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BREEDING BAUNA KALANAMAK 102 AS NEW AROMATIC VARIETY OF HERITAGE RICE FROM UTTAR PRADESH

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Abstract: Kalanamak is a prestigious rice of Eastern U.P. Its first variety Kalanamak KN3 that is a tall variety was released and notified in 2010. Nevertheless, it lodges and is low yielding hence breeding for dwarf and high yielding Kalanamak was undertaken. Bauna Kalanamak 101 was developed as the first semi-dwarf variety of Kalanamak released and notified in 2016 but its husk colour is not black. Therefore, with a cross-made between Kalanamak KN3 and Improved Sambha Mahsuri, most promising pedigreed line UPCAR-KN-1-5-1-1 was developed. It was tested in extensively Uttar Pradesh (U.P.) and throughout the country during 2012 - 2015. Department of Agriculture of U.P. released it as Bauna Kalanamak 102 in 2016 and the Ministry of Agriculture and Farmers Welfare, Government of India notified it in 2017. Its grain quality is similar to its parent variety Kalanamak KN3 but has 50% higher yield. Other morpho- agronomic and grain quality characters are described in this article. It is rich in Iron and Zinc. It has excellent cooking quality and aroma and it fetches three to four times higher price than common rice.
Keywords: Kalanamak rice, Bauna Kalanamak, triple income, High iron, High Zinc.

Introduction

Kalanamak rice (Chaudhary, 2016: Chaudhary et al.) is an epitome of best aromatic rice cultivated and consumed in northeastern part of Uttar Pradesh (U. P.). It is a heritage rice variety, which has been under cultivation since time immemorial, as it finds links with Lord Buddha. 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), and deterioration in its quality, 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. However, nothing concrete was done to ameliorate the situation. Participatory Rural Development Foundation (PRDF), Gorakhpur,

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rose to the occasion to save Kalanamak from extinction and developed technologies to bring its old glory back.

Outshining Basmati, Kalanamak, a non-basmati and short-grained scented rice variety grown primarily in the *tarai* region of Uttar Pradesh, is so named because its husk is black. This variety has raised much hope amongst Indian farmers and rice-exporters due to traits superior even to the most preferred Basmati. Thus, it is looked for diversification of rice exported from India.

Historical Background

Cultivation of Kalanamak rice is recorded since the Buddhist period (900 BC). The grains were found from excavation of Kapilvastu (now Aligarhwa) now in district Siddharth Nagar, Uttar Pradesh, India). This site is located close to Nepal border. The site of 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 (blessed with pure knowledge) position, while passing through Bajaha jungle, he was stopped at Mathla (now Mudila) 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. The original belt of Kalanamak rice is still believed to be the tract between Bajaha and Aligarhwa. Kalanamak variety of rice, if sown elsewhere, loses its original aroma, shape and size of the grain and its quality, it is believed.

Research on Kalanamak at PRDF

Scattered attempts were made by other institutions on one or the other aspects of Kalanamak rice but systematic research started at Participatory Rural Development Foundation (PRDF), Gorakhpur (U. P.) since 1998. More than 174 accessions in bulk and 1,455 single panicles were collected from farmers' fields of eastern U. P. Besides collections from N. D. University of Agriculture and Technology (NDUAT), Faizabad; National Gene Bank of National Bureau of Plant Genetic Resources (NBPGR), New Delhi; Directorate of Rice Research (DRR) Hyderabad and Central Rice Research Institute (CRRI, now NRRI), Cuttack were also acquired for systematic evaluation. Kalanamak germplasm was assembled (Chaudhary et al.

2010) in order to get some superior types for varietal improvement. After due evaluation, purelines were developed from the 33.58% original aromatic lines. Observations were recorded on 37 descriptors namely seedling vigour, seedling height, leaf length, leaf width, leaf blade colour, basal leaf sheath colour, leaf blade pubescence, flag leaf angle, ligule colour, collar colour, auricle colour, ligule shape, awning, awn colour, apiculus colour, stigma colour, lemma and palea colour, lemma and palea pubescence, culm angle, stem borer, leaf folder, scent, grain quality.

Out of the 71 best Kalanamak accessions identified superior, the best pureline KN3-27-3-3 was found to be the most aromatic and desirable. On the proposal of PRDF in 2007, U. P. State Variety Release Committee released Kalanamak KN3 as a variety for cultivation (Chaudhary, 2016: Chaudhary et al.). The Central Sub-Committee on Crop Standards, Notification and Release of Varieties for Agricultural Crops of Government of India approved in its 75th meeting and gazetted on 31st August 2010 vide its notification No. SO.2137 (E). It spread far and wide as the first notified variety of Kalanamak. However, it was tall and low yielding.

Breeding of Bauna Kalanamak 102

Breeding of Bauna Kalanamak 102 started in a UPCAR funded project by making a cross between Kalanamak KN3 x Improved Sambha mahsuri. The segregating generations handled by Pedigree Method of breeding as UPCAR-KN-1-5-1-1. Taking advantage of growing two crops in one year, 2 generations were advanced at Gorakhpur and CRRI (now NRRI) Cuttack. It was tested as UPCAR-KN-1-5-1-1 at Regional Testing and Demonstration Station (RATDS) during 2012 until 2015 (Table 1). It was identified as superior in its class and identified for release in 2015 meeting of the Department of Agriculture. During 2014 -15, it was tested by All India Coordinated Rice Improvement Project (AICRIP) of ICAR extensively throughout the country. Results were very promising (Table 2).

Bauna Kalanamak 102 is a semi-dwarf, high yielding variety of heritage rice Kalanamak. Its morpho-agronomic characters are given in Table 3. This variety has strong stem and does not lodge even due to strong wind. It has large panicles and more number of grains than its parent varieties, which gives it higher yield. It matures 10 days earlier than Kalanamak KN3. In the tests conducted by the Department of Agriculture, U.P., at RATDS reported 40 percent increase in yield over its parent variety Kalanamak KN3 (Table 1). The replicated trials were repeated over a period of 3 years (2012–2015) and the same performance of Bauna Kalanamak 102 was observed. Bauna Kalanamak 102 is a strongly photoperiod sensitive

variety and thus its duration depends on the date of sowing (Table 4), as it flowers around 20th of October. However realizing the yield and cost of cultivation, the best sowing is during last week of June to first week of July. Bauna Kalanamak 102 is highly photoperiod sensitive rice and thus panicle initiation takes place only during the third week of September when days are shorter than 12 hours. It takes about 30 days from panicle initiation to panicle emergence. From panicle emergence to maturity, Kalanamak takes about 45 days, longer than normal rice varieties. The reason is that it matures during last week of November under the atmospheric conditions of low temperature, shorter days, higher humidity, dew formation during night and low evaporation. Thus the grain moisture, which could have dried from 30% to 15% faster, takes much longer. The other problem is the black husk colour, which stays the same in immature and mature grains. Thus, often time new farmers cannot judge the proper crop maturity, and commit mistake of harvesting Kalanamak before its full maturity. The result is green coloured rice after milling, softer rice grain and less aroma. Its package of practice have been perfected (Chaudhary et al. 2016).

Development, Release and Notification of Bauna Kalanamak 102

Regional Agricultural Technology Demonstration & Testing Station (RATDS) of Department of Agriculture conduct varietal trials annually on the new varieties to be considered for release. PRDF had proposed a number of semi-dwarf breeding lines of Kalanamak for testing. These breeding lines were tested at RATDS during the years 2012 to 2015 in state trial called “Paddy standard varietal trial: local aromatic, irrigated”. The average yield superiority of UPCAR-KN-1-5-1-1 was 46.41 over its check, which was Kalanamak KN3 (Table 1). Based on the superior performance of UPCAR-KN-1-5-1-1 was proposed to put up for release by the State Variety Release Committee in 2015. UPCAR-KN-1-5-1-1 was proposed by PRDF and U. P. State Variety Release Committee released it in 2016. They sent the proposal to Central Sub-Committee on Crop Standards, Notification and Release of Varieties for Agricultural Crops of Government of India. The committee approved its 75th meeting and notified it in its Gazette No. 3-51/2016-SD.IV dated 23rd December 2016 with the name “Bauna Kalanamak 102”. In its 76th meeting of Central Sub-Committee on Crop Standards, Notification and Release of Varieties for Agricultural Crops held on 31st January 2017, notified Bauna Kalanamak 102.

