 44 potential restorers and 20 effective maintainers. These indigenous restorers with indica/indica tropical japonica background also resulted in several heterotic hybrids with high grain number, high fertility restoration and medium to late duration rice hybrids, highly desired for cultivation in the state of Andhra Pradesh.

Lavanya *et al.* (2005) evaluated thirty rice hybrids and their parents (5 cms lines and 6 restorer testers) for their stability in two seasons with different nitrogen levels. The study indicated that a substantial portion of the G x E interaction was due to the linear component for tiller number, plant height, panicle length, spikelet fertility percentage, test weight and harvest index. Hybrids were less stable than parents except for the hybrid IR 62829A x Vajram. Several high yielding hybrids and parents were identified for favourable and poor environments. The present study revealed that stable hybrids were developed from stable parents but stable parents may not necessarily generate a stable hybrid.

Ajeet *et al.* (2005) conducted experiment at Agriculture College, Rewa (M.P.) and found that the rice hybrid "KRH-2" exhibited significant superiority in respect of yield-components viz. effective tillers/hill, length and weight of panicle over both the conventional varieties "Jaya" and "IR-36". On the other hand, "IR-

36" proved the best with respect to filled grains/panicle, while "Jaya" gave significantly higher 1000-grain weight over "KRH-2" and "IR-36". Similar results on variation in yield components among rice varieties and hybrids have been reported by Subbaiah *et al.* (2002). The rice hybrid "KRH-2" produced significantly more grain and straw yields (76.3 and 180.5 q/ha, respectively) as compared to other varieties. The enormous increase in grain and straw yields of "KRH-2" over "Jaya" and "IR-36" might be due to overall better performance in growth and yield components. Consequently, the net returns were also higher by Rs.7675 and Rs.5563 /ha over "Jaya" and "IR-36", respectively.

Swain *et al.* (2005) conducted field experiment at CRRI, Cuttack on AVT-2 rice hybrids and high yielding varieties and revealed that among the hybrids, HRI 160 produced significantly highest grain yield (6.19 t/ha) closely followed by HRI 120 (5.86 t/ha), whereas among the high yielding varieties NDR 359 produced highest grain yield (5.55 t/ha). Similar trend was followed with plant height, panicle number, total dry matter and harvest index. Though HRI 126 showed highest 1000 grain weight among the hybrids, grain yield was recorded lowest (4.32 t/ha) due to lower filled grain percentage (75.1).

Rosamma and Vijayakumar (2005) evaluated twenty hybrids along with their nine parents were evaluated at Agriculture Research Station, Mannuthy, Kerala. Five genetically diverse and widely adapted rice varieties of Kerala viz., Annapooma (Ptb 35), Matta Triveni (Ptb 45), Kanchana (Ptb 50), IR 36 and Aiswarya (Ptb 52) were crossed with four stable cytoplasmic genetic male sterile lines viz., IR62829 A, IR 68890 A, IR 68891 A PMS 10 A in a line x tester mating design. Among the testers high gca for different characters were expressed by different genotypes. Kanchana (Ptb 50) exhibited high gca for panicles per plant and grain yield, whereas Aiswarya recorded high gca values for days to flowering, grain yield and hundred seed weight. Among the hybrids evaluated IR 68890 A x Aiswarya was identified as the most superior specific combiner. The two parents involved in this hybridization were having high gca effect for almost all the characters under study. Other hybrids having significant sca effect for grain yield were IR68891A x IR 36, IR62829A x Matta Triveni, IR

62829A x Kanchana and IR 68891A x Annapooma. Most of the hybrids expressed negative sca effect for number of filled grains per panicle. Only three hybrids viz., IR 62829A x Aiswarya, IR 68890A x Kanchana and IR68891A x IR 36 expressed positive significant sca effect for number of filled grains per panicle. Since hybrid breeding programme in rice involve male sterile lines, combining ability for number of filled grains per panicle assume greater importance.

Singh and Lal (2005) planned to develop basmati rice hybrids as well as non-aromatic ones with better quality, and to estimate the heterosis for various quality characters and yield. Twenty five aromatic varieties/mutants and three CMS lines (IR68888A, IR68891A and IR58025A) were crossed to generate 41 F₁ hybrids with normal fertility. These F₁s along with parents and Pusa Basmati 1 as the standard control were evaluated at the Agricultural Research Farm of the Banaras Hindu University, Varanasi. The present study showed the higher magnitude of all the physio-chemical characters were not expressed in a single hybrid combination which was vary from cross to cross due to genetic background of their diverse parents. Overall two hybrids IR68888A x PB-3-17-57-1 and IR58025A x PB-6-12-55-5 were identified superior over Pusa Basmati-1 for most of the quality characters as well as grain yield per plant, which could be utilized commercially for exploitation of heterosis to these characters.

Latha *et al.* (2005) evaluated a set of 20 two line rice (*Oryza sativa* L.) hybrids obtained by crossing thermo-sensitive genic male sterile (TGMS) lines with male parents in this study for grain and cooking quality parameters viz. grain length, grain breadth, length/breadth ratio, kernel length after cooking, kernel breadth after cooking, linear elongation ratio and breadth-wise expansion ratio. Generally, rice with more linear elongation and less breadth wise expansion is preferred. Kernel length after cooking in some of the hybrids was on par with the variety Improved White Ponni, the most preferred variety by the consumers of Tamilnadu. The hybrid TS29 x CR689-612 was the best followed by TS29 x IR63883, TS18 x CB96026, TS18 x CB96073 and TS16 x CB97033 for this trait. None of the hybrids was superior to Improved White Ponni for

linear elongation ratio but some were either superior or on par with the three-line hybrid, ADTRH 1.

Gnanasekaran *et al.* (2006) evaluated thirty two rice hybrids involving four TGMS (Thermo Sensitive Gene Male Sterile) lines and eight testers for combining ability and heterosis. Among the parents, the TGMS lines viz., GD98049 and GD98014, and the testers CB97033 and IR72 were the best based on the mean and gca effects. Considering the mean performance, sca effects and standard heterosis, six hybrids viz., GD 98013/CB 97033, GD 98013/CO 47, GD 98014/ADT 45, GD 98014/PMK 2, GD 98049/AST 39 and GD 98049/CB 97033 were superior for grain yield and kernel quality traits and recommended for further evaluation.

The longer growth period of hybrid is one of the limitations for the utilization of intersubspecific *indica japonica* heterosis in rice. In this study, Chen *et al.* (2006) used three *indica* cytoplasmic male sterile lines and four *japonica* restorer lines with wide compatibility as parents to make crosses. The additive and nonadditive genetic effects on heading date were analyzed using an additive-dominance-epistatic model. The results showed that the genetic variation of heading date could be attributed to additive, dominance and additive x additive epistatic effects, with dominance genetic effects being predominant, followed by additive x additive epistatic effects. Analysis of genetic effects showed that the additive genetic effect from R 348 increases heading time, while the additive x additive epistatic effects from Zhensan 97 A, R 456 and R 496 reduce heading time. In the progenies of crosses heading time was reduced by dominance genetic effects, whereas it was increased by additive x additive epistatic effects.

Vijayakumar *et al.* (2006) screened two hundred rice varieties released for cultivation under various ecologies in a puddled field (clay soil) under non-flooded, irrigated (aerobic) conditions, with Rasi and Vandana as check varieties. The checks known for their adaptation to water stress were planted at regular intervals (after every ten entries) to serve as controls. Twenty seven

varieties showed yield advantages over the check Rasi. The popular varieties grown under irrigated conditions such as Jaya, IR 8, IR 64 etc. were found unsuitable. Most of the varieties with high yield potential and adaptation to aerobic conditions were found among rainfed shallow lowland and hill rice upland varieties, while the frequency of such varieties was very low among rainfed upland group varieties. Most of the selected irrigated varieties showed better performance under favourable moisture conditions with a few exceptions like Vikas which combined high yield and adaptation to aerobic environments. However, the semi deep water and deep water varieties were found unsuitable under aerobic conditions. Planting of checks at regular intervals as grids was very useful not only in detecting varying levels of stress across length and breadth of the field, but also in identifying suitable cultures for varying levels of stress.

Dushyantha Kumar and Shadakshari (2006) made attempts at the Zonal Agricultural Research Station, Mudigere to identify a suitable variety for the region of the selections obtained from the cross between Intan and IET-7191, KHRS-21 was the most promising one. The results from different trials conducted for five years from 1999 to 2003 revealed that KHRS-21 recorded higher grain yield and straw yield at different locations (ZARS-Mudigere, ARS-Ponnampet and ARS-Sirsi). By considering overall per cent increase over check KHRS-21 recorded 32 % and 34 % higher grain yield compared to Intan and Hemavathi respectively. It also recorded 32 % and 24 % higher straw yield compared to Intan and Hemavathi respectively. As revealed by the data from the trials conducted at different stations, KHRS-21 was better than the other two varieties with higher grain as well as straw yield.

Rautaray (2006) conducted a field experiment to study the response of promising rice (*Oryza sativa* L.) hybrids to double transplanting in late sown situation. The results revealed that "PA 6201" rice hybrid with high seedling height in early stage gave highest grain yield (6.36 t/ha) and net return (Rs.9973). Adoption of double transplanting using seedlings grown for 30 days in first nursery followed by 20 days in second nursery was beneficial

considering easy stand establishment, low weed pressure, high grain yield (6.31 t/ha) and net return (Rs.9682) compared with the standard practice of single planting (6.03 t/ha and Rs.7726). However, allowing seedlings for 40 or 50 days in the second nursery resulted in low grain yield (5.68 or 5.40 t/ha) and net return (Rs.7439 or 6330).

Swain *et al.* (2006) conducted the field experiment during dry season under irrigated shallow lowland condition at the Institute, Cuttack, is characterized by sandy clay loam soil. Rice hybrids NRH 1, NRH 3, NRH 4, NRH 5, PA6113, P6201 and DRRH1 both released and pre-released along with 3 local checks IR 64, CR 749-20-2 and Lalat were tested. Among 7 rice hybrids both released and pre-released with 3 local checks tested under field condition. PA 6201 was found to be most efficient with maximum leaf area index and total chlorophyll content at all growth stages, least tiller mortality (7.6 %) at maximum tillering stage, highest grain yield (6.4 t/ha), grain number/m² (35379) and harvest index (0.48) with moderate sterility (26 %) and panicle number/m₂ (336) at maturity.

MATERIALS AND METHODS

MATERIALS AND METHODS

The present investigation entitled “**Performance of promising rice hybrids for the superior yield attributing traits and productivity under Kymore plateau**” was undertaken to evaluate the suitability of rice hybrid for Rewa region and to ascertain the fertilizer requirement for the same.

The details of materials used and methods adopted during the time of investigation are given in this chapter.

1. Experimental site

The experiment was conducted at All India coordinated Rice Improvement project, J.N.K.V.V., College of Agriculture, Rewa (M.P.) during *kharif* season, 2006. The selection of site was done such that it was the representative of one of major rice growing area of the region. The topography of the experimental site was fairly leveled. All the required facilities including irrigation, transportation etc. were available on the site.

2. Meteorology of the site

Rewa is situated in the North-eastern part of Madhya Pradesh at latitude $24^{\circ}31'N$, longitude $81^{\circ}15'E$ and altitude of 365.7 m above the mean sea level. The region falls under subtropical climate having extreme winter and summer seasons. More or less the weather conditions throughout the crop season were quite favourable for growth and development of rice crops.

The weekly maximum and minimum temperatures, rainfall, relative humidity, number of rainy days, number of bright sun-shine hours and wind velocity during the crop growth season of June 2006 to November 2006 are presented in Table 1 and graphically illustrated in Fig. 1

Table 1 Meteorological data during the *kharif* season (2006)

Week No.	Period	Rainfall (mm)	No. of rainy days	Temp (°c)		Relative Humidity %		Wind velocity (km/hr)	Bright sunshine (hrs)
				Max	Min	Max	Min		
23	June 4-10	00.00	0	38.35	27.14	84.00	42.71	2.90	7.80
24	11-17 June	00.00	0	39.38	27.25	82.85	41.57	5.10	2.50
25	18-24 June	00.00	0	39.92	29.21	84.42	42.71	4.00	4.10
26	25 June- 1 July	37.40	2	36.28	27.14	87.28	54.42	2.50	8.50
27	2 to 8 July	11.40	2	34.15	27.22	88.28	56.57	4.94	4.64
28	9 to 15 July	145.00	6	30.72	25.58	93.28	74.71	3.14	1.72
29	16 to 22 July	113.40	6	30.92	26.10	92.71	73.85	1.44	1.78
30	23 to 29 July	64.40	3	30.34	25.17	90.71	63.42	1.20	2.84
31	30 July to 5 Aug	54.40	3	30.07	25.14	91.57	68.28	2.98	5.18
32	6 to 12 Aug	32.00	2	31.27	25.11	91.71	60.28	1.24	7.31
33	13 to 19 Aug	44.80	3	32.32	25.60	91.14	59.71	1.84	7.70
34	20 to 26 Aug	114.40	5	30.28	25.37	92.57	70.28	3.08	3.64
35	27 Aug to 2 Sep	11.00	1	29.34	24.48	91.57	68.00	3.32	6.47
36	3 to 9 Sep	22.80	2	31.65	25.08	90.14	62.42	1.97	7.67
37	10 to 16 Sep	00.00	0	33.98	25.60	89.85	55.28	0.90	8.05
38	17 to 23 Sep	4.80	1	32.11	24.30	89.71	62.71	1.70	5.30
39	24 to 30 Sep	00.00	0	30.68	21.92	89.14	59.42	0.50	7.40
40	1 to 7 Oct	00.00	0	34.22	22.20	88.28	55.71	0.90	7.90
41	8 to 14 Oct	00.00	0	34.64	19.81	86.57	52.42	0.90	7.50
42	15 to 21 Oct	00.00	0	33.42	18.52	87.00	55.42	0.50	9.20
43	22 to 28 Oct	0.60	0	30.48	15.68	86.57	64.42	0.30	7.70
44	29 Oct to 4 Nov	68.00	2	29.42	18.00	89.71	64.57	0.50	6.80
45	5 to 11 Nov	00.00	0	29.58	15.01	90.00	67.00	0.40	7.20
46	12 to 18 Nov	00.00	0	28.97	13.34	86.00	59.14	0.70	6.20
47	19 to 25 Nov	00.00	0	28.61	12.65	84.14	64.57	0.50	6.50
Total		723.40	38						

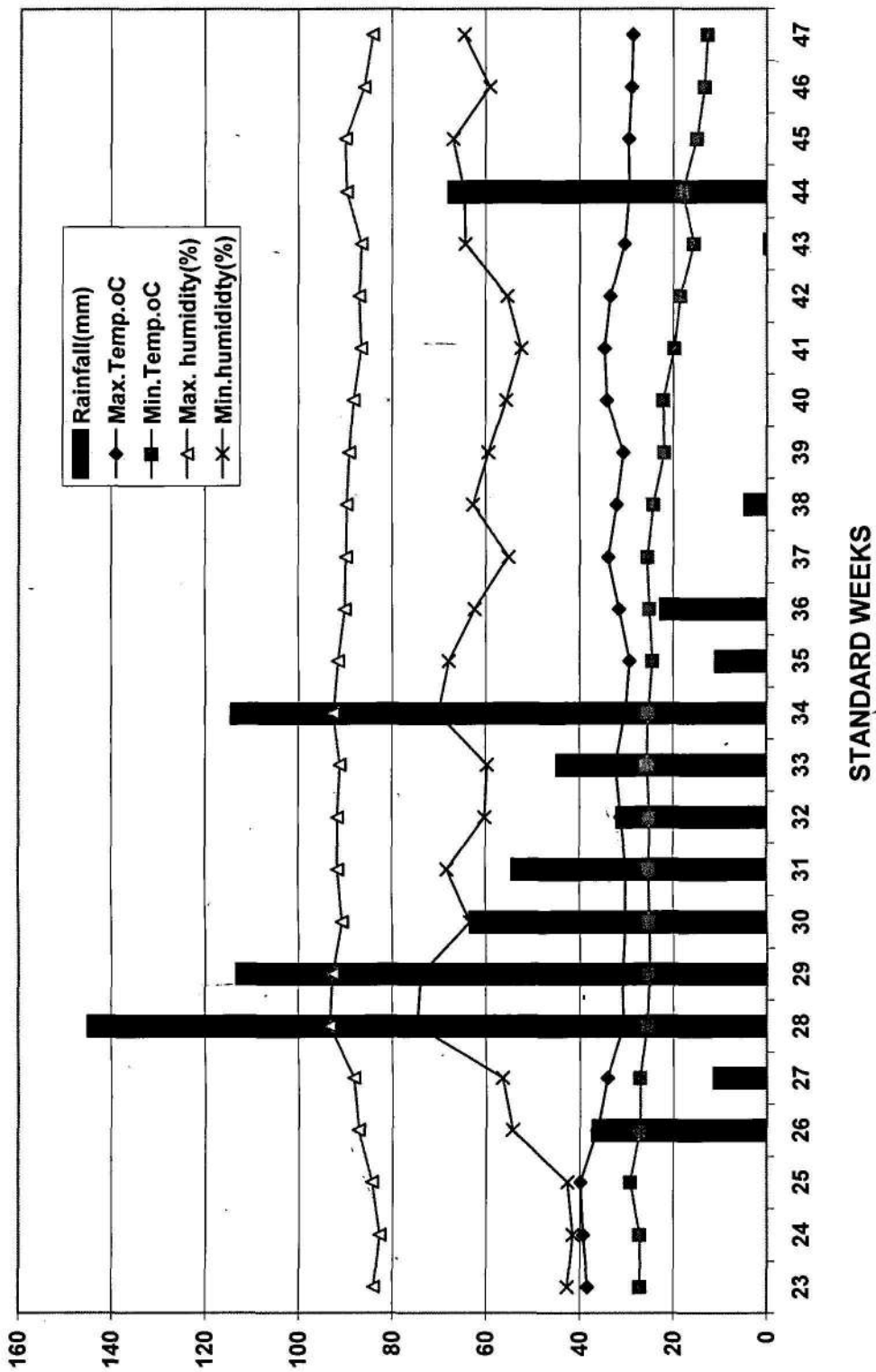


Fig.1: Meteorological data of the kharif season

3. Edaphology of the site

Before conducting the experiment, soil samples representing the entire experimental area were taken from 15 cm depth by the help of soil auger, a single sample quartering method was adopted. Then the sample was analysed for various physico-chemical properties.

The values of different parameters of the physical and chemical properties of soil are presented in Table 2.

Mechanical composition in table reveals that the textural class of soil was clay loam. Chemical composition indicates that soil was medium in nitrogen, low in phosphorus and low in potassium.

Table 2 Physico-chemical properties of the soil

S. No.	Constituents	Values
A.	Mechanical properties	
	1. Sand (%)	30.3 %
	2. Silt (%)	32.3 %
	3. Clay (%)	37.5 %
B.	Chemical properties	
	1. Organic carbon (%)	0.61 %
	2. Available nitrogen (kg/ha)	270.0
	3. Available phosphorus (kg/ha)	8.25
	4. Available potash (kg/ha)	153.0
	5. Soil reaction (pH)	7.1
	6. Electrical conductivity (dsm ⁻¹) at 25 °C	0.31

4. Cropping history of experimental field

During the last five years the sequences of crops adopted in the experimental field have been presented in Table 3.

Table 3 Cropping history of experimental field

S. No.	Years	Kharif season	Rabi season	Zaid/Summer
1.	2001	Soybean	Berseem	Fallow
2.	2002	Rice	Berseem	Fallow
3.	2003	Rice	Wheat	Fallow
4.	2004	Rice	Wheat	Fallow
5.	2005	Rice	Wheat	Fallow
6.	2006	Rice -hybrid	Wheat	Fallow

(Experimental plot)

Treatments: Rice hybrids/ varieties -11

V₁-Pro-Agro 6444

V₂-Pro-Agro 6201

V₃-Pro-Agro 6129

V₄-Pro-Agro 6111

V₅-PHB-71

V₆-Shabnam (403)

V₇-Tara (MPH 222)

V₈-Advanta 801

V₉-JRH -4

V₁₀-JHR-5.

V₁₁-IR 36

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6.	2006	Rice -hybrid	Wheat	Fallow

(Experimental plot)

Treatments: Rice hybrids/ varieties -11

V₁-Pro-Agro 6444

V₆-Shabnam (403)

V₂-Pro-Agro 6201

V₇-Tara (MPH 222)

V₃-Pro-Agro 6129

V₈-Advanta 801

V₄-Pro-Agro 6111

V₉-JRH -4

V₅-PHB-71

V₁₀-JHR-5.

V₁₁-IR 36

Layout of the experiment

Design	:	R.B.D.
Replications	:	4 (Four)
Gross plot size	:	5.0 m x 2.0 m
Net plot size	:	4.60 m x 1.60 m
Replication border	:	1.0 m
Plot border	:	0.5 m
Row to row spacing	:	20 cm
Plant to plant spacing	:	20 cm
No. of rows/plot	:	10
No. of seedlings/hill	:	1
Method of sowing	:	Transplanting

5. Field operations

The field operations practiced in the field from the nursery raising to threshing of the crop are presented in Table 4.

(a) Nursery raising

Wet bed method was adopted for raising three separate nursery beds prepared for three varieties by ploughing twice by tractor mounted cultivator. The area of nursery bed was twelve per cent of the total area to be transplanted. Fifty gram of seed was sown per metre square area for nursery.

(b) Field preparation

After harvesting of the Rabi crop (Wheat), the field was ploughed by the tractor mounted cultivator and then harrowed and planked during the Zaid season. With the onset of monsoon, the field was flooded and puddled twice by paddy puddler.

(c) Transplanting

The 23 days old seedlings were transplanted in well puddled main field. One seedling per hill was transplanted manually. The spacing was kept 20 cm between two rows and 20 cm between one hills.

(d) Nutrient application

An uniform dose of 120 kg N, 60 kg P₂O₅ and 30 kg K₂O /ha was applied to all the treatments. Nitrogen was applied as urea, 50 % as basal dose, 25 % as top dressing at maximum tillering stage and 25 % as top dressing at booting stage. Phosphorus as SSP and potassium as MOP were applied as basal. An uniform dose of 25 kg zinc sulphate per hectare was also applied in all plots as basal dose.

Table 4 List of field operations

S. No.	Operations	DAT	Date
1.	Preparation of nursery bed		25/06/2006
2.	Sowing of seed in nursery		27/06/2006
3.	Flooding of main field		21/07/2006
4.	Puddling of the main field		19/07/2006
5.	Layout of the field		18/07/2006
6.	Basal application of nutrients		20/07/2006
7.	Transplanting of seedlings		20/07/2006
8.	Gap filling		25/07/2006
9.	Top dressing of N at maximum tillering stage	26	15/08/2006
10.	Top dressing of N at booting stage	41	30/08/2006
11.	Top dressing of N at panicle initiation stage	41	30/08/2006
12.	I st irrigation	19	08/08/2006
13.	II nd irrigation	31	30/08/2006
14.	III rd irrigation	47	15/09/2006
15.	IV th irrigation	52	20/09/2006
16.	V th irrigation	60	28/09/2006
17.	VI th irrigation	67	05/10/2006
18.	VII th irrigation	72	12/10/2006
19.	VIII th irrigation	78	18/10/2006
20.	IX th irrigation	82	22/10/2006
21.	X th irrigation	90	30/10/2006
22.	Harvesting of crop	115 136	22/10/2007 12/11/2007
23.	Threshing of crop		27/11/2007

Observations recorded

(a) Pre-harvest observations

- (i) Plant height at 30, 60 and 90 DAT.
- (ii) No. of tillers/hill 30, 60 and 90 DAT.

(b) Post-harvest observations

- (i) Length of panicle (cm)
- (ii) No. of chaffy and sound grains/panicle
- (iii) Weight of panicle (g)
- (iv) Grain yield (q/ha)
- (v) Straw yield (q/ha)
- (vi) Test weight of 1000 grain (g)
- (vii) Harvest index (%)
- (viii) Economics of the treatment
 - (a) Net return (Rs/ha)
 - (b) B:C ratio
- (ix) Leaf blast , brown spot and false smut disease index
- (x) Production efficiency
- (xi) Correlation studies

6. Observations and their procedures

Observations of the characters under study were recorded for comparing the effect of varieties and effect of nutrient levels. For each observation, five randomly selected plants were tagged and used from each net plot. The mean values of the recorded data were taken as the actual values of the respective characters.

(a) Pre-harvest observations

(i) Plant population (No./m²)

The plant population/m² was recorded at 30 DAS from five random spots in each treatment and the mean was worked out.

(ii) Plant height (cm)

Height of the five tagged sample plants were measured in centimetre at 30, 60 and 90 DAT with the help of wooden scale and their mean value were worked out. Height of the main shoot of the sample plant was measured from the base of the plant to tip of the longest leaf. After panicle emergence, it was measured from base of the plant to tip of the panicle.

(iii) No. of tillers/hill

No. of tillers per hill was recorded for the five tagged plants at 30, 60 and 90 DAT and average was worked out. Each shoot arising from the plant was counted as tillers including the main shoot.

(b) Post-harvest observations

Tagged sample plants were taken out from the field after maturity for post harvest studies. The following observations were recorded as post harvest observations:

(i) No. of effective tillers/hill

Tillers bearing panicles were counted as effective tillers from each sample hill and averages were worked out.

(ii) Length of panicle (cm)

The length of panicle was measured in centimetre from the base of rachis to tip of the panicle. The length of five sampled panicles was measured and averages were worked out.

(iii) Weight of panicle (g)

The weight of five sampled panicles was taken by the help of electronic balance of high precision and averages were worked out.

(iv) No. of grains per panicle

No. of grains per panicle both sound and chaffy were counted separately.

1. No. of sound grains/panicle

Spikelets bearing a well developed caryopsis were counted as sound grains.

2. No. of chaffy grains/panicle

Spikelets with undeveloped or underdeveloped caryopsis were counted as chaffy grains from the same panicle.

(v) Grain yield (q/ha)

The yield of grains obtained from each net plot was recorded in kilograms after sun drying of grains.

The grain yield per plot was converted into quintal per hectare by multiplying the same with conversion factor 26.042

(vi) Straw yield (q/ha)

The straw yield obtained by subtracting the grain weight in kilogram from the bundle weight in kilogram and this was recorded as straw yield per plot.

The straw yield per plot was converted into quintal per hectare by multiplying the same with the conversion factor 26.042.

(vii) Test weight (g)

Two samples of one thousand grains were drawn from the grain heap of each plot at the time of threshing and weighed by electronic balance in grams. Their mean were worked out as test weight.

(viii) Harvest index (%)

It is the ratio of economic yield in total biological yield and it is expressed in percentage. Harvest indices of treatments were calculated by using the formula-

$$\text{Harvest index (\%)} = \frac{\text{Grain yield}}{\text{Biological yield (grain + straw)}} \times 100$$

(ix) Leaf blast, brown spot and false smut disease index

Brown spot

The entries were evaluated based on brown spot disease incidence following the SES scale given as under:

Table 5 SES scale (1996) for brown spot disease

Score	Description (Affected leaf area)
0	No incidence
1	Less than 1%
2	1-3%
4	4-5%
5	6-10%
6	11-15%
7	16-25%
8	26-50%
9	51-75%

Weekly disease progress

Date of first appearance of the disease on different cultivars was recorded during the crop season symptoms particularly size, shape, colour of the lesions were studied in different crop stages in the field five randomly

marked plants in the plot were used for recording the disease severity. Leaf blast severity was recorded by following the international standard evaluation system (scale 0.9)

Leaf blast

Table 6 SES scale (1996) for leaf spot disease

Scale	Description
0	No lesions
1	Small brown specks of pinhead size without sporulating centre
2	Small roundish to slightly elongated necrotic gray spots about 1 mm in diameter with a distinct brown margin lesions are most found on the lower leaves
4	Typical sporulating blast lesions 3 mm or longer, infecting less than 2 % of the leaf area
5	Typical blast lesions infecting 2-10 % of the leaf area
6	Blast lesions infecting 11-25 % leaf area
7	Blast lesions infecting 26-50 % leaf area
8	Blast lesions infecting 51-75 % leaf area
9	More than 75 % leaf area affected.

False smut

Observations to be recorded for false smut

- Fix three sampling units of 1 sqm at random in each plot and record observations as follows:
 - Per cent panicle affected.
 - Per cent spikelets affected.
 - Phyto-toxicity on 0-10 scale for epinasty, hyponasty, chlorosis, necrosis, stunting etc.

The present disease index (PDI) was calculated by adopting the formula.

$$\text{PDI} = \frac{\text{Sum of numerical rating} \times 100}{\text{Total number of observations} \times \text{Maximum disease scale}}$$

Observations on disease incidence were recorded at weekly intervals for three successive weeks. The disease index (%) value were transformed by adopting the angular transformation table (Snedecor and Cochran, 1967).

(x) Production efficiency

The production efficiency (PF) of different rice hybrids was calculated by dividing the total grain production of each variety in kg/ha with its crop duration (days).

$$\text{PE (kg/ha/day)} = \frac{\text{Grain production of the variety (kg/ha)}}{\text{Crop duration of this variety}}$$

7. Economics of the treatments

Economics (net return per hectare) were worked out from all the treatments by deducting the total (gross income) from the produce (grain plus straw) obtained from the respective treatments. The cost of labour, seed, fertilizer, field preparation as well as return from the produce was calculated based on the prevailing market rates (Appendix I and II).

(8) Statistical analysis

The data collected during the investigation were analysed statistically by the method of analysis of variance. The significance of various results were judged as suggested by Fisher (1937), applying F-test.

The skeleton of analysis of variance is given in Table 7.

Table 7 Skeleton of analysis of variance

Source of variation	d.f.	S.S.	M.S.S.	"F" cal.	"F" tabulated at	
					5%:	1%
Replication	3					
Hy. rice variety	10					
Error	30					
Total	43					

Standard errors and critical differences

Standard error of the mean (S.Em.) was calculated for each result either it was significant or non-significant, but critical differences (C.D.) was calculated only for significant results. The S.Em. and C.D. at 5% level has been given alongwith each table of result. To test the significant difference among the treatment means, the following formulae were used for calculating the critical difference.

$$S.Em \pm = \sqrt{\frac{\text{Variance (MSS)}}{r}}$$

$$C.D. (5\%) = \sqrt{2} \times S. Em \times 't' \text{ at } 5\% \text{ error degree of freedom(d.f.)}$$

RESULTS

CHAPTER IV

RESULTS

The field experiment entitled “**Performance of promising rice hybrids for the superior yield-attributing traits and productivity under Kymore plateau**” was conducted during *khari*f season 2006. The aim of the experiment was to identify the suitable rice hybrid for Kymore plateau region of Madhya Pradesh. The results obtained from periodical observations in the investigation are being presented in this chapter.

The summary of the data related to growth, development, yield and economics from the different rice hybrids are highlighted with the help of appropriate tables and illustrations. The periodical data were statistically computed and indicated by the analysis of variance (ANOVA) tables in the Appendix section. An attempt has been made to work out the economical gain from the various rice hybrids. In this chapter, the findings are presented in the following parameters.

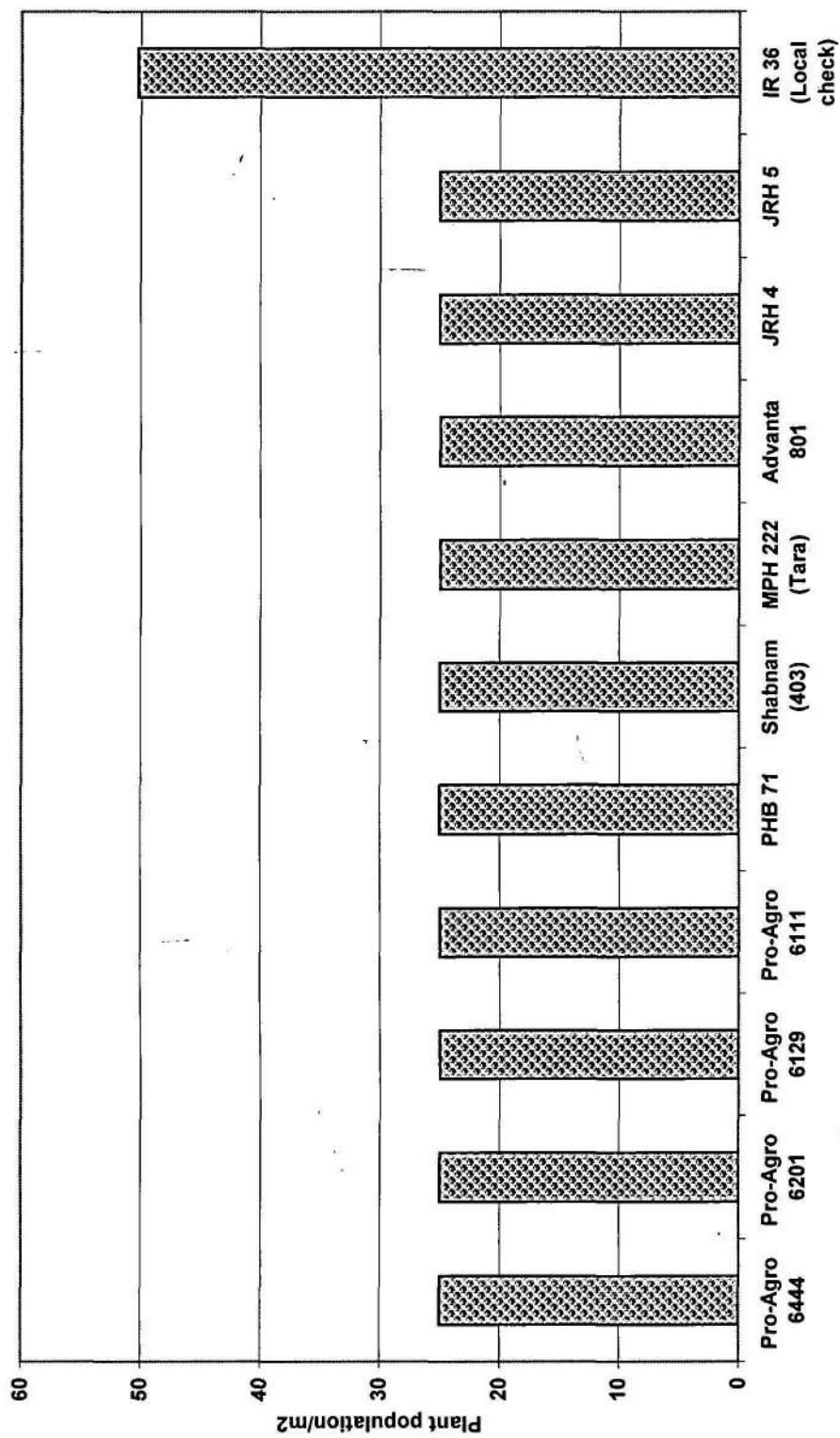
Growth parameters

Plant population (No./m²)

The data pertaining to plant population which were recorded /m² at 30 DAT under different treatments were statistically analysed as shown in Appendix IV. These are presented in Table 8 and depicted in Fig. 3: The plant population/m² was found to vary significantly in case of different rice hybrids. The plant population ranged from 25 plants/m² in all the hybrids to the highest 50.25 /m² in case of IR 36 (local check). Thus, IR 36 attained the maximum population per unit area because it was planted two seedlings/hill whereas hybrid varieties were planted one seedling per hill.

