LMA Convention Journal
Vol. 8, No. 1, 2012, 7-14

Extinction to Distinction: Current Status of Kalanamak, the Heritage Rice of Eastern Uttar Pradesh and its likely Role in Farmers' Prosperity

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ABSTRACT

Kalanamak, the heritage rice of Eastern U. P. has been cultivated since last 4,000 years. Locally considered superior to Basmati in aroma and taste, it does not require any special rice mill. But this black-husked and short-grained rice is tall and yields low. Farmers complained of poor yield and consumers of its deteriorated aroma and taste. No researches were done on it, and due to double onslaught of poor yield and taste, and competition with HYV, its area reduced from 50,000 ha to almost extinction. In order to revive Kalanamak, PRDF Gorakhpur collected 71 germplasm of Kalanamak and made comparative evaluation to identify one accession (KN3-27-3-3) as most aromatic and true to perceived Kalanamak quality. Using pureline selection, Kalanamak KN3 was tested and released as a variety by U. P. State Government in 2007 and notified by the Government of India in 2010. PRDF has systematized production of Nucleus, Breeder, Foundation and Certified Seeds. During 2012, more than 300 quintals of certified seeds of Kalanamak KN3 were made available to farmers. In a research project to develop HYV of Kalanamak, more than 205 semi-dwarf breeding lines developed using hybridization and mutation breeding techniques are at various stages of testing. Some breeding lines in F6 and M8 generations have out-yielded Kalanamak KN3 by 40%. Five breeding lines are under field test of Department of Agriculture, U. P., which if found promising will be released to farmers as HYV.

Exported and organic rices fetch more money but under GIS of Basmati, eastern U. P. can't grow it for export. Thus Kalanamak is the hope as export candidate as normal and Organic Kalanamak". Under a separate research project, protocol to produce organic Kalanamak is being developed and farmers are being trained in organic production. They will be linked to organic market for local consumption and export. With the high yield of HYV Kalanamak and high price, Kalanamak rice may bring fast prosperity to eastern U. P.

INTRODUCTION

Kalanamak rice is an epitome of best aromatic rice cultivated and consumed in north-eastern part of Uttar Pradesh (U. P.). It is a heritage rice variety, which has been under cultivation since time immemorial (Chaudhary and Tran, 2001; Chaudhary and Mishra, 2010). Exact history of its cultivation is not recorded but it is believed that Kalanamak was the preferred variety for offerings given to Lord Buddha some 3,000 years ago. Kalanamak has been in cultivation mainly in north-eastern part of Uttar Pradesh and western and central part of Nepal Tarai. Over centuries under cultivation, and farmers' way of handling seeds, neglect by rice research institutions and double onslaught on economic front by high yielding varieties (HYV), deterioration in its quality and the area under cultivation has reduced. Many voices have been raised for its declining grain quality and reducing cultivation area from 50,000 hectares in the past to 2,000 ha currently. Nothing concrete was done to ameliorate the situation. Participatory Rural Development Foundation (PRDF), Gorakhpur, rose to the occasion to save Kalanamak from extinction and developed technologies to bring its old glory back. On the proposal of PRDF, U. P. State Variety Release Committee (SVRC) released Kalanamak KN3 as a variety for cultivation in U. P. in its meeting held on 10th August 2007 (Chaudhary et al. 2008a, 2008b, 2008c). The Central Sub Committee on Variety Release and Notification of Government of India gazetted it on 31st August 2010 vide its notification No. SO.2137 (E).

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ISSN 2319-3700

KALANAMAK ON THE BRINK OF EXTINCTION

Kalanamak consumers complained of the loss of aroma and taste. Kalanamak farmers also complained but started leaving its cultivation primarily due to consumers losing interest and cultivation becoming less profitable as compared to other HYVs. This double onslaught brought the area down from more than 50,000 ha to less than 2,000 ha (Chaudhary, 2005). With this speed of reduction in the area, Kalanamak would have been extinct just in a few years, if not for some farmers who continued its cultivation for home consumption.

EFFORTS OF PRDF GORAKHPUR

At this juncture in the year 2000, PRDF Gorakhpur became aware of this grave condition of Kalanamak and eastern U. P. losing its most prestigious and heritage rice.

Germplasm collection

On its own initiative possible accessions from the National Gene Bank, located at National Bureau of Plant Genetic Resources (NBPGR), New Delhi; Gene bank of Central Rice Research Institute, Cuttack; N.D. University of Agriculture and Technology (NDUAT) Faizabad collected all the accessions stored there (Chaudhary et al. 2010). Additional collections were made from the fields and houses of the farmers of Basti, Deoria, Gorakhpur, Sant Kabir Nagar, Siddharth Nagar, Kushinagar and Mahrajganj districts (Table 1).

TABLE 1:
Kalanamak germplasm (bulks and panicles) collected by PRDF Gorakhpur (2000-03)

District / Organization	Bulk	Panicle	Total
National Gene Bank, NBPGR, New Delhi	16		16
Gene Bank, CRRI Cuttack (Odisha)	15		15
NDUAT Faizabad (U. P.)	8		8
Siddharth Nagar	138	1,005	1,143
Mahrajganj	21	220	241
Sant Kabir Nagar	70	230	300
Total	**268**	**1,455**	**1,723**

Causes of Loss of aroma and taste

Extensive testing of these collections was done under two projects financed by U. P. Council of Agricultural Research (UPCAR) during 2003 - 2007. It was not surprising to find out that some of the collections of Kalanamak were non-aromatic although the grain appearance was identical to Kalanamak. Most accessions had mixtures of scented and non scented Kalanamak in various proportions (Table 2). It was hypothesised that due to mutation from scented to non-scented type and resulting outcrossing and segregation, each accession became a population rather than a pure variety. There was no released variety of Kalanamak and no scientific seed production. Thus under bulk harvesting and cultivation, the mixtures of aromatic and non-aromatic was cultivated.

TABLE 2:
Loss of Kalanamak aroma and quality due to mutation, crossing aggravated by unscientific seed production. Frequency of aromatic lines for each accession (2000–01)

Designation of Kalanamak accessions	Number of lines		Percentage
	Total	Aromatic	
KN2 bulk	75	17	22.66
KN3 bulk	34	11	32.35
KN7 bulk	21	7	33.33
KN20 bulk	29	3	10.34
KN29 bulk	67	17	25.37
Total	**226**	**55**	**124.05**
Average			**24.81**

Pureline Selection and development of Kalanamak KN3

The collected germplasm (bulks and single plants were tested (Table 3) and the best ones (bulk 54, 57) were

TABLE 3 :
Analysis of yield data of 39 Kalanamak bulks tested in Randomized Block Design at 3 locations during (2001–02)

District / Factor	D. F.	Variance	Variance ratio	CD
Gorakhpur				
Replication	1	0.07		
Variety	38	0.04	1.74 *	0.300
Error	39	0.23		
Total	78			
Siddharth Nagar:				
Replication	1	0.12		
Variety	38	0.02	3.30 **	0.151
Error	39	0.006		
Total	78			
Sant Kabir Nagar				
Replication	1	0.39		
Variety	38	0.326	3.84 **	0.571
Error	39	0.085		
Total	78			

developed as pureline by panicle-to-row method. The resulting putative purelines were tested for grain quality and grain yield by PRDF. The best pureline (KN3-27-3-3) with good combination of aroma and yield was tested in the State Trials of the Department of Agriculture, U.P., conducted at its Regional Agricultural Technology Demonstration Stations (RATDS) during 2004-2007. Therefore, this pureline was proposed for release as Kalanamak KN3 (Table 4) by PRDF in 2010 in U.P. (Chaudhary et al. 2008a, 2008b, 2008c). PRDF is recognized to maintain Nucleus Seed and produce Breeder Seed. Organizations of public and private sectors, desirous to multiply Foundation and Certified Seeds obtain Breeder Seed from PRDF.

TABLE 4:
Distinguishing morpho-agronomic and quality characters of Kalanamak KN3

S. No.	Traits	Description
1	Basal leaf sheath colour	Green
2	Seedling vigour	Vigorous
3	Seedling height (cm)	30.5 cm
4	Date of 50% flowering	115 days (Photoperiod sensitive)
5	Tillering ability	Good, (15-20 tiller/plant)
6	Culm angle	Slightly Open (45^0)
7	Leaf length	59 cm.
8	Leaf width	1.4 cm.
9	Culm length	111 cm. (stiff)
10	Plant height	142 cm.
11	Panicle length	31 cm.
12	Maturity date	145 days (Photoperiod sensitive)
13	Aroma (scent code)	Highly scented
14	Panicle type	Open
15	Panicle exertion	Well exerted
16	Apiculus colour	Brown (tawny)
17	Awning	Absent
18	Lemma, Palea colour	Purplish Black
19	Stigma colour	Purplish Black
20	Kernel length	5.76 mm
21	Kernel width	2.18 mm
22	L/B Ratio	2.64 mm
23	Grain type	Medium slender
24	Kernel colour	White
25	1,000 grain weight	15 grams
16	Hulling	80 %
17	Milling	75 %
18	Head rice	70 %
19	Alkali value	6 - 7
20	Volume Expansion Ratio	4.5
21	Gel consistency	80 mm

FEATURES OF KALANAMAK KN3

Morpho-agronomic Characters of Kalanamak KN3

Kalanamak KN3 is strongly photo-period sensitive variety with short basic vegetative phase. Thus even in delayed planting, its flowering is not affected and it flowers during mid October. Its morpho-agronomic and grain characters described using SES (IRRI, 1996) are given in Table 4. Consumers in north-eastern Uttar Pradesh consider Kalanamak superior and prefer it for eating over Basmati.

Cultivation practice

Cultivation practices for Kalanamak were developed, published and communicated to the farmers (Chaudhary et al. 2008a, 2008b, 2008c, 2008d). Ideal time of its nursery sowing is last week of June to first week of July. Once the seedlings have attained the age of about 30 days, these are ready for transplanting. This recommendation is based on the fact that best grain quality and maximum aroma in the grain is retained when the heading of Kalanamak synchronizes with cooler (25C) temperature. At 30 degree Celsius or more, the leaves will synthesise the aroma but will evaporate and will not accumulate in the grain. 30 kg/ha seed and transplanting distance of 20cm X 15 cm is ideal. Green manure of *Sesbania* (Dhaincha) or *Crotolaria juncea* (sunhemp) or Mung or 6 – 10 tons of FYM should be used. If using chemical fertilizer a dose of 60:30:30 kg /ha of N:P:K should be used. The response of rice grain yield to inorganic fertilizers like Urea, DAP, Ammonium Sulphate etc. is very well known in HYV. Farmers need not be convinced to use these fertilizers to increase the yield. But the grain quality of quality rice like Kalanamak deteriorates if such fertilizers are used. Exact reasons and precise scientific data are yet to be collected and analyzed but traditional Kalanamak farmers have their traditional knowledge and experience to convince anyone not to use inorganic fertilizers to cultivate Kalanamak. For Zinc deficiency, 25 Kilogram Zinc Sulphate should be applied per ha before transplanting. One hand weeding or one application of herbicides like Nominee Gold is enough to control weeds. Among pests stem borer appears but causes no economic loss. Gundhi bug (*Leptocorisa* sp.) is serious but dusting of BHC or Malathion controls it. Crop should be harvested only at full maturity which comes after 35 days of full flowering. After threshing, grains should be dried and stored at 14% moisture for milling later.

BREEDING HIGH YIELDING VARIETIES OF KALANAMAK KN3

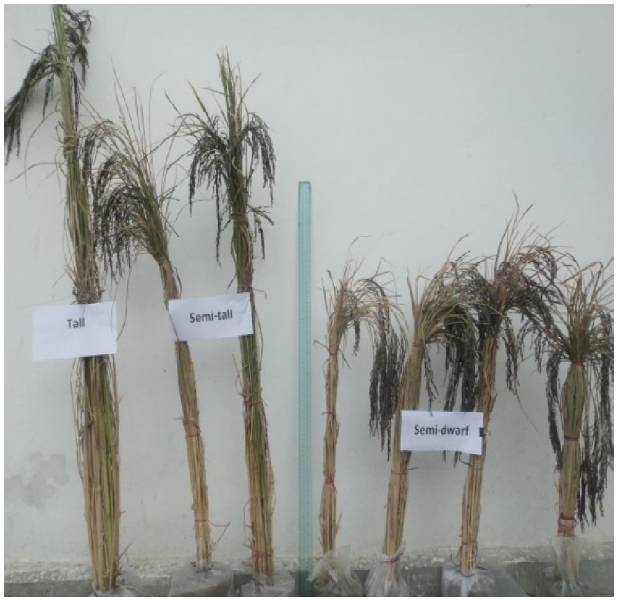
Hybridization and mutation breeding methods were used to develop Semi-dwarf high yielding varieties of Kalanamak. Two doses of Ethyl Methane Sulfonate (EMS), 0.50% and 0.25%, were given to kernel of Kalanamak KN3 using standard procedure (Chaudhary, 1979). It was found that in M_2 generation progenies showing chlorophyll mutation namely albina, xantha, chlorina, zebra etc. (Table 5, Fig. 1.1) had much higher and broad spectrum of mutants. Thus, it was concluded that only M_2 progenies

FIGURE 1 :
Glimpses of achievements on Kalanamak breeding at PRDF Gorakhpur

1.1 Albina mutants in of Kalanamak KN3: Indicator of useful mutants in M2 population

1.2 One of the 2 early segregants (UPCARKN3-16-1) is 30 days early than normal Kalanamak

1.3 Woman farmer smelling Kalanamak KN3 panicle in her field in Siddharth Nagar to test it



1.4 Promising high yielding mutants and segregants of Kalanamak KN3 at extreme left (marked Tall)

TABLE 5:
Type of economically important mutants isolated in M_3 and M_4 generations of the populations showing or not showing chlorophyll mutants in M_2

S. N.	Mutant type	Chlorophyll mutant		Non-Chlorophyll mutant	
		0.50%	0.25%	050%	0.25%
1	Semi-dwarf (< 100)	7	1	3	0
2	Dark green leaf	2	1	0	0
3	Medium tiller (10-15)	9	3	0	0
4	High tiller (> 25)	1	1	0	0
5	Brown spot resistant	7	0	0	0
6	Bacterial blight resistant	2	1	0	0
7	Stem borer resistant	12	5	3	0
8	Leaf folder resistant	6	3	3	0

with chlorophyll mutation should be advanced to save time of plant breeder and field resources, and to increase efficiency of mutation breeding (Chaudhary, 2011; Mishra and Chaudhary, 2010, 2011). In hybridization, non-aromatic and short grained varieties with excellent resistance to bacterial blight and submergence tolerance namely Improved Sambha Mahsuri (ISM), BPT5204 Sub1, Swarna Sub 1 and RAU3036 were used. Using off-season nursery, within a span of 3 years, breeding lines have been advanced to M_8 and F_6 generations. More than 201 semi-dwarf breeding lines developed using hybridization and mutation breeding techniques are at various stages of testing (Table 7, Fig. 1.4). Some lines in F6 and M8

FIGURE 2:
A typical chromatogram (SIM) obtained for the breeding line KN50-70-5-29-1

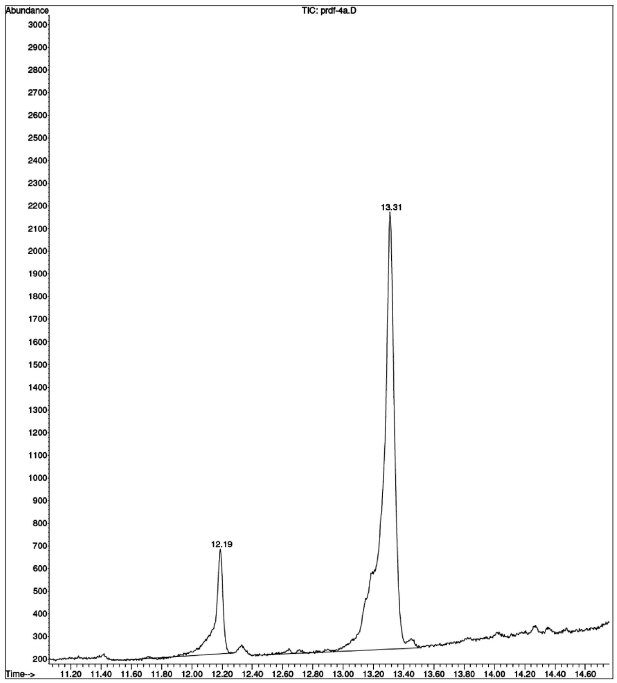


TABLE 6:
Aroma in segregants and mutants vis a vis as Kalanamak KN3 (cf. IICT, Hyderabad)