Pest and disease resistance

Bauna Kalanamak 102is resistant to most common diseases of rice. However, it is moderately susceptible to sheath blight, which can be controlled by spraying 0.2% solution of

Hexaconazole or Propiconazole with 500 litre water per ha. It can also be controlled by seed treatment with *Trichoderma* and also its spray (10g per litre of water) during panicle initiation stage. It is also susceptible, like other rice varieties, to sheath rot but can be controlled by spaying Trichoderma. Among pests, Bauna Kalanamak 102 is attacked by stem borer as much as other aromatic varieties but economic losses are negligible. In early planting, attack of stem borer is more. However, to control it, spray Cartop Hydrochloride 4G@20 kg/ha or use 8 Trichochord 3 times per 1 month after transplanting. But these treatments are more expensive than the actual crop yield lost. Gundhi bug sucks milk from its grains and can be controlled by using Carbaryl or Malathion as dust or spray.

Grain quality

Bauna Kalanamak 102 has short grain and classed as Medium Slender variety. It has high head rice recovery. It cooks soft and has excellent elongation upon cooking (Tables 6). In all India testing under AICRP, coordinated by Indian Institute of Rice Research, Hyderabad it was found to have all favourable grain quality characters (Tables 6, 7 and 8). Bauna Kalanamak 102 has the highest level of Iron and Zinc combined. Due to this reason, it was the only variety from north India that was included in the Nutri-Farm Project of the Ministry of Agriculture, Government of India. Government of U. P. has included Kalanamak in the Nutri-Farm project since. Bauna Kalanamak 102 has excellent aroma as can be seen in Fig. 1 and Tables 3 and 8. Bauna Kalanamak 102 has the same level of Iron and Zinc as its original parent Kalanamak KN 3, thus included in the Nutri-Farm scheme, and can be included in any other biofortification schemes.

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 (Table). However, 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. Our recommendation given to the farmers is to sow Kalanamak rice during the last week of June to the first week of July. Farmers have liked it and it was already cultivated in more than 21,000 ha during Kharif 2015-16. The grain quality characters of Bauna Kalanamak 102 are exactly the same as of tall Kalanamak KN3.

Conclusion

Out of a cross between Kalanamak KN3 and Improved Sambha Mahsuri, a pedigree line UPCAR-KN-1-5-1-1 was identified as promising. It was tested in multi location trials in India and more intensively in U.P. during the years 2012 – 2015. It's morpho-agronomic and

grain quality characters were characterised. The aroma quantified was found similar to Kalanamak KN3. This pedigree line was released in 2015 by Department of Agriculture of U. P., and notified by the Ministry of Agriculture, Government of India in 2016 as Bauna Kalanamak 102. It is photoperiod sensitive variety that flowers in mid October and yields 50% higher than Kalanamak KN3. Besides, it has higher amount of Iron and Zinc making it nutritionally rich. Therefore, it was included in the NutriFarm Project of the Government of India. Belonging to heritage Kalanamak group it fetches 3 to 4 times higher price and thus Kalanamak farmers can triple their income by growing it.

Acknowledgement

Thanks due to All India Coordinated Rice Improvement Project (AICRIP) of ICAR for testing Bauna Kalanamak 102 at 15 locations all over India and providing the results of yield etc. Thanks are also due to Indian Institute of Chemical Technology (IICT) Hyderabad testing the aroma of Bauna Kalanamak 102 and providing the results (Table 8 and Gig. 1). Last but not least, thanks to U.P. Council of Agricultural Research (UPCAR) for funding the development of germplasm from which breeding line UPCAR-KN-1-5-1-1 was developed.

Table 1. Yield (kg/ha) of Bauna Kalanamak 102 compared to check varieties in State Trials conducted at RATDS Azamgarh, Barabanki, and Varanasi during Kharif 2012 – 15 by the Dept. of Agriculture, U. P.

Test entry	Azamgarh	Barabanki	Varanasi	Mean of 3 centres over 3 years	Increase % over	
	2012 – 13	2013 – 14	2014 – 15		KN3	Lalmati
Bauna Kalanamak 101	3496	3696	3496	3643.8	46.41%	31.37%
Kalanamak KN3 (Check)	-	3197	2264	2488.8	-	-
Lalmati (Check)	2331	2764	2331	2756.9	-	-

Table 2. Yield (kg / ha) of Bauna Kalanamak 102 compared to Bauna Kalanamak 101 and Kalanamak KN 3 across India during Kharif 2014-15 (Courtesy: ICAR-IIRR Report 2014, Vol. 1; 1.570 – 1.580)

Location	Bauna Kalanamak 101	Bauna Kalanamak 102	Kalanamak KN3	CD at 5%	CV %
J & K Chatha	2150	2300	1000	760	14.08
NRRI Cuttack	5493	5085	4388	1053	9.96
WB Hathwara	3480	2250	3580	442	7.16
NDUAT Masodha	6084	3759	2540	355	4.82
Jabalpur	5539	3265	2766	15	0.15
Karjat	2995	3913	2705	1112	13.83
Sakoli	2992	2227	3025	452	6.76
Shirgaon	3114	3698	4484	812	9.18

Nawagam	2013	2254	2013	783	10.29
Navsari	3379	3229	1419	645	9.60
Mean	**3723**	**3198**	**2792**	**258**	**12.49**

Table 3. Morpho-agronomic and grain characters of Bauna Kalanamak 102 (courtesy: DRR, CRRI, PRDF)

Morpho-agronomic traits	**Description**	**Grain Traits**	**Description**
Basal leaf sheath colour	Green	Kernel length	5.76 mm
Tillering ability	Medium (20 tiller/hill)	Kernel width	2.18 mm
Days to 50% flowering	110 days (Photosensitive)	L/B Ratio	2.64 mm
Days to maturity	135 days (Photosensitive)	Grain type	Medium Slender
Culm angle	Slightly Open (45^0)	Kernel colour	White
Leaf length	59 cm	1,000 grain weight	15 grams
Leaf width	1.4 cm	Hulling	80 %
Panicle length	31 cm	Milling	75 %
No. of grains / panicle	400	Head rice	70 %
Plant height	95 cm	Alkali value	6 - 7
Aroma in plant	Highly scented	Volume Expansion	4.5 times
Apiculus colour	Brown (tawny)	Gel consistency	80 mm
Awning	Absent	Amylose content	20 %
Lemma, Palea colour	White – Green – P Black	Aroma in grain	Strong
Stigma colour	White	Taste	Soft aromatic
Stem strength	Very strong (non-lodging)	Yield	50 q/ha

Table 4. Reaction of Bauna Kalanamak 102 to major pests and diseases (PRDF Kharif 2013, Kharif 2014)

S.N.	**Diseases**	**Reaction**	**S.N.**	**Pests**	**Reaction**
1	Bacterial blight	Mod. Resistant	1	Stem borer	Mod. Susceptible
2	Blast	Mod. Resistant	2	Brown Plant Hopper	Mod. Resistant
3	Sheath blight	Mod. Susceptible	3	Green Leaf Hopper	Mod. Resistant
4	Sheath rot	Mod. Susceptible	4	Gundhi bug	Susceptible
5	Tungro	Resistant	5	Leaf folder	Mod. Resistant
6	Bacterial Leaf Streak	Resistant	6	Caseworm	Mod. Resistant
7	Brown spot	Resistant	7	Root weevil	Resistant

Table 5. Response of Bauna Kalanamak 102 to different levels of nitrogen, Kharif 2014

S.N.	Treatment	Fertilizer dose	Yield (kg /ha)
1	No	Native fertility	21.11
2	N1	60:60:60	30.28
3	N2	120:60:60	47.00
4	N3	180:60:60	47.29
			CV = 9.87 5
			CD = 25 kg

Table 6. Grain quality characters as analysed from the samples collected from the trial at IIRR Hyderabad, Kharif 2014 -15

Paramaeter	**Bauna Kalanamak 101**	**Bauna Kalanamak 102**	**Kalanamak KN 3**	**Sambha Mahsuri**
Hulling %	78.9	80.5	80.1	78.5
Milling %	68.5	68.1	70.5	69.9
Head rice %	63.2	63.5	63.1	68.2
Kernel Length (mm)	5.06	5.00	5.55	5.20
Kernel Breadth (mm)	1.98	1.92	2.06	1.85
Length / Breadth ratio	2.55	2.60	2.69	2.81
Grain type	Medium Slender	Medium Slender	Medium Slender	Medium Slender
Chalkiness	Absent	Occasional	Absent	Absent
Volume Expansion Ratio	4.8	5.5	4.7	4.6
Water Uptake	250	255	150	195
Kernel length after cooking	9.6	9.4	10.8	10.2
Elongation Ratio	1.89	1.88	1.94	1.96
Alkali Spreading Value	4.0	4.0	5.0	4.0
Amylose	18.86	18.83	23.17	24.05
Gel Consistency	45	64	68	54

Table 7. Iron (Fe) and Zinc (Zn) content of Bauna Kalanamak 102 as compared to Bauna Kalanamak 101 and KN3 tested at 15 locations (Data of AICRP coordinated by IIRR Hyderabad during 2014 – 2015

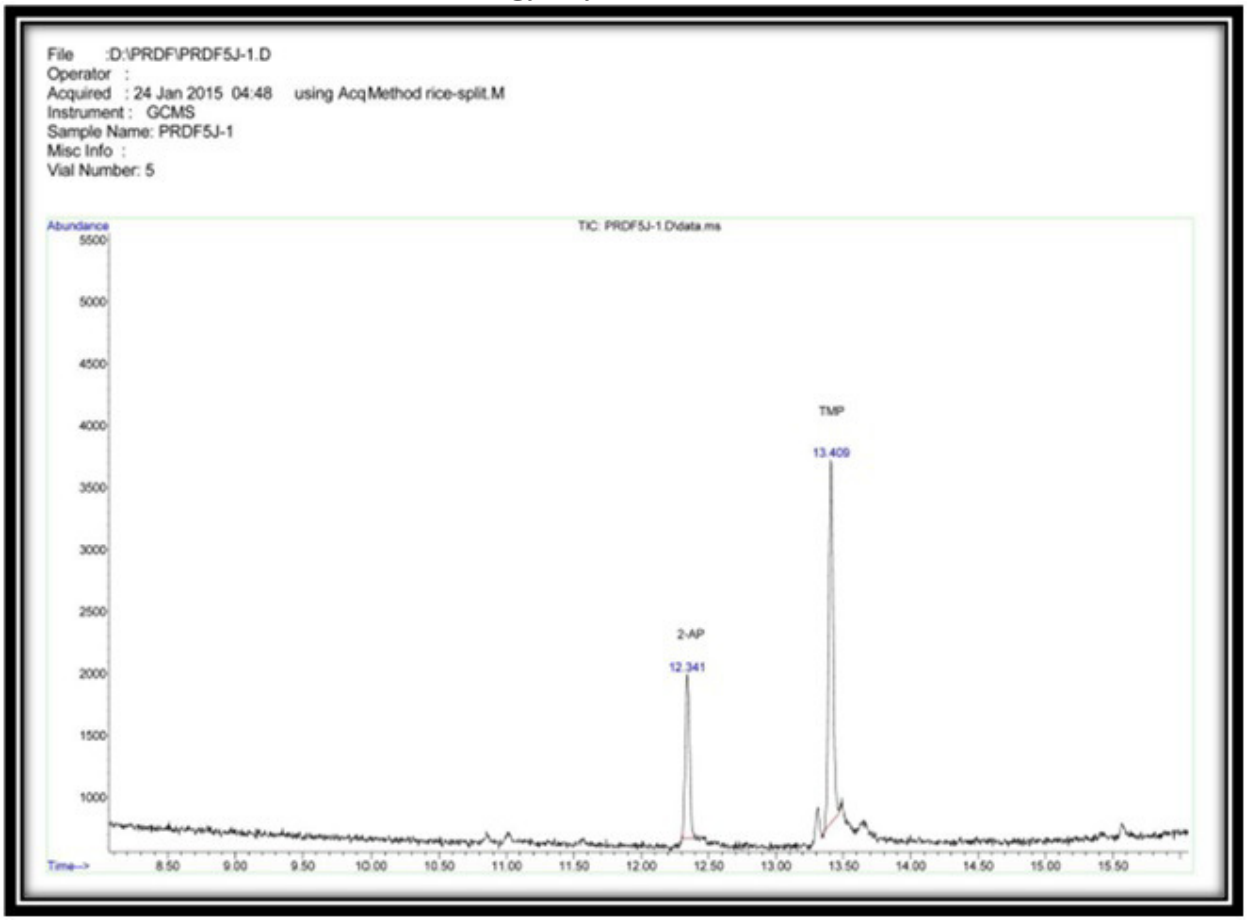
Location		**Iron (Fe) ppm**			**Zinc (Zn) ppm**	
	Bauna Kalanamak 101	**Bauna Kalanamak 102**	**Kalanamak KN 3**	**Bauna Kalanamak 101**	**Bauna Kalanamak 102**	**Kalanamak KN 3**
Ludhiana	4.6	4.4	4.95	18.90	20.75	22.05
J & K Chatha	3.95	4.05	3.0	10.90	19.05	16.00
NRRI Cuttack	3.75	4.45	2.85	17.95	17.80	17.60

WB Hathwara	3.3	2.65	4.7	7.30	10.55	13.00
Purulia	5.6	8.85	3.9	15.95	18.35	13.09
Raipur	3.85	4.05	3.3	12.10	13.80	16.00
Sirsi	4.45	5.8	4.55	15.80	15.00	18.50
Coimbatore	3.45	5.2	2.8	10.00	12.25	11.65
Shirgaon	4.7	6.1	4.2	19.60	15.00	20.40
Jabalpur	4.8	5.8	4.25	9.65	10.85	12.20
Sakoli	2.65	5.25	3.25	11.70	15.35	14.15
Navsari	3.75	5.2	5.2	14.35	12.90	21.35
IIRR Hyderabad	7.8	5.6	3.2	18.75	19.45	17.60
Pattambi	5.7	5.5	4.2	21.60	22.00	25.40
Mandya	2.95	4.05	2.95	14.70	16.40	15.70
Mean	**4.35±0.98**	**5.13±1.22**	**3.82±1.14**	**14.61±**3.82	**16.84±4.12**	**16.97±4.13**

Table 8. Quantification of Aroma of Bauna Kalanamak 102 and its parent variety Kalanamak KN3 (IICT Hyderabad)

Sample name	**Peak area of ion for 2-AP**	**Peak area of ion for TMP**	**2-AP/TMPx100**
PRDF-5D **(Bauna Kalanamak 102)**	28855.33	70625.33	41.29
PRDF-15 **(Kalanamak KN3)**	42736.33	81252.00	53.74

Fig. 1 Aroma anlysis of Bauna Kalananam 102 done at National Centre for Mass Spectrometry
Indian Institue of Chemical Technology, Hyderabad-500007



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