Table 8 Mean plant population/m² of different hybrids and the local variety of rice

S. No.	Treatments (Rice hybrids)	Plant population/m ² at 30 DAT
1	Pro-Agro 6444	25.00
2	Pro-Agro 6201	25.00
3	Pro-Agro 6129	25.00
4	Pro-Agro 6111	25.00
5	PHB 71	25.00
6	Shabnam (403)	25.00
7	MPH 222 (Tara)	25.00
8	Advanta 801	25.00
9	JRH 4	25.00
10	JRH 5	25.00
11	IR 36 (Local check)	50.25
	S.Em _t	0.226
	C.D. (5%)	0.653



RICE HYBRIDS AND LOCAL CHECK VARIETY

Fig.3 Mean plant population/m² of rice hybrids and local check variety

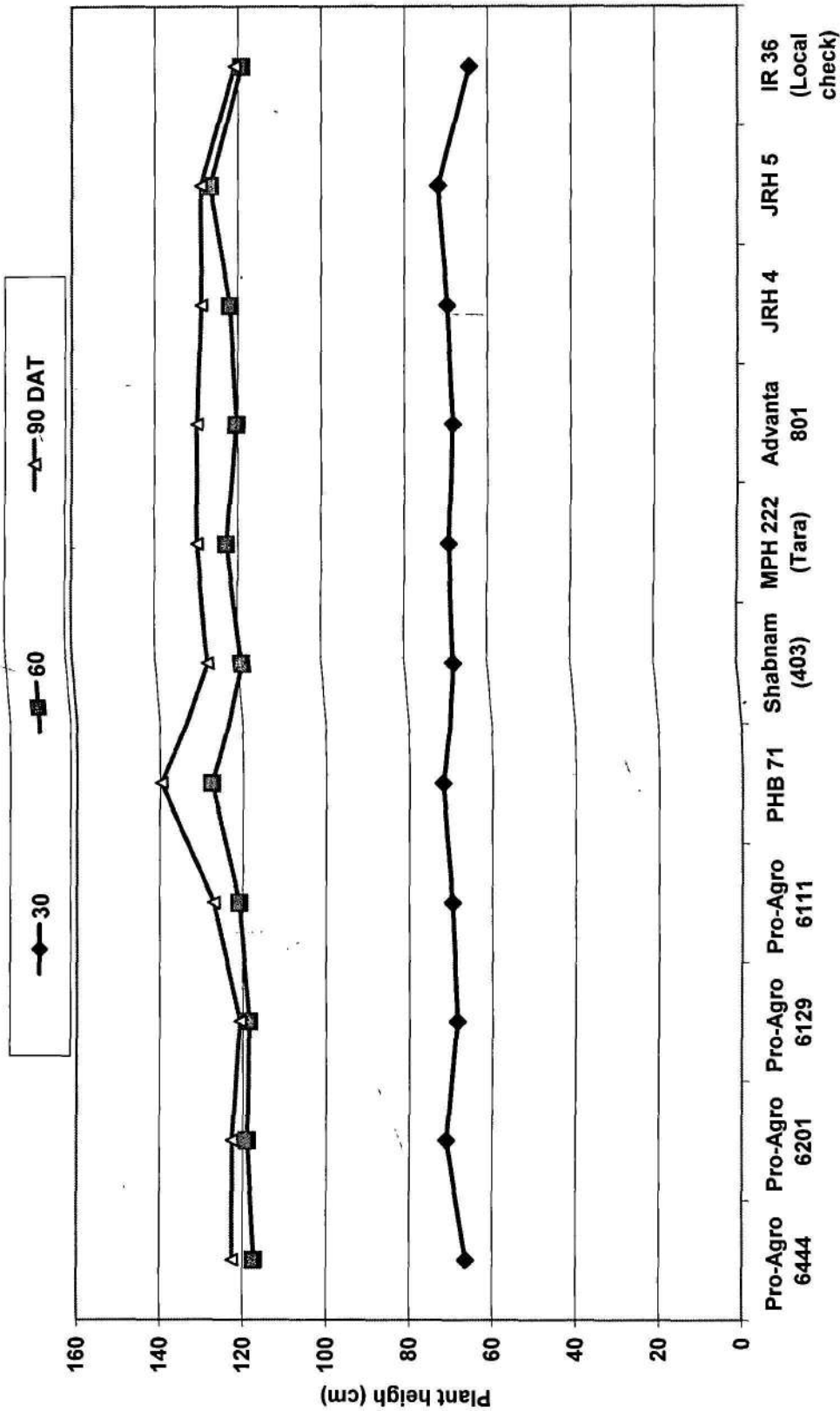
Plant height (cm)

The plant height was measured treatmentwise at different growth intervals and the data so obtained were statistically computer (Appendix V to VII). The mean values are presented in Table 9. The final plant height values are exhibited through Fig. 4 . The plant height, in general, increased with the age of plant growth up to 90 days of observation. The increase in height was very fast between 30 and 60 days stage of growth, thereafter the increase was slow.

There was significant differences among the different varieties with respect to plant height at every stage of observation. At 30 DAT, Pro-Agro 6201, PHB 71 and JRH 5 varieties were found the tallest (71.10 to 71.95 cm) as compared to other varieties. In contrast to this, the significantly minimum height (64.35 cm) was measured in case of IR 36 (local check), closely followed by Pro-Agro 6444 (66.45 cm). At 60 DAT stage, PHB 71 attained the maximum height up to 127.55 cm, being significantly higher to that of all the remaining varieties except JRH 5 (126.70 cm). However, the third position was attained by MPH 222 (122.85 cm). The lowest height (117.35 cm) was observed in case of Pro-Agro 6444 hybrid. The other varieties showed the intermediate position, being statistically identical to each other in this character. At 90 DAT stage also, the results trend continued almost the same. The same hybrid PHB 71 became the significantly tallest one measuring up to 139.75 cm as compared to all the rest of the varieties. On the other hand, the almost lowest height (120.75 to 120.80 cm) was recorded in varieties IR 36 (local check) as well as in case of Pro-Agro 6129 hybrid. The remaining varieties attained the intermediate position wherein the differences in their height were not significant (122.65 to 129.85 cm).

Table 9 Mean plant height of rice different hybrids at different growth intervals

S. No.	Treatments (Rice hybrids)	Plant height (cm)		
		30 DAT	60 DAT	90 DAT
1	Pro-Agro 6444	66.45	117.35	122.65
2	Pro-Agro 6201	71.10	119.00	122.70
3	Pro-Agro 6129	68.50	118.55	120.75
4	Pro-Agro 6111	69.60	120.80	127.00
5	PHB 71	71.95	127.55	139.75
6	Shabnam (403)	68.20	119.15	127.40
7	MPH 222 (Tara)	69.35	22.85	129.85
8	Advanta 801	68.40	120.35	129.85
9	JRH 4	69.65	121.90	128.80
10	JRH 5	71.95	126.70	129.00
11	IR 36 (Local check)	64.35	119.15	120.80
	S.Em±	1.56	1.58	2.66
	C.D. (5%)	4.50	4.57	7.68



RICE HYBRIDS AND LOCAL CHECK VARIETY

Fig. 4 Mean plant height at different growth intervals of rice hybrids and local check variety

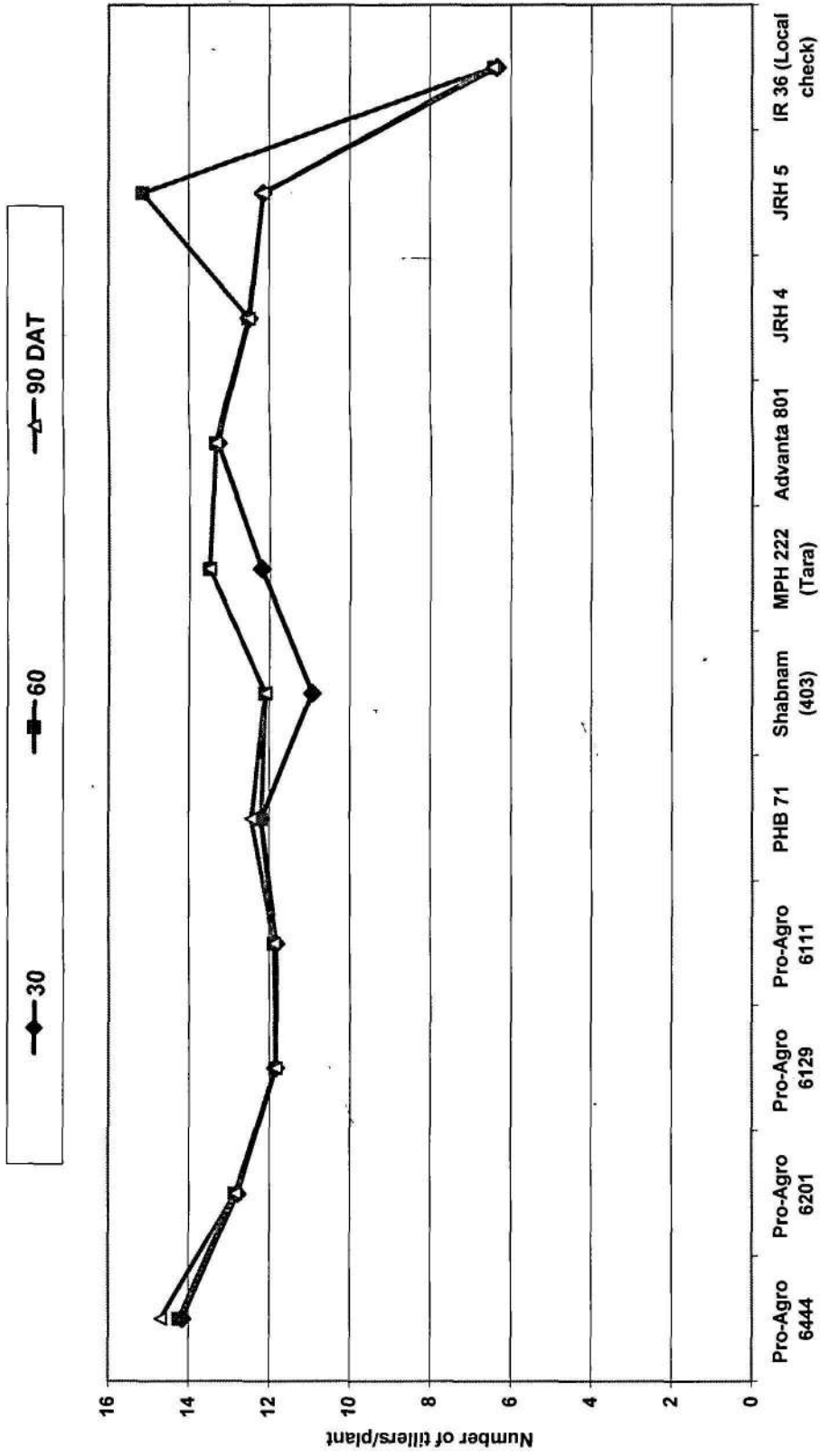
Number of tillers/hill

The number of tillers/hill were recorded treatmentwise at different growth intervals. The data so obtained were subjected to statistical analysis (Appendix VIII to X). The mean values are presented in Table 10 and Fig. 5.

Table 10 Mean number of tillers/hill of different rice hybrids at different growth intervals

S. No.	Treatments (Rice hybrids)	Number of tillers/hill		
		30	60	90 DAT
1	Pro-Agro 6444	14.16	14.24	14.70
2	Pro-Agro 6201	12.80	12.85	12.85
3	Pro-Agro 6129	11.85	11.85	11.85
4	Pro-Agro 6111	11.83	11.88	11.88
5	PHB 71	12.20	12.20	12.45
6	Shabnam (403)	10.93	12.10	12.10
7	MPH 222 (Tara)	12.20	13.50	13.50
8	Advanta 801	13.30	13.35	13.35
9	JRH 4	12.50	12.51	12.51
10	JRH 5	12.15	15.15	12.15
11	IR 36 (Local check)	6.35	6.42	6.46
	S.Em \pm	0.48	0.52	0.57
	C.D. (5%)	1.39	1.51	1.67

The final tillers recorded at 90 DAT are shown as in Fig. . There was significant differences in this parameter among the different rice varieties at every stage of observation. The hybrid variety Pro-Agro 6444 registered the highest tillers/plant in different stages (14.16 to 14.70 tillers/plant). This was



RICE HYBRIDS AND LOCAL CHECK VARIETY

Fig. 5 Mean number of tillers/plant at different growth intervals of rice hybrids and local check variety

significantly superior to all the varieties except Shabnam and Advanta 801 (12.20 to 13.50 tillers/plant). In contrast to this, the lower tiller counts (11.83 to 11.88/plant) were noted in case of Pro-Agro 6129 and Pro-Agro 6111 hybrids at every stage. The other varieties attained the intermediate position in this character.

Number of effective tillers/hill

The number of effective tillers/hill was counted treatmentwise and the data obtained were subjected to statistical analysis (Appendix XI). The mean values are presented in Table 11 and diagrammatically illustrated in Fig.6.

Table 11 Mean number of effective tillers/hill of different rice hybrids and the local variety

S. No.	Treatments (Rice hybrids)	Number of effective tillers/hill
1	Pro-Agro 6444	14.41
2	Pro-Agro 6201	12.21
3	Pro-Agro 6129	11.31
4	Pro-Agro 6111	11.35
5	PHB 71	12.05
6	Shabnam (403)	11.52
7	MPH 222 (Tara)	12.73
8	Advanta 801	12.85
9	JRH 4	12.24
10	JRH 5	11.73
11	IR 36 (Local check)	5.26
	S.Em±	0.064
	C.D. (5%)	0.195

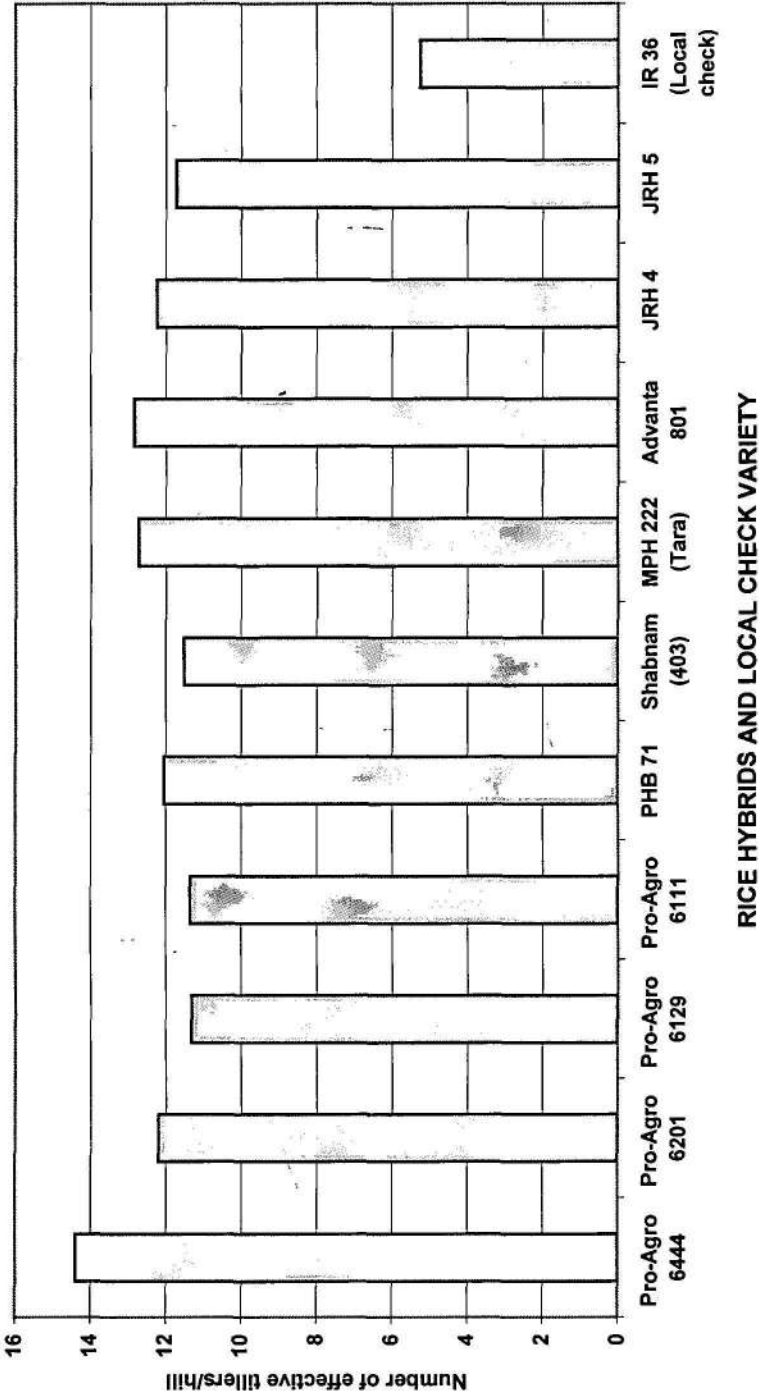


Fig.6 Mean number of effective tillers/hill of rice hybrids and local check variety

This parameter was found to influence significantly in different rice hybrids. The rice hybrid Pro-Agro 6444 recorded the significantly higher effective tillers (14.41/hill) over rest of the rice hybrids. However, this was equally followed by Advanta 801 and Tara (MPH 222) i.e. 12.73-12.85/hill. On the other hand, IR 36 gave the lowest value (5.26 effective tillers/hill). The remaining hybrids attained the intermediate position.