Pedigree	Peak area of ion for 2-AP	Peak area of ion for TMP	2-AP/ TMPx 100
Kalanamak KN3	26184	245230	10.677
KN50-6-1-51-1 (mutant)	34823	181700	19.165
KN50-33-2-99-4 (mutant)	22171	167060	13.271
KN50-70-5-29-1 (mutant)	17380	107082	16.230
KN25-3-2-26-9 (mutant)	6447	102379	6.297
KN25-25-1-24-9 (mutant)	8248	105131	7.845
UPCARKN1-5-1 (segregant)	18235	108553	16.798
UPCARKN1-5-9 (segregant)	10813	103379	10.459
UPCARKN1-6-7 (segregant)	17385	108689	15.995
UPCARKN1-8-5 (segregant)	14265	112840	12.641
UPCARKN1-11-8 (segregant)	11216	99161	11.310
UPCARKN1-13-5 (segregant)	10936	99810	10.956
UPCARKN1-23-7 (segregant)	16232	102139	15.892
UPCARKN2-1-3 (segregant)	14206	108098	13.141
UPCARKN2-10-9 (segregant)	14681	107039	13.715
UPCARKN2-10-1 (segregant)	18460	103267	17.875
UPCARKN2-13-11 (segregant)	22185	105078	21.112
UPCARKN2-14-8 (segregant)	15164	105884	14.321
UPCARKN2-19-8 (segregant)	11390	97841	11.641
UPCARKN2-19-14 (segregant)	15760	100233	15.723

generations are early or late (Fig. 1.2) and have out-yielded Kalanamak KN3 by 40%. Five lines UPCARKN1-5-1, UPCARKN2-10-1, UPCAR -KN2-10-9, UPCARKN2-14-8, and UPCAR KN2-19-14 are being tested at RATDS by U. P. State Department of Agriculture during Kharif 2012. If found high yielding, these will be released as varieties for U. P.

HIGHER AROMA AND YIELD

Most promising mutants and segregants on M6 and F5 generations were also tested for grain aroma at Indian Institute of Chemical Technology (IICT), Hyderabad by estimating 2 AP (2-acetyle pyrroine). A typical chromatogram (SIM) obtained for KN50-70-5-29-1 is given in Figure 1. Each sample was run in triplicate and the average peak area values were used for the quantification. The quantification summary is given in the Table 6, Fig. 2). Thus it is possible to recover mutants with increased (KN50-33-2-99-4; KN50-70-5-29-1) aroma. It has been possible to develop semi-dwarf and semi-tall high yielding breeding lines namely KN50-6-1-51-1, KN50-33-2-99-4, KN50-70-5-29-1, UPCARKN2-10-1, UPCA RKN2-10-9, UPCARKN2-13-11, UPCARKN2-19-14 with aroma even more than the original Kalanamak (Mishra et al. 2011, Table 6). Thus the varieties coming out of these breeding lines will be highly acceptable to high-end growers, processors and consumers. A number of promising breeding lines with higher aroma and yield are under test at PRDF Gorakhpur, and at RATDS in State Trial (Table 7).

ORGANIC PRODUCTION OF KALANAMAK

Protocol to produce organic Kalanamak does not exist. Thus a multi-location trial with various combinations of Herbozyme, Pseudomonas, Trichoderma, Bhumi Shakti, and FYM is established in the districts of Gorakhpur, Mahrajganj and Siddharth Nagar. Few hundred farmers are being trained to grow organic Kalanamak. Large scale demon-strations of putative organic inputs are being demonstrated on the farmers' fields in the above districts. They are also being linked to rice processors and super markets. Hopefully we shall succeed and farmers will benefit economically, and the country will benefit by better human health and safer environment. Overall Kalanamak will be saved from extinction and raised to distinction.

PROSPERITY THROUGH KALANAMAK

Exported and organic rices fetch more money but under GIS of Basmati, eastern U. P. can't grow it for export. Thus Kalanamak is the hope as export candidate as "*Normal*" and "*Organic Kalanamak*". Under a separate research project, Protocol to produce organic Kalanamak is being developed and farmers are being trained in organic production. They will be linked to organic market for local consumption and export. With the high yield of HYV Kalanamak and high price, Kalanamak rice may bring fast prosperity to eastern U. P. Kalanamak is the premium quality rice and has premium price. During the year 2011-12, the price of rice (paddy) ranged between Rs.

TABLE 7 :
Summary of the selected breeding lines under testing at PRDF Gorakhpur, Kharif 2012

S.N.	Cross Designation	Parentage	Progeny advanced	Bulks in test	Current generation
1	UPCARKN1	ISM / Kalanamak KN3	6	1	F5
2	UPCARKN2	Swarna Sub_1 / Kalanamak KN3	13	7	F5
3	UPCARKN3	BPT 5204 Sub_1 / Kalanamak KN3	14	4	F5
4	UPCARKN4	RAU3036 / Kalanamak KN3	15	1	F5
5	UPCARKN1	ISM / Kalanamak KN3	34	26	F6
6	UPCARKN2	Swarna Sub_1 / Kalanamak KN3	46	28	F6
7	Mutant	KN50-70-5-29-1-1	-	1	M8
8	Mutant	KN50-70-5-29-1-2	-	1	M8
9	Mutant	KN25-25-1-24-9-1-1	1	-	M8
10	Mutant	KN25-25-1-24-9-1-2	1	-	M8
11	Mutant	KN25-25-1-24-9-2-1	1	-	M8
12	Mutant	KN25-25-1-24-9-2-2	1	-	M8
		Total			

2,000 to Rs.3,000 per quintal. As milled rice (60% head rice recovery) it was selling at Rs. 4,500 to Rs. 6,000 per quintal. Calculating an average yield of 20 quintal per ha, Kalanamak KN3 can give a gross profit between Rs. 29,500 to Rs. 31,000 per ha to the farmers. Deducting a production cost of Rs. 40,000 to Rs. 47,500 per ha, the net profit would be between 10,500 per ha. In case of organic rice, the net profit would jump to Rs. 16,500 even with the currently bred variety Kalanamak KN3. Once the new semi-dwarf varieties of Kalanamak being bred come under cultivation, the net profit would be as high as double of the current one i.e. Rs. 33,000 (Table 8). This should bring prosperity to the farmers of eastern U. P. who will grow this variety. In the local (Chaudhary, 2009) and international markets, there is an increasing demand for such rices (Chaudhary, 2012).

SCIENTIFIC SEED PRODUCTION

With the release of Kalanamak KN3 by U. P. State in 2007, and Notification by Government of India on 31.08.2010 vide Government Gazette # SO. 2137 (E), it has been possible to produce Nucleus Seed, Breeder Seed, Foundation Seed and Certified Seed now. Kalanamak KN3 has also been registered (12-1-/07/3046 dated 06.02.2012) by Plant Variety Protection of Plant Varieties & Farmers Rights Authority (PVP&FRA) of Government of India. PRDF holds the right to produce Nucleus Seed and Breeder Seed. For the current Kharif 2012, more than 300 quintals of Foundation Seed was distributed to farmers, which are expected to cover 1,000 ha. Thus it is expected that Kalanamak KN3 will revive the Kalanamak cultivation and new semi-dwarf versions of Kalanamak due soon will revolutionise it.

TABLE 8 :
Comparative profitability of normal Kalanamak KN3, organically grown Kalanamak KN3 vis vis common types of rice in Eastern Uttar Pradesh (2011-12).

Item**	Common rice	Normal Kalanamak	Organic Kalanamak
Rice area (ha)	9,14,976	4,000 ha	1,000 ha
Average yield (Quintal /ha)	35.0	20.0	19.0
Selling price of paddy (Rs. / Quintal)	Rs. 1,250	Rs. 2,000	Rs. 2,500
Gross profit (Rs. / ha)	Rs, 43,750	Rs. 40,000	Rs. 47,500
Cost of production (Rs. / ha)	Rs. 33,200	Rs. 29,500	Rs. 31,000
Net profit (Rs. Ha)	Rs. 10,550	Rs. 10,500	Rs. 16,500
Extra per Ha profit compared to existing system & variety			Rs 6,000

ACKNOWLEDGEMENT

Thanks to UPCAR Lucknow for supporting the project financially. Thanks to Sir Dorabji Tata Trust for their generous support in developing organic protocol to grow Kalanamak rice, which will make the farmers more prosperous, and lead Kalanamak from extinction to distinction. Thanks to the Department of Agriculture, U.P. to test the Kalanamak entries at RATDS during 2004 – 2006 and in 2012 and beyond.

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