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National Innovations on Climate Resilient Agriculture

Climate Resilient Crop Varieties for Sustainable Food Production under Aberrant Weather Conditions

M Maheswari, B Sarkar, M Vanaja, M Srinivasa Rao, Ch Srinivasa Rao, B Venkateswarlu, AK Sikka

ICAR-Central Research Institute for Dryland Agriculture, Hyderabad
Natural Resource Management Division
Indian Council of Agricultural Research, New Delhi

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M Maheswari, B Sarkar, M Vanaja, M Srinivasa Rao, Ch Srinivasa Rao, B Venkateswarlu and AK Sikka

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E-mail: director@crida.in

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डा. एस. अय्यप्पन
सचिव एवं महानिदेशक
Dr. S. AYYAPPAN
SECRETARY & DIRECTOR GENERAL

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GOVERNMENT OF INDIA
DEPARTMENT OF AGRICULTURAL RESEARCH & EDUCATION
AND
INDIAN COUNCIL OF AGRICULTURAL RESEARCH
MINISTRY OF AGRICULTURE, KRISHI BHAVAN, NEW DELHI 110 001
Tel.: 23382629; 23386711 Fax: 91-11-23384773
E-mail: dg.icar@nic.in

FOREWORD

Climate change and climate variability are emerging as major challenges to Indian agriculture. Building resilience of the farming community to face climate variability and extreme weather events is the key to ensure food and nutritional security for growing population under changing climate. Abiotic stresses such as droughts, floods, cyclones, unseasonal rains, heat and cold waves individually and in combination are major factors limiting crop production. In view of these factors, identifying stress tolerant genotypes with consistently high yields for different agro-ecological zones in the country is an urgent priority. Climate resilient crop varieties play a crucial role in coping with climate variability in agriculture, along with other adaptation strategies in the area of crop production and efficient management of natural resources. Contingency planning and implementation is the key to counter the adverse effects of climate change and in this context, cultivation of varieties tolerant to various stresses is vital.

Indian National Agricultural Research System (NARS), including various ICAR Institutes and State Agricultural Universities, has been making concerted efforts over the past several decades for developing improved genotypes in different crops with enhanced tolerance to various abiotic stresses to cope with weather aberrations. These efforts have resulted in successful adoption of such varieties tolerant to drought, flooding, heat and other stresses in various regions across the country. This publication attempts to present information on available crop varieties that are suitable for cultivation under stresses like drought, heat, cold, salinity and flooding with details on agro climatic zones and the possible sources of seed availability. Strategies to ensure access to resilient crop varieties have been dealt in the document with focus on institutional interventions such as community seed banks and seed villages.

Focused efforts on developing genotypes with enhanced tolerance to various abiotic stresses as well as with multiple stress tolerance are being made under the National Innovations on Climate Resilient Agriculture (NICRA) project and also in several other research programmes. These efforts are expected to make available multiple stress tolerant varieties with high yield potential.

I compliment the authors for bringing out this important publication and I am sure that it will be useful to various stakeholders in coping with climate variability.

(S. Ayyappan)

Dated the 6th August, 2015
New Delhi

Acknowledgements

Climate change impacts on agriculture are being witnessed all over the world but countries like India are more vulnerable in view of the huge population depending upon agriculture, excessive pressure on natural resources and poor coping mechanisms. There has been a significant rise in the frequency of extreme weather events in the recent years affecting farm level productivity and adversely impacting stability in food grain availability at the national level. Weather extremes, such as, drought and flood are being experienced in the same season posing serious problems. Suitable technology interventions are of paramount importance to cope with these aberrant weather conditions. National Innovations on Climate Resilient Agriculture (NICRA), a flagship programme of ICAR is being implemented with an aim to enhance resilience covering all spectrum of Indian agriculture. In this project, the technologies available with NARS to cope with climate variability are being demonstrated on farmers' fields in vulnerable districts across the country. The use of drought/submergence/heat/cold/salinity tolerant varieties during aberrant weather situations is one of the key interventions in this project.

In this context, the NICRA High level monitoring committee chaired by the Hon'ble Secretary, DARE and Director General, ICAR recommended that a comprehensive list of crop varieties possessing tolerance to climatic stresses may be compiled and made available. Accordingly, a list of varieties of major crops possessing tolerance to abiotic stresses for different zones across the country has been prepared with valuable inputs from various Institutes/AICRPs/SAUs in the country.

The authors thank the guidance and encouragement received from Hon'ble Director General, ICAR, DDG (NRM), DDG (Crop Sciences) and DDG (Horticulture Sciences). The authors place on record their sincere gratitude to all the Vice Chancellors of State Agricultural Universities for valuable information regarding the varieties tolerant to various abiotic stresses. The authors thank immensely Dr. JS Chauhan, Assistant Director General (Seed) for valuable inputs and guidance in this task. The valuable contributions of Assistant Director General (Field & Fodder Crops), Assistant Director General (Horticulture Sciences) and Assistant Director General (AAF & CC) are gratefully acknowledged. The contributions and support of all the Directors of ICAR Institutes, Project Coordinators of various AICRPs of ICAR, Directors of Research of various SAUs, Professors and Scientists of different SAUs and ICAR Institutes and Senior Officers of NRM Division, ICAR are gratefully acknowledged. It is our earnest desire that this list of varieties tolerant to various abiotic stresses would be useful to all the concerned to cope with weather aberrations. The list needs periodical updating with inclusion of newly available varieties. The authors acknowledge the support received from 'National Innovations on Climate Resilient Agriculture' (NICRA) project.

CRIDA, Hyderabad
Date : 6th August, 2015

Authors

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Introduction

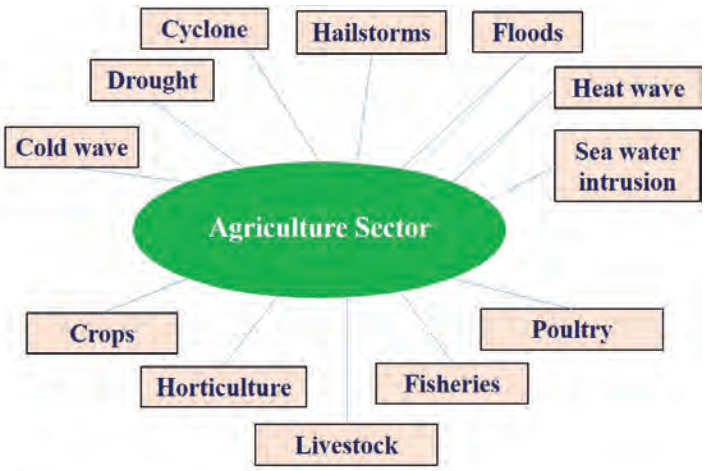
India's agricultural growth has been phenomenal over last four decades as the country moved from severe food crisis before 1960's to self-sufficiency and surplus food grain production. Most of this increase in agricultural output could be attributable to green revolution under irrigated environments. In the early stages of the green revolution, the area under cultivation increased rapidly. However, it is no longer increasing and in fact there is a decline in the last two decades owing to urbanization and rapid industrialization. Currently the country is facing a challenge of producing adequate food to meet the demands of ever increasing population from shrinking natural resource base. Intensification of agriculture through enhanced productivity and resource use efficiency has to be the main focus as competition for land and water are increasing from non-farm sectors. Further in recent years climate change and its variability are emerging as major challenges to Indian agriculture. In view of these, immediate thrust is needed on enhanced production with reduced natural resources under a variable climate. On the other hand, over the past several decades the productivity levels under rainfed condition has not increased substantially as these areas are constrained by various abiotic stresses and other issues (Srinivasa Rao et al., 2015). Agriculture in India is predominantly rainfed with nearly 58% of the total cultivated area and contributes about 40% of the country's food production (Venkateswarlu and Prasad, 2012). In addition to the temporal variation of the environment, there is also a large spatial variation in the rainfed belt. Feeding the ever-increasing population remains an uphill task with this rapid increase in population along with climatic adversities.

Identifying stress tolerant cultivars for different agro-ecologies of the country appears to be the major challenge to increase the productivity in order to meet the demand of more food. Tolerant crop varieties with consistently higher yields under deficit and excessive rainfall and other abiotic stresses, such as temperature extremes, salinity etc. is of paramount importance. Further, integrated and efficient agronomic management strategies including optimal time of sowing, nutrient and pest management strategies contribute immensely for realizing the maximum genetic potential.

Climate change and Agriculture

In recent years climate change and its variability are emerging as major challenges to Indian Agriculture. The projections of global climate change include altered

average temperatures, rainfall, and increased extreme events (e.g., heat and cold waves, flooding), enhanced atmospheric carbon dioxide and ground-level ozone concentrations and rise in sea level leading to inundation of coastal areas etc. In recent past it is more evident, as one or the other part in the country is affected by droughts, excessive rains, floods, cyclones, frost, heat wave and other climatic events. The 4th and 5th IPCC reports clearly outlined the global and regional impacts of projected climate change on agriculture, water resources, natural ecosystems and food security. Although, climate change impacts are being witnessed world over, the countries in which larger population is dependent on agriculture, such as India, are more vulnerable. The risks are likely to be experienced more by small and marginal farmers of rainfed and other risk prone regions with poor coping mechanisms.



Weather aberrations impact different sectors of agriculture

The major agents of climate change has been ascribed to the increased levels of greenhouse gases (GHGs) beyond their natural limits due to the uncontrolled activities such as burning of fossil fuels, increased use of refrigerants etc. Agriculture sector also contributes to climate change through emissions of GHGs as well as its expansion to non-agricultural land (e.g., forests) into agricultural land. The increase in frequency of weather aberration is being witnessed in various regions of the country during last 15 years. Recent research indicated that monsoon rainfall in India became more erratic with intense rainfall events and reduced number of rainy days during the latter half of the 20th century thus increasing the risk of drought and flood damage to crops like rice (Auffhammer *et al.,* 2012). The country witnessed

a drought in 2002 with 19% deficit rainfall. There was extreme cold wave in winter 2002-03 leading to frost damage of winter crops. The state of Andhra Pradesh faced three weeks of heat wave during May, 2003. The high temperatures during March 2004, adversely affected crops like wheat, apple and potato across northern India, while there was a drought like situation in July, 2004 with overall deficit rainfall of 13%. The year 2005, witnessed destructive hurricanes/cyclones across the globe with some major floods in India (Venkateswarlu, 2013). During 2006, the states of Rajasthan, Andhra Pradesh witnessed floods while, it was a drought year for North Eastern States of the country. During 2012, wide spread drought was reported in the states of Punjab, Haryana, Gujrat and Karnataka while cyclone Neelam hit east coast of the country including severe flood in Andhra Pradesh. The year 2014 was yet another year that witnessed number of natural calamities including hailstorms, early season dry spells; devastating floods in Kashmir and Hudhud cyclone in coastal Andhra Pradesh. The increase in frequency of heavy rainfall events in last 50 years over Central India points towards a significant change in climate pattern in India (Goswami, 2006).

Impact of weather aberrations on crops

Climate change will have negative effects on irrigated crops yield across regions in India both due to temperature rise and changes in water availability. While rainfed agriculture primarily impacted due to rainfall variability and reduction in number of rainy days (Venkateswarlu and Shankar, 2012). Shifts in seasons, increase in temperatures and change in rainfall pattern are already being observed. In view of these, the crops may encounter extreme weather events like drought, flood, heat and cold during its life cycle, resulting in substantial yield losses. The impacts of these may vary with region, crop and cropping systems, soils and management practices. The yield reductions are likely to be caused by shortening of growing period, negative impacts on reproduction, grain filling and decrease in water availability at critical growth stages. The negative impacts due to terminal heat in the month of January/February, increased water stress and reduction in number of rainy days on yield of wheat and paddy are already being felt (Rao and Bapuji Rao, 2013). Climate change impacts the crop yields both directly and indirectly. The direct effects are mainly due to change in crop duration and impacts reproductive processes such as pollination and fertilization. While the indirect effect are largely due to changes in water availability, altered pest, disease and weed dynamics. The impacts of climate

change on all crops is obviously not similar, as the model outputs reveal that the yields of wheat, rice and maize will decrease while it could be neutral or positive with groundnut, soybean and chickpea (Aggarwal, 2008).

Rainfed crops are more vulnerable to climate change because of the limited options for coping with variability of rainfall and temperature. This will result in shift in sowing time and shorter growing season, which may necessitate effective adjustment in sowing and harvesting dates. Frequent and more intense extreme events may become the norm of the day for common farming community (IPCC 2013). Despite making substantial progress in post-independence to bring more areas under irrigation, the fact remains that >58 % of cultivated area in India is still under rainfed. It is estimated that even after achieving the full irrigation potential, >50% of the net cultivated area will remain dependent on rainfall (Sharma, 2011, Srinivasa Rao *et al*., 2012). Among various crops, cultivation of coarse cereals (91%), pulses (91%), oilseeds (80%) and cotton (65%) predominates rainfed regions in India. There are various factors that can be affected due to weather aberration, especially in areas under rainfed where more than 80% farmers are small and marginal (having less than 1 ha of land), thus having less capacity to cope with ill effects.

Long dry spells may be of early season, mid-season and terminal drought which affect production adversely (Sharma *et al*., 2006). Early season drought generally occurs either due to delayed onset of monsoon or due to prolonged dry spell soon after the onset of the rainy season. Mid-season drought occurs due to inadequate soil moisture availability between two successive rainfall events during the crop growth period. Late season or terminal drought occurs as a result of early withdrawal of monsoon rains. Water stress at any stage of crop growth cycle will adversely impact the productivity, while terminal droughts are more critical as the reproductive stage is highly sensitive. Water stress, which is mostly, associated with an increase in ambient temperatures results in forced maturity. Drought and heat stress at terminal stage of crop is high in the northern, western and central India, resulting in high yield loss in case of major food crops such as, wheat. This necessitates the real time implementation of contingency plans to overcome the adverse impacts of weather aberration in agriculture. In recent past, this has been demonstrated and realized under actual field conditions through successful adoption of flood tolerant rice varieties like Swarna Sub1 in coastal districts while, drought tolerant and high

yielding groundnut cultivar Narayani in the district of Anantapur, Andhra Pradesh. Similarly in case of wheat, Lok-1 is one the most successful variety grown under heat stress in states of Gujrat, Madhya Pradesh and other areas where crop is exposed to terminal heat stress during post flowering reproductive stages and maturity.

Strategies for coping with weather aberrations in Indian agriculture

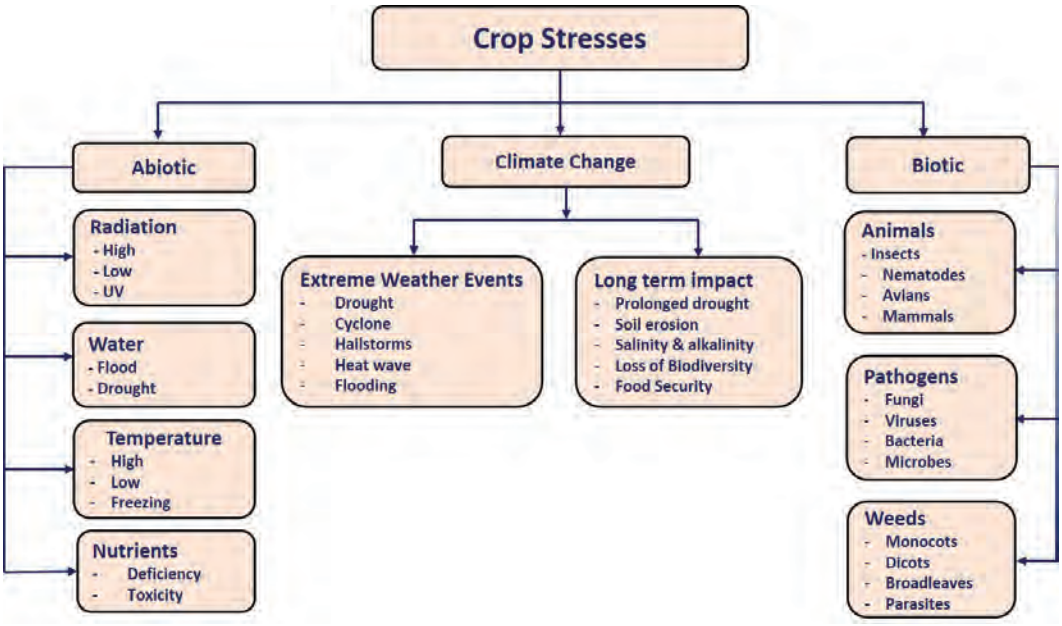
Various adaptation and mitigation strategies including use of climate resilient crops and cultivars for different regions are most essential for agriculture to successfully cope with climate variability. Improved agricultural practices evolved over time for diverse agro-ecological regions in India have potential to enhance climate change adaptation, if deployed carefully (Venkateswarlu *et al*., 2011). Management practices that improve agricultural production under adverse climatic conditions enhance resilience under variable climate and extreme events. Major strategies of adaptation to climate change include water saving technologies such as in-situ and ex-situ moisture conservation, water harvesting for supplemental irrigation, residue incorporation (to avoid it's burning), growing tolerant varieties, conservation agriculture, site specific nutrient management practices etc. Developing and diffusing crop cultivars with tolerance to climatic stresses such as, drought, heat, submergence is of urgent priority. Indeed, climate resilient crop varieties play a crucial role for coping with climate variability in agriculture. Further, strengthening institutional interventions will go a long way in promoting collective action and build resilience among communities.

Plant's response to abiotic stresses is crop and cultivar specific. For example, in case of pigeonpea, higher temperatures will shorten the crop duration so that it matures when the wet season is still active, while, sorghum experiences greater shortening of the vegetative phase relative to the grain-filling phase resulting in increased harvest index. Understanding of photoperiod sensitivity, genetic variation for transpiration efficiency will help in identifying short duration high yielding varieties that escape the terminal drought as well as other impending abiotic and biotic stresses. Indian National Agricultural Research System (NARS) including various ICAR institutes and state agricultural universities are making concerted efforts over the years for developing genotypes of different crops with enhanced tolerance to multiple abiotic stresses which could be utilized by the farming communities in the event of extreme weather situation. Climate resilient crop varieties along with other suitable

adaptation and mitigation strategies will help to overcome the adverse impact of climate change by lowering the yield losses under stress condition.

Climate resilient crop varieties for different abiotic stresses

The development and identification of climate resilient crop varieties, with enhanced tolerance to heat, drought, flooding, chilling and salinity stresses are essential in order to sustain and improve crop yields to cope with the challenges of climate change. It is essential to bridge the yield gaps, enhance the productivity and profitability, minimize risk and improve the livelihoods of millions of people dependent on agriculture. While, abiotic stresses such drought, heat or cold may trigger a series of responses in plants that include changes in gene expression, signal transduction pathways, metabolic and molecular mechanisms as well as cumulative manifestations of these in terms of source and sink relations for adaptation. The major biotic and abiotic stresses affecting crops that limit crop productivity is given in the following figure. Among various abiotic stresses, drought, heat, salinity, cold and flooding are the major factors that adversely affect plant growth and productivity (Maheswari *et al.*, 2012).



All these adverse environmental conditions have potential to drastically reduce yields in warmer regions. To develop stress tolerant cultivars, it is essential to identify the traits that maintain and promote the growth and development of

plants during the stress period (Maheswari *et al*., 2012; Shanker *et al*., 2014). The tolerance to a particular stress is related to the plant's ability to withstand adverse conditions, survive, and reproduce successfully. The tolerance to abiotic stress is manifested in terms of the ability to cope with resource limitation under stress as well as the ability to recover along with high production potential when the stress is relieved. In several crops, the genetic control of both stress tolerance and resource-use efficiency is quantitatively inherited involving many loci distributed in different regions of the genome (Wu *et al*., 2011). Quantifying and understanding the genetic relationship between these two is the key to improve productivity of crops by developing climate resilient varieties. Several crop improvement programs are focused on improving productivity with tolerance to various abiotic stresses *viz*., drought, heat, cold, salinity, flooding etc. The sufficient quantities of quality seeds of climate resilient crop varieties need to be available to the farmers for sustaining the production system and meeting the increasing demand of food grains. The farmer requires cultivars that produce a satisfactory yield when subjected to stress conditions but that have a high productivity potential under favourable conditions.

Crop vareties suitable for cultivation under different abiotic stresses

Drought and delayed monsoon

There have been tremendous advances in understanding the physiology, biochemistry and molecular genetics of plant response to different abiotic stresses. Number of adaptive traits have been studied and used for improvement of drought tolerance like early vigour, osmotic adjustment, leaf senescence, stay green etc. Stay-green trait in plants, usually refer to tolerance against drought-induced post-flowering senescence. Roots also play an important role in the adaptation of several crops to drought stress. Various ICAR institutes and state agricultural universities are making concerted efforts to develop high yielding cultivars of different crops with enhanced tolerance to delayed monsoon and drought over the years which can be utilized by the farming communities. Major food, vegetable and horticultural crop varieties with tolerance to drought stress and delayed monsoon released by various Institutes/ Universities are given in the following tables (Table 1 and Table 2).

Table 1: Crop varieties suitable for cultivation under drought stress

Sl. No.	Varieties	Zone	Sub-Zone	State	Source of seed availability
			Cereals		
Rice					
1	Ashoka-200F	ACZ-IV B	ARS Banswara	Rajasthan	RSSC, Rajasthan
2	Gujarat Nagli-4	ACZ	Very Heavy Rainfall Zone	Gujarat	DRNAU, Gujarat
3	Kalinga, Sahabhagi, IR-36	ACZ-II	Red and Laterite Zone	West Bengal	BCKV, Kalyani
4	Kalinga-2, Kalyani-3, Narendar dhan 97	ACZ-I, ACZ-III	New Alluvial & Coastal Saline Zone	West Bengal	BCKV, Kalyani
5	Pant Dhan 16, Barani, Dhan-1, Aditya, Kalinga-3	ACZ-III & II	NEPZ	Uttarakhand, Chhattisgarh	GBPUA&T, Pantnagar; IGKV, Jabalpur
6	Pradhan, Poornima	ACZ-III	Bastar Plateau	Chhattisgarh	IGKV, Jabalpur
7	Sahbhagi, Sushak Samrat	ACZ-I, II & III	NEPZ & NWPZ, Southern alluvial zone	Bihar	BAU, Sabour
8	Sukara Dhan-I, VL221	ACZ-II	Mid Hills Sub-Humid Zone	Himachal Pradesh	CSKHPKV, Palampur
Wheat					
9	HD2888, K8027	ACZ-I, II, III	North Eastern Plain Zone	Bihar, Eastern UP, West Bengal	BAU, Sabour
10	Sujata, C-306, JWS-17, HI-8627, HI-1531	ACZ-II	Northern Hills	Chhattisgarh	IGKV, Jabalpur
11	HPW-155, HPW-236	ACZ-III	High Hills Temperate Wet Zone	Himachal Pradesh	CSK HPKVV, Palampur
12	VL421, HS277, VL Gehun 829, HPW249, VL907, HS420, HPW236	ACZ-I &II	Northern Hill Zone	Himachal Pradesh	CSK HPKV, Palampur
13	PBW 644, PBW 527, PBW 175	ACZ-I, II, III, IV, V	North Western Plain Zone	Punjab	PAU, Ludhana
14	HI-1500	ACZ-IV A	Sub-humid southern plains and Aravali Hills	Rajasthan	IARI, RS, Indore
15	Raj 3077, Raj 3765, KRL-1-4	ACZ-II-B	Transitional Plan of Luni Basin, Jaipur	Rajasthan	RSSC, Rajasthan
16	UP1109, UP2572	ACZ-I	Northern Hill Zone	Uttarakhand	GBPUA&T, Pantnagar
17	PBW 527, PBW 644, PBW 396		North Western Plain Zone	Punjab, Haryana, UP, Rajasthan	PAU, Ludhiana
18	HI 1531 and HI 8627		Central Zone	MP, Rajasthan	IARI, Indore

Sl. No.	Varieties	Zone	Sub-Zone	State	Source of seed availability
19	DBW 110, MP 3288, MP 3173, HI 1531, HI 1500		Central Zone	MP, Rajasthan	DWR, Karnal; IARI, Indore; JNKVV, Jabalpur
20	NIAW 1415, HD 2987, HD 2781		Peninsular Zone	Karnataka, Maharashtra	MPKV, Niphad; IARI New Delhi
21	WH 1080, HD 3043		North Western Plain Zone	Punjab, Haryana, UP, Rajasthan	CCS HAU, Hisar; IARI, New Delhi
Maize					
22	Suwan	ACZ-I	North eastern plain zone	Bihar	BAU, Sabour / RAU, Pusa
23	HQPM-5, HQPM-1	ACZ-III	Bastar Plateau	Chhattisgarh	IGKV, Raipur
24	Vivek-21, Vivek-9	ACZ-II	Northern Hills	Chhattisgarh	Private dealers/ sectors
25	Nithyashri, Hema (NAH-1147)	ACZ-IV, V, VI	Central, Eastern, Southern Dry Zone	Karnataka	NSP, GKVK, UAS(B) / KSSC/NSC
26	PMH-2, Parkash	ACZ-III	Central Plain Zone	PUNJAB	PAU, Ludhiana
27	Mahi Dhawal	ACZ-IV B	ARS Banswara	Rajasthan	RSSC, Rajasthan
25	PEHM-1, Pratap Makka-5, Pratap Makka-3, Pratap Hybrid Makka-1	ACZ-IV A	Sub-humid southern plains and Aravali Hills	Rajasthan	IARI, New Delhi
26	HM 4		North Western Plain Zone and Southern Zone	Haryana, UP, AP, Maharashtra	CCS HAU, Karnal
Pearl millet					
27	GHB-538 and GHB-719	ACZ-III, IV, V, VI, VII & VIII	Middle, North Gujarat, South Shurashtra	Gujarat	JAU, Jamnagar
28	WCC-75	ACZ-IV, VI	Central and Southern Dry Zone	Karnataka	GKVK, UAS(B)/ KSSC / NSC
29	Raj-171	ACZ-II-A	Fatehpur	Rajasthan	RSSC, Rajasthan
30	GHB-538, RHB-177	ACZ-I-A, I-C	Arid Western Plains, Hyper arid and Western Plains	Rajasthan	RSSC, GSSC, NSC
31	HHB-67(I), RHB-177	ACZ-II-B	Plan of Luni Basin, Jaipur	Rajasthan	RSSC, Rajasthan
32	RBH-177, RBH-154, RBH-173	ACZ-III-A	Semi-arid Eastern Plains, Jaipur	Rajasthan	RSSC, Rajasthan

Sl. No.	Varieties	Zone	Sub-Zone	State	Source of seed availability
33	HHB-234, HHB-226, HHB-216, Bio 70 (MH 1632), RHB-177, RHB-154, GHB-757, GHB-719, GHB-538, CZP 9802	ACZ-I	North Western Plain Zone, West zone	Western Rajasthan, Gujarat & Haryana	CCS HAU, Hisar; Bioseed Pvt Ltd; ARS Durgapura; AICPMIP MRS Jamnagar; CAZRI Jodhpur
Barley					
34	PL-419	ACZ-I, II, III, IV, V	North Western and Eastern Plain Zone	Punjab	PAU, Ludhiana
35	K603	NEPZ	North Eastern Plain Zone	UP, Bihar	CSAUAT, Kanpur
36	RD2660	ACZ-IV	North Western Plain Zone	Rajasthan, UP, Haryana	ARS, Durgapura
Foxtail millet					
37	RS-118, K-211-1, PS-4, SIA-326	ACZ-IV, VI	Central & Southern Dry Zone	Karnataka	GKVK, UAS(B)/ KSSC / NSC
Finger millet					
38	VR-708 (Padmavati), HR-374	ACZ-III	Bastar Plateau	Chhattisgarh	IGKV / NRC millets Bangalore
39	MR-1, MR-6, GPU-66, GPU28, KMR-301, ML-365	ACZ-V,VI, IV	Central, Eastern, Southern Dry Zone	Karnataka	GKVK, UAS(B) / KSSC
40	Phule Nachani	ACZ	Sub montane Ghat Zone of Maharashtra State	Maharashtra	MPKV, Rahuri; ZARS, Kolhapur, Maharashtra
Sorghum					
41	CSH-5, CSH-9, CSV-4, DSV-2	ACZ-VI	Southern Dry Zone	Karnataka	GKVK, UAS(B)/ KSSC / NSC
42	Parbhani Moti	ACZ-I	Marathwada Region	Maharashtra	VNMKV, Parbhani
43	CSV-17	ACZ-IV A	Sub-humid southern plains and Aravali Hills	Rajasthan	ARS, Udaipur
44	Pant Chari 5, Pant Chari 7	ACZ-I	Northern Hill Zone	Uttarakhand	GBPUA&T, Pantnagar;
45	M-35-1, Phule Chitra, Phule Vasudha, Phule Panchami, CSH19R, CSV 18		Rabi Sorghum growing area	Maharashtra	MPKV, Rahuri

Sl. No.	Varieties	Zone	Sub-Zone	State	Source of seed availability
			Sugar Crops		
Sugarcane					
1	Co 86032, Co 85019, Co 94008, Co 94012, Co 99004, Co 2001-13, Co 0218, Co 0403 and Co 06027		Peninsular Zone of India	Tamil Nadu, Karnataka, Maharashtra	SBI, Coimbatore
2	Co 2001-15, Co 98014, Co 0238, Co 0118, Co 0124, Co 0239		Northern Zone	UP, Haryana, Punjab, Bihar	SBI RS, Karnal, Lucknow
			Pulses		
Blackgram					
1	BDU-1	ACZ-II	Marathwada Region	Maharashtra	VNMKV, Parbhani
Chickpea					
2	JG-14, Indira Chana, JG-315, JG-11	ACZ-I	Chhattisgarh Plains Zone	Chhattisgarh	IGKV farm/ Private sector
3	JG-11, C101, ICCV10	ACZ-VI	Southern Dry Zone	Karnataka	GKVK, UAS(B)/ KSSC / NSC
4	JG 16, JAKI 9218, JG 6, JG-11, RVG 201, RVG 202, RVG 203	ACZ-I, II, III, IV, V, VI	Vindhya Plateau Zone, Bundelkhand, Malwa Plateau Zone	Madhya Pradesh	RVSKVV, Gwalior
5	BDN-9-3	ACZ-III	Marathwada Region	Maharashtra	Seed Processing Plant VNMKV, Parbhani
6	PDG 3, PDG 4	ACZ-IV & V	Western Plain Zone	Punjab	PAU, Ludhiana
7	Pratap chana-1	ACZ-IV B	ARS Banswara	Rajasthan	RSSC
8	Pratap chana-1, RSG-973 (Aabha), RSG-991	ACZ-IV A	Sub-humid Southern plains and Aravali Hills	Rajasthan	ARS, Banswara, Rajasthan
9	RSG 888, GNG 663, RSG14, RSG44	ACZ-I & I-B	North West Plain Zone of Rajasthan	Rajasthan	NSC, RSSC, NSP
10	Raj Vijay Gram 202 (RVG 202), JSC 55, JSC 56	ACZ-I, II, III, IV, V, VI	Central Zone	M.P., Maharashtra, Gujarat, Rajasthan, U.P.	RVSKVV, Gwalior
Field bean					
11	HA-4	ACZ-IV, V, VI	Southern Zone	Karnataka	GKVK, UAS(B)/ KSSC / NSC
Greengram					
12	RMG-268	ACZ-IV A	Sub-humid Southern plains and Aravali Hills	Rajasthan	ARS, Durgapura, Jaipur

Sl. No.	Varieties	Zone	Sub-Zone	State	Source of seed availability
Horsegram					
13	CRIDA-18R, CRHG-4, CRHG-19		Southern zone	AP, Karnataka, TN and Kerala	CRIDA, Hyderabad
14	PHG-9	ACZ-IV	Central Dry Zone	Karnataka	GKVK, UAS(B)/ KSSC / NSC
15	Dapoli Kulthi-1	ACZ-I, II	North, South Konkan zone	Maharashtra	BSKVV, Dapoli
14	AK-21, Pratap Kulthi-1 (AK-42), GC3	ACZ-IV A	Sub-humid southern plains and Aravali Hills	Rajasthan	DFRS, Arjia, Bhilwara
Lathyrus					
15	Mahateoda, Prateek	ACZ-I	Chhattisgarh Plains Zone	Chhattisgarh	IGKV farm / Private sector
Lentil					
16	JL-3, RVL-31, Vamban	ACZ-I, II, III, IV, V, VI	Vindhya Plateau Zone, Gird Zone, Bundelkhand, Malwa Plateau Zone	Madhya Pradesh	RVSKVV, Gwalior
Moth bean					
17	RMO-40, RMO-225, RMO-425, RMO-297, CZM1, CZM2, CZM3	ACZ-I-A, I-C	Arid Western Plains, Hyper arid and Western Plains	Rajasthan	RSSC, NSC, SKRAU, Bikaner
Pigeonpea					
18	Rajeev Lochan, Asha, UPAS-120, Paras	ACZ-I	Chhattisgarh Plains Zone	Chhattisgarh	IGKV farm / Private sector
19	Number-148, C-11, Paras	ACZ-III	Bastar Plateau	Chhattisgarh	IGKV seed farm/ Research station
20	TTB-7, BRG-1, BRG-2	ACZ-IV, V, VI	Central Zone & Southern Zone	Karnataka, AP	GKVK, UAS(B)/ KSSC / NSC
21	Paras	ACZ-I, II, III, IV, V, VI	Vindhya Plateau Zone, Bundelkhand, Malwa Plateau Zone	Madhya Pradesh	RVSKVV, Gwalior
22	BDN-711, BDN-708, Paras	ACZ-I	Marathwada Region	Maharashtra	Seed Processing Plant VNMKV, Parbhani
23	ICPL-87, ICPL-151, Paras	ACZ-IV A	Sub-humid Southern plains and Aravali Hills	Rajasthan	IIPR, Kanpur; ICRISAT, Hyderabad
Oilseeds					
Brassica (Brown Sarson)					
1	KBS-3	ACZ-II	Mid Hills Sub-Humid Zone	Himachal Pradesh	CSKHPKVV, Palampur
Brassica (Rapeseed & Mustard)					
2	Aravali, RGN-48, RB-50	ACZ-III-B	Flood Prune Eastern Plains, Navgaon (Alwar)	Rajasthan	ARS, Navgaon; RSSC, Rajasthan

Sl. No.	Varieties	Zone	Sub-Zone	State	Source of seed availability
3	RGN 48	ACZ-IV A	Sub-humid Southern plains and Aravali Hills	Rajasthan	ARS, Ganganagar, Rajasthan
4	Pant Rai 20	ACZ-II	Northern Western Plain Zone	Uttarakhand	GBPUA&T, Pantnagar
Brassica (Raya)					
5	RCC-4	ACZ-I	Sub-Montane & Low, Mid Hills Sub-Tropical Zone	Himachal Pradesh	CSKHPKV, Palampur
Castor					
6	DCS-9 (Jyothi), Jwala	ACZ-IV, V, VI	Southern Zone	Karnataka	GKVK, UAS(B)/ KSSC / NSC
Groundnut					
7	GG-2 and GG-5, ICCV9114	ACZ-II	South Gujarat	Gujarat	JAU, Junagadh
8	JL-24, TMV-2, KCG-2, GPBD-4, ICGV-91114, GG5, IGN3	ACZ-IV, V	Central and Eastern Dry Zone	Karnataka	GKVK, UAS(B)/ KSSC / NSC
9	GG5	ACZ-II, III, V	Bundelkhand, Nimar Valley	Madhya Pradesh	RVSKVV, Gwalior
10	LGN-1	ACZ-III	West zone	Maharashtra	Oilseeds Research Station, Latur
11	Kadiri 5, Kadiri 9	ACZ-V	Southern Zone	Andhra Pradesh	ANGRAU, Kadiri
12	Abhaya, Greeshma, Narayani , Dharani	ACZ-V	Southern Zone	Andhra Pradesh	ANGRAU, Tirupati
13	ICGV 91114		Southern Zone	Andhra Pradesh	ICRISAT, Hyderabad
14	K 134	ACZ-V	Southern Zone	Andhra Pradesh and Tamil Nadu	ANGRAU, Kadiri
15	TMV 13		Southern Zone	TN	TNAU, Coimbatore
16	ICGS 5	ACZ-I	North Western Plain Zone	UP, Bihar, Haryana, Punjab and Rajasthan	ICRISAT, Hyderabad
17	JGN 3, JGN 23		Central Zone	MP	JNKVV, Khargone, MP
18	CSMG 84-1	ACZ-I	North Western Plain Zone	UP, Rajasthan, Haryana	CSAUAT, Kanpur

Sl. No.	Varieties	Zone	Sub-Zone	State	Source of seed availability
Karan Rai					
19	Jayanti	ACZ-I, II	Low Hills Sub-Tropical Zone, Mid Hills Sub-Humid Zone	Himachal Pradesh	CSK HPKV, Palampur
Linseed					
20	R-552, RLC-78, RLC-81, RLC-92	ACZ-I	Chhattisgarh Plains Zone	Chhattisgarh	IGKV, Jabalpur
21	Nagarkot, Himani	ACZ-I, II	Low Hills Sub-Tropical Zone, Mid Hills Sub-Humid Zone	Himachal Pradesh	CSK HPKV, Palampur
Safflower					
22	PBNS-40, PBNS-12, PhuleKusum	ACZ-I	Marathwada Region	Maharashtra	VNMKV, Parbhani
Sesame					
23	G.Til-4	ACZ-VII	North Shurashtra	Gujarat	ARS, JAU, Amreli
Soybean					
24	JS-80-21, Indira Soya-9, Ahilya, JS 71-05, NRC -7	ACZ-I	Chhattisgarh Plains Zone	Chhattisgarh	IGKV farm / Private sector
Sunflower					
25	KBSH-44, KBSH-53	ACZ-IV, VI	Central, Southern Dry Zone	Karnataka	GKVK, UAS(B)/ KSSC / NSC
25	LSPH-35 (Hv)	ACZ	Central Maharashtra (Plateau zone)	Maharashtra	Oilseeds Research Station, Latur, Maharashtra
Toria					
26	Bhawani	ACZ-I	Sub-Montane & Low Hills Sub-Tropical Zone	Himachal Pradesh	CSKHPKV, Palampur, HP
			Fibre Crops		
Cotton					
1	G. Cot-18	ACZ-VI, VII	North Shurashtra	Gujarat	Cotton Research Station, JAU, Junagadh, Gujarat
2	PhuleAnmol (RAC 024)		Rainfed, Khandesh region of Maharashtra	Maharashtra	MPKV, Rahuri, Maharashtra
3	SVPR 4		Tamil Nadu	Tamil Nadu	Cotton Research Station, Srivilliputhur, TN

Sl. No.	Varieties	Zone	Sub-Zone	State	Source of seed availability
Jute (*C. capsularis*)					
4	JRC-80, JRC-7447, JRC -212	ACZ-II, III,IV	North Eastern Plain Zone	Assam, North Bengal, UP	CRIJAF, Barrackpore
5	JRO- 524, JRO-204	ACZ-I, III,II,IV,V	New Alluvial Zone, Coastal Saline Zone, All jute growing states	West Bengal	BCKV, Kalyani; CRIJAF, Barrackpore
6	JRC 80, JRC 7447, JRC 212	ACZ II, III, IV		Assam, North Bengal, UP	CRIJAF, Barrackpore, WB
Tossa jute (*C. olitorius*)					
5	JRO 524, JRO 204,	ACZ II, III, IV, V	All India	All jute growing states	CRIJAF, Barrackpore, WB
Roselle (*H. sabdariffa*)					
6	GR 27, HS 4288, HS 7910	ACZ XI	Odisha, AP, Maharashtra, Tamil Nadu	Odisha, AP, Maharashtra, Tamil Nadu	CRIJAF, Barrackpore, WB
7	AMV 5, AMV 7	ACZ XI	Odisha, AP, Maharashtra, Tamil Nadu, Karnataka	Odisha, AP, Maharashtra, Tamil Nadu, Karnataka	ARS Amadalavalasa, AP
Mesta (Roselle)					
8	GR-27, HS-4288, HS-7910	ACZ-XI	Odisha, AP, Maharashtra, Tamil Nadu	Odisha, AP, Maharashtra, Tamil Nadu	CRIJAF, Barrackpore, WB
9	AMV-5, AMV-7	ACZ-XI	Odisha, AP, Maharashtra, Tamil Nadu, Karnataka	Odisha, AP, Maharashtra, Tamil Nadu, Karnataka	ARS, Amadalavalasa, AP
Fodder Crops					
Anjan grass/ Buffalo grass					
1	Marwar Anjan (CAZRI-75)		Arid and semi-arid areas in the country		CAZRI, jodhpur
2	Bundel Anjan-1, Bundel Anjan-3	All zones	All zones	All over India	IGFRI, Jhansi
3	Kolukkattai grass CO-1		Southern Zone	Tamil Nadu	TNAU Coimbatore
Sorghum					
4	Haryana Chari-171	All sorghum growing areas	All over country	-	HAU, Hisar

Sl. No.	Varieties	Zone	Sub-Zone	State	Source of seed availability
5	Haryana Chari-308	All sorghum growing areas	All over country	-	HAU, Hisar
6	CO-27	South zone	Tamil Nadu	Tamil Nadu	TNAU, Coimbatore
7	CO(FS)-29	South zone	Tamil Nadu	Tamil Nadu	TNAU, Coimbatore
8	Pusa Chari-9	All India	Single cut in India	Two cut in Gujarat	IARI, New Delhi
9	Pusa Chari-1	All India	Northern region	-	IARI, New Delhi
10	Pusa Chari-23	All India	Sorghum growing areas	Maharashtra & Gujarat	IARI, New Delhi
Rice bean					
11	Bidhan-1, Bidhan-2, Bidhan-3		North Eastern Region	WB, Orissa, Jharkhand, Assam, Sikkim, Mizoram, Manipur, Nagaland & Bihar	BCKV, Kalyani
Pearl millet-Napier (Fodder)					
12	BN Hybrid CO-1		Southern Zone	Tamil Nadu	TNAU, Coimbatore
13	NB-37	Hill Zone	Northern Hill Zone	Himachal Pradesh	CSKHPKVV, Palampur
14	Yeshwant			Maharashtra	MPKV, Rahuri
15	KKM-1	South zone	Southern zone of TN	TN	TNAU, Coimbatore
16	PBN-83	North West Zone	Punjab	Punjab, Haryana, & HP	PAU, Ludhiana
Cowpea (Forage)					
17	Type -2 , Bundel Lobia -1	All zones	All zones	All over India	IGFRI, Jhansi
18	GFC-2	All zones	All zones	All over India	GAU, Banaskantha
19	EC-4216	All zones	All zones	All over India	IARI, New Delhi
20	MFC-09-1		South zone	South zone	UAS, Mandya
21	HFC -42-1, C-88		North Zone	Haryana	HAU, Hisar
22	EC-4216	All India	All India		IARI, New Delhi
Dhaman grass / Bird wood grass					
23	Marwar Dhaman (CAZRI-76)		Arid and semi-arid areas	Rajasthan	CAZRI, Jodhpur

Sl. No.	Varieties	Zone	Sub-Zone	State	Source of seed availability
24	Jawahar Pennisetum-12		Central Zone	MP, Chhattisgarh	JNKVV, Jabalpur
25	Bundel-1, Bundel Dinanath-2	All zones	All zones	All over India	IGFRI, Jhansi
26	CO-1		Southern Zone	Tamil Nadu	TNAU, Coimbatore
Forage Cowpea					
27	UPC 9202	ACZ-III	Central Zone	Uttarakhand	GBPUA&T, Pantnagar
28	UPC 628	ACZ-III	Central Zone	Uttarakhand	GBPUA&T, Pantnagar
Guinea grass					
29	Bundel Guinea-2, JHGG-08-1, RSDGG-1		All Zones	All over India	IGFRI, Jhansi; SRSS, Dharward
30	Haritha, Makueni	South Zone	Southern Zone	Kerala	KAU, Vellayani; KLDB, Pattom
31	Bundel Guinea-2	All India	Humid, Arid, tropical & sub-tropical	Rainfed condition all over country	IGFRI, Jhansi
32	Riversdale	South Zone	Uplands & Homesteads in Kerala, Tamil Nadu & AP	Kerala, Tamil Nadu & AP	Kerala Livestock Development Board, Trivandrum
Niger					
33	KBN-1, JNC1, JNC6, JNC9	ACZ-IV, V, VI	Central, Eastern, Southern Dry Zone	Karnataka	GKVK, UAS(B)/ KSSC / NSC
34	PNS-6, JNC1, JNC6, JNC9	ACZ-I	Scarcity zone of Marathwada Region	Maharashtra	VNMKV, Parbhani
Setaria grass					
35	Setaria-92, S-18, PSS-1, Nandi		Northern Hill Zones	Himachal Pradesh, Uttarakhand	CSKHPKVV, Palampur
Tall Fescue					
37	Tall Fescue				
38	Hima-4	Hill Zone	Temperate grasslands of HP	HP	CSKHPKV, Palampur
39	EC-178182	Hill Zone	Temperate & sub temperate grasslands of HP	HP	CSKHPKV, Palampur

Sl. No.	Varieties	Zone	Sub-Zone	State	Source of seed availability
			Fruits		
Apple					
1	York Imperial	ACZ-III	Temperate & Warm Temperate Zone	Jammu & Kashmir	SKUA&T-Jammu
Apricot					
2	Badami, Inzhirnyl, Rannil	ACZ-II	Intermediate Zone	Jammu & Kashmir	SKUA&T-Jammu
Banana					
3	Karpuravalli (ABB)		Southern Zone	Southern A.P., Northern Karnataka	NRC Banana, Trichy, Kerala
Ber					
4	Sev, Gola, Umran	ACZ-I-C	Hyper arid and Western Plains	Rajasthan	CIAH-Bikaner
5	Seb, Mudia, Jogia, Gola	ACZ-I	Sub-Tropical Zone	Jammu & Kashmir	SKUA&T-Jammu
6	Sev, Gola	ACZ-II-B	Transitional Plain of Luni Basin, Jaipur	Rajasthan	CAZRI, Jodhpur; CIAH, Bikaner
Citrus					
7	Mosambi	ACZ-I	Sub-Tropical Zone	Jammu & Kashmir	SKUA&T, Jammu
Water Melon					
8	Durgapura, Madhu, Durgapura kesher	ACZ-II-A	Fatehpur (Sikar)	Rajasthan	NSC & RSSC
Guava					
9	Allahabad Safeda, Lucknow-49	ACZ-I	Sub-Tropical Zone	Jammu & Kashmir	SKUA&T, Jammu
Mango					
10	Arka, Neelachal, Kesari		Coastal regions of Orissa and A.P.	Orissa and A.P.	CHES, IIHR, Bhubaneswar
11	Sinduri	ACZ-II-B	Luni Basin, Jaipur	Rajasthan	Anand, Gujrat
12	Jalore seedless / Sindhuri	ACZ-I-A, I-C	Arid Western Plains, and Western Plains	Rajasthan	CIAH, Bikaner; Anand, Gujrat
			Vegetables		
Ash gourd					
1	Kashi Dhawal		North Eastern Plain Zone	Uttar Pradesh, Bihar, Delhi	IIVR, Varanasi

Sl. No.	Varieties	Zone	Sub-Zone	State	Source of seed availability
Bottle gourd					
2	Thar Samridhi	ACZ-I & ACZ-I-C	North Western Plain Zone	Rajasthan	CIAH, Bikaner
3	Kashi Ganga		NEP North Eastern Plain Zone	Uttar Pradesh	IIVR, Varanasi
Brinjal					
4	PKM-1	ACZ-VI	Southern Zone	Tamil Nadu	HC & RI, Periyakulam
5	Kashi Sandesh, Kashi Taru		North Eastern Plain Zone	Uttar Pradesh, Bihar, Jharkhand	IIVR, Varanasi
Carrot					
6	Ooty-1	ACZ-V	High altitude zone	Tamil Nadu	Horticultural Research Station, Ooty
Cassava					
7	Shri Sahya	ACZ-III	Bastar Plateau	Chhattisgarh	IGKV, Raipur
Chillies					
8	Samrudhi	ACZ-V	Eastern Dry Zone	Karnataka	GKVK, UAS(B)/ KSSC / NSC
9	Kashi Anmol	All Zones	All Zones	Uttar Pradesh, Bihar, M.P., Karnataka	IIVR, Varanasi
Clusterbean					
10	RGC-936, RGC-1017	ACZ-IV A	Sub-humid southern plains and Aravali Hills	Rajasthan	ARS, Durgapura, Jaipur
11	RGC-1017, RGC-1003, RGC-1066	ACZ-I-A	Arid Western Plains	Rajasthan	RSSC, NSC, SKRAU, Bikaner
12	Thar Bhadavi	ACI-I & ACZ-I-C	North Western Plain Zone	Rajasthan	CIAH, Bikaner
Colocasia					
13	White Goriya, Haloo Kesoo	ACZ-III	Bastar Plateau	Chhattisgarh	IGKV, Jabalpur
Cowpea					
14	IT-38956-1, TVX -944-02E	ACZ-IV, V	Central Dry Zone, Eastern Dry Zone	Karnataka	GKVK, UAS(B)/ KSSC / NSC
15	RC-19, RC-101	ACZ-II-A	Fatehpur (Sikar)	Rajasthan	RSSC, Rajasthan

Sl. No.	Varieties	Zone	Sub-Zone	State	Source of seed availability
Cumin					
16	GC-4	ACZ-II-B	Transitional Plan of Luni Basin, Jaipur	Rajasthan	RSSC, Rajasthan
Drumstick					
17	Bhagya-KDM-01	ACZ-I	Northern, North Eastern and Central Dry zone	Karnataka	UHS, Bagalkot, Karnataka
Elephant Foot Yam					
18	NDA-5, Gajendra	ACZ-III	Bastar Plateau	Chhattisgarh	IGKV, Jabalpur
Onion					
19	Agrifound Dark Red, Arka Kalyan	ACZ-I, II	Chhattisgarh Plains Zone, Northern Hills	Chhattisgarh	Private sector
20	Raseedpura local	ACZ-II-A	Fatehpur (Sikar)	Rajasthan	NSC & RSSC
Taramira					
21	RTM-314	ACZ-IV A	Southern plains and Aravali Hills	Rajasthan	SKN College of Agriculture, Jobner
Tomato					
22	Arka Meghali, Arka Vikas	ACZ-I, II, III	Chhattisgarh Plains Zone, Northern Hills, Bastar Plateau	Chhattisgarh	Private sector

Table 2: Crop varieties suitable for cultivation under delayed monsoon

Sl. No.	Varieties	Zone	Sub-Zone	State	Source of seed availability
Cereals					
Rice					
1	Sushak Samrat	ACZ-I, II & III	NEPZ, NWPZ & Southern alluvial zone	Bihar	BAU, Sabour / RAU, Pusa
2	Indira Rajeshwari, Vanaprabha, Indira Sona	ACZ-II	Northern Hills	Chhattisgarh	IGKV, Jabalpur; State Seed Corporation, Chhattisgarh
3	Vanprabha, Annada, Aditya, Samleshwari, Indira Sona	ACZ-III	Bastar Plateau	Chhattisgarh	IGKV, Jabalpur; State Seed Corporation, Chhattisgarh
4	Vanprabha, Indira Rajeswari, Indira Sona, Aditya, Danteshwari	ACZ-I	Chhattisgarh Plains Zone	Chhattisgarh	IGKV Jabalpur

Sl. No.	Varieties	Zone	Sub-Zone	State	Source of seed availability
5	ARIZE 6129, PAC807	ACZ-I	Sub-Montane & Low Hills Sub-Tropical Zone	Himachal Pradesh	CSKHPKV, Palampur
6	Govind	ACZ-I, II & III	NHZ, NWPZ & NEPZ	Uttarakhand	GBPUA&T, Pantnagar
7	Khitish, Swarna mahsuri, Sada Swarna, Lalat, IR 36	ACZ-I	New Alluvial Zone	West Bengal	BCKV, Kalyani, WB
8	Shatabdi, Khitish, Ranjit, Swarna mahsuri, Lalat	ACZ-III	Coastal Saline Zone	West Bengal	BCKV, Kalyani, WB
9	Swarna Mahsuri, Sada Swarna, Kalinga, Latat, 1001, Sahabhagi	ACZ-II	Red and Laterite Zone	West Bengal	BCKV, Kalyani, WB
10	RC Maniphou 12		Valley areas	Manipur	ICAR, Manipur
11	Narendra 97		North Eastern Plain Zone	Tripura	NDUAT, Faizabad
12	PR 113		North Western Plain Zone	Uttarakhand, Uttar Pradesh	PAU, Ludhiana
13	MTU 1010		North Eastern, Central, Southern Zone	Chhattisgarh, Odisha, MP, AP, Karnataka	ANGRAU, Hyderabad; IGKVV, Raipur,
14	Gontra Bidhan Dhan 3	ACZ-II	North Eastern Plain Zone	West Bengal	BCKV, Kalyani
15	Rasi, IR 64		North Eastern, Central, Southern Zone	AP, MP, Jharkhand	DRR, Hyderabad; JNKVV, Jabalpur; IGKVV, Raipur
16	ADT 37, ADT 39		Southern Zone	Tamil Nadu	TNRRI, Aduthurai
17	ADT 37, ADT 39		Southern Zone	Andhra Pradesh	TNRRI, Aduthurai
18	Karjat 5		West Zone	Maharashtra	RRS, Karjat
Wheat					
19	DBW-14	ACZ-I, II, III	North Eastern Plain Zone	Bihar	DWR, Karnal
Maize					
20	Hishell	ACZ-III	Bastar Plateau	Chhattisgarh	IGKV, Raipur
21	Prakash, Pusa Hybrid-1, Pro 4212	ACZ-II	Northern Hills	Chhattisgarh	Private Seed Company
22	Early Composite, Bajaura Makka	ACZ-I & II	Lower Hills in Himalayas	Himachal Pradesh	CSKHPKV, Palampur
23	C-6, Mansar	ACZ-III	Temperate & Warm Temperate Zone	Jammu & Kashmir	SKUA&T, Jammu
24	C-8, Mansor Vivek, Maize-25, Vivek QPM-9	ACZ-II	Intermediate Hill Zone	Jammu & Kashmir	SKUA&T, Jammu

Sl. No.	Varieties	Zone	Sub-Zone	State	Source of seed availability
25	Vivek maize-25, Vivek QPM-9	ACZ-I	Sub-Tropical Zone	Jammu & Kashmir	VPKAS, Almora
26	NAC-6004 Composite, NAC-6002 Composite, Nithyashri (NAH-2049), Hema (NAH-1147)	ACZ-IV, V, VI	Central, Eastern, Southern Dry Zone	Karnataka	NSP, GKVK, UAS(B) / KSSC/ NSC
27	JVM-421	ACZ-I	Vindhya Plateau Zone	Madhya Pradesh	RVSKVV, Gwalior
Pearl millet					
28	WCC-75	ACZ-IV, VI	Central, Southern Dry Zone	Karnataka	GKVK, UAS(B)/ KSSC / NSC
29	JBV-2, JBV-3	ACZ-II, III	Bundelkhand, Malwa Plateau Zone, Nimar Valley, Jhabua Hill	Madhya Pradesh	RVSKVV, Gwalior
30	HHB-67	ACZ-II-A	Transitional Plain of Inland Drainage, Fatehpur (Sikar)	Rajasthan	RSSC, Rajasthan
31	HHB-67 (I), RHB-177	ACZ-I-A, I-C	Arid Western Plains, Hyper arid and Western Plains	Rajasthan	RSSC, GSSC, NSC
32	HHB-67(I)	ACZ-II-B	Transitional Plan of Luni Basin, Jaipur	Rajasthan	RSSC, Rajasthan
33	HHB-67(I), ICMH-356	ACZ-III-A	Semi-arid Eastern Plains, Jaipur	Rajasthan	RSSC, Rajasthan
Foxtail millet					
34	RS-118, K-211-1, PS-4, SIA-326	ACZ-IV, VI	Central, Southern Dry Zone	Karnataka	GKVK, UAS(B)/ KSSC / NSC
Kodo Millet					
35	Jawahar Kodo-13 (JK-13)	ACZ-III	Bastar Plateau	Chhattisgarh	IGKV / NRC millets Bangalore
36	PSC-1, JNK-364, RBK-155, GPUK-3	ACZ-IV, VI	Central, Southern Dry Zone	Karnataka	GKVK, UAS(B)/ KSSC / NSC
Little Millet					
37	CO-2, PRC-3, OLM-203	ACZ-IV, VI	Central, Southern Dry Zone	Karnataka	GKVK, UAS(B)/ KSSC / NSC
Finger millet					
38	GPU-26, GPU-48, Indaf-5	ACZ-V,VI, IV	Central, Southern Dry Zone	Karnataka	GKVK, UAS(B)/ KSSC / NSC

Sl. No.	Varieties	Zone	Sub-Zone	State	Source of seed availability
Sorghum					
39	JJ-983, JJ-1041, CSH-18	ACZ-I, II, III, IV & VI	Vindhya Plateau Zone, Bundelkhand, Malwa Plateau Zone	Madhya Pradesh	RVSKVV, Gwalior
40	Parbhani Moti	ACZ-I	Marathwada Region	Maharashtra	VNMKV, Parbhani
41	M35-1 (Muguthi-5-4-1)	ACZ-VI	Southern Dry Zone	Karnataka	GKVK, UAS(B)/ KSSC / NSC
Pulses					
Blackgram					
1	BDU-1	ACZ-II	Marathwada Region	Maharashtra	VNMKV, Parbhani
2	Pant U-31, Pant U-19, WBU-108 (Sharada), WBU-109 (Sulota)	ACZ-I	New Alluvial Zone	West Bengal	BCKV, Kalyani
Chickpea					
3	Vijay	ACZ-I	Chhattisgarh Plains	Chhattisgarh	IGKV farm/ Private sector
4	Vijay	ACZ-VI	Southern Dry Zone	Karnataka	GKVK, UAS(B) / KSSC / NSC
5	Vijay	ACZ-I, II, III, IV, V, VI	Vindhya Plateau Zone, Bundelkhand, Malwa Plateau	Madhya Pradesh	RVSKVV, Gwalior
6	Vijay	ACZ-IV & V	North Western Plain Zone	Punjab	PAU, Ludhiana
7	Vijay	ACZ-IVA& B	Sub-humid Southern plains and Aravali Hills	Rajasthan	RSSC, ARS, Banswara, Rajasthan
8	Vijay	ACZ-I, IB, IIIA	NWPZ, Semi-arid Eastern Plains, Jaipur	Rajasthan	NSC, RSSC, NSP
Field bean					
9	HA-4	ACZ-IV, V, VI	Central, Eastern, Southern Dry Zone	Karnataka	GKVK, UAS(B)/ KSSC / NSC
Greengram					
10	JM-721, TJM-3	ACZ-I, II, III, IV	Vindhya Plateau Zone, Bundelkhand,	Madhya Pradesh	RVSKVV, Gwalior
11	SML-668	ACZ-I	North West Plain Zone-1B, Rajasthan	Rajasthan	NSC, RSSC, NSP, IIPR KANPUR
Horsegram					
12	CRIDA-18R, CRHG-4, CRHG-19 (CRIDA Harsha)		Southern zone	AP, Karnataka, TN and Kerala	CRIDA, Hyderabad

Sl. No.	Varieties	Zone	Sub-Zone	State	Source of seed availability
13	PHG-9	ACZ-IV	Central Dry Zone	Karnataka	GKVK, UAS(B)/ KSSC / NSC
14	GC3	ACZ-IV A	Sub-humid southern plains and Aravali Hills	Rajasthan	DFRS, Arjia, Bhilwara, Rajasthan
Moth bean					
15	RMO-40, RMO-225, RMO-425, RMB-25, RCG1033, CZM1, CZM3, CZM2	ACZ-I-A, I-C	Arid Western Plains, Hyper arid and Western Plains	Rajasthan	RSSC, NSC, SKRAU, Bikaner
Pigeonpea					
16	Asha	ACZ-III	Bastar Plateau	Chhattisgarh	IGKV Jabalpur / Research station
17	BRG-2	ACZ-IV, V, VI	Central, Eastern, Southern Dry Zone	Karnataka	GKVK, UAS(B) / KSSC
18	RVICPH-2671, RVA-28, JKM-7, TJT-501, JA-4, JKM-189	ACZ-I, II, III, IV, V, VI	Vindhya Plateau Zone, Bundelkhand	Madhya Pradesh	RVSKVV, Gwalior
19	BDN-711, BDN-708, BSMR-853	ACZ-I	Marathwada Region	Maharashtra	VNMKV, Parbhani
			Oilseeds		
Brassica (Rapeseed & Mustard)					
1	RGN145, NRCH B101	ACZ-III-B	Flood Prune Eastern Plains, Navgaon (Alwar)	Rajasthan	ARS, Navgaon RSSC
2	B-9, Jhumka, Agrani, Varuna, B-9, Vardan	ACZ-I, III	New Alluvial Zone, Coastal Saline Zone	West Bengal	BCKV, Kalyani
Castor					
3	DCS-9 (Jyothi)	ACZ-IV, V, VI	Central, Eastern, Southern Dry Zone	Karnataka	GKVK, UAS(B)/ KSSC / NSC
Groundnut					
4	JGN-3, JGN-23	ACZ-II, III, V	Bundelkhand, Nimar Valley	Madhya Pradesh	RVSKVV, Gwalior
5	VRI 3		South Zone	Tamil Nadu	TNAU, Vriddhachalam
Safflower					
6	PBNS-40, PBNS-12, PhuleKusum	ACZ-I	Marathwada Region	Maharashtra	VNMKV, Parbhani

Sl. No.	Varieties	Zone	Sub-Zone	State	Source of seed availability
Sesame					
7	Tilottoma (B 67), Rama Savitri, Kanke White	ACZ-II	Red and Laterite Zone	West Bengal	BCKV, Kalyani
Soybean					
8	GJS-3	ACZ-VII	North Shurashtra	Gujarat	ARS, JAU, Amreli
9	JS-335, RVS-2001-4	ACZ-I, II, III, IV, V, VI	Vindhya Plateau Zone, Bundelkhand, Malwa Plateau Zone	Madhya Pradesh	RVSKVV, Gwalior
10	MAUS-71, MAUS-162	ACZ-II	Marathwada Region	Maharashtra	VNMKV, Parbhani
11	JS 20-34, JS-95-60	ACZ-I		Rajasthan	RVSKVV, Gwalior
12	JS 95-60, JS 20-34, JS-335, JS 93-05		Vidarbha and Marathwada regions	Southern Maharashtra	RVSKVV, Gwalior
Sunflower					
13	KBSH-44, KBSH-53	ACZ-IV, VI	Central & Southern Dry Zone	Karnataka	GKVK, UAS(B)/ KSSC / NSC
Toria					
14	JT-1, RVM-2	ACZ-I, II, III, IV	Vindhya Plateau Zone, Gird Zone, Bundelkhand, Malwa Plateau Zone	Madhya Pradesh	RVSKVV, Gwalior
			Fibre Crops		
Cotton					
1	JKH-1, JKH-2, HY-8	ACZ-IV, V, VI	Malwa Plateau Zone, Nimar Valley, Jhabua Hill Zone	Madhya Pradesh	RVSKVV, Gwalior
2	PA-225, PA-402	ACZ-III	Marathwada Region	Maharashtra	VNMKV, Parbhani
Jute (*C. olitorius*)					
3	JRO-7835, JRO-632, JRO-204, JRO-128 , JRO- 524, JRO-3690	ACZ-I, III,II,IV,V	New Alluvial Zone, Coastal Saline Zone	West Bengal	BCKV, Kalyani & CRIJAF, Barrackpore
4	AAU-OJ-1	ACZ -II	All zones	Assam, North Bengal	AAU, Assam
5	JRO 524, JRO 66, JRO 204, JRO 3690, JRO 632	ACZ II, III, IV, V	All zones	All jute growing states	CRIJAF, Barrackpore, WB

Sl. No.	Varieties	Zone	Sub-Zone	State	Source of seed availability
Mesta Kenaf (*H. cannabinus*)					
6	JBM-71	ACZ-II,III,IV,XI	West Bengal, Bihar, Odisha, Tripura	West Bengal, Bihar, Odisha, Tripura	CRIJAF, Barrackpore
7	JBM 71	ACZ II, III, IV, XI	West Bengal, Bihar, Odisha, Tripura	West Bengal, Bihar, Odisha, Tripura	CRIJAF, Barrackpore, WB
Roselle (*H. sabdariffa*)					
8	AMV 7	ACZ XI	Eastern, western and southern zone	Odisha, AP, Maharashtra, Tamil Nadu	CRIJAF, Barrackpore, WB
9	AMV-7	ACZ-XI	Eastern, western and southern zone	Odisha, AP, Maharashtra, Tamil Nadu	CRIJAF, Barrackpore
			Fodder Crops		
Guinea Grass					
1.	PGG-1, PGG-9		North Western Plain Zone	Punjab & Haryana	PAU, Ludhiana
2.	PGG-14, PGG-19		North, Central and North Eastern Plain Zone	Punjab, Haryana, Gujarat, MP, Chhattisgarh	PAU, Ludhiana
3.	PGG-101, PGG-518		North Western Plain Zone	Punjab	PAU, Ludhiana
4.	PGG-616		North, South and Hill Zone	Punjab, Haryana, Rajasthan, UP & Uttarakhand	PAU, Ludhiana
5.	Haritha, Marathakam, Harithasree		South Zone	Kerala	KAU, Vellayani
6.	Riversdale		South Zone	Kerala, Tamil Nadu & Andhra Pradesh	Kerala Livestock Development Board, Trivandrum
7.	Hamil, Makueni		South Zone	Kerala, Tamil Nadu & Andhra Pradesh	Kerala Livestock Development Board, Trivandrum

Sl. No.	Varieties	Zone	Sub-Zone	State	Source of seed availability
8.	CO-1, CO-2, CO-3		South Zone	Tamil Nadu	TNAU, Coimbatore
9.	BG-1, BG-2	All India	All zone		IGFRI, Jhansi
Dinanath grass					
10	Jawahar Pennisetum-12		Central Zone	Gujarat, MP, Maharashtra, Chhattisgarh	JNKVV, Jabalpur
11	Bundel-1, BD-2	All India			IGFRI, Jhansi
12	COD-1		South Zone	Tamil Nadu	TNAU, Coimbatore
13.	Pusa Dinanath grass		Northern Hill Zone	J&K, HP	IARI, New Delhi
Dharaf grass					
14	GAUD-1		Central and North Western Plain Zone	Gujarat & Rajasthan, Maharashtra	JAU, Dhari, Gujarat
15	BDG-1	All India			IGFRI, Jhansi
16	Dongari Gawat 2-4-11		Central Zone	Maharashtra	MPKV, Rahuri, Maharashtra
Anjan Grass					
17	Bundel Anjan-1, Bundel Anjan-3		North West & South Zone	Punjab, Haryana, Rajasthan, Gujarat, TN, AP	IGFRI, Jhansi
18	Marwar Anjan		Arid & Semi-arid area in country	Gujarat, Rajasthan, Karnataka, TN, AP, Maharashtra	CAZRI, Jodhpur
19	CO-1 (Neela Kolukattai)		South Zone	Tamil Nadu	TNAU, Coimbatore
20	Gujarat Anand Marvel grass-2		North Western Plain Zone	Gujarat	AAU, Anand, Gujarat
Dhaman grass					
21	Marwar Dhaman (CAZRI-76)	Arid & Semi-arid area in the country	West & South Zone	Gujarat, Rajasthan, Karnataka, TN, AP, Maharashtra	CAZRI, Jodhpur
Lampa ghas					
22	Bundel Lampa Ghas	All India	All Zones	-	IGFRI, Jhansi

Sl. No.	Varieties	Zone	Sub-Zone	State	Source of seed availability
23	Marvel Grass				
24	Gujarat Marvel grass-1		North West Plain Zone	Gujarat & Rajasthan	AAU, Anand, Gujarat
25	Marvel-7, Marvel-8, Marvel-93		Central Zone	Maharashtra, Gujarat & Rajasthan	MPKV, Rahuri, Maharashtra
26	Gujarat Anand Marvel grass-2		North Western Plain Zone	Gujarat	AAU, Anand, Gujarat
Pearl millet (Fodder)					
27	PAC-981		North Western Plain Zone	Punjab, Haryana, Rajasthan, Gujarat, MP, UP	Advanta Pvt. Ltd.
Cowpea (Forage)					
28	Type -2		All India	All over India	IGFRI, Jhansi
29	UP C 9202, UPC 628	ACZ-III	Central Zone	Uttarakhand	GBPUA&T, