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GLIMPSES OF THREE DECADES OF RICE RESEARCH IN GOA

ICAR RESEARCH COMPLEX FOR GOA
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FOREWORD

Rice is the major food crop of India as well as the State of Goa and adjoining regions. I am happy to note that ICAR Research Complex for Goa is bringing out the Research Bulletin entitled "GLIMPSES OF THREE DECADES OF RICE RESEARCH IN GOA" to highlight the rice research carried out by the Institute in Goa.

Rice occupies a special status in the food habits of Goa and adjoining regions as rice- fish curry is preferred by vast majority of the region. Of late, rice production is facing specific constraints affecting the production in the region. I am happy to note that the Institute has introduced and evaluated different groups of rice including local, salt tolerant, red kernelled, medium duration, scented and rice hybrids with a series of genotypes over a period of three decades and selected suitable genotypes in each group. The efforts made to replace the local/ traditional rice varieties with latest high yielding ones keeping in view the local preference and thereby improve the productivity of rice is commendable. Similarly, for adding value to local rice production, introduction and evaluation of scented types has shown the feasibility of augmenting its production in Goa. Further, improved productivity will also serve as a means to reduce the cost of production per unit quantity in turn sustaining the crop cultivation in the region.

This compilation "GLIMPSES OF THREE DECADES OF RICE RESEARCH IN GOA" of rice research in Goa will serve as a comprehensive document for developing high production package and for formulating future research strategies as well as to provide relevant information to the researchers, extension workers as well as the farming community.

I am sure that this Bulletin will serve as a reference material to all those who are involved in rice industry and will go a long way in improving the rice production and livelihood security of small and marginal farmers of the region.

My best wishes on the occasion.

April 2009

Dr. M. Mahadevappa

PREFACE

Rice being the staple food crop of the region, is widely cultivated in lowlying areas of Goa and adjoining regions. The agro-climatic conditions prevailing in the region are ideal to realise higher productivity of the crop. However, during the recent years owing to labour scarcity coupled with other socio-economic constraints, the cropped area under rice is dwindling and thus, posing a serious challenge to meet the food security of the region.

Improvement of rice productivity needs to be the main approach to meet this challenge. Keeping this in view, ICAR Research Complex for Goa, right from its inception during 1977 (then the Research centre of CPCRI, Kasaragod) has undertaken rice research especially through evaluation of a series of local and introduced varieties as well as hybrids so as to identify a suitable genotype for different situations of rice cultivation. Since then, research efforts at various levels have given a renewed direction to this crop to improve production and productivity.

This Research Bulletin is a compilation of rice research carried out by various scientists at this Instiute right from inception. The Research efforts and the achievements during the last three decades will identify the gaps and needs which would pave the way for drawing the future course of research for the benefit of rice growers, developmental agencies and the planners.

While bringing out this bench mark publication, I sincerely acknowledge the invaluable contributions rendered by various visionaries, research workers and scientists and Indian Council of Agricultural Research, New Delhi for encouraging the research on rice crop.

My sincere thanks are to Dr.V S. Korikanthimath, Director, ICAR Research Complex for Goa for his inspiration, constant encouragement, leadership in introduction and evaluation of various rice types suited to the region, seed production, effective transfer of technology by taking up large scale field demonstrations, etc .

Special thanks are due to Dr. B.C. Viraktamath, Director, who was also one of the former pioneering rice researchers at this Institute and the team of Scientists of DRR, Hyderabad for their continued cordination and co-operation at various stages of rice research at this Institute.

My sincere thanks to all the research workers who handled this monumental work on the staple food crop at different stages including Dr. N. P. S. Varde, Dr. R.C. Mandal, Dr. P.K. Desai, Dr. B. Krishnamurthy, Dr. D. Sunderraju, Dr. K. D. Singh, Dr. K. Venu Gopal, Dr. K.D. Patil, etc. Further, the co-operation and help rendered by scientists of the Institute at different stages of rice research is greatfully acknowledged.

The conduct of various on–farm trials and frontline demonstrations in rice was possible with the co-operation of Shri Satish Tendulkar, present and former Directors, Dy. Directors and Zonal Agricultural Officers of Directorate of Agriculture, Government of Goa over the years.

The co-operation and enthusiasm evinced by the farmers of Goa deserves high appreciations.

B.L.MANJUNATH

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I. INTRODUCTION

Rice (*Oryza sativa* L) is the world's most important food crop and a primary source of food for more than half of the population. More than 90 per cent of the world's rice is grown and consumed in Asia, where 60 per cent of the earth's people live. In India, rice is cultivated round the year in one or the other part of the country, in diverse ecologies spread over 44 m ha with a production of around 90 m tonnes representing the largest area and second highest production in the world. The production almost tripled from 30.4 m tonnes (milled rice) during last three decades. With the advent of improved rice varieties yield can be substantially enhanced using appropriate inputs in terms of quality seed, fertilizer, plant protection measures and judicious use of irrigation.

Rice is the predominant staple food crop of Goa occupying more than 39 per cent (52,442 ha) of the total cultivated area in the State. It is cultivated under three distinct ecologies during k*harif* season. The crop is cultivated in *morod* lands (lateritic uplands covering 16.4 % of area accounting to 8,600 ha), midlands or *kher* lands totaling to 32 per cent of area (16,900 ha) and the *khazan* lands 32 per cent (17,200 ha) and the rest covered under *rabi* season.

The rice based cropping systems include rice-pulse (local cowpea) and rice-groundnut under residual soil moisture situations in rice fallows from early December to March and rice-vegetables, rice- sweet potato in areas where life saving irrigation can be provided by traditionally developed sunken wells mostly in *kher* lands. These constitute the predominant cropping pattern which dominates nearly 42-45 per cent of the agrarian scenario in the region.

ICAR Research Complex for Goa is a multi-commodity and multi-disciplinary Institute catering to the applied agricultural research requirements of Goa State and adjoining areas with a mandate to introduce and improve all potential crops and various species / breeds of livestock and scientific exploitation of various aquatic resources for improving fish production. Rice, being the major mandate crop of the Institute, efforts were made to screen the local rice germplasm and introduce and evaluate the suitable genotypes for different ecologies of rice production right from the inception of the Institute during 1977.

II. Screening of Local germplasm of rice

During the period 1977-78, 23 collections of local germplasm of paddy were made from different places of Goa with the coordination the Directorate of Agriculture. The collections included Damgo (Valpoi), Damgo (Kolpet), Damgo (Amona), Damgo (Nanora), Damgo (Mayem) Korgut (white), Korgut (Red), Babri (Mayem), Babri (Quepem), Babri (Curti), Babri (Chandor), Khochri (Quepem), Khochri (Malkarnem), Khochri (Ponda), Khochri (Nanora), Kendal, Olsugo, Patni (Margao), Dhavi-Patni, Morod Kendal, Belo, Tamdi and Nermar.

Based on the observations indicated in Table 1, these local varieties may be grouped as follows:

1. Long duration (135-150 days) and very tall (above 160 cm) : Damgo, Babri.
2. Medium duration and tall (120 to 130 days) : Patni, Belo, Nermar .
3. Short duration : Khochri, Kendal, Olsugo and Tamdi (110 to 120 days).
4. Very short duration (90-110 days) : Korgut white, Korgut red, Dhavi-Patni, Morod. Kendal.

The long duration varities - Damgo, Babri and medium duration accessions - Patni and Nermar were found to be high yielding (above 4 t/ha). Korgut, Red Khochri and Belo were

Table 1. Growth and yield of local rice varieties during *kharif* 1977

Rice variety	Mean height (cm)	Mean tillers/hill	Mean effective tillers/hill	Mean length of panicle (cm)	Average no. of grains/ panicle	Mean grain yield (kg/ha)	Duration (days)	Lodging character
Damgo	177.6	5.8	.5.1	25.4	180	4666	144	Lodging
Babri	173.0	5.8	4.8	24.6	186	4740	142	
Patni	174.0	5.1	5.0	24.0	243	5222	126	Non-Lodging
Belo	158.0	5.8	4.5	25.2	215	3037	124	
Nermar	161.0	4.8	4.4	23.0	380	4074	122	
Khochri	162.6	5.1	4.3	26.8	237	3629	114	
Kendal	114.0	5.6	5.0	28.0	150	2888	112	
Olsugo	124.0	7.1	7.0	24.7	128	1926	112	
Tamdi	157.0	5.5	5.0	27.2	234	2963	117	Lodging
Korgut (white)	158.0	4.7	4.3	32.0	136	2520	104	
Korgut (Red)	140.0	5.0	4.8	30.0	109	3037	104	
Dhavi Patni	124.0	6.1	6.0	20.0	141	2800	92	Non-Lodging
Morod Kendal	129.0	5.5	5.4	26.0	115	1667	92	
C. D. (P=0.05)						**253**		

found to be next in yield potential giving an yield of over 3 t / ha. However, Korgut White, Kendal, Dhavi-Patni and Tamdi recorded low yields (below 3 t / ha) while Olsugo and Morad Kendal recorded less than 2 t / ha. The grain quality of Dhavi-Patni, Morad Kendal and Olsugo are found to be very good, which are also short duration accessions.

The local variety Nermar has very good yield potential (4 t / ha) and produced highest number of grains / panicle (380). It was also observed that the local varieties had low incidence of pests and diseases. But the main drawback of some of the local high yielding varieties *viz* Damgo, Babri are that they are tall and have lodging tendency which causes much damage during cyclonic weather.

During 1978, out of 13 varieties screened during *kharif* 1977, ten were tried in a replicated trial. The growth characters and the yield recorded are depicted in Table 2.

Table 2. Growth characters and yield of local paddy varieties during *kharif* 1978

Variety	Height (cm)	Tiller number		Panicle length (cm)	Grains/ Panicle	Yield (t/ha)	Duration (days)
		Total	Effective				
Damgo	186	5.7	4.8	27.3	175	4.86	135
Babri	180	5.6	4.8	26.7	169	4.66	135
Belo	170	5.9	5.1	24.2	181	3.03	118
Nermar	170	4.9	4.5	22.3	328	4.18	118
Khochri	156	4.9	4.5	24.3	186	3.67	114
Kendal	120	5.5	5.1	27.3	143	2.64	108
Olsugo	118	6.7	6.2	22.1	118	2.60	108
Korgut (red)	134	5.3	4.5	23.4	91	2.95	106
Korgut (white)	140	4.4	4.2	27.4	124	2.63	106
Dhavi Patni	120	5.7	5.1	20.3	132	2.70	93
C.D (P=0.05)	-	-	-	-	-	**0.41**	-

It was observed that

1. The varieties Damgo and Babri are long in duration, tallest but possess very good yield potential (4.75 t/ha).
2. The varieties Belo, Nermar and Khochri are medium in duration, giving good yield. Among these, Khochri is having non-lodging habit, good yield with good cooking quality and hence holds a great promise. Nermar produced more number of grains / panicle.
3. The varieties Kendal, Olsugo, Korgut (Red) and Korgut (white) are short in duration (105 days) but are low yielders (mean 2.7 t / ha)
4. Dhavi Patni is shortest in duration (93 days), low yielder (2.7 t / ha) but possesses good grain quality.

In general, the local accessions were found to be resistant / tolerant to pests and diseases. Studies on the screening of 35 local varieties against pest resistance recorded negligible damage and no damage on account of leaf roller and gall midge, respectively. All the varieties were susceptible to whorl maggot and varieties *viz*., Korgut (Black), Tamdi, Bangar Sal, Jira Sal, Mandla, Morod, Pandya, Kotambi Sal, Novan and Salsi recorded less than 10 per cent damage. The maximum damage (30.33 %) was observed in Germal and minimum in Sal (3.36 %).

Based on the studies, it was concluded that the varieties "Damgo" and "Babri" being tall and late maturing were found suitable for low lying areas. For *Kher* lands the medium duration varieties such as "Nermar", "Kochri Patni" and " Belo" proved to be promising. Varieties "Dhavi Patni" and "Morod Kendal" were the early varieties (95 days) suitable for *Morod* lands.

III. Screening of rice varieties for tolerance to salinity

Soil salinity is a serious problem in the coastal saline soils of Goa. These lands locally known as *Khazan* lands are subjected to periodical inundation of sea or creek water during high tides. As a result, these lands are progressively rendered saline. Even if these lands are protected from the ingression of sea or creek water by constructing embankments, salts from the shallow water table rises to the surface through capillaries making the surface soils, saline in Goa. The problematic area is estimated to be around 18,000 ha, out of which about 12,000 hectares are utilized for cultivation of rice in *kharif*. To overcome the problem and decide the strategy for increasing production and productivity of rice in the problematic saline soil, efforts have been made to identify the high yielding salt tolerant rice varieties suitable for saline (*khazan*) lands as local rice varieties like Korgut and Azgo which are tall and lodging type are low yielders.

Characterisation of saline soils

The salt affected soils of Goa classified under Zuari series, mainly occur in the flood plain along Zuari and Mandovi rivers. These are subjected to flood during monsoon and inundated with sea water during high tide. A survey of salt affected area along the Zuari river and Cumbharjuna canal was carried out and soil of the area was characterized physico-chemically.

1. Soils of low lying plains of river basin

Soils are grey to dark black in colour, completely dispersed, puddled when wet, very hard on drying, made up of riverine alluvial deposits with less than one per cent slope towards river. The striking features of the soils are - the electrical conductivity and free and

exchangeable Na content of the soil decreases from 33 to 4 m mhos /cm and 76 to 27 me / 100g, respectively as the distance increases from the river banks. Organic carbon and calcium content of the soil range from 0.89 to 2.66 per cent and 5.6 to 8.0 me / 100g, respectively. The soil sampled along the Sal river basin showed comparatively low organic carbon, exchangeable calcium and potassium. The average values of organic carbon, exchangeable calcium and potassium are 0.45 per cent, 1.6 me / 100g and 0.8 me / 100g soil, respectively.

2. Soils of higher elevation but subjected to tidal water away from river basin

Soils are light reddish to yellow in colour, hard on drying, more than one per cent slope towards river. Soils are colluvial in origin. The electrical conductivity of these soils is low (0.7 to 3.1m mhos/cm) whereas free and exchangeable sodium is high (15.4 to 46.9 me/ 100g). Potassium content of the soils is high (0.8 to 4.5 me/100g) and calcium is low to medium (0.6 to 6.4 me/100g). The organic carbon content is medium to high (0.67 to 1.81 %). As compared to first group of soils, the E.C, Ca and K are comparitively low.

Soil profile characteristics of saline soils

Studies conducted on soil profile characteristics of Aquic ustropepts soils of the saline paddy fields indicated that the soils are strongly acidic (pH 5.3) in surface soil, containing 1.83 per cent organic carbon and bulk density of 1.32 g/cm. Soil moisture retention at 15 b was 33.43 per cent and at 1/3 b was 52.49 per cent. Cation exchange capacity of soil was 16.5 c mol $^{(+)}$ / kg soil with a base saturation of 43 per cent. In the extremely acidic sub soil region (pH 3.6 to 4.4), organic carbon ranged from 0.82 to 1.01 per cent, bulk density from 0.78 to 1.48 g/ cm^3. Soil moisture retention in these soils at 15 b was 34.75 per cent and at 1/3 b was 51.61 per cent. Cation exchange capacity of soil varied from 21.0 to 34.5 c mol $^{(+)}$ / kg soil with a base saturation from 22 to 53 per cent. Further, in the glazed weathered ultra acidic (pH 2.76 to 3.1) C horizon, organic carbon ranged from 2.65 to 4.25 per cent and bulk density from 0.73 to 0.79 g/ cm^3 . Cation exchange capacity of soil was from 30.1 to 37.4 c mol $^{(+)}$ / kg soil with a base saturation from 58 to 87 per cent. Electrical conductivity of the saturation extract ranged from 28.7 to 37.4 dS/m, exchangeable sodium from 14.0 to 33.7 c mol $^{(+)}$ / kg soil. The sulfate content raised from 12.42 to 24.25 c mol $^{(+)}$ / kg soil. This indicates a potential acid sulfate condition with salinity and sodicity. The soil contained medium level of nitrogen and potassium very low level of phosphorus and adequate levels of micronutrients.

Water analysis

The analytical results of water samples collected in the month of November recorded 21.3 m mhos/cm, 2.9 me K /litre and 11.9 me Ca /litre. The initial water sample collected during monsoon period from the same field indicated E.C of 0.13 to 0.19 m mhos/cm only. A reclamation study at Durga farm in South Goa revealed the change in specific conductance of stagnant water from 21.9 m mhos/cm during summer to 0.70 m mhos/cm during rains and of river water from 21.9 m mhos/cm in June to 0.37 m mhos/cm in October in Southern area. Seepage studies revealed the non movement of water through sub-soil (up to 50 cm) from river during high tide. The infiltration rate in ploughed land was 2.64 cm/h as compared to 1.18 cm/h of unploughed land. Reclamation studies indicated that the maximum removal of salts could be effected by ploughing plus impounding and sub surface drainage. A scheme for reclamation was suggested.

Korgut - Local salt tolerant rice variety

CSR - 27 - An introduced salt tolerant rice variety with high yield potential

Table 3. Growth and yield observations of different varieties during 1977

Varieties	Mean plant height (cm)	Mean tillers / hill	Grain yield (t/ha)	Duration (days)
A.U-1	82	10.4	4.07	94
Vittyla-1	144	8.4	2.63	149
SR 26 B	136	7.0	2.40	160
Rajarajan	96	12.8	3.70	177
Korgut	122	6.6	2.98	105
C.D (P=0.01)	-	-	0.64	-

Evaluation of salt tolerant varieites

Twelve varieties of paddy known for salt tolerance collected from different sources were tried under the typical inundated saline area near Durga Farm (Salcete) in South Goa in the first week of June 1977, to screen for salt tolerance under the local conditions. The varieties *viz* Vyttila-1, Rajarajan, A.U-1, SR-26 B, PVR-1, RPG-17, RPA 5929, MR-18, MR-340, MR-343, Mangala and Korgut (local check) were included in this trial. The first four varieties and the local performed well and remaining ones could not recover from the damage caused due to initial high salinity. Hence, the observations were collected from the five varieties. Regular growth data recorded periodically indicated that among the five varieties (Vyttila, Rajarajan, A.U-1, SR-26 B & Korgut), A.U-1 and Korgut showed good growth during the initial high salinity (10 to 15 days after transplanting) period whereas the other varieties showed fair growth. However, in the later stages (i.e about five weeks after transplanting), Rajarajan recovered well. A.U-1 also showed very good growth followed by Korgut and Vyttila-1.

The above data clearly indicates that A.U-1 is a short duration, dwarf, high tillering and high yielding variety which also showed high tolerance to salinity from transplanting to harvest. Korgut, the local check showed tolerance to salinity next to A.U-1. Though Rajarajan yielded more than Korgut, it is not preferable due to very long duration. Vyttila-1and SR 26 B recorded low yields and also matured late.

In another trial, grown under normal condition in Margao farm mainly for seed multiplication and general performance studies, varieties CSR-1, 2 and 3 were found to be long duration compared to CSR-4. However all the CSR varieties, Jhona-349 and BR 4-10 were found to be early, but most of the varieties recorded low yield due to typical chaffy and empty panicle formation. Based on the results of 1977 *kharif* season, AU-1, Korgut were selected and a few need based salt-tolerant varities were included during *kharif* 1978. This six varieties are local Korgut, MCM-1, MCM-2, CSR-3 (Getu), AU-1, SR-1-64-2 tested in a replicated (4) trial at a typically *Khazan* (salt affected) land in a farmer's field at Raia (Margao) inundated by saline water during high tides, remain completely flooded during *kharif* season, which is a common feature of *Khazan* lands. Growth characteristics and the yield recorded are summarized in Table 4.

Under the typical conditions of the representative of *khazan* soils, it is clear from the Table 4 that the varieties MCM-1, MCM-2 which are medium in duration performed the

Table 4. Growth and yield of salt-tolerant rice varieties

Variety	Plant height (cm)	Tiller number.		Grains / panicle	Yield (t/ha)
		Total	Effective		
MCM-1	132	10.0	8.2	140	3.67
MCM-2	144	11.4	7.2	158	3.49
AU-1	97	8.4	6.4	107	1.67
CSR-3	119	10.0	7.4	120	2.67
SR-1-63-1	103	9.0	6.9	88	2.03
Korgut (local)	154	4.7	4.2	137	2.32
CD (P=0.05)	-	-	-	-	**0.93**

best. The high yields are attributable to more number of tillers, more number of grains / panicle under salinity. Because of tallness like in Korgut (local), farmers keep higher water level during high tides, escaping flood. The variety AU-1 which is a salt tolerant variety and performed well during *kharif* 1977 near Durga Farm (not affected by tidal water), could not perform well under this typical condition, apparently due to fact that it is a dwarf type (97 cm height.) and hence suffered badly due to submergence during high tides, particularly at boot-leaf stage turning the flag leaf completely white, the panicles becoming chaffy. The varieties CSR-3 (Getu) and SR-1-63-1 performed well initially as indicated by periodical growth observation; but due to longer duration and comparatively low yield, these are not suitable for the tract. The local check Korgut is a short duration (105 days) variety, tall in nature but is having lodging habit. It produced less number of tillers but the yield is satisfactory.

Further, an experiment with six salt tolerant rice varieties i. e. CSR-4, CSR-10, Panvel-1, Panvel -2, Korgut and Azgo, was conducted on two different locations. i.e. Chodan and Kumbharjua of Goa at the farmers fields during the *kharif* seasons of 1990 and 1991. Another trial consisting of seven salt tolerant rice varieties i.e. CSR-4, CSR-10, Palghar-1, Panvel-1 Panvel-2, CO-3 and Korgut was conducted during the *kharif* seasons of 1993, 1994 and 1995 in a randomized block design with three replications. Field experiments were also conducted during *kharif* seasons of 1997, 1998 and 1999 in a randomized block design, replicating thrice with eight salt varieties i.e. CSR-10, CSR-22, CSR-23, CSR-26, CSR-27, CSR-28, Korgut, and Azgo. Nitrogen at the rate of 100 kg/ha through urea in three splits, phosphorous and potash at the rate of 50 kg/ha through single super phosphate and muriate of potash, were applied basally. All inter-culture operations were carried out as per recommended practices. The observations on

height of plant, number of tillers and number of panicles per meter square, 1000 grain weight and grain yield were recorded. The grain and straw samples of rice varieties CSR-10, CSR-27 and Korgut were sampled, washed, dried, processed and analysed for macro and micronutrient contents. The uptake of nutrients by the salt tolerant rice was estimated as per standard procedures. Further, field experiments were conducted with three salt tolerant rice varieties *viz* CSR-10, CSR-27 and Korgut at three different salinity levels. The soil and ground water at different intervals were collected, analysed by standard methods. The results of the six salt tolerant rice varieties during 1990 to 1992 indicated that the rice variety CSR-10, out yielded all the varieties in both the locations with mean yield of 4.34 and 5.33 t/ha during 1990 and 3.18 and 3.20 t/ha during 1991.

The rice variety CSR-4 also performed better as compared to the local varieties. During the two years study it was found that CSR-10 and CSR-4 out yielded other varieties due to higher number of effective tillers, more number of panicles per meter square and boldness of grain as reflected by higher weight of 1000 grain than the local rice varieties. i.e. Korgut and Azgo which yielded 2.0 t/ha.

Three years pooled data from 1993 to 1995 on seven salt tolerant rice varieties revealed that the rice yield obtained with CSR-4 (3.5 t/ha), CSR-10 (3.44 t/ha) and Palghar-1 (3.22 t/ha) were consistently higher and significantly superior to the traditional local rice variety Korgut (1.95 t/ha).

Table 5. Growth, yield contributing characters and yield of different salt tolerant rice varieties during *kharif* 1990 and 1991

Location	Rice variety	Plant height (cm)		No. of effective tillers/hill		Panicle length (cm)		No. of grains/ panicle		No. of panicles/ m^2		1000 grain weight (g)		Grain yield (t ha^{-1})		
		90-91	91-92	90-91	91-92	90-91	91-92	90-91	91-92	90-91	91-92	90-91	91-92	90-91	91-92	Mean
Chodan	CSR-4	86	68	5	5	19	18	109	71	133	113	31	39	3.62	2.59	3.11
	CSR-10	70	85	5	6	17	22	119	120	158	143	29	28	4.33	3.18	3.76
	Panvel-1	93	85	6	5	22	25	84	176	129	142	30	29	3.11	2.48	2.80
	Panvel-2	71	89	6	5	21	25	78	187	156	186	29	30	2.78	2.57	2.68
	Korgut	140	124	4	5	17	26	80	101	110	91	29	28	2.80	2.18	2.49
	Azgo	145	115	5	4	23	26	169	103	124	113	28	29	2.60	1.88	2.24
Kumbarjua	CSR-4	93	85	7	5	20	22	117	104	137	153	32	31	3.98	3.08	3.53
	CSR-10	83	86	7	5	17	21	136	122	145	122	30	29	5.33	3.20	4.27
	Panvel-1	81	65	7	6	23	19	99	73	129	134	29	30	2.33	2.50	2.42
	Panvel-2	78	89	7	6	23	26	77	199	152	182	28	29	1.89	2.75	2.32
	Korgut	122	135	6	4	19	28	88	90	88	93	28	27	1.78	2.13	1.96
	Azgo	138	118	6	3	25	23	203	107	86	83	28	29	2.11	2.00	2.06

The three years pooled data from 1997 to 1999 on eight salt tolerant rice varieties revealed that the rice yield obtained by CSR-10 (3.95 t ha^{-1}) and CSR-27 (4.0 t ha^{-1}) were consistently higher than Korgut 2.0 t ha^{-1} .

Table 6. Mean performance of salt tolerant rice varieties (1993 to 1995)

Variety	Height (cm)	No. of Tillers /hill	Panicles / m^2	1000 grain wt (g)	Yield (t ha^{-1})
CSR-4	89.0	6.3	295	25.23	3.53
CSR-10	84.1	6.3	284	24.90	3.44
Palghar-1	85.7	6.3	282	28.00	3.26
Panvel-1	84.4	5.7	268	26.33	2.82
Panvel-2	77.1	6.0	273	24.43	2.66
Co-43	76.1	5.3	268	24.26	2.74
Korgut	144.6	3.7	266	25.56	1.95
C.D. (P=0.05)	**7.17**	**1.23**	**22**	**1.43**	**0.63**

Table 7. Pooled mean performance of salt tolerant rice varieties

Variety	Grain yield (t ha^{-1})			
	1993	1994	1995	Pooled mean
CSR-4	4.34	3.14	3.12	3.53
CSR-10	4.08	3.29	2.93	3.44
Palghar-1	3.85	2.90	3.03	3.26
Panvel-1	3.26	2.70	2.49	2.82
Panvel-2	2.79	2.54	2.64	2.66
Co-43	3.13	2.30	2.78	2.74
Korgut	1.92	1.90	2.02	1.95
C. D. (P=0.05)	**0.72**	**0.56**	**0.62**	**0.63**

Table 8. Performance of salt tolerant rice varieties during 1997 to 1998

Variety	Plant Height (cm)	No. of tillers/hill	Panicles/ m^2	1000 grain weight (g)	Yield (t ha^{-1})
CSR-10	85.30	6.70	291	25.37	4.05
CSR-22	82.40	6.30	280	24.90	3.55
CSR-23	82.00	6.40	272	26.10	3.85
CSR-26	86.30	6.50	281	26.80	3.25
CSR-27	88.10	7.00	293	27.12	4.10
CSR-28	75.30	5.75	213	23.90	2.55
Korgut	120.25	4.50	253	24.54	2.10
Azgo	115.25	3.75	247	25.12	1.95
C.D. (P=0.05)	**7.75**	**1.36**	**23**	**1.45**	**0.64**

In the uptake studies, to get rice yield 4,000 kg ha^{-1} in CSR-27, the nutrient uptake from the saline soils were 64 kg ha^{-1} N, 18 kg ha^{-1} P, 127 kg ha^{-1} K, 7 kg ha^{-1} Ca, 5 kg ha^{-1} Mg, 1.3 kg ha^{-1} Fe, 2.6 kg ha^{-1} Mn, 0.4 kg ha^{-1} Zn, 0.1 kg ha^{-1} Cu and 0.04kg ha^{-1} B. To obtain the rice yield 3,950 kg ha^{-1} in CSR-10, 56 kg ha^{-1} N, 18 kg ha^{-1} P, 105 kg ha^{-1} K, 3 kg ha^{-1} Ca, 6 kg ha^{-1} Mg, 2.1 kg ha^{-1} Fe, 2.1 kg ha^{-1} Mn, 0.4 kg ha^{-1} Zn, 0.1 kg ha^{-1} Cu and 0.04 kg ha^{-1} B, respectively were takenup as compared to 35 kg ha^{-1} N, 10 kg ha^{-1} P, 48 kg ha^{-1} K, 2 kg ha^{-1} Ca, 3 kg ha^{-1} Mg, 0.9 kg ha^{-1} Fe, 1.5 kg ha^{-1} Mn, 0.15 kg ha^{-1} Zn, 0.05 kg ha^{-1} Cu and 0.03 kg ha^{-1} B, by 2000 kg ha^{-1} of Korgut variety of traditional rice under coastal saline soils of Goa.

The coastal soils of Goa are characterized by low elevation and high water table. The soils are deep, heavy textured, silty clay to silty clay loam having heavier sub horizon. The soil pH is slightly acidic to neutral (6.0-7.0), with electrical conductivity 4 to 15 dS m^{-1}, and organic carbon content 6.3-7.7 g kg^{-1}. The soils had available N 244 kg ha^{-1}, P 6.3 kg ha^{-1} and K 807 kg ha^{-1}. The ionic preponderance decreased in the order: Na^{+1} 105 me l^{-1} > Cl^{-1} 82 me l^{-1} > SO_4^{-2} 4.5 me l^{-1} > Mg^{+2} 2.9 me l^{-1}> Ca^{+2} 2.5 me l^{-1} > HCO_3^{-1} 0.76 me l^{-1}. The DTPA extractable nutrients were Fe 19.28 mg kg^{-1}, Mn 7.90 mg kg^{-1}, Zn 0.75 mg kg^{-1} and Cu 2.80 mg kg^{-1}.

The quality of ground water at different intervals selected from the sampling sites of the soil samples showed an increase in the salinity levels after October as compared to the previous months. The maximum salinity in the ground water was recorded with electrical conductivity of 3.55 dS m^{-1} with higher concentration of Sodium (24.56 me l^{-1}), Chloride (26.86 me l^{-1}) and SAR (29.86).

The root distribution pattern of these salt tolerant rice varieties in different locations registered a reduction in root length, less number of tertiary roots and increase in the weight of root to shoot ratio in the rice plants growing at higher salinity level. The root damage of five per cent and 30 per cent reduction in the yield of traditional Korgut rice was observed with the ground water having electrical conductivity of 3.55 dS m^{-1}.

Table 9. Physico-chemical properties of the soil at three different locations

Physico-chemical properties	Ela	Carambolim	Chodan
pH (1:2.5)	5.95	4.84	6.94
E. C. (dS m^{-1})	0.09	0.36	1.06
Organic carbon (g kg^{-1})	14.10	7.70	6.30
Available N (kg ha^{-1})	241	257	244
Available P (kg ha^{-1})	34	7.16	6.3
Available K (kg ha^{-1})	112	102	807
Available Ca (kg ha^{-1})	650	170	370
Available Mg (kg ha^{-1})	192	367	850
Available Na (kg ha^{-1})	46	225	950
Available S (kg ha^{-1})	152	109	20
DTPA extractable Fe (mg kg^{-1})	25.51	24.60	19.28
DTPA extractable Mn (mg kg^{-1})	12.50	9.59	7.90
DTPA extractable Zn (mg kg^{-1})	1.49	1.07	0.75
DTPA extractable Cu (mg kg^{-1})	7.53	4.00	2.80
Water exctractable Chlorides (mg kg^{-1})	105	311	1330

Table 10. Quality of ground water during different months at different sites

Parameters	Ela			Carambolim			Chodan		
	Aug	Sept	Oct	Aug	Sept	Oct	Aug	Sept	Oct
Ph (1:2.5)	4.14	5.70	5.88	4.57	6.59	7.02	7.00	7.34	7.37
E.C. (dS m^{-1})	0.10	0.15	0.15	0.24	0.29	0.42	0.85	3.0	3.55
Na (me l^{-1})	0.10	0.22	0.27	0.97	1.39	2.78	11.57	24.13	24.56
Mg (me l^{-1})	0.25	0.20	1.30	0.15	0.12	0.34	0.20	1.06	1.11
Ca (me l^{-1})	0.40	0.56	1.20	0.10	0.13	0.20	0.25	0.33	0.38
K (me l^{-1})	0.15	0.21	0.23	0.03	0.03	0.05	0.35	0.55	0.59
HCO_3 (me l^{-1})	0.10	0.11	0.16	0.15	0.25	0.35	0.38	0.70	0.76
Cl (me l^{-1})	0.45	0.63	1.11	1.20	2.40	4.20	7.06	26.28	26.86
SO4 (me l^{-1})	0.20	0.30	0.50	1.06	1.16	1.57	1.20	1.81	2.03
S.A.R.	0.10	0.16	0.17	3.08	4.20	5.68	24.4	29.0	29.30

Table 11. Effect of soil salinity on root development and yield of salt tolerant rice varieties.

Parameters	Ela			Carambolim			Chodan		
	CSR-27	CSR-27	Korgut	CSR-27	CSR-27	Korgut	CSR-27	CSR-27	Korgut
Root length (cm)	33	26	40	34	36	32	23	22	21
No.of tertiary roots	224	218	232	221	94	212	106	76	97
No. of damaged roots	0	0	0	0	0	0	0	0	4
Root weight (g plant^{-1})	0.90	1.40	1.00	2.80	1.10	1.10	1.90	0.60	0.90
Shoot weight (g plant^{-1})	15.20	18.60	7.60	33.00	11.50	13.50	4.90	4.40	10.50
Ratio of Root: Shoot	0.06	0.07	0.06	0.08	0.09	0.08	0.39	0.14	0.09
Yield (t ha^{-1})	4.50	4.00	2.00	4.00	3.90	2.00	2.20	2.10	1.50

Conclusion

1. Pooled data analysis of different years for salt tolerant rice varieties revealed that the rice yield obtained by CSR-27 (4.0 t ha^{-1}) and CSR-10 (3.95 t ha^{-1}) were consistently higher than the traditional Korgut (2.0 t ha^{-1}).

2. In all, 64 kg N, 18 kg P, 127 kg K, 7 kg Ca, 5 kg Mg, 1.3 kg Fe, 2.6 kg Mn, 0.4 kg Zn, 0.1 kg Cu per hectare were removed by CSR-27 as compared to 35 kg N, 10 kg P, 48 kg K, 2 kg Ca, 3 kg Mg, 0.9 kg Fe, 1.5 kg Mn, 0.15 Zn and 0.05 kg Cu per hectare removed by Korgut in coastal saline environment of Goa.

3. The ionic preponderance in coastal soil decreased in the order of Na 105 me l^{-1} > Cl 82 me l^{-1} > SO_4 4.5 me l^{-1} > Mg 2.9 me l^{-1} > Ca 2.5 me l^{-1} > HCO_3 0.76 me l^{-1}.

4. Reduction in root length, less number of tertiary roots, increase in root to shoot ratio, five per cent root damage and 30 per cent reduction in the yield of traditional Korgut rice was observed with the ground water having electrical conductivity of 3.50 dS m^{-1}.

IV. Introduction and evaluation of Red kernelled Rice

There has been a preference for red kernelled rice in Goa and adjoining coastal region. Par boiled red rice being the most preferred along with fish curry, nine high yielding red kernelled rice genotypes were introduced from RARS, Moncompu, Kerala and evaluated for their local adaptability and suitability during the period from 2003 to 2005 .

Significantly higher plant height (97.4 cm) was recorded in variety Mo-5 (97.4 cm) as compared to other varieties like Mo-9 (83.6 cm), Mo-17 (89.4 cm) and Mo-7 (89.7cm). Although, non significant differences were observed among the varieties, relatively more number of productive tillers (9.5 / hill) was observed in variety Mo-5 and was followed by Mo-13 (9.3 tillers / hill). Though, the total dry matter production was higher in Mo-5, another variety Mo-8 recorded higher Harvest Index (0.50).

The pooled mean yield attributes also indicated that panicle number per unit area did not vary significantly among the varieties although variety Mo-5 had more panicles (312 / m^2). However, variety Mo-17 recorded higher panicle length (23.9 cm) significantly differing from the control variety Jyoti (22 cm). Another variety Mo-7 had significantly more grains (194 / panicle) as compared to local check Jyoti (131 grains/panicle). Further, the variety Mo-17 also recorded least sterility (7.9 %) significantly differing from rest of the varieties except Mo-6 (11.5%).

The grain yield recorded in the red kernelled rice varieties differed significantly in all the three years of study and their pooled mean. The pooled yield data for three years showed that the variety Mo-17 recorded significantly higher yield (6.20 t/ha) as compared to rest of the varieties except variety Mo-7 (5.70 t/ha) thus, recording an yield advantage of 72.2 and 58.3 per cent, respectively over the local check 'Jyoti' (3.60 t/ha).

Table 12. Pooled mean grain yield of red kernelled rice varieties for three years

Variety	Grain yield (t/ha)				Yield advantage over check variety (%)
	2003	2004	2005	Pooled Mean	
MO-5	4.53	5.71	5.30	5.18	**43.9**
MO-6	3.70	6.21	6.13	5.34	**48.3**
MO-7	5.53	6.38	5.10	5.67	**57.5**
MO-8	3.17	6.04	5.46	4.89	**35.8**
MO-9	5.57	5.48	5.00	5.33	**48.1**
MO-13	2.53	5.50	4.83	4.28	**18.9**
MO-17	6.57	5.30	6.70	6.19	**71.9**
MO-19	4.57	6.31	5.33	5.40	**50.0**
Jyoti (check)	2.83	3.93	4.16	3.60	--
C.D (P=0.05)	**1.77**	**1.17**	**1.16**	**0.60**	

Table 13. Pooled mean straw yield of red kernelled rice varieties for three years

Variety	Straw yield (t/ha)				Yield advantage over check variety (%)
	2003	2004	2005	Pooled Mean	
MO-5	8.20	5.96	7.60	7.25	**40.0**
MO-6	6.37	6.73	8.57	7.22	**39.4**
MO-7	9.13	6.17	8.53	7.94	**53.3**
MO-8	5.37	5.95	9.39	6.90	**33.2**
MO-9	6.27	6.53	6.45	6.41	**23.7**
MO-13	4.20	6.30	8.74	6.41	**23.7**
MO-17	8.10	6.62	7.68	7.46	**44.0**
MO-19	6.90	5.96	5.44	6.10	**17.8**
Jyoti	3.83	6.81	4.90	5.18	--
CD(P=0.05)	**2.22**	**0.55**	**1.37**	**1.02**	

Higher yield in variety Mo-17 (Revathy) may be attributed to significantly lengthy panicles (23.9 cm) with least sterility (7.9 %) in the grains while that of Mo-7 could be a result of significantly higher number of grains in the panicle (194).

Significant differences were observed in straw yield of the nine red kernelled rice varieties during all the three years of study as well as in pooled mean performance. As compared to a straw yield of 5.18 t / ha recorded in Jyoti, the control variety, red kernelled rice varieties Mo-7 and Mo-17 yielded significantly higher straw yield (7.94 and 7.46 t/ha, respectively), recording 53.3 and 44 per cent advantage.

Thus, the evaluation trial over three years conclusively proved the yield advantage of two varieties Mo-17 (which has been released by Kerala Agricultural University as Revathy) and Mo-7 both in grain and straw showing the relative advantage.

The identified genotypes were of medium bold grain type with nearly similar duration yielding 58 to 72 per cent higher for the same management and as such were recommended for large scale cultivation in the region.

On-farm demonstration of red kernelled rice

In order to create an awareness among the farmers / visitors on the superiority of selected rice varieties over the ruling varieties, each year demonstrations were undertaken at the Institute farm. Both the selected / promising genotype and the traditional varieties were established under the same management practices of common nursery management, time of planting, spacing, manures and fertilizers, water management practices etc. All the varieties were grown with recommended package and observations were recorded on all the growth and yield parameters.

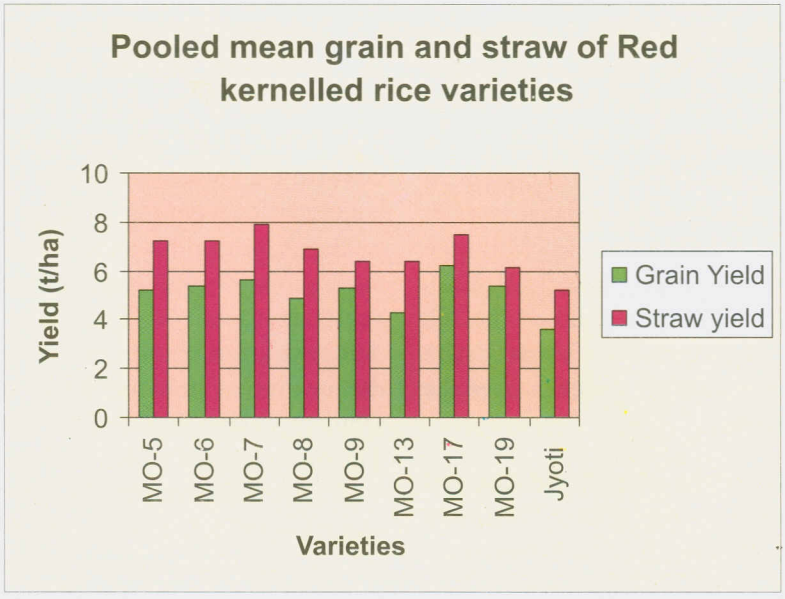

Fig 1. Pooled mean performance of red kernelled rice varieties under Goa conditions

Revathy (Mo-17), a cosistently high yielding red kernelled rice variety

A view of Front line demonstration of red kernelled rice at Dhulapi, Goa

Among the demonstrated red kernelled rice varieties, productive tillers were higher (12.3/hill) in Mo-17 as compared to check variety Jyoti (10.1/hill). More number of panicles were observed in variety Mo-9 (284/m^2) as compared to Jyoti (271/m^2). Further, the spikelet number was higher in Mo-9 (155/panicle) while the spikelet sterility was lower in Mo-9 (21.2 %).

The grain and straw yield of the red kernelled rice varieties also showed the superiority of demonstrated varieties over the traditional variety Jyoti.

Table 14. Performance of high yielding red kernelled rice varieties under demonstrations (Pooled mean of three years)

Red kernelled rice variety	Grain yield (t/ha)	Straw yield (t/ha)
Revathy (Mo-17)	4.61	9.67
Mo-9	4.83	8.71
Jyoti	4.14	7.04

Front Line Demonstrations on Red kernelled rice

During the year 2006-07, Front Line Demonstrations were conducted in 9.2 ha in farmers fields to assess the performance of red kernelled rice variety Mo-17 (Revathy) keeping Jyoti / Jaya varieties as check. Feed back from the farmers at Paddem, Bastora, Karmali, Sangolda, Neura and Pilar villages of Goa revealed that the varieties demonstrated performed better than the check in all the locations with the cost : benefit ratio ranging from 1:1.32 to 1 : 1.2.13.

The yields of Mo-17 in these locations varied from 4.60 to 5.48 t/ha. Further, the seed produced in these demonstrations is being shared and re-used for the next season. It is pertinent to mention that Mo-17 (Revathy) created a major impact among the farmers with its success being highlighted in a Field day held on 6th March, 2006 and subsequent news papers coverages.

During *kharif* season of 2007, Front Line Demonstrations were conducted in five villages viz. Dhulapi (2 ha), Pilar (2 ha), Porvorim (4 ha), Parra (1.75 ha) and Saligao (0.25 ha) covering a total of 10.0 ha. Altogether 67 beneficiaries were included in the programme to assess the performance of red kernelled rice variety Mo-17 (Revathy) keeping Jyoti / Jaya varieties as check. Pooled analysis of the demonstration results indicated that highest demonstration yield for Mo-17 was 5.62 t/ha at Dhulapi village followed by Pilar (5.25 t /ha). The mean highest yield in all the locations was 5.14 t /ha. However, the lowest yield was 4.15 t/ha at Porvorim followed by 4.18 t/ha at Dhulape village with mean lowest yield of 4.42 t/ha.

The results clearly indicated the superiority of newly introduced red kernelled rice variety Mo-17 over the traditional variety Jyoti. The Front Line Demonstrations conducted in all the five villages registered an overall yield increase of 22.3 per cent with red kernelled rice variety Revathy over the traditional variety Jyoti. The farmers perception was that the variety matures 10 days later than Jyoti but has added advantage of non-shattering of grain. The threshing and milling quality were also found satisfactory.

Production and distribution of Red kernelled Rice seeds

Keeping in view the requirement of vital input "seed" for expansion of area under the red kernelled rice, constant efforts were made each year to procure the breeder seed of the red kernelled rice variety Mo-17 (Revathy) from RRS, Moncompu, Kerala and seed production was taken up both at the Institute farm and in farmers fields under Mega seed Project. During the period from 2006 to 2008, a total of 1430 kg of foundation seed of Revathy variety of red kernelled rice was produced on the Institute farm and distributed to State Directorate of Agriculture and Co-operative Societies for further multiplication and distribution of seed.

Field reaction of red kernelled rice varieties to major insect pests and diseases

All the red kernelled rice varieties evaluated were studied for insect pest and disease incidence

Insect Pests: Infestation of all the insects slightly increased during 2005 compared to 2004. However, the insect pest infestation was less than 6 numbers of damaged plants per square meter.

Diseases: Bacterial leaf blight (BLB) was the major disease during 2004 and 2005. Incidence increased during 2005 (58 %). Sheath rot was recorded during 2004 however, the incidence was very less. During 2005 incidence of false smut was recorded to a maximum of 12 panicles/ square meter.

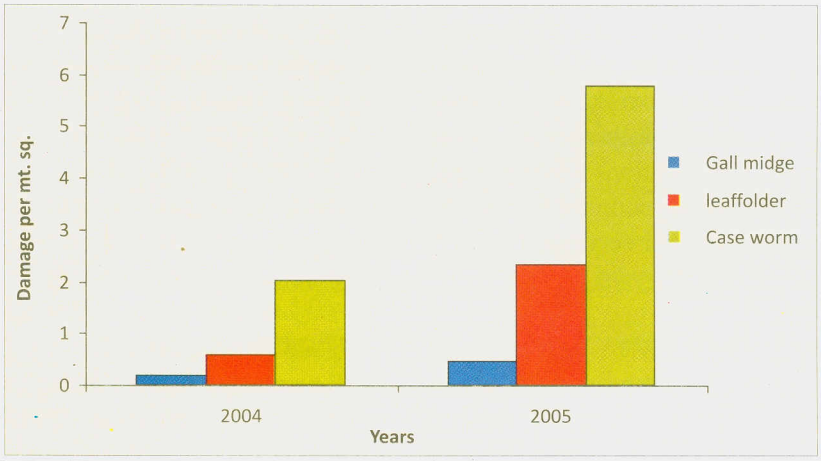

Fig. 2. Incidence of major insect pests in red kernel rice varieties over years

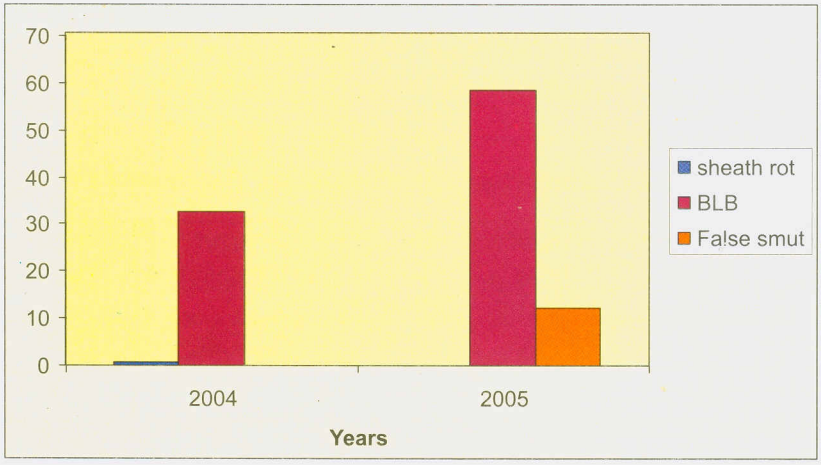

Fig. 3. Incidence of major diseases in red kernel rice varieties over years

Sheath rot: Number of panicles infected from 10 tillers randomly selected from one square meter area.

BLB, Blast, Brown spot: Percent Disease Index

False Smut: Number of panicles infected/m² area

Data were recorded 60-75 days after transplanting and presented as mean of all varieties.

V. Introduction and selection of high yielding medium duration rice varieties

To improve the productivity levels of paddy, improved varieties of rice were introduced from similar agro-climatic conditions in the country and were evaluated for the local situations.

During the year 1977, five rice varieties namely Co-40 (Rajarajan), Co-39, Bhavani, Intan and Phalguna were evaluated along with the local check (IR-8), Recommended manuring and cultural practices were followed for all the varieties and growth observations were recorded periodically. Observations recorded five weeks after transplanting indicated very good growth and stand of Co-40 and Bhavani.

The variety Co-39 also had a good appearance and was markedly dark green compared to other varieties. From the Table it is clear that the varieties Co-39 and Bhavani are preferable at the outset due to the following reasons:

1. Co-39 has the shortest duration (85 days) and recorded fairly good yield (4.20 t/ha). It is dwarf with high effective tillers. Being considerably shorter in duration than the other popular high yielding short duration varieties such as Bala, Annapurna, Rohini, etc. It is preferable for quick yield to fit in in multiple sequential cropping programme. It has good grain quality and having on an average, 123 grains/panicle.
2. Bhavani has recorded the highest yield of 6.18 t/ha which is more than the normal high yield recorded by popular varieties such as Jaya, and IR-8. It is also medium in duration, slightly taller than IR-8.
3. Jaya with good upright appearance and heavy panicle bearing as much as 150 grains / panicle was found to be a promicing variety. The grain is long and fine, having good cooking quality.
4. The variety Intan although recorded good yield, due to tall stature (148 cm) it has got a lodging habit, long duration and is as such not apparently preferable during *kharif* season.
5. CO-40 is found to be very long duration variety.

Table 15. Growth and yield characteristics of different introduced varieties at harvest

Variety	Mean plant height (cm)	No. of total tillers/hill	No. of effective tillers/hill	No. of grains/panicle	Yield (t/ha)	Duration (days)
CO-40	135	6.8	5.6	150	4.20	169
CO-39	100	13.0	12.0	125	3.48	85
Bhavani	119	10.8	9.6	141	6.18	124
Intan	148	8.6	8.0	108	5.61	153
Phalguna	85	6.0	5.0	95	4.58	135
IR-8	90	7.8	7.0	120	4.79	125
C.D (P=0.01)	-	-	-	-	**0.42**	-

Table 16. Performance of introduced high yielding medium duration rice varieties

Varieties	Grain yield (t/ha)		
	1977	1978	Mean
CO-39	3.48	-	3.48
Bhavani	6.18	3.27	4.73
IR-8	4.79	4.06	4.43
IET-1785	4.0	3.29	3.65
IET-2222	3.7	3.06	3.38
Jaya	2.8	3.34	3.07

Varieties	Grain yield (t/ha)		
	1989-90	1990-91	Mean
ADT-36	2.94	2.22	2.58
ADT-37	4.47	3.51	3.99
Narendra-2	4.48	3.63	4.06
PUSA-169	3.05	3.78	3.42
PUSA-2-21	2.72	1.19	1.96
Kalinga-1	4.69	4.34	4.52
RTN-1	3.75	2.30	3.03
Mangala	1.61	0.30	0.90
Triveni	4.05	2.15	3.10
CO-43	2.81	1.74	2.26
MO-5	5.26	3.63	4.45
BPT-1235	4.37	4.26	4.32

In another trial on assessment of high yielding rice varieties, 13 introduced promising rice varieties were evaluated during 1977 *kharif* at Margao farm.

The yield data indicated that IET-1785 and IET-2222 are the high yielders, followed by RPW-13, IR-8, Madhu and Jaya. Among the short duration varieties, Annapurna recorded the highest yield.

Among the high yielding introduced medium duration rice varieties tested during 1977 and 1978, with Jaya as control, variety Bhavani recorded consistently better performance (4.73 t/ha) as compared to Jaya (3.07 t/ha) with a yield advantage of 54 .1 per cent. Another high yielding introduced rice variety IR-8 also recorded better yield 4.43 t/ha with an advantage of 31 per cent over control.

In another set of rice trial on evaluation of medium duration rice varieties, Kalinga-1 recorded higher yield (4.52t/ha) and was followed by Mo-5 (4.45t/ha).

In another set of 11 introduced high yielding medium duration rice varieties evaluated

Table 17. Performance of high yielding medium duration rice varieties during 1989 to 1991

Varieties	Grain yield (t/ha)		
	1989-90	1990-91	Mean
ADT-36	2.94	2.22	2.58
ADT-37	4.47	3.51	3.99
Narendra-2	4.48	3.63	4.06
PUSA-169	3.05	3.78	3.42
PUSA-2-21	2.72	1.19	1.96
Kalinga-1	4.69	4.34	4.52
RTN-1	3.75	2.30	3.03
Mangala	1.61	0.30	0.90
Triveni	4.05	2.15	3.10
CO-43	2.81	1.74	2.26
MO-5	5.26	3.63	4.45
BPT-1235	4.37	4.26	4.32

during the period 1989 to 1992, the pooled mean performance indicated that the medium duration variety Pusa-205 recorded higher performance (4.90 t/ha yield) followed by Karna (4.81 t/ha).

A set of 17 medium duration rice entries of AICRP on rice were evaluated during the period from 2002 to 2004. The mean yield recorded indicated that entries IET-17113 (6.99 t/ha), IET-17527 (6.85 t/ha) were superior in their performance as compared to local check Jaya (6.36 t/ha).

Although, variety "Jaya" occupies a substantial area under rice growing situations with 130-135 days duration and the yield levels of the variety are fairly stable, yet the variety at times yields low and becomes susceptible to pests and diseases. New genetic material with a similar duration having higher yield potential was thought to be one of the alternatives to overcome the problem of increasing cost of production and consequent fallowing of lands.

From the year 2002-03, a new set of 14 AVT entries were introduced from DRR, Hyderabad and evaluated for their performance against the local check *Jaya*. The results indicated the superiority of variety *IET-17127* (7.73 t/ha) which resulted in 23 per cent increase over the traditional check *Jaya* (6.28 t/ha). All the other varieties tested were found to be at par with each other. These results confirmed the superiority of medium duration variety *IET-17127* over three years of experimentation under *kharif* as well as *rabi* seasons where it was found to consistently yield highest among the fourteen varieties tested, indicating better promise for it's recommendation.

The yield contributing characters like panicles / m^2 (434), earhead length (23 cm), productive tillers/hill (11.6), test weight (30g as against 26.7g in *Jaya*), harvest index (1.02) and visual score of 6.5 on 1-10 scale and medium bold characters of the grain were observed in the variety *IET 17127*, which was consistently higher among the fourteen varieties tested, indicating good promise for it's recommendation.

Table 18. Pooled mean performance of high yielding medium duration introduced varieties

Varieties	Grain yield (t/ha)			
	1989-90	1990-91	1991-92	Mean
ASD-16	4.23	4.28	4.11	4.21
Annada	3.8	1.26	3.48	2.85
CO-44	4.55	3.63	4.47	4.22
MO-7	4.89	2.1 5	5.5	4.18
PUSA -205	5.22	4.07	5.5	4.90
MO-6	5.92	3.56	4.58	4.69
Sarjoo-52	5.15	3.07	4.36	4.19
Mahaveera	6.07	2.89	6.45	5.14
Karna	5.58	4.15	4.8	4.81
Jaya	6.15	3.04	4.4	4.53
Jyoti	4.3	4.85	4.77	4.64

Table 19. Performance of medium duration rice entries of AICRP on rice

Rice entries	Grain yield (t/ha)				
	Kharif 2002	Rabi 2002-03	Kharif 2003	Kharif 2004	Mean
IET-16521	6.25	5.03	6.67	6.83	6.2
IET-17527	6.37	6.10	6.3	8.62	6.85
IET-17136	-	-	4.5	5.81	5.16
IET-17128	5.75	5.35	6.71	6.05	5.97
IET-17521	6.82	5.84	6.68	6.94	6.57
IET-17522	5.42	4.75	7.15	7.4	6.18
IET-17528	5.75	5.35	6.71	6.48	6.07
IET-17114	6.16	6.42	6.77	7.43	6.7
IET-17127	8.33	6.75	6.3	5.33	6.68
IET-17536	6.33	5.65	4.5	7.2	5.92
IET-17544	6.25	5.35	6.77	7.2	6.39
IET-17113	7.75	5.75	6.7	7.76	6.99
IET-17142	4.25	4.85	-	-	4.55
SURAKSHA	6.32	5.45	6.63	7.0	6.35
SONASALI	5.23	4.86	-	-	5.05
NARENDRA-359	7.0	6.05	-	-	6.53
JAYA	6.91	5.8	6.27	6.45	6.36

Evaluation of AVT 2-IM rice hybrids/ varieties of AICRIP during 2005-06

During the year 2005, the entries of "Irrigated Medium" group of AICRP on rice which included both the varieties and hybrids were introduced and evaluated consecutively to select genotypes with consistent performance.

The performance of the entries revealed that the rice hybrid CRHR-7 significantly out yielded all the other varieties / hybrids yielding 7.30 t/ha as against the local check 'Jaya' which exhibited a yield level of 4.50 t/ha which corresponded an increase of 62.2 per cent. The variety IR 68830 ranked second with a yield of 6.6 t/ha.

The straw yield of different hybrids/varieties also indicated that KRH-2 yielded highest (16.3 t/ha) and was followed by the local check 'Jaya' giving a mean yield of 14.5 t / ha.

The trial on medium duration high yielding rice varieties / hybrids, was continued during 2006-07 with inclusion of 16 medium duration entries from AICRP on rice. Highest plant height (139.3 cm) was observed in rice hybrid RPHR 203-3 differing significantly from the ruling variety Jaya. It was followed by HRI-155 (135 cm). Productive tillers were higher in Narendra-359, KRH-2 and Jaya (> 10). As regards to total dry matter production, NDR-99 (97.8 g/hill) recorded significantly higher dry matter production from rest of the entries including the check variety Jaya. However, harvest index was highest in HRI-158 (0.50) but at par with Jaya (0.45).

As regards panicle number, national hybrid check KRH-2 recorded significantly higher number of panicles over rest of the entries (377/m^2). Although not much variation was observed among the entries with respect to panicle length, highest was recorded in RPHR 203-8-2 (29 cm) significantly differing from ruling variety Jaya (26.4 cm). Total grains / panicle were significantly higher (233) in HRI-156 as compared to all the other entries except KRH-2 (224). Further, KRH-2 also recorded lowest sterility (9 %).

Significantly higher grain yield of 8.44 t/ha was recorded in hybrid HRI-155 as compared to rest of the entries and was followed by

Table 20. Performance of AVT 2-IM rice varieties/hybrids of AICRIP during *kharif* 2005

Varieties	Grain yield (t/ha)	Straw yield (t/ha)
CRHR-7	7.30	11.2
JKRH-2000	5.80	9.9
IR-68830	6.60	10.6
MTU-1072	5.60	11.1
OR 2310-12	6.20	12.7
PAC-80035	5.00	12.6
KRH-2	5.00	16.3
Triguna	5.20	7.7
Jaya	4.50	14.50
C.D (P=0.05)	**1.65**	--

Table 21. Performance of AVT 2-IM rice varieties/hybrids of AICRIP during 2006

Varieties	Grain yield (t/ha)	Duration (days)
NDR-9930096	6.00	135
Karjat-5	6.37	133
Narendra-359	3.68	105
NDR-3108	4.90	135
NDR-2063	5.63	133
OR-1967-15	6.50	135
KRH-2	5.60	121
NDR-3110	5.08	123
NDR-2067	5.44	131
RPHR 203-8-2	6.16	113
UPR-2581-16-2-1	6.84	119
MTU-1075	5.67	131
HRI-155	8.44	123
RPHR-203-3	5.26	135
HRI-156	7.22	131
JAYA	4.79	116
C.D (P = 0.05)	**0.89**	--

another hybrid HRI-156 (7.22 t/ha). Higher yield in HRI-155 could be attributed to the higher harvest index (0.50) recorded in the hybrid. Among the varieties, OR 1967-15 (6.50 t/ha) and Karjat-5 (6.37 t/ha) recorded higher yield.

Based on the performance of entries under medium duration group of AICRIP, a set of seven medium duration rice varieties were selected and evaluated continuously during *kharif* 2007 and 2008 in RBD with three replications. All the relevant growth and yield parameters were recorded and the data analysed.

Among the seven varieties tested, Karjat-3 recorded higher productive tillers (12.4 / hill). Entry NDR-9930 recorded significantly higher number of panicles / unit area with more plant height (128 cm) as compared to check variety Jaya. However, another entry UPR-2581 recorded significantly longer panicles (28 cm) while Jaya (control) recorded 25.2 cm long panicles.

Rice entry NDR- 9930 recorded significantly more grains per panicle (232) and was followed by variety Karjat-3 (205 grains / panicle). Although sterility was lower (12.5 %) in variety Jaya, the number of grains were only 155 / panicle. As regards test weight, Karjat -5 recorded highest (32.7 g / 1000 grains).

The pooled mean grain yield of varieties over three years period (from 2006 to 2008) indicated that the variety Karjat-3 is significantly superior to the ruling variety Jaya with yield advantage of 28.6 per cent. The higher yield in the variety was a consequence of more number of productive tillers per hill. It was followed by

Table 22. Pooled mean grain yield of medium duration rice varieties

Variety	Grain Yield (t/ha)				Yield increase over local check (%)
	2006	2007	2008	Pooled mean	
UPR-2581	6.84	5.10	5.89	**5.94**	18.1
OR-1967-15	6.50	5.05	6.74	**6.10**	21.3
Karjat-3	5.50	6.04	7.87	**6.47**	28.6
NDR-9930	6.00	5.45	7.60	**6.35**	26.2
OR-2310	4.33	5.63	7.76	**5.91**	17.5
Karjat-5	6.37	5.78	6.68	**6.28**	24.9
Jaya	4.79	3.81	6.48	**5.03**	--
C.D (P=0.05)	**0.89**	**0.57**	**1.33**	**0.61**	

Table 23. Pooled mean straw yield of medium duration rice varieties

Variety	Straw Yield (t/ha)				Straw yield increase / decrease over local check (%)
	2006	2007	2008	Pooled mean	
UPR-2581	7.18	2.73	5.43	5.11	-4.5
OR-1967-15	7.10	3.60	5.92	5.54	0.7
Karjat-3	3.32	3.88	6.50	4.56	14.8
NDR-9930	9.65	4.54	6.48	6.85	28.0
OR-2310	4.18	4.13	6.17	4.83	-9.7
Karjat-5	8.29	3.60	5.53	5.80	8.4
Jaya	5.91	4.00	6.15	5.35	--
C.D (P=0.05)	**0.81**	**0.78**	**NS**	**0.96**	

other varieties like NDR-9930 (6.35 t/ha) and Karjat-5 (6.28 t/ha) which also registered a yield increase of 26.2 and 24.9 per cent, respectively.

The straw yield of the selected entries under medium duration group differed significantly during 2006 and 2007 and consequently their pooled mean. Significantly higher straw yield was recorded in NDR-9930 (6.85 t / ha) with an increase of 28.0 per cent over local check Jaya on a pooled mean basis. Karajt-5 with a mean straw yield of 5.80 t / ha was next best with an increase of 8.4 per cent higher yield over Jaya (5.35 t / ha). The higher straw yield recorded in the varieties was due to the higher plant height and biomass recorded in the varieties.

Thus, the variety Karjat-3 with more than 28 per cent yield advantage both in grain and straw is recommended for large scale cultivation in areas traditionally occupied by Jaya under medium duration.

On-farm demonstration in medium duration rice varieties

In order to create an awareness among the farmers / visitors on the superiority of selected rice varieties over the ruling varieties, demonstrations were undertaken every year at the Institute farm from the year 2002 onwards. Both the selected genotype and the traditional varieties were established under the same management practices of time of planting, spacing, manures and fertilizers, common nursery management, water management practices etc. All the varieties were grown with recommended package and observations were recorded on all the growth and yield parameters. The superiority of the variety Karjat-3 was further reflected in the on farm demonstrations during all the five years from 2003 onwards.

Among the medium duration high yielding varieties evaluated under the on-farm demonstrations, Karjat-3 was found better in terms of productive tillers, number of panicles per unit area recording a grain yield of 6.02 t/ha as compared to 5.67 t/ha in Jaya, the check variety.

Table 24. Performance of high yielding varieties of rice under demonstrations (Pooled mean of three years)

High yielding rice variety	Grain yield (t/ha)	Straw yield (t/ha)
Karjat-3	6.02	7.05
Karjat-5	5.14	10.01
Jaya	5.67	8.70

Table 25. Results of On-farm demonstration of improved varieties

Genotype	Grain yield (t/ha)	Straw yield (t/ha)	Gross returns (Rs./ha)	Cost of production (Rs./ha)	Net returns (Rs./ha)	B:C ratio
Jyoti	4.92	7.48	33,260	22,500	10,760	1.49
Jaya	5.67	8.70	38,370	22,800	15,570	1.68
Karjat-3	6.02	7.05	42,655	23,800	18,855	1.79

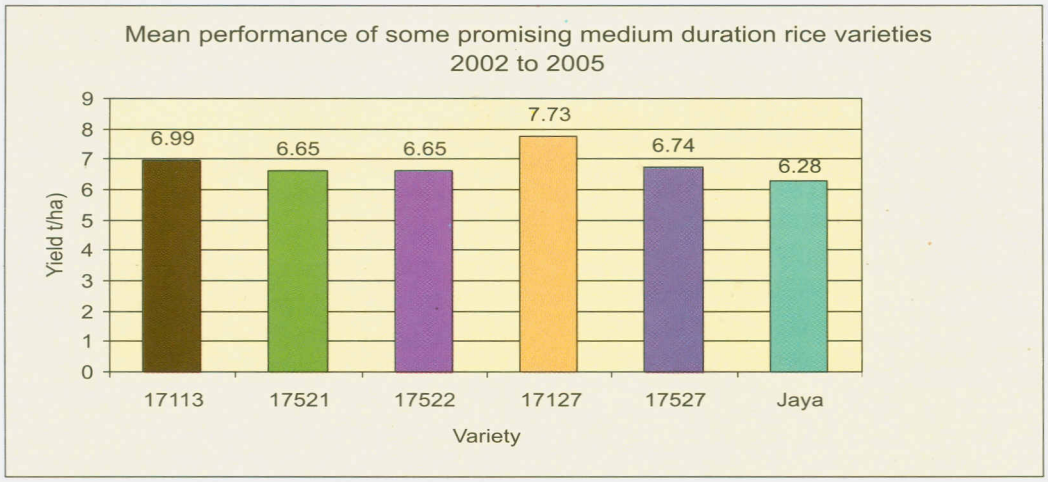

Fig 4. Performance of medium duration rice varieties under Goa conditions

CRHR - 7, an improved rice hybrid from CRRI Cuttack with bumper yield

Karjat - 3, high yielding medium duration rice variety with consistently better performance

The variety Karjat-3 with a mean grain yield of 6.02 t/ha and a straw yield of 7.05 t/ha. showed higher gross and net returns (Rs.42,655 and 18,855 / ha, respectively) as compared to ruling varieties Jyoti and Jaya.

Front Line Demonstrations in high yielding medium duration rice'

All out efforts were made to take the promising results of research to the door steps of farmers through Front line demonstrations at major rice belts in coastal areas of Goa with the co-ordination of KVK associated with the Institute. The farmers at Paddem, Pernem-Goa have evinced keen interest for the popularization of the high yielding medium duration entries. The productivity levels in farmers fields (5,183 kg/ ha) have convincingly proved the superiority of high yielding medium duration entries (80.9 % higher) over the ruling varieties.

Seed production in high yielding medium duration Rice varieties

A great demand was observed for the seed of Karjat-3 rice over the period as the variety has become very popular among the farmers. Owing to its unique characters of high yield, earliness (115-120 days duration), higher milling recovery (60-65 %) and suitability both for raw rice and par-boiling, the demand for seed has increased in geometric progression and in the current *rabi* season alone quality seed required for 400 ha has been distributed with the co-ordination of Institute Mega Seed Project and the State Directorate of Agriculture, Government of Goa.

Field reaction of medium duration rice varieties to major insect pests and diseases

During 1978 to 1988 many blast resistant paddy varieties / accessions were screened during rabi under Goa conditions. Further the rice lines were screened against gall midge infestation. Results revealed that varying levels of tolerance or susceptibility to blast disease and gall midge infestation was recorded.

Insect pests: Gall midge, leaf folder and case worm are the major insect pests of rice during *kharif*. Infestation of all the insects reduced from 2002 to 2004. During 2007, slight increase in the pest incidence was recorded; however during 2008 the infestation reduced.

Diseases: Sheath rot and bacterial leaf blight (BLB) are the major diseases during *kharif* over the years. Maximum BLB incidence of 28 percent was recorded during 2004. Sheath rot incidence reduced since 2000 and started increasing after 2007. Blast and brown spot diseases are common in rabi crop and the maximum incidence of 10 percent was recorded during 2000.

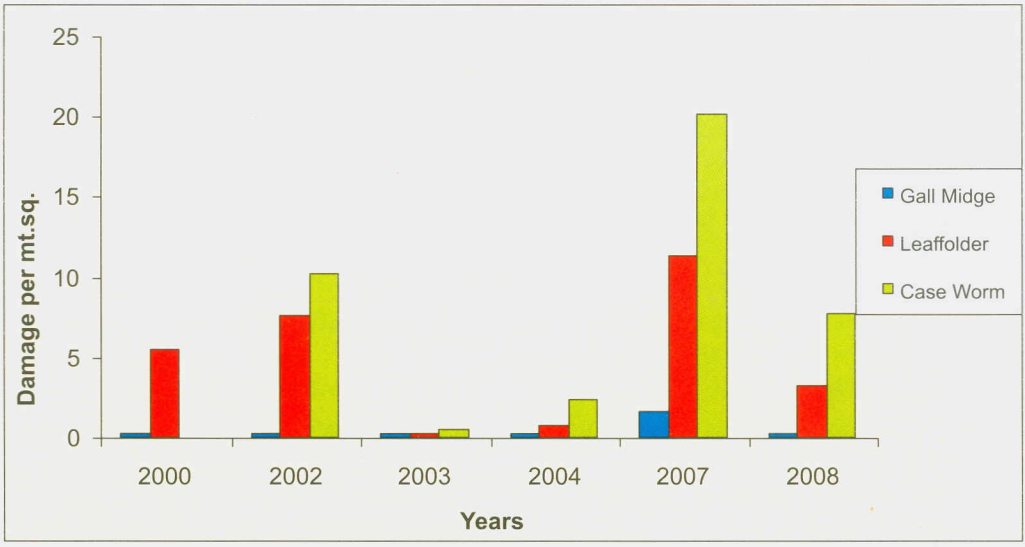

Fig. 5. Incidence of major insect pests in medium duration rice varieties over years

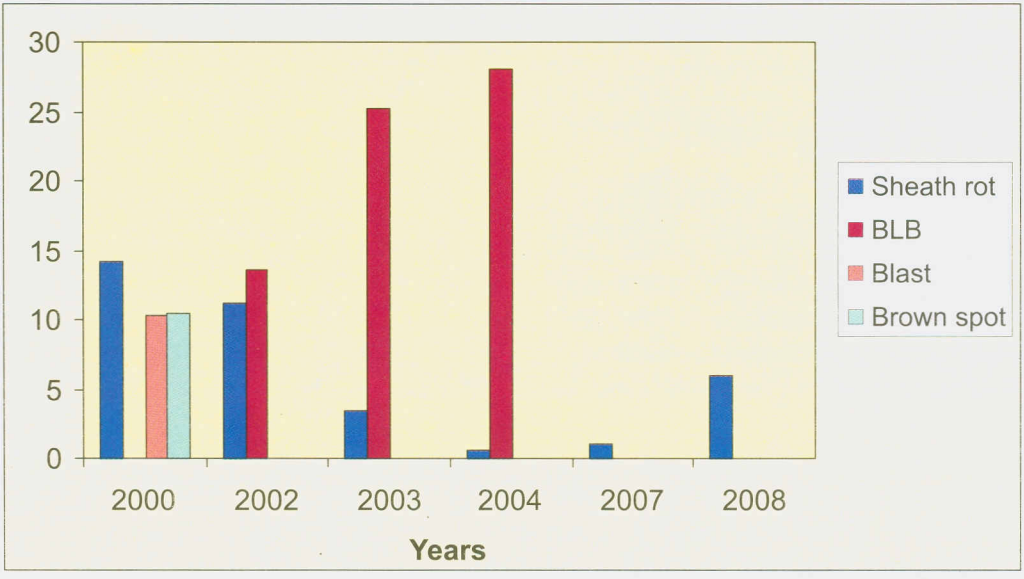

Fig. 6. Incidence of major diseases in medium duration rice varieties over years

Sheath rot: Number of panicles infected from 10 tillers randomly selected from one square meter area.

BLB, Blast, Brown spot: Percent Disease Index

Data were recorded 60-75 days after transplanting and presented as mean of all varieties.

VI. Introduction and feasibility studies on Scented Rice:

Northern parts of India has been a domain of Basmati and known for its quality all over the world. The research on this high value rice was specifically attempted to provide a cushion against the spiraling cost in traditional paddy cultivation in order to make it remunerative with a better benefit-cost ratio.

In an attempt to introduce Basmati / fine grain rice, six varieties including Pusa Basmati-1 as control were included for evaluation during the period 1995 to 1998.

Among these varieties, variety Indrayani out yielded rest of the varieties with yield of 6.36 t/ha as compared to Pusa Basmati-1 (3.89 t/ha).

Further, the work done in this area suggested that Basmati can be successfully grown in the region if planted early in *kharif* season. The results showed accumulation of adequate amounts of *2 Acetyl-1 pyroline* content in the grain. The quantification of the active ingredient was to an extent of 0.030 ppm under Goa conditions as against 0.061 ppm recorded in marketed brand of Basmati rice.

During the period 1998-99 research agenda was diversified into high value fine grain /scented rice by introducing different elite material through interventions with Regional Rice Research Station, Vadgao near Pune and introduced promising varieties like *Indrayani, Pawan, Kundalika, Ambemohar* which have performed better than the local check in terms of value.

In the year 2000-01, a collaborative project with Goa University, Panaji was taken up to study the quality aspects of some fine grain/ scented and Basmati varieties grown under local conditions for *2 Acetyl-1 pyroline* content, the active ingredient of Basmati rice. Further, the cooking characteristics as well as other related parameters like alkali spreading value, gelatinization temperatures and amylose content of these varieties were also studied.

During the period from 2004 to 2006, improved Basmati varieties were introduced from Indian Agricultural Research Institute, New Delhi and seven scented rice varieties were evaluated in a randomised block design with three replications. Among them, maximum plant height (136.4 cm) was recorded in check variety Pusa Basmati-1 differing significantly from rest

Table 26. Pooled mean grain yield of different scented rice varieities

Varieties	Grain yield (t/ha)				
	1995	1996	1997	1998	Mean
Pusa-Basmati-1	3.34	4.75	4.02	3.49	3.89
Basmati-370	2.43	2.83	3.86	3.38	3.13
Basmati-385	2.36	3.58	3.69	3.19	3.27
Ambemohar	-	2.93	2.78	2.56	2.76
Tarori Basmati	2.17	3.75	3.29	-	3.07
Indrayani	-	5.66	6.42	7.0	6.36
Pawan	-	4.25	5.64	4.68	4.86

Table 27. Grain quality characteristics of different scented rice varieties

Variety	L/B ratio		Kernel	Cooking
	Before cooking	After cooking	Elongation ratio	Coefficient
Ambe mohar	1.916	2.716	1.832	3.951
Girga	2.016	1.750	1.663	1.466
Ghansal	1.960	1.842	1.724	1.724
Indrayani	2.845	3.152	2.325	2.546
Kernal local	4.230	3.384	2.286	5.973
Pusa Basmati	4.185	4.565	2.849	4.913
IET-15390	4.192	4.438	1.735	4.652
IET-15391	4.230	4.133	2.294	4.060
IET-15392	4.620	4.078	2.057	3.586

of the entries tested except the varieties Mugad Sugandh (132.8 cm) and Vasumati (132.7 cm). Although, no significant differences were observed with respect to productive tillers and total dry matter production, variety Mugadh Sugandh (13.9/hill) and Vasumati (51.3 g/hill) recorded relatively higher values. Further, the harvest index recorded in different varieties differed significantly. The variety Pusa Sugandh-5 recorded significantly higher harvest index (0.44) as compared to check variety Pusa Basmati-1 (0.31) indicating its superiority.

Table 28. Grain quality characteristics of of different scented rice varieties

Variety	Alkali spreading value	Gelatinization Temperature	Amylose content (%)
Ambe mohar	2.00	74.5 -80	12.50
Girga	1.00	74.5 -80	14.75
Ghansal	1.00	74.5 -80	17.00
Indrayani	1.75	74.5 -80	17.00
Kernal local	2.00	74.5 -80	17.00
Pusa Basmati	7.00	55-69	19.50
IET-15390	5.00	70-74	18.00
IET-15391	4.00	70-74	20.50
IET-15392	7.00	55-69	20.00

The yield attributes of scented rice varieties differed significantly among the varieties except for earhead length and 1000 grain weight. Panicles per unit area were significantly higher (353 panicles/m^2) with the control variety Pusa Basmati-1 which differed with rest of the entries except Mugadh Sugandh (343 panicles/m^2) and Pusa Sugandh-2 (341 panicles/ m^2) while the lowest (286 panicles/m^2) was recorded in Vasumati. Significantly higher number of grains were observed in varieties Mugad Sugandh (160 / panicle) and Pusa Sugandh-3 (159 grains/panicle).

Further, least sterility (16.2 %) was observed in variety Vasumati. As regards test weight, 1000 grain weight was higher with variety Kasturi (29.6 g) and was followed by another variety Pusa Sugandh-3 (28.0 g).

The pooled mean analysis of scented rice varieties for grain yield indicated that the overall performance of variety Pusa Sugandh-5 was significantly higher (4.66 t/ha) over the check variety Pusa Basmati-1 (3.49 t/ha) with an additional yield of 1.17 t/ha recording 33.5 per cent increase in yield. Further, the yield levels of the variety were also consistent over the years. The higher yield of the variety could be attributed to higher harvest index (0.44) recorded in the variety indicating that the translocation of photosynthates was more towards economic parts. The straw yield of the variety was however, significantly lower (6.41 t/ha) as compared to Pusa Basmati-1 (10.08 t/ha).

Pusa Sugandh-3 was another promising variety recording 4.50 t/ha as a pooled mean yield with better consistency over the years. Higher yield in the variety could be attributed to more number of grains per panicle (159/panicle) coupled with relatively lower sterility (19 %). This variety also recorded 28.9 per cent higher yield over Pusa Basmati-1 (control variety). However, the straw yield of this variety was also poor (6.92 t/ha).

Higher straw yield was recorded in varieties Pusa Basmati-1 (10.08 t/ha) and was followed by varieties Vasumati (9.65 t/ha). The higher straw yield in the varieties could be attributed to the moderately higher stature (133 to 136 cm) with more dry matter accumulation (upto 51 g/hill) in these varieties. This was further reflected by lower harvest index of these varieties (0.22-0.31).

Table 29. Pooled mean grain and straw yield of scented rice varieties

	Grain yield (t/ha)				Straw yield (t/ha)
	2004	2005	2006	Pooled mean	
Kasturi	4.44	4.17	3.88	4.16	8.50
Pusa Sugandh-2	4.91	4.70	3.27	4.29	8.55
Pusa Sugandh-3	4.54	4.07	4.88	4.50	6.92
Pusa Sugandh-5	5.00	4.13	4.84	4.66	6.41
Vasumati	5.01	4.37	3.95	4.44	9.65
Mugadh Sugandh	5.17	3.53	3.61	4.10	8.82
Pusa Basmati-1	4.16	3.20	3.10	3.49	10.08
C.D (P= 0.05)	**0.39**	**N.S**	**0.43**	**0.49**	**0.82**

Table 30. Quality characteristics of scented rice varieties under Goa conditions

Variety	Milling (%)	Kernel length (mm)	Kernel breadth (mm)	L/B ratio	Grain Type	Grain Chalk	Volume Expansion Ratio
Kasturi	60.0	8.90	2.00	4.50	Long Slender	Present	3.3
Pusa Sugandh-2	68.0	8.80	2.00	4.40	Long Slender	Absent	3.0
Pusa Sugandh-3	66.0	8.55	2.00	4.30	Long Slender	Ocassionally Present	3.1
Pusa Sugandh-5	67.0	8.55	1.90	4.50	Long Slender	Ocassionally Present	3.7
Vasumati	64.0	8.30	1.85	4.50	Long Slender	Ocassionally Present	3.6
Mugadh Sugandh	64.0	8.20	1.70	4.80	Long Slender	Present	2.8
Pusa Basmati-1	61.5	8.55	1.25	6.84	Long Slender	Very Ocassionally Present	3.0

Quality characteristics of scented rice

All the scented rice varieties were analysed for physico-chemical characteristics to assess the consumers acceptability of cooked rice based on appearance, cohesiveness, texture, taste, aroma and elongation on cooking. Basmati rice varieties grown under Goa conditions were also found to possess superior grain qualities as reflected from the quality characteristics recorded in different varieties.

The milling percentage of the varieties ranged from 60 to 68 with Pusa Sugandh-2 recording highest milling turn over (68 %) while Pusa Sugandh-5 recorded 67 per cent milling. All the varieties tested have long slender grains. Highest kernel length (8.90 mm) was recorded in variety Kasturi followed by Pusa Sugandh-2 (8.80 mm). Pusa Basamti-1 recorded lowest kernel breadth (1.25 mm) in turn recording highest L/B ratio (6.84) suggesting its superiority over the other varieties tested. The variety Pusa Sugandh-5 recorded higher volume expansion ratio (3.60).

Table 31. Quality characteristics of scented rice varieties under Goa conditions

Variety	Water uptake (ml)	KLAC (mm)	ER (mm)	ASV	Gel consistency (mm)	Aroma
Kasturi	280	9.30	1.04	5.0	36	Mild scented
Pusa Sugandh-2	310	9.25	1.05	5.0	31	Strongly scented
Pusa Sugandh-3	300	9.60	1.12	5.0	33	Strongly scented
Pusa Sugandh-5	310	9.40	1.10	7.0	31	Mild scented
Vasumati	320	9.75	1.17	6.0	34	Mild scented
Mugadh Sugandh	300	9.90	1.20	2.0	30	Mild scented
Pusa Basmati-1	335	10.10	1.18	7.0	29	Strongly scented

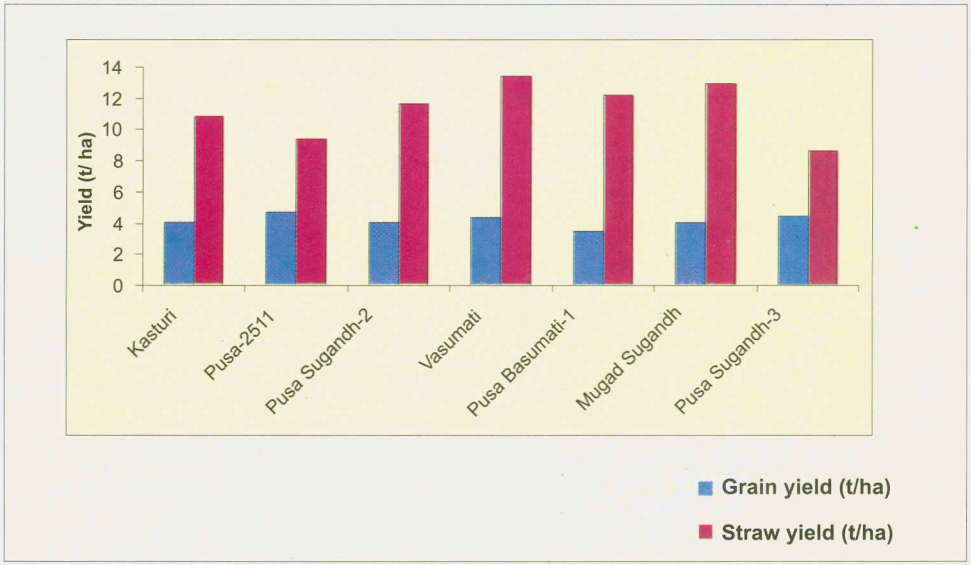

Fig. 7. Mean grain and straw yield (t/ha) in different scented rice varieties (mean of four years)

Pusa Suagndh-5, a high yielding scented rice for higher profits

Among the varieties tested, Pusa Basmati-1 recorded higher water uptake (335 ml) and was fallowed by Vasumati (320 ml). Further, the variety Pusa Basmati-1 also recorded higher kernel length after cooking (10.1 mm). The varieties Pusa Sugandh-2, Pusa Sugandh-3 and Kasturi recorded intermediate alkali spreading value (5.0). Further, the varieties Pusa Basmati-1, Pusa Sugandh-2 and Pusa Sugandh-3 were found to possess strong aroma.

KLAC- Kernel length after cooking, ER-Elongation ratio, ASV-Alkali spreading value

Economics of scented rice production

Highest gross return (Rs. 45,145 /ha) was obtained with variety Pusa Sugandh-5 followed by the variety Vasumati (Rs. 44,785 /ha). This was mainly due to higher yield recorded in the varieties coupled with higher unit price for the produce being fine grained and scented. The net returns followed a similar trend as that of gross returns with the varieties Pusa Sugandh-5 and Vasumati recording higher returns (Rs.17,3450 and 16,985/ha, respectively). The returns from other varieties ranged from Rs.8,650 to 16,160/ha.

Further, higher benefit cost ratio (1.62) was also recorded with Pusa Sugandh-5 suggesting its profitability for the region.

Value addition and returns

The economics of processing and value addition in different scented rice varieties were studied after milling. Based on the milling recovery and the prevailing prices in the market for the produce, the returns were calculated.

It was observed that the milling percentage of varieties tested varied from 60 to 68 with Pusa Sugandh varieties recording higher values (66 to 68 %). Milled rice yield followed a similar trend as that of grain yield with variety Pusa Sugandh-5 recording higher (3.12 t/ha) milled rice yield. The cost of milling depended on the quantity of milled rice obtained / ha.

The highest gross and net returns through processing and value addition were obtained with the scented variety Pusa Sugandh-5 (Rs.61,705/ ha and Rs.29,885/ha, respectively). The increased returns may be attributed to the better

Table 32. Economics of scented rice production under Goa conditions

Variety	Gross returns* (Rs./ha)	Cost of Production (Rs./ha)	Net returns (Rs./ha)	B:C ratio
Kasturi	41,690	27,800	13,890	1.50
Pusa Sugandh-2	42,885	27,800	15,085	1.54
Pusa Sugandh-3	43,960	27,800	16,160	1.58
Pusa Sugandh-5	45,145	27,800	17,345	1.62
Vasumati	44,785	27,800	16,985	1.61
Mugadh Sugandh	41,310	27,800	13,510	1.49
Pusa Basmati-1	36,450	27,800	8,650	1.31

*considering a prevailing rate of Rs.9000/tonne for paddy and Rs.500/tonne of straw.

T able 33. Economics of scented rice production with processing

Variety	Grain yield (t/ha)	Milling (%)	Milled rice yield (t/ha)	Total cost including milling (Rs/ha)	Gross returns (Rs./ha)	Net returns (Rs/ha)
Kasturi	4.16	60.0	2.50	30,300	51,125	20,825
Pusa Sugandh-2	4.29	68.0	2.92	31,620	59,025	27,405
Pusa Sugandh-3	4.50	66.0	2.97	31,670	59,145	27,475
Pusa Sugandh-5	4.66	67.0	3.12	31,820	61,705	29,885
Vasumati	4.44	64.0	2.84	31,540	58,075	26,535
Mugadh Sugandh	4.10	64.0	2.62	31,320	53,535	22,215
Pusa Basmati-1	3.49	61.5	2.15	30,850	50,730	19,880

value of the produce even with additional cost of milling. The rate of increase of returns with processing were higher with Pusa Sugandh varieties owing to their higher milling recovery.

It is amply clear from the study that the net returns can be enhanced by nearly 70 per cent especially with Pusa Sugandh-5 by resorting to value addition by processing. Earlier studies conducted in Goa also indicated that processing and value addition in rice improved the net returns substantially.

On-farm demonstrations in scented rice:

In order to create an awareness among the farmers / visitors on the superiority of selected scented rice varieties over the ruling varieties, each year demonstrations were undertaken at the Institute farm. Both the selected genotype and the traditional varieties were established under the same management practices of time of planting, spacing, manures and fertilizers, common nursery management, water management practices etc. All the varieties were grown with recommended package and observations recorded on all the growth and yield parameters.

The variety Pusa sugandh-3 yielded a mean grain yield of 4.37 t/ha with a straw yield of 7.29 t/ha as compared to 3.39 t grain yield and 10.21 t/ha straw yield in Pusa Basmati-1.

The variety Pusa Sugandh-5 yielded relatively less owing to the stem borer damage noticed especially during the third year.

Relative comparison of different rice genotypes in improving the profitability

The pooled mean yield data of proven rice varieties / hybrids were compared over three years from 2003 to 2005 in improving the profitability.

Table 34. Pooled grain and straw yield in different rice genotypes (mean of 2003 to 2005)

Genotype	Grain yield (t/ha)	Straw yield (t/ha)
Jyoti	4.92	7.48
Jaya	5.67	8.70
Karjat-3	6.02	7.05
Pusa Basmati-1	5.29	7.86
Sahyadri-1	6.92	6.97
KRH-2	6.15	6.57

Table 35. Economics of cultivation of different rice genotypes in Goa (mean of 2003-05)

Genotype	Gross returns (Rs./ha)	Cost of production (Rs./ha)	Net returns (Rs./ha)	B:C ratio
Jyoti	33,260	22,500	10,760	1.49
Jaya	38,370	22,800	15,570	1.68
Karjat-3	42,655	23,800	18,855	1.79
Pusa Basmati-1	51,510	22,600	28,910	2.28
Sahyadri-1	43,275	25,300	17,975	1.71
KRH-2	38,650	24,300	14,350	1.59

It was observed that the net returns were higher with scented rice varieties like Pusa Basmati-1 (Rs.28,910 /ha) and was followed by another popular variety Karjat-3 (Rs.18, 855/ ha). The benefit cost ratio was also higher for these varieties (2.28 and 1.79, respectively) indicating their superiority to offset the escalating production costs. Further, it was observed that hybrids in rice although yielded higher, due to their price per unit quantity of produce, could not result in substantial returns.

Front Line Demonstrations on Scented rice:

Frontline demonstrations were conducted in farmers fields involving 20 farmers covering an area of 4.25 ha with the co-ordination of KVK associated with the Institute to highlight the superiority of high yielding scented rice varieties. A mean yield of 3,525 kg/ha was recorded with 23 per cent higher yield over check variety. Notable feature of the scented rice demonstration was that the gross returns were higher (Rs.56,000 / ha) with highest Cost : Benefit ratio (1:1.96) compared to other groups of rice.

Thus, for increased profitability of rice cultivation in the region, there is a need to grow scented rice especially varieties like Pusa Sugandh-5 by resorting to processing and marketing. Cultivation of scented rice with fine grain quality is all the while most important in Goa which has carved a niche as an internationally renowned tourist destination.

Field reaction of scented rice varieties to major insect pests and diseases

The incidence of insect pests and disease but also recorded in the scented rice varieties evaluated during all the four years from 2003 to 2006.

Insect pests: Gall midge, leaf folder and case worm are the major insect pests during *kharif*. Infestation of all the insects increased 2003 to 2005. However, during 2006, slight decrease in the pest incidence was recorded.

Diseases: Sheath rot and bacterial leaf blight (BLB) are the major diseases during *kharif*. BLB incidence increased over the years from 24-56 percent (2003 - 2005). On contrary sheath rot incidence decreased from 11 to 1.9 panicles/10 tillers/sq.m. During 2005, incidence of false smut was recorded however; the incidence was less compared to other groups.

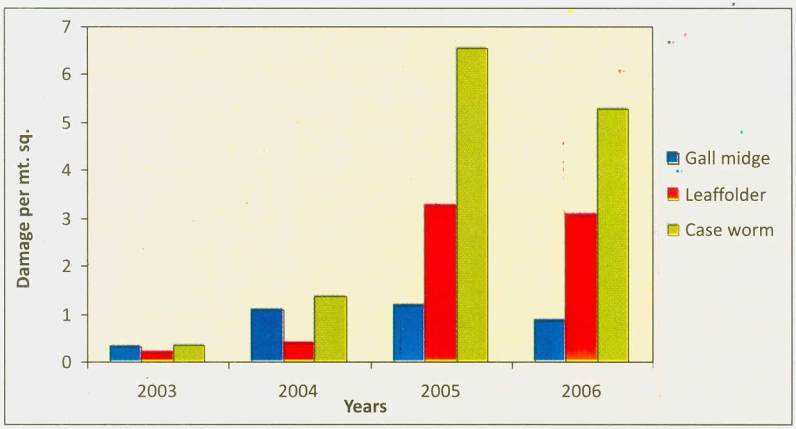

Fig. 8. Incidence of major insect pests in scented rice varieties over years

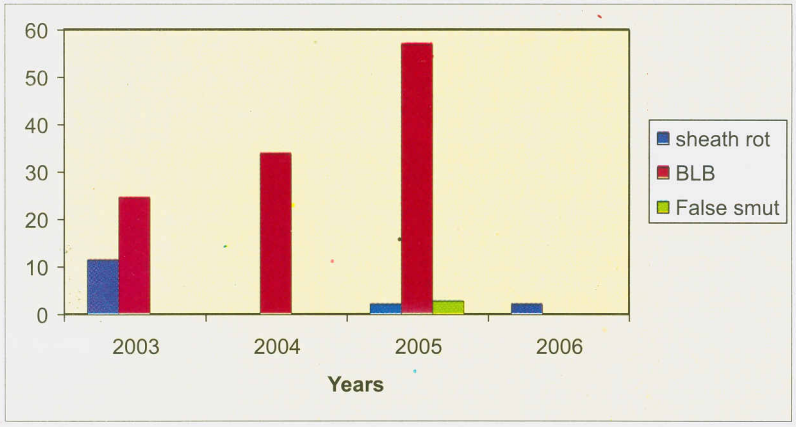

Fig. 9. Incidence of major diseases in scented rice varieties over years

Sheath rot: Number of panicles infected from 10 tillers randomly selected from one square meter area.

BLB: Percent Disease Index

False Smut: Number of panicles infected/m² area

Data were recorded 60-75 days after transplanting and presented as mean of all varieties.

VII. Rice Hybrids in breaking the yield barriers

In order to break the yield barriers in the traditional inbred varieties popularly cultivated, the research efforts were further intensified for introduction and evaluation of rice hybrids.

During the period 1998-99 to 2001, the Institute under it's rice research programmes has introduced and evaluated 27 rice hybrids from the ICAR network as well as private companies. Under the Cess fund project (1998-2000), eleven hybrids were evaluated along with the best inbred varieties *viz Jaya, Jyoti* and *Triguna* as checks. Among the eleven hybrids tested, the evaluation of the proven public bred rice hybrids viz, Sahyadri, KRH-2 and DRRH-1, was continued.

The studies resulted in recommendation of hybrids like *Sahyadri* (7.53t/ha) and *KRH-2* (7.04 t/ha) which were found to be highly significant over the three check varieties Jaya (6.1 t/ha), Jyoti (4.84 t/ha) and Triguna (5.88 t/ha) for the region. The yield advantage of *Sahyadri* over the check varieties *Jaya, Jyoti and Triguna* was 23.44 per cent, 55.57 per cent and 28.06 per cent, and that of KRH-2 was found be 15.40 per cent, 45.45 per cent and 19.72 per cent, respectively. This corresponded to a yield advantage of 1,430 kg, 2,690 kg and 1,650 kg/ha in case of *Sahyadri* and 940 kg, 2,200 kg and 1,160 kg/ha in case of KRH-2, respectively.

Further, in a separate trial on advanced hybrids, a set of eleven rice hybrids were evaluated for their performance with three local checks *viz Jaya, Jyoti and Triguna*. The results indicated that hybrids *Sahyadri* (7.77 t/ha) and *MRP-5401* (7.77 t/ha) were found to be at par followed by another hybrid *INDAM-012* (7.10 t/ha) and *RH-2041*(6.97 t/ha). The results also showed that the recommended hybrid *KRH-2* (6.67 t/ha) yielding at par with inbred control *Jaya* (6.43 t/ha) and *Triguna* (6.93 t/ha).

The hybrid rice programme was continued from 2006 onwards under Multi-locational testing of released / pre-release rice hybrids under AICRP on rice. Evaluation of both public and private sector rice hybrids were taken up keeping the ruling varieties of the region as control checks (Jaya & Jyothi).

The pooled mean analysis over three years indicated that among the rice hybrids and varieties tested, significantly higher number of productive tillers were recorded in hybrids *viz* DRRH-2, Suruchi, CRHR-7 while the panicle number per unit area was significantly higher in rice hybrids Suruchi (346/m^2), PSD-3 (333/m^2) differing from rest of the entries including the check varieties. CRHR-7 recorded significantly more length (30.1 cm). However, PA-6444 recorded significantly higher number of spikelets (242) in the panicle. The ruling varieties recorded significantly lower sterility and among the hybrids tried, PSD-3 recorded relatively lesser chaffy grains in the panicle.

The pooled mean grain yield in different entries indicated that PA-6444 is consistent in its performance. The entry recorded a pooled mean grain yield of 8.16 t/ha, thus significantly differing from all the check varieties and other hybrids except JKRH-2000 (7.65 t/ha), PSD-3 (7.60 t/ha) and Suruchi (7.37 t/ha) in comparison to National hybrid check KRH-2 which recorded 7.14 t/ha registering a yield increase of 14.3 per cent. The medium duration check variety Jaya recorded 5.45 t/ha in the same trial, thus the hybrid PA-6444 was found superior by 50 per cent in terms of grain yield.

As regards straw yield, the mean yield was higher with hybrid PSD-3 (5.45 t / ha) and was followed by Suruchi (5.38 t/ha) and PA-6444 (5.45 t/ha) while National hybrid check KRH-2 yielded 5.29 t /ha. In contrast, the ruling varieties yielded 3.2 to 4 t/ha straw yield.

Thus, considering both grain and straw yield, PA-6444 is a better hybrid compared to rest of the hybrids tested.

KRH - 2, National level public sector rice hybrid for cultivation in Goa

Sahyadri - an introduced proven rice hybrid from BSKKV, Dapoli

PA-6444 - A private sector rice hybrid breaking the yield barriers

Table 36. Pooled mean grain and straw yield in different rice hybrids / varieties

Rice Hybrid / Variety	Grain yield (t/ha)				Straw yield (t/ha)			
	2006	2007	2008	Pooled Mean	2006	2007	2008	Pooled Mean
DRRH-2	7.64	5.58	5.93	**6.38**	3.49	4.55	4.49	4.17
CRHR-7	8.06	6.64	5.87	**6.86**	3.32	3.91	5.38	**4.20**
JKRH-2000	8.58	6.05	8.34	**7.65**	5.78	3.83	4.67	**4.76**
SURUCHI	7.42	5.97	8.70	**7.37**	5.69	5.27	5.19	**5.38**
PSD-3	8.14	6.03	8.64	**7.60**	5.36	4.85	6.15	**5.45**
PA-6444	8.64	6.71	9.13	**8.16**	4.84	5.40	5.64	**5.29**
KRH-2	7.70	5.72	8.01	**7.14**	5.61	4.97	4.82	**5.18**
JYOTHI	6.57	4.39	5.08	**5.35**	2.89	3.02	3.78	**3.24**
JAYA	4.44	4.16	7.78	**5.45**	3.06	4.21	4.67	**3.98**
ANNADA	4.24	1.56	6.41	**4.07**	4.05	4.59	3.54	**4.06**
C.D(P=0.05)	**1.28**	**0.65**	**1.67**	**0.81**	**0.78**	**0.17**	**0.66**	**0.52**

Front Line Demonstrations in Hybrid Rice

Rice hybrids *viz.* "Sahyadri" and "KRH-2" were evaluated in farmers fields under front line demonstrations in comparison with the ruling varieties *i.e* Jaya or Jyoti in all the ten talukas of Goa state in close collaboration with Directorate of Agriculture, Government of Goa (Taluka level Zonal Agricultural Offices), by imparting relevant training and supply of critical inputs. Before launching this massive programme, exhaustive field survey was conducted in all the talukas of the State and strategic locations were selected so as to create an awareness about the hybrid rice production / cultivation technology. The total number of beneficiaries in these demonstrations were 559 including 63 farm women. The demonstrations were regularly monitored and three field days were organized at Sristhal in Canacona, Bandiwade in Ponda and Mandrem in Pernem talukas to highlight the yield advantage of the demonstrated hybrids. Random sampling was done to assess the productivity levels, cost of production and the returns both in hybrids v/s ruling varieties.

The mean harvest data at 10 locations in each taluka of the State showed a clear edge of rice hybrids over the ruling inbred varieties. Sahyadri and KRH-2 with an overall mean yield of 7.3 t/ha were found to be 70.9 per cent and 107.1 per cent higher over Jaya and Jyoti giving a mean yield advantage of 2,949 kg/ha over State yield.

The mean cost of cultivation on various input costs in 10 talukas on hybrid rice indicated that the maximum expenditure was incurred towards manures and fertilizers followed by seed. The additional cost involved in hybrid rice demonstrations on an average was found to be Rs.1,450/ha towards the seed. The major operation involving the highest cost was the transplanting operation. The mean operative cost

Table 37. Economics of hybrid rice cultivation in Goa State

Taluka	Cost of production (Rs/ha)	Grain yield (t/ha)	Straw yield (t/ha)	Gross returns (Rs/ha)	Net returns (Rs/ha)	B : C ratio
Tiswadi	31268	8.8	15.2	50650	19411	1.6
Pernem	27748	7.6	19.1	49396	21648	1.3
Margao	24550	6.2	18.9	36936	12386	1.8
Quepem	29865	7.9	19.8	48400	18535	1.6
Canacona	22690	8.2	15.2	47040	24349	2.1
Ponda	20670	7.8	12.1	41340	20580	2.0
Bicholim	25690	6.9	16.5	41250	15560	1.4
Sattari	19825	5.2	15.1	30865	11040	1.8
Mean	**25288**	**7.3**	**16.49**	**43235**	**17939**	**1.4**

was found to be Rs. 18,170/ha while the total cost of production was Rs. 25, 290/ha. The mean benefit cost ratio of the demonstration plots was 1.43:1 and the highest ratio was obtained at Ponda (Bandora) followed by Canacona taluka (Sristhal).

Besides conducting several field days of interested farmers, stake holders, NGO's, SHG's, etc, adequate press and electronic media coverage was given to highlight the success of hybrid rice technology in the selected areas, wherein the yield advantage was highlighted compared to local check (Jaya and Jyoti).

Field reaction of rice hybrids to major insect pest and diseases

Insect pests

Gall midge, leaf folder and case worm are the major insect pests in hybrid rice during *kharif*. Infestation of all the insects was less than six infected panicles per square meter during 2002 and further reduced incidence was recorded during 2003. During 2005 and 2007 slightly increased infestation was recorded when compared to the preceding years.

Diseases

Sheath rot and bacterial leaf blight (BLB) are the major diseases during *kharif* season. Incidence of BLB was in increasing trend from 2002 and the maximum BLB incidence of 57 percent was recorded during 2005; after 2005 the incidence was negligible. Sheath rot was the major concern since 2002 and the incidence reduced till 2006 and again showed increasing trend during 2007 and 2008. False smut incidence was noticed during 2005 and a maximum of 10 panicles infected per m^2 area.

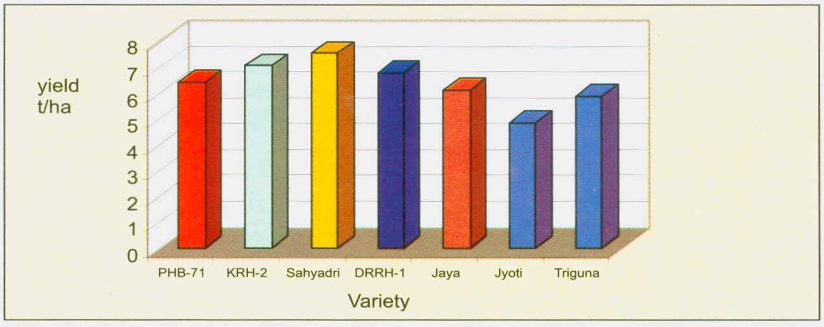

Fig. 10. Mean performance of rice hybrids between 1998-99 to 2001

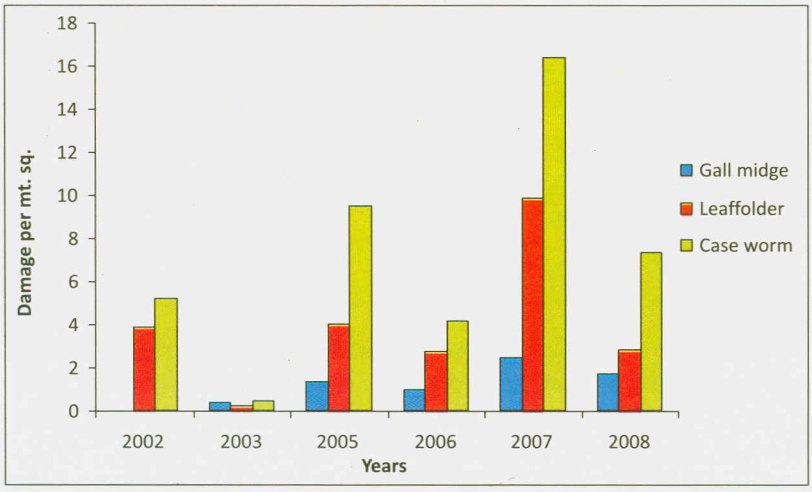

Fig. 11. Incidence of major insect pests in rice hybrid over years

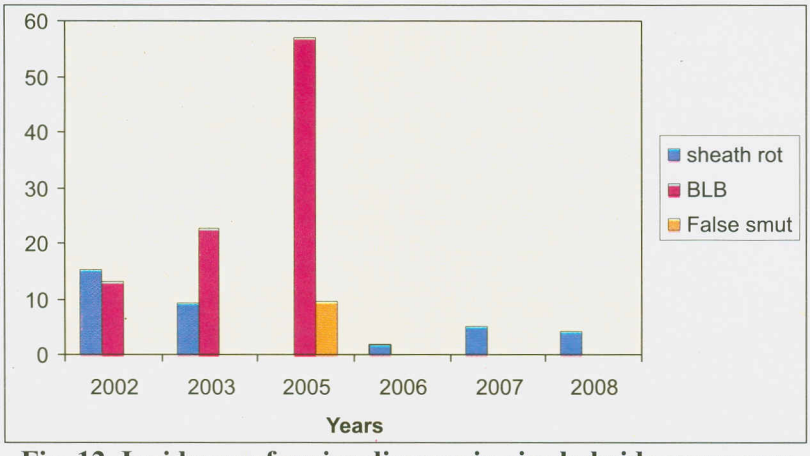

Fig. 12. Incidence of major diseases in rice hybrids over years

Sheath rot: Number of panicles infected from 10 tillers randomly selected from one square meter area.
BLB: Percent Disease Index
False Smut: Number of panicles infected/m^2 area
Data were recorded 60-75 days after transplanting and presented as mean of all varieties.

VIII. Standardisation of Seed production practices in Hybrid rice

Availability of quality hybrid seeds in bulk at an affordable cost and at an appropriate time is very essential to bring more area under the rice hybrids. Thus, seed production is the most crucial link between development of hybrids and their cultivation by the farmers. Hybrid rice seed production involves several intricacies which have to be managed efficiently to obtain a higher seed yield. Further, development of an economic and efficient seed production package is a pre-requisite for commercial viability of the hybrid rice technology.

Achieving proper synchronization between parental lines, determining the optimum row ratio, identifying appropriate dosage and stage for application of GA_3, finding out precise and appropriate timing for supplementary pollination etc., are some of the aspects which need to be standardized for different locations.

Keeping these points in view, attempts were made to standardize the seed production practices for agro-climatic conditions of Goa.

Field trials were conducted for at ICAR Research Complex for Goa, Old Goa to standardize the seed production practices for Hybrid rice KRH-2. The male parent of KRH-2 rice hybrid (KMR-3) was sown in three staggered nurseries to synchronise its flowering with the female parent IR-58025A (A Line). Male and female lines were transplanted simultaneously and raised with recommended package of practices. Leaf clipping was undertaken by cutting the top one-third of flag leaf at boot leaf stage. GA_3 spray was taken at 5-10 per cent heading of female line on two consecutive days.

1. Days to Flowering

To achieve perfect synchronization between A and R lines it is very essential that the days taken from seeding to flowering are correctly identified. This duration for flowering not only depends on genetic characteristics of the parental lines but also varies with temperature and other environmental conditions. It was observed that female (A) line requires 100 days for heading as compared to 93 days in male (R) line during *rabi* season and no variation was observed over the years. This clearly reveals that A line needs to be sown a week earlier under *rabi* extended summer situations in Goa to get proper synchronisation of flowering.

2. Row-ratio

For hybrid rice seed production, the seed parent and the pollen parent need to be planted in a definite row ratio at required spacing. The row ratio and the spacings of pollen parent and seed parent have a distinct effect on the hybrid seed yields. The ratio of pollen parent (R line) and seed parent (A line) is determined by the characteristics of the parental lines. Row ratio should be wider to ensure higher yields. With good management, the row ratio can be widened so as to obtain good pollen load and higher seed set.

Studies conducted in this direction, have clearly indicated the superiority of wider row ratio to obtain higher seed yields. Increase in row ratio from 2:3 to 2:8 although reduced the mean seed set per cent from 36.1 to 19.4, increased the mean seed yield from 635 kg/ha to 1555 kg/ha clearly suggesting the advantage of wider row ratio for obtaining higher seed yields. This is because, the grain yield per plant is found to be significantly and positively correlated with number of productive tillers per plant, biological yield and harvest index at phenotypic and genotypic levels.

3. Flag Leaf Clipping

Enhancing out-crossing rate is one of the key factors to increase the seed yield. Normally, the flag leaves are erect and longer than the panicles and they come in the way of easy pollen disbursal, thus affecting the out-crossing rate. Flag leaves should be clipped when the main culms are in booting stage. Hence, flag leaf clipping helps in uniform pollen movement and wide disbursal of the pollen grains to give higher seed set.

Generally leaf clipping is suggested for A line. However, when R line is much taller and is not synchronizing in flowering with A line, partial flag leaf clipping of R line may also be useful. However, it is desirable to resort to a minimal leaf clipping when higher seed yields are aimed at. As such, studies were made on the effect of flag leaf clipping both in A and R lines along with control.

It was observed that leaf clipping in A line improved seed set (42.2% with leaf clipping compared to 39.5% without leaf clipping). However, clipping flag leaf in R line was found to be detrimental to obtain higher seed set (22.8%).

4. Root disturbance

Success of hybrid seed production depends to a greater extent on achieving perfect synchronization. Though staggered sowing of R lines helps to prolong the availability of pollen over a long period, it is not sufficient to get maximum seed set. Keeping this in view, few practical approaches need to be evolved to achieve better synchronization.

Disturbance of root spread in rice hills by partially uprooting the male rows will be a technique worth trying especially under situations of early flowering of R line. Efforts made in this direction revealed that root disturbance helped to enhance the seed set from 35.6 to 47.4 per cent . The increased seed set may be attributed to the delay in flowering by the plant to offset the root disturbance.

5. Economics of seed production

Large scale seed production would be a reality if the returns from seed production are lucrative enough to offset the additional operations / risks involved in such venture. With this aim, the economics of seed production in hybrid rice KRH-2 was assessed.

The mean cost of seed production was Rs.36,000/ha including the additional operations for staggered nurseries of parental lines, maintenance of row ratio and transplanting, flag leaf clipping, GA_3 spray, supplementary pollination, rouging, harvesting of male and hybrid lines separately and threshing and cleaning. The mean yield obtained was 1,490 kg of hybrid rice seeds and 1325 kg of male parent / ha. At the existing farm prices the mean gross returns worked out to Rs.97,875 / ha resulting in a net return of Rs.61,875 / ha, with a benefit cost ratio of 2.72.

Thus, there is a good scope for taking up the seed production of hybrid rice in the region as an economic proposition especially by the rural youths with adequate training.

6. Development efforts for popularisation of the programme

To bring an awareness of the seed production programme in hybrid rice and its concomitant benefits, regular training programmes were organised involving all the stake holders which included Officers of the State Directorate of Agriculture, progressive growers and the personnel of Krishi Vigyan Kendra. The field level training and visit to the demonstration plots were well received by the clientele as reflected by the enthusiasm and interest expressed to take up the programme in their fields.

Hybrid rice seed production - a paying venture with proper care

On the spot assessment of rice hybrid performance by the trainees

Strengthening Seed production in high yielding rice varieties

As a sequel to demonstrations and conduct of field days, growing demand for quality rice seed was observed over the years although the seed replacement of the region is only 20 to 25 per cent in rice at present. In order to meet this demand a project proposal was sent to ICAR Head Quarters, New Delhi under the Mega seed project and sanction for an amount of Rs. 67.71 lakhs was obtained under revolving fund mode.

By strengthening the crucial infrastructure, the seed production was taken up both in the experimental farm of the Institute and in the farmers fields. High yielding rice varieties which are in demand *viz*., Karjat-3, Mo-17, Karjat-5 were specifically multiplied on a large scale and supplied to State Directorate of Agriculture and Co-operative Societies operating in the region to meet the alarming demand. Further, the seed production was encouraged in the farmers fields as per demand and parental seed availability.

IX. Organisation of Field days / Kissan Melas

Coinciding with the physiological maturity of the majority of demonstrated varieties/ hybrids, farmers days were organized each year in co-ordination with KVK attached to the Institute and the results of the trias were shown to the visiting farmers through "Seeing is believing" concept. Every year an overwhelming response was observed by the visiting farmers demanding the seed of improved varieties for replacement in their farming activities.

The response was further strengthened with the active collaboration of State Directorate of Agriculture wherein the Extension Officers mobilized the needy farmers from different zones of the region.

X. Interface meetings with the Developmental Departments

The technologies ready for transfer were periodically discussed in the *Pre-kharif* and *Pre-rabi* Interface meetings organized at the Institute and in Directorate of Agriculture, Panaji, Goa. The performance of the identified varieties was discussed at length in light of research findings, on-farm and demonstration results and a consensus for recommendation of specific genotypes for the region was made. Further, a follow-up by making the seed available for cultivation on a pilot scale as well as monitoring of the demonstrations was co-ordinated. The field problems were further discussed for refinement of technologies in the regular training programmes being conducted by the State Directorate of Agriculture.

XI. Co-ordinations with different organisations

Collaborations were established with Directorate of Rice Research, Hyderabad through All India Co-ordinated Rice Improvement Programme and with relevant State Agricultural Universities like Kerala Agricultural University, Thrissur, Konkan Krishi Vidyapeeth, Dapoli, University of Agricultural Sciences, Bangalore, etc., to introduce the relevant high yielding rice varieties / hybrid parental lines each year. Consistent efforts were made to screen a series of genetic material to select a suitable genotype for different rice growing situations.

Further, efforts were made to popularize the identified genotypes through collaboration with State Directorate of Agriculture, Government of Goa and with input distribution agencies like Goa Bhagayatdar Society, Ponda-Goa and all out efforts were made to ensure the reach of quality seed for further multiplication and distribution to the farmers on time.

XII. Organisation of National Seminar on "Rice and rice based systems for sustainable production"

A National Seminar was organized at the Institute on **"Rice and rice based systems for sustainable production"** during 18-19, October, 2005 by involving Directorate of Rice Research, Hyderabad, Central Rice Research Institute, Cuttack, and other relevant institutions including Directorate of Agriculture, Government of Goa. Delegates from all over India participated and presented papers in five technical sessions. The problems of rice cultivation in general and Goa in particular were discussed and deliberated.

The seminar was successful in bringing out useful and practical recommendations, *viz* selection of improved varieties / hybrids, improved management practices for rice and rice based crops, integrated pest and disease management, use of improved machinery for mechanization and processing, extension and economics of the rice based cropping system etc.

XIII. Impact analysis of research and developmental efforts in rice

As a result of research and develomental interventions between 1998-99 to 2004-05 and due to technology transfer through KVK in association with departmental programmes as well as field demonstrations conducted over the years, an overall encouraging impact is seen in terms of productivity. During the period 1998-99 to 2004-05, the productivity of rice increased by 8.85 per cent in the State.

The production of rice in the State during the period 1998-99 to 2004-05 rose by 12,096 mt (5.88 %) mainly due to the effect of enhancement/ improvement in the per unit productivity levels each season.

Table 38. Production of rice (mt) in the State during the period 1998-2005

Year	Production of rice (mt)			
	Kharif	Rabi	Total	% increase
1998-99	139506	66118	205694	5.88
2004-05	150909	66881	217790	

The impact analysis on the research and technological interventions by the Institute and a close linkage with the developmental agencies *viz* Directorate of Agriculture, Government of Goa has resulted in overall growth increase in both production and productivity of rice, suggesting that the technology of rice if adopted on a wider scale can bring about a major change with increased production of rice in the State.

XIV. Conclusions

Based on the research work carried out over a period of three decades, the following conclusions can be drawn:

- Among the local varieties "Damgo" and "Babri" being tall and late maturing were found suitable for low lying areas. For "Kher" lands the medium duration varieties such as "Nermar", "Kochri Patni" and " Belo" proved to be promising. "Dhavi Patni" and "Morod Kendal" were the early varieties (95 days) suitable for "Morod" lands.
- The rice yield obtained by CSR-27 (4.0 t ha^{-1}) and CSR-10 (3.95 t ha^{-1}) were consistently higher than the traditional Korgut (2.0 t ha^{-1}).
- The ionic preponderance in coastal soil decreased in the order of Na 105 me l^{-1} > Cl 82 me l^{-1} > SO_4 4.5 me l^{-1} > Mg 2.9 me l^{-1} > Ca 2.5 me l^{-1} > HCO_3 0.76 me l^{-1}. Reduction in root length, less number of tertiary roots, increase in weight of root to shoot ratio, five per cent root damage and 30 per cent reduction in the yield of traditional Korgut rice was obtained with the ground water having electrical conductivity of 3.50 dS m^{-1}.
- Red kernelled rice variety Mo-17 (Revathy) shown consistently superior performance (6.19 t/ha) over the ruling variety Jyoti (3.60 t/ha) recording an advantage of 72 per cent.
- The variety Karjat-3 is significantly superior to the ruling variety Jaya with yield advantage of 28.6 per cent. The higher yield in the variety was a consequence of more number of productive tillers per hill. It was followed by other varieties like NDR-9930 (6.35 t/ha) and Karjat-5 (6.28 t/ha) which also registered a yield increase of 26.2 and 24.9 per cent, respectively.
- Evaluation of scented rice varieties for grain yield indicated that the overall performance of variety Pusa Sugandh-5 was significantly higher (4.66 t/ha) over the check variety Pusa Basmati-1 (3.49 t/ha) with an additional yield of 1.17 t/ha recording 33.5 per cent increase in yield. Further, the yield levels of the variety were also consistent over the years. The higher yield of the variety could be attributed to higher harvest index (0.44) indicating that the translocation of photosynthates was more towards economic parts. The straw yield of the variety was however, significantly lower (6.41 t/ha) as compared to Pusa Basmati-1 (10.08 t/ha). The net returns could be enhanced by nearly 70 per cent especially with Pusa Sugandh-5 by resorting to value addition through processing.
- Among the rice hybrids evaluated, PA-6444 has been consistent in its performance. The entry recorded grain yield of 8.16 t/ha, thus significantly differing from all the check varieties and other hybrids except JKRH-2000 (7.65 t/ha), PSD-3 (7.60 t/ha) and Suruchi (7.37 t/ha) in comparison to National hybrid check KRH-2 (7.14 t/ha) registering a yield increase of 14.3 per cent. The hybrid PA-6444 was found superior by 50 per cent in terms of grain yield over local check Jaya.
- The mean Front Line Demonstrations harvest data at 10 locations in each taluka of the State showed a clear edge of rice hybrids over the ruling inbred varieties.

Sahyadri and KRH-2 with an overall mean yield of 7.3 t/ha were found to be 70.85 per cent and 107.1 per cent higher over Jaya and Jyoti giving a mean yield advantage of 2,949 kg/ha over State yield.

- The mean cost of hybrid rice seed production was Rs.36,000/ha including the additional operations for staggered nurseries of parental lines, maintenance of row ratio and transplanting, flag leaf clipping, GA_3 spray, supplementary pollination, rouging, harvesting of male and hybrid lines separately and threshing and cleaning. The mean yield obtained was 1,490 kg of hybrid paddy seeds and 1,325 kg of male parent / ha. At the existing farm prices the mean gross returns worked out to Rs. 97,875 / ha resulting in a net return of Rs.61,875 / ha. In contrast to hybrid rice cultivation, the seed production thus, fetched an additional net returns of Rs.44,000/ha with an increased benefit cost ratio (2.72 in seed production as compared to 1.71 in hybrid rice cultivation).

XV. Future Line of Research:

Although, the productivity of rice is higher in Goa and adjoining regions, still rice is being imported from neighbouring areas to meet the local demand. Keeping in view the potential of the crop and the feasible and practical options based on the research work carried out at the Institute, the following future line of research has been suggested:

1. Development of high yielding salt tolerant rice varieties, resistant to lodging through the crossing of local Korgut with high yielding varieties and their popularization.
2. Development and popularization of red kernelled rice hybrids suitable to uplands and mid lands.
3. Collection, conservation and catalouguing of local germplsm and its systematic use for breeding programme.
4. Intensive studies on post harvest and value addition in rice with out reach programmes.
5. Selection of genotypes for organic rice production with suitable infrastructure development.
6. Development of suitable rice hybrids with higher heterosis, grain quality and standardization of seed production practices.

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