पारंपरिक चावल किस्म में सुधार

19

विकिरण प्रेरित उत्परिवर्तन प्रजनन के माध्यम से पारंपरिक चावल किस्म में सुधार और पुनरुज्जीवन

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मूल विष्णुभोग के साथ ट्रॉम्बे छत्तीसगढ़ विष्णुभोग उत्परिवर्ती (टी. सी. वी. एम.) का तुलनात्मक क्षेत्र दृश्य।

सारांश

परंपरागत चावल की प्रजातियों में कई अमूल्य विशेषताएं हैं जिनका उपयोग उपजाऊ, जलवायु के अनुकूल और पोषण से भरपूर व्यावसायिक किस्में विकसित करने के लिए किया जा सकता है। हालांकि, पौधे के लंबे आकार, परिपक्वता की लंबी अवधि, पौधों में झुकाव की संभावना, दाने का बिखड़ना और उपज क्षमता में कमी के कारण ये बहुत कम क्षेत्रफल पर लगाए जाते हैं तथा विलुप्ति के कगार पर हैं। इन भू-अनुकूल प्रजातियों के अद्वितीय गुणधर्म में परिवर्तन किए बिना एक या दो प्रमुख अवांछनीय विशेषताओं को सुधारने के लिए उत्परिवर्तन प्रजनन एक सरल, लागत प्रभावी और कुशल विधि है। भाभा परमाणु अनुसंधान केंद्र, मुंबई और आईजीकेवी, रायपुर ने विकिरण प्रेरित उत्परिवर्तन प्रजनन के माध्यम से इन भू-अनुकूल प्रजातियों के सुधार और पुनरुज्जीवन के लिए सहयोगात्मक अनुसंधान एवं विकास कार्य किया है। १० वर्षों के निरंतर अनुसंधान एवं विकास कार्य में, सुधार के लिए ~१०० चावल की भू-अनुकूल प्रजातियों का अध्ययन किया गया जिसमें से कई उच्च उपज देने वाली एवं आशाजनक उत्परिवर्ती विकसित की गई हैं। अब तक चावल की पाँच उत्परिवर्ती किस्मों (यथाः टीसीडीएम-१, विक्रम-टीसीआर, सीजी जवाफूल ट्रांबे, टीसीवीएम और टीसीएसएम) को जारी किया गया है तथा भारत सरकार द्वारा राजपत्र के माध्यम से वाणिज्यिक कृषि हेतु अधिसूचित किया गया है। अनेक उच्च उपज देने वाली एवं आशाजनक उत्परिवर्ती अन्वेषणाधीन हैं तथा राज्य और राष्ट्रीय स्तर के अनेक परीक्षण स्थलों पर उनका मूल्यांकन किया जा रहा है। व्यापक प्रसार के लिए बड़े पैमाने पर बीज उत्पादन कार्यक्रम शुरू किए गए हैं। सर्वविदित है कि यह भारत में चलाया जा रहा विश्व का सबसे बड़ा व्यापक चावल उत्परिवर्तन प्रजनन कार्यक्रम है। उच्च उपज क्षमता वाली उन्नत उत्परिवर्ती चावल भू-अनुकूल प्रजातियाँ/किस्में सीमांत और पारंपरिक किसानों के बीच व्यापक स्वीकार्यता प्राप्त कर रही हैं जिसके परिणामस्वरूप सामाजिक-आर्थिक परिस्थितियों में सुधार तथा कुपोषण और भूख के स्थायी समाधान के साथ पारंपरिक ज्ञान परंपरा को बचाना संभव होगा।

Improvement of Traditional Rice Landraces

19

Improvement and Revival of Traditional Rice Landraces through Radiation Induced Mutation Breeding

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Comparative field view of Trombay Chhattisgarh Vishnubhog Mutant (TCVM) along with parent Vishnubhog

ABSTRACT

Traditional rice landraces have several invaluable traits which could be utilized to develop high yielding, climate resilient and nutritionally enriched commercial varieties. However, due to tall plant stature, late maturity duration, susceptible to lodging, grain shattering habit, and low yield potential, these have been marginalised and are at the verge of extinction. Mutation breeding offers simple, cost effective and efficient way to improve one or two major undesirable traits without altering the unique characters of these landraces. BARC, Mumbai and IGKV, Raipur, have undertaken collaborative R&D work for improvement and revival of these landraces through radiation induced mutation breeding. Over 10 years of continuous R&D work, ~100 rice landraces have been undertaken for improvement and many promising mutants have been developed. So far 5 rice mutant varieties (*viz*. TCDM-1, Vikram-TCR, CG Jawaphool Trombay, TCVM and TCSM) have been released and gazette notified by Government of India for commercial cultivation. Many high yielding and promising mutants are in pipe line and being evaluated at state and national level multi-location trials. Large scale seed production programme for wide dissemination have been undertaken. Ostensibly, this is one of the world's largest comprehensive rice mutation breeding programme being carried out in India. Improved mutant rice landraces/ varieties with high yielding potential are getting wider acceptability among the marginal and conventional farmers and will result in better socio-economic conditions and bring back the traditional wisdom of combating malnutrition and hunger on sustainable basis.

KEYWORDS: *Rice landraces, Radiation induced mutation breeding, Mutant rice varieties, Farmers' varieties, and Food security*

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Introduction

Rice is the most important food crop of the developing world and the staple food of more than half of the world's population. In developing countries alone, more than 3.3 billion people depend on rice for more than 20% of their calories. However, to maintain future global rice supplies many challenges must be addressed, which primarily include high nutrient content, better grain quality, tolerance to different stresses and improved yield. The rice landraces or farmers' varieties are a rich source of several valuable and useful genes viz. resistance to biotic and abiotic stresses (drought, salinity, toxic heavy metals, herbicides), rich in essential micronutrients, premium grain-quality attributes (viz. aroma) and health benefits (medicinal properties). It is a fact that traditional landraces/farmers' varieties (with aroma and unique grain-quality attributes) have great export potential, fetching premium price (Rs. 100-150 per kg). These landraces are being marginalized due to their tall stature, which makes them prone to lodging, late maturity that results in more inputs and time management in field operations, photoperiod sensitivity, grain shattering habit, open plant canopy, non-synchronous maturity in grains of the same panicles, and ultimately poor yield potential. Hence, these are not preferred by the farmers for commercial cultivations (Fig.1). Moreover, due to introduction of high-yielding varieties and hybrids, area of cultivation of these landraces has been significantly reduced. It is a matter of concern that many of these landraces are at the verge of extinction from the farmers' field resulting severe loss of rich rice biodiversity. Such problems need to be addressed carefully in a sustainable manner.

Rectification of undesirable traits by altering few major genes may bring these landraces back into cultivation. This will help to improve the yield potential of these varieties without compromising the premium grain attributes. Conventional plant breeding methods have not been very successful in improving these landraces due to genome-wide recombination and alteration in their premium grain quality traits. However, mutation breeding has been used as a potential tool for rectifying a few defects such as tall stature, late maturity etc. while keeping the original unique quality of the landraces intact/ unaltered and bringing them back into channel of commercial cultivation (Fig.1). High yielding and improved rice landraces will result in wider acceptability among the marginal and conventional farmers, resulting better socio-economic conditions and help to bring back the traditional wisdom of combating malnutrition and hunger on sustainable basis. This will also ascertain national food and nutritional security and gain foreign exchange in the country through worldwide export.

Advantages of Mutation Breeding

Plant mutation breeding accelerates crop improvement through creation of genetic mutations leading to genetic diversity that facilitates selection from a large mutant population. It is a powerful technique to improve one or two major defects in rice landraces by maintaining their original qualities and unique features. It doesn't make huge changes in the genome of plant. It enhances the variability by making minor, random and reversible changes in the genome which allows plant breeders to make efficient selection in the segregating mutant populations. Till date, ~ 3406 mutant varieties in more than 228 crop species have been developed through induced mutagenesis by different countries and registered in the FAO/IAEA Mutant Variety Database (MVD), International Atomic Energy Agency, Vienna, Austria database (FAO/IAEA MVD, 2023, https://nucleus.iaea.org/sites/mvd/SitePages/Search.aspx) which has made significant impact in assuring global food and nutritional security. Moreover, the developed mutant varieties enhance the crop biodiversity and offers useful breeding material for further crop improvement.

BARC-IGKV Collaboration for Improvement & Revival of Traditional Rice Landraces through Radiation Induced Mutation Breeding

Chhattisgarh state of India is endowed with more than 23,250 traditional rice landraces which have several valuable and useful genes for yield and attributing traits, resistance against biotic and abiotic stresses, resistant to herbicides, nutritional properties, medicinal properties, carrying low heavy metal accumulation, micronutrient enrichments, premium quality attributes (viz. aroma) and agronomic suitability etc. These landraces were collected by Dr. R.H. Richharia, a renowned rice breeder in the World during 1970 to 1985 from Chhattisgarh (then Madhya Pradesh) and nearby districts. All these traditional varieties are huge treasures which have unique qualities which are not present in high yielding and hybrid varieties. Mutation breeding is the only option to improve and revive these traditional varieties. Currently, these landraces are being conserved and maintained by Indira Gandhi Krishi Vishwavidyalaya (IGKV), Raipur (C.G.) accounting the largest collection in India and second largest collection in the world after International Rice Research Institute, Manila, Philippines. However, these landraces are not under the

Fig.1: Problems associated with rice landraces and improvement through mutation breeding.

Table 1: Current Status of Rice Landraces Improvement Program under BARC-IGKV joint collaboration.

Sr. No	Mutant Population/ Generation	Number of Mutants/ Entries
1	No. of landraces undertaken for improvement till date	100
2	Rice Mutants Released and Notified by Govt. of India	5
3	Rice mutant identified by UVIC for release	1
4	National AICRIP (MLT) Trials (2023)	5 in the background of 4 landraces
5	National AICRIP (MLT) Trials (2022)	6 in the background of 5 rice landraces
6	State Multi-Location Trials (2023)	8 in the background of 7 landraces
7	State Multi-Location Trials (2022)	8 in the background of 7 rice landraces
8	Station Trials (2023) of Stable Mutants (M8 & above)	33 mutants in the background of 30rice landraces
9	Special type mutants (*Kharif* 2023)	24 in the background of 12 landraces
10	Other agronomic superior mutants (*Kharif* 2023)	49 in the background of 21 landraces
11	Hybridization b/w Mutants & Parents for developing mapping populations & molecular studies	>50 crosses
12	M1 population (*Kharif* 2022)	13 M1 population in the background of 9 landraces
13	M2 Population (*Kharif* 2022)	33 M2 population in the background of 29 rice landraces
14	M3 Population (*Kharif* 2023)	116 lines in the background of 14 landraces
15	M4 population (*Kharif* 2023)	1 mutant line in the background of 1 landrace
16	M5 population (*Kharif* 2023)	108 mutant lines in the background of 24 landraces
17	M6 population (*Kharif* 2023)	56 mutant lines in the background of 3 landraces
18	M7 population (*Kharif* 2023)	63 mutant lines in the background of 13 landraces

cultivation in farmers' field due to their poor yield potential, late maturity duration and tall plant stature. Therefore, these are almost at the verge of extinction from the farmers' field. To utilize these available genetic resources of rice for the societal benefits, IGKV, Raipur and BARC, Mumbai, have undertaken collaborative R&D work for improvement and revival of traditional rice landraces through radiation induced mutation breeding since 2013.

Current Status and Achievements under BARC-IGKV Collaboration

Our collaborative R&D work initially focused on evaluating and characterizing ~300 popular and traditional rice landraces with unique properties, which could be suitable candidates for improvement through radiation-induced mutation breeding. After 10 years of continuous and systematic breeding efforts, ~100 rice landraces have been undertaken for improvement using radiation-induced mutation breeding. These mutants, which may have agronomic or academic significance, are at different developmental stages and are maintained in a huge rice mutant repository (Table 1). More than 80 advanced agronomically superior mutant lines in the background of 50 landraces have already been stabilized and are in final stages of station trials. 24 unique mutant lines such as extremely dwarf, high tillering, male sterile, red kernel, disease resistant mutants have been developed, which can be used as potential donor for future rice breeding programs. In view of quantum of rice mutation breeding work being carried out by BARC and IGKV, this collaborative effort is envisaged as the world's largest comprehensive radiation-induced mutation

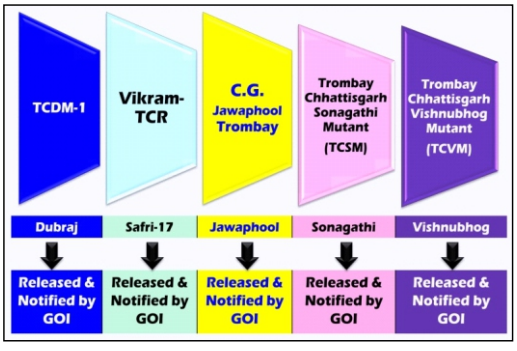


Fig.2(a): Rice mutants released under BARC-IGKV collaboration.

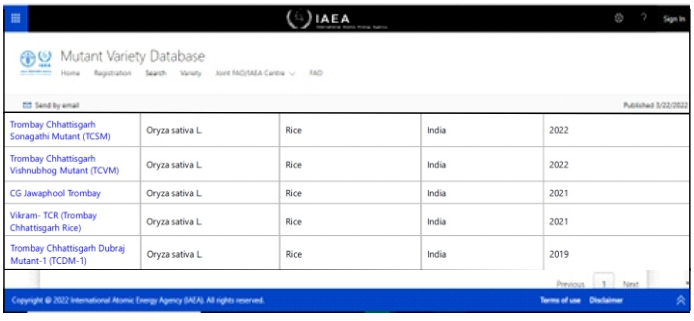


Fig.2(b): Mutant Rice Varieites (released under BARC-IGKV collaboration) at FAO/ IAEA Mutant Variety Database (https://nucleus.iaea.org/sites/mvd/SitePages/Search.aspx)

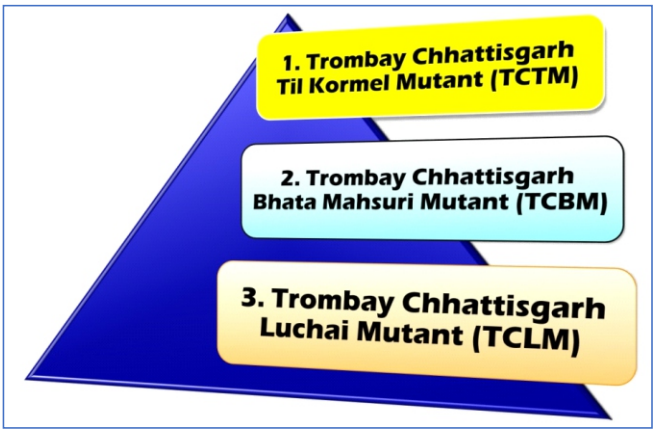


Fig.3: Rice mutants in pipeline of release under BARC-IGKV collaboration.

breeding program for improvement and revival of traditional rice varieties/landraces. It is worth to note that under this joint collaborative effort, five rice mutant varieties viz.(1)Trombay Chhattisgarh Dubraj Mutant-1 (TCDM-1), (2) Vikram-Trombay Chhattisgarh Rice (Vikram-TCR), (3) CG Jawaphool Trombay (CGJT), (4)Trombay Chhattisgarh Vishnubhog Mutant (TCVM) and (5) Trombay Chhattisgarh Sonagathi Mutant (TCSM) All these have been released and notified for commercial cultivation by Government of India (Fig.2(a)). All the 5 rice mutant varieites have been registered under the FAO/ IAEA Mutant Variety Database (https://nucleus.iaea.org/sites/mvd/SitePages/Search.aspx) (Fig.2(b)). In addition, three mutant lines *viz.,* Trombay Chhattisgarh Til Kormel Mutant (TCTM), Bauna Luchai-CTLM (Chhattisgarh Trombay Luchai Mutant) and Trombay Chhattisgarh Bhata Mahsuri Mutant (TCBM) have been developed. These lines are being evaluated in state and national multi-location trials and are in pipeline for identification and release (Fig.3).

