

Study on Relative Performance of Various Hybrids and Improved varieties of Rice under System of Rice Intensification (SRI) cultivation

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By

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2010

CERTIFICATE-I

This is to certify that the thesis entitled, **study on related performance of various hybrids and improved varieties of rice under system of rice intensification (SRI) cultivation** submitted in partial fulfillment of the requirement for the degree of **MASTER OF SCIENCE in AGRICULTURE** of Jawaharlal Nehru Kirshi Vishwa Vidyalaya, Jabalpur is a record of the bonafide research work carried out by **Mr. BIRENDRA LAL PRAJAPATI** 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, **study on relative performance of various hybrids and improved varieties of rice under system of rice intensification (SRI) cultivation** submitted by **Mr. BIRENDRA LAL PRAJAPATI** to Jawaharlal Nehru Kirshi Vishwa Vidyalaya, Jabalpur in partial fulfillment of the requirement 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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LIST OF ABBREVIATIONS

Words	Abbreviations
Centimeter	cm.
Co-workers	<i>et al.</i>
Critical difference	C.D.
Degree of celcius	⁰ C
Degree of freem	d.f.
Days after transplanting	DAT
Figure	Fig.
Fisher's value	"F" value
Gram(s)	Gm
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	/
Percent	%
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	*
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
Thermo Sensitive Genetic Male Sterile	TGMS
Variety	V

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VITA

The author was born on 1th July 1984 at village-Makari, post Manipur tehshil – Ajaygarh Distt-Panna (M.P.). He passed his High School Certificate Examination from Govt. R.P. Higher Secondary School Panna, during the year 2000 and also passed Higher Secondary School Examination from. Govt. R.P. Higher Secondary School, Panna during the year 2003 with first division.

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The author actively participated in NSS and various co- curricular activities of the college during this study.

CHAPTER I

INTRODUCTION

Rice Almost 90% of the world's area under the rice is in Asia and an equal percentage is produced and consumed in Asia itself. Rice is the main food crop not only in the world, but in India and Madhya Pradesh. It is cultivated in about 154 million ha of land across the globe which produce 603 million tons of grain with the productivity of 3916 kg/ha. Rice supplying 23% of the per capita energy to six billion people world wide and fulfill 43% of calorie requirement of more than 70% Indian population. Presently, rice is grown in 48.6 million ha area with the production of about 97.68 million tons in India. In M.P. rice is grown in the area of about 15.59 lakh ha with production of 14.62 lakh tons and productivity of 989 kg/ha which is far below than the average national productivity (2010 kg/ha).

In Madhya Pradesh nearly 15.59 lakh ha area is under rice cultivation out of which around 5000 ha is under hybrid rice, particularly in under irrigated condition production system. Rice hybrid produce about 14-18% higher grain yield, have a more vigorous and extensive root system (Yang and Sung, 1988), increased growth rate during vegetative phase, more efficient sink formation and greater sink size (Kabaki,1993), greater carbohydrate translocation from vegetative part to spikelets (Song et al.1990), larger leaf area index (LAI) during the grain filling period and increased spikelet number and to some extent in grain weight (Agata,1990). In recent years, farmers are growing rice hybrids in lowlands and bunded uplands under irrigated ecosystem in M.P. and Rewa division in particular consequently : the productivity of rice is shaving rising trend in the irrigated agro-ecosystem.

To assure food security in the rice-consuming countries of the world, those countries will have to produce 50% more rice with improved quality to meet consumers' demand by 2025. This additional rice will have to be produced on less land with less water, less labour, and fewer chemicals. The task becomes

even more difficult when rice quality preferences gradually receive more attention. Crop improvement and management have played an important role in increasing the production of major food crops in the past. There is no doubt that the task of making gains becomes even more difficult when rice yield is already at the high level. The System of Rice Intensification (SRI), developed in Madagascar over a 20-year period and synthesized in the early 1980s (Stoop et al 2002; Uphoff et al 2002), offers opportunities to researchers and farmers to expand their understanding of potentials already existing in the rice genome. Experience with SRI methods suggests that average rice yields can be about double the present world average without requiring a change in cultivar's or the use of purchased input (Wang et al 2002). Moreover, only about half as much water per season is required for these higher yields. Crop protection requirements are reduced because SRI plants are more resistant to damage by pests and diseases. The SRI methodology for raising rice production makes three main changes in irrigated rice cultivation: transplanting younger seedlings, preferably 8-15 days old before the plants enter their fourth phyllochron of growth, planting the seedlings singly rather than in clumps of 3-6 plants, and keeping the paddy soil moist but not continuously saturated during the plants' vegetative growth phase.

System of rice intensification is referred as a set of practices rather than a technology based upon a number of insights in to how to create the best growing environments for rice plants as compared to other improved methods of rice cultivation under limited water resources.

Keeping these facts in view, the present investigation is, therefore, proposed to study on response of hybrid rice variety under SRI system of rice intensification with the following objectives:

1. To study the rice hybrid under SRI for growth and yield attributing characters.
2. To identify the suitable rice hybrids under SRI for maximum grain yield under Kymore plateau region .
3. To find out the economic viability of rice hybrids.

CHAPTER II

REVIEW OF LITERATURE

There is enormous literature available supporting the different aspect of agronomic management of conventional system of cultivation with high yielding rice varieties, but literature supporting SRI with hybrid varieties is limited. SRI is coming forward for different agro- climatic condition across the land as well as of India and M.P. also. In this chapter, an attempt has been made to present the review of available literature on performance of different hybrids varieties under system of rice intensification.

Verma *et al.* (1991) stated that the highest number of effective tillers/hill was recorded with the widest spacing of 20cm x 20cm than the 20cm x 15cm and 20cm x 10cm spacing.

Wagh and Thorat (1992) reported that higher plant density reduced harvest index as compared with lower plant density, which might be due to more straw yield at closer spacing particularly during rainy season.

Padamja and Reddy (1998) evaluated the performance of hybrid rice APHR 2 to varying plant spacing and reported that the crop transplanted at 15cm x 15cm spacing registered higher grain yield mainly due to increased dry matter production/m² and panicles/m² as compared to 15cm x 20cm spacing. They further noted that increased panicle weight, filled grains per panicle and numerically higher 1000 grain weight under 15cm x 20cm spacing could not compensate the plant population per unit area to that of closer spacing at 15cm x 15cm.

Shrinivasula *et al.* (1999) reported from Bapatla (Andhra Pradesh) that performance of rice hybrids APHR 1 and APHR 2 were identical but better than inbred rice cultivar Chaitanya with regards to LAI, CGR and NAR during the early stage of growth when planted at a normal spacing of 20cm x 10cm.

Shivani and Sree Rama Reddy (2000) conducted investigation involving ten hybrids and two other varieties of rice to study the nature and extent of relationship of yield components and physiological traits. Grains yield showed positive correlation with plant height, days to 50% flowering and leaf area per plant as 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 LAI and NAR showed positive direct effect on grain yield per plant.

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

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 (3.08g) over other hybrids. The hybrids 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.

Barison (2002) reported that planting distances of 25cm x 25cm and 20cm x 20cm were more efficient than 14cm x 14cm showing that root length density (cm) and proliferation in broad having comparably more grains/m² as well as 1000-grain weight(gm).

Stoop *et al.* (2002) reported that SRI works to improve the growth and function of rice plants root systems and enhance the numbers and diversity of the soil biota that contribute to plant health and productivity.

Oteng and Anna (2003) Ghana (S.Africa) observed that 10-15 days old seedlings produced more number of effective tillers and grains/ panicle than those of 15-20 days and 20-25 days old seedlings under SRI.

Zhang Jiaguo (2004) conducted O.F.T over 100 in China and comparing SRI methods with the yields obtained with modern, high input methods. These gave an average of 7.5 tons/ha, while SRI plots gave an average of 10.5 t/ha.

Thiyagarajan (2004) reported that 11% reduction in costs of production in Tamil Nadu state for 100 farmers using SRI vs standard methods. With higher SRI yields, farmer's net returns/ha went up by 114% with SRI.

Zhu Defeng *et al.* (2004) reported that yields of 18 to 20.3 t/ha in Yunnan Province of China combining SRI methods with hybrid varieties.

Alapti Satyanarayana (2004) reported that during cold period in Andhra Pradesh in February had no effect on SRI plots while it had an adverse impact on conventionally grown rice.

Mahadevappa (2004) reported that as a result of concerted and coordinated efforts, for the first time in country the states released for 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 trials of commercial hybrids tested during kharif of 1999 - 2000 in 64 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 Sahyardi 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.

Uphoff (2004) reported that the SRI system has been adopted in China and now various countries are also operate their rice cultivation under SRI system as the production has increased from 14 to 209% over traditional system of cultivation across various countries from China to Gambia.

Panwar (2005) conducted experiment at Agriculture research station, Kota, 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 programmed involving Kasturi, Basmati 370, Pusa Basmati 1 Taraori Basmati, IET 13846 and IR-64 as parents may be taken up to generate desirable segregates for selections. 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 insure 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 in this view, Sharma et al. (2005) evaluated ten cms lines with varying sowing dates at IARI, New Delhi. Environment-wise analysis of variance revealed significant difference 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

difference in performance of cms lines may disappear for these two traits due to the influence of sowings 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 the development of high yielding heterotic rice hybrids 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 (5cms 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 liner 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 may not necessarily generate a stable hybrid.

Swain *et al.* (2005) conducted field experiment at 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. Through 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 Vijay Kumar (2005) evaluated twenty hybrids along with their nine parents at Agriculture Research Station Mannuthy Kerala. Five genetically diverse and widely adapted rice varieties of Kerala viz., Annapoorna (Ptb 35) Matta Triveni (Ptb 45) Kanchana (Ptb50), IR 36 and Aiswarya (Ptb 52) were crossed with four stable cytoplasm genetic male sterile lines viz., IR62829 A, IR 68890 A, PMS 10 A in a line x tester mating design. Among the tester high gca for different characters were expressed by different genotype. Kanchana (Ptb50) 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 most all the characters under study. Other hybrids having significant sca effect for grain yield were IR68891A x IR 36, IR62829A x Matta Triveni, IR62829A x Kanchana and IR 68891A x Annapoorna. Most of the hybrids expressed negative sca effect for number of field grains per panicle. Only three hybrids viz., IR62829A 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 involves male sterile lines combining ability for number of filled grains per panicle assumes 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 (IR68891A, 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 Agriculture 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 varied from cross to cross due to genetic background of their diverse parents. Overall two hybrids IR 68888A x PB 3-17-57-1 and IR 58025A 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 lines 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, length elongation ratio and breadth-wise expansion ratio. Generally rice with more length 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 consumer of Tamilnadu. The hybrid TS 29 x CR 689-612 was the best followed by TS 29 x IR 63883, TS 18 x CB 96073 and TS 16 x CB 90733 for this trait. None of the hybrids was superior to improved White Ponni for length elongation ratio but some either superior or on par with the three line hybrid ADTRH 1.

Li Xiaoyuan *et al.* (2005) reported that 8% reduction in costs of production in Xinsheng village, Sichuan province in China, where SRI use went from 7 farmers in 2003 to 398 farmers in 2004. The net profit /ha with SRI was 22% higher in 2004.

Shekhar Kumar and Jayesh Talati (2005) reported that 17% reduction in cost of production for 110 farmers in Purulia district, West Bengal, where SRI use in upland production went from 4 farmers to 150 over 3 seasons. An IWMI (International Water Management Programme - India) evaluation team compared

their costs of production for SRI vs for standard upland rice production. Farmer's net returns /ha with SRI were 67% higher.

Gnanasekaran *et al.* (2006) evaluated thirty two rice hybrids involving four TGMS lines and eight testers for combining ability and heterosis. Among the parents, the TGMS lines viz., GD 98049, and GD 98014, and the testers CB 97033 and IR 72 were the best based on the mean and gca effects. Considering the mean performance, sca effect 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 strawl 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 indicia cytoplasm male sterile lines and four japonica restorer lines with wide compatibility as parents to make crosses . The an additive-dominance-epistatic on heading date were analyzed using an additive-dominance-epistatic model. The result showed that the genetic variation of heading date could be attributed to additive dominance and additive x additive epistatic effects with domains genetic effect being predominant followed by additive x additive epistatic effects. Analysis of genetic effect 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 under non-flooded irrigated conditions with Rasi and Vandna as check varieties. The checks known for their adaptation to water stress were planted at regular intervals to serve as controls. Twenty seven varieties showed yield advantages over the check Resi. The popular varieties grown into irrigated conditions such as "Jaya" IR8, 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 were very low among rainfed upland group varieties. Most of the selected irrigated varieties showed better performance under favorable moisture condition 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 condition. 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 level 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. KJHRS 21 was the most promising one. The result from trials conducted for five years from 1999 to 2003 revealed that KHR 21 recorded higher grain yield at different locations (ZARS-Mudigere, ARS- Ponnampet and ARS- Sirsi). By considering overall % increase over check KHR 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 KHR 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 result revealed that "PA 6201" rice hybrids with high seedling height in early stage gave highest grain yield (6.36 t/ha) and net return. Adoption of double transplanting using seedling 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 and net return compared with the standard practice of single planting. However, allowing seedling for 40 or 50 days in

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 Cuttak is characterized by sandy clay loam soil. Rice hybrids NRH 1, NRH 3 and NRH 4 are 3 local checks IR 64 CR 749-20-2 and Lalat were tasted. Among 7 rice hybrids both released and pre released with 3 local checks tested under field condition. PA6201 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 no./m² (35379) and harvest index (48%) with moderate sterility (26%) and panicle number/m² (336) at maturity.

Rahman *et al.* (2006) reported that trials were conducted during the boro season of 2002-03 and 2003-04 in Nandigram and Kahala upazilas, Bogra district, Bangladesh, to evaluate the system of rice intensification (SRI) practice and make a comparative study between SRI and farmer practice in rice cultivation. The analyses of data, showed that the number of tiller per hill, number of effective tiller per hill, panicle length, number of grains panicle, and 1000-grain weight were higher for SRI plots than under farmer plots. Both yield and gross return were significantly higher under SRI. Net return per hectare under SRI was also significantly higher (59%) over farmers practice.

Chen (2006) reported that Yongyou6 was planted in Xiaoshan area (Zhejiang Province, southeast China) using the system of rice intensification. Under same soil conditions with same water and fertilizer application, the yield of Yongyou6 decreased from 791.0 kg to 781, 751 and 733 kg when the density increased from 9 000/667 m² to 12 000, 15 000 and 18 000/667 m². The total grains per panicle and the filled grains per panicle decreased when the density increased, while the rate of seed setting and the 1000-grain weight only showed slight differences when the planting density changed. The growth duration (143 days) was not affected by the density.

Kabir Humayun and Uphoff (2007) reported that SRI yields on Farmer Field School (FFS) in the wet season, without any supplementary irrigation, were 6.4 t ha⁻¹ compared with farmers' prior average yields of 2.1 t ha⁻¹. Three years after, one third of the farmers in a community had received FFS training, almost all of its farmers were using SRI methods. This study confirmed many previously reported benefits from SRI practices, particularly important for limited-resource households.

Haden *et al.* (2007) observed that system of rice intensification prescribes the use of young seedlings, planted at reduced densities and managed using reduced irrigation and frequent mechanical weeding, as a means of optimizing rice yields and reducing input costs. The weed competitive cultivar (Sarinah) more effectively suppressed the dry weight of sedges and grasses than did the control variety (IR-64), but had no influence on the dry weight of broadleaved weeds. Despite reducing total weed dry weight by 32%, use of a competitive cultivar had no effect on the density and species number of weed classes or any of the community-scale measures of diversity.

Zhao Hui *et al.* (2007) reported that using the system of rice intensification (SRI) as a basic mode, the effect of various cultivation methods on super hybrid rice Liangyou0293 growth characteristics and yield were investigated. A grey correlation analyses between the main economic characters and actual yield, and between dissimilarity cultivation way and ideal way were conducted to select and establish a cultivation technique target method of super hybrid rice to integrate big panicle with many panicles. The results showed that a valid panicle number is the characteristic closest to yield, followed by 1000-grain weight and burliness rate.

Uphoff (2007) discussed in agro ecological approaches, and specifically the system of rice intensification. SRI is raising yields 30 -100 % without requiring new seeds, chemical fertilizers or agrochemicals, while using less water and obtain maximum performance from the genetic potential of agricultural plan.

Uphoff (2007) reported that SRI crop were more resistant to most pests and diseases and better able to tolerate adverse climate influences such as drought, storms, hot spells or cold snaps. The length of the crop cycle is also reduced with higher yields. Resistance to biotic and abiotic stresses will become more important in the coming decades as farmers around the world have to cope with the effects of climate change and the growing frequency of extreme events. The resistance of rice plants to lodging caused by wind and/ or rain, given their larger root systems and stronger stalk, can be quite dramatic. It also says that use of SRI methods reduces the agronomic and economic risks that farmers face.

A co-ordinated trial was initiated to evaluate the genotypic response (Early, medium, late and hybrids) in SRI at 16 locations of India under AICRIP programme in the kharif 2008. The grain yield of cultivars differed significantly at all locations. At Southern region (Aduthurai, Coimbatore, Ammbasamudram, Pundicherry, DRR - Hyderabad and Siruguppa) in clay and clay loam soils, the performance of hybrids was promising at Aduthurai (9.04 t/ha with CO-RH 3) and Siruguppa (7.22 t/ha with HB 6516) while medium duration cultivar COR 48 (9.13 t/ha) DRR-Hyderabad (6.52 t/ha and 7.45 t/ha with PA 6444 and PA 6201) and Siruguppa (7.22 t/ha with HB 6516) while medium duration cultivars COR 48 (9.13 t/ha) at coimbtore recorded higher grain yield. The performance of late and medium duration cultivars were promising and recorded higher grain yield at Coimbtore, Ammbasamudram, Siruguppa and Pundicherry as compared to early duration cultivars.(Anonymus,2008).

J. Shekher *et al.* (2009) found that the plants under SRI were taller by 7.4 cm and matured 7 days earlier compared to conventional transplantin. panical weight was significantly more is SRI (3.7 gm) compared to conventional transplanting (2.85 gm) and B:C (1.79/SRI) and (1.73/conventional) .

CHAPTER – III

MATERIALS AND METHODS

The present investigation entitled **Study on relative performance of various hybrids and improved varieties of rice under system of rice intensification (SRI) cultivation** was undertaken to evaluate the suitability of rice hybrid for Rewa region.

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 under All India Co-ordinate Rice Improvement Project, J.N.K.V.V., College of Agriculture Farm, Rewa (M.P.) during *kharif* season, 2009. The selection of site was done such that it was the representative of one of major rice growing areas 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°31'N, longitude 81°15'E and altitude of 365.7 metre 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 favorable for growth and development of rice crop.

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 2009 to November 2009 are presented in Table no. 1 and graphically illustrated in Fig.1.

Table no.1 Meteorological data during crop season (Kharif 2009- 2010)

SMW	Date	Rainfall in mm	Temperature		Humidity		Sun shine	No. of rainy day
			Max.	Min.	Max.	Min.		
23	1-7 June	0.0	41.9	26.8	71.6	55.3	7.05	0
24	8-14	0.0	41.7	28.5	72.4	65.6	8.50	0
25	15-21	0.0	43.2	23.3	64.4	71.2	8.90	0
26	22-28	13.4	40.2	24.2	66.8	64.4	8.70	1
27	29-5 July	75.0	36.1	21.6	87.3	44.3	3.3	4
28	6-12	154.0	31.8	21.4	91.1	52.7	3.7	4
29	13-19	64.4	32.2	22.2	90.6	57.1	6.3	3
30	20-26	8.0	30.9	23.4	88.2	53.3	7.2	1
31	27-1 August	24.4	34.5	25.6	79.1	45.3	6.8	2
32	2-8	42.4	33.8	25.3	77.1	45.0	4.6	3
33	9-15	38.2	31.8	25.6	65.3	51.3	6.3	3
34	16-22	12.0	32.9	25.1	85.7	53.3	7.4	4
35	23-29	49.0	32.0	24.7	87.6	53.0	6.9	3
36	30-5 September	95.0	31.1	24.3	88.8	64.3	5.6	1
37	6-12	22.0	31.7	24.3	86.8	60.4	8.6	2
38	13-19	0.0	33.8	23.0	83.8	48.4	8.6	0
39	20-26	0.0	34.9	24.1	80.4	41.3	4.3	0
40	27-3 October	83.2	30.4	23.6	89.4	68.4	6.9	2
41	4-10	0.0	31.9	19.0	87.3	61.3	8.1s	0
42	11-17	0.0	33.5	16.6	86.1	53.8	8.9	0
43	18-24	0.0	32.2	12.1	86.7	50.1	8.3	0
44	25-31	0.0	31.8	12.6	84.1	47.8	7.6	0
45	1-7 N0vember	0.0	31.0	12.2	86.1	51.1	2.7	0
46	8-14	78.8	29.3	18.2	89.1	67.4	7.0	3
	Total	759.0						36

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 analyzed for various physico - chemical properties. The values of different parameters of the physical and chemical properties of soil are presented in Table no. 2

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

Table no. 2 Physico-chemical properties of the soil

S. No.	Constituents	Values
A.	Mechanical properties	
	1. Sand (%)	30.30%
	2. Silt (%)	32.30%
	3. Clay (%)	37.50%
B.	Chemical properties	
	1. Organic carbon (%) Walkey and Black rapid titration method (walkely and black,1934)	0.61%
	2. Available nitrogen(kg/ha)Alkaline permanganet method (Subbiah and Asija,1958)	270
	3. Available phosphorus (kg/ha) Calorimetric method (olsen et all., 1954)	8.25
	4. Available potash (kg/ha) Flame photometer (Chapman and Pratt, 1961)	153
	5. Soil reaction (pH) Grass electrode pH meter (Piper 1967)	7.1
	6. Electrical conductivity (dsm ⁻¹)at 25 °C S0i0u, Bridge method (Black,1965)	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 no.3

Table no. 3 Cropping history of experimental field

S. No	Years	Kharif season	Rabi season	Zaid/Summer
1.	2004	Rice	Berseem	Fallow
2.	2005	Rice	Wheat	Fallow
3.	2006	Rice	Wheat	Fallow
4.	2007	Rice	Wheat	Fallow
5.	2008	Rice-hybrid	Wheat	Fallow
6.	2008	Rice-hybrid	Wheat	Fallow
(Experimental plot)				

5. Treatments:

Rice hybrids - 10 + Control - 1 = 11

1. JRH 4	V ₁	7. NPH-4113	V ₇
2. JRH 5	V ₂	8. SBH-999	V ₈
3. Bayer-158	V ₃	9. NPH-369	V ₉
4. Bayer-6129	V ₄	10. NPH-567	V ₁₀
5. Tej	V ₅	11. IR-36 (Control)	V ₁₁
6. NPH-207	V ₆		

6. Layout the experiment

Design	:	R.B.D.
Replications	:	3(Three)
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 seedling/hill	:	1
Method of sowing	:	Transplanting

7. Field operations

The field operations practiced in the field from the nursery raising to threshing of the crop are presented in Table no. 4.

(a) Seed rate

Hybrids varieties of rice seed rate seven kg/ha used for nursery raising.

(b) Seed treatment

Seed treatment with bavistin 3g. per 10 kg seeds before sowing.

(c) Nursery raising

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

(d) Field preparation

After harvesting of the rabi crop (Wheat), the field was cultivated 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.

(e) Transplanting

The 15 days old seedlings were transplanted in well puddled main field. Single seedling per hill was transplanted manually. The spacing was kept 20 cm between rows and 20 cm between hills.

(f) Nutrient application

An uniform dose of 120 kg N, 60 kg P₂O₅ and 40 kg K₂O 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.

(g) Weeding

One hand weeding in nursery raising condition and one hand weeding 30-35 day after transplanting of seedling, transplanted rice and nursery conditions, sedge like *Cyperus Difformis*, *Cyperus Iria.*, *Fimbristylis Miliacea*, *Scirpus Articulatus* and common grasses like *Echinochloa Colonum* and *E. crusgalli* weeds were experiments plot and nursery raising time.

(h) Harvesting and Threshing

In general the crop is harvested with traditional sickles by labours. The bundles are kept lying in the field for sun drying and threshing by paddy pedal-operated thresher.

Table no. 4 List of field operations

S. No	Operations	DAT	Date
1.	Preparation of nursery bed		29/06/2009
2.	Sowing of seed in nursery		01/07/2009
3.	Flooding of main field		11/07/2009
4.	Puddling of the main field		14/07/2009
5.	Layout of the field		15/06/2009
6.	Basal application of nutrients		15/07/2009
7.	Transplanting of seedlings		16/07/2009
8.	Top dressing of N at maximum tillering stage	18	03/08/2009
9.	Top dressing of N at booting stage	44	29/08/2009
10.	I st irrigation	19	04/08/2009
11.	II nd irrigation	31	16/08/2009
12.	III rd irrigation	47	01/09/2009
13.	IV th irrigation	52	06/09/2009
14.	V th Irrigation	60	14/09/2009
15.	VI th irrigation	67	21/09/2009
16.	VII th irrigation	72	26/09/2009
17.	VIII th irrigation	78	02/10/2009
18.	IX th irrigation	82	06/10/2009
19.	X th irrigation	90	14/10/2009
20.	Harvesting of crop	100	24/10/2009
		106	30/10/2009
		113	06/11/2009
21.	Threshing of crop		12/11/2009

8. Observations recorded:

(A) Pre-harvest observations :

(a) Morphological observation:

- (i) Plant height at 30 days interval from 30 DAT and maturity
- (ii) No. of tiller/hill 30 days interval from 30 DAT and maturity
- (iii) No. of leaves/ tiller at 30, 60 and 90 DAT
- (iv) No. of root/ hill at 30, 60 and 90 DAT
- (v) Length of root at 30, 60 and 90 DAT

(b) Growth analytical observation:

- (i) DM production/hill at 30 days interval from 30 DAT and maturity
- (ii) CGR at 60 DAT, 90 DAT and Maturity
- (iii) RGR at 60 DAT, 90 DAT and Maturity
- (iv) LAI at 30, 60 and 90 DAT

(B) Post-harvest observations:

- (i) No. of tillers/m²
- (ii) No. of tillers/hill
- (iii) No. of effective tillers/ m²
- (iv) Length of panicle
- (v) Weight of panicle
- (vi) No. of chaffy and sound grains/panicle
- (vii) Grain yield/plot
- (viii) Straw yield/plot
- (ix) Weight of 1000 grains
- (x) Sterility percentage

- (xi) Grain yield /ha
- (xii) Straw yield / ha
- (xiii) Harvest index

(C) Economics analysis of the treatment (per ha basis)

- (i) Cost of cultivation
- (ii) Gross monetary returns
- (iii) Net monetary returns
- (iv) B:C ratio

9. Observation and their procedures

Observations of the characters under study were recorded for comparing the yield performance of varieties. 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 observation :

(a) Morphological observation:

(i) Plant height (cm)

The height of five tagged plants of rice were measured in “cm” from the ground level to tip of the leave at 30 days growth intervals and at harvest stage and the average value were calculated.

(ii) Number of tillers/hill

The number of tillers/hill were recorded for each tagged plant and each shoot arising from the plant was counted as culms including the main shoot and the average was worked out at 30 days growth intervals and at maturity stage.

(iii) Number of leaves /tiller

The number of leaves/tiller was recorded for each tagged plant at 30, 60 and 90 DAT and the average value was calculated.

(iv) Number of roots /hill

The number roots/hill was recorded randomly selected plant at 30, 60 and 90 DAT and the average values were calculated.

(v) Length of roots (cm)

The root length of randomly selected plants of rice were measured in “cm” and the average was work out at 30, 60 and 90 DAT.

(b) Growth analytical observation:

(i) DM production /hill (gm)

Drying of randomly selected plant sample with the help of hot air oven and measured in electronic balance and average were worked out at 30 days growth intervals and at maturity stage.

(ii) Crop Growth Rate

Crop Growth Rate of different hybrids was determined by using following formula and expressed in terms of gm /cm² /day:

$$\text{CGR} = \frac{W_2 - W_1}{Px(t_2 - t_1)}$$

Where W_1 = dry weight per unit at t_1 , W_2 = dry weight per unit area at t_2 ,

t_1 = time of first sampling, t_2 = time of second sampling.

(iii) Relative Growth Rate

Relative growth rate of different hybrids was determined by using following formula and express in terms of gm /gm /day :

$$\text{RGR} = \frac{\log_e W_2 - \log_e W_1}{t_2 - t_1}$$

Where W_1 = dry weight per unit at t_1 , W_2 = dry weight per unit area at t_2 ,

t_1 = time of first sampling, t_2 = time of second sampling.

(iv) Leaf Area Index

LAI is the ratio of leaf area to the area of ground cover. It is also determine by using following formula:

$$\text{LAI} = \frac{\text{LeafArea}}{\text{GroundArea (cm)}}$$

(B) Post-harvest observations:

The sample plant tagged earlier were taken out separately for recording the desired biometrical observations. The yield obtained from those plants were added in the net plot yield.

The following observations were recorded as post harvest studies of the crop.

(i) Number of tillers/hill/m²

The number of tillers/hill/m² were recorded for each tagged plant and each shoot arising from the plant was counted as culms including the main shoot and the average was worked out at maturity stage.

(ii) Number of effective tillers/m²

Tillers bearing panicles were counted as effective tillers from each sampled plants and average were worked out.

(iii) Length of panicle (cm)

The length of panicle was measured in “cm” from the base of rachis to tip of the panicle for each tagged plants and average was worked out.

(iv) Weight of panicle (gm)

The weight of five panicles of tagged plants was taken by electronic balance and average was worked out as weight per panicle.

(v) Number of sound grains/panicle

Spikelets bearing a well developed caryopsis were counted for each tagged plant as the filled grains and average was worked out.

(vi) **Number of chaffy grains/panicle**

Spikelets with developed or undeveloped caryopsis were counted as unfilled grain from the same panicle and average was worked out.

(vii) **Grain yield / plot (kg)**

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

(viii) **Straw yield / plot (kg)**

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.

(ix) **Test weight (gm)**

One thousand paddy grains were counted and weight was recorded in gram and average was worked out.

(x) **Sterility (%)**

The Spikelets with undeveloped or underdeveloped caryopsis were counted as chaffy grains from the same panicle and this was divided with total no. of grains and multiplied by hundred to obtain the sterility index.

$$\text{Sterility (\%)} = \frac{\text{No.OfChaffyGrain / Panicle}}{\text{TotalNo.OfGrain / Panicle}} \times 100$$

(xi) **Grain yield (q/ha)**

Produce of the each net plot was threshed separately to obtain clean grains. The weight of seeds including seed from sample plants were first recorded in “kilograms” and then it was converted into quintal per hectare with the use of following formula:

$$\text{Yield (q/ha)} = \text{yield of net plot (kg)} \times \frac{100}{7.36}$$

(xii) Straw yield (q/ha)

The straw yield was obtained by deducting grain yield from the total biomass produced (grain + straw), which was recorded with spring balance before threshing. The conversion into quintal per hectare was done by the same formula as in case of grain yield.

(Xiii) Harvest index (%)

Harvest index is the ratio of grain yield (per plant or per hectare) and biological (grain+ straw) yield (per plant or per hectare) and expressed in percentage.

$$\text{Harvest index (\%)} = \frac{\text{EconomicYield}}{\text{BiologicalYield}} \times 100$$

Where,

Economic yield = Grain yield (q/ha)

Biological yield = Grain yield + straw (q/ha)

(C) Economics of the treatments on per hectare basis

(a) Cost of cultivation

Cost of cultivation is the summarization of all the individual cost carried out in different cultivation practices. The cost of cultivation included in each treatment was worked out by considering the prevailing market rates of input used.

(b) Gross monetary return

The gross monetary return was calculated by adding the cost of grain and the cost of straw according to the prevailing market rates.

$$\text{Gross monetary return} = \text{Cost of grain} + \text{Cost of straw}$$

(c) Net monetary return

Net monetary return was obtained by subtracting total cost of cultivation from gross monetary return.

Net monetary return = Gross monetary return – Total cost of cultivation

(d) Benefit cost ratio

Benefit cost ratio is the ratio of gross monetary return to the total cost of cultivation and it is calculated for each treatment with the use of following formula

$$\text{Benefit cost ratio} = \frac{\text{Gross Monetary Return}}{\text{Total Cost Of Cultivation}}$$

10. Statistical analysis

The data collected during the investigation were analysed statistical 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 no. 5.

Table no. 5 Skeleton of analysis of variance

Source of variation	d.f.	S.S.	M.S.S.	"F" cal.	"F" tab at5%
Replication	2				
Rice varieties	10				
Error	20				
Total	32				

Standard errors and critical differences

Standard error of the mean (S. Em $\pm$) 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 along with each of result. To test the significant difference among the treatment means, the following formulae were used for calculating the critical difference.

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

$$\text{C.D. (5\%)} = \sqrt{2} \times \text{S. Em} \times \text{"t" at 5\% error degree of freedom (d.f.)}$$

CHAPTER IV

RESULTS

The field experiment entitled **Study on relative performance of various hybrids and improved varieties of rice under system of rice intensification (SRI) cultivation** was conducted during *kharif* season 2009. 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 of the different rice hybrids has been indicated 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.

A. Pre-harvest studies:

(a) Morphological observation

(i) Plant height (cm)

The plant height was measured, treatmentwise at different growth intervals and the obtained data were statistically computed (Appendix IV to VII). The mean values are presented in Table no. 6. The plant height values are exhibited through Fig. 3. 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 to 90 day -stage of growth, thereafter the slight decrease in height was noticed at maturity stage.

There were significant differences among the different varieties with respect to plant height at every stage of observation. At 30 DAT, NPH-567, NPH-207 and SBH-999 hybrids were found taller (60.20 to 60.93 cm) as compared to other varieties. In contrast to this significantly.

Table no. 6 Mean Plant height of hybrids of rice under SRI cultivation system at different growth intervals

S.No	Rice hybrids	Plant height (cm)			
		30 DAT	60 DAT	90 DAT	At maturity
1.	JRH-4	46.80	92.95	122.20	120.15
2.	JRH-5	45.20	90.00	120.80	116.80
3.	Bayer-158	54.93	97.02	119.00	118.02
4.	Bayer-6129	48.20	93.20	115.20	113.07
5.	Tej	58.93	101.33	125.73	123.16
6.	NPH-207	60.86	102.00	126.26	124.23
7.	NPH-4113	48.86	85.00	106.20	103.80
8.	SBH-999	60.20	100.10	125.66	124.02
9.	NPH-369	53.26	97.00	124.13	122.20
10.	NPH-567	60.93	103.78	112.00	110.20
11.	IR-36	43.20	86.50	105.63	103.50
	SEm$\pm$	0.64	0.69	0.78	0.63
	C.D. (5%)	1.90	2.05	2.32	1.86

minimum height (43.20 to 45.20 cm) was measured in case of IR-36 and JRH-5 followed by Bayer-6129 and NPH-4113 (48.20 to 48.86 cm). At 60 DAT stage, NPH-567 attained the maximum height up to 103.75 cm being

significantly higher to that of all the remaining varieties. However, the second position was attained by NPH-207(102.00 cm). The lowest height (85.00 cm) was observed in case of NPH-4113. The other varieties showed the intermediate position in this character. At 90 DAT stage, NPH-207 became significantly. The tallest one measuring up to 126 . 26cm as compared to rest of the varieties . On the other hand, almost equal height (124.13 to 125.66 cm) was recorded in varieties NPH-369, Tej and SBH-999. The lowest height (105.63cm) was observed in case of IR-36 (control). The remaining varieties attained the intermediate position where differences in their height were significant (106.20 to 120.20 cm). At maturity stage also, the results trend was exactly the same, however, the height as very slightly decreased in all the varieties.

(ii)Number of tillers/ hill

The number of tillers/hill was recorded treatment wise at different growth intervals. The obtained data were subjected to statistical analysis (Appendix VIII to XI). The mean values are presented in Table no. 7. and Fig. 4.

The tillers/hill were, generally increased with the age of plant growth up to 90 days of observation. The increase in tillers was normal between 30 to 90 days stage of growth, thereafter the slight decrease in tillers was noticed at maturity stage. At 30 DAT, NPH-567 and NPH-207 varieties were found the maximum (16.44 to 16.63) tillers/hill as compared to other varieties. In contrast to this, the significantly minimum tillers/hill (12.20 to 13.90) were obtained in case of JRH 4, SBH-999, Tej, Bayer-158, NPH-4113, NPH-369 and JRH-5 followed by IR-36 and Bayer-6129 (11.44 to 11.46) tillers/hill. At 60 DAT stage, NPH-567 attained the maximum tillers (19.93) being significantly higher to that of all the remaining varieties. However, the second position was attained by NPH-207(16.86) and Tej (16.26). The lowest number (12.21) was observed in case of IR-36 (control). The other varieties showed the intermediate position (13.20 to 14.98) in this character. At 90 DAT NPH-567 and NPH-207 registered first and second position continuously while IR-36 produced minimum (13.40)

tillers/hill. The other varieties attained the intermediate position in this character. Thereafter, a slight decline was noticed, in general, at maturity stage due to dryness of plants.

Table no. 7 Mean number of Tillers/hill of hybrids rice under SRI cultivation system at different growth intervals

S.No.	Rice hybrids	Tillers/hill			
		30 DAT	60 DAT	90 DAT	At maturity
1.	JRH-4	13.90	14.98	15.10	14.56
2.	JRH-5	12.20	13.90	14.50	14.05
3.	Bayer-158	13.34	14.93	16.10	14.93
4.	Bayer-6129	11.46	14.53	15.20	13.32
5.	Tej	13.46	16.26	17.50	15.40
6.	NPH-207	16.44	16.86	18.88	17.62
7.	NPH-4113	12.86	13.20	14.56	13.00
8.	SBH-999	13.60	14.73	16.00	15.06
9.	NPH-369	12.93	13.33	14.00	13.63
10.	NPH-567	16.63	19.93	22.00	20.78
11.	IR-36	11.44	12.21	13.40	12.05
	SEm_±	0.58	0.65	0.69	0.57
	C.D. (5%)	1.73	1.93	2.06	1.68

(ii) Number of Leaves/ tiller

The number of leaves/tiller was recorded treatment wise at different growth intervals. The obtained data were subjected to statistical analysis (Appendix XII to XIV). The mean values are presented in Table no. 8 and Fig. 5.

Table no. 8 Mean number of Leaves/tiller of hybrids rice under SRI cultivation system at different growth intervals

S.No.	Rice hybrids	Leaves/tiller		
		30 DAT	60 DAT	90DAT
1.	JRH-4	2.00	2.50	3.50
2.	JRH-5	1.75	2.50	3.25
3.	Bayer-158	2.20	3.25	3.75
4.	Bayer-6129	1.75	2.15	3.50
5.	Tej	2.25	3.25	3.25
6.	NPH-207	2.25	3.00	3.75
7.	NPH-4113	2.00	2.75	3.75
8.	SBH-999	2.25	2.75	3.50
9.	NPH-369	2.15	2.75	3.50
10.	NPH-567	2.50	3.45	4.00
11.	IR-36	1.50	2.25	3.50
	SEm$\pm$	0.12	0.09	0.15
	C.D. (5%)	0.37	0.28	0.46

The leaves/tiller increased with the age of plant growth up to 90 days of observation. At 30 DAT, NPH-567 produced the maximum average leaves/tiller

(2.5), was higher to other varieties. In contrast, the significantly minimum leaves/tiller was (1.5) in case of IR-36. On the other hand, almost equal number of leaves/tiller were recorded remaining varieties in (1.75 to 2.25) . At 60 DAT stage, NPH-567 attained the maximum leaves/ tiller (3.45) being higher to that of all the remaining varieties. However, the second position was attained by Tej and Bayer-158 (3.25) . The lowest (2.15) was observed in case of Bayer-6129. The other varieties showed the intermediate position in this character. At 90 DAT NPH-567 registered also first position while JRH-5 and Tej produced minimum (3.25) leaves/ tiller. The other varieties attained the intermediate position in this character.

(iv) Number of Roots/ hill

The number of Roots/hill was recorded treatment wise at different growth intervals. The obtained data were subjected to statistical analysis (Appendix XV to XVII). The mean values are presented in Table no. 9 and Fig. 6.

The roots/hill were , increased with the age of plant growth up to 90 days of observation. At 30 DAT, NPH-567 produced the maximum average roots/hill (102.75), which was higher to other varieties. In contrast, the significantly minimum roots/hill were obtained (69.50) in case of IR 36. At 60 DAT stage, NPH-567 attained the maximum average roots/hill (169.24) being significantly higher to that of all the remaining varieties. However, the second position was attained by NPH-207(130.25). The lowest (100.5) average roots/hill were observed in case of IR-36. The other varieties showed the intermediate position in this character. At 90 DAT NPH-567 also registered first position while IR-36 produce minimum (102.75) roots/hill. The other varieties attained the intermediate position in this character with the mean average roots/hill (123.93).

Table no. 9 Mean number of Roots/hill of hybrids rice under SRI cultivation system at different growth intervals

S.No.	Rice hybrids	Roots/hill		
		30 DAT	60 DAT	90DAT
1.	JRH-4	95.75	114.75	118.50
2.	JRH-5	93.00	108.75	113.25
3.	Bayer-158	97.50	118.50	120.25
4.	Bayer-6129	95.50	114.25	117.25
5.	Tej	98.50	118.50	122.50
6.	NPH-207	100.50	130.25	132.50
7.	NPH-4113	96.50	117.00	119.75
8.	SBH-999	98.70	122.25	125.75
9.	NPH-369	96.50	116.25	120.25
10.	NPH-567	102.75	169.24	170.50
11.	IR-36	69.50	100.50	102.75
	SEm_±	0.59	0.63	0.66
	C.D. (5%)	1.76	1.87	1.97

(v) Length of roots (cm)

The root length was measured, treatment wise at different growth intervals and the obtained data were statistically computed (Appendix XVIII to XX). The mean values are presented in Table no. 10. The root length values are exhibited through Fig. 7. The root length, in general, increased with the age of plant growth up to 90 days of observation.

Table no. 10 Mean Root length of hybrids rice under SRI cultivation system at different growth intervals

S.No.	Rice hybrids	Root length(cm)		
		30 DAT	60 DAT	90DAT
1.	JRH-4	15.50	20.75	25.50
2.	JRH-5	14.75	19.50	23.00
3.	Bayer-158	18.50	23.25	28.75
4.	Bayer-6129	15.25	20.00	23.75
5.	Tej	19.00	23.50	29.00
6.	NPH-207	20.00	23.00	30.00
7.	NPH-4113	18.25	22.25	27.25
8.	SBH-999	19.25	23.75	30.50
9.	NPH-369	18.50	23.75	28.50
10.	NPH-567	22.75	28.00	30.50
11.	IR-36	12.50	16.50	20.00
	SEm_±	0.55	0.55	0.48
	C.D. (5%)	1.63	1.65	1.43

There were significant differences among the different varieties with respect to root length at every stage of observation. At 30 DAT, NPH-567, NPH-207, SBH-999 and Tej were found higher (19 to 22.75cm) as compared to other varieties. In contrast to this, the significantly minimum root length (12.5 to 15.50 cm) was measured in case of IR-36, JRH-5, Bayer6129 and JRH-4, followed by Bayer-158, NPH-369, NPH-4113 (18.25 to 18.50 cm). At 60 DAT stage, NPH-567 attained the maximum length up to 28 cm, being significantly higher to that of all

the remaining varieties. While NPH-4113, Bayer-158, Tej, SBH-999 and NPH-369 recorded almost length (22.25 to 23.75 cm) as compared to other varieties. The least length (16.5 cm) was observed in case of IR-36 (control). At 90 DAT stage, NPH-567 and SBH-999 became the significantly longest, measuring up to 30.50 cm as compared to all the rest of the varieties. However, the second position was shown by NPH-207(30.00 cm). On the other hand, more or less the equal length (27.25 to 29.00 cm) was recorded in varieties NPH-4113, SBH-999, Bayer-158 and Tej. The least length (20.00cm) was observed in case of IR-36 (Control). The remaining varieties attained the intermediate position.

(b) Growth analytical observation:

(i) Dry Matter Production/hill (gm)

Dry matter was recorded treatment wise at different growth intervals. The obtained data were subjected to statistical analysis (Appendix XXI to XXIV). The mean values are presented in Table no.11. and Fig.8

Table no. 11 Mean Dry Matter Production/hill of hybrids rice under SRI cultivation system at different growth intervals

S.No.	Rice hybrids	Dry matter/hill (gm)			
		30 DAT	60 DAT	90 DAT	At maturity
1.	JRH-4	24.99	57.85	71.53	72.81
2.	JRH-5	22.20	53.43	63.46	64.37
3.	Bayer-158	27.78	70.02	88.80	91.26
4.	Bayer-6129	20.44	52.09	68.64	71.40
5.	Tej	29.57	72.43	84.74	87.17
6.	NPH-207	31.73	70.69	88.63	90.34
7.	NPH-4113	26.74	62.57	75.47	77.89
8.	SBH-999	30.35	69.89	82.36	85.87
9.	NPH-369	27.71	66.44	85.52	87.71
10.	NPH-567	34.75	94.57	116.93	119.26
11.	IR-36	20.20	45.76	58.28	59.37
	SEm_±	0.66	0.98	0.67	0.80
	C.D. (5%)	1.96	2.89	1.98	2.38

The dry matter/hill was, generally increased with the age of plant. At 30 DAT, NPH-567 produced the maximum dry matter/hill (34.75 gm), which was higher to other varieties. In contrast, the significantly minimum dry matter production/hill was (20.20 gm) in case of IR-36. At 60 DAT stage, NPH-567 attained the maximum dry matter production/hill (94.57 gm) being significantly higher to that of all the remaining varieties. However, the second position was attained by Tej (72.43 gm). The lowest (45.76 gm) dry matter/hill was observed in case of IR-36. The other varieties showed the intermediate position in this character. At 90 DAT NPH-567 also registered first position with 116.93 gm while IR-36 produced minimum (58.28 gm) dry matter/hill. The other varieties attained the intermediate position in this character with the range of 63.46 to 88.80 gm dry matter production/hill. At maturity stage NPH-567, Bayer-158 and NPH-207 were found to attain maximum dry matter/hill (90.34 to 119.26 gm) as compared to other varieties. In contrast to this, the significantly minimum dry matter (59.37 to 64.37 gm) was obtained in case of IR-36 and JRH 5.

(ii) Crop Growth Rate

Crop growth rate ($\text{gm/cm}^2/\text{day} \times 10^{-4}$) was recorded treatment wise at different growth intervals. The obtained data were subjected to statistical computed (Appendix XXV to XXVII). The mean values are presented in Table no.12 and Fig. 9.

The crop growth rate was, decreased with the age of plant growth. At 60 DAT, NPH-567 obtained the maximum crop growth rate ($49.67 \text{ gm/cm}^2/\text{day} \times 10^{-4}$) which was higher to all other varieties. In contrast, the significantly minimum crop growth rate was ($21 \text{ gm/cm}^2/\text{day} \times 10^{-4}$) in case of IR-36. At 90 DAT stage, NPH-567 attained the maximum crop growth rate ($18 \text{ gm/cm}^2/\text{day} \times 10^{-4}$) being significantly higher to that of all the remaining varieties. However, the second position was attained by Bayer-6129 ($15.33 \text{ gm/cm}^2/\text{day} \times 10^{-4}$). The lowest ($8.33 \text{ gm/cm}^2/\text{day} \times 10^{-4}$) was observed in case of JRH-5. The other varieties showed the intermediate position in this character. At maturity SBH-999 ($2.17 \text{ gm/cm}^2/\text{day} \times 10^{-4}$) and Bayer-158 ($2.13 \text{ gm/cm}^2/\text{day} \times 10^{-4}$) also registered higher

positions while JRH-5 obtained minimum ($0.73 \text{ gm/cm}^2/\text{day} \times 10^{-4}$). The other varieties attained the intermediate position in this character with the mean average $1.6 \text{ gm/cm}^2/\text{day} \times 10^{-4}$.

Table no.12 Mean Crop Growth Rate of hybrids rice under SRI cultivation system at different growth interval

S.No.	Rice hybrids	Crop growth rate ($\text{gm/cm}^2/\text{day} \times 10^{-4}$)		
		60 DAT	90 DAT	At maturity
1.	JRH-4	27.40	11.39	1.27
2.	JRH-5	25.33	8.33	0.73
3.	Bayer-158	34.67	15.33	2.13
4.	Bayer-6129	25.67	13.67	1.93
5.	Tej	35.33	10.24	1.98
6.	NPH-207	32.00	14.67	1.66
7.	NPH-4113	29.00	10.73	1.67
8.	SBH-999	32.33	10.23	2.17
9.	NPH-369	32.00	15.33	2.13
10.	NPH-567	49.69	18.00	1.90
11.	IR-36	21.00	10.00	0.87
	SEm$\pm$	0.58	0.52	0.30
	C.D. (5%)	1.71	1.54	0.88

(iii)Relative Growth Rate

Relative growth rate ($\text{gm/gm/day} \times 10^{-4}$) was recorded treatment wise at different growth intervals. The obtained data were subjected to statistical computed (Appendix XXVIII to XXX). The mean values are presented in Table no.13 and Fig. 10.

Table no.13 Mean Relative Growth Rate of hybrids rice under SRI cultivation system at different growth interval

S.No.	Rice hybrids	growth rate ($\text{gm/gm/day} \times 10^{-4}$)		
		60DAT	90DAT	At maturity
1.	JRH-4	127.00	30.33	3.06
2.	JRH-5	126.67	24.33	2.43
3.	Bayer-158	133.33	34.00	3.33
4.	Bayer-6129	135.00	39.33	4.87
5.	Tej	129.33	25.00	3.00
6.	NPH-207	115.67	31.67	2.46
7.	NPH-4113	122.33	26.67	3.87
8.	SBH-999	120.33	23.33	4.50
9.	NPH-369	126.00	36.00	2.77
10.	NPH-567	144.67	30.30	2.85
11.	IR-36	118.00	34.33	2.63
	SEm$\pm$	0.70	0.60	0.23
	C.D. (5%)	2.06	1.77	0.87

The Relative growth rate was, generally decreased with the age of plant growth. At 60 DAT, NPH-567 obtained the maximum relative growth rate ($144.67 \text{ gm/gm/day} \times 10^{-4}$), was higher to other varieties. At 90 DAT stage, Bayer-6129 attained the maximum relative growth rate ($39.33 \text{ gm/gm/day} \times 10^{-4}$) being significantly higher to that of all the remaining varieties. However, the second position was attained by Bayer-158 ($34.00 \text{ gm/gm/day} \times 10^{-4}$). The lowest value ($23.33 \text{ gm/gm/day} \times 10^{-4}$), was observed in case of SBH-999. The other varieties showed the intermediate position in this character. At Maturity, Bayer-6129, SBH-999 and NPH-4113 were having higher value (3.87 to $4.87 \text{ gm/gm/day} \times 10^{-4}$) as compared other varieties while JRH-5 obtained minimum ($2.43 \text{ gm/gm/day} \times 10^{-4}$). The other varieties attained the intermediate position in this character with the mean average of $3.2 \text{ gm/gm/day} \times 10^{-4}$.

(iv) Leaf Area Index

The Leaf area index was measured, treatmentwise at different growth intervals and the obtained data were statistically computed (Appendix XXXI to XXXIII). The mean values are presented in Table no.14. The index values are exhibited through Fig. 11. The Leaf area index, in general, increased with the age of plant growth.

There were significant differences among the different varieties with respect to L.A.I. at every stage of observation. At 30 DAT stage, NPH-567 attained the maximum L.A.I. (3.67) as compared to other varieties. In contrast to this, the significantly minimum L.A.I. (2.12) was measured in case of IR-36. At 60 DAT stage, NPH-567 attained the maximum L.A.I (6.86), being higher to that of all the remaining varieties. While NPH-207 recorded (6.05) L. A. I. The lower L.A.I. (4.81) was observed in case of IR-36. At 90 DAT stage, NPH-567 had the maximum index (7.28) as compared to the rest of the varieties. However, the second position was shown NPH-207 (7.01). while lowest index was (5.37) in case of IR-36. The remaining varieties attained the intermediate position with mean average index of 6.32.

Table no.14 Mean L.A.I. of hybrids rice under SRI cultivation system at different growth interval

S.No.	Rice hybrids	Leaf area index		
		30 DAT	60 DAT	90 DAT
1.	JRH-4	2.24	5.59	5.87
2.	JRH-5	2.16	5.36	5.47
3.	Bayer-158	2.73	5.45	6.53
4.	Bayer-6129	2.48	5.20	5.81
5.	Tej	2.96	5.61	6.84
6.	NPH-207	3.41	6.05	7.01
7.	NPH-4113	2.56	5.56	6.23
8.	SBH-999	3.12	5.25	6.89
9.	NPH-369	2.54	5.77	6.24
10.	NPH-567	3.67	6.87	7.28
11.	IR-36	2.12	4.81	5.37
	SEm_±	0.15	0.31	0.39
	C.D. (5%)	0.45	0.94	1.17

(B). Post -harvest observation:

(I) Number of Tillers/m²

The number of tillers/m² was also recorded in each treatment and the obtained data were statistically computed (Appendix XXXIV). The mean values are presented in Table no.15 and diagrammatically illustrated in Fig.12.

The rice hybrids registered significant variation in this parameter also. The variety NPH-567 recorded significantly higher number of tillers (502.47) as compared to the rest of the varieties under test. However, NPH-207(488.20) and SBH-999 (415.50) tillers/m² attained later positions. While IR-36 produce minimum (254.62) tiller/m² and attained lowest position. The remaining varieties attained the intermediate position where in the difference in their number were significant (305.55 to 412.52 tillers/m²).

Table no.15 Mean number of Tillers/m² of hybrids rice under SRI cultivation system

S.No.	Rice hybrids	Tiller/m ²
1.	JRH-4	322.06
2.	JRH-5	305.55
3.	Bayer-158	395.23
4.	Bayer-6129	325.54
5.	Tej	412.52
6.	NPH-207	488.20
7.	NPH-4113	335.77
8.	SBH-999	415.50
9.	NPH-369	386.44
10.	NPH-567	502.47
11.	IR-36	254.62
	SEm±	1.08
	C.D. (5%)	3.20

(ii) Number of Effective tillers/hill

The number of effective tillers/hill was counted treatment wise and the data obtained were subjected to statistical analysis (Appendix XXXV). The mean values are presented in Table no.16 and diagrammatically illustrated in Fig.13.

Table no.16 Mean number of Effective tillers/hill of hybrids rice under SRI cultivation system

S.No.	Rice hybrids	Effective tillers/hill
1.	JRH-4	13.23
2.	JRH-5	12.37
3.	Bayer-158	13.97
4.	Bayer-6129	13.07
5.	Tej	14.60
6.	NPH-207	18.28
7.	NPH-4113	12.63
8.	SBH-999	14.76
9.	NPH-369	12.55
10.	NPH-567	19.10
11.	IR-36	9.80
	SEm_±	0.52
	C.D. (5%)	1.54

This parameter was found to influence significantly in different rice hybrids. The rice hybrid NPH-567 recorded significantly higher number of effective tillers (19.10/hill) over rest of the rice varieties. However The second position was attained by NPH-207(18.28/hill), this was equally followed by SBH-999 ,Tej, Bayer-158, JRH-4 and Bayer-6129 (13.07 to 14.76/hill). On the other hand, NPH-4113, NPH-369, JRH-5 and IR-36 gave the lower values (9.80 to 12.36 effective tillers/hill).

(iii) Number of Effective tillers/m²

The number of effective tillers/m² was recorded treatment wise and the obtained values were subjected to statistical analysis (Appendix XXXVI). The mean data are highlighted in Table no.17 and diagrammatically illustrated in Fig.14.

Table no.17 Mean number of Effective tillers/m² of hybrids rice under SRI cultivation system

S.No.	Rice hybrids	Effective tillers/m ²
1.	JRH-4	307.38
2.	JRH-5	280.83
3.	Bayer-158	365.26
4.	Bayer-6129	308.76
5.	Tej	380.78
6.	NPH-207	445.87
7.	NPH-4113	303.63
8.	SBH-999	385.76
9.	NPH-369	361.34
10.	NPH-567	490.67
11.	IR-36	203.32
	SEm_±	0.89
	C.D. (5%)	2.63

Among the different hybrids of rice, NPH-567 brought about significantly higher number of effective tillers (490.67/m²). However, The second position was attained by NPH-207(445.87/ m²) this was closely followed by SBH-999,

Tej, Bayer-158, NPH-369, Bayer-6129, JRH-4 and NPH-4113 varieties (303.63 to 385.76 effective tillers/m²). On the other hand, IR-36 and JRH-5 produced lowest number of effective tillers (203.32 to 280.83 tiller/m²).

(iv) Length of panicle (cm)

The length of panicle was measured in each treatment and the obtained data were statistically computed (Appendix XXXVII). The mean values are presented in Table no.18 and diagrammatically illustrated in Fig.15.

The length of panicle was found to deviate significantly in different rice hybrids. The rice hybrid NPH-567 recorded the maximum panicle length (30.80 cm), This was equally followed by NPH-207, SBH-999, Tej and Bayer-158 measuring 28.80 to 29.60 cm panicle length.

Table no.18 Mean Length of panicle of hybrids rice under SRI cultivation system

S.No.	Rice hybrids	Length of panicle(cm)
1.	JRH-4	27.60
2.	JRH-5	27.40
3.	Bayer-158	28.80
4.	Bayer-6129	27.20
5.	Tej	29.00
6.	NPH-207	29.60
7.	NPH-4113	26.40
8.	SBH-999	29.20
9.	NPH-369	27.60
10.	NPH-567	30.80
11.	IR-36	25.20
	SEm$\pm$	0.62
	C.D. (5%)	1.85

(v) Weight of panicle (gm)

The panicle weight was recorded from the sample plants under each treatment and the mean data were subjected to statistical analysis (Appendix XXXVIII). The mean values are presented in Table no.19 and diagrammatically exhibited in Fig.16.

Table no.19 Mean Panicle weight of hybrids rice under SRI cultivation system

S.No.	Rice hybrids	Weight of panicle(gm)
1.	JRH-4	4.86
2.	JRH-5	4.53
3.	Bayer-158	5.10
4.	Bayer-6129	3.60
5.	Tej	5.38
6.	NPH-207	5.61
7.	NPH-4113	4.58
8.	SBH-999	5.31
9.	NPH-369	4.36
10.	NPH-567	5.81
11.	IR-36	3.43
	SEm_±	0.28
	C.D. (5%)	0.82

Amongst the rice varieties, NPH-567, NPH-207, Tej, SBH-999 and Bayer-158 recorded the equally maximum panicle weight (5.10 to 5.81 gm), being significantly superior to rest of the varieties. IR-36 and Bayr-6129

varieties recorded the lowest panicle weight only 3.43 to 3.60 gm. The panicle weight of the remaining varieties occupied intermediate range (4.36 to 4.86gm).

(vi) Number of Sound grains/panicle

The number of sound grains/panicle was counted under each treatment and the obtained data were subjected to statistical calculation (Appendix XXXIX). The mean values are depicted in Table no.20 and diagrammatically illustrated through Fig.17.

Table no.20 Mean number of Sound grains/panicle of hybrids rice under SRI cultivation system

S.No.	Rice hybrids	Sound grain/panicle
1.	JRH-4	186.26
2.	JRH-5	196.46
3.	Bayer-158	194.13
4.	Bayer-6129	215.46
5.	Tej	206.73
6.	NPH-207	200.66
7.	NPH-4113	206.53
8.	SBH-999	185.89
9.	NPH-369	205.60
10.	NPH-567	232.93
11.	IR-36	147.68
	SEm_±	0.79
	C.D. (5%)	2.35

This parameter being one of the major yield attributes, was found to differ among the different rice varieties. The variety NPH-567 recorded the maximum number of sound grains up to 232.93 sound grains/panicle , being superior to all the remaining varieties. However, the second best was Bayer-6129 producing 215.46 sound grains/panicle . The variety Tej ranked third in this respect (206.63 sound grains) and then NPH-4113 (206.53 sound grains). The lowest number of sound grains were 147.68 sound grain/panicle which was noted in case of IR-36. The sound grains of the remaining varieties which occupied the intermediate range was 185.89 to 205.60 /panicle .

(vii) Number of Chaffy grains/panicle

The number of chaffy grains/panicle were observed treatment wise and the obtained data were subjected to statistical analysis as revealed from (Appendix XXXX). The mean data are presented in Table no.21 and diagrammatically exhibited in Fig.18.

The number of chaffy grains were found to differ significantly among the different rice hybrid varieties. Among the hybrid varieties, NPH-567 possessed significantly lowest number of chaffy grains (22.00/panicle) as against the highest (57.86/panicle) in case of Bayer-6129. Amongst the rice hybrids which recorded the chaffy grains in the lower range were Tej, JRH-5, IR-36 and NPH-369 (23.06 to 24.20 grains/panicle). On the other hand, those varieties which possessed the chaffy grains in the higher range were NPH-4113, SBH-999, Bayer-158, NPH-207 and JRH-4 (26.80 to 46.60 grains/panicle).

Table no.21 Mean number of Chaffy grains/panicle of rice under SRI cultivation system

S.No.	Rice hybrids	Chaffy grains/panicle
1.	JRH-4	26.80
2.	JRH-5	23.60
3.	Bayer-158	31.73
4.	Bayer-6129	57.86
5.	Tej	24.20
6.	NPH-207	28.26
7.	NPH-4113	46.60
8.	SBH-999	35.00
9.	NPH-369	23.06
10.	NPH-567	22.00
11.	IR-36	23.46
	SEm_±	0.76
	C.D. (5%)	2.25

(viii) Sterility percentage

The sterility percentage of different rice hybrids was calculated and the obtained data were subjected to statistical computation (Appendix XXXXI). The mean values are depicted in Table no.22. and diagrammatically exhibited in Fig.19.

Table no.22 Mean Sterility percentage of different rice hybrids under SRI cultivation system

S.No.	Rice hybrids	Sterility percentage
1.	JRH-4	14.38
2.	JRH-5	12.01
3.	Bayer-158	16.34
4.	Bayer-6129	27.27
5.	Tej	11.70
6.	NPH-207	14.08
7.	NPH-4113	22.56
8.	SBH-999	18.83
9.	NPH-369	11.27
10.	NPH-567	9.44
11.	IR-36	15.90
	SEm_±	0.42
	C.D. (5%)	1.26

The hybrid NPH-567 recorded the lowest sterility percentage (9.44 %) as compared to rest of the varieties under study. However, this was followed by NPH-369 (11.27 %), Tej (11.70 %) and then JRH-5(12.01%). The hybrid Bayer-6129 and NPH-4113 recorded significantly higher sterility percentage (22.56 to 27.27 %) over hybrids as referred above. The other varieties showed the intermediate position in this character with mean value of 15.79%.

(ix) Weight of 1000 grains (gm)

The test weight of grains was recorded in each treatment and the data so obtained were statistically computed (Appendix XXXXII). The mean values are highlighted in Table no 23 and diagrammatically illustrated in Fig. 20.

The test weight was found to differ significantly in different rice hybrids. The equally maximum test weight (26.07 to 26.65 gm) was recorded in rice hybrids NPH-369, JRH-4 and JRH-5 followed by NPH-567 (24.93 gm) , NPH-4113 (24.74gm) and then Bayer-158 (24.42 gm). On the other hand, significantly lowest test weight (19.30 gm) was noted in case of IR-36(Control). The remaining four varieties exhibited variations in test weight among each other with the range of 21.94 to 23.71 gm.

Table no.23 Mean Weight of 1000-grains of hybrids rice under SRI cultivation system

S.No.	Rice hybrids	Test weight (gm)
1.	JRH-4	26.43
2.	JRH-5	26.07
3.	Bayer-158	24.42
4.	Bayer-6129	21.94
5.	Tej	23.71
6.	NPH-207	22.52
7.	NPH-4113	24.74
8.	SBH-999	23.34
9.	NPH-369	26.65
10.	NPH-567	24.93
11.	IR-36	19.30
	SEm$\pm$	0.33
	C.D. (5%)	0.98

(x) Grain yield /plot (kg)

The grain yield/plot was obtained from each treatment. The data so obtained were subjected to statistical analysis (Appendix XXXXIII). The mean values are presented in Table no.24 and diagrammatically illustrated in Fig. 21.

Table no.24 Mean Grain yield per plot of hybrids rice under SRI cultivation system

S.No.	Rice hybrids	Grain yield/plot (kg)
1.	JRH-4	5.56
2.	JRH-5	5.29
3.	Bayer-158	5.91
4.	Bayer-6129	5.53
5.	Tej	6.19
6.	NPH-207	6.56
7.	NPH-4113	5.65
8.	SBH-999	6.26
9.	NPH-369	5.78
10.	NPH-567	7.06
11.	IR-36	4.73
	SEm_±	0.40
	C.D. (5%)	1.19

The grain yield/plot of different rice hybrids was found to deviate significantly. The maximum grain yield/plot (7.06 kg) was recorded from NPH-567 rice hybrid, being significantly superior to the remaining rice hybrids. All the remaining ten varieties were statistically different with respect to yielding potentiality (4.73 to 6.26 kg/plot). The best rice hybrid NPH-567 gave the extra

yield of 2.33 kg (49.26 %) as compared to the lowest yielder IR-36. However, this was followed by NPH-207SBH-999 and Tej , producing grain yield of 6.19 to 6.56kg/plot. The other varieties showed the intermediate position in this character with mean value of 5.86 kg/plot.

(xi) Straw yield /plot (kg)

The straw yield/plot was recorded from each treatment. The data so obtained were subjected to statistical analysis (Appendix XXXXIV). The mean values are presented in Table no.25 and diagrammatically illustrated through Fig. 22.

The hybrid rice varieties were found to vary significantly in producing the straw (Kg/plot). Amongst the hybrids, Bayer-6129 recorded the maximum straw yield (8.79 kg/plot), being significantly superior to rest of varieties. However, NPH-4113 was found the second best variety in producing the straw (8.70 kg/plot). The third best variety was JRH-4 producing 8.67 kg/plot straw. On the other hand, the lowest straw producing variety was IR-36 (67.52 kg/plot). The other hybrid varieties recorded the straw yield in the intermediate range (7.87 kg to 8.47 kg/plot).

Table no.25 Mean Straw yield per plot of hybrids rice under SRI cultivation system

S.No.	Rice hybrids	Straw yield/plot (kg)
1.	JRH-4	8.67
2.	JRH-5	8.41
3.	Bayer-158	7.98
4.	Bayer-6129	8.79
5.	Tej	8.05
6.	NPH-207	7.87
7.	NPH-4113	8.70
8.	SBH-999	8.07
9.	NPH-369	8.20
10.	NPH-567	8.47
11.	IR-36	7.52
	SEm_±	0.31
	C.D. (5%)	0.92

(xii) 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 XXXXV). The mean values are presented in Table no.26 and diagrammatically illustrated in Fig. 23.

Table no.26 Mean Grain yield per hectare of hybrids rice under SRI cultivation system

S.No.	Rice hybrids	Grain yield (q/ha)
1.	JRH-4	75.54
2.	JRH-5	71.87
3.	Bayer-158	80.29
4.	Bayer-6129	75.14
5.	Tej	84.10
6.	NPH-207	89.12
7.	NPH-4113	76.76
8.	SBH-999	85.06
9.	NPH-369	78.53
10.	NPH-567	95.92
11.	IR-36	64.27
	SEm$\pm$	0.68
	C.D. (5%)	2.01

The grain yield of different rice hybrids were found to deviate significantly. The maximum grain yield (95.92 q/ha) was recorded from NPH-567 rice hybrid, being significantly superior to the remaining rice hybrids. All the remaining varieties were statistically different with respect to yielding potentiality

64.27 to 89.12 q/ha. The best rice hybrid NPH-567 gave the extra yield up to (31.65 q/ha or 49.24 %) as compared to the lowest yielder IR-36. However, this was followed by NPH-207 producing 89.12 q/ha grain. The variety attaining the third position (85.06 q/ha) was SBH-999. This was followed by Tej and Bayer-158 (80.29 to 84.10 q/ha), NPH-369 (78.53q/ha), NPH-4113, (76.76q/ha), JRH-4(75.54q/ha) , Bayer-6129 (75.14q/ha),and JRH-5(71.87q/ha) having significant differences among them selves..

(xiii) 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 XXXXVI). The mean values are presented in Table no.27 and diagrammatically illustrated through Fig. 24.

The hybrid rice varieties were found to vary significantly in producing the straw per hectare. Amongst the hybrids, Bayer-6129 recorded the maximum straw yield up to 119.43 q/ha, being significantly superior to rest of varieties. However, NPH-4113 hybrid was found the second best variety in producing the straw (118.20 q/ha). The third best variety was JRH-4 producing 117.80 q/ha straw. On the other hand, the lowest straw producing variety was IR-36 (102.17 q/ha). The other hybrid varieties recorded the straw yield in the intermediate range (106.92 to 115.03 q/ha).

Table no.27 Mean Straw yield per hectare of hybrids rice under SRI cultivation system

S.No.	Rice hybrids	Straw yield (q/ha)
1.	JRH-4	117.80
2.	JRH-5	114.26
3.	Bayer-158	108.29
4.	Bayer-6129	119.43
5.	Tej	109.23
6.	NPH-207	106.92
7.	NPH-4113	118.20
8.	SBH-999	109.65
9.	NPH-369	111.41
10.	NPH-567	115.03
11.	IR-36	102.17
	SEm_±	1.12
	C.D. (5%)	3.33

(xiv)Harvest index (%)

The harvest index was calculated treatment wise and the data so obtained were subjected to statistical computation (AppendixXXXXVII). The mean values are presented in Table no.28 and diagrammatically exhibited in Fig. 25 .

Table no.28 Mean Harvest index of different hybrids of rice under SRI cultivation system

S.No.	Rice hybrids	Harvest index
1.	JRH-4	39.07
2.	JRH-5	38.61
3.	Bayer-158	42.57
4.	Bayer-6129	38.62
5.	Tej	43.50
6.	NPH-207	45.45
7.	NPH-4113	39.37
8.	SBH-999	43.68
9.	NPH-369	41.34
10.	NPH-567	45.46
11.	IR-36	38.61
	SEm_±	0.82
	C.D. (5%)	2.42

The harvest index in different rice varieties was found to deviate significantly. The maximum harvest index (45.46 to 45.45 %) was recorded in case of NPH-567 and NPH-207hybrids. It was significantly superior to the remaining hybrid varieties. The varieties NPH-4113, JRH-4, Bayer-6129, JRH-5 and IR-36 were found to give the lowest harvest index (38.61 to 39.37%).The other hybrid varieties recorded the harvest index in the intermediate range(41.34 to 43.68%).

(C) Economical gain

The economical (monetary) return per hectare was worked out treatment wise based on the existing market rates of the experimental inputs and outputs. The mean values are presented in Table no.29 and diagrammatically illustrated in Fig. 26.

Table no.29 Mean Net Return (Rs/ha) and B:C ratio from different rice hybrids under SRI cultivation system

S.No.	Rice hybrids	Net return(Rs/ha)	B:Cratio
1.	JRH-4	39984	2.08
2.	JRH-5	36247	1.98
3.	Bayer-158	44454	2.20
4.	Bayer-6129	39574	2.07
5.	Tej	48312	2.31
6.	NPH-207	52859	2.43
7.	NPH-4113	41223	2.11
8.	SBH-999	49276	2.33
9.	NPH-369	42672	2.15
10.	NPH-567	60287	2.63
11.	IR-36	29739	1.83

Among the rice hybrids, NPH-567 gave the maximum net return (Rs.60287.00/ha) and B:C ratio (2.63). This was equally followed by NPH-207, SBH-999 and Tej (Rs.48312.35 to 52859.05/ha) with B:C ratio of 2.31 to 2.43. This was followed by Bayer-158, NPH-369, NPH-4113, JRH-4, Bayer-6129 and JRH-5 with B:C ratio of 1.98 to 2.20. lowest net return only Rs. 29739.00/ha with B:C ratio of 1.83 was recorded in case of IR-36.

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 on 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 hybrids and one control variety of rice were involved in the study. The discussion on the performance of rice varieties 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 no.1 and depicted through Fig.1 .

The meteorological parameters show that during the crop season of five months sum of 759.0 mm rainfall occurred in 36 rainy days. Most of the total rainfall occurred during the vegetative growth stage of crop, and at reproductive stage, there was a little rainfall which favoured the crop growth.

Apart from this, average maximum (43.2 °C) and minimum (12.1 °C) temperature, higher relative humidity (91.1%) and good sunshine hours (8.9) prevailed during the crop season favored 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.

Growth parameters

There were significant differences in the plant height of different hybrid varieties of rice at 30, 60, 90 DAT and at harvest stages of observations (Table no.6). The rice hybrid NPH-567 and NPH-207 showed significant superiority, throughout the growth period in respect of plant height in comparison to the other varieties. This was followed by Tej and then Bayer-158 hybrids. On the other hand, IR-36 and NPH-4113 possessed the shorter height.

The differential growth behavior among the hybrids could be attributed to the different genetically make up of rice hybrids. All the rice hybrids except NPH-369, proved significantly superior to the other varieties in respect of tillering ability of plants at every stage of observation. Amongst the rice hybrids NPH-567, NPH-207 and Tej proved superior over other hybrid. The superiority of NPH-567 in respect of maximum tillering with lowest sterility % over others might be due to variation in hybrid vigor and in more nutrient uptake from the initial stage of growth.

The results obtained for the number of tillers per hill or per m² by these hybrids in comparison to other varieties are in agreement with the findings of Oteng and Anna (2003).

Similarly NPH-567, NPH-207 and Tej show significant superiority in other morphological characteristic like number of leaves, number of root, root length. While IR-36 and NPH-4113 showed poor performance in these characteristics.

Amongst the rice hybrids NPH-567, NPH-207 and Tej proved superior to other hybrid for various physiological parameters. The superiority of NPH-567 in respect to dry matter production, crop growth rate and relative growth rate at different stages indicated higher physiological efficiency over mass. These findings are supported by Shrinivasula *et al.* (1999), Shivani and Sree Rama Reddy (2000) and Barison (2002).

Yield-attributes

It is evident from the results presented in previous chapter that the rice hybrids NPH-567 and NPH-207 exhibited significant superiority in respect of yield-attributes viz. number of effective tillers/hill and /m², length and weight of panicle and number of sound grains over other hybrids (Summary Table no.30).

The number of chaffy (unfilled) grains per panicle was higher in range of Bayer-6129 and NPH-4113 which was significantly higher to all other hybrids. On the other hand, the hybrids producing the higher sound grains recorded the lower chaffy grain as observed in NPH-567 and NPH-207 might be due to higher accumulation of biomass at vegetative stage and their efficient translocation toward sink.

The weight of one thousand grains was recorded maximum in case of NPH-369 JRH-4, and JRH-5 which was significantly superior over all the hybrids. The higher values of yield attributes viz. panicle length recorded from NPH-567, sound grains and panicle weight recorded was from NPH-567. 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 were noted particularly in case of NPH-567 which might be due to better grain filling character inherited in this hybrids variety. The maximum test weight recorded in case of NPH-369, 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 Singh (2004).

Grain and straw yield

The rice hybrid NPH-567 produced significantly more grain yield as compared to rest of the hybrids. On the other hand, IR-36 produced significantly lowest grain. The remaining varieties recorded the intermediate grain yields, differing significantly to each other.

The enormous extra increase in grain yield to the tune of 31.65 q/ha (49.24%) was recorded by NPH-567 over check viz. IR-36 might be due to superior physiological growth characters which translated into the higher yield attributing characters viz. panicle length, number of sound grains/panicle and panicle weight and harvest index. Grain yield is the end result of all the vegetative and reproductive growth characters and genetic yield potential of NPH-567 which further lead to produce higher grain. Ajeet et al. (2005) 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 (119.43 q/ha) in case of Bayer-6129. Such an increase in straw yield of these rice hybrids might be due to the superiority in dry matter production and crop growth rate and relative growth rate which resulted into superior plant height and number of tillers per plant, number of leaves in these varieties. Alapati Satyanaryan (2005) and Zhang Jiaguo (2004) also reported the superiority of rice hybrids in respect to straw yield.

Economical gain

Amongst the rice hybrids, the maximum net return (Rs.60287.00/ha) and B:C ratio up to 2.63 was obtained from NPH-567. This was followed by NPH-207(Rs.52859.05/ha) with B:C ratio of 2.43. The third position was attained by SBH-999 (Rs.49276.05/ha) with B:C ratio 2.33. The higher net return and B:C ratio may be due to higher grain and straw yields of these varieties which enhanced the gross income and there by the net profit. On the other hand, IR-36 (control) gave the lowest net income (Rs.29739.00/ha) as well as B:C ratio (1.83) which was due to lowest grain and straw yields and there by lowest gross income. The skillful use of SRI methods gave higher net income has also been reported by Thiagarajan (2004) and J. Shekhar et al.(2009) in their econometric analysis studies.

Table no.30 Summary of Growth, yield attributes, yield and net income from hybrids rice under SRI cultivation

Rice hybrids	Plant height (cm) 90 DAT	Effective tillers/ hill	Effective tillers/ m ²	Panicle length (cm)	Panicle weight (gm)	Sound grains/ panicle	Chaffy grains/ panicle	Sterility (%)	1000-grains weight (gm)	Grain yield (q/ha)	Straw yield (q/ha)	Harvest index (%)	Net return (Rs/ha)	B:C ratio
JRH-4	122.20	13.23	307.38	27.60	4.86	186.26	26.80	14.38	26.43	75.54	117.80	39.07	39984.60	2.08
JRH-5	112.80	12.37	280.83	27.40	4.53	196.46	23.60	12.01	26.07	71.87	114.26	38.61	36247.45	1.98
Bayer-158	119.00	13.97s	365.80	28.80	5.10	194.13	31.73	16.34	24.42	80.29	108.29	42.57	44454.35	2.20
Bayer-6129	115.20	13.07	308.76	27.20	3.60	215.46	57.86	27.27	21.94	75.14	119.43	38.62	39574.00	2.07
Tej	125.73	14.60	380.78	29.00	5.38	206.73	24.20	11.70	23.71	84.10	109.23	43.50	48312.35	2.31
NPH-207	126.26	18.28	445.87	29.60	5.61	200.66	28.26	14.08	22.52	89.12	106.92	45.45	52859.05	2.43
NPH-4113	106.20	12.63	303.63	26.40	4.58	206.53	46.60	22.56	24.74	76.76	118.20	39.37	41223.25	2.11
SBH-999	125.26	14.76	385.76	29.20	5.31	185.89	35.00	18.83	23.34	85.06	109.64	43.68	49276.05	2.33
NPH-369	124.13	12.55	361.34	27.6	4.36	205.60	23.06	11.27	26.65	78.53	111.41	41.34	42672.10	2.15
NPH-567	112.00	19.10	490.67	30.80	5.81	232.93	22.00	9.44	24.93	95.92	115.03	45.46	60287.00	2.63
IR-36	105.63	9.80	203.32	25.20	3.43	147.68	23.46	15.90	19.30	64.27	102.17	38.61	29739	1.83
C.D. (5%)	2.32	1.54	2.63	1.85	0.82	2.35	2.25	1.26	0.98	2.01	3.33	2.42		

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 **Study on relative performance of various hybrids and improved varieties of rice under system of rice intensification (SRI) cultivation** was conducted at AICRIP, College of Agriculture, Rewa (M.P.) during *kharif* season 2009. The objectives of the investigation were as under:

1. To study the rice hybrid under SRI for growth and yield attributing characters.
2. To identify the suitable rice hybrids under SRI for maximum grain yield under Kymore plateau region.
3. To find 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 potassium and low in phosphorus. The seasonal rainfall was 759.0 mm with 36 rainy days.

The treatments comprised of hybrid rice varieties JRH-4, JRH-5, Bayer-158, Bayer-6129, Tej, NPH-207, NPH-4113, SBH-999, NPH-369, NPH-567 and IR-36 (control). The experiment was laid out in a randomized block design with three replications. An uniform dose of 120 kg N, 60 kg P₂O₅ and 40 kg K₂O/ha was applied to all the treatments. Fifteen days old single seedling was transplanted with the spacing of 20 cm x 20 cm on 15.07.2009. The crop was harvested on 24.10.2009, 30.10.2009 and 06.11.2009.

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

1. The results indicated that rice hybrid NPH-567 and NPH-207 were significantly superior from the remaining variety in respect of, Number of tillers/ hill /m², Effective tillers, Number of roots/plant, Root length, Dry matter, Crop growth rate, Relative growth rate, LAI, Weight and length of panicle, Number of sound and less chaffy (unfilled) grains per panicle, Test weight, Grain and Straw yields and Harvest index.
2. The maximum tillers at 90 DAT (20.78) was recorded in the hybrid NPH-567 followed by NPH-207 and Tej (15.40 to 17.62).
3. The rice hybrid NPH-567 produced the maximum number of effective tillers per hill (19.10) as well as effective tillers/m² (490.67/m²). It was followed by NPH-207 and SBH-999 hybrids. On the other hand, JRH-5 hybrid and IR-36 recorded the lowest number of effective tillers/hill.
4. The length of panicle was found maximum (30.80 cm) in rice hybrid NPH-567 followed by NPH-207 and SBH-999 (29.20 to 29.60 cm). while the shorter panicles were recorded in IR-36 (25.20 cm).
5. The maximum panicle weight (5.81 gm) was produced in NPH-567 hybrid, which was closely followed by NPH-207 (5.61 gm) and Tej (5.38 gm). Lowest panicle weight ranged 3.43 to 3.60 gm in IR-36 and Bayer-6129 hybrid rice varieties.
6. The maximum number of sound grains per panicle was recorded in NPH-567 (232.93) followed by Bayer-6129 (215.46) and then Tej (206.73 grains/panicle). The lowest sound grains (147.68) /panicle was produced in the check variety IR-36.
7. The hybrids NPH-567 and NPH-369 showed superiority by producing minimum number of chaffy (unfilled) grains per panicle (22.00 to 23.06). The IR-36 and JRH-5 also showed lower unfilled grains per panicle (23.40

to 23.60) with lower sterility %. The maximum chaffy grains (57.86 /panicle) were noted in Bayer-6129 followed by NPH-4113 (46.60/panicle) with higher sterility %.

8. The maximum test weight was recorded in NPH-369 (26.65 gm) which was closely followed by JRH-4 (26.43 gm), JRH-5 (26.07 gm), NPH-567 (24.93 gm) and NPH-4113 (24.74 gm). The lowest test weight (19.30 gm) was recorded in case of IR-36.
9. The harvest index also differed significantly among the varieties. The maximum harvest index (45.46 %) was recorded in NPH-567 followed by NPH-207(45.45%) and then SBH-999 and Tej (43.50 to 43.68%). the lowest (38.61%) in IR-36.
10. The maximum dry matter per plant was produced in rice hybrid NPH-567 (119.26 gm) which was followed by Bayer-158 (91.26 gm) and NPH-207(90.34gm) at maturity. The lowest dry matter (59.37 gm)/plant was recorded in check variety IR-36 at maturity.
11. The maximum CGR and RGR were recorded in rice hybrid, NPH-567 in all three growth stages (30,60and 90 DAT) The lowest CGR and RGR was recorded in IR-36(control).
12. The LAI was increased with crop age and maximum LAI was recorded in rice hybrid NPH-567 (3.67, 6.86 and 7.28) at 30, 60 and 90 DAT which was followed by NPH-207(3.41, 6.05 and 7.01). The minimum LAI was record in IR-36 . (2.12, 4.81 and 5.37) in all three stages.
13. In respect of grain yield, the rice hybrids NPH-567 and NPH-207 exhibited significant superiority in producing the highest grain yield (95.92 to 89.12q/ha), IR-36 produced lowest grain yield (64.27q/ha).
14. The rice hybrid Bayer-6129 and NPH-4113 also produced significantly higher straw yields (119.43 to 18.20 q/ha) over rest of the varieties. This was followed by NPH-567 and JRH-4 (115.03 to 117.80 q/ha). The lowest straw yield (102.17 q/ha) was recorded from IR-36.

15. The highest net returns (Rs. 60287.00/ha) were recorded by rice hybrid NPH-567. This was followed by NPH-207 (Rs. 52859.05/ha). The variety SBH-999 attained the third position (Rs. 49276.05/ha). The lowest net returns only Rs. 29739/ha was obtained from IR-36. The benefit cost ratio eventually followed the same trend. It was highest (2.63) in case of NPH-567 and then NPH-207 (2.43) while the lowest (1.83) was in case of IR-36.

CONCLUSION

The rice hybrids viz. NPH-567 and NPH 207 proved promising and gave significantly higher grain yield and net profit/ha as against the existing recommended rice variety IR-36 under system of rice intensification. The growth and yield attributing characters in these varieties also attained significantly greater values from IR-36.

SUGGESTIONS

1. The results of the present study appears to be highly encouraging, the rice hybrids are the new plant types to rice growers in 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 other 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.

BIBLIOGRAPHY

- Anonymus (2008) AICRIP annual report on Agronomy soil science and Physiology, **3** : 153-154.
- Agata, W. (1990). Mechanism of high yield achievement in Chinese F1 rice compared with cultivated rice varieties. *Japan Journal of Crop Science*, **59** (extra) 270-273.
- Barison, Joili (2002). Nutrient-use efficiency and nutrient uptake in conventional and intensive (SRI) rice cultivation system in Madagascar. M. Sc. (Ag) Thesis, Department of Crop & Soil Science, Cornell University, Ithaca, NY.
- Chen, Jianguo; Zhou, YonPg; Ju, Coaming and Zu, Guocheng (2006). Effects for heading date in *Indica japonica* crosses of rice. *Indian J. Genet.*, **66**(2): 103-106.
- Black,C.A. (1965). Method of soil analysis.plant-I and ii. *Agronomy series, No.9*. American society of Agronomy, Madison Wisconsin, USA, pp 1367-1573.
- Black mass,G.S. (1968). The application of the concept Of growth analysis to assessment of production. Eckward,S.E(ed). Functioning of Terristial Eco-system of primary production level. UNEFCOL (i) paris:243-259.
- Champman,H.D. and Pratt, P.E. (1961).Method of analysis of soil, plant and water university Of California, Berley. USA.
- Chen Jin Hong; Guo Heng De; Mao Guojuan; Tao ZhiBiao; Zhang GupPing; Zhao WeiMing; Chen J.H.; Guo-H.D.; Mao, GJ; Tao, Z.B.; Zhang, G.P. and Zhao, W.M. (2001). Characteristics of dry matter production and

- nutrient uptake and utilization of super high yielding *japonica* hybrid rice. *Chinese Journal of Rice Science* **15**(4): 271-275.
- Chen, S. X. (2006). The effects of plants density on the yield of yongyou 6 using the System of Rice Intensification (SRI). *China Rice*. (5) : 22.
- Dushyantha Kumar, B.M. and Shadakshari, Y.G. (2006). KHRS-21 (KHP-9) – A new high yielding rice variety for lowlands in hill zone of Karnataka. *Indian J. Genet.*, **66**(1): 77-78.
- Fisher, R.A.(1937). Statistical Method for Research Workers, Oliver and Boyd, Edinburgh, Edd-12.
- Gnanasekaran, M.; Vivekanandan, P. and Muthuramu, S. (2006). Combining ability and heterosis for yield and grain quality in two line rice hybrids. *Indian J. Genetc.*, **66**(1): 6-9.
- Haden, V. R. , Duxbury, J.M. , Di Tommaso and Losey, J. E. (2007). Dynamics of weel community in the system of rice intensification (SRI). *Journal. of Sustainable Agriculture* ; **30** (4) ; 5 – 26.
- Humayun, K. and Uphoff, N. (2007). Results of disseminating the SRI with farmer field School methods in northern Myanmar. *Experimental – Agriculture* , **43** (4) : 463 – 476.
- Jiaguo, Z.(2004). SRI yield increased by farmers producing currently at lowlevels. Sichuan Academy of Agriculture Science , Chengdu, china September,
- Kabaki, N. (1993). Growth and yield of Japonica Indica hybrid rice. *Japan Agriculture Research*, **Q27**, 88-94.
- Latha, R.; Senthilvel and Thiyagarajan, K. (2005). Grain and cooking quality characteristics of two-line hybrids rice. *Indian J.Genet.*, **65**(1): 45-46.

- Lavanaya, C.; Vijaykumar, V. and Sreeramareddy, N. (2005). Choice of rice hybrids for varying environments. *Oryza*, **42**(1): 1-4.
- Mahadevappa, M. (2004). Rice production in India- Relevance of hybrid and transgenic technologies. *Indian J. Genet.*, **64**(1): 1-4.
- Naik, K.R.; Pariyani, A.K. and Nema, M.L. (2002). Response of rice hybrids to number of seedlings and nitrogen fertilization. *Extended Summaries*, Vol.1: 2nd Intl. Agronomy Congress, Nov. 26-30, 2002, New Delhi, pp. 401-402.
- Olsen, S.R. Cole, C.N. Watnabe, F. S and Dean, L.A. (1954). Estimation Of available phosphorus in soil by extraction with sodium bicarbonate. UFDA Sular No. (1939).
- Oteng J.W. and R. Anna (2003). Senior research scientist, Faculty of Agriculture University Ghana, Accra; Rice Production in Africa through SRI, pp 10-17.
- Pandmaja, K. and B. B. Reddey (1998). Effect of seedling density in nusery, age of seedlings and crop geometry on growth and yield of rice during wet season. *Oryza*, **35** (4): 380-381.
- Panwar, L.L. (2005). Line x tester analysis of combining ability in rice. *Indian J. Genet.*, **65**(1): 51-52.
- Piper, C.S. (1967). Soil and Plant anlysis. Asia publication House, Bombay PP.157-176.
- Rautaray, S.K. (2006). Yield and economics of promising rice hybrids under double transplanting in late spring summer (*boro*) situation. *Indian Journal of Agricultural Sciences*, **76**(8): 469-471.

- Rahman, A.B.M.Z., Haque, M.A., Pervin, M.S. and Alam Q.A. (2006). Evaluation of SRI practice for boro rice cultivation. *International- Journal- of- Sustainable- Agriculture- Technology* **2**(4):24-27.
- Rosamma, C.A. and Vijayakumar, N.K. (2005). Heterosis and combining ability in rice hybrids developed for Kerala state. *Indian J. Genet.*, **65**(2): 119-120.
- Satyanarayana, A. (2004). SRI is more resistant to other biotic and abiotic stress besides drought Acharya N.G. Ranga Agricultural University Hyderabad, India February.
- Satyanarayana, P.V.; Sankar Rao, P.; Raghava Reddy, P.; Srinivas, T.; Madhuri, H. and Suneetha, Y. (2005). Parental line improvement through *indica* x tropical *japonica* crosses in rice. *Oryza*, **42**:15-19.
- Sharma, V.K.; Singh, V.P.; Singh, A.K. and Prabhakaran, V.T. (2005). Agronomic evaluation for phenotypic stability of cytoplasmic male sterile lines in rice. *Indian J. Genetc.*, **65**(3): 209-210.
- Shekhar, J., Mankatia, B. S. and Dev, S. P. (2009). Production and productivity and economics of rice (*Oryza sativa*) in system of rice intensification in North-Western Himalayas. *Indian journal of Agronomy* **54**(4):423-427.
- Shivani, D. and Sree Rama Reddy, N. (2000). Correlation and path analysis in certain rice (*Oryza sativa* L.) hybrid. *Oryza*, **37**(3): 183-186.
- Shrinivasulu, K., R. Veeraraghuviriah and K. Madhavi (1999). Growth performance of rice hybrids under different methods and densities of planting. *Crop Research Hissar*, **18**: 110-115.
- Singh, R. (2004). Relative performance of hybrid rice with inbreds under different N, P and K combinations. M.Sc. *Thesis* (Agronomy), JNKVV, College of Agriculture, Rewa (M.P.).

- Singh S.K. and Talati,J. (2005). Impact of system of Rice Intensification (SRI) International water Management Program – India, Annual IWMI – Tata Meeting, Anand, Gujrat, February.
- Singh, R.K. and Lal, J.P. (2005). Exploitation of heterosis in aromatic rice for different physico-chemical traits. *Indian J. Genetc.*, **65**(1): 47-48.
- Song, X : Agata W. and Kawamistu Y. (1990). Studies on dry matter and grain production of F1 hybrid rice in China. II .Characteristics of grain production. *Japan Journal of Crop Science*, **59** : 29-3.
- Stoop W, Uphoff N and Kassam A (2002). System of Rice Intensification (SRI) from Madagascar: Opportunities for improving farming systems for resource-poor farmers. *Agricultural Systems* **71**:249-274.
- Subbiah, B.V. and Asija, C.L. (1956). A rapid procedure for the estimation of available Nitrogen in soil. *Current Science* **25** (4): 259-260.
- Swain, P.; Poonam, A. and Rao, K.S. (2005). Response of selected AVT-2 rice hybrid / varieties under high and low nitrogen management. *Ann. Pl. Soil Res.*, **7**(2): 129-133.
- Swain, P.; Poonam, A. and Rao, K.S. (2006). Evaluation of rice hybrids in terms of growth and physiological parameters and their relationship with yield under transplanted condition. *Indian Journal of Agricultural Sciences*, **76**(8): 496-499.
- Thiyagarajan, T. M. (2004). Farmer profitability and income with SRI usually go up more than yield. World Rice Research Conference. Tsukuba Japan November 15 -17.
- Uphoff ,N. (2004) ; Paper presented in International year of rice conference , FAO , Rome. Feb 12 – 13, 2004.

- Uphoff, N. (2007) Reducing the vulnerability of rural house hold through agroecological practice ; Considering the System of Rice Intensification (SRI), *Mondes en Development*, **35**:4.
- Uphoff, N. (2007) Agroecological alternatives : capitalizing on existing genetic potentials. *Journal – of – Development – Studies* ; **43** (1) : 218 – 236.
- Verma, N. S., P. Ragavulu, and T.R. Reddy (1991). Effect of spacing and number of seedlings per hill on kharif rice. *Andhra Agricultural Journal*, **38** : 97-98.
- Vijayakumar, C.H.M.; Shobha Rani, N.; Subba Rao, L.V.; Mahendra Kumar, R.; Voleti, S.R.; Viraktamath, B.C. and Mishra, B. (2006). Breeding for high yielding rice varieties and hybrids adapted to aerobic (non-flooded, irrigated) conditions-II. Evaluation of released varieties. *Indian J. Genet.*, **66**(3): 182-186.
- Wagh, R. G. and S.T. Thorat (1992). Effect of split application of nitrogen and plant densities on yield and attributes of rice. *Oryza*, **24** (1) : 169-171.
- Walkey, A and Black, C.A.(1934).An Experimentation on the delay Reff method for determining soil organic matter of the chromic acid titration method. *Journal of Agriculture science*, **37** (1): 29-38.
- Wang S, Cao W, Jiang D, Dai T and Zhu Y (2002). Physiological characteristics of Rice Intensification: Proceedings of an International Conference, Sanya, China, April 1-4, 116-124.
- Watson, D.J. (1952). Physiological basis of variation in yield. *Advance in Agronomy*, **4** (1): 101-145.
- Wu, Z. H. Yuan, L. P. ,Qing, X.G. Ma. G. G. and Xiong, X. R. (2007). Effects of cultivation patterns on growth and yields of super hybrid rice and its

analysis of grey correlation. *Journal – of – Hunan – Agricultural – University*, **33** (4) : 379-385.

Xiaoyun, Li. (2005). A Socio – Economic Assessment of the system of Rice Intensification (SRI) College of Humanities and Development China Agricultural University, Beijing, February.

Yang, X. and Sung X. (1988). Characteristics of F1 hybrid rice roots in hybrid rice. Manil, Philippines, International Rice Research. Institute. pp. 159-164.

APPENDICES

Prevailing market rates

APPENDIX – I

S. No.	Particulars	Rate
1.	Land preparation (a) One tractor ploughing / harrowing (b) One discing and planking (c) One puddling and leveling	Rs. 350/ha Rs. 250/ha Rs. 350/ha
2.	Labour rate (Untrained)	Rs. 110/day
3.	Seed (a) Hybrid seed (b) Foundation seed	Rs. 200/Kg Rs. 25/Kg
4.	Fertilizers (a) Urea (b) S.S.P. (c) Muriate of potash (MOP) (d) Zinc sulphate	Rs. 502/ 50 Kg Rs. 10.04/ Kg Rs. 363/ 20Kg Rs. 18.15/Kg Rs. 463/ 50 Kg Rs. 9.26/kg Rs. 1770/q
5.	Seed treatment (Bavistin)	Rs. 38/100g
6.	One irrigation	Rs. 810/ha
7.	Sale price (a) Grain-i) From hybrid seed ii) from certified seed (b) Straw	Rs. 950q Rs. 950/q Rs. 45/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

Cost of cultivation /ha excluding treatments

APPENDIX – II

S. No.	Particulars	Number /Quantity	Cost of Rs.
1.	Nursery bed preparation	1/10ha	100.00
2.	Raising of nursery	3 labour	330.00
3.	Seed treatment (Bavistin)	24 gm	9.12
4.	Uprooting and transplanting	40 labour	4400.00
5.	Ploughing and harrowing (main field)	1 Nos.	350.00
6.	Levelling and puddling (main field)	2 Nos.	700.00
7.	Fertilizer 120 kg N/ha	261Kg Urea	2620.40
8.	Fertilizer 60kg P ₂ O ₅ /ha	375Kg SSP	6806.00
9.	Fertilizer 40 kg K ₂ O/ha	66.6KgMOP	617.00
10.	Fertilizer-Zinc as Zinc sulphate	25 kg	442.50
11.	Two top dressing	2 labour	220.00
12.	Irrigation	10 Nos.	8100.00
13.	Weeding in main field	15 labour	1650.00
14.	Cost of triazophos	2.4 lit	960.00
15.	Spraying of insecticide	4 labour	440.00
16.	Harvesting of crop	25 labour	2750.00
17.	Threshing and winnowing	25 labour	2750.00
18.	Land revenue	1 ha	15.00
19.	Interest on working capital (Rs. 33,260.02/ year)	8 months	2217.33
		Total	35477.35

Net return from the different rice hybrids and control variety

Appendix – III

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			
JRH-4	75.54	71763.0	113.31	5098.9	76861.95	35477.35	7	1400	36877.3	39984.6	2.08
JRH-5	71.87	68276.5	107.74	4848.3	73124.80	35477.35	7	1400	36877.3	36247.4	1.98
Bayer-158	80.29	76275.5	112.36	5056.2	81331.70	35477.35	7	1400	36877.3	44454.3	2.20
Bayer-6129	75.14	71383.0	112.63	5068.3	76451.35	35477.35	7	1400	36877.3	39574.0	2.07
Tej	84.10	79895.0	117.66	5294.7	85189.70	35477.35	7	1400	36877.3	48312.3	2.31
NPH-207	89.12	84664.0	124.72	5072.4	89736.40	35477.35	7	1400	36877.3	52859.0	2.43
NPH-4113	76.76	72922.0	115.08	5178.6	78100.60	35477.35	7	1400	36877.3	41223.2	2.11
SBH-999	85.05	80797.5	119.02	5355.9	86153.40	35477.35	7	1400	36877.3	49276.0	2.33
NPH-369	78.53	74603.5	109.91	4945.9	79549.45	35477.35	7	1400	36877.3	42672.1	2.15
NPH-567	95.92	91124.0	134.23	6040.3	97164.35	35477.35	7	1400	36877.3	60287.0	2.63
IR-36	64.27	61056.5	96.33	4334.8	65391.35	35477.35	7	175	35652.3	29739.0	1.83

Sale price of rice grain Rs.950/q and rice straw Rs.45/q

Plants height (30, 60, 90 DAT and at maturity Conti.....)

Appendix IV

Source of variation	d.f	SS	MSS	F value	F tab at 5%
Replication	2	2.725	0.109	0.087	3.45
Treatment	10	1352.160	54.309	43.62*	2.35
Error	20	24.897	1.245		
Total	32				

Appendix V

Source of variation	d.f	SS	MSS	F value	F tab at 5%
Replication	2	9.52	0.32	0.22	3.45
Treatment	10	1210.66	41.40	28.32*	2.35
Error	20	29.23	1.46		
Total	32				

Appendix VI

Source of variation	d.f	SS	MSS	F value	F tab at 5%
Replication	2	0.46	0.013	0.006	3.45
Treatment	10	1753.86	46.91	25.10*	2.35
Error	20	37.38	1.86		
Total	32				

Appendix VII

Source of variation	d.f	SS	MSS	F value	F tab at 5%
Replication	2	1.11	0.04	0.03	3.45
Treatment	10	1770.34	73.61	61.22*	2.35
Error	20	24.04	1.20		
Total	32				

Tillers/ hill (30, 60, 90 DAT and at maturity Conti.....)

Appendix VIII

Source of variation	d.f	SS	MSS	F value	F tab at 5%
Replication	2	2.91	0.14	0.13	3.45
Treatment	10	88.45	4.27	4.12*	2.35
Error	20	20.69	1.03		
Total	32				

Appendix IX

Source of variation	d.f	SS	MSS	F value	F tab at 5%
Replication	2	2.21	0.08	0.06	3.45
Treatment	10	134.01	5.18	4.01*	2.35
Error	20	25.84	1.29		
Total	32				

Appendix X

Source of variation	d.f	SS	MSS	F value	F tab at 5%
Replication	2	4.83	0.16	0.11	3.45
Treatment	10	188.84	6.45	4.41*	2.35
Error	20	29.25	1.46		
Total	32				

Appendix XI

Source of variation	d.f	SS	MSS	F value	F tab at 5%
Replication	2	0.75	0.03	0.03	3.45
Treatment	10	176.69	9.02	9.21*	2.35
Error	20	19.58	0.97		
Total	32				

Leaves / tiller (30, 60 and 90 DAT Conti.....)

Appendix XII

Source of variation	d.f	SS	MSS	F value	F tab at 5%
Replication	2	0.36	0.37	7.55	3.45
Treatment	10	2.52	2.57	52.37*	2.35
Error	20	0.98	0.04		
Total	32				

Appendix XIII

Source of variation	d.f	SS	MSS	F value	F tab at 5%
Replication	2	0.01	0.02	1.03	3.45
Treatment	10	5.32	9.62	347.81*	2.35
Error	20	0.55	0.02		
Total	32				

Appendix XIV

Source of variation	d.f	SS	MSS	F value	F tab at 5%
Replication	2	0.16	0.11	1.49	3.45
Treatment	10	1.53	1.02	13.63*	2.35
Error	20	1.50	0.07		
Total	32				

Roots / hill (30, 60 and 90 DAT Conti.....)

Appendix XV

Source of variation	d.f	SS	MSS	F value	F tab at 5%
Replication	2	4.00	0.18	0.17	3.45
Treatment	10	2346.17	108.78	100.88*	2.35
Error	20	21.56	1.07		
Total	32				

Appendix XVI

Source of variation	d.f	SS	MSS	F value	F tab at 5%
Replication	2	3.15	0.13	0.10	3.45
Treatment	10	9359.54	386.46	319.15*	2.35
Error	20	24.21	1.21		
Total	32				

Appendix XVII

Source of variation	d.f	SS	MSS	F value	F tab at 5%
Replication	2	5.02	0.18	0.13	3.45
Treatment	10	8786.65	327.56	244.22*	2.35
Error	20	26.82	1.34		
Total	32				

Length of root (30, 60 and 90 DAT Conti.....)

Appendix XVIII

Source of variation	d.f	SS	MSS	F value	F tab at 5%
Replication	2	1.51	0.08	0.87	3.45
Treatment	10	249.10	13.43	14.49*	2.35
Error	20	18.54	0.92		
Total	32				

Appendix XIX

Source of variation	d.f	SS	MSS	F value	F tab at 5%
Replication	2	6.37	0.33	0.36	3.45
Treatment	10	265.80	14.15	15.08*	2.35
Error	20	18.77	0.93		
Total	32				

Appendix XX

Source of variation	d.f	SS	MSS	F value	F tab at 5%
Replication	2	4.00	0.18	0.17	3.45
Treatment	10	2346.17	108.78	100.88*	2.35
Error	20	21.56	1.07		
Total	32				

Dry matter production / hill (30, 60, 90 DAT and at maturity Conti.....)

Appendix XXI

Source of variation	d.f	SS	MSS	F value	F tab at 5%
Replication	2	4.21	0.15	0.11	3.45
Treatment	10	653.55	24.45	18.29*	2.35
Error	20	26.73	1.33		
Total	32				

Appendix XXII

Source of variation	d.f	SS	MSS	F value	F tab at 5%
Replication	2	14.97	0.25	0.08	3.45
Treatment	10	5223.50	90.43	31.31*	2.35
Error	20	57.75	2.88		
Total	32				

Appendix XXIII

Source of variation	d.f	SS	MSS	F value	F tab at 5%
Replication	2	8.09	0.29	0.22	3.45
Treatment	10	7617.67	281.11	207.48*	2.35
Error	20	27.09	1.35		
Total	32				

Appendix XXIV

Source of variation	d.f	SS	MSS	F value	F tab at 5%
Replication	2	16.36	0.41	0.21	3.45
Treatment	10	7954.63	203.67	104.29*	2.35
Error	20	39.06	1.95		
Total	32				

C.G.R. (60, 90 DAT and maturity Conti.....)

Appendix XXV

Source of variation	d.f	SS	MSS	F value	F tab at 5%
Replication	2	3.61	0.17	0.17	3.45
Treatment	10	1682.72	83.20	82.28*	2.35
Error	20	20.22	1.01		
Total	32				

Appendix XXVI

Source of variation	d.f	SS	MSS	F value	F tab at 5%
Replication	2	3.75	0.22	0.27	3.45
Treatment	10	271.47	16.46	19.96*	2.35
Error	20	16.49	0.82		
Total	32				

Appendix XXVII

Source of variation	d.f	SS	MSS	F value	F tab at 5%
Replication	2	0.33	0.06	0.22	3.45
Treatment	10	7.72	1.42	5.26*	2.35
Error	20	5.42	0.2		
Total	32				

R.G.R (60, 90 DAT and maturity Conti.....)

Appendix XXVIII

Source of variation	d.f	SS	MSS	F value	F tab at 5%
Replication	2	3.15	0.10	0.07	3.45
Treatment	10	2094.84	70.97	48.09*	2.35
Error	20	29.51	1.47		
Total	32				

Appendix XXIX

Source of variation	d.f	SS	MSS	F value	F tab at 5%
Replication	2	3.76	0.17	0.16	3.45
Treatment	10	812.93	37.58	34.75*	2.35
Error	20	21.63	1.08		
Total	32				

Appendix XXX

Source of variation	d.f	SS	MSS	F value	F tab at 5%
Replication	2	0.90	0.16	0.63	3.45
Treatment	10	20.19	3.79	14.25*	2.35
Error	20	5.32	0.26		
Total	32				

L.A.I. (30, 60 and 90 DAT Conti.....)

Appendix XXXI

Source of variation	d.f	SS	MSS	F value	F tab at 5%
Replication	2	0.04	0.03	0.49	3.45
Treatment	10	7.86	5.57	78.98*	2.35
Error	20	1.41	0.07		
Total	32				

Appendix XXXII

Source of variation	d.f	SS	MSS	F value	F tab at 5%
Replication	2	0.79	0.13	0.42	3.45
Treatment	10	8.46	1.38	4.53*	2.35
Error	20	6.11	0.30		
Total	32				

Appendix XXXIII

Source of variation	d.f	SS	MSS	F value	F tab at 5%
Replication	2	0.72	0.07	0.16	3.45
Treatment	10	12.40	1.31	2.78*	2.35
Error	20	9.44	0.47		
Total	32				

Number of Tillers / m²
Appendix XXXIV

Source of variation	d.f	SS	MSS	F value	F tab at 5%
Replication	2	0.49	0.00	0.00	3.45
Treatment	10	176159.92	2493.23	705.7*4	2.35
Error	20	70.65	3.53		
Total	32				

Effective tillers / hill

Appendix XXXV

Source of variation	d.f	SS	MSS	F value	F tab at 5%
Replication	2	0.68	0.04	0.05	3.45
Treatment	10	212.96	12.98	15.84*	2.35
Error	20	16.39	0.82		
Total	32				

Effective tiller / m²

Appendix XXXVI

Source of variation	d.f	SS	MSS	F value	F tab at 5%
Replication	2	6.07	0.12	0.05	3.45
Treatment	10	190524.74	3980.44	1663.19*	2.35
Error	20	47.86	2.39		
Total	32				

Length of panicle

Appendix XXXVII

Source of variation	d.f	SS	MSS	F value	F tab at 5%
Replication	2	3.77	0.16	0.13	3.45
Treatment	10	75.42	3.18	2.69*	2.35
Error	20	23.65	1.18		
Total	32				

Weight of a panicle

Appendix XXXVIII

Source of variation	d.f	SS	MSS	F value	F tab at 5%
Replication	2	0.01	0.00	0.01	3.45
Treatment	10	34.31	7.27	30.86*	2.35
Error	20	4.71	0.23		
Total	32				

Sound grains / panicle

Appendix XXXIX

Source of variation	d.f	SS	MSS	F value	F tab at 5%
Replication	2	1.18	0.03	0.01	3.45
Treatment	10	13718.16	357.45	186.28*	2.35
Error	20	38.37	1.91		
Total	32				

Chaffy grains / panicle

Appendix XXXX

Source of variation	d.f	SS	MSS	F value	F tab at 5%
Replication	2	2.97	0.08	0.04	3.45
Treatment	10	3924.51	111.83	63.73*	2.35
Error	20	35.09	1.75		
Total	32				

Sterility percentage

Appendix XXXXI

Source of variation	d.f	SS	MSS	F value	F tab at 5%
Replication	2	0.92	0.08	0.15	3.45
Treatment	10	851.58	77.56	141.30*	2.35
Error	20	10.97	0.54		
Total	32				

Weight of 1000 grain

Appendix XXXXII

Source of variation	d.f	SS	MSS	F value	F tab at 5%
Replication	2	1.36	0.20	0.60	3.45
Treatment	10	143.60	21.32	63.34*	2.35
Error	20	6.73	0.33		
Total	32				

Grain yield kg / plot

Appendix XXXXIII

Source of variation	d.f	SS	MSS	F value	F tab at 5%
Replication	2	2.97	0.30	0.60	3.45
Treatment	10	12.15	1.22	2.47*	2.35
Error	20	9.91	0.49		
Total	32				

Straw yield kg / plot

Appendix XXXXIV

Source of variation	d.f	SS	MSS	F value	F tab at 5%
Replication	2	1.32	0.22	0.76	3.45
Treatment	10	4.72	0.804	2.74*	2.35
Error	20	5.87	0.29		
Total	32				

Grain yield q/ ha

Appendix XXXXV

Source of variation	d.f	SS	MSS	F value	F tab at 5%
Replication	2	1.15	0.041	0.02	3.45
Treatment	10	2243.30	80.40	57.64*	2.35
Error	20	27.89	1.39		
Total	32				

Straw yield q / ha

Appendix XXXXVI

Source of variation	d.f	SS	MSS	F value	F tab at 5%
Replication	2	1.38	0.01	0.00	3.45
Treatment	10	873.63	11.42	2.98*	2.35
Error	20	76.50	3.82		
Total	32				

Harvesting index

Appendix XXXXVII

Source of variation	d.f	SS	MSS	F value	F tab at 5%
Replication	2	4.97	0.12	0.06	3.45
Treatment	10	229.92	5.65	2.78*	2.35
Error	20	40.64	2.03		
Total	32				

Net monetary return = Gross monetary return – Total cost of cultivation

(d) Benefit cost ratio

Benefit cost ratio is the ratio of gross monetary return to the total cost of cultivation and it is calculated for each treatment with the use of following formula

$$\text{Benefit cost ratio} = \frac{\text{Gross Monetary Return}}{\text{Total Cost Of Cultivation}}$$

10. Statistical analysis

The data collected during the investigation were analysed statistical 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 no. 5.

Table no. 5 Skeleton of analysis of variance

Source of variation	d.f.	S.S.	M.S.S.	"F" cal.	"F" tab at 5%
Replication	2				
Rice varieties	10				
Error	20				
Total	32				

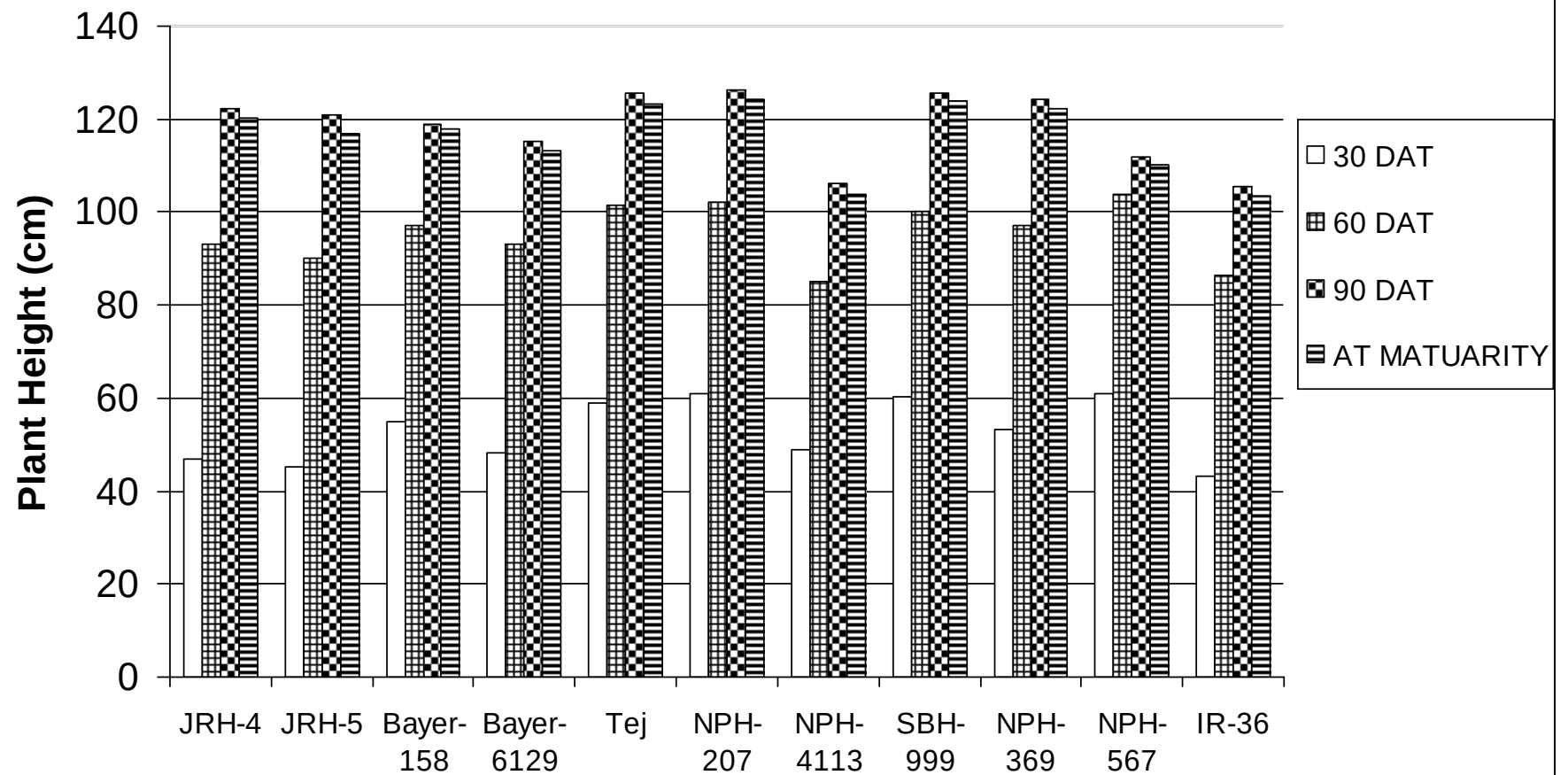


Fig-3 Mean plant height of hybrids of rice under SRI cultivation system at different growth intervals

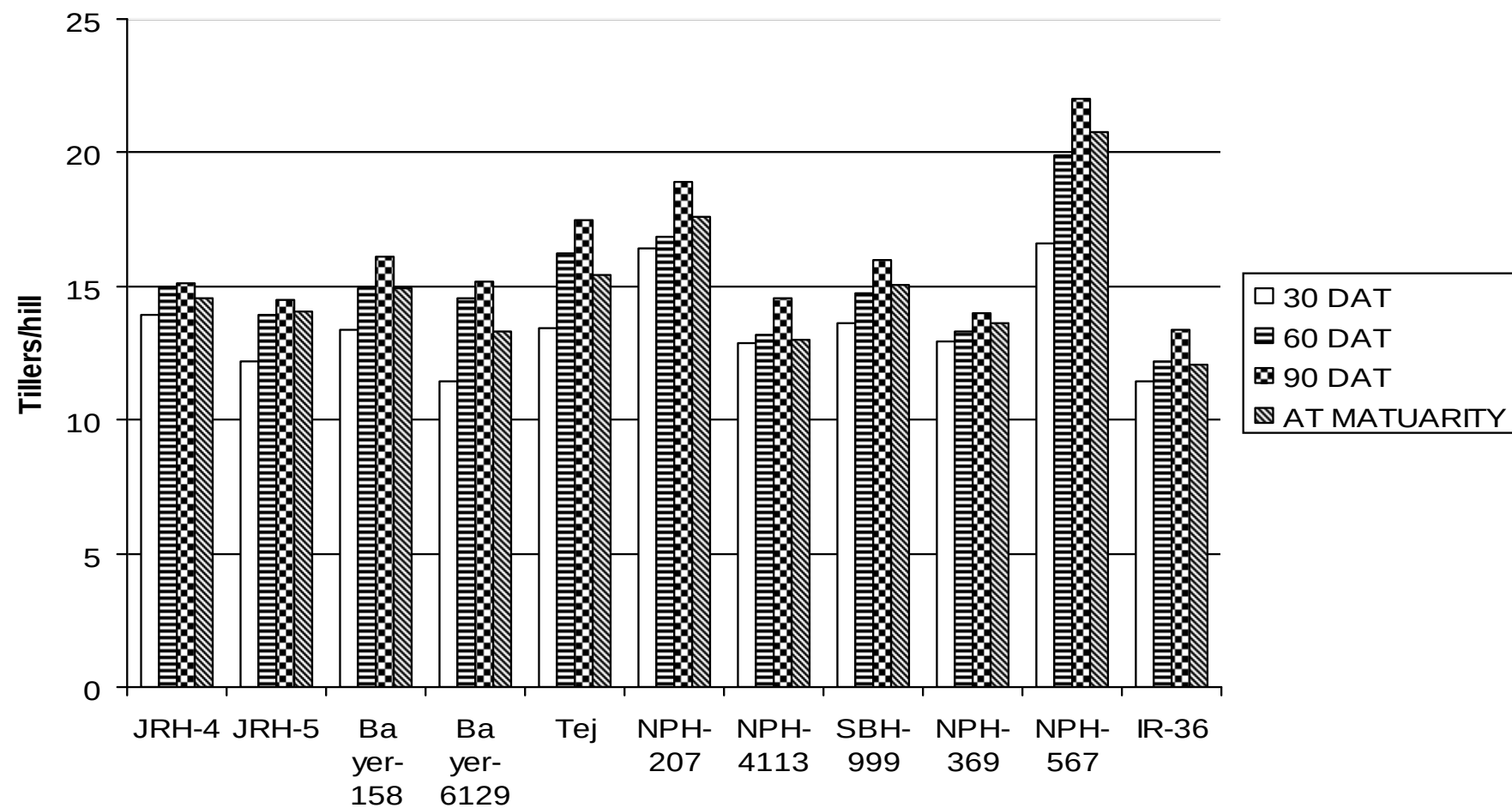


Fig-4 Mean number of tillers/hill of hybrids of rice under SRI cultivation system at different growth intervals

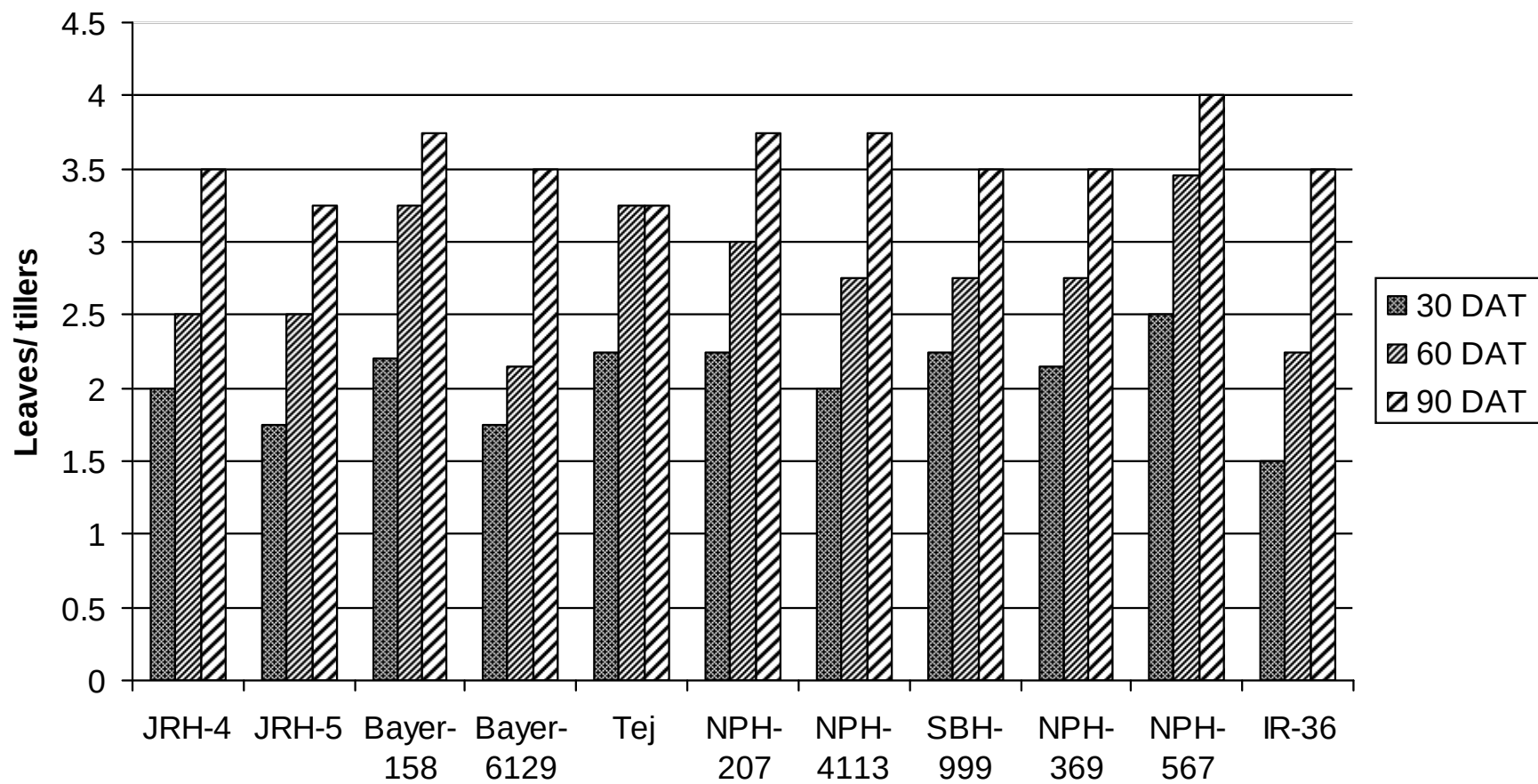


Fig-5 Mean number of Leaves/tiller of hybrids of rice under SRI cultivation system at different growth intervals

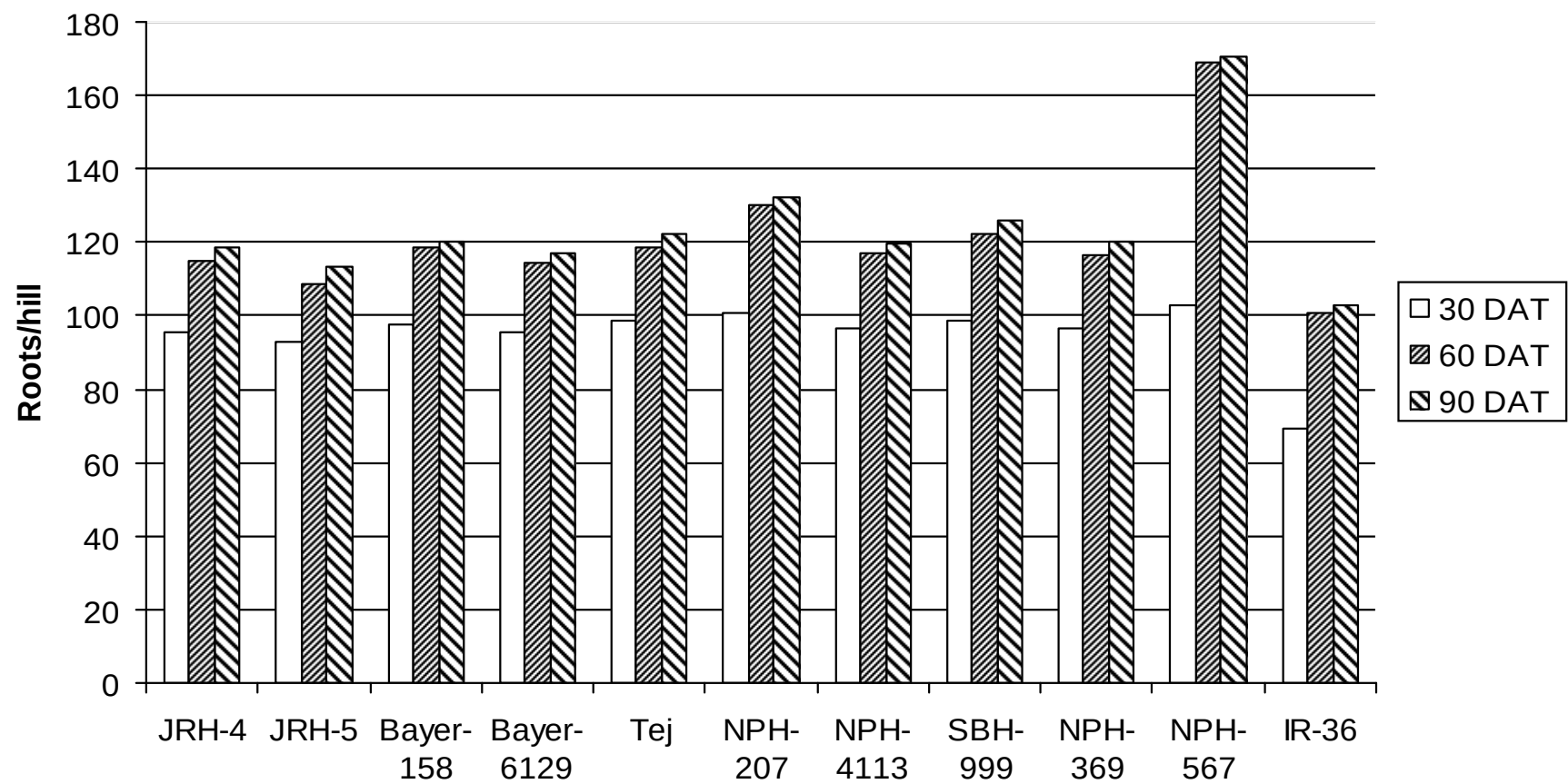


Fig-6 Mean number of Roots/hill of hybrids of rice under SRI cultivation system at different growth intervals

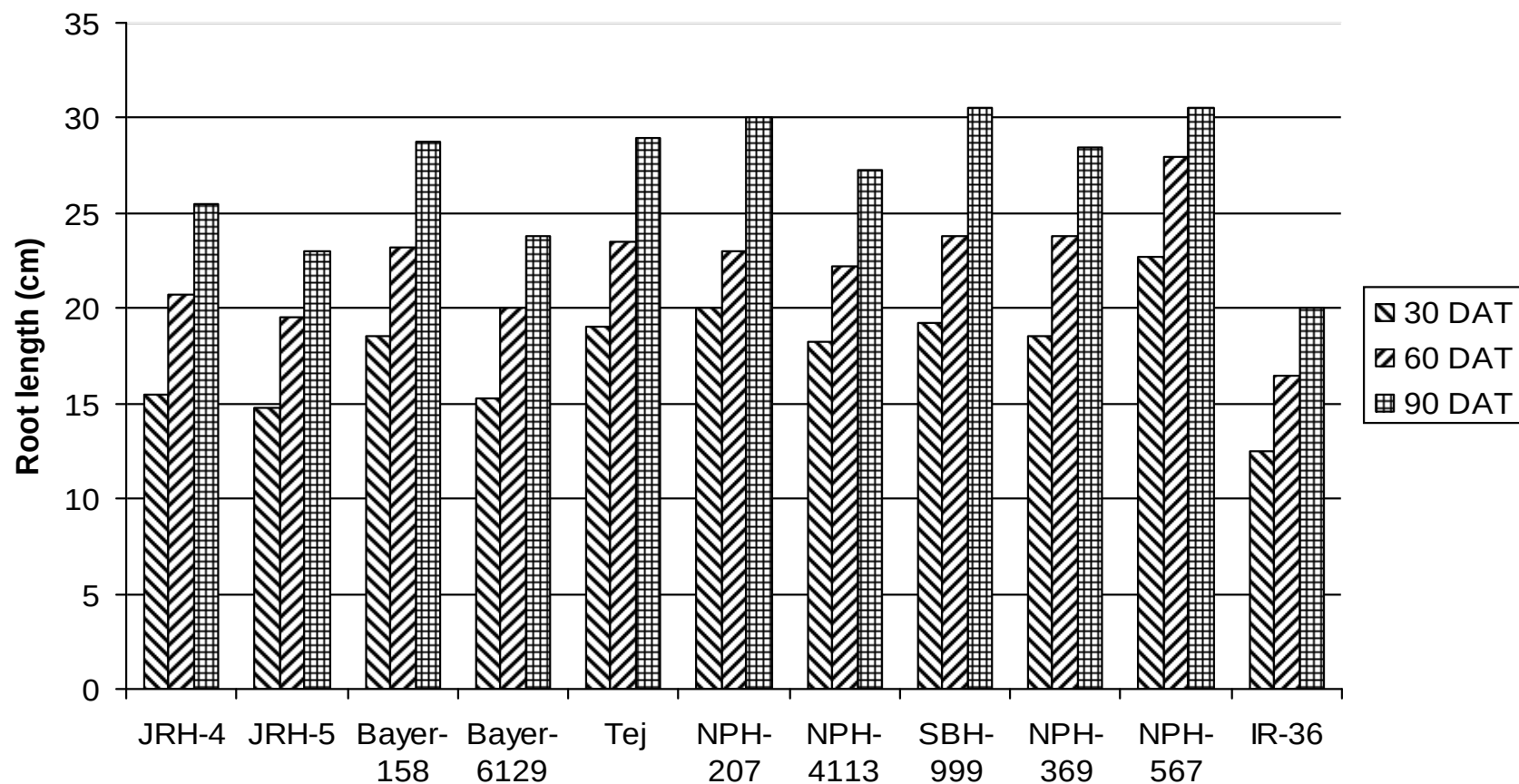


Fig-7 Mean Root length of hybrids of rice under SRI cultivation system at different growth intervals

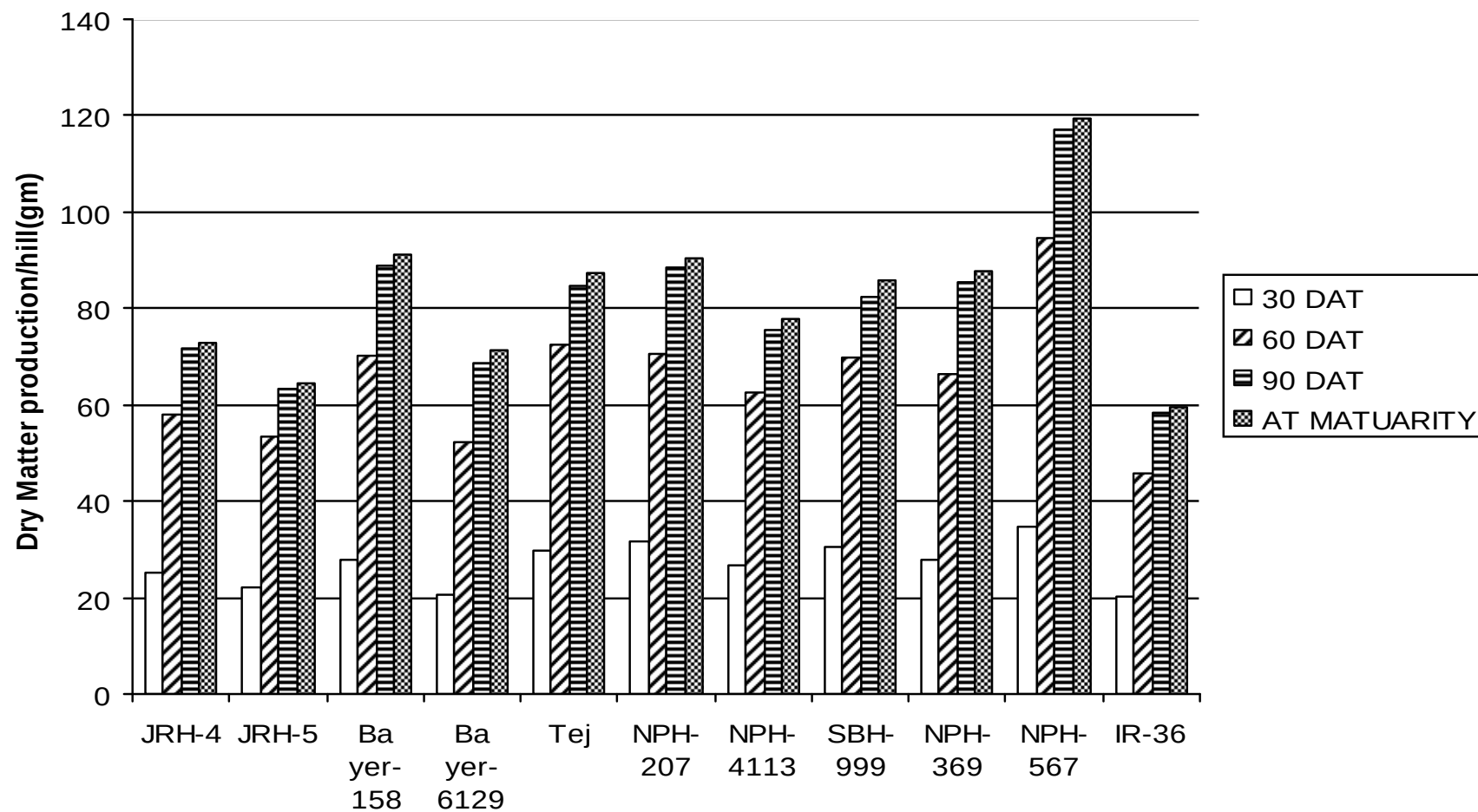


Fig-8 Mean Dry Matter production/hill of hybrids of rice under SRI cultivation system at different growth intervals

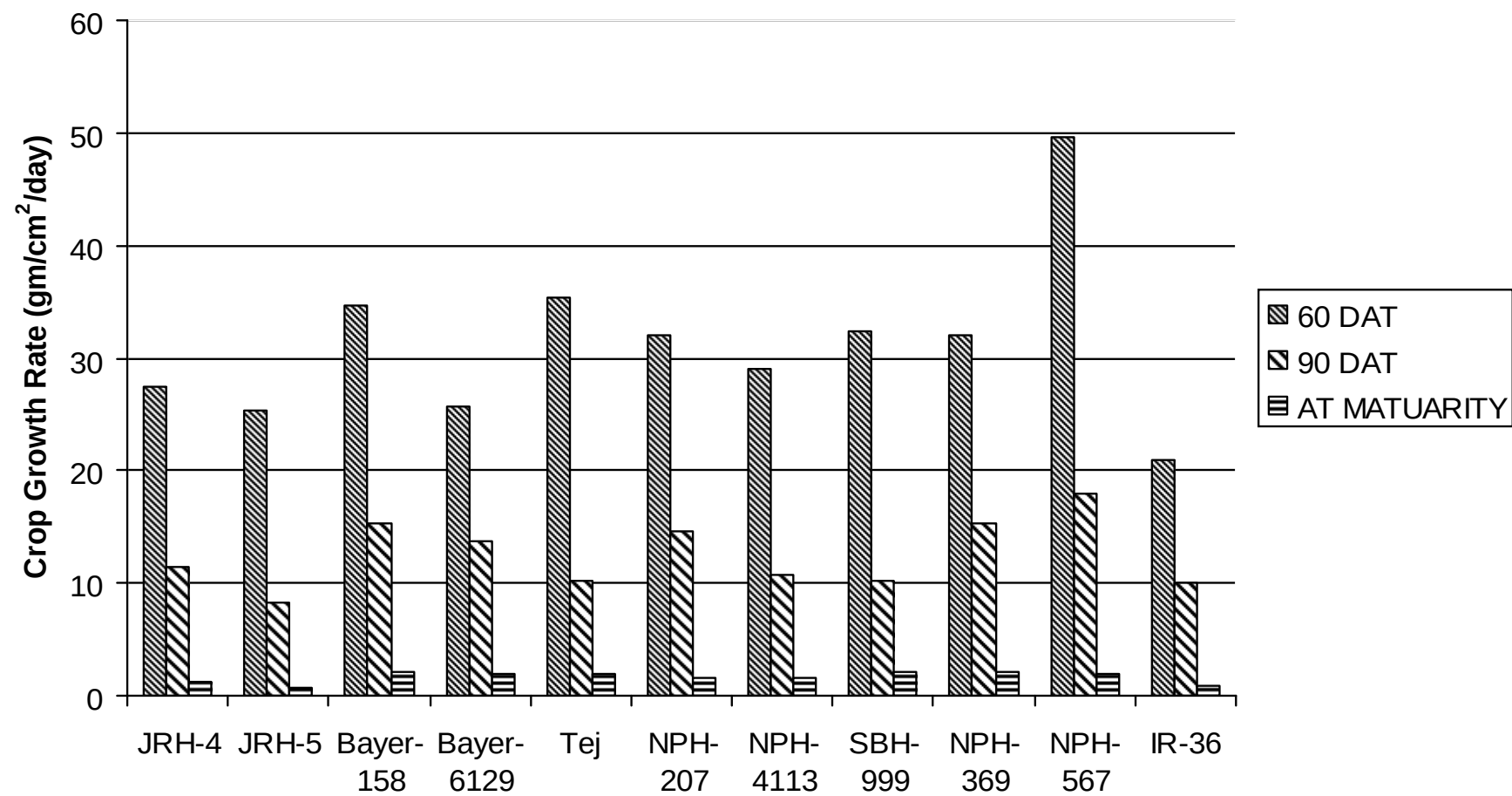


Fig-9 Mean crop growth rate of hybrids of rice under SRI cultivation system at different growth intervals

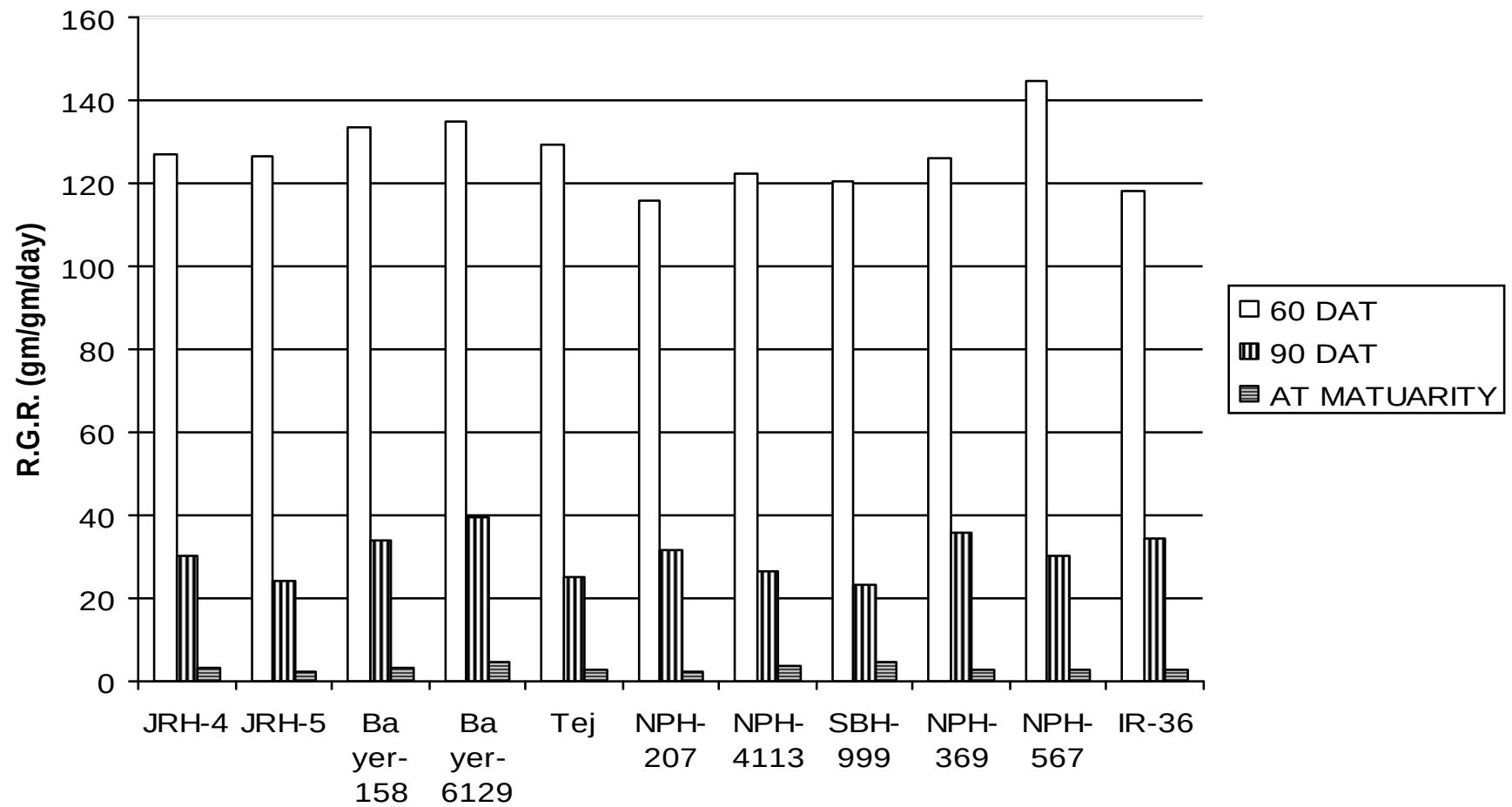


Fig-10 Mean R.G.R. of hybrids of rice under SRI cultivation system different growth intervals

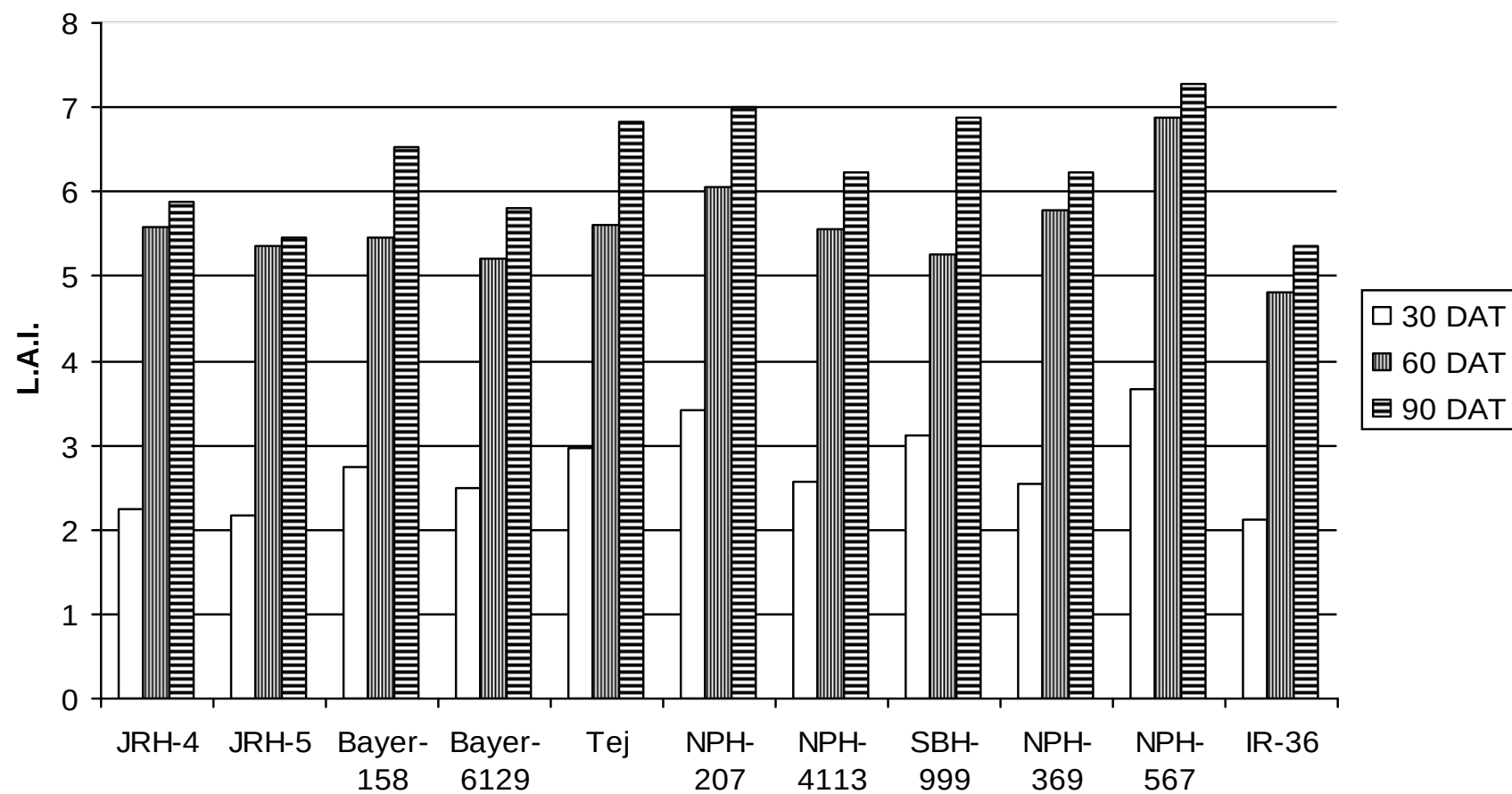


Fig-11 Mean L.A.I. of hybrids of rice under SRI cultivation system at different growth intervals

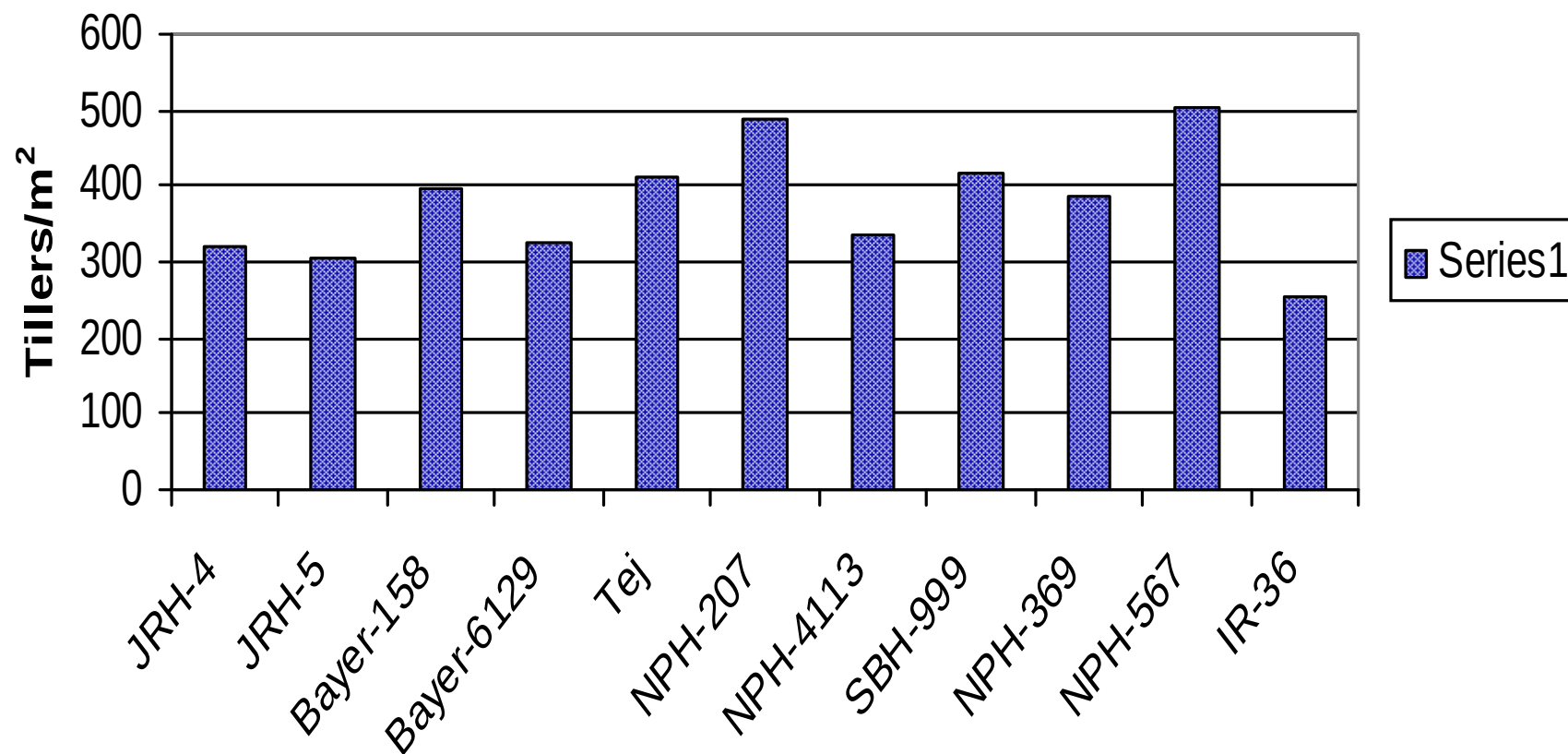


Fig-12 Mean number of Tillers/m² of hybrids of rice under SRI cultivation syste

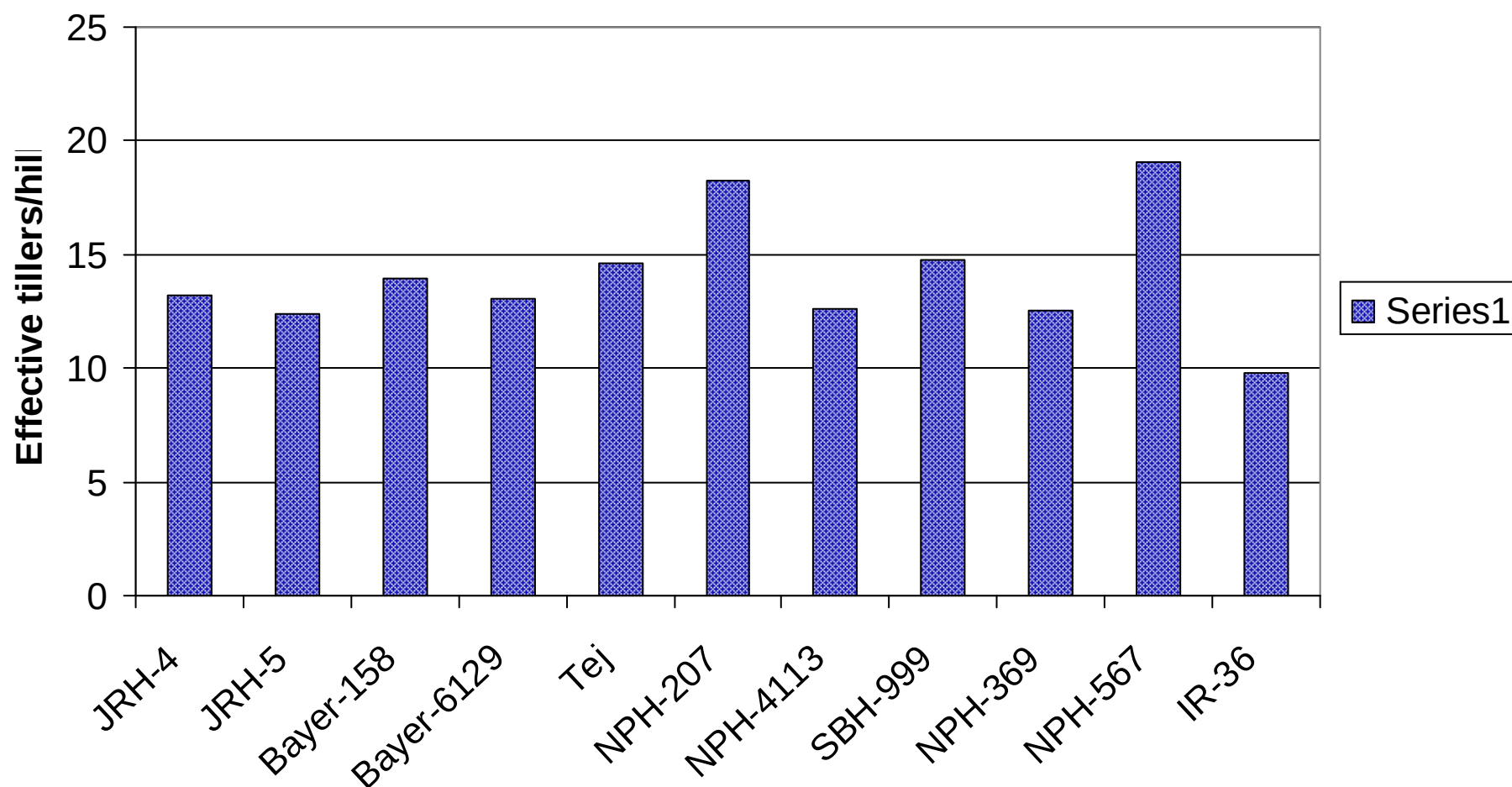


Fig- 13 Mean number of effective tillers/hill of hybrids of rice under SRI cultivation syste

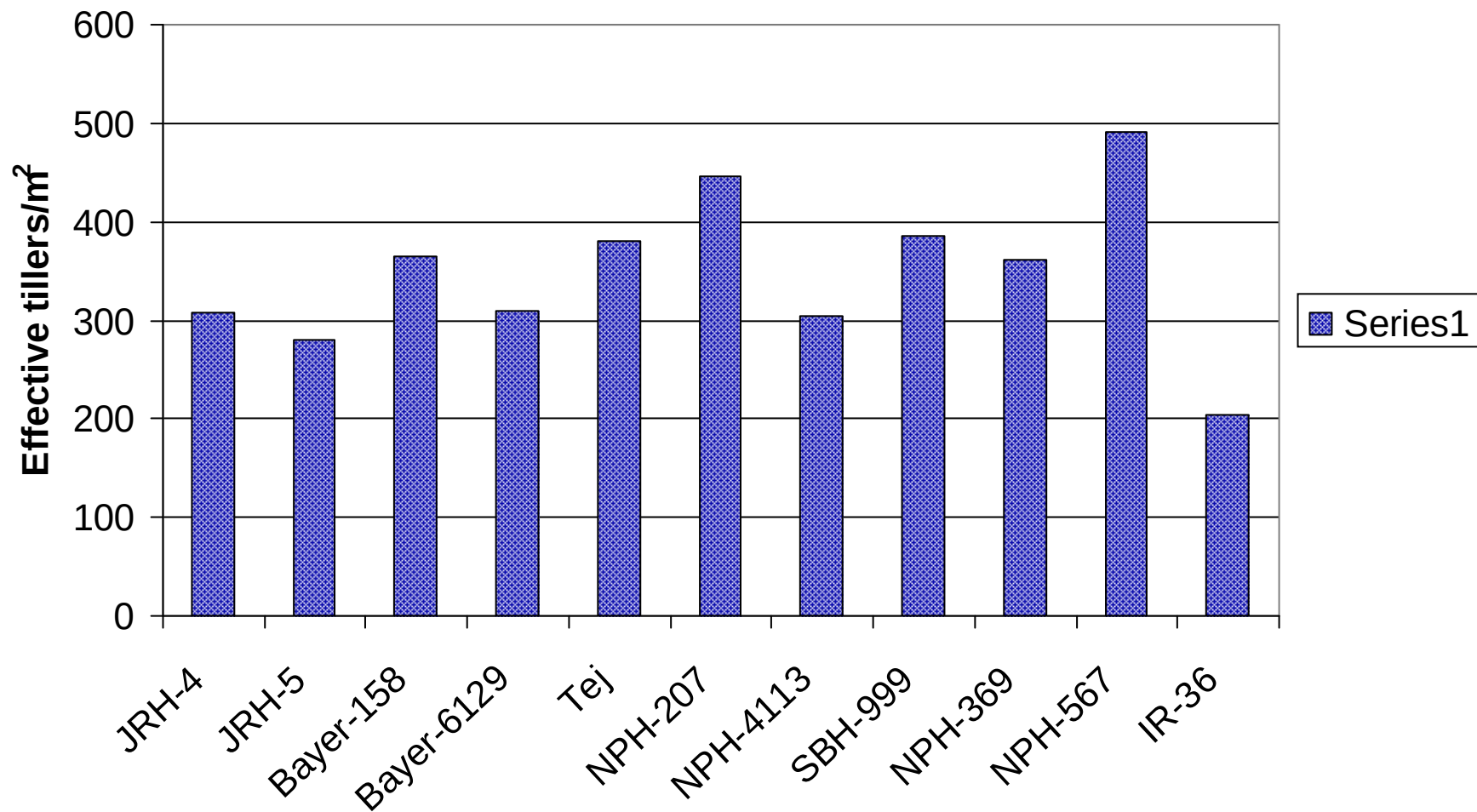


Fig-14 Mean number of effective tillers/m² of hybrids of rice under SRI cultivation system

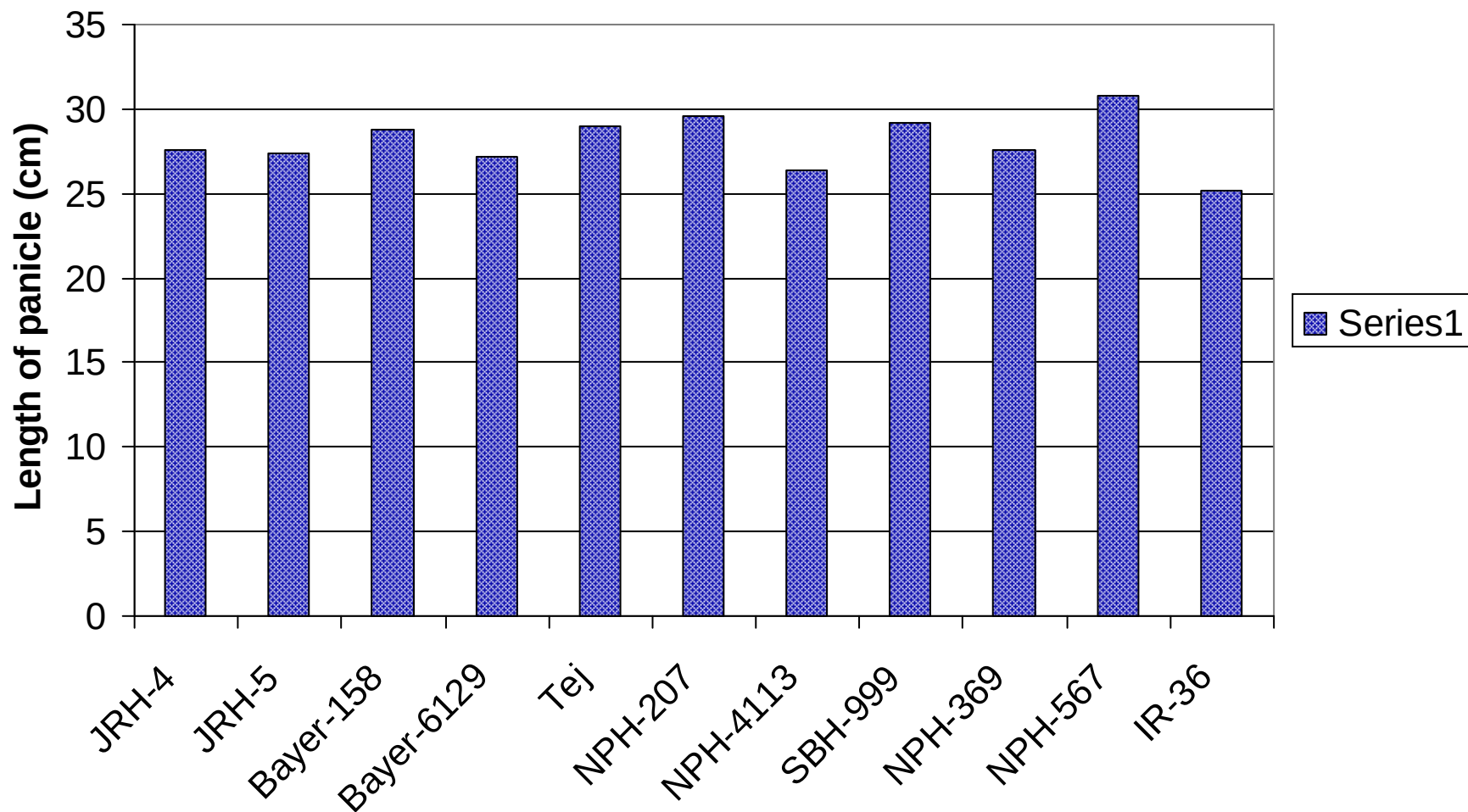


Fig- 15 Mean Length of panicle of hybrids of rice under SRI cultivation system

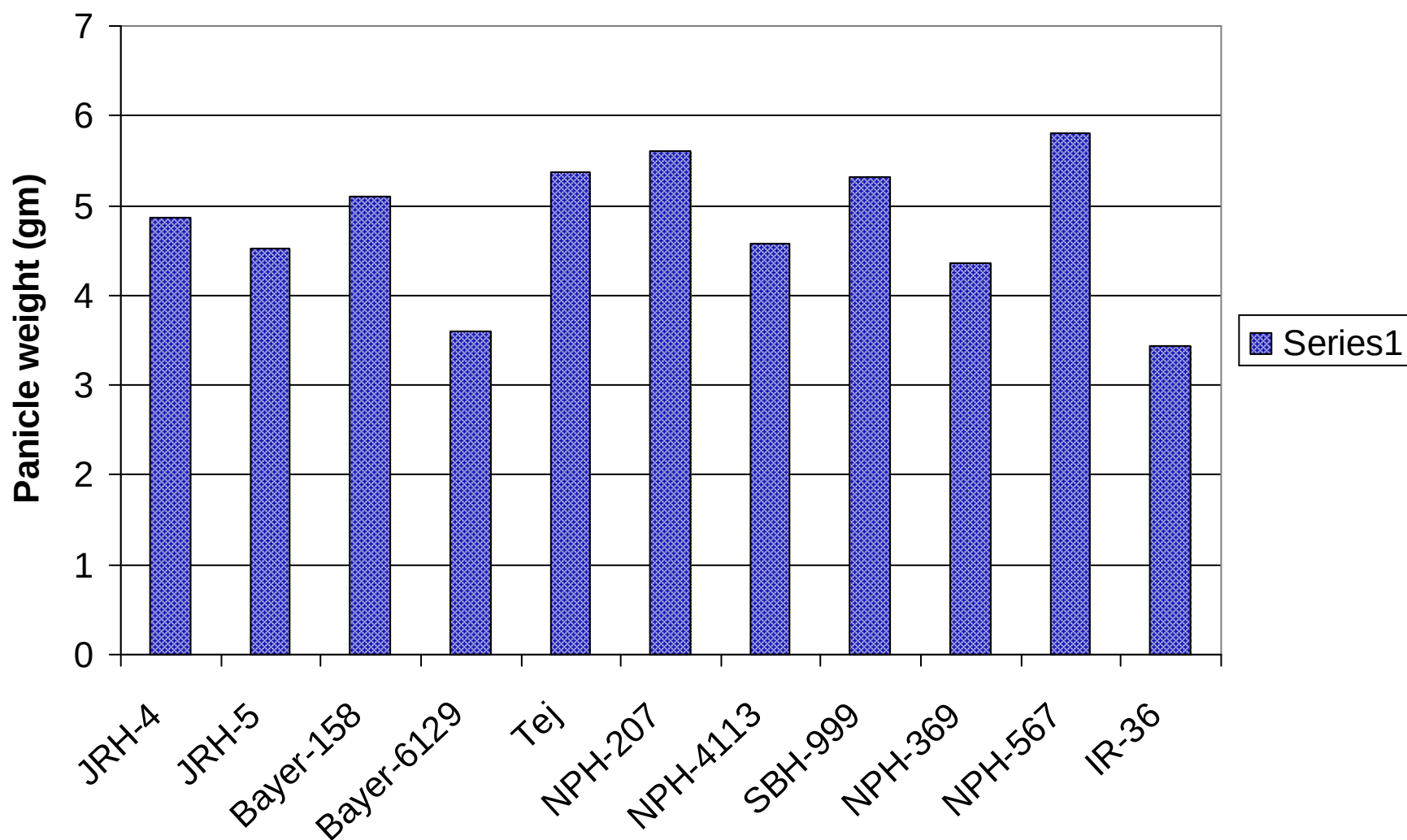


Fig-16 Mean panicle weight of hybrids of rice under SRI cultivation system

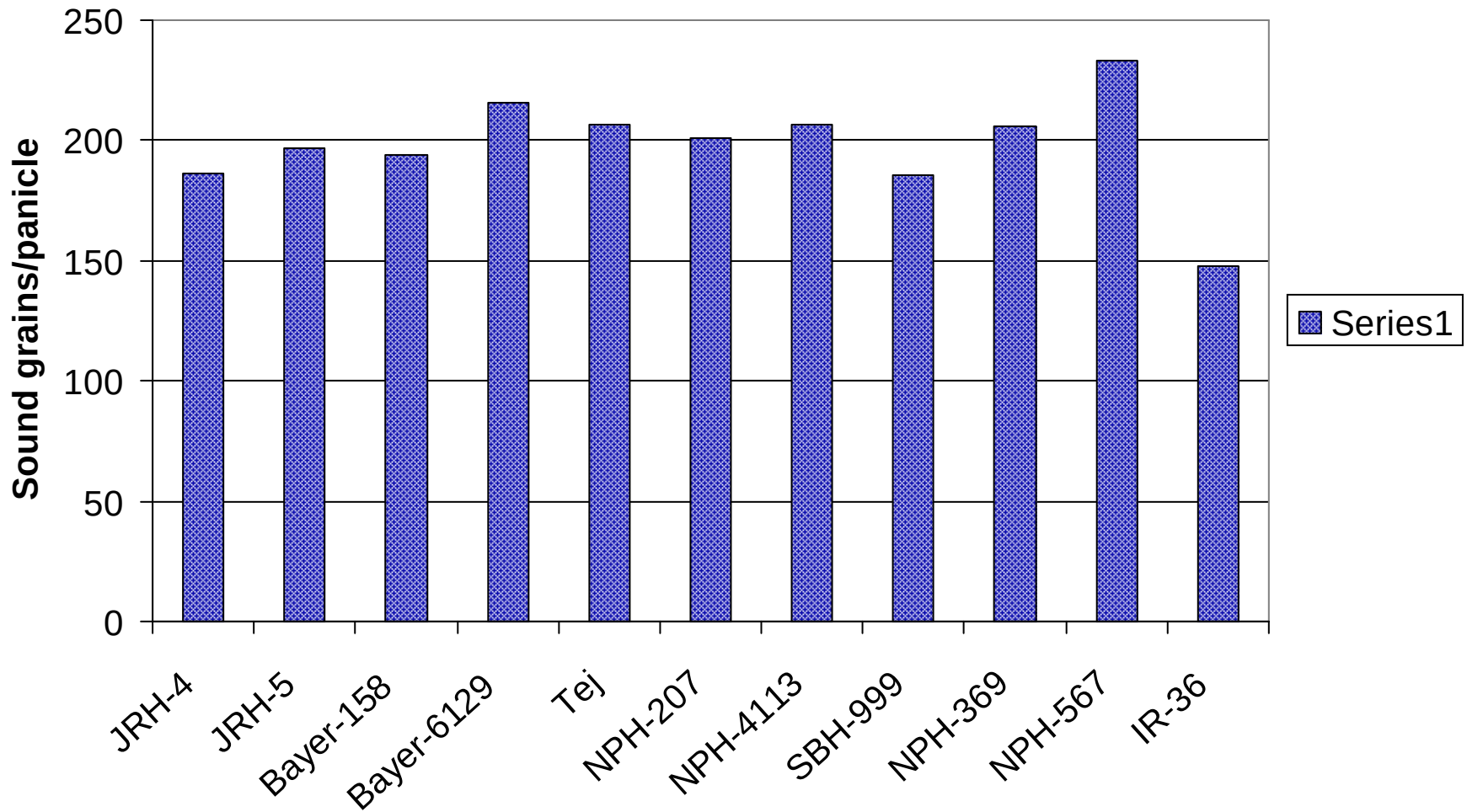


Fig- 17 Mean number of sound grains/panicle of hybrids of rice under SRI cultivation system

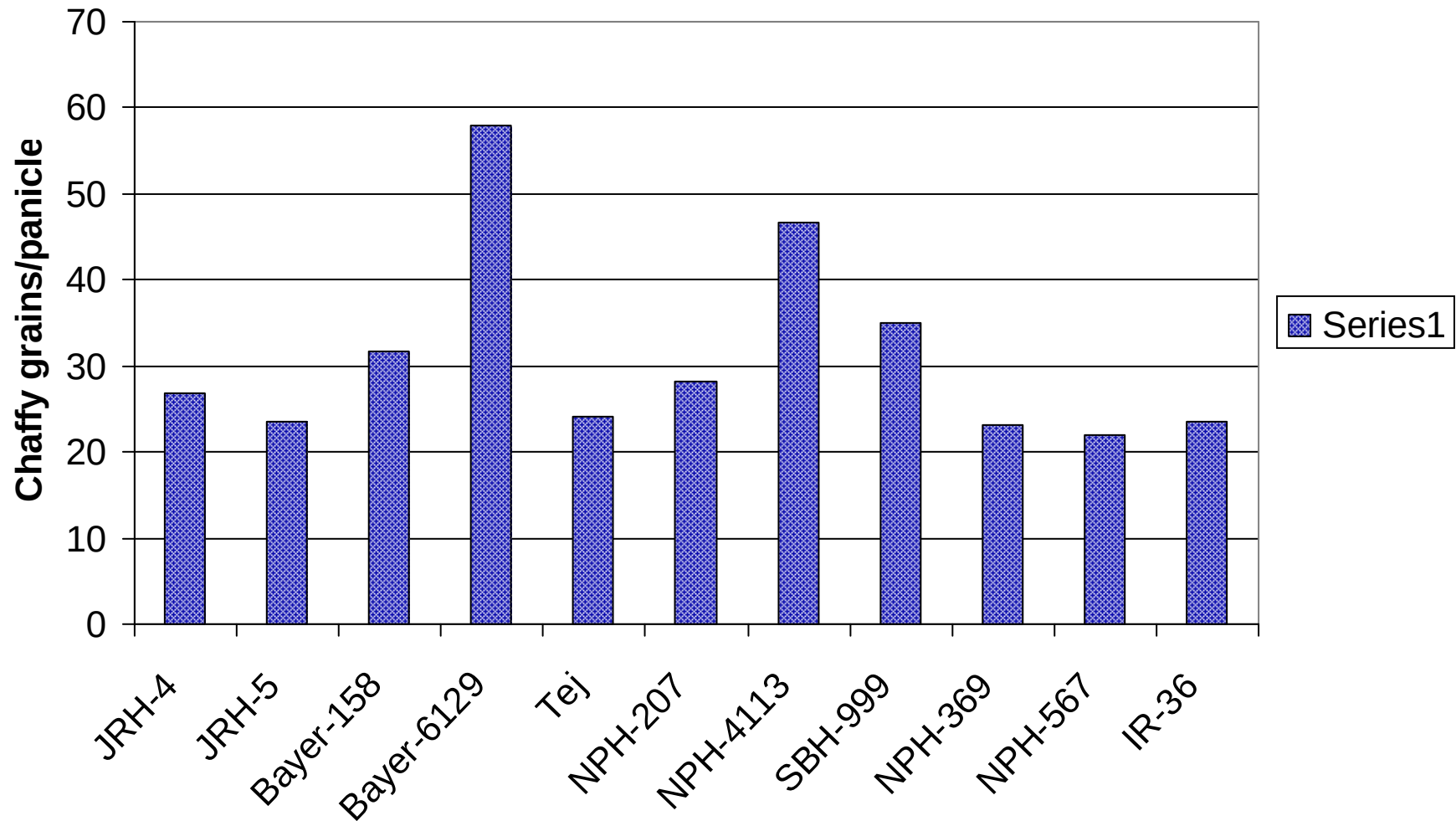


**Fig- 18 Mean number of Chaffy grains/panicle of hybrids
under SRI cultivation system**

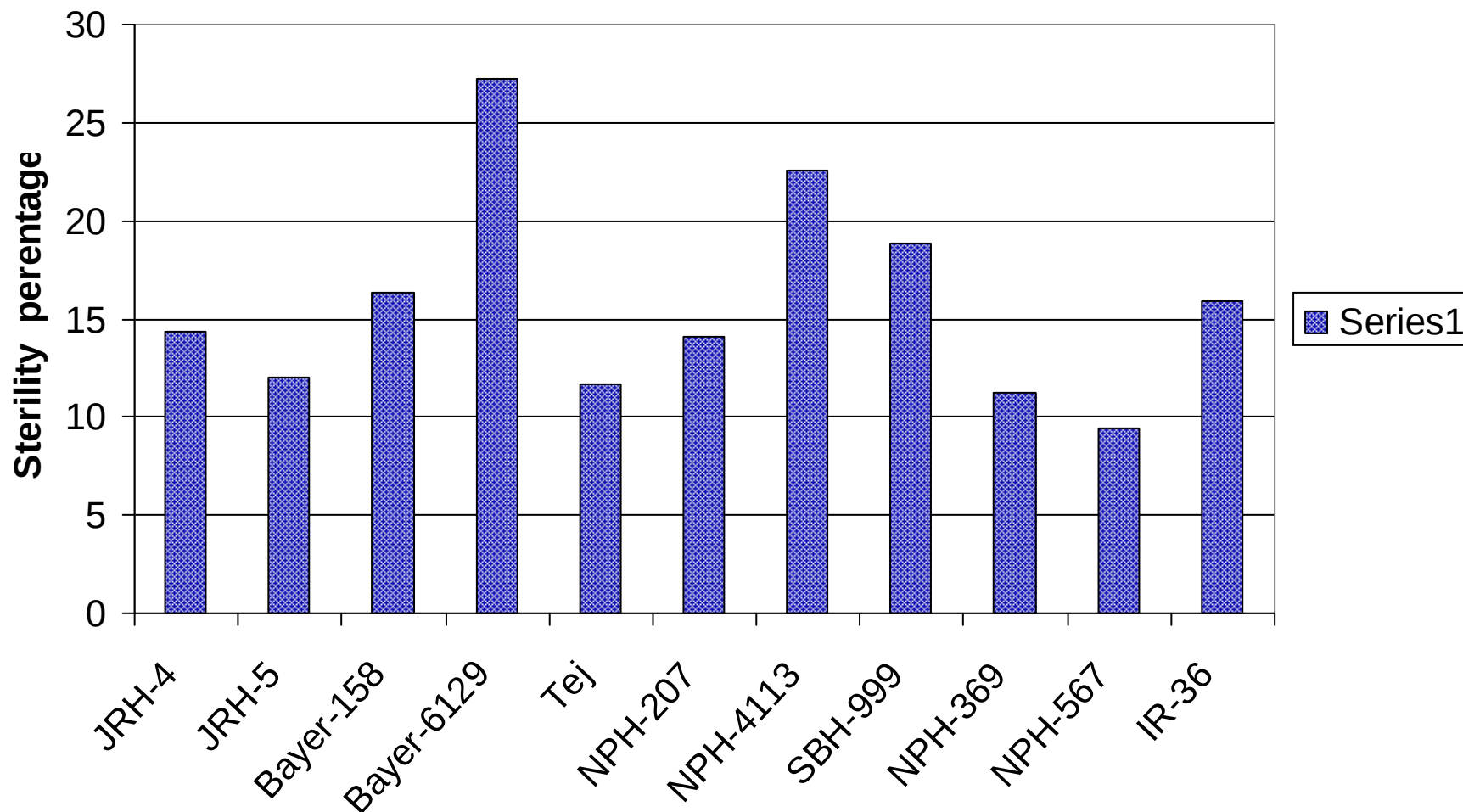


Fig- 19 Mean sterility percentage of hybrids of rice under SRI cultivation system

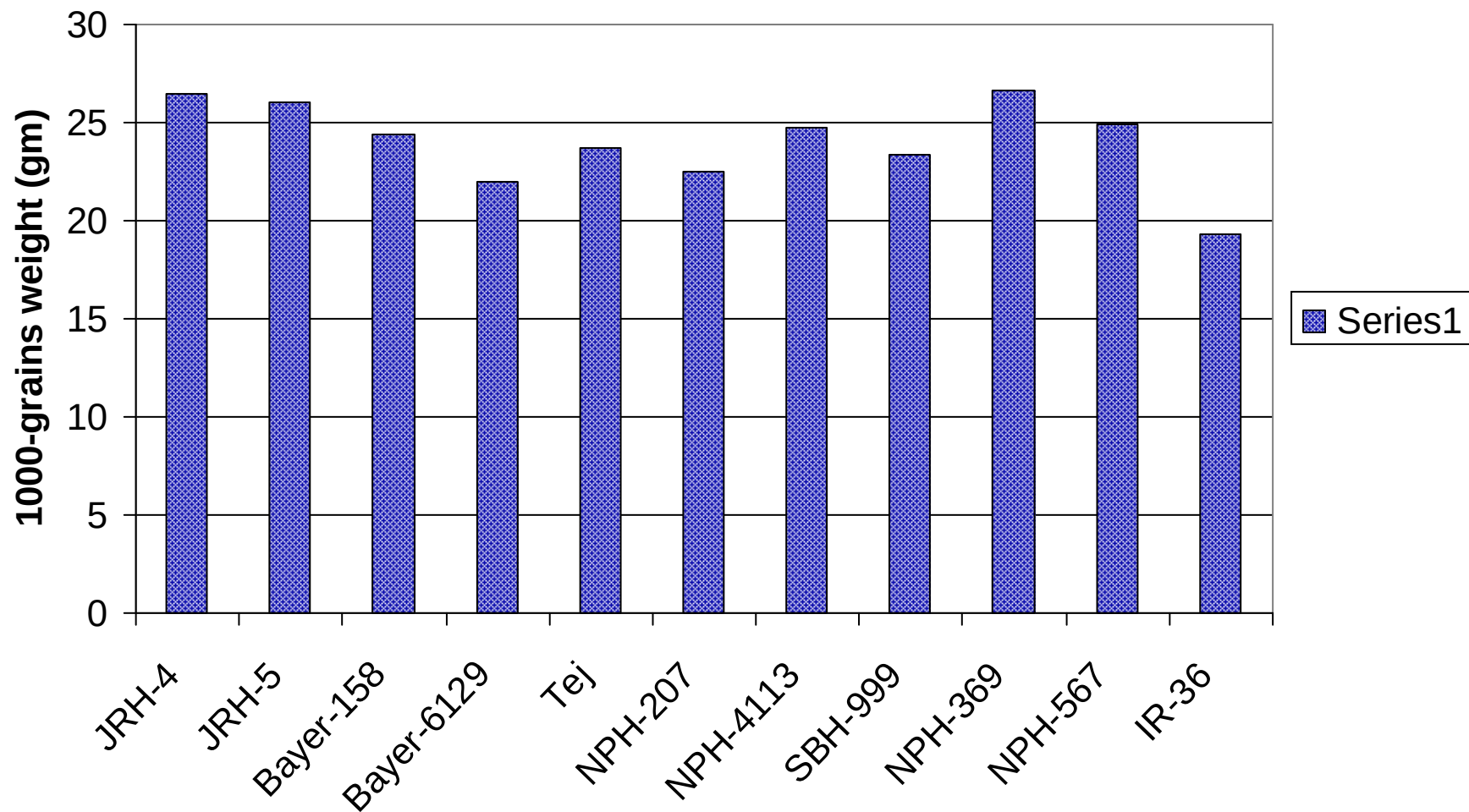


**Fig- 20 Mean weight of 1000-grains of hybrids of rice
under SRI cultivation system**

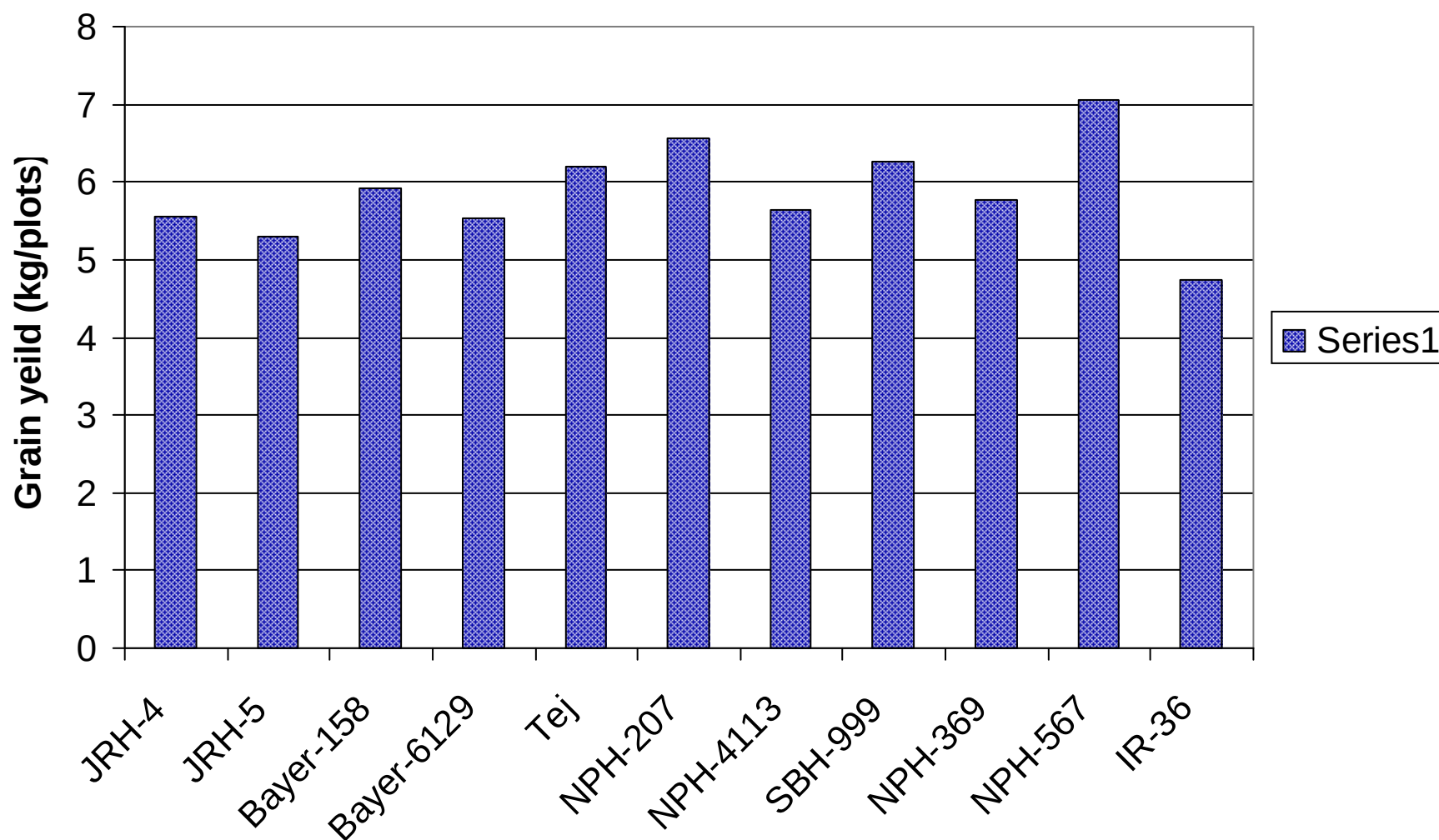


Fig- 21 Mean grain yeild/plot of hybrids of rice under SRI cultivation system

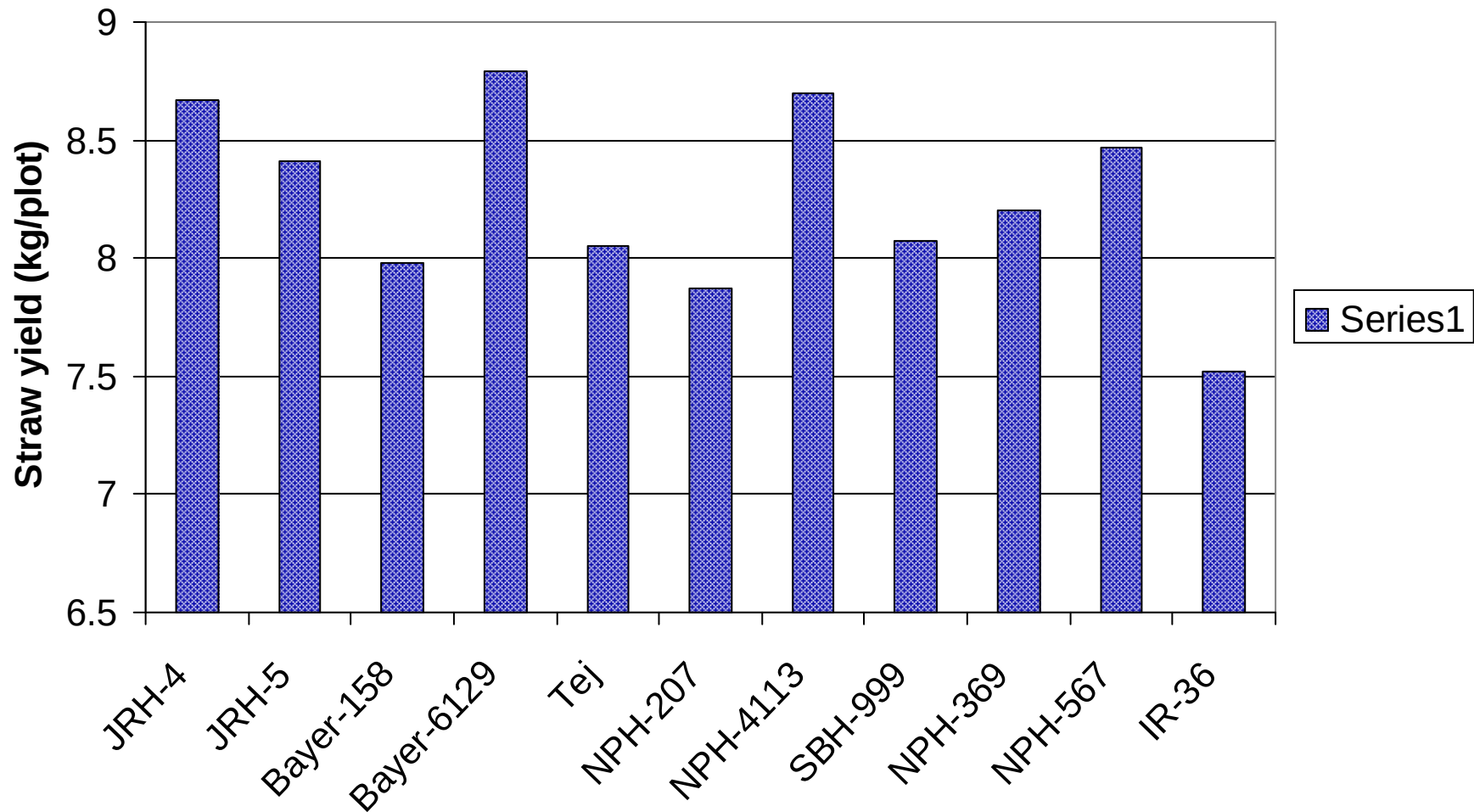


Fig-22 Mean Straw yield per plot of hybrids of rice under SRI cultivation system

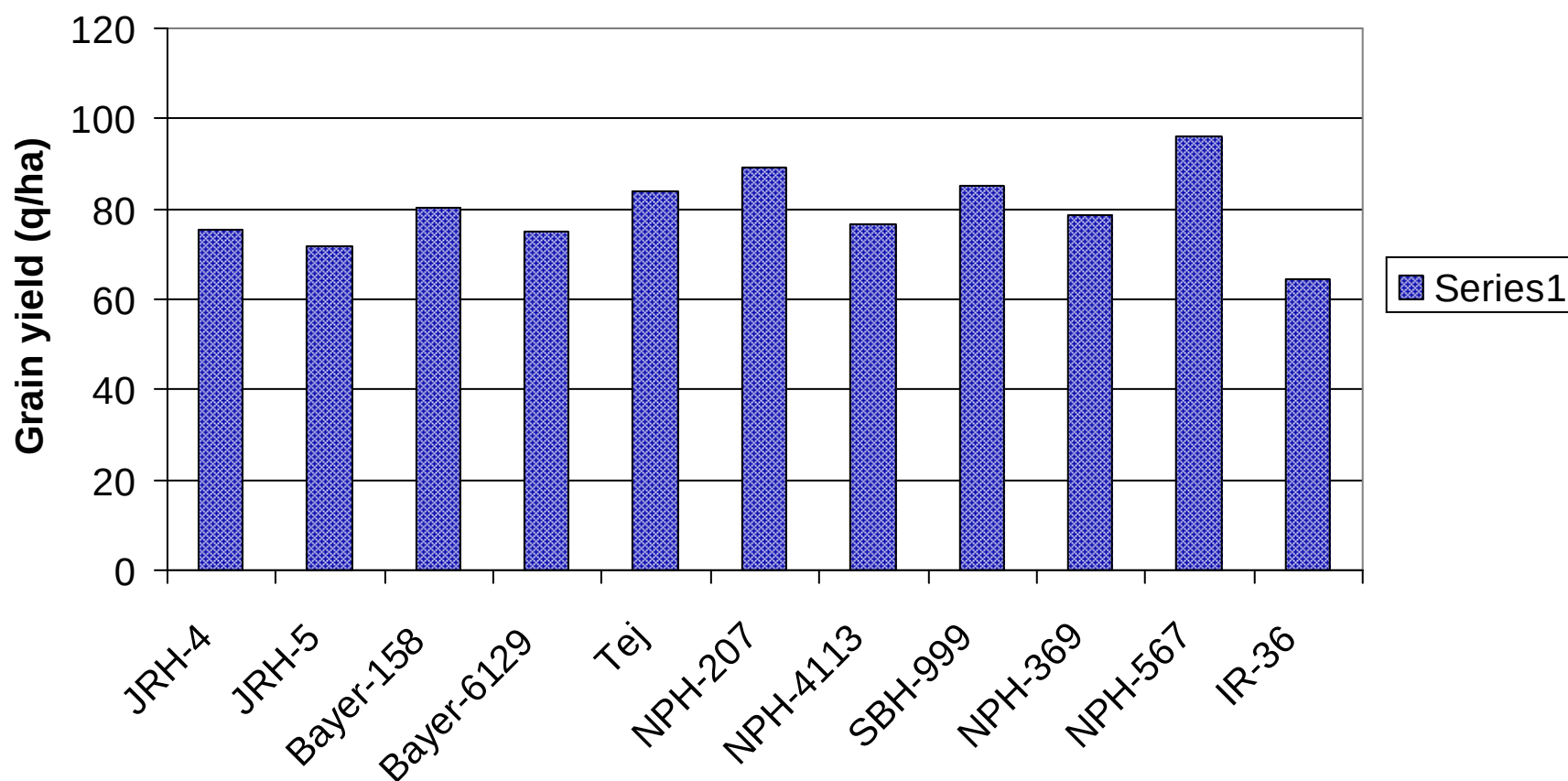


Fig-23 Mean Grain yield per hectare of hybrids of rice under SRI cultivation

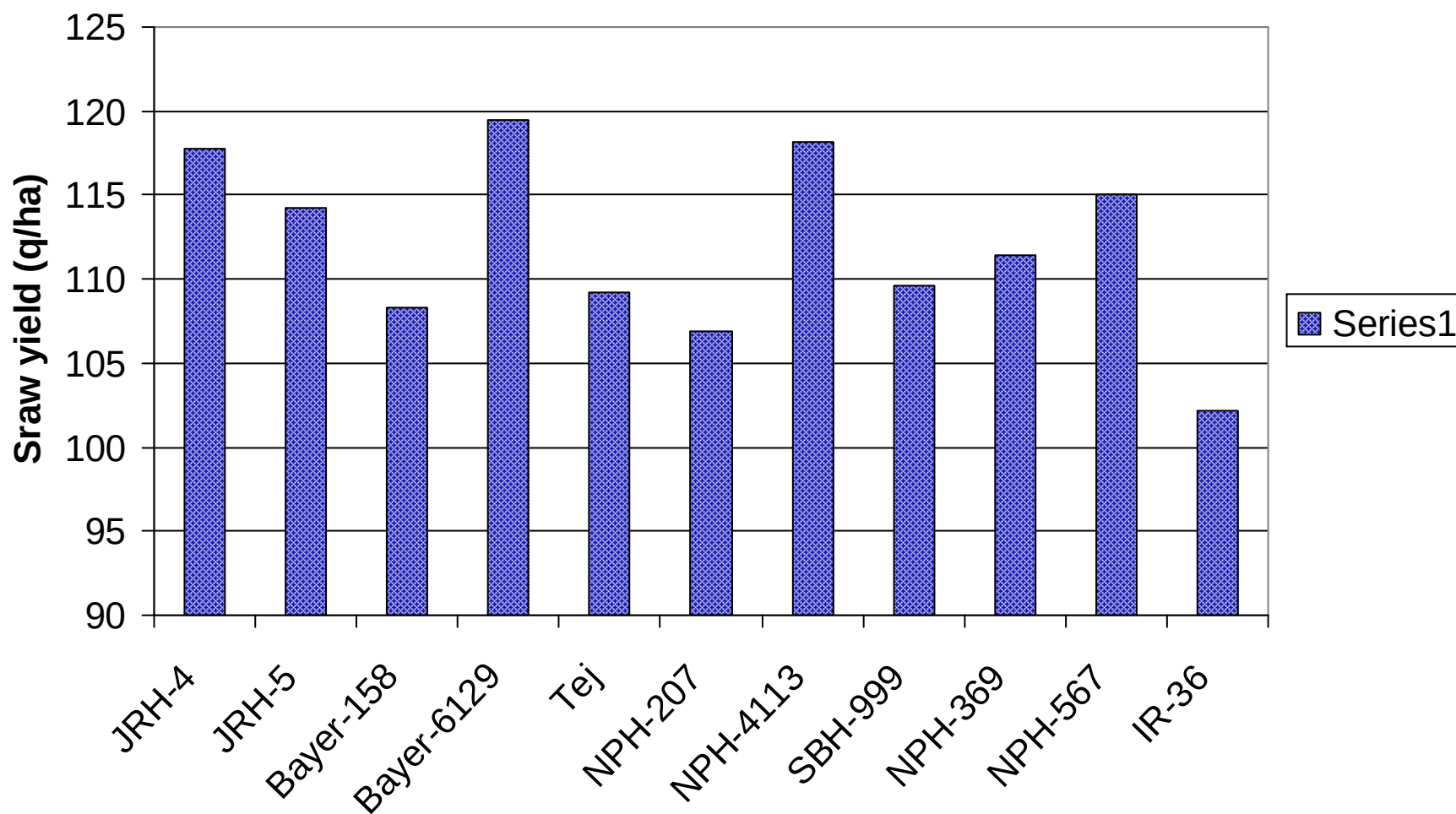


**Fig-24 Mean Straw yield per hectare of hybrids of rice
under SRI cultivation system**

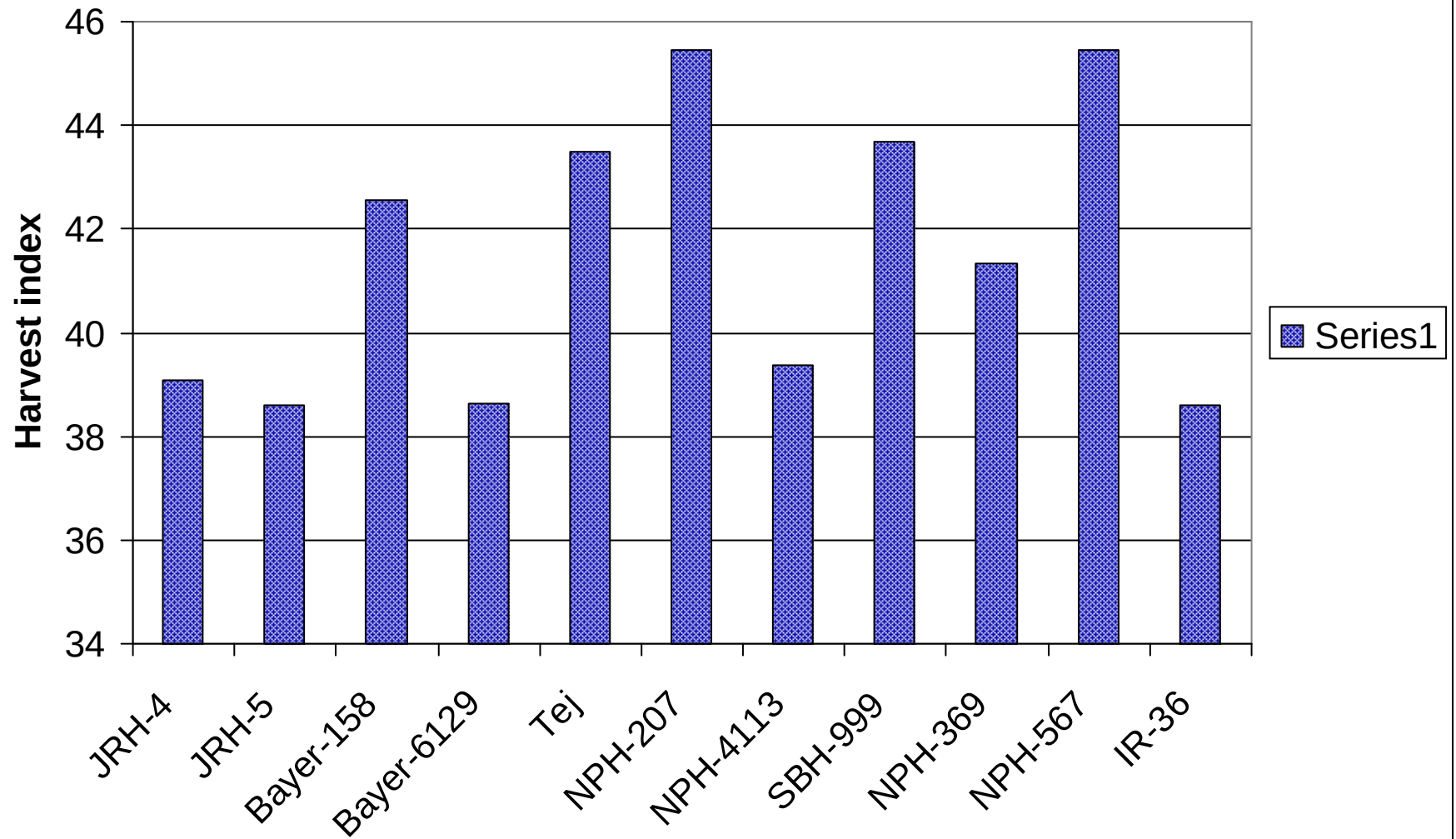


Fig-25 Mean Harvest index of hybrids of rice under SRI cultivation system

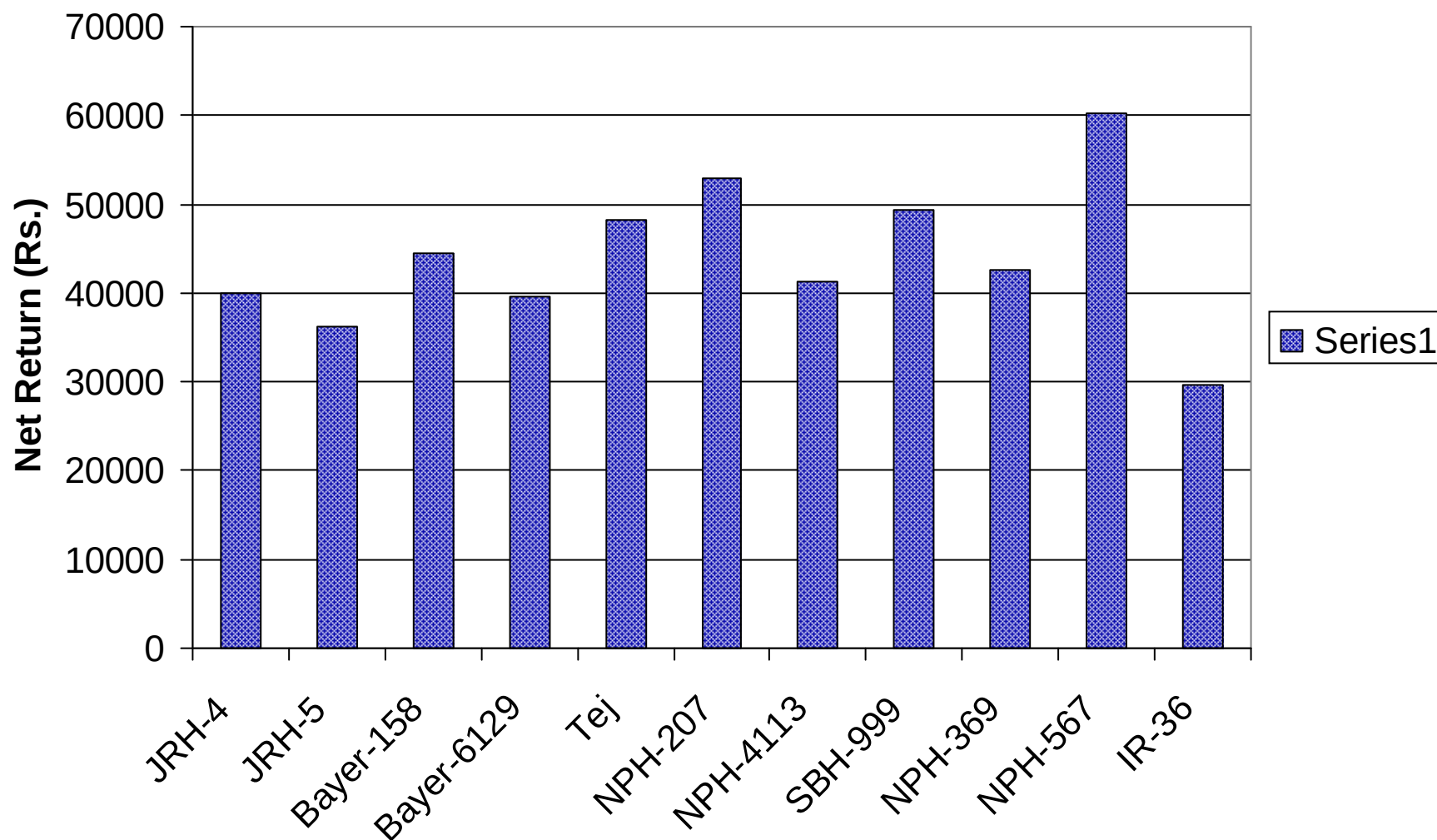


Fig-26 MEan Net Return (Rs/ha) of hybrids of rice under SRI cultivation system