Length of panicle (cm)

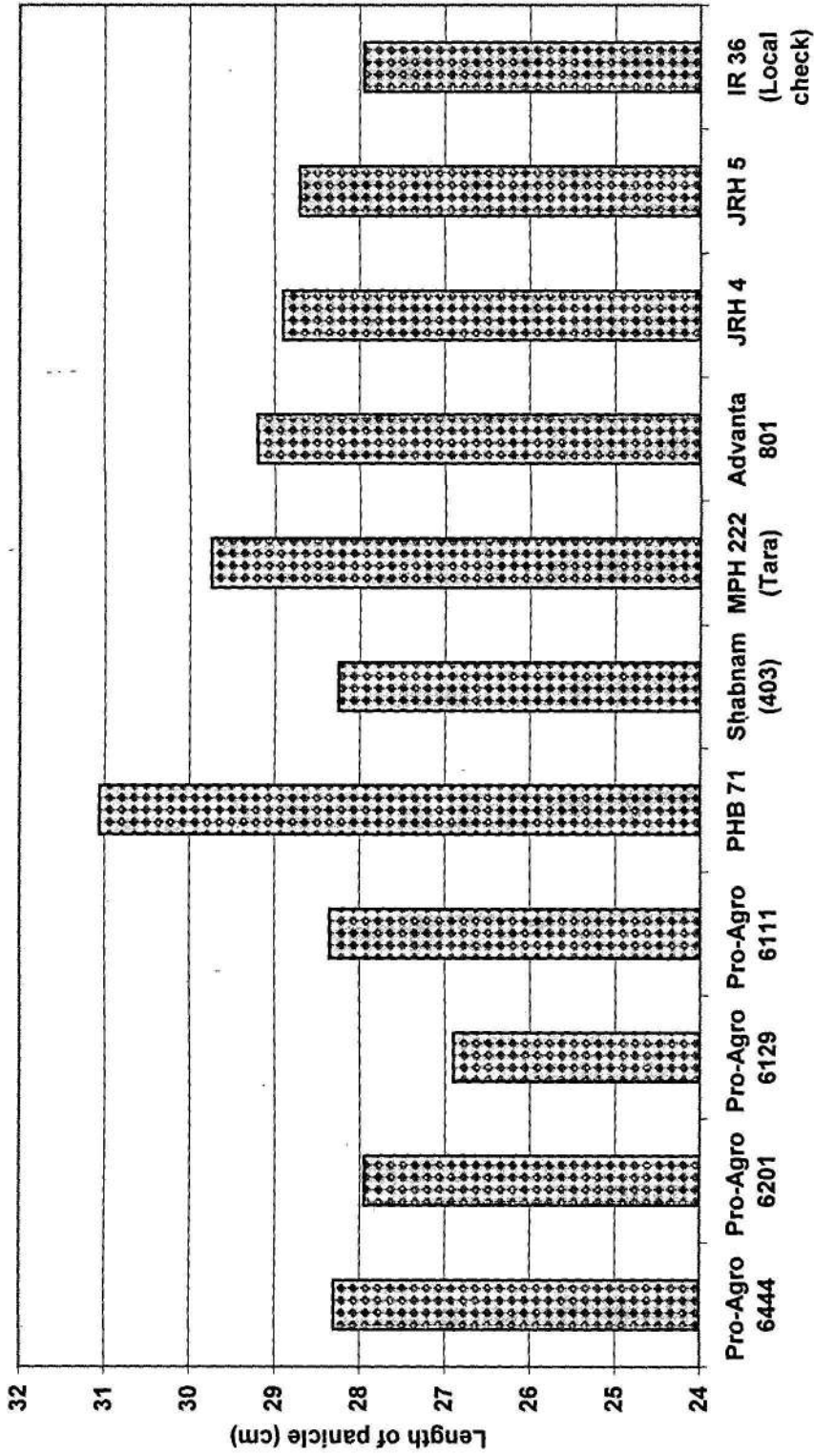
The length of panicle was measured in each treatment and the data obtained were statistically computed (Appendix XII). The mean values are presented in Table 12 and diagrammatically illustrated in Fig. 7. The length of panicle was found to deviate significantly in different rice hybrids. The rice hybrid PHB 71 recorded the maximum panicle length (31.06 cm), being significantly superior to rest of the rice varieties except MPH 222 and Advanta 801 (29.20 to 29.75 cm). This was followed by Pro-Agro 6444, Pro-Agro 6111, Shabnam, JRH 4 and JRH 5 hybrids measuring 28.25 to 28.90 cm panicle length. In contrast to this, the minimum panicle length (26.90 cm) was recorded in case of Pro-Agro 6129, closely followed by Pro-Agro 6201 and IR 36 (27.95 cm).

Weight of panicle (g)

The panicle weight was recorded from the sample plants under each treatment and the mean data were subjected to statistical analysis (Appendix XIII). The mean values are presented in Table 13 and diagrammatically exhibited in Fig.8.

Table 12 Mean length of panicle of different rice hybrids and the local variety

S. No.	Treatments (Rice hybrids)	Length of panicle (cm)
1	Pro-Agro 6444	28.30
2	Pro-Agro 6201	27.95
3	Pro-Agro 6129	26.90
4	Pro-Agro 6111	28.35
5	PHB 71	31.06
6	Shabnam (403)	28.25
7	MPH 222 (Tara)	29.75
8	Advanta 801	29.20
9	JRH 4	28.90
10	JRH 5	28.70
11	IR 36 (Local check)	27.95
	S.Em \pm	0.74
	C.D. (5%)	2.13

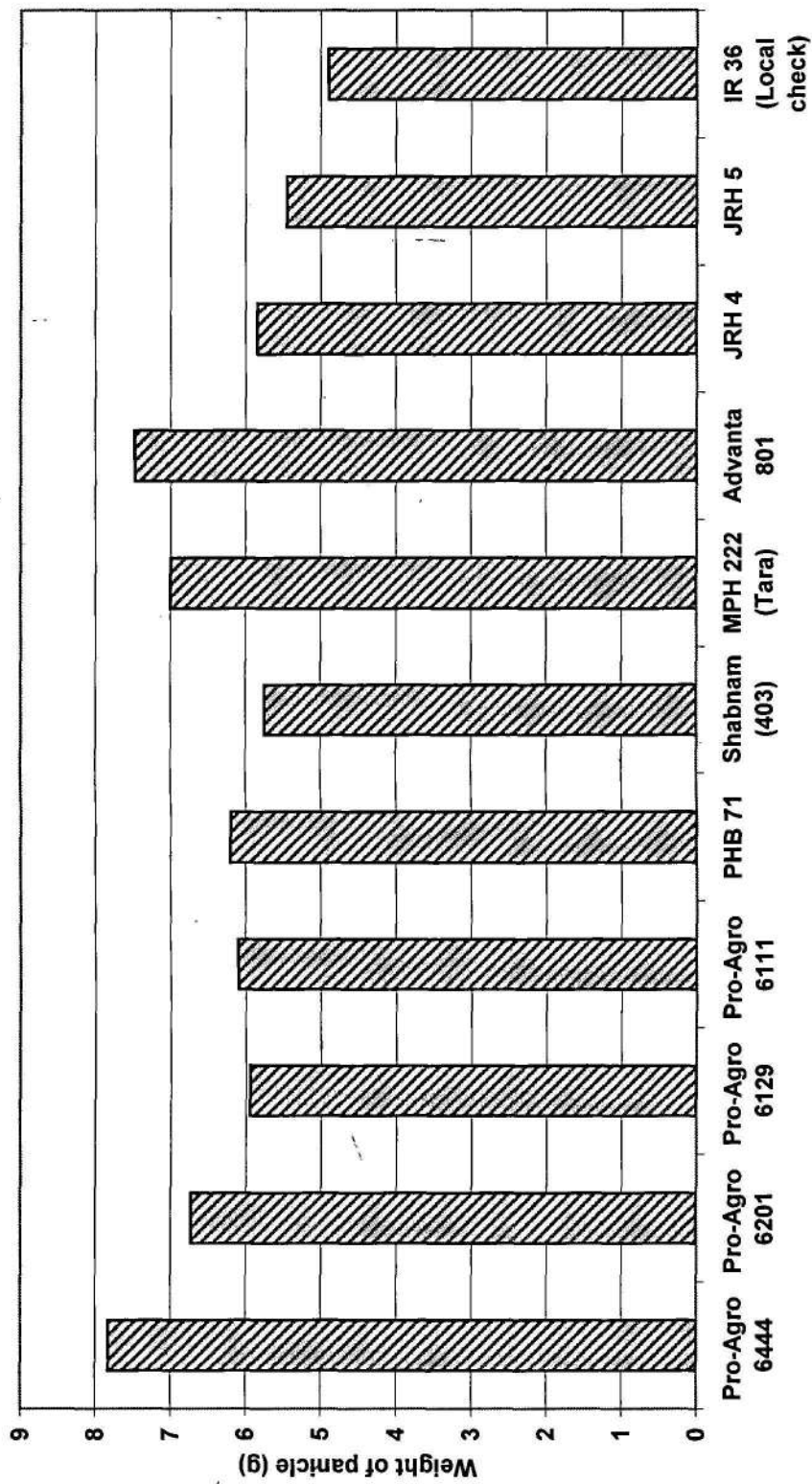


RICE HYBRIDS AND LOCAL CHECK VARIETY

Fig. 7 Mean length of panicle of rice hybrids and local check variety

Table 13 Mean weight of panicle (g) of rice different hybrids and the local check variety

S. No.	Treatments (Rice hybrids)	Weight of panicle (g)
1	Pro-Agro 6444	7.83
2	Pro-Agro 6201	6.73
3	Pro-Agro 6129	5.95
4	Pro-Agro 6111	6.10
5	PHB 71	6.20
6	Shabnam (403)	5.75
7	MPH 222 (Tara)	7.00
8	Advanta 801	7.48
9	JRH 4	5.85
10	JRH 5	5.45
11	IR 36 (Local check)	4.90
	S.Em±	0.42
	C.D. (5%)	2.00



RICE HYBRIDS AND LOCAL CHECK VARIETY

Fig. 8 Mean weight of panicle of rice hybrids and local check variety

Amongst the rice hybrids, Pro-Agro 6444 recorded the maximum panicle weight up to 7.83 g, closely followed by Advanta 801 (7.48 g) and then MPH 222 (Tara) (7.00 g). The maximum panicle weight of Pro-Agro 6444 was found significantly superior only to Shabnam, JRH 5 and IR 36 rice varieties (4.90 to 5.75 g). The panicle weight of varieties which came under the intermediate range was 5.85 to 6.73 g. The local check variety IR 36 recorded the lowest panicle weight only 4.90 g.

Number of sound grains/panicle

The number of sound grains/panicle were counted under each treatment and the data so obtained were subjected to statistical calculation (Appendix XIV). The mean values are depicted in Table 14 and diagrammatically illustrated through Fig.9. This parameter being one of the major yield attributes was found to differ significantly among the different rice varieties. The hybrid variety Pro-Agro 6444 recorded the maximum number of sound grains up to 1133.75 grains/panicle, being significantly superior to all the remaining varieties except Advanta 801 (1054.75 grains), Pro-Agro 6201 (976.75 grains), PHB 71 (924.25 grains) and MPH 222 (979.25 grains/panicle). This means, all these five varieties were found statistically identical to each other in this parameter. The varieties which produced the sound grains/panicle in the lower range were Pro-Agro 6111, JRH 5 and IR 36 (651.25 to 689.25 grains/panicle). The varieties Pro-Agro 6129, Shabnam and JRH 4 recorded almost equally sound grains in the intermediate range (823.50 to 871.0/panicle).

Table 14 Mean number of sound grains/panicle of different rice hybrids and the local check variety

S. No.	Treatments (Rice hybrids)	No. of sound grains/ panicle
1	Pro-Agro 6444	1133.75
2	Pro-Agro 6201	976.75
3	Pro-Agro 6129	823.50
4	Pro-Agro 6111	658.00
5	PHB 71	924.25
6	Shabnam (403)	856.50
7	MPH 222 (Tara)	979.25
8	Advanta 801	1054.75
9	JRH 4	871.00
10	JRH 5	689.25
11	IR 36 (Local check)	651.25
	S.Em _±	74.30
	C.D. (5%)	214.57

Number of chaffy grains/panicle

The number of chaffy grains/panicle were observed treatmentwise and the data so obtained were subjected to statistical analysis as revealed from Appendix XV. The mean data are presented in Table 15 and diagrammatically exhibited in Fig.10.

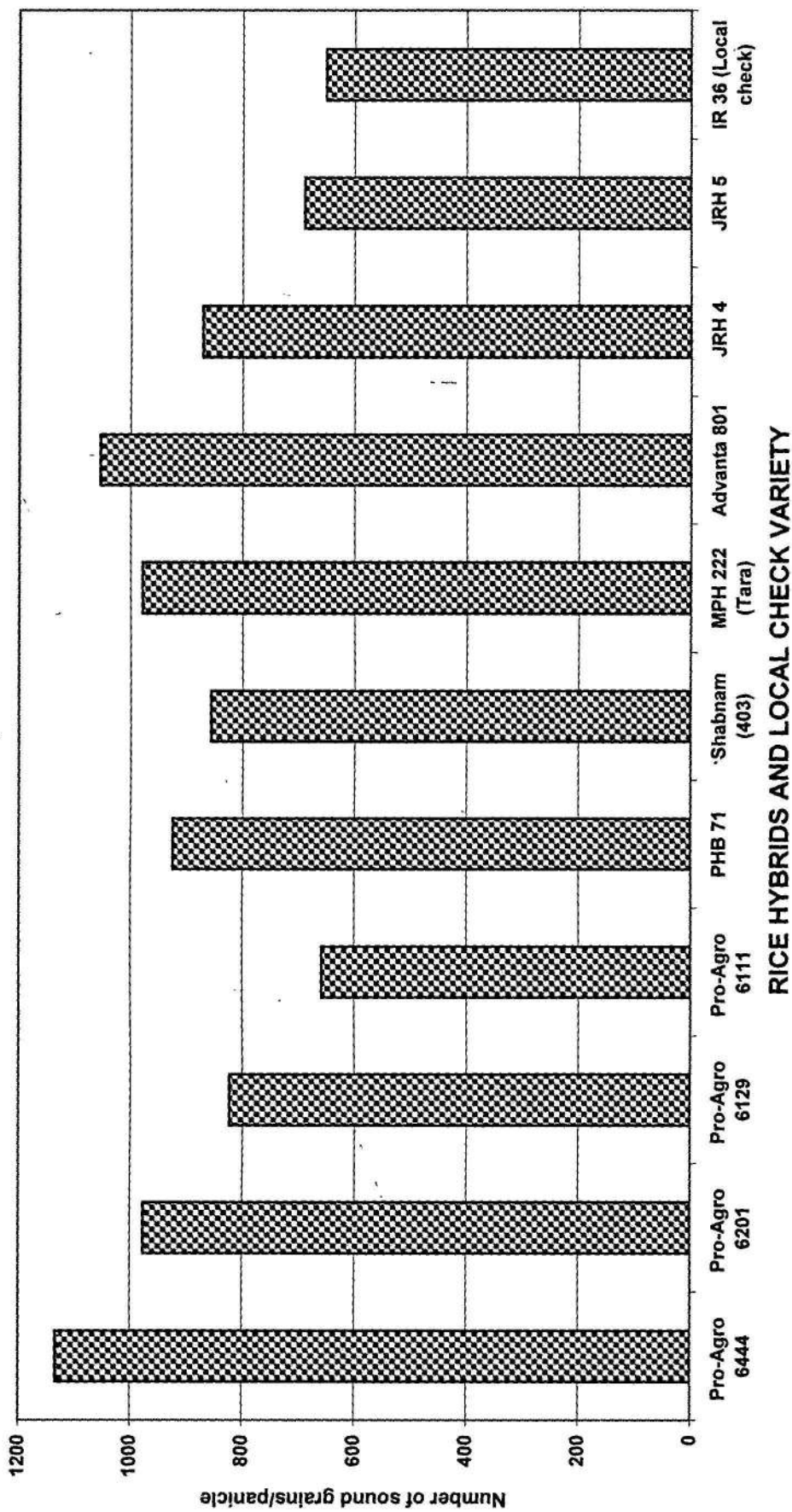
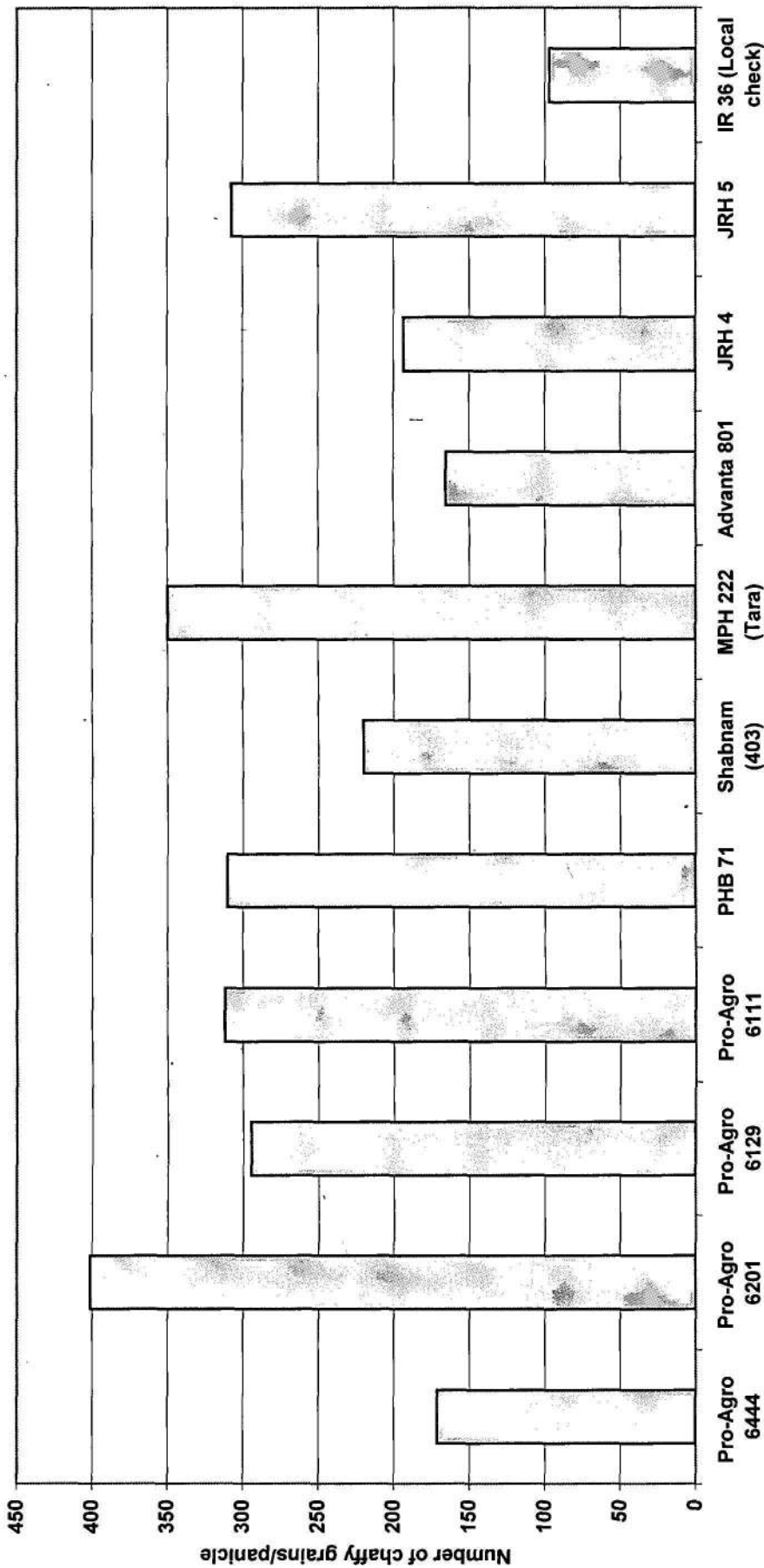


Fig.9 Mean number of sound grains/panicle of rice hybrids and local check variety

Table 15 Mean number of chaffy grains/panicle of different rice hybrids and the local check variety

S. No.	Treatments (Rice hybrids)	No. of chaffy grains/panicle
1	Pro-Agro 6444	171.50
2	Pro-Agro 6201	401.25
3	Pro-Agro 6129	294.75
4	Pro-Agro 6111	312.00
5	PHB 71	310.26
6	Shabnam (403)	220.25
7	MPH 222 (Tara)	350.00
8	Advanta 801	165.25
9	JRH 4	193.50
10	JRH 5	307.50
11	IR 36 (Local check)	97.25
	S.Em _±	48.16
	C.D. (5%)	139.09



RICE HYBRIDS AND LOCAL CHECK VARIETY

Fig. 10 Mean number of chaffy grains/panicle of rice hybrids and local check variety

The number of chaffy grains were found to differ significantly among the different rice hybrids and the local check variety. Among the hybrid rice varieties, Advanta 801 possessed the significantly lowest number of chaffy grains (165.25/panicle) as against the highest (401.25/panicle) in case of Pro-Agro 6201. The local check IR 36 recorded still lower chaffy grains (97.25/panicle). Amongst the rice hybrids which recorded the chaffy grains in the lower range were Pro-Agro 6444 (171.5 grains) and JRH 4 (193.50 grains/panicle). On the other hand those hybrids which possessed the chaffy grains in the higher range were MPH 222 (350.0 grains), Pro-Agro 6111 (312.0 grains), PHB-71 (310.25 grains) and JRH 5 (307.50 chaffy grains/panicle). In case of Shabnam and Pro-Agro 6129, the chaffy grains ranged from 220.25 to 294.75/panicle.

Test weight of 1000 grains (g)

The test weight of 1000 grains was recorded in each treatment and the data so obtained were statistically computed (Appendix XVI). The mean values are highlighted in Table 16 and diagrammatically illustrated in Fig. 11. The test weight was found to differ significantly in different rice hybrids and the local check variety. The maximum test weight up to 25.99 g was recorded in rice hybrid JRH 4, closely followed by JRH 5 (25.97 g) and then Pro-Agro 6444 (24.95 g). On the other hand, the significantly lowest test weight (21.90 g) was noted in case of local check IR 36. The remaining seven varieties brought about the identical test weight among each other (22.18 to 24.48 g). The test weight of the variety MPH 222 was in the same range (23.22 g). Similarly, Pro Agro 6201 and Shabnam also recorded equal test weight in the same range (22.18 to 22.52 g). The test weight of Pro-Agro 6129 and Pro-Agro 6111 was the same (23.96 g).

Table 16 Mean test weight (g) of 1000-grains of different rice hybrids and the local check variety

S. No.	Treatments (Rice hybrids)	Test weight of 1000- grains (g)
1	Pro-Agro 6444	24.95
2	Pro-Agro 6201	22.18
3	Pro-Agro 6129	23.96
4	Pro-Agro 6111	23.96
5	PHB 71	24.48
6	Shabnam (403)	22.52
7	MPH 222 (Tara)	23.22
8	Advanta 801	24.06
9	JRH 4	25.99
10	JRH 5	25.97
11	IR 36 (Local check)	21.90
	S.Em±	0.95
	C.D. (5%)	2.75

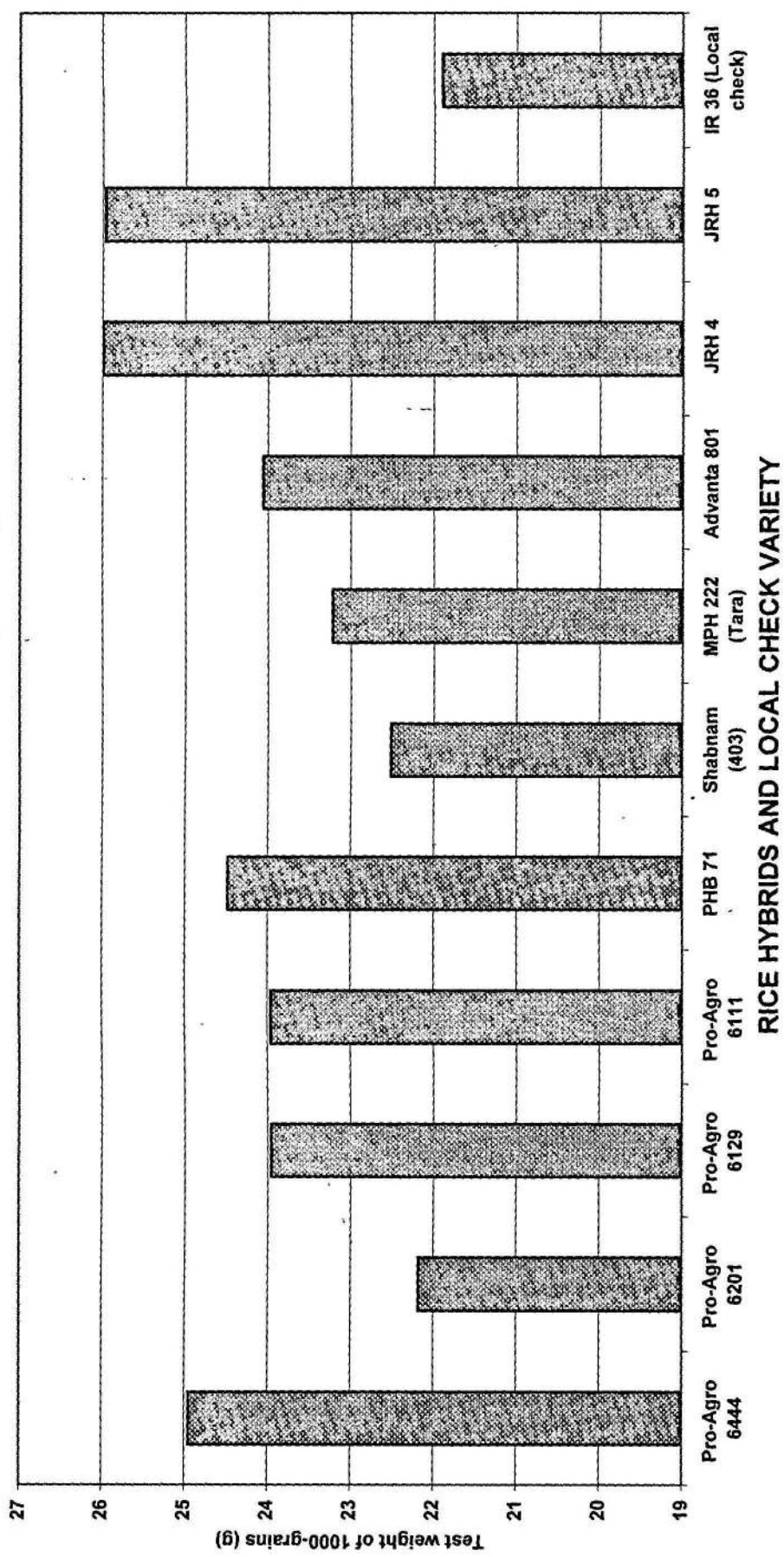


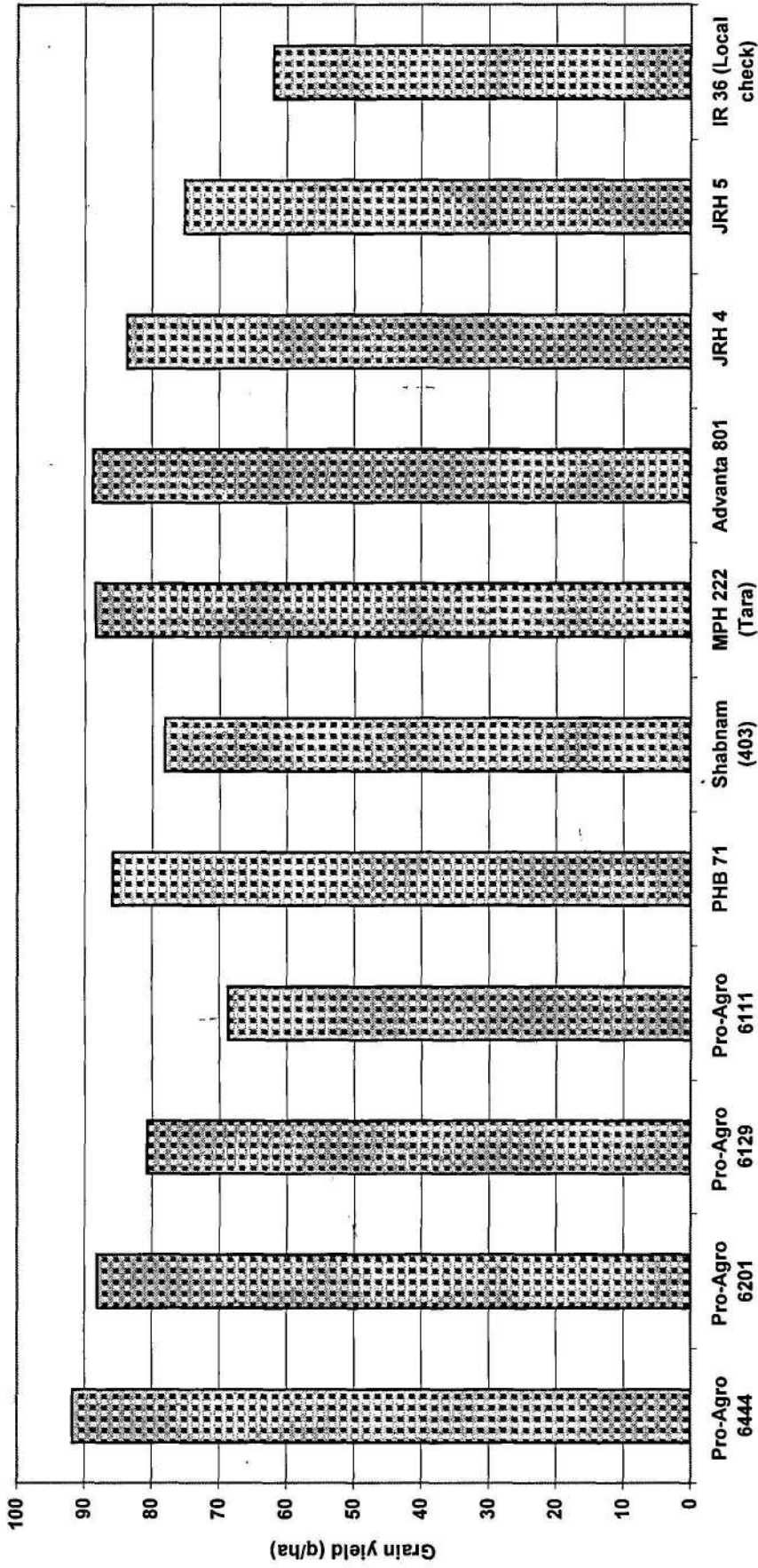
Fig. 11 Mean test weight of 1000-grains (g) of rice hybrids and local check variety

Grain yield (q/ha)

The grain yield/ha was obtained from each treatment by multiplying the grain yield/plot with the plot-size factor. The data so obtained were subjected to statistical analysis (Appendix XVII). The mean values are presented in Table 17 and diagrammatically illustrated in Fig. 12 .

Table 17 Mean grain yield (q/ha) from different rice hybrids and the local check variety

S. No.	Treatments (Rice hybrids)	Grain yield (q/ha)
1	Pro-Agro 6444	91.74
2	Pro-Agro 6201	88.12
3	Pro-Agro 6129	80.74
4	Pro-Agro 6111	68.67
5	PHB 71	85.87
6	Shabnam (403)	78.12
7	MPH 222 (Tara)	88.37
8	Advanta 801	88.74
9	JRH. 4	83.74
10	JRH 5	75.23
11	IR 36 (Local check)	61.99
	S.Em \pm	5.37
	C.D. (5%)	15.52



RICE HYBRIDS AND LOCAL CHECK VARIETY

Fig. 12 Mean grain yield of rice hybrids and local check variety

The grain yield of different rice varieties were found to deviate significantly. The maximum grain yield (91.74 q/ha) was recorded from Pro-Agro 6444 rice hybrid, being significantly superior only to Pro-Agro 6111 (68.67 q/ha), JRH 5 (75.23 q/ha) and IR 36 (61.99 q/ha). That means, all the remaining seven varieties were statistically equal with respect to yielding potentiality (78.12 to 88.74 q/ha). The best rice hybrid Pro-Agro 6444 gave the extra yield up to 29.75 q/ha (48 %) as compared to the local check IR 36. However, this was followed by other hybrids (Pro-Agro 6201, MPH 222 and Advanta 801) yielding in the similar range (88.12 to 88.74 q/ha) i.e. 26.13 to 26.75 q/ha extra or 42 to 43 % higher over IR 36.

Straw yield (q/ha)

The straw yield/ha was recorded from each treatment by multiplying the straw yield/plot with the plot-size factor. The data so obtained were subjected to statistical analysis (Appendix XVIII). The mean values are presented in Table 18 and diagrammatically illustrated through Fig. 13. The hybrid rice varieties including the local check were found to vary significantly in producing the straw per hectare. Amongst the hybrids, Pro-Agro 6444 recorded the maximum straw yield up to 113.74 q/ha, being significantly superior to rest of varieties except Advanta 801 (110.99 q/ha). Thus, Advanta 801 was found the second best variety in producing the straw. However, the third and fourth best variety was JRH 4 and Pro-Agro 6201 producing 107.99 and 106.81 q/ha straw, respectively. On the other hand, the equally lower straw producing varieties were IR 36 and JRH 5 (87.24 to 89.74 q/ha). The other varieties viz. PHB 71, Pro-Agro 6129, Pro-Agro 6111, Shabnam and MPH 222 produced the straw in the intermediate range (92.68 to 101.62 q/ha).



Table 18 Mean straw yield (q/ha) from different rice hybrids and the local check variety

S. No.	Treatments (Rice hybrids)	Straw yield (q/ha)
1	Pro-Agro 6444	113.74
2	Pro-Agro 6201	106.81
3	Pro-Agro 6129	98.98
4	Pro-Agro 6111	92.68
5	PHB 71	94.10
6	Shabnam (403)	94.12
7	MPH 222 (Tara)	101.62
8	Advanta 801	110.99
9	JRH 4	107.99
10	JRH 5	89.74
11	IR 36 (Local check)	87.24
	S.Em±	1.02
	C.D. (5%)	3.93

Harvest index (%)

The harvest index was calculated treatmentwise and the data so obtained were subjected to statistical computation (Appendix XIX). The mean values are presented in Table 19 and diagrammatically exhibited in Fig. 14 .