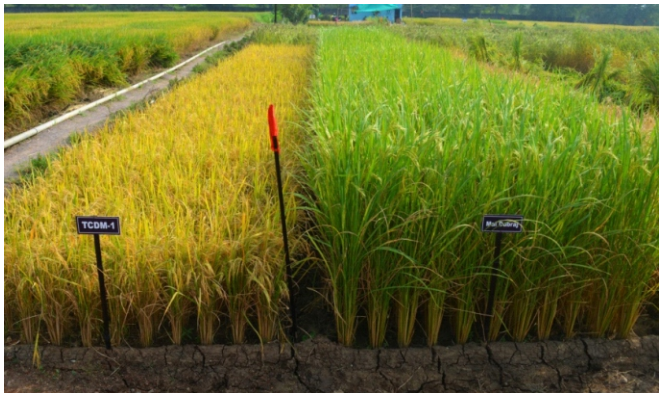


Fig.4: Comparative field view of TCDM-1 along with parent Mai Dubraj.

Brief Description of the Released and Notified Mutant Rice Varieties

TCDM-1

It is the first successful dwarf and high yielding mutant derived from the rice landrace Mai Dubraj parent (Mai Dubraj is very popular rice landraces of Chhattisgarh state and famous as 'Basmati of Chhattisgarh'). It has fine aromatic grains. TCDM-1 has -39.74% reduced plant height and -15.71% reduced maturity duration as compared to Mai Dubraj whereas it has 53.13% higher yield potential over the parent (Table 2; Fig. 4). The average yield of TCDM-1is 45 q/ha whereas its potential yield is about 55 q/ha. Most of the farmers prefer to grow the mutant variety TCDM-1 developed from Mai Dubraj. This variety was notified by Govt. of India [vide S.O. 1498(E), Gazette of India No. 1326, dated 02 April 2019 for commercial cultivation].

Vikram-TCR

It was developed from Safri-17, a traditional rice variety from central Chhattisgarh, India. Safri-17 is very popular for

Table 2: Percentage change in flowering duration, plant height and grain yield of released rice mutant varieties over the original parent landraces.

Sr. No.	Name of Genotypes	Days to 50% Flowering (days)	Percentage reduction in Days to 50% Flowering (%)over corresponding parent	Plant Height (cm)	Percetage reduction in plant height (%) over corresponding parent	Grain Yield (kg/ha)	Percetage increase in Yield over Parent (%)over corresponding parent
1.	Mai Dubraj(Parent)	121		171.11		3236.11	
2.	TCDM-1	102	-15.70	103.11	-39.74	4955.56	53.13
3.	Safri-17(Parent)	110		195.11		3594.44	
4.	Vikram TCR	84	-23.63	109.67	-43.79	5555.56	54.56
5.	Jawaphool (Parent)	123		154.11		3058.33	
6.	C. G. Jawaphool Trombay	114	-7.31	125.89	-18.31	4080.78	33.43
7.	Sonagathi (Parent)	118		121.56		4327.78	
8.	TCSM	107	-9.32	117.22	-3.57	6305.56	45.70
9.	Vishnubhog (Parent)	115		152.56		2783.22	
10.	TCVM	94	-18.26	114.44	-24.98	4312.44	54.94

Fig.5: Comparative field view of Vikram-TCR (R) along with parent Safri-17(L).

Fig.6: Comparative field view of CG Jawaphool Trombay (L) along with parent Jawaphool (R).

long slender grains, drought tolerance ability and good puffed rice making quality. Vikram-TCR has all these traits along with dwarf stature, early maturity habit and high yield potential. It has 54.56% higher yield, -43.79% reduced plant height and -23.64% reduced maturity duration over the corresponding parent, Safri-17 (Table 2; Fig.5). Vikram-TCR name was given in the honor of Professor Vikram Sarabhai (former Chairman, Atomic Energy Commission, Government of India) to commemorate his birth centenary year 2019-2020. This variety was notified for commercial cultivation [vide S.O. 500(E), Gazette of India No. 456, dated on 02-February-2021]. The average yield of Vikram-TCR is 60-65 q/ ha whereas its yield potential is up to75q/ha with drought tolerance and excellent puffed rice (murmura) making quality. This variety has been widely cultivated by the farmers in Chhattisgarh and adjoining states.

CG Jawaphool Trombay (CGJT)

It has aromatic short slender grains with semi-dwarf stature and mid late maturity duration. It has very good grain quality and *Kheer* making quality. It has 33.43% higher yield potential, -18.35% reduced plant height and -7.31% reduced maturity duration over the corresponding parent, Jawaphool (Table 2; Fig.6), a very popular aromatic short grain variety in Chhattisgarh. CG Jawaphool Trombay has yield potential of 40-45 q/ ha; and has been notified for commercial cultivation [vide S.O. 500 (E), Gazette of India No. 456, dated 02-February-2021].

Trombay Chhattisgarh Vishnubhog Mutant (TCVM)

This is the improved mutant variety of a popular traditional rice variety Vishnubhog of Chhattisgarh. It has aromatic short grains (similar to Vishnubhog), semi-dwarf stature (110-115 cm), and medium maturity duration (120-125 days). Plant height and maturity duration of TCVM has been reduced by -24.98% and -18.26%, respectively. Grain yield potential (40-45 q/ha) of TCVM has been increased by ~54.94% as compare to parent (27-30 q/ha) which made this variety more preferable (Table 2; Fig.7). It has high head rice recovery (61%) and intermediate amylose (25%) content which indicated the excellent grain quality of the mutants. Furthermore, it becomes very soft after cooking indicating its good cooking quality. This variety is suitable as steam rice as well as for *Kheer* making purpose. This has been notified for commercial cultivation [vide S.O. 8(E), Gazette of India No. 8, dated 03-January-2022].

Fig.7: Comparative field view of Trombay Chhattisgarh Vishnubhog Mutant (TCVM) along with parent Vishnubhog.

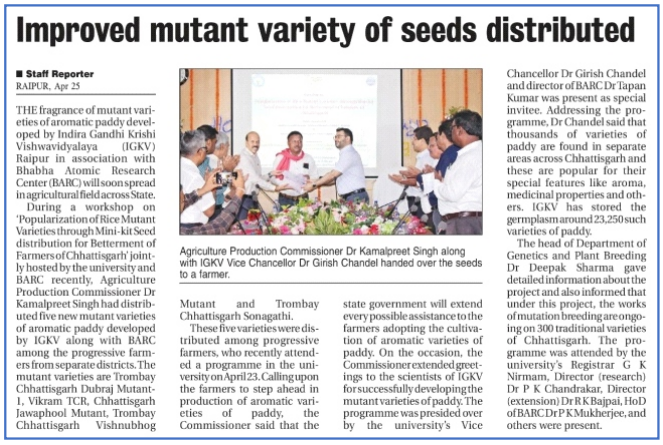
Trombay Chhattisgarh Sonagathi Mutant (TCSM)

This is an improved mutant variety of a popular traditional rice variety Sonagathi of Chhattisgarh. This mutant has very high yield potential (60-65 q/ha) which is comparable to yield potential of a hybrid rice variety. It has semi-dwarf plant stature (110-115 cm) and late maturity duration (135-140 days). Its maturity duration has been reduced by -9.32% (10-15 days) days and grain yield has been increased by 45.70% over the parental Sonagathi (Table 2; Fig. 8). TCSM plant type is similar to most popular rice variety Swarna and has potential to replace it. It is resistant to lodging and shattering and has dark green and erect leaves and good culm strength. Grain type is medium bold having dark straw-colored hull and brown spots on husk. Moreover, it has high head rice recovery (56 %) and intermediate amylose (22 %) content which indicated the excellent grain quality of the mutants. This has been notified for commercial cultivation [vide S.O.8(E), Gazette of India No. 8, dated 03-January-2022].

Large-scale Seed Production & Popularization of Mutant Rice Varieties among the Farmers

In addition to the development of rice mutants, both the institutions are also working for wider dissemination through demonstration of released rice mutant varieties at farmers' field. During *Kharif* season 2022, mini kit seeds of TCDM-1, Vikram-TCR, CG Jawaphool Trombay, Trombay Chhattisgarh Vishnubhog Mutant (TCVM) and Trombay Chhattisgarh

Fig.8: Comparative field view of Trombay Chhattisgarh Sonagathi Mutant (TCSM) along with parent Sonagathi.



Improved mutant variety of seeds distributed

■ Staff Reporter
RAIPUR, Apr 25

THE fragrance of mutant varieties of aromatic paddy developed by Indira Gandhi Krishi Vishwavidyalaya (IGKV) Raipur in association with Bhabha Atomic Research Center (BARC) will soon spread in agricultural field across State.

During a workshop on 'Popularization of Rice Mutant Varieties through Mini-kit Seed distribution for Betterment of Farmers of Chhattisgarh' jointly hosted by the university and BARC recently, Agriculture Production Commissioner Dr Kamalpreet Singh had distributed five new mutant varieties of aromatic paddy developed by IGKV along with BARC among the progressive farmers from separate districts. The mutant varieties are Trombay Chhattisgarh Dubraj Mutant-1, Vikram TCR, Chhattisgarh Jawaphool Mutant, Trombay Chhattisgarh Vishnubhog Mutant and Trombay Chhattisgarh Sonagathi.

These five varieties were distributed among progressive farmers, who recently attended a programme in the university on April 23. Calling upon the farmers to step ahead in production of aromatic varieties of paddy, the Commissioner said that the state government will extend every possible assistance to the farmers adopting the cultivation of aromatic varieties of paddy. On the occasion, the Commissioner extended greetings to the scientists of IGKV for successfully developing the mutant varieties of paddy. The programme was presided over by the university's Vice Chancellor Dr Girish Chandel and director of BARC Dr Tapan Kumar was present as special invitee. Addressing the programme, Dr Chandel said that thousands of varieties of paddy are found in separate areas across Chhattisgarh and these are popular for their special features like aroma, medicinal properties and others. IGKV has stored the germplasm around 23,250 such varieties of paddy.

The head of Department of Genetics and Plant Breeding Dr Deepak Sharma gave detailed information about the project and also informed that under this project, the works of mutation breeding are ongoing on 300 traditional varieties of Chhattisgarh. The programme was attended by the university's Registrar G K Nirmam, Director (research) Dr P K Chandrakar, Director (extension) Dr R K Bajpai, HoD of BARC Dr P K Mukherjee, and others were present.

Agriculture Production Commissioner Dr Kamalpreet Singh along with IGKV Vice Chancellor Dr Girish Chandel handed over the seeds to a farmer.

Fig.9: Front Line Demonstrations and organization of Field Days & distribution of mini-seed kits for popularization of mutant varieties.

Table 3: Seed production (in q) of Mutant Varieties during Kharif-2022.

Sr. No	Name	Year of Notification	Seed Kit Distribution	Breeder Seed production	Foundation Seed production	Truthful Seed production	Remarks
1	TCDM-1	2019	May-2019 & Apr-2022	27.00	303.11	92.00	This is the 1st mutant variety developed through collaborative R&D work
2	Vikram TCR	2021	May-2019 & Apr-2022	39.00	462.60	15805.00	The variety is spreading fast among the farmers and may cover 14-15 % rice area in coming 2 years
3	CGJT	2021	Apr-2022	6.60	-	132.00	For popularisation, seed kit distribution and Kisan Mela(s) will be taken up in coming years along with Frontline Demonstrations
4	TCVM	2022	Apr-2022	4.60	-	145.00	
5	TCSM	2022	Apr-2022	5.25	-	210.00	

Sonagathi Mutant (TCSM) were distributed to more than 200 farmers of Chhattisgarh and nearby states. During preceding year (*Kharif* season 2021), mini-kit seeds of TCDM-1, Vikram-TCR, TCVM and TCSM were distributed to the farmers of Chhattisgarh, Uttar Pradesh and Maharashtra. Interestingly, all the farmers were happy to grow those mutant varieties and recorded an average yield 46 q/ha for TCDM-1 and 65 q/ha for Vikram-TCR. Workshops-cum-Field demonstrations and Field Days of mutant varieties are being organized every year for popularization of released rice mutant varieties among the farmers and also by distributing them mini kits of seeds (Fig.9). Furthermore, hand ready pamphlets on cultivation practices and unique features of mutants are also published and being distributed among the farmers for their convenience. Moreover, print media are also used for popularization of rice mutants. Many local and national print media covered the miracle of radiation techniques for development of rice varieties. With the help of these activities, huge numbers of farmers are benefitted and mutants are popularized among the farmers in short period of time. All the 5 rice mutant varieties are in National seed Chain(www.seednet.gov.in). The breeder seed indent for *Kharif*-2024 is as follows: Vikram TCR (45. 05 q), TCDM-1(25.00 q), TCVM (21.00 q), CGJT (12.00 q) & TCSM (1.00 q). These new varieties account for ~3.15% of total National seed indent; which is a good indication. Year after year, the Breeders seed indent is increasing and much more quantity of seeds are being produced and disseminated through BARC-IGKV collaboration. Looking at the huge demand from the State Seed Corporations (through Govt. of India national indent) and the farmers, in *Kharif*-2022, large scale

Fig.10: Field view of large scale breeder seed production of Vikram TCR & TCVM.

seed production (Breeders Seed, Foundation Seed, Truthful Seed) of mutant varieties were taken up (Table-2, Fig.10). During the *Kharif*- 2022, Vikram-TCR was cultivated in more than 1000 ha area of Chhattisgarh state. On the basis of breeders' seed dissemination (Breeder Seed-to-Foundation Seed-to-Certified Seed-to-Farmers Field), it is estimated that, 'Vikram TCR' (mutant of Safri-17 rice landrace) may occupy ~14-15% of rice area in Chhattisgarh state within 2 years. Within 4-5 years, this variety (due to its high yield potential, lodging resistance, good grain quality, resistance to major diseases) may replace MTU-1010 (a mega variety occupying ~30% rice area).

Future Road Map & Molecular Mapping/Molecular Insights of Mutant Traits & Validation of Therapeutic Properties of Medicinal Rice Landraces/Varieties

Rice mutation breeding is being practiced all over the world. However, BARC-IGKV collaboration has given a new dimension in improvement of traditional rice landraces/farmer's varieties increasing rice biodiversity using radiation induced mutation breeding. Our efforts have helped to generate large number of mutant reservoirs which will be tested and released for commercial cultivation in future. In addition to this, identification and mapping of causal mutations in the genome through advanced genomic approaches viz. RNA sequencing and MutMap is also being carried out. During *Kharif* season 2021, RNA sequencing of a dwarf and high tillering mutant (Samundchini mutant S-49) of Samundchini landrace along with corresponding parent and TRR-4 & corresponding parent Mai Dubraj were performed to identify the differentially expressed genes and to define the causal mutations. Furthermore, large numbers of crosses (~50) were attempted between mutants and corresponding parents to generate F2& F2:3 mapping population for MutMap studies. These populations will be used for MutMap studies in future to map the mutant loci and to find out the causal mutation. Also, genomic similarity study based on SSR and SNP markers are also being studied to confirm the trueness of mutants. Till now major focus were given for improvement in grain yield potential by reducing their height and maturity duration. Many dimensions are there to go with. Therefore, both the institutions will soon start the mutation breeding for developing disease resistant mutants, biofortified mutants, mutants with medicinal values and climate resilient varieties. Scientific validation of medicinal properties of a few traditional rice varieties has been undertaken. Studies on 'Gathuwan' and 'Layacha' on animal models have been carried out (and published in peer reviewed journals). Further clinical trials in patients will be undertaken.

Conclusion

With this huge quantum of research work carried out under BARC-IGKV collaboration, it is worthwhile to mention that at present, this is ostensibly one of the world's largest active & comprehensive radiation-induced mutation breeding program for the improvement and revival of traditional rice landraces/farmers' varieties. The development of improved rice mutant varieties will not only help for improvement of the socio-economic conditions of the poor and marginal farmers who have been preserving these varieties since generations, but also will bring back the traditional wisdom of combating malnutrition and hunger on sustainable basis.

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