

Dream

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MILLETS: COARSE CEREALS WITH SMOOTH BENEFITS



**NUTRI CEREALS
MILLETS-
THE FUTURE
SMART FOOD**

**RIDING THE
MILLETS
REVOLUTION**

**THE GM CROP
DEBATE**



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EDITORIAL**DR NAKUL PARASHAR**

2023 – International Year of Millet

MILLETS ARE

versatile. You can have them for breakfast, lunch or dinner and stay healthy. They are easily digestible. They have a low glycemic index, thereby making them an ideal cereal substitute. They are high in fibre, rich in essential amino acids, vitamins and minerals, gluten-free, alkaline, and non-allergenic. Thus, they are good for cholesterol, diabetes and weight loss. Interestingly, with so many benefits, India is home to most of them. This means that India produces more than forty per cent of the world's millet production. Amongst the Indian states, Rajasthan, UP and Haryana lead millet production in the country. Besides being a healthy food, the kind of climate and soil conditions that millet requires to grow to take India to the helm of associated export businesses worldwide. A warm, temperate climate with sustainable temperature for millet growth is 20-30 degrees Celsius.

Thanks to the Hon'ble Prime Minister, Shri Narendra Modi. His efforts yielded, and the UN General Assembly dedicated 2023 as the International Year of Millet (IYM). Efforts like IYM will, for sure, propel global awareness about this food, and in turn, they enhance revenue prospects for the country. Efforts are thus on to make IYM 2023 a people's movement. This will, thus, make India the global pith for millet. In any case, India is the largest producer of millet in the world.

Pearl Millet or Bajra, Finger Millet or Ragi, Sorghum Millet or Jowar, Brown Top Millet Kangni Choti, Foxtail Millet or Kangni, Barnyard Millet or Samwa, Kodo Millet or Kodo, Little Millet or Sama, and Proso Millet or Chena are major millets that we are cognizant of.

At Vigyan Prasar, we shall make IYM a nationwide and year-long event of general

awareness through lectures, films, radio talks, seminars, conferences, exhibitions and fairs all over the country in every possible language and dialect. All of this is a part of its mandate of SCoPE-for-all (science communication popularisation and its extension).

Besides, if you recall Feb 2022, Vigyan Sarvatra Pujyate (VSP). Bucked up by its accomplishment, under Azadi Ka Amrit Mahotsav 2.0, Vigyan Prasar shall launch it on National Science Day on February 28th in New Delhi. There shall be five campaigns under the theme – of building & achieving a self-reliant India through science & technology. The first one, obviously, would be the bigger version of VSP would be visible at 56 locations across the nation in a staggered manner. A year-long radio serial on the theme would be broadcast through 119 MW and 14FM radio stations of All India Radio. This will be the second campaign. Printing & Publishing 52 books on various topics of how self-reliant India has been achieved through science & technology will be the third campaign. In this queue, 52 short films would be produced through IndiaScience, the OTT Channel team, on the theme allotted to us. We've all been keen to meet and talk to architects of those experts who've made self-reliant India through their path-breaking achievements. Hence, the fifth campaign would be 52 episodes of face-to-face with such noted personalities during this year. A year packed with much excitement. So stay tuned with us in our journey to achieve yet another milestone.

Happy National Science Day Greetings in advance.

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Millets: Coarse cereals with smooth benefits

Jyoti Maurya, Anurag Panchal, Manoj Prasad

Millet is a broad and general term used for small seeded cereals which are grown mostly in semi-arid tropics of Asia and Africa. Millets are naturally tolerant to unfavourable weather conditions like drought, heat and salinity and are nutrient rich as compared to major cereals like wheat, rice and maize. Millets are not only adapted to nutrient poor, dry or infertile soil but also give enormous number of seeds. Millets are also called “coarse cereals” due to the rough surface of their seeds. While most of the major cereal crops are rice in carbohydrates but have low nutrients, millets are a powerhouse of nutrients including proteins, folic acid, iron, calcium and dietary fibre. These plants are called “orphan crops” because of its diminished human consumption due to higher acceptance of wheat, rice and maize in the present time. Millets have been categorised into two groups: major millets and minor millets. Major millets include pearl millet, sorghum, finger millet and minor millets include foxtail millet, kodo, barnyard, little millet and proso millet.









Proposed and sponsored by India at United Nations General Assembly (UNGA), Year 2023 has been declared as “International Year of the Millets” (IYM) by the food and agriculture organization



(FAO). IYM aims to raise awareness towards importance of the millets as a source of food security and nutrition, particularly in arid and semi-arid regions. This campaign also focuses on increasing the production of millets and unravelling its potential to contribute to the sustainable food system and ultimately improve the livelihood of smallholder farmers, indigenous people and women in particular.

After getting underutilized, neglected and marginalized for several decades, all the limelight that millets are getting recently, owes to its relevance and potential to solve most of the modern time challenges of food security and climate change. Millets are a powerhouse of nutrition. They are good source of proteins, dietary fibres, vitamins (niacin, folic acid and tocopherol) and its precursors (like carotene) and minerals such as calcium, iron and zinc. Millets also have good amount of antioxidants, which help in reducing the risk of cancer and heart diseases. Also being, gluten free and easy to digest they are very useful to people suffering from gluten intolerance and celiac diseases. Millets have a low glycaemic index (GI) and due to release of sugars slowly into blood they are also beneficial to the people with diabetes. Hence, millets are healthy and nutritious in addition

BENEFITS OF MILLETS

Pearl Millet	Sorghum	Finger Millet	Foxtail Millet	Proso Millet	Kodo Millet	Barnyard Millet	Little Millet
 <ul style="list-style-type: none"> ▪ 11.5% dietary fiber ▪ Highest Niacin among all cereals ▪ Rich in Calcium and Unsaturated Fatty acids ▪ Contains high amount of proteins and Lipids with Vitamin E and B complex 	 <ul style="list-style-type: none"> ▪ Rich in Potassium, Phosphorus and Calcium ▪ Sufficient amount of Iron, Zinc and Sodium ▪ Rich source of dietary fiber, protein, riboflavin, folic acid and carotene 	 <ul style="list-style-type: none"> ▪ Rich source of Calcium (~300mg/100 mg) ▪ Highest Mineral content among millets ▪ Contains more of Sulphur containing amino acids ▪ Excellent malting and high antioxidant properties 	 <ul style="list-style-type: none"> ▪ Contains double the amount of protein in rice ▪ Higher Thiamin than all the millets and rice ▪ Sufficient amount of Iron, Zinc and Sodium ▪ One of the most digestible and non-allergic grain 	 <ul style="list-style-type: none"> ▪ Contains high amount of protein (12.5%) ▪ Cheaper source of Manganese ▪ Reduces Cholesterol and the risk of Heart diseases ▪ Has high amount of Calcium required for bones 	 <ul style="list-style-type: none"> ▪ Rich in Vitamin B especially Niacin, Pyridoxine and Folic acid ▪ High Minerals including Calcium, Iron, Magnesium and Zinc ▪ High amount of Lecithin excellent for strengthening nervous system 	 <ul style="list-style-type: none"> ▪ Rich source of crude fibre and Iron ▪ Possess functional constituents i.e., Gamma amino butyric acid (GABA) and Beta - glucan, used as antioxidants and in reducing blood lipid levels. 	 <ul style="list-style-type: none"> ▪ High in Iron and Phosphorus content ▪ Possess high antioxidant properties ▪ Beneficial in diabetes and stomach related disorders ▪ Constitutes 38% dietary fiber

Source: <https://vikaspedia.in/health/nutrition/nutritive-value-of-foods/nutritive-value-of-cereals-and-millets>
 Picture courtesy : Dr. Vetriventhan Mani, ICRISAT, Hyderabad

to being a well-balanced diet. Some selected millets with their nutritional benefits are summarized in Fig. 1.

Apart from the health benefits and food diversity millets can serve as torch bearers of climate sustainability. Since past century, to meet the food demands of increasing global population, Green Revolution paved a way towards enhanced productivity by introducing high yielding varieties of wheat and rice which ensured food availability up to a certain extent. As a result, other cereals and millets have faced rapid decline in their production and hence consumption. As it is said that great things comes at a good price,

the production of these rice and wheat varieties were suitable for favourable climatic conditions and were highly dependent on fertilizer applications demanding high natural resources and economic inputs. Adverse consequences of rapidly changing climate with long term shifts in global temperature on agricultural sector are much evident nowadays. For example, increased draught affected land, nutrient poor soil and untimely rainfalls are being reflected in drop of worldwide yield and productivity of food grains. Therefore, to combat the changing climate, millets being tolerant to unfavourable weather conditions like drought, heat and

salinity are a great alternative. Millets are not only adapted to nutrient poor or infertile soil but are also resistant to insects and pests which correlates to negligible requirement of inorganic fertilizers and pesticides.

In conclusion, millets present a good nutritious alternative towards food diversity and security and must have for a well-balanced diet. There are several challenges that need to be addressed to make millet cultivation smooth, such as more flexible policies to increase procurement and distribution of millets through the public distribution system, more farmer friendly schemes and improvement of cultivated millet varieties in terms to enhance their yield. An alarming concern should also be the conservation of minor millets as many of them are endangered and some have already become extinct. Reclaiming their potential at global level through IYM is worth praising, gives us a hope to address the most concerning challenges together.



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Nutri Cereals

Millets- The Future

Smart Food

Siddhartha N Joardar

Millets are considered important by the virtue of its mammoth potential to generate livelihoods, increase farmers' income and ensure food & nutritional security all over the world. As the global agri-food systems face challenges to feed an ever-growing global population, resilient cereals like millets provide an affordable and nutritious option, and efforts need to be scaled-up to promote their cultivation. The year 2023 has been declared by the United Nations as the International Year of the Millet, following a proposal by India, which wants to position itself as a global hub for millets. It is predicted that millets can play an important role and contribute to our collective efforts to empower smallholder farmers, achieve sustainable development, eliminate hunger, adapt to climate change, promote biodiversity, and transform agrifood systems. Millets use 70% less water than rice; grow in half the time of wheat; and need 40% less energy in processing. Moreover, they are hardy crops that can withstand extreme heat conditions.

HEALTH BENEFITS

Health benefits of millets are remarkable. They are not only source of different useful nutrients, but also congenial to prevent various regular ailments.



Millet is an excellent source of phosphorus, potassium, magnesium, calcium, iron, Vitamin A, Vitamin D, niacin and anti-oxidants. Each component is quite useful to body physiological functions. Niacin, for example, manages functions of more than 400 enzymes. It helps in healthy skin and organ functions. Potassium supports healthy kidney and heart functions. Moreover, it has got role in nerve signal transmission that communicates bone and muscle. Magnesium regulates heart rhythm. Dark variety of millet is a rich source

of beta carotene which is a precursor of Vitamin A (required for healthy eye) and itself an anti-oxidant that fight against free radicals. Millet alleviates oxidative stress in the hippocampus and down regulates the expression of Alzheimer's disease.

Millet possesses more complex carbohydrates for which it takes longer time to digest making it a low glycemic index (GI) food. Low-GI foods can help keep our blood sugar from spiking after eating that allows people with diabetes to manage their blood sugar levels more easily.

SMART FOOD

Millet is a good source of dietary fibres, both soluble and insoluble. It may be considered as a pre-biotic as it possesses insoluble fibres that supports probiotics i.e. good bacteria in our gut (intestine) thereby influencing immunity of the body. Moreover, these insoluble fibres regulate bowel movement, help in forming bulk stool and reduce the chance of colon cancer. The soluble fibres of millet reduces the amount of bad cholesterol (low density lipoprotein, LDL) in blood thereby lowers the risk of atherosclerosis. The soluble fibres turn into gel in the stomach and absorb cholesterol to be carried to the body system. Millet can also help to raise good cholesterol (high density cholesterol, HDL) thereby reduces risk of heart diseases. Millet helps elevating the protein adiponectin that protects cardiovascular tissues.

INDIA PERSPECTIVE

Evidences show that millets were among the first crops that had been domesticated in India. There is evidence of the cultivation of millets in the Korean peninsula around 3500 B.C. In India, millets have been mentioned in Yajurveda Texts. Even people of Indus valley civilization used to consume millets. Being grown in more than 130 countries, millets are traditional food for more than half a billion people across Asia and Africa. In India, it is primarily a kharif crop that requires less water and agricultural inputs than other similar grains.

Recognizing the enormous potential of Millets that aligns with several UN Sustainable Development Goals (SDGs), the Government of India (GoI) has prioritized Millets. In April 2018, Millets were rebranded as “Nutri Cereals”, followed by the year 2018 being declared as the National Year of Millets, aiming at larger promotion and demand generation.

On 6th December 2022, the Food and Agriculture Organization (FAO) of the United Nations,

organized an opening ceremony for the International Year of Millets – 2023 at Rome, Italy. The event was attended by a delegation of senior government officials from India. Subsequently, prior to the year-long celebration of ‘International Year of Millets (IYM) 2023’, the Department of Agriculture & Farmers Welfare hosted a special ‘Millet Luncheon’ for the Members of the Parliament at the Parliament house. The Department of Agriculture & Farmers Welfare has taken a proactive multi-stakeholder engagement approach. It engaged all the central government ministries, states/UTs, farmers, start-ups, exporters, retail businesses, hotels, Indian Embassies etc. to achieve the aim of IYM 2023 and taking Indian millets globally. Ministries, states and Indian embassies have been allocated different focused months in 2023 to carry out various activities for promotion of IYM and increase awareness about benefits of millets for the Consumer, Cultivator and Climate.

Some of the other ministries which have planned events in January are Ministry of Food Processing Industries which will be organizing Millet Fair-cum-exhibitions in Andhra Pradesh, Bihar and Madhya Pradesh; FSSAI will organize Eat Right Melas in Punjab, Kerala and Tamil Nadu etc. With respect to states, Chhattisgarh, Mizoram and Rajasthan have been allocated the month of January for carrying out specific activities for sensitization and promotion of IYM. The

states will be conducting millet centric activities including mahotsavs/ melas and food festivals, training of farmers, awareness campaigns, workshops/seminars, placement of hoardings and distribution of promotional material at various key locations in the state, etc. Other states that are organizing similar activities in the month of January include Maharashtra, Uttarakhand and Punjab.

Embassies of India across more than 140 countries will be participating in celebration of IYM during 2023 by conducting side events on IYM involving the Indian Diaspora through exhibition, seminars, talks, panel discussions, etc.

STATISTICS MILLET CONSUMPTION IN INDIA AND OTHER COUNTRIES

Millet was extensively cultivated till around 50 years back. But due to the Western development model, India has neglected its traditional wisdom. Millets are cited as too primitive and coarse grains. It was looked at only as the food of rural people or ancestors. Besides that, the Green revolution had a negative impact on the production of millet. Before Green Revolution, the millets are 40 percent of total grain production.

At present, India produces 170 lakh tons of millet (20 % of the global output). The global average yield is 1,229 kg per hectare, while the average yield of millets in India is 1,239 kg per hectare.

In India, Jowar and Bajra are grown in most states like Maharashtra,



Karnataka, Andhra Pradesh, Madhya Pradesh, Gujarat, Rajasthan, Uttar Pradesh, and Tamil Nadu, except North East states, Himachal Pradesh and Jammu and Kashmir. Both can be grown as Kharif (July -November) and Rabi(October – February) crops. Traditional varieties of these crops are available in India. They exhibit a wide range of variations concerning duration and quality. They can be grown as sole crops, intercrop, and mixed crops. The crop duration varies from 90 -120 days. The mixed cropping of Jowar-Arhar and Jowar with other pulses and even Bajra and other cereals could be done. The crop rotation of mung followed by Jowar improves soil fertility. Bajra can also be grown as a mixed crop. Finger millet (Ragi) is an important cereal of Karnataka. It grows as summer and Rabi crops in Southern India but mainly as a Kharif crop in Northern India. It can grow in alkaline soil with a pH as high as 11. The duration of the Ragi crop is 135 days. It grows as the sole crop in Southern India and Orissa, as a mixed crop with Jowar, Bajra, Oilseed, and Pulses, and as an off-season crop in rice fallow. Foxtail (Italian) millet can grow under tropical and temperate conditions. It grows throughout the year in Southern India. The duration of the crop is 80-100 days. The Little millet and Barnyard millet are also produced under rainfed conditions. Both can

withstand drought and waterlogging conditions. Proso, Kodo, and Browntop millets are highly drought resistant. Browntop has the shortest duration of 70-75 days among all millets.

CHALLENGES

It is observed that before the Green Revolution, production of rice and millets were higher than the production of wheat, barley, and maize combined all together. But since then, the production of millets has gone down, and the crops that were once consumed in every household became a fodder crop in just a few decades after the Green Revolution. Till the 1965-70 time-frame, millets formed 20% of our food grain basket but are now down to 6%.

The fact is that, after the Green Revolution in the 1960s, the Indian government pushed for hybrid, high-yield varieties of wheat and rice to increase food production for both domestic consumption and export. Being officially called a "coarse grain" didn't help millets' cause either, as this designation signified something less desirable to processed rice and wheat. Millets began to be seen as the food of rural and tribal communities, who ate rustic dishes like ragi mudde and jowar roti as cheap and filling meals. However, now mainstream society is beginning to understand and appreciate the long-lost benefits of millets too. Given this, over

the last decade the Indian government has begun to encourage the growth and consumption of millets, starting with rebranding millets as "nutricereals" instead of calling them "coarse grains."

FUTURE DIRECTIONS

There are several areas that offer opportunities. The government has funded 66 start-ups with investments exceeding a cumulative ₹6 crore. However, Govt. has to act on both demand creation and incentivize production.

If policy and technological innovation could make rice and wheat go up in consumption more than 50 years ago, the reverse in favour of millets is also likely possible, if that's what the country wants.

CONCLUSIONS

The international year of millets provides an opportunity to highlight how the sustainable production, processing, marketing, and consumption of millets can contribute to alleviating hunger. Moreover, it can also help us move forward on all areas of the 2030 agenda for sustainable development. IYM 2023 aims to contribute to the UN 2030 Agenda for Sustainable Development, particularly SDG 2 (Zero Hunger), SDG 3 (Good health and well-being), SDG 8 (Decent work and economic growth), SDG 12 (Responsible consumption and production), SDG 13 (Climate action) and SDG 15 (Life on land).

Towards this endeavour, through a collaborative approach, the DA&FW urges everyone including the International Organizations, Academia, Hotels, Media, Indian Diaspora, Start-up communities, Civil Society, and all others in the Millets value-chain to come forward and join hands to revive the forgotten glory of 'Miracle Millets' through the grand celebration of International Year of Millets - 2023.



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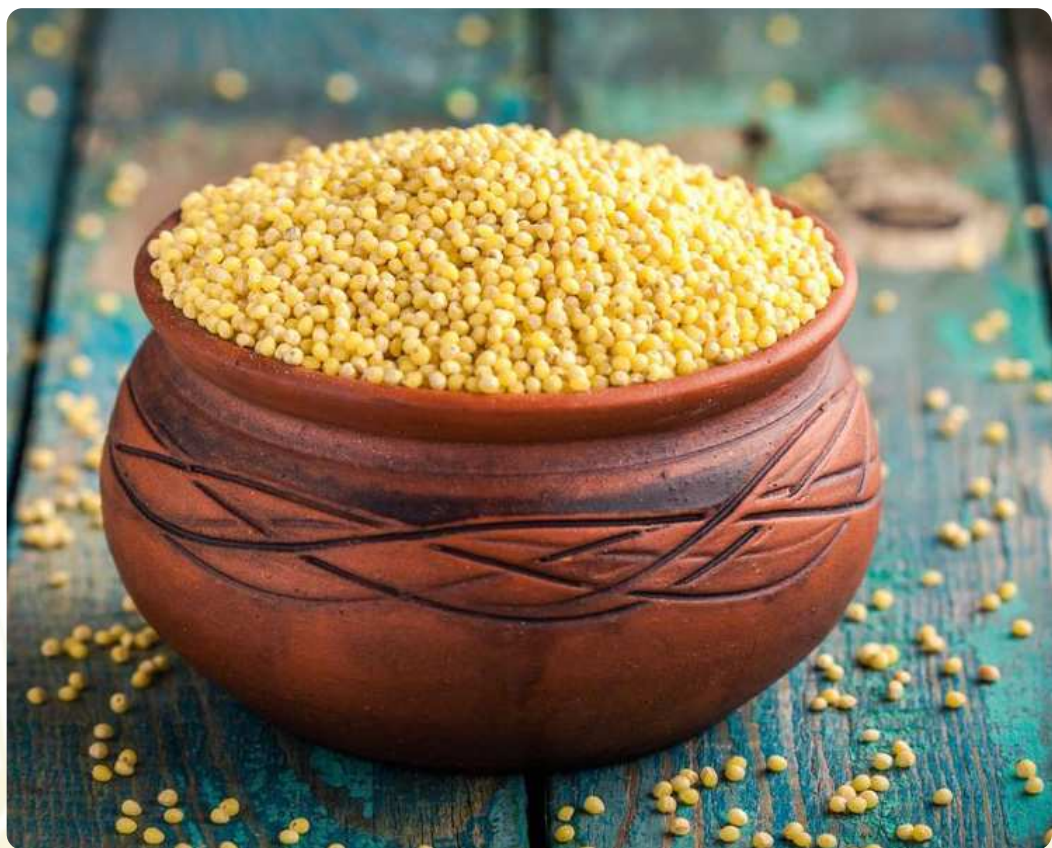


Riding the Millets Revolution

Manas Pratim Das

Food is for filling the stomach, food is for supplying nutrition to the body. However certain food items including those that are labelled as 'staple' can add a disturbing dimension to the order. A large number of people can fall sick after consuming such food. Wheat, the essential ingredient for roti-biscuit-cakes, is capable of triggering an allergic reaction in the human body leading to several unwelcome symptoms. The component of wheat that plays a villainous role is called gluten. Gluten intolerance is quite widespread in our country than is commonly believed. Such intolerance could express itself in a nagging disease termed Celiac. B S Ramakrishna, in an editorial in the Indian Journal of Medical Research, had warned that celiac disease can turn into an epidemic in India. Given the prevalence of gluten intolerance in our country it is imperative that we search for some alternatives that does not contain gluten at all. Millets present itself as a just answer to this search.

The varieties of millets like jowar (sorghum), bajra (pearl millet), kodra (kodo millet) etc are all free from gluten. Among all the grains in the world millets are the least allergic. It is consumed basically for its carbohydrate content but millets are also rich in proteins and minerals. Furthermore millets are a rich



source of dietary fibre that can help in digestion. The saying 'all disease begins in the gut' is ascribed to Hippocrates. The father of medicine is believed to have uttered this more than two thousand years ago. Indians have been consuming millets since another two millennium earlier. The Encyclopaedia Britannica mentions that Europe treated millets as major grains in the middle ages. As economies evolved across the nations and as people became more affluent, millets were dumped in favour of finer flour giving grain – the wheat. Rice also

played its role of nudging out millets. These days the USA and the countries of Western Europe use millets mainly for pasture and hay. India could have done otherwise and depended on millets to feed its percentage of population that is reasonably categorised as 'poor'. But the commercial winds unsettled our sustainable fabric and made us follow the west and opt for rice and wheat. The choice is however changing in recent times across the economic spectrum. But to the administrator's disappointment the cultivation of millets in the country

is far from sufficient. India remains the leader in millet production but sadly the share of millets in the total grain production has dropped to half of what it used to be before the Green Revolution. Again, 81 per cent of the total millet production is contributed by three states only - Rajasthan, Uttar Pradesh and Haryana.

A turnaround is certainly possible if certain conditions are met. Firstly, of course, encouragement through state policies is required. The government at the centre has already demonstrated that it is eager to have more variety in grain production. The minimum support price for millets has been increased and seed kits are being made available. Necessary technical help for increasing productivity is also essential. The MS Swaminathan Research Foundation (MSSRF) has come up with a few good examples in this regard. One example is from Koraput where women doing subsistence farming of ragi in the past have been benefitted by the advice of MSSRF. The blend of traditional agricultural practice with modern inputs has resulted in a threefold increase in crops. But looking at the larger picture what seems most crucial is the increase in demand for millets. The industry would only step in when it feels confident that enough demand has been generated for millets in the market. Only then the farmers would find interest in millet cultivation as greater procurement at better prices would be done by food processing factories. Useful intervention in this regard has been made by state agencies as well as NGOs. The state of Karnataka tied up with the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT). Building a private-public consortium is on the anvil. Other states like Mizoram, Chhattisgarh and Rajasthan has chipped in with specific programmes and festivals to create awareness about millets. These activities have been in tune with the agenda announced at the launch of the International Year of Millets (IYM) on January 1, 2023 by the union government.

Gen Z has always held the key to increasing market demand of



consumables. The Indian Institute of Millets Research in Hyderabad has well-thought plans for attracting the younger generation to food items made from millets. Recipes of cookies, noodles, pasta, flakes etc made with millets have been carefully designed by scientists. The institute claims to have transferred technologies of such food processing to commercial entities. The scientists are oozing confidence about making the once 'irrelevant' crop count and ensure its presence on every plate. In fact the menu cards at restaurants in different small and big cities are now featuring millet food.

Millets hold out hope for a changing world. Our planet is plagued by warming leading to crop failures. Human conflicts resulting in full blown wars are making food supply uncertain. In such a situation we need to act wisely and choose crops that can withstand extreme temperatures and survive inconsistent rainfall. Millets, the hardy grain, suits the bill for a warm globe with umpteen uncertainties. It is a super crop in that sense. It is evident that citizens around the world will never respond kindly to a plan of completely changing their diet plans. That is not wanted even because doing away with food habits developed over a long period of time can be detrimental to health. However, in order to feed the exploding population of the world, millets can be handy. The crop can bring in beneficial changes to our health with its unique features. The

low glycaemic index of millets mean that it is digested slowly and there is no unhealthy increase of sugar levels in the blood. India will have to be alert and active as the largest producer of millets as demands rise across countries. Our country can be a benefactor as well as a beneficiary in this revolution.

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The GM crop debate

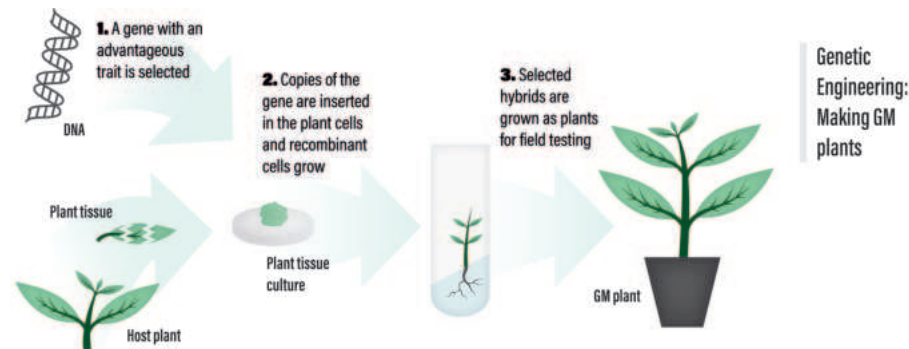
Atin Sharma

The Supreme Court of India is deliberating on a landmark case. The Union government approved the commercial release of a genetically modified (GM) variety of mustard, DMH-11, which has caused a huge uproar. Although India is yet to see commercial production of a GM food crop, this could change very soon depending on the decision made by the apex court. Many scientists are excited at the prospect of GM crops, which hold the promise to ensure food security for the soon-to-be most populous country in the world. However, India has had a terrible history of legal scuffles over the adoption of GM crops and yet again the anti-GMO activists have presented a strong case against the commercial release of GM mustard. The government agencies, in turn, are up to the task with equally strong counter-arguments and this is turning out to be an interesting contest.

WHAT ARE GM CROPS?

DNA, or deoxyribonucleic acid, is a molecule that forms the basis of heredity in most life forms. It is a polymer, a large molecule made up of four nucleotides or the building blocks, namely, Adenine (A), Guanine (G), Cytosine (C), and Thymine (T). The sequence of arrangement of these building blocks forms the entire code of life. A small section of DNA sequence called a gene, encodes for a protein that determines individual characteristics of a living organism like eye colour, height, or hair colour. Thus, multiple genes work together as a blueprint of life, carrying all the necessary information required for all functions of a living organism.

With the advent of molecular biology,



it became possible to sequence the DNA allowing scientists to establish which gene sequences are responsible for specific traits and functions. However, since DNA is a universal code, with almost all life forms carrying it, deciphering and understanding the code meant that different parts of this code could be combined, edited, or deleted to make a completely new and customized code. This ability to modify the DNA is termed genetic engineering and any organism, microbe, plant, or animal, whose genetic makeup has been engineered synthetically is called a genetically modified organism, or a GMO.

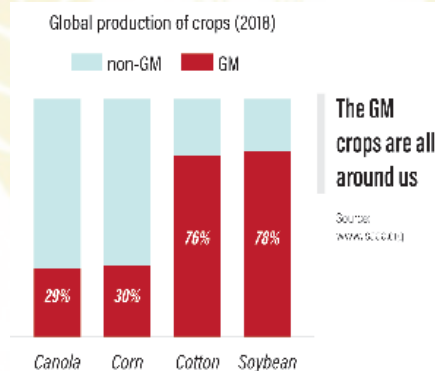
Crops are the mainstay of human nutrition and the economy. For centuries, humans have been engineering crops by crossbreeding varieties with desired traits, resulting in the generation of hybrid crops with combined traits of parent crops. However, this process is

random and doesn't necessarily result in the desired characteristics in the hybrid crop. Fortunately, with genetic engineering using recombinant DNA techniques, this process has become very specific, faster, and much easier. It is possible to select genes and generate GMO crops which are resistant to pests, more tolerant to weather conditions, or have increased yields.

Global perspective on GM crops

In 1994, a variety of tomato named Flavr Savr became the first commercial GM crop available for human consumption. The tomatoes were engineered with recombinant DNA techniques to have an improved shelf life, increased resistance to fungal infections, and high viscosity. Since then, the global use of GM crops has only increased. According to 2019 estimates by the International Service for the Acquisition of Agri-biotech Applications (ISAAA), GM crops are grown on more than 190 million hectares of agricultural land in 26 countries and are approved for consumption by 70 countries. These crops include staple food crops like corn (maize), soybeans, canola, and other cash crops like cotton and alfalfa.

More than 75% of all cotton planted worldwide is GM cotton which includes India where about 7.5 million farmers and their families have benefitted from the use of pest-resistant GM cotton. GM soybean has also been highly successful



accounting for about 80% of all soybean produced in the world. Developed countries like the United States and Canada are world leaders in the plantation of GM crops with about 95% of canola in Canada being genetically modified.

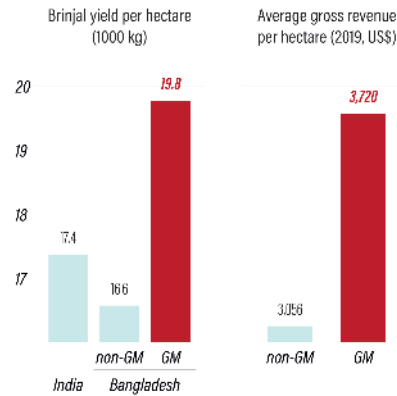
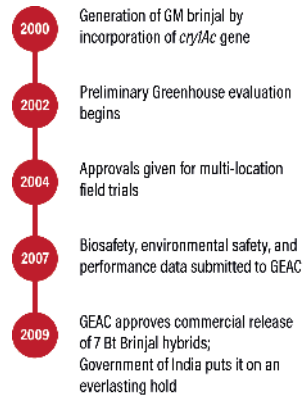
In addition to uplifting farmers from poverty, decreasing global insecticide usage, and reducing overall farm CO2 emissions, GM crops have also resulted in upwards of 185 billion US dollars in farm gains.

INDIA'S TRYST WITH GM CROPS

India is the world's leading producer of cotton. However, the cotton crop is highly susceptible to pest infestations. Therefore, to ensure steady crop production, India adopted a pest-resistant GM variety of cotton, commonly known as Bt-cotton, in 2002. The Bt-cotton carries a gene from a soil bacterium, *Bacillus thuringiensis* (Bt), that results in the production of Cry1Ac or the Bt toxin in the plant cells. This toxin is deadly to bollworm, the major cotton pest but harmless to other plants and animals. Though it was met with both support and criticism, Bt-cotton was enthusiastically adopted by Indian farmers. The area under Bt-cotton cultivation increased from 29,000 hectares in 2002-03 to about 12 million hectares in 2019-20 with the average yields of cotton increasing from 191 kg/hectare to 436 kg/hectare during the same period.

Inspired by the success of Bt-cotton, the Genetic Engineering Appraisal Committee (GEAC) or India's GM regulatory body, approved the commercial release of seven varieties of Bt-brinjal—GM brinjal (eggplant) modified to express Bt toxin. This was the first time when a GM food crop was approved for cultivation in India. However, the approval was met with fierce resistance from multiple NGOs and anti-GMO activists. This pushed the Union government of India to put a moratorium on Bt-brinjal in 2009, the same year it was approved for cultivation.

About four years later, Bangladesh also approved Bt-brinjal for commercial production but unlike India, it was widely



Bt Brinjal: India's loss, Bangladesh's gain

Source: Genetic Engineering Appraisal Committee (GEAC), Ministry of Environment, Forests and Climate Change, Government of India (2009-10); National Bureau of Aquaculture and Fisheries (2019).

adopted by Bangladeshi farmers. In 2019, the average yield of Bt-brinjal was about 20% higher than the non-GM brinjal even beating the Indian yield of brinjal by about 14%. At the same time, the average gross revenue from the Bt-brinjal grew to 3,720 US\$, about 22% higher than the non-GM variety. Ironically, Bangladesh adopted the same varieties that were developed by the Indian government's Department of Biotechnology and the Maharashtra Hybrid Seeds Company (Mahyco).

A CASE FOR GM MUSTARD IN INDIA

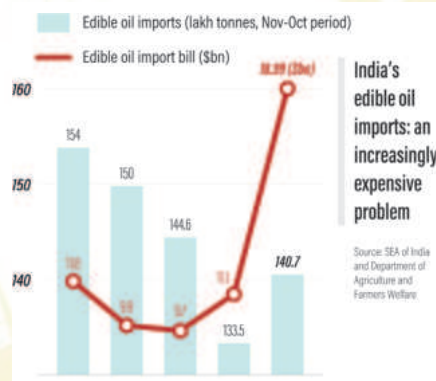
India is poised to become the world's most populous country this year. With more than 1.3 billion mouths to feed, India's edible oil production is woefully low. Every year, the country has to import 60-70% of its consumption of edible oil which puts immense pressure on the foreign reserve and threatens India's food security. In 2022, India imported upwards of 140 lakh tonnes of edible oil, a little more than a 5% increase from the previous year. However, the import bill in the same year skyrocketed to about 19

billion US\$ resulting in an eye-watering 71% hike over last year's import bill. The current situation in Europe has also jeopardised India's supply of sunflower oil which is normally imported from Russia and Ukraine.

Rapeseed-mustard oil is one of the most consumed edible oils in India with a 40% share of the total domestic production and a 14% share of the total consumption. However, despite a sizeable area under mustard cultivation, edible oil production suffers from dismally low productivity in India. The Government of India's estimates put the mustard yield at 1,254 kg/hectare which is about 40% lower than the global average of 2000 kg/hectare. Therefore, the opportunity has long existed to improve the yield of mustard and work towards self-reliance in oil production.

WHAT IS DMH-11?

Delhi University developed DMH-11, a GM variety of mustard that promises higher yields. It was generated by crossing two well-established varieties of mustard - Early Hira mutant (EH -2) and Varuna bn 3.6. Unfortunately, mustard is a self-pollinating plant, which means crossing the two varieties naturally was almost impossible. Therefore, the scientists used a Bar/Barnase/Barstar system that makes a parental crop male sterile so that it can't self-pollinate. The other parent works as a restorer and only the seeds produced by cross-pollination are fertile. This system simplifies the process of cross-breeding. This system also uses Bar as a selection marker (to differentiate between GM and non-GM plants) as GM plants become resistant



to some herbicides which kill the non-GM plants. In field testing, the DMH-11 mustard was found to have 28% and 37% higher yields than the national and the zonal check (the reference variety), respectively.

VEHEMENT RESISTANCE TO GM MUSTARD AND SUPREME COURT INTERVENTION

The GEAC approved the GM mustard in 2016 and the Union government also approved the commercial release in 2022. Unfortunately, much like the release of Bt-brinjal, it was fiercely resisted by anti-GMO activists who moved the Supreme Court asking the release to be withheld. This, however, is not the first time the Supreme Court had to intervene. The top court had stayed the release of GM mustard in 2016 which resulted in the Union government asking GEAC to re-evaluate its biosafety and environmental safety.

The activists have alleged that the biosafety and environmental safety assessment by GEAC is inadequate and the results have not been made public. All the testing protocols were formulated by the Delhi University itself, which the activists have likened to a student setting the exam questions himself. The usage of the Bar/Barnase/Barstar system has also come under heavy scrutiny. The introduction of herbicide tolerance by the system has sparked the fear of increased usage of herbicides, especially glyphosate, which has been recognized as a potential carcinogenic (cancer-causing) agent. The activists have also expressed concern over the impact of GM plants on the visitation of pollinating insects like honeybees, which could hurt both pollination and honey production.

Additionally, some economic reservations have also been expressed by the activists. They are worried that the seed and herbicide disbursal, if managed by private sector multi-national companies (MNCs), might limit the gains to affluent farmers only. Moreover, they claim that the marginal increase in the mustard yields will still not be enough to solve India's edible oil import woes

2002

- University of Delhi develops GM mustard (DMH-11)

2008-15

- Biosafety, environmental safety, efficacy, and productivity studies are conducted

2016

- GEAC approves GM mustard
- The Supreme Court stays commercial release of GM mustard

2017

- GEAC asks Union government for approval
- Anti-GM activists approach SC again
- Union government asks GEAC for re-evaluation

2018

- GEAC directs more biosafety and environment safety tests

2022

- GEAC again green lights commercial release of GM mustard
- Anti-GM activists move SC yet again

GM mustard:
A bumpy ride
towards
approval

and the government, and the GEAC by extension, have shown unnecessary haste in approving the commercial release of GM mustard.

THE GOVERNMENT HITS BACK AT DETRACTORS

The Union government, in its response to the activists, has repeatedly insisted that due scientific process was followed during the assessment of the GM crop. The protocols were designed on recommendations from not just the Delhi University but also the Panjab Agricultural University (PAU) and the Indian Council of Agricultural Research (ICAR). In a press release, the Ministry of Agriculture & Farmers Welfare has rubbished the claims of safety concerns regarding the Bar/Barnase/Barstar system. The government maintains that the system has been rigorously tested and is already in use in multiple parts of the world, even citing the example of Canada where 95% of the canola crop is genetically modified using the same system and had no impact on honey bee visitation or honey production. The same press release also stressed the fact that the high yield of mustard and not the herbicide tolerance brought about by the Bar/Barnase/Barstar system is the commercially valuable trait of the DMH-11 crop. The system is essential to ensure successful crossing and subsequent selection but is not designed to promote the crop as herbicide tolerant. It argued that the Indian agricultural sector, unfortunately, already uses

upwards of 15,000 tonnes of foreign MNC-owned herbicide worth Rs 7,000 crores every year, thereby labelling the activists' claim of MNC monopoly and wide-spread herbicide use as an 'ill-conceived apprehension'. In an affidavit filed in the Supreme Court, the Union government opined that the additional toxicity and allergy concerns over the usage of the Bar/Barnase/Barstar system were 'unfounded' as India is already importing edible oil derived from GM crops that use the system. Accepting that the GM mustard alone won't help India's troubles with high-cost edible oil imports, the Union government added that the introduction of DMH-11 is instead expected to be the first in a series of steps to ensure widespread cultivation of high-yielding GM crops in India.

WHAT DOES THE FUTURE HOLD?

The future of GM food crops in India now hinges on the Supreme Court verdict. In the latest hearings on the matter, the apex court has reaffirmed that the top concern remains the biosafety and risk assessment of GM crops. Although the government has expressed faith in the scientific endeavour that went into the development and assessment of the crop, the activists seem to be convinced that GM crops are nothing but a threat to the environment and the general health of animals and humans. The ICAR, meanwhile, has already drawn a roadmap and expects to commercially release blight-resistant potato, insect-resistant chickpea, and pro-vitamin rich banana, all of which are in different stages of development. However, it remains to be seen if these plans will come to fruition or if it will result in a repetition of the Bt-brinjal episode of 2009.

This is an actively developing situation and the Supreme Court is expected to deliver a verdict soon.

Atin Sharma obtained a PhD in molecular biology from IIT Roorkee. He is a science communicator and in addition to writing, he draws funny science comics on Instagram and Twitter @FridgeComics.

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INDIA INTERNATIONAL SCIENCE FESTIVAL (IISF) 2022:

MARCHING TOWARDS AMRIT KAAL WITH SCIENCE, TECHNOLOGY AND INNOVATION.

India International Science Festival (IISF-2022) with the theme of 'Moving towards Amritkal with Science, Technology and Innovation', was organized from 21 to 24 January 2023 at Bhopal, the city of lakes. The event was jointly organized in collaboration with the Ministry of Science and Technology, Ministry of Earth Sciences, Department of Atomic Energy, Department of Space, Madhya Pradesh Council of Science and Technology and Government of Madhya Pradesh and Vijnana Bharti. The Department of Biotechnology under the Ministry of Science and Technology was the nodal department for organizing this mega event. Regional Centre for Biotechnology (RCB), Faridabad was the Nodal agency for the IISF-2022.

This event highlighted the science movement inculcating the Indian scientific spirit led by eminent scientists of the country.

GLANCE AT THE IISF 2022

IISF2022 kicks off with zest and enthusiasm. A Galaxy of scientists graced the event with their presence. In an inaugural ceremony of IISF2022 Hon'ble Union Minister Dr Jitendra Singh, Madhya Pradesh CM



Shivaraj Chouhan along with eminent delegates released IISF2022 Newsletter.

1. ARTISAN'S TECHNOLOGY VILLAGE – VOCAL FOR LOCAL

Dr N Kalaiselvi, Secretary, DSIR spoke at Artisan's Technology Village & emphasized on increased participation of next-generation human capital to automate & do the S&T value addition while conserving the originality for the sustainable livelihood system. The event showcased various traditional arts and crafts from each corner of the state. At the Artisan Technology Village



exhibition, a local innovation system that crafted a bamboo art wowed the audience and became the topic of discussion at IISF 2022.

2. GUINNESS BOOK OF WORLD RECORDS

World Records attempts have been an integral part of India International Science Festival. It is recognised as one of the global authorities for recording and validating record-breaking achievements. This time Guinness World of Records witnessed the 1448 participation of students who assembled the Agri-bot models and broke the record of Hong Kong 2019.

3. INTERNATIONAL SCIENCE FILM FESTIVAL OF INDIA

In the context of Science-20 (S-20), one of the working groups of the G-20 being presided over by India in 2023, one of the renowned scientists Dr. Nautiyal gave his keynote speech on "Films to Reflect India's Emergence as Science & Technology Leader." It was addressed at a scientist group who were interested in making science movies who had gathered in Bhopal, Madhya Pradesh.

IISFI also witnessed the panel discussion on the side-lines of India's G20's priorities and role of science films.

A total of 437 films were received and meticulously viewed by the Nomination Jury. Out of these, 95 have been nominated. Other than India, films were received from Australia, Austria, Brazil, Bulgaria, Colombia, Germany, Greece, the Islamic Republic of Iran, Italy, Malaysia, Nigeria, Spain, The Philippines, The United Kingdom, The United States, Turkey, Tunisia, and Ukraine.

4. MEGA SCIENCE AND TECHNOLOGY EXHIBITION

This time at IISF 2022, the Mega Expo had more than 300 stalls, although the Start up Conclave only had roughly 200. The Expo was attended by thousands of individuals, including young people and



schoolchildren. Start Ups hosted booths, including E Panipuri Kartz, Earth Tatva, and MedPrime Technology. They gave product demonstrations that showcased their superior innovation.

5. START UP CONCLAVE

The start-up conclave was swarmed by start-up entrepreneurs and young innovators who enthusiastically showcased their innovations and products. Hon'ble Minister Om Prakash Sakhlecha, Science & Technology, MSME visited the Start-up India Expo and interacted with the start-up and exhibitors. *Session was focused on setting up innovation ecosystem across the country & was filled with loads of information for aspiring entrepreneurs, startups & incubators*

Department of Biotechnology, won the Best pavilion award of IISF 2022 for the amazing participants and the relentless effort to provide the platform to the young innovators and eloquently hold the pavilion

6. STATE SCIENCE AND TECHNOLOGY COUNCILS CONCLAVE

INNOVATION IS NOT “JUGAAD”! IT IS BASED ON SUSTAINABILITY ATTAINMENT, DR. VIPIN KUMAR! Dr Vipin Kumar, Director of the National Innovation Foundation (NIF), addressed the S&T conclave on the necessity and significance of 'Innovation' during the 8th Edition of the India International Science Festival.

In the Sate Science Release of Compendium on Indian Heritage Protected through Geographical Indications by Hon'ble MP State Minister of S&T Shri Om Prakash Saklecha during State S&T Conclave. Additionally, during the IISF 2022 S&t Conclave Hon'ble MP State Minister of S&T Shri Om Prakash Sakhlecha released the Compendium on Inventions protected through Patent Facilitation.

7. NATIONAL SOCIAL ORGANISATION AND INSTITUTIONS MEET (NSOIM)

The National Social Organizations and Institutions Meet (NSOIM), a key event in the IISF, kickstart on January 21 in



the Civil Engineering Hall at MANIT, BHOPAL. The event gathered all the stakeholders of societal development for to discuss and exchange ideas under the theme “Livelihood Centric Technology Transfer for Reducing Multidimensional Poverty and Building Atmanirbharat”.

“Our constitution promotes scientific temper and India is the first country to adopt Scientific temper in its constitution, Dr Debapriya Dutta, Advisor, DST-SEED spoke in the NSOIM event of IISF2022.”

8. STUDENT SCIENCE FESTIVAL

IISF Bhopal deliberated on 15 important



events in a four-day science festival like the ‘Student Science Village’ where 2500 students participated and get exposed to new technologies and innovations. IISF Bhopal deliberated on 15 important events in a four-day science festival like the ‘Student Science Village’ where 2500 students participated and get exposed to new technologies and innovations.

9. STUDENT INNOVATION FESTIVAL

Dr Sanjay Mishra, Scientist H; Convener at IISF2022 & Chief Guest, Student Innovation Festival encouraged students to innovate for solutions & develop



clearly defined solutions as per needs & challenges of our country.

At Student Innovation Festival, IISF2022, Prof Sandeep Sancheti, Jury Chairperson said that 25 experts from ministry, academia & industry evaluated around 100 projects at SIF.

10. NEW AGE TECHNOLOGIES

‘New Age Technologies Show’, was an important dimension of the 8th edition of the India International Science Festival (IISF), was organized in Bhopal from 21 to 24 January 2023. The event showcased the Technology Readiness Levels of engineered prototypes and products in various cutting-edge areas. This event brought together participants from all over India to discuss and showcase New Age Technologies, encourage research and development in cutting-edge technologies, and identify growth areas.

On the inaugural session of the New Age Technologies Show, the keynote

speaker, Dr. Gagandeep Kang, an Indian Microbiologist and virologist and Professor at CMC Vellore, addressed the enthusiastic audience with her informative talk on “Current and Future Vaccine for COVID-19”.

Dr Nitesh Priyadarshi from NABI, Mohali shared his amazing instrumentation development for bacterial detection at New Age Tech Show during New Age Technology Show.

11. MENTORING AND COUNSELLING (SCIENTIFIC DISCUSSION)

Through a mentorship journey by Science, Technology, Engineering and Mathematics [STEM] experts, the program helped school and college students explore and understand their career goals.

There were five mentoring sessions for various science streams held at MANIT Bhopal from the 22nd to the 24th of January 2022. “It is important to mentor a student at the age of 13-16, because when they come out of school, they have a lot of confusion about further studies,” said Dr. Shiva Umapathi, Director of IISER. Dr. Bramh Prakash Pethiya, Vice Chancellor of Rabindranath Tagore University, stated, “If students work with passion, they will rise to the top.”

The students were mentored by Dr. Anita Gupta, Adviser/Scientist G and Head-NSTEDB, DST, Mrs Suman Gupta, Chief Operations Officer at BBB, RCB, Dr. B.K. Tyagi, Consultant Vigyan Prasar, Dr. Nitin Kumar Jain, Scientist F, DBT, and many others.

12. VIGYANIKA

The Science Literature Festival ‘Vigyanika’ at IISF2022 is a platform where science mingles with art and literature for lively and easy comprehension. It was a unique way to promote science and in still scientific temper among the masses through scientific literature, science poetry, drama, and folk art. During the Viganika Festival Dr N Kalaiselvim Director General, CSIR, India stresses the importance of using native language as it is the most effective mode of communication for impact and development at grassroots level.

Also, during IISF- 2022 two books of Vigyan Prasar and two of NISPER were released at Vigyanika Science Literature Festival at MANIT Bhopal.

13. YOUNG SCIENTISTS CONFERENCE

At Young Scientist’s Conference “It was a perfect mix of minds and magic”. During the IISF 2022, prominent scientists enlightened the younger generation with futuristic ideas.

Eminent scientists & professors participate in a Panel discussion at the Young Scientists Conference IISF2022. Numerous poster presentation on display by young scientists across the country at Young scientist’s conference IISF2022.

14. SCIENCE THROUGH GAMES AND TOYS

The event “Science with Games and Toys” coincided with the 8th edition of the India International Science Festival (IISF) 2022, which had the theme “Marching towards Amrit Kaal with Science, Technology, and Innovation.” In the curtain raiser program, Dr Ajay Sood, the Principal Scientific Advisor to the Govt. of India, stressed the need to integrate science with our thinking process, celebrating it as a festival, and suggested distributing games and toys in schools. ‘It will enable the students to learn its technology with a hands-on experience in a scientific manner,’ said Dr. Sood

Science and math were taught at the event using homemade toys and games. It brought together professors and scientists to help understand science in a new way while also carrying students to their childhood memories.

15. NEW FACE TO FACE FRONTIERS IN SCIENCE

Dr. Krishna M. Ella, Executive Chairman Bharat Biotech International Ltd. at IISF advises students to keep their mind open to innovate during QA session at Face to Face with New Frontiers in Science. Dr. Krishna M. Ella concluded his session with 7-point formula for effective career at Face to Face with New Frontiers in Science in this session.

“The opportunities of New Space to be grabbed by the young generation ” said Dr S. Somanath, Chairman, ISRO at Face to Face with New Frontiers in Science event at MANIT, Bhopal. New Face to face Frontiers in Science session became remarkable after the MOU signed between ISRO & Vijnana Bharati for joint Nation-wide Space Science outreach Program “Space on Wheels”.

CONCLUSION

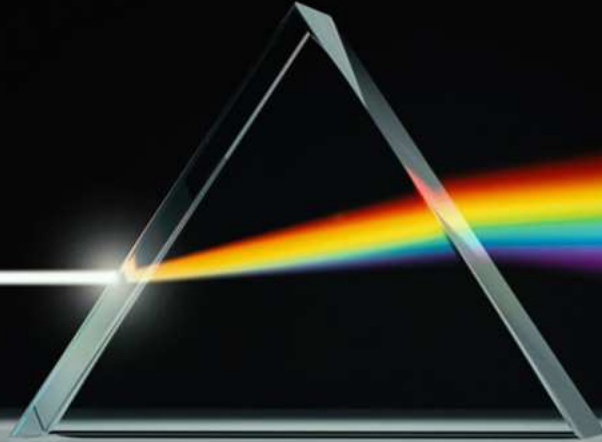
During the closing ceremony of the India International Science Festival 2022, Shri Narendra Singh Tomar addressed the valedictory ceremony. He emphasized the connection between “Jai Jawan, Jai Kisan, Jai Vigyan, and Jai Anushandhan”. He also spoke on efforts by Govt of India to enable the S&T Ministry to work extensively on



numerous thematic areas by significantly increasing the funding resources while Shri Om Prakash Sakhlecha addressed the gathering and said "This festival will pour many more new young science thinkers from here "

IISF 2022 not only turned out to be joyful and entertained science festival for students and young learners but it was also a full educating and enlightening session for everyone. Through its creative programs and activities, IISF provided opportunities to people and scientific fraternity in the country and abroad to come together, work together and experience the joy of doing science for the sound knowledge on India and Science Space together as a whole.

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SIR C. V. RAMAN
(7 November 1888 - 21 November 1970)

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