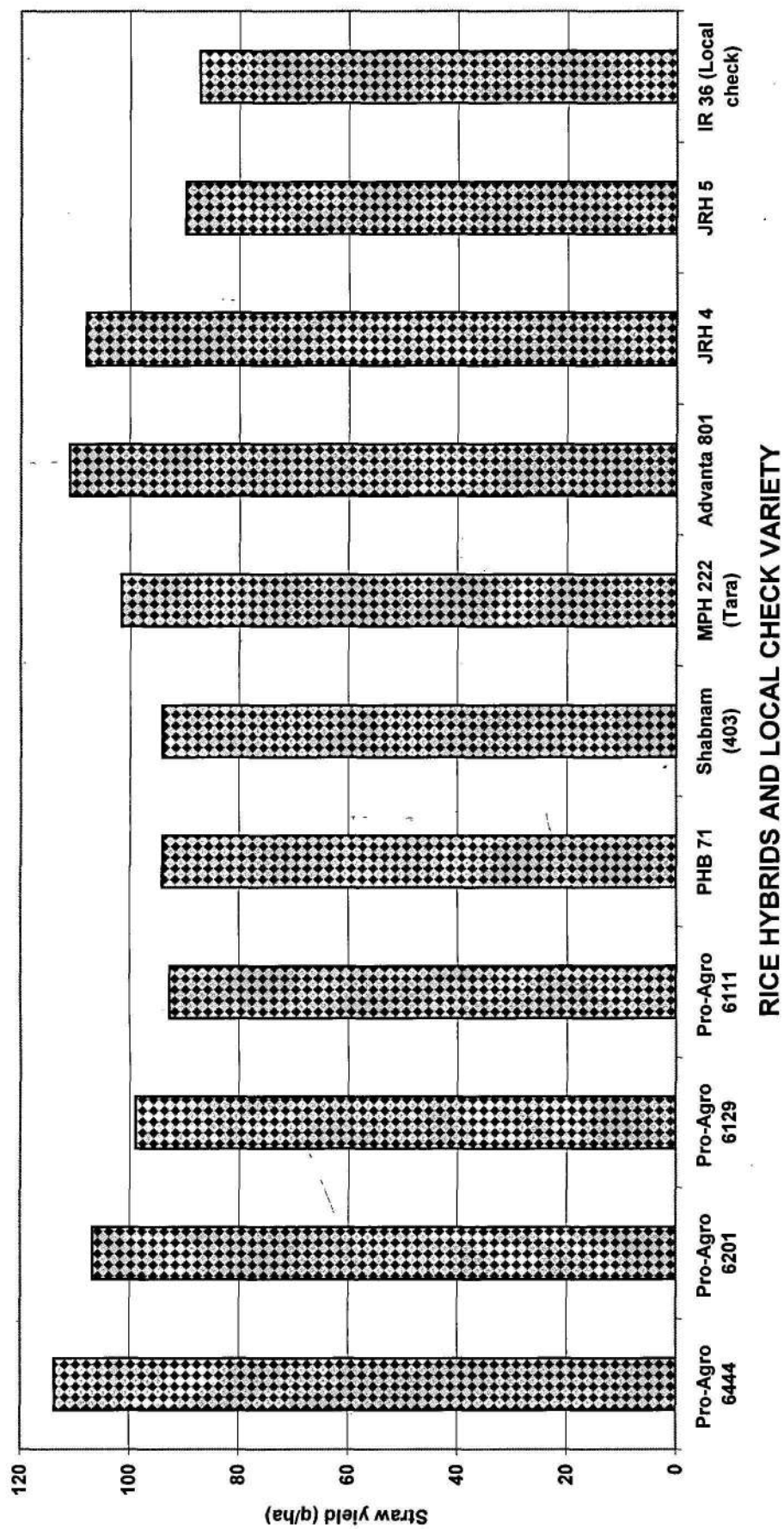


Fig. 13 Mean straw yield of rice hybrids and local check variety

Table 19 Mean harvest index of different rice hybrids and the local check variety

S. No.	Treatments (Rice hybrids)	Harvest index (%)
1	Pro-Agro 6444	44.65
2	Pro-Agro 6201	45.21
3	Pro-Agro 6129	44.93
4	Pro-Agro 6111	42.56
5	PHB 71	47.71
6	Shabnam (403)	45.36
7	MPH 222 (Tara)	46.51
8	Advanta 801	44.43
9	JRH 4	43.68
10	JRH 5	45.60
11	IR 36 (Local check)	41.54
	S.Em _±	1.11
	C.D. (5%)	3.22

The harvest index in different rice varieties was found to deviate significantly. The maximum harvest index (47.71 %) was recorded in case of PHB 71 hybrid. This was significantly superior to Pro-Agro 6111 (42.56 %), Advanta 801 (44.43 %), JRH 4 (43.68 %) and IR 36 (41.54 %). That means the remaining varieties were statistically identical to each other with respect to this physiological parameter (44.65 in Pro-Agro 6444 to 46.51 % in MPH 22). The local check variety (IR 36) was found to give the lowest harvest index (41.54 %).

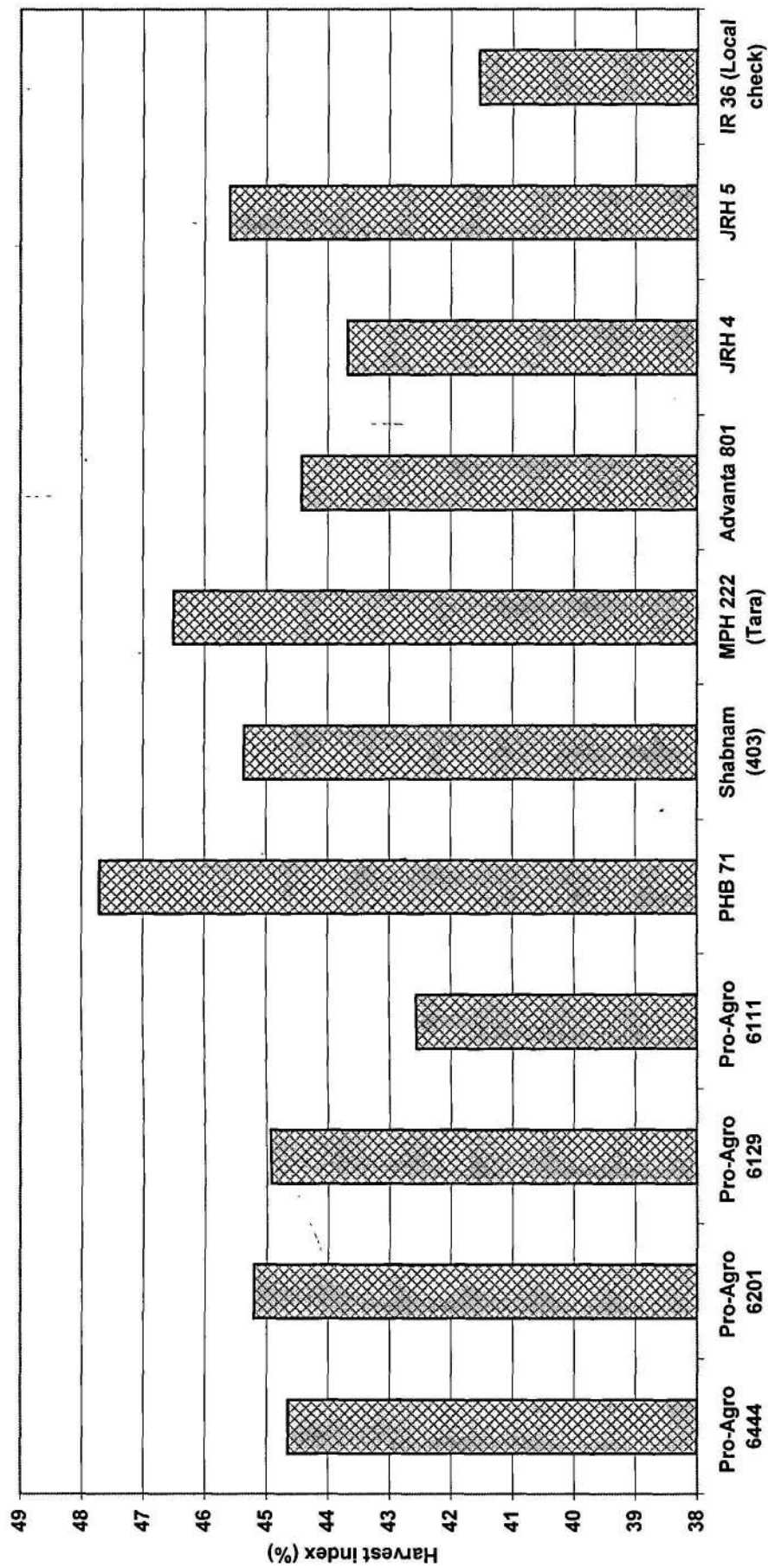


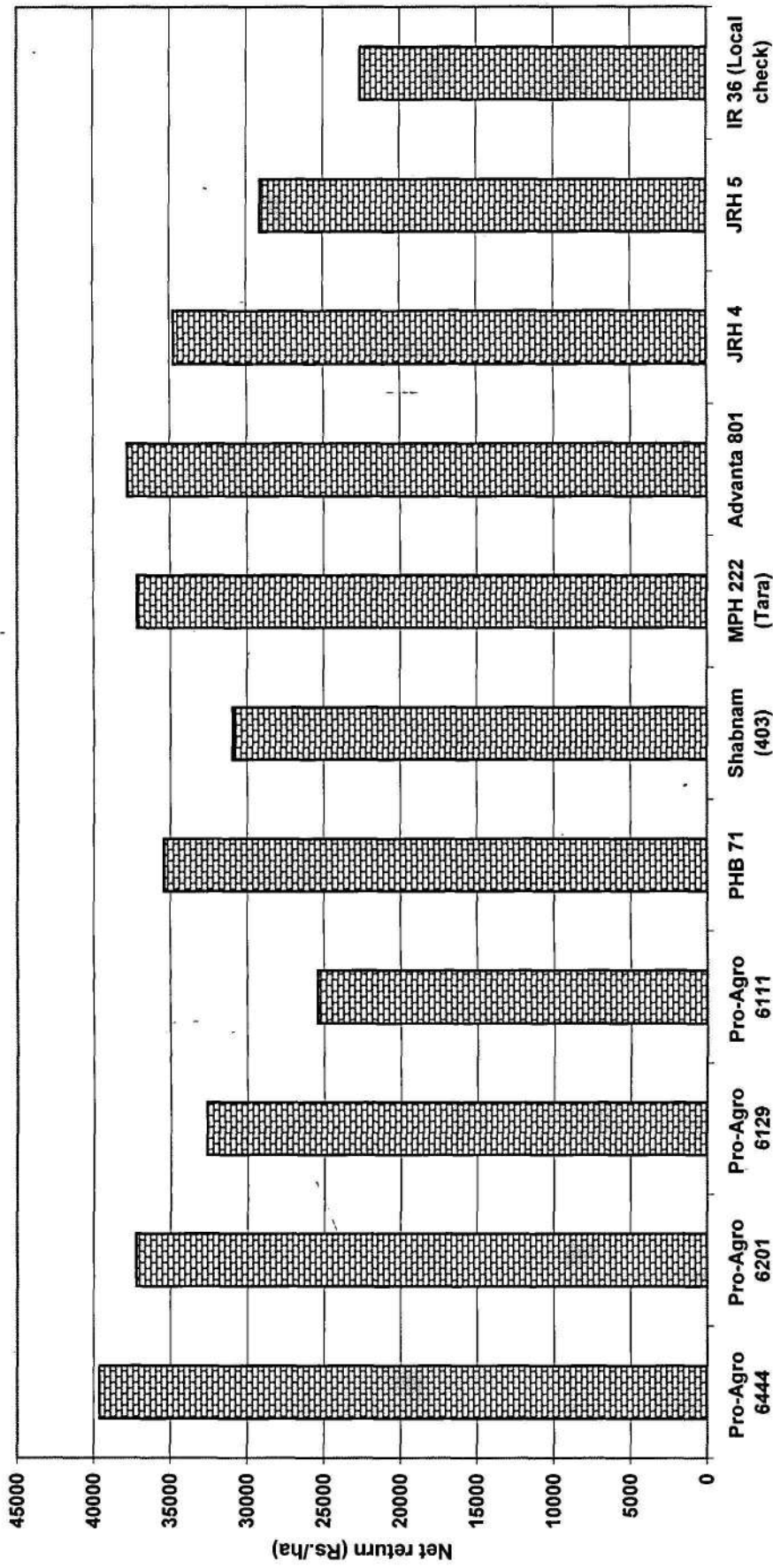
Fig.14 Mean harvest index of rice hybrids and local check variety

Economical gain

The economical (monetary) return per hectare was worked out treatmentwise based on the existing market rates of the experimental inputs and outputs. The data so obtained were subjected to statistical analysis. The mean values are presented in Table 20 and diagrammatically illustrated in Fig. 15.

Table 20 Mean net return (Rs/ha) and B:C ratio from different rice hybrids and the local check variety

S. No.	Treatments (Rice hybrids)	Net return (Rs/ha)	B:C ratio
1	Pro-Agro 6444	39620	3.18
2	Pro-Agro 6201	37243	3.05
3	Pro-Agro 6129	32649	2.80
4	Pro-Agro 6111	25397	2.40
5	PHB 71	35430	2.95
6	Shabnam (403)	30936	2.71
7	MPH 222 (Tara)	37181	3.05
8	Advanta 801	37770	3.08
9	JRH 4	34750	2.92
10	JRH 5	29084	2.60
11	IR 36 (Local check)	22580	2.34
	S.Em _±		
	C.D. (5%)		



RICE HYBRIDS AND LOCAL CHECK VARIETY

Fig.15 Mean net return of rice hybrids and local check variety

Among the rice hybrids, Pro-Agro 6444 gave the maximum net return (Rs.39620/ha) and B:C ratio (3.18). This was equally followed by Pro-Agro 6201, MPH 222 and Advanta 801 (Rs.37243 to Rs.37770) and B:C ratio (3.05 to 3.08). Thereafter the hybrids PHB 71 and JRH 4 also gave equally net return (Rs.34750 to Rs.35430/ha) and B:C ratio (2.92 to 2.95). Among the hybrid varieties, JRH 5 gave the lowest net return (Rs.29084/ha) and B:C ratio (2.60). The local check IR 36 further lowered down the net return (Rs.22580) and B:C ratio (2.34).

Leaf blast, brown spot and false smut disease

Leaf blast

Leaf blast caused by *Pyricularia grisea* was assessed in the tested hybrids under natural epiphytosis (Table 21 and Appendix XX).

Table 21 Mean leaf blast severity (%) in the rice hybrids

S. No.	Treatments (Rice hybrids)	Leaf blast DI (%)
1	Pro-Agro 6444	5.30 (13.31)
2	Pro-Agro 6201	4.43 (12.11)
3	Pro-Agro 6129	4.18 (11.68)
4	Pro-Agro 6111	3.43 (10.63)
5	PHB 71	4.98 (12.79)
6	Shabnam (403)	3.60 (10.94)
7	MPH 222 (Tara)	6.00 (14.18)
8	Advanta 801	4.90 (12.79)
9	JRH 4	3.10 (10.14)
10	JRH 5	3.73 (11.09)
11	IR 36 (Local check)	6.40 (14.65)
	S.Em \pm	0.530
	C.D. (5%)	1.531

() The data in parenthesis are angular transformed values.

Among the tested hybrids none was found to be immune however, highly resistant reaction was recorded in the hybrids. Leaf blast disease index varied from 3.10 to 6.40 % in the tested hybrids. Highly resistant hybrids were Pro-Agro 6111, PHB 71, JRH 4 and JRH 5 whereas, moderate resistant reactions exhibited by Pro-Agro 6201, Pro-Agro 6444, Advanta 801, MPH 222 and Shabnam over local check IR 36 (6.40 %).

Brown spot

Brown leaf spot caused by *Helminthosporium oryzae* is a very common disease and known as poor farmers disease in the region. The disease index was assessed in the hybrids under natural conditions.

Table 22 Mean brown spot severity (%) in the rice hybrids

S. No.	Treatments (Rice hybrids)	Brown spot DI (%)
1	Pro-Agro 6444	7.85 (16.22)
2	Pro-Agro 6201	6.48 (14.65)
3	Pro-Agro 6129	5.53 (13.56)
4	Pro-Agro 6111	4.38 (11.97)
5	PHB 71	7.98 (16.32)
6	Shabnam (403)	7.08 (15.34)
7	MPH 222 (Tara)	6.83 (15.12)
8	Advanta 801	6.23 (14.42)
9	JRH 4	3.88 (11.24)
10	JRH 5	4.25 (11.83)
11	IR 36 (Local check)	7.98 (16.32)
	S.Em \pm	0.241
	C.D. (5%)	0.671

() The data in parenthesis are angular transformed values.

The data (Table 22 and Appendix XXI) reveal that none of the hybrids exhibited immune reaction to brown spot however the hybrids that had exhibited highly resistant reaction to brown spot were JRH 4, JRH 5, PA 6111, PA 6129 ranging from 4.25 to 7.90 % under natural epiphytotics. Pro-Agro 6444, Pro-Agro 6201, PHB 71 and Shabnam showed moderately resistant reaction to brown spot over IR 36 local check (7.98 %).

False smut

False smut caused by the *Cleviceps oryzae* was in traces (Table 23 and Appendix XXII).

Table 23. Mean false smut severity (%) in the rice hybrids

S. No.	Treatments (Rice hybrids)	False smut DI (%)
1	Pro-Agro 6444	1.30 (6.55)
2	Pro-Agro 6201	0.90 (5.44)
3	Pro-Agro 6129	0.65 (4.62)
4	Pro-Agro 6111	0.60 (4.44)
5	PHB 71	1.25 (6.29)
6	Shabnam (403)	0.00 (0.00)
7	MPH 222 (Tara)	0.35 (3.39)
8	Advanta 801	1.13 (6.02)
9	JRH 4	0.00 (0.00)
10	JRH 5	0.00 (0.00)
11	IR 36 (Local check)	0.00 (0.00)
	S.Em±	0.172
	C.D. (5%)	0.497

() The data in parenthesis are angular transformed values.

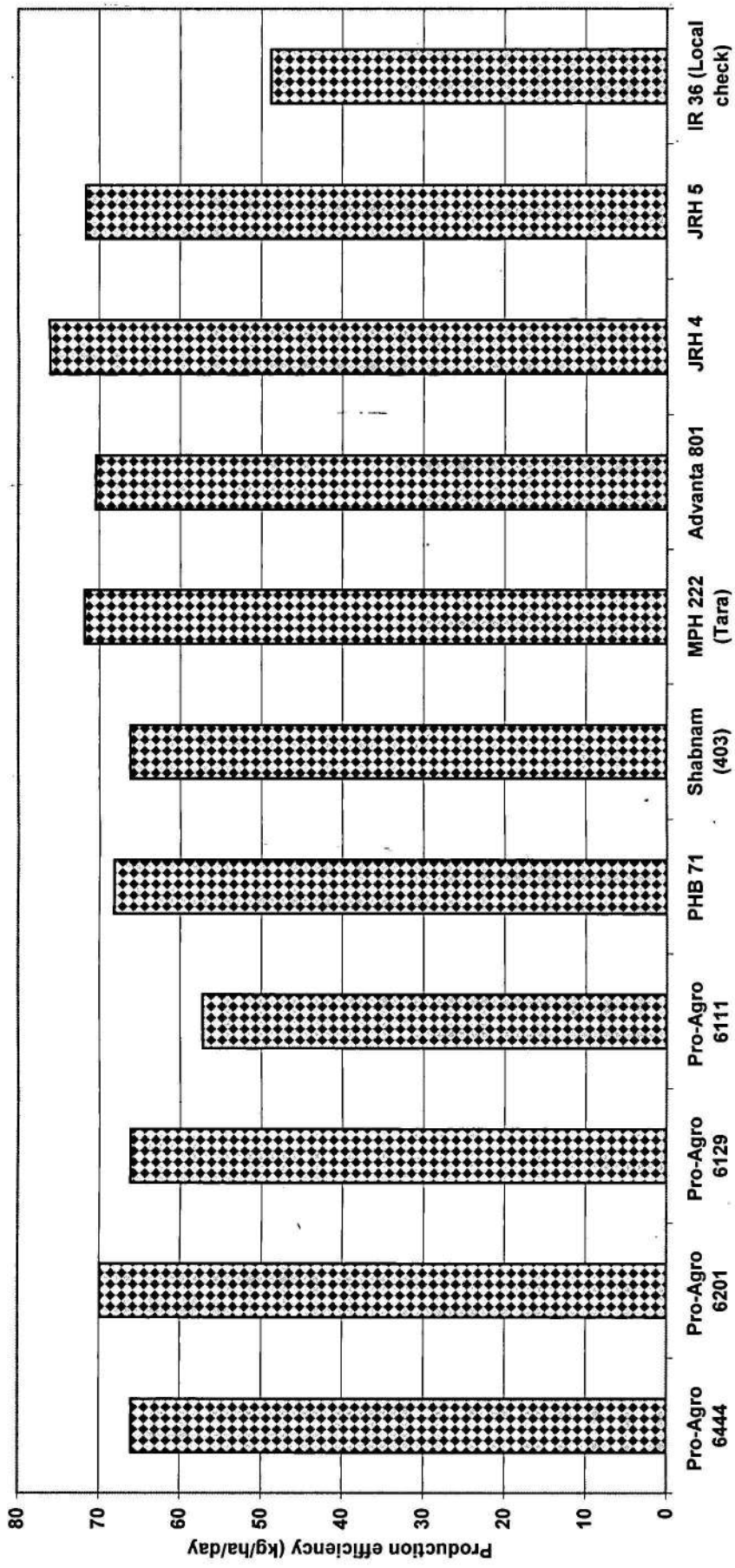
It was observed that most of the hybrids were found to be free from false smut incidence however, Pro-Agro 6444 (1.30 %), PHB 71 (1.25 %), Advanta 801 (1.13 %) and Pro Agro 6201 (0.90 %) showed very less false smut severity ranked in traces during grain filling stages under natural epiphytotics. Rest of the hybrids exhibited immune reaction to false smut under study.

Production efficiency

The production efficiency of different rice hybrids was worked out and the data so obtained have been statistically computed (Appendix XXIII). The mean values are presented in Table 24 and diagrammatically illustrated in Fig. 16.

Table 24. Mean production efficiency of rice hybrid varieties against the local check

S. No.	Treatments (Rice hybrids)	Production efficiency (kg/ha/day)	Crop duration (days)
1	Pro-Agro 6444	66.00	139
2	Pro-Agro 6201	69.93	126
3	Pro-Agro 6129	66.18	122
4	Pro-Agro 6111	57.22	120
5	PHB 71	68.15	126
6	Shabnam (403)	66.20	118
7	MPH 222 (Tara)	71.84	123
8	Advanta 801	70.43	126
9	JRH 4	76.12	110
10	JRH 5	71.65	105
11	IR 36 (Local check)	48.81	127
	S.Em±	4.516	--
	C.D. (5%)	13.042	--



RICE HYBRIDS AND LOCAL CHECK VARIETY

Fig. 16 Mean production efficiency of rice hybrids and local check variety

The production efficiency was found to vary significantly among the different hybrid varieties. The hybrid JRH 4 recorded the maximum production efficiency up to 76.12 kg/ha/day, closely followed by MPH 222 (Tara) (71.84 kg/ha/day), JRH 5 (71.65 kg/ha/day) and then Advanta 801 (70.43 kg/ha/day). These were significantly superior to only Pro-Agro 6111 and IR 36 (local check) showing the equally lower production efficiency 57.22 and 48.81 kg/ha/day, respectively. Thus, among all the varieties, Pro-Agro 6111 and IR 36 recorded significantly lowest production efficiency.

Correlation studies

The correlation studies was made amongst the different growth and yield-attributing characters each other as well as with the grain yield of hybrid rice. The data in Table 25 indicate that the panicle length of hybrid rice was found to be positively correlated with the plant height at 1 % level of significance (+0.933).

The panicle weight was positively correlated with the number of tillers/plant at 5 % level of significance (+0.649).

The sound grains/panicle was found to be positively correlated with the tillers/plant (+0.658), whereas, correlated with panicle weight at 1 % level of significance (+0.887).

The test weight of 1000 grains was found to be negatively correlated with chaffy grains/panicle at 5 % level of significance (-0.029).

The grain yield of hybrid rice was found to be positively correlated with number of tillers/plant (+0.748), panicle weight (+0.826) and sound grains/panicle (+0.939) at 1 % level of significance.

Table 25. Correlation studies

	Plant height	No. of tillers/hill	Panicle length (cm)	Panicle weight (g)	Sound grains/panicle	Chaffy grains/panicle	1000-grains weight (g)
No. of tillers/hill	0.288						
Panicle length (cm)	0.933**	0.202					
Panicle weight (g)	0.077	0.649*	0.215				
Sound grains/panicle	0.102	0.658*	0.228	0.887**			
Chaffy grains/panicle	0.228	0.319	0.319	0.108	0.024		
1000-grains weight (g)	0.367	0.282	0.266	0.110	0.067	-0.029	
Grain yield (q/ha)	0.273	0.748*	0.340	0.826**	0.939**	0.270	0.255

* Significant at 5% ** Significant at 1 %

DISCUSSION

CHAPTER V

DISCUSSION

The results of field and laboratory studies made during the course of investigation have been presented and interpreted in the previous chapter. In this chapter, the attempts have been made to explain and substantiate the cause and effect relationships which may be responsible for some of the important observations recorded during the course of investigation to derive some valid conclusions. The main discussion is centered around the effect of treatments on the various plant characters as they are ultimately responsible for the grain yield, because the grain yield is final criterion for the evaluation of different treatments.

Ten rice hybrids and one local check IR 36 were involved in the study. The discussion on the performance of rice hybrids in respect of growth, yield-attributing characters and yield are discussed in the following pages.

Effect of weather on crop

The crop plants are greatly affected by weather conditions during the crop season. Thus, the results of field experiment in agriculture are greatly influenced by weather conditions prevailing during the crop season. Therefore, any discussion of the experimental result would be incomplete without considering the crop-weather relationship to arrive at correct interpretation and conclusion. Weather details of temperature, sunshine hours, humidity and precipitation pertaining to the crop season are presented in Table 3.1 and depicted through Fig. 3.1.

The meteorological parameters show that during the crop season of five months sum of 723.40 mm rainfall occurred in 38 rainy days. Most of the total rainfall occurred during the vegetative growth stage of crop and at ripening stage there was little rainfall which favoured the crop growth.

Apart from this, average maximum (32.44 °C) and minimum (22.90 °C) temperature, higher relative humidity (72.84 %) and good sunshine hours (6.31) prevailed during the crop season favoured the better growth and development of the crop. Most of the precipitation during the peak demand of crop and a narrow difference between maximum and minimum temperature also helped in filling of grains which ultimately resulted to produce higher grain yield.

Plant population

The uniform plant density is an important requisite for obtaining higher precision when it is not a variable factor as the treatments. The data in Table 4.1 indicate that the plant population was maintained among the hybrids as 25 plants/m² @ one plant per hill however, in case of IR 36 (local check) two plants/hill were transplanted, therefore the plant population in this case was 50.25/m² which brought about the significant difference between hybrids and the local check variety.

Growth parameters

There was significant differences in the plant height of different rice hybrids at 30, 60 and 90 DAT stages of observation (Summary Table 5.10). The rice hybrid PHB 71 showed significant superiority throughout the growth period in respect of plant height in comparison to the other hybrids as well as the local check IR 36. The differential growth behaviour among the hybrids could be attributed to the different genetical make up of rice hybrids. Paramasivan and Sreerangaswami (1988) and Hari Om *et al.* (1997) and Ajeet (2003) have also reported variation in the plant height of rice hybrids. All the rice hybrids proved significantly superior to IR 36 in respect of tillering ability of plants at every stage. Amongst the rice hybrids Pro-Agro 6444 proved superior to all the remaining hybrids as well as IR 36 (Table 4.3). This was followed by MPH 222 and Advanta 801. The superiority of Pro-Agro 6444 in respect of highest tillering over others might be due to variation in hybrid vigour and in more nutrient uptake right from the initial stage of growth.

The results obtained for the number of tillers per hill by these hybrids in comparison to other varieties are in agreement with the findings of Surekha *et al.* (1999) and Ajeet (2003).

Yield-attributes

It is evident from the results presented in previous chapter that the rice hybrid Pro-Agro 6444 exhibited significant superiority in respect of yield-attributes like number of effective tillers/hill, number of sound grains and weight of panicle over the other hybrids and the local check variety like IR 36 (Summary Table 5.1).

The number of chaffy (unfilled) grains per panicle was maximum in case of Pro-Agro 6201 which was significantly superior to most of the hybrids as well as IR 36.

The test weight of one thousand grains was recorded maximum in case of JRH 4 and KRH 5 which was significantly superior to hybrid Pro-Agro 6201, Shabnam, MPH 222 and IR 36. The higher values of yield attributes viz. panicle length recorded from PHB 71, sound grains and panicle weight recorded from Pro-Agro 6444 and the test weight noted in case of JRH 4 and JRH 5 might be due to better growth and development of reproductive organs (sink) and better performance under the existing agro-climatic conditions and finally the better genetic make up with their respective characters. The higher number of sound grains and lower number of chaffy grains noted particularly in case of Pro-Agro 6444 and Advanta 801 might be due to better grain filling character inherited in these hybrids. The maximum test weight recorded in case of JRH 4 and JRH 5 might be due to formation of larger size grains.

Similar results on variation of yield-attributes by rice hybrids have also been supported by Rao *et al.* (1985), IRI (1988) and Lokprakash *et al.* (1992), Singh *et al.* (2002), Chellamuthu *et al.* (2002) and Ajeet (2003).

Grain and straw yield

The rice hybrid Pro-Agro 6444 produced significantly more grain yield as compared to Pro-Agro 6111, JRH 5 and the local check IR 36. Thus, the remaining seven varieties were identical with respect to yield potential (Summary Table 5.2).

The enormous extra increase in grain yield to the tune of 29.75 q/ha (48 %) recorded by Pro-Agro 6444 over local check IR 36 might be due to overall better performance in growth characters and appreciable improvement in the yield attributing characters viz. number of tillers per hill, number of sound grains/panicle and panicle weight. Grain yield is the end result of all the vegetative and reproductive growth characters and genetic yield potential of Pro-Agro 6444 which further lead to produce higher grain. Rao *et al.* (1985), Yuan (1988) and Sarial and Singh (1998), Singh *et al.* (2002), Tripathi and Jaiswal (2002) and Ajeet (2003) also found similar results with respect to variation in the grain yield of hybrid rice varieties and the local check (IR 36). Like grain yield, the straw yield was also recorded maximum (113.74 q/ha) in case of Pro-Agro 6201 (106.81 q/ha). Such an increase in straw yield of these rice hybrids might be due to the superiority of growth parameters viz. plant height and number of tillers per plant as well as chaffy grains/panicle in these varieties. Ajeet (2003) have also reported the superiority of rice hybrids in respect to straw yield.

Economical gain

Amongst the rice hybrids, the maximum net return (Rs.39620/ha) and B:C ratio up to 3.18 was obtained from Pro-Agro 6444. This was equally followed by Pro-Agro 6201, MPH 222 and Advanta 801 giving the net returns up to Rs.37243, Rs.37181 and Rs.37770/ha with B:C ratio 3.05, 3.05 and 3.08, respectively. The higher net return and B:C ratio may be due to higher grain and straw yields from these varieties which enhanced the gross income and thereby the net profit. On the other hand, IR 36 (local check) gave the lowest

net income (Rs.22580/ha) as well as B:C ratio (2.34) which was due to lowest grain and straw yields and thereby lowest gross income.

Production efficiency

The results indicate that the production efficiency was maximum up to 76.12 kg/ha/day in hybrid variety JRH 4 along with the earlier crop maturity in 110 days. On the other hand, the rice hybrid Pro-Agro 6444 although producing maximum grain up to 91.74 q/ha, gave the production efficiency only up to 66 kg/ha/day i.e. less than 10 kg/ha/day than JRH 4. This may be due to maximum crop duration (139 days) in case of Pro-Agro 6444 as compared that of JRH 4 (110 days). There were two other hybrids (MPH 222 and JRH 5) which gave the equally higher production efficiency (71.65 to 71.84 kg/ha/day) but JRH 5 would be preferred due to its earliest crop maturity (105 days) as compared to that of MPH 22 which matures in 123 days. Thus, from the view point of production efficiency, JRH 4 proved the best, followed by JRH 5 rice hybrid. The rice variety IR-36 (local check) gave the poor performances in comparison to all rice hybrids under test.

Summary Table 26 Mean plant population and growth parameters at different growth intervals of rice hybrid and local check variety

S. No.	Rice hybrids	Plant population/m ²	Plant height (cm)			Number of tillers/plant		
			30	60	90 DAT	30	60	90 DAT
1	Pro-Agro 6444	25.00	66.45	117.35	122.65	14.16	14.24	14.70
2	Pro-Agro 6201	25.00	71.10	119.00	122.70	12.80	12.85	12.85
3	Pro-Agro 6129	25.00	68.50	118.55	120.75	11.85	11.85	11.85
4	Pro-Agro 6111	25.00	69.60	120.80	127.00	11.83	11.88	11.88
5	PHB 71	25.00	71.95	127.55	139.75	12.20	12.20	12.45
6	Shabnam (403)	25.00	68.20	119.15	127.40	10.93	12.10	12.10
7	MPH 222 (Tara)	25.00	69.35	22.85	129.85	12.20	13.50	13.50
8	Advanta 801	25.00	68.40	120.35	129.85	13.30	13.35	13.35
9	JRH 4	25.00	69.65	121.90	128.80	12.50	12.51	12.51
10	JRH 5	25.00	71.95	126.70	129.00	12.15	15.15	12.15
11	IR 36 (Local check)	25.25	64.35	119.15	120.80	6.35	6.42	6.46
	C.D. (5%)	0.653	4.50	4.57	7.68	1.39	1.51	1.67

Summary Table 27 Mean yield-attributes, yield and economics from different rice hybrid as against the local

check variety

S. No.	Rice hybrids	Number of effective tillers/hill	Length of panicle (cm)	Weight of panicle (g)	No. of sound grains/panicle	No. of chaffy grains/panicle	Test weight of 1000-grains (g)	Grain yield (q/ha)	Straw yield (q/ha)	Harvest index (%)	Net return (Rs/ha)	B:C ratio	Production efficiency (kg/ha/day)	Crop duration (days)
1	Pro-Agro 6444	14.41	28.30	7.83	1133.75	171.50	24.95	91.74	113.74	44.65	39620	3.18	66.00	139
2	Pro-Agro 6201	12.21	27.95	6.73	976.75	401.25	22.18	88.12	106.81	45.21	37243	3.05	69.93	126
3	Pro-Agro 6129	11.31	26.90	5.95	823.50	294.75	23.96	80.74	98.98	44.93	32649	2.80	66.18	122
4	Pro-Agro 6111	11.35	28.35	6.10	658.00	312.00	23.96	68.67	92.68	42.56	25397	2.40	57.22	120
5	PHB 71	12.05	31.06	6.20	924.25	310.26	24.48	85.87	94.10	47.71	35430	2.95	68.15	126
6	Shabnam (403)	11.52	28.25	5.75	856.50	220.25	22.52	78.12	94.12	45.36	30936	2.71	66.20	118
7	MPH 222 (Tara)	12.73	29.75	7.00	979.25	350.00	23.22	88.37	101.62	46.51	37181	3.05	71.84	123
8	Advanta 801	12.85	29.20	7.48	1054.75	165.25	24.06	88.74	110.99	44.43	37770	3.08	70.43	126
9	JRH 4	12.24	28.90	5.85	871.00	193.50	25.99	83.74	107.99	43.68	34750	2.92	76.12	110
10	JRH 5	11.73	28.70	5.45	689.25	307.50	25.97	75.23	89.74	45.60	29084	2.60	71.65	105
11	IR 36 (Local check)	5.26	27.95	4.90	651.25	97.25	21.90	61.99	87.24	41.54	22580	2.34	48.81	127
	C.D. (5%)	0.064	2.13	2.00	214.57	139.09	2.75	15.52	3.93	3.22			4.516	--
													13.042	--

SUMMARY, CONCLUSION
AND SUGGESTIONS

CHAPTER VI

SUMMARY, CONCLUSION AND SUGGESTIONS

In this chapter, a brief summary of investigation is presented. Attempts have also been made to conclude the results.

SUMMARY

The present study entitled “**Performance of promising rice hybrids for the superior yield-attributing traits and productivity under Kymore plateau**” was conducted at AICRIP, College of Agriculture, Rewa (M.P.) during *kharif* season 2006. The objectives of the investigation were as under:

1. To evaluate the hybrid rice varieties for yield attributing characters and grain yield and their suitability in Rewa division.
2. To study the correlation between yield and yield attributing traits of rice hybrid.
3. To work out the economics of different treatments

The soil of experimental field was clay-loam in texture and neutral in reaction (pH 7.1). The soil was medium in nitrogen and low in phosphorus and potassium.

The treatments comprised eleven rice hybrids including one local check variety (Pro-Agro 6444, Pro-Agro 6201, Pro-Agro 6129, Pro-Agro 6111, PHB 71, Shabnam (403, MPH 222 (Tara), Advanta 801, JRH 4, JRH 5 and local check IR 36). The experiment was laid out in a randomised block design with four replications. An uniform dose of 120 kg N, 60 kg P₂O₅ and 30 kg K₂O/ha was applied to all the treatments. An uniform dose of 25 kg zinc sulphate per hectare was also applied in all plots as basal dose. Twenty three day old seedlings were transplanted on 20.7.2006 at the rate of one seedling per hill at

the spacing of 20 cm x 20 cm whereas two seedlings/hill in case of IR 36. The crop was harvested on 22.10.2007 and 12.11.2007.

The salient findings of the present investigation are summarized as below:

1. The results indicated that rice hybrid PHB 71 significantly differed from the local check variety IR 36 in respect of plant height, number of tillers/hill, weight of panicle, length of panicle, number of sound and chaffy i.e. unfilled grains per panicle, test weight, grain and straw yield and harvest index.
2. The maximum plant height at 90 DAT (139.75 cm) was recorded by the hybrid PHB 71 followed by MPH 222 and Advanta 801 (129.85 cm).
3. The rice hybrid Pro-Agro 6444 produced the maximum number of tillers per hill at 90 DAT (14.70), followed by MPH 222 (13.50) and then Advanta 801 (13.35). The local check (IR 36) produced less than half tillers/hill.
4. The effective tillers/hill was found significantly maximum (14.41/hill) in rice hybrid Pro-Agro 6444 over rest of the hybrids. However, the equally second and third best hybrids were Advanta 801 and Tara (MPH 222) i.e. 12.73-12.85/hill. IR 36 produced the lowest effective tillers (5.26/hill).
5. The length of panicle was found maximum (31.06 cm) in rice hybrid PHB 71, followed by MPH 222 (29.75 cm). The significantly lowest length of panicle was recorded by Pro-Agro 6129 (26.90 cm).
6. The maximum panicle weight (7.83 g) was produced by Pro-Agro 6444, closely followed by Advanta 801 (7.48 g) and then MPH 222 (7.00 g). The lowest panicle weight (4.90 g) was noted in case of local check (IR 36).
7. The maximum number of sound grains per panicle was recorded by Pro-Agro 6444 (1133.75), closely followed by Advanta 801 (1054.75) and the lowest (651.25) in case of IR 36 (local check).

8. The hybrid Advanta 801 and Pro-Agro 6444 showed superiority by producing minimum number of chaffy (unfilled) grains per panicle (165.25 to 171.50). The local check IR 36 further lowered down the unfilled grains per panicle (only 97.25). The maximum chaffy grains (401.25/panicle) was noted in case of Pro-Agro 6201.
9. The equally maximum test weight (25.97 to 25.99 g) was recorded in case of JRH 5 and JRH 4 rice hybrids. This was closely followed by Pro-Agro 6444 (24.95g), PHB 71 (24.48 g) and then Advanta 801 (24.06 g). The lowest test weight (21.90 g) was recorded in case of IR 36 (local check).
10. In respect of grain yield, the rice hybrid Pro-Agro 6444 maintained its significant superiority by producing the highest grain yield up to 91.74 q/ha, being significantly higher only to Pro-Agro 6111, JRH 5 and the local check IR 36. The extra increase in grain yield from Pro-Agro 6444 was up to 29.75 q/ha (48 %) over the local check IR 36.
11. The rice hybrid Pro-Agro 6444 also produced significantly higher straw yield (113.74 q/ha) over rest of the varieties except Advanta 801 (110.99 q/ha). This was followed by JRH 4 (107.99 q/ha). The lowest straw yield (87.24 q/ha) was from IR 36.
12. The harvest index also differ significantly among the varieties. The maximum harvest index (47.71 %) was recorded by PHB 71, followed by MPH 222 (46.51 %) and then JRH 5 (45.60 %) and the lowest (41.54 %) in case of local check IR 36.
13. The highest net return (Rs.39620/ha) was recorded by rice hybrid Pro-Agro 6444 equally followed by Advanta 801 (Rs.37770), Pro-Agro 6201 (Rs.37243) and MPH 222 (Rs.37181/ha). The PHB 71 attained the fifth position (Rs.35430/ha). The lowest net return only Rs.22580/ha was obtained from the local check (IR 36). The benefit L cost ratio eventually followed the same trend. It was highest (3.18) in case of Pro-Agro 6444 and the lowest (2.34) in case of IR 36.

14. Leaf blast, brown spot and false smut disease severity were assessed in the tested hybrids under irrigated ecosystem. Among the tested hybrids, the entries that had exhibited highly resistant reaction showing broad spectrum of resistance were JRH 4, JRH 5, Pro-Agro 6201, Pro-Agro 6111 and PHB 71 over local check IR 36.
15. The hybrid JRH 4 recorded the maximum production efficiency (76.12 kg/ha/day), closely followed by MPH 222 (Tara) (71.84 kg/ha/day), JRH 5 (71.65 kg/ha/day) and then Advanta 801 (70.43 kg/ha/day). The Pro-Agro 6111 and IR 36 (local check) recorded significantly lowest production efficiency (48.81 to 57.22 kg/ha/day).
16. The correlation studies indicate that panicle length was positively correlated with the plant height, panicle weight with tillers/hill, sound grains/panicle was correlated positively with tillers, panicle length and weight. Chaffy grains were positively correlated with plant height. Test weight positively correlated with plant height and panicle length whereas negatively correlated with chaffy grains. The grain yield was positively correlated with tillers, panicle weight, sound grains/panicle at 1 % level of significance, whereas correlated with panicle length, chaffy grains and test weight at 5 % level of significance.

CONCLUSION

1. Amongst the rice hybrids studies, Pro-Agro 6444 proved it's suitability for Rewa region for performing the best in respect of number of tillers per hill, number of effective tillers/hill, number of sound grains/panicle, weight of panicle, grain yield (91.74 q) and straw yield (113.74 q/ha). Also the maximum net return up to Rs.39,620/ha was secured from Pro-Agro 6444.
2. This was equally followed by Advanta 801 (Rs.37770), Pro-Agro 6201 (Rs.37243) and then MPH 222 (Rs.37181/ha net return).

3. JRH 4, JRH 5, Pro- Agro 6201 and PAC 801 exhibited highly resistant reaction to leaf blast, brown spot and false smut diseases under natural epiphytotics.
4. As far as production efficiency is concerned, the rice hybrid JRH 4 performed the best, followed by JRH 5 giving production efficiency up to 76.12 and 71.64 kg/ha/day, respectively

SUGGESTIONS

1. The results of the present study appears to be highly encourageous. The rice hybrids are the new plant types to rice growers of India, so there is a great need of evaluating the actual package of practices for different agro-climatic zones/regions. Research experiments on other agronomic aspects should also be conducted on rice hybrids in comparison to the conventional varieties of the regions/zones for the next few seasons.
2. The present study should be repeated for a five years more at different locations to draw a definite (valid) conclusion.

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APPENDICES

APPENDIX – I

Prevailing market rates

S. No.	Particulars	Rate
1.	Land preparation (a) One tractor ploughing / harrowing (b) One discing and planking (c) One puddling and levelling	Rs. 300/ha Rs. 200/ha Rs. 300/ha
2.	Labour rate (Untrained)	Rs. 78/day
3.	Seed (a) Hybrid seed (b) Foundation seed	Rs. 11000/q Rs. 2500/q
4.	Fertilizers (a) Urea i.e.N (b) S.S.P. i.e.P ₂ O ₅ (c) Muriate of potash (MOP) i.e.K ₂ O (d) Zinc sulphate	Rs. 505/q Rs. 11/kg Rs. 242/q Rs. 15/kg Rs. 466/q Rs. 7.75/kg Rs. 1770/q
5.	Seed treatment (Bavistin)	Rs. 38/100g
6.	One irrigation	Rs. 808/ha
7.	Sale price (a) Grain-i) From hybrid seed ii) from certified seed (b) Straw	Rs. 580/q Rs. 580/q Rs. 40/q
8.	Insecticide (Triazophos)	Rs. 400/1000ml
9.	Interest on working capital	10% per annum
10.	Nursery bed preparation	Rs. 1000/ha
11.	Land revenue	Rs. 15/ha

APPENDIX – II

Cost of cultivation /ha excluding treatments

S. No.	Particulars	Number /Quantity	Cost of Rs.
1.	Nursery bed preparation	1/10ha	100.00
2.	Raising of nursery	3 labour	234.00
3.	Seed treatment (Bavistin)	270 g	100.00
4.	Uprooting and transplanting	40 labour	3120.00
5.	Ploughing and harrowing (main field)	1 Nos.	600.00
6.	Levelling and puddling (main field)	2 Nos.	600.00
7.	Fertilizer 120 kg N/ha		1320.00
8.	Fertilizer 60kg P ₂ O ₅ /ha		900.00
9.	Fertilizer 30 kg K ₂ O/ha		232.00
10.	Fertilizer-Zinc as Zinc sulphate	25 kg	442.00
11.	Two top dressing	2 labour	156.00
12.	Irrigation	10 Nos.	1600.00
13.	Weeding in main field	15 labour	1170.00
14.	Cost of triazophos	2.4 lit	960.00
15.	Spraying of insecticide	4 labour	312.00
16.	Harvesting of crop	25 labour	1950.00
17.	Threshing and winnowing	25 labour	1950.00
18.	Land revenue	1 ha	15.00
19.	Interest on working capital (Rs. 11,257.00/ year)	8 months	785.00
		Total	16474.00

Net return from the different rice hybrids and the local check variety

Rice Varieties	Grain yield (q/ha)	Value of grain (Rs./ha)	Straw yield (q/ha)	Value of straw (Rs./ha)	Gross income (Rs./ha)	Cost of Cultivation (Rs./ha)	Treatment cost		Total expenditure (Rs/ha)	Net income (Rs/ha)	B:C rates
							Seed rate	Cost of seed			
Pro. Agro-6444	91.74	53209	113.74	4550	57759	16474	15	1650	18139	39620	3.18
Pro. Agro-6201	88.12	51110	106.81	42.72	55382	16474	15	1680	18139	37243	3.05
Pro. Agro-6129	80.74	46829	98.98	3959	50788	16474	15	1650	18139	32649	2.80
Pro. Agro-6111	68.67	39829	92.68	3707	43536	16474	15	1680	18139	25397	2.40
PHB-71	85.87	49805	94.10	3764	53569	16474	15	1650	18139	35430	2.95
Shabam (403)	78.12	45310	91.12	3765	49075	16474	15	1680	18139	30936	2.71
MPH-222 (Tara)	88.37	51255	101.62	4065	55320	16474	15	1650	18139	37181	3.05
Advanta-801	88.74	51469	110.99	4440	55909	16474	15	1680	18139	37770	3.08
JRH-4	83.74	48569	107.99	4020	52889	16474	15	1650	18139	34750	2.92
JRH-5	75.23	43633	89.74	3590	47223	16474	15	1680	18139	29084	2.60
IR-36 (Local check)	61.99	35954	87.24	3490	39444	16474	15	375	16864	22580	2.34

Appendix IV

Plant population

Source of variation	d.f	SS	MSS	F cal	F Tab
Replication	3	0.614	0.204	1.000	2.92
Treatment	10	2318.409	231.840	1133.444	2.09
	30	6.136	0.204		
Total	43				

Appendix V

Plant height at 30 DAT

Source of variation	d.f	SS	MSS	F cal	F Tab
Replication	3	67.716	22.572	2.320	2.92
Treatment	10	208.082	20.808	2.139	2.09
Error	30	291.824	9.727		
Total	43				

Appendix VI

Plant height at 60 DAT

Source of variation	d.f	SS	MSS	F cal	F Tab
Replication	3	97.758	32.586	3.256	2.92
Treatment	10	780.642	78.064	7.801	2.09
Error	30	300.202	10.006		
Total	43				

Appendix VII

Plant height at 90 DAT

Source of variation	d.f	SS	MSS	F cal	F Tab
Replication	3	213.392	71.130	2.512	2.92
Treatment	10	1203.61	120.361	4.252	2.09
		6			
Error	30	849.198	28.306		
Total	43				

Appendix VIII

Number of tillers/hill at 30 DAT

Source of variation	d.f	SS	MSS	F cal	F Tab
Replication	3	22.592	7.530	8.019	2.92
Treatment	10	163.205	16.320	17.380	4.252
Error	30	28.170	0.938		
Total	43				

Appendix IX

Number of tillers/hill at 60 DAT

Source of variation	d.f	SS	MSS	F cal	F Tab
Replication	3	12.372	4.123	3.731	2.92
Treatment	10	163.571	16.357	14.800	2.09
Error	30	33.154	1.105		
Total	43				

Appendix X

Number of tillers/hill at 90 DAT

Source of variation	d.f	SS	MSS	F cal	F Tab
Replication	3	11.466	3.822	2.841	2.92
Treatment	10	171.905	17.190	12.780	2.09
Error	30	40.352	1.345		
Total	43				

Appendix XI

Number of effective tillers/hill

Source of variation	d.f	SS	MSS	F cal	F Tab
Replication	3	0.018	0.006	3.00	2.92
Treatment	10	208.301	20.830	10.7	2.09
Error	30	0.497	0.017		
Total	43				

Appendix XII

Length of panicle

Source of variation	d.f	SS	MSS	F cal	F Tab
Replication	3	14.457	4.819	2.214	2.92
Treatment	10	47.241	4.724	2.170	2.09
Error	30	65.299	2.176		
Total	43				

Appendix XIII

Weight of panicle

Source of variation	d.f	SS	MSS	F cal	F Tab
Replication	3	2.403	0.800	1.159	2.92
Treatment	10	30.945	3.094	4.480	2.09
Error	30	20.720	0.690		
Total	43				

Appendix XIV

Number of sound grain/panicle

Source of variation	d.f	SS	MSS	F cal	F Tab
Replication	3	41324.432	13774.811	0.623	2.92
Treatment	10	1330283.182	103028.32	4.665	2.09
Error	30	662500.818	22083.361		
Total	43				

Appendix XV

Number of chaffy grains/panicles

Source of variation	d.f	SS	MSS	F cal	F Tab
Replication	3	18070.0	6023.363	0.649	2.92
Treatment	10	343692.045	34369.205	3.703	2.09
Error	30	278373.409	9279.113		
Total	43				

Appendix XVI

Test weight of 1000-grain in gram

Source of variation	d.f	SS	MSS	F cal	F Tab
Replication	3	11.189	3.729	1.031	2.92
Treatment	10	77.796	7.779	2.151	2.09
Error	30	108.492	3.616		
Total	43				

Appendix XVII

Grain yield (q/ha)

Source of variation	d.f	SS	MSS	F cal	F Tab
Replication	3	1309.339	436.446	3.777	2.92
Treatment	10	3435.526	346.552	2.999	2.09
Error	30	3466.431	115.547		
Total	43				

Appendix XVIII

Straw weight (q/ha)

Source of variation	d.f	SS	MSS	F cal	F Tab
Replication	3	1.499	0.499	0.120	2.92
Treatment	10	3256.485	325.648	78.843	2.09
Error	30	123.902	4.130		
Total	43				

Appendix XIX

Harvest index

Source of variation	d.f	SS	MSS	F cal	F Tab
Replication	3	19.530	6.510	1.309	2.92
Treatment	10	266.204	26.620	5.356	2.09
Error	30	149.104	4.970		
Total	43				

Appendix XX

Leaf blast disease

Source of variation	d.f	SS	MSS	F cal	F Tab
Replication	3	3.997	1.332	1.184	2.92
Treatment	10	45.992	4.599	4.089	2.09
Error	30	33.740	1.124		
Total	43				

Appendix XXI

Brown spot disease

Source of variation	d.f	SS	MSS	F cal	F Tab
Replication	3	0.282	0.094	0.403	2.92
Treatment	10	92.984	9.298	39.821	2.09
Error	30	7.005	0.233		
Total	43				

Appendix XXII

False smut disease

Source of variation	d.f	SS	MSS	F cal	F Tab
Replication	3	0.041	0.013	0.114	2.92
Treatment	10	11.067	1.106	9.334	2.09
Error	30	3.557	0.118		
Total	43				

Appendix XXIII

Production efficiency

Source of variation	d.f	SS	MSS	F cal	F Tab
Replication	3	909.961	303.320	3.717	2.92
Treatment	10	2307.814	230.781	2.828	2.09
Error	30	2447.625	81.587		
Total	43				

VITA

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