



## Development and use of organic protocol to promote Kalanamak rice (*Oryza sativa*) and its certification under PGS mode

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### ABSTRACT

Aromatic Kalanamak is a prized and heritage rice variety of north-eastern Uttar Pradesh. It was on the brink of extinction down from peak acreage of 50,000 hectares. There were no released varieties of Kalanamak and quality of land races had deteriorated. Due to poor quality, yield and income farmers abandoned its cultivation. PRDF developed Kalanamak KN 3 was notified in 2010, and 2 high yielding versions (50% higher yield) Bauna Kalanamak 101 and Bauna Kalanamak 102 developed through hybridization were identified by the Department of Agriculture Uttar Pradesh in 2015 for release. Protected under PPV & FRA since 2011, and registered under Geographical Indications since 2014, protocol for its organic production has been developed. Many combinations of organic inputs were tested in multi-location trials but maximum yields were obtained in the treatments where *Trichoderma* (5 kg ha<sup>-1</sup>) and *Pseudomonas* (10 g kg<sup>-1</sup> seed) together were used in either with farmyard manure-FYM (10 t ha<sup>-1</sup>) or Bhumi Shakti (1.8 t ha<sup>-1</sup>) or *Herbozyme* (40 kg ha<sup>-1</sup>) or green manure (25 kg seed ha<sup>-1</sup>). These combinations were significantly superior from *Trichoderma* or *Pseudomonas* was used with *Herbozyme* or FYM or Bhumi Shakti. A clear case of “Synergistic effect” of *Trichoderma* + *Pseudomonas* was observed. Based on these observations, protocol for organic production was perfected and 1,000 farmers were trained. Using organic protocol the yield increased, rather than decreased as commonly perceived, under organic production. Participatory Guarantee System (PGS) promoted by the Government of India as cheapest and best system of organic certification, was used for organic certification. PRDF recognized as the Regional Council for PGS certifications is best placed in promoting it. Kalanamak’s area increased in 2015 to 21,000 hectares due to higher yielding and better quality Kalanamak varieties under organic production system and farmers profiting from it.

**Key words:** Kalanamak, Organic, Organic protocol, PGS, Paramparagat Kheti, PKVY

Kalanamak, the heritage rice (*Oryza sativa* L.), is an epitome of best aromatic rice cultivated and consumed in north-eastern part of Uttar Pradesh. It has been under cultivation since time immemorial (Chaudhary and Tran, 2001; Chaudhary, 2002; Chaudhary and Mishra, 2010). It is believed that Kalanamak was the preferred variety for offerings given to Lord Buddha some 3,000 years ago. 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, the area under its cultivation shrank (Chaudhary *et al.*, 2007; Chaudhary, 2009). Concerns were raised for its declining grain quality and reducing area from 50,000 hectares in the past to 2,000 hectares, but nothing concrete was done to ameliorate the situation.

Cultivation of Kalanamak rice is recorded since the Buddhist period (600 BC). The grains were found from excavation of Kapilvastu (later named Aligarhwa) now in district Siddharth Nagar, Uttar Pradesh, India. Located close to Nepal border, Kapilvastu was the kingdom of King Shuddhodhan (meaning pure rice), father of Lord Buddha. During the

excavation carbonized rice grains resembling to Kalanamak Rice were recovered from one of the rooms, which was supposed to be the kitchen store of King Shuddhodhan. Fa-Hien, the Chinese traveller wrote that when Prince Siddhartha (Lord Buddha) visited Kapilvastu for the first time after attaining Bodhisatva position, while passing through Bajaha jungle, he was stopped at Mathla village by the people. The villagers begged Lord Buddha to give them ‘*prasad*’ (Blessings). He took the rice from his alms and gave it to the people, asking them to sow it in a marshy place. The rice thus produced will have typical aroma which will always remind people of me. Bajaha jungle has vanished now but its place has been taken by Bajaha village near Kapilvastu. Mathla village exists with its changed name Mudila village.

The first effort for the promotion of Kalanamak was made by the Englishmen William Pepe, JH Hemprey, and Edcan Walker (English Jamindars of Alidapur, Birdpur, and Mohana) during the colonial period. They built four reservoirs at Bajaha, Marthi, Moti, and Majhauri to produce Kalanamak in a large quantity. They not only produced this variety for their own consumption, but transported to England from Uska-bazar mandi, passing through Dhaka. Due to its increasing demand, the British

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captured the land around Kapilvastu, and established Birdpur and Alidapur states. When Gujarati businessmen came to know about its lucrative business potential, they formed a *mandi* at Uska-bazar to export Kalanamak. To counter them the British “shopkeepers” built a rail route to carry rice on the goods train.

## MATERIALS AND METHODS

Germplasm of Kalanamak was collected from farmers locally and from ND University of Agriculture and Technology, Faizabad (Uttar Pradesh); National Gene Bank of NBPGR, New Delhi; IIRR, Hyderabad and CRRI, Cuttack. These were evaluated for 37 morpho-agronomic characters using IRR1's Standard Evaluation System (Chaudhary, 1996) before their conservation at the National Gene Bank. Pureline selection was used for developing Kalanamak KN 3, and hybridisation for developing Bauna Kalanamak. Kalanamak KN 3 was used to develop the protocol for organic farming. There were 5 treatments, viz. control (T<sub>1</sub>), basal (T<sub>2</sub>), basal + seed treatment with *Pseudomonas* @ 10 g kg<sup>-1</sup> of seed (T<sub>3</sub>), basal + soil treatment with *Trichoderma* @ 5 kg ha<sup>-1</sup> (T<sub>4</sub>), and basal + *Trichoderma* + *Pseudomonas* as per Treatment 3 and 4 (T<sub>5</sub>).

Variation in ‘Basal’ treatments was made, which at Gorakhpur was *Herbozyme* @ 40 kg ha<sup>-1</sup>, at Mahrajganj, FYM @ 10 t ha<sup>-1</sup>, and at Siddharth Nagar, Bhumi Shakti @ 1750 kg (35 bags) ha<sup>-1</sup>. *Pseudomonas*, *Trichoderma* and *Herbozyme* were sourced from Excel Crop Care Ltd. and Bhumi Shakti (from Balrampur Sugar Mills). With plot size of 5 m x 3 m and 4 replications, the experiment was conducted in randomized block design. 30 day-old seedlings were transplanted at a distance of 20 cm x 15 cm with 2 to 3 seedlings per hill. Only *Azadirachtin* (concentration 3000 ppm, dose 875 ml ha<sup>-1</sup>) was sprayed after panicle emergence to scare away the *gundhi* and other bugs. Observations were recorded using Standard Evaluation System (Chaudhary, 1996). Grain aroma was analysed at Indian Institute of Chemical Technology (IICT), Hyderabad using GC-MS analysis for 2-AP with reference to trimethyl pyridine standard by solvent extraction method. Each sample was run in triplicate and the average peak area values are used for the quantification.

## RESULTS AND DISCUSSION

### Collection of germplasm and development of Kalanamak KN 3

Total of 174 bulks and 1455 panicles collected from farmers' fields of Basti, Deoria, Gorakhpur, Kushinagar, Maharajganj, Sant Kabir Nagar and Siddharth Nagar districts and institutions (Chaudhary, 2005; Chaudhary *et al.*, 2007; Chaudhary and Prajapati, 2007; Chaudhary and Mishra, 2010) in order to get some superior types for further varietal

improvement program. After due evaluation, purelines were developed from the best 7 accessions. Observations were recorded on 37 descriptors (Chaudhary, 1996). A total of 174 accessions of Kalanamak collected were characterised and conserved at National Gene Bank of NBPGR, New Delhi and CRRI, Cuttack (Chaudhary *et al.*, 2010; Chaudhary *et al.*, 2012).

### Purification, release and notification of Kalanamak KN 3

A total of 223 putative- purelines from 7 selected accessions were developed and evaluated. The best pureline was KN 3-27-3-3 was released as Kalanamak KN 3 on 10<sup>th</sup> August 2007 (Chaudhary *et al.*, 2008a, 2008b, 2008c, 2008d, 2014) and notified on 31<sup>st</sup> August 2010 vide its notification No. SO.2137 (E). This is the first variety of Kalanamak rice and its nucleus seed, breeder seed and foundation seed is being produced by PRDF. Kalanamak is protected under PPV & FRA since 2011 and since 2014 it is registered under Geographical Indications for Agroclimatic Zone 6, which covers 11 districts of Uttar Pradesh (GI Journal, August 2014).

### Development of Bauna Kalanamak

Due to the tall stature and poor yield of Kalanamak KN 3, attempt was made to develop high yielding varieties through hybridisation (Kalanamak KN 3 x Swarna sub 1 and Kalanamak x Improved Sambha Mahsuri). Tested by the Department of Agriculture, 2 semi-dwarf breeding lines were identified (Table 1); UPCARKN-2-19-14 as Bauna Kalanamak 101, and UPCARKN 1-5-1 as Bauna Kalanamak 102. Farmers cultivated these in more than 12000 hectares during *kharif* 2015.

### Development of protocol for organic production of Kalanamak

Statistical analyses were performed using standard analysis of variance. No replication differences were noticed but treatment differences were highly significant for yield (Table 2). The visible maximum crop vigour and yields were obtained

Table 2. Grain yield of rice in different treatments at various locations during *kharif* 2012

Treatment	Grain yield (t ha <sup>-1</sup> )		
	Gorakhpur	Mahrajganj	Sidharth Nagar
T <sub>1</sub> : Control (No treatment)	5.332	5.730	7.867
T <sub>2</sub> : Basal only	6.167	6.657	8.382
T <sub>3</sub> : Basal + <i>Pseudomonas</i>	5.832	6.220	8.082
T <sub>4</sub> : Basal + <i>Trichoderma</i>	6.042	7.292	8.000
T <sub>5</sub> : Basal + <i>Trichoderma</i> + <i>Pseudomonas</i>	7.655*	8.992*	8.957*
LSD (P=0.05)	515.00	493.10	287.83

\* Highest yield and significantly higher than all other treatments

Table 1. Grain yield of Bauna Kalanamak (BK) 101 and 102 compared to KN 3 during 2012 to 2014

Varieties	Grain yield (t ha <sup>-1</sup> )									
	Varanasi			Azamgarh			Barabanki			Mean
	2012-13	2013-14	2014-15	2012-13	2013-14	2014-15	2012-13	2013-14	2014-15	
UPCARKN 2-19-14 = BK 101	3.666	3.577	3.496	3.152	3.696	3.150	3.986	3.700	4.027	3.606
UPCARKN 1-5-1 = BK102	3.633	3.399	3.263	2.952	3.460	3.250	3.389	3.433	3.355	3.348
Kalanamak KN 3 (Check 2)	3.422	2.555	2.264	2.664	2.764	1.217	2.569	3.250	3.194	2.655

in the treatments where *Trichoderma* and *Pseudomonas* were used in combination (Table 2) either FYM or Bhumi Shakti or *Herbozyme* as basal. The treatments were significantly different from control as well as from *Trichoderma*, *Herbozyme*, FYM and Bhumi Shakti used singly. A clear case of “Synergistic effect” was observed. The reason will need further investigation but results are clear. No damage of insect-pests or diseases was noticed in the treated plots. Chau and Heong (2005) also reported such effects. Both *Pseudomonas* and *Trichoderma* have been reported to control fungal disease, collar rot, root rot (Latha *et al.*, 2011) and root knot nematodes. Control of blast disease of rice and increase in yield was reported by Lucas *et al.* (2009) by the use of *Pseudomonas*. Control of sheath blight of rice and leaf folder was reported by Radja Commare *et al.* (2002) by the use *Pseudomonas*. But in the present case synergistic effect observed may be more than due to control of disease and pests. Indications of plant growth promoting *Rhizobacteria* including *Pseudomonas* comes from the review of Singh *et al.* (2011), which can't be ruled out in current study. *Trichoderma* is known to produce and number of hormones under the complex soil environment. However, a clear case of “Synergistic effect” was observed in the combined treatment of *Trichoderma* and *Pseudomonas*, which increased the yield rather than decrease it. Combining these observations and of others (Surekha *et al.*, 2011; Yadav, 2011; Chaudhary *et al.*, 2013) a protocol was prepared for growing Kalanamak rice organically (Chaudhary *et al.*, 2014).

### Effect of variety and sowing date

It was concluded that there is some effect of date of sowing on the content of the grain aroma as reflected in 2AP content and also the 2AP divided by TMP (Fig. 1). There was significant reduction in plant height and other plant characters like tillering, panicle length, number of grains per panicle etc. Thus the total effect of the sowing date impacted the grain yield (Table 3). Our recommendation given to the farmers is to sow Kalanamak (Kalanamak KN 3 and Bauna Kalanamak) during the last week of June to the first week of July.

Table 3. Effect of date of sowing on Kalanamak KN 3 and Bauna Kalanamak 101

S. No.	Date of sowing	Date of initial flowering	Plant height (cm)	Gain yield (t ha <sup>-1</sup> )	Aroma content	
					2 AP	2AP/TMP x 100
<i>Kalanamak KN 3</i>						
1	15 May 2013	26.10.2013	158	6.963	49847.68	19.13
2	30 May 2013	25.10.2013	152	5.800	71429.00	27.26
3	15 June 2013	26.10.2013	147	4.750	64387.33	25.16
4	30 June 2013	26.10.2013	146	4.900	80153.00	33.84
5	15 July 2013	27.10.2013	138	5.055	73303.68	32.70
6	30 July 2013	27.10.2013	118	4.392	72088.33	28.96
<i>Bauna Kalanamak 101</i>						
1	15 May 2014	15.10.2014	98	8.777	27930.67	25.65
2	30 May 2014	15.10.2014	95	8.250	24722.33	25.95
3	15 June 2014	14.10.2014	92	9.167	25296.33	30.64
4	30 June 2014	16.10.2014	92	8.750	28855.33	41.29
5	15 July 2014	16.10.2014	85	6.500	30166.67	38.28
6	30 July 2014	17.10.2014	72	6.067	27272.33	33.69

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Acquired  : 27 Dec 2011 17:47 using AcqMethod PRDF.M
Instrument: Instrument #2
Sample Name: prdf-4
Misc Info :
Vial Number: 4
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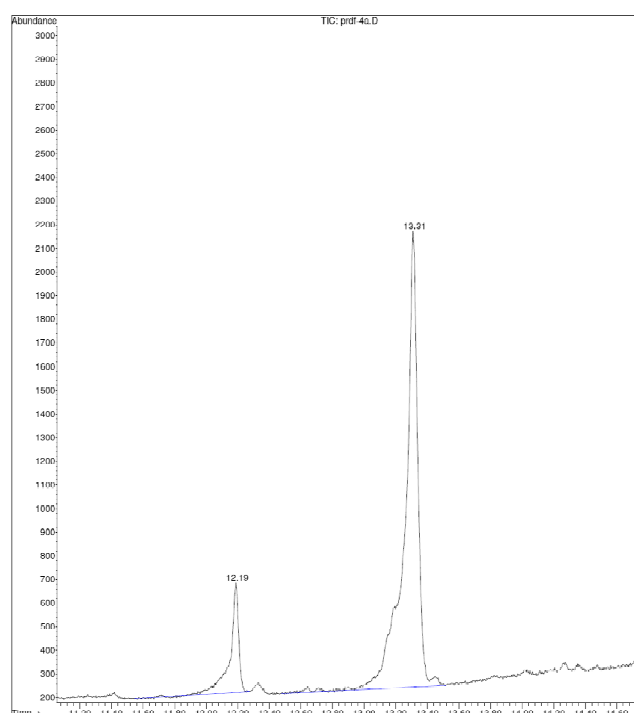


Fig. 1. A typical chromatogram (SIM) obtained for the breeding line KN 50-70-5-29-1

### Use and spread of Kalanamak cultivation

After the development of Kalanamak KN 3, Bauna Kalanamak and organic method of cultivation, farmers gave enthusiastic response. Its cultivation has expanded during *kharif* 2015 to 21000 hectares (Gorakhpur 2500 ha; Kishinagar 1500 ha; Mahrajganj 3000 ha; Siddharth Nagar 5000 ha; Sant Kabir Nagar 1500 ha; Basti 2500 ha; Deoria 500 ha and others 4500 ha). Thousands of farmers received an average yield of 4.5 t ha<sup>-1</sup> from Bauna Kalanamak and sold at ₹ 25000 t<sup>-1</sup> to get gross profit of ₹ 112500, unmatched by any rice variety. Thus what was destined for extinction has received distinction.

### INFERENCES

The heritage rice Kalanamak of eastern Uttar Pradesh was conserved, registered under PPV & FRA, GI obtained, pureline selection Kalanamak KN 3 released, and Bauna Kalanamak through hybridization was developed. Protocol for organic production was developed and popularised among several thousand farmers in the GI area. Exploiting synergistic effect of *Trichoderma* + *Pseudomonas* yield increase under organic system of production was proven. Organic certification under PGS system was done and now farmers and consumers are benefitting from it. With equal yields to any HYV and double the price, Bauna Kalanamak and its organic version Kalanamak is bringing prosperity to eastern U.P. PRDF has saved Kalanamak from extinction and brought to distinction and its old glory is back.

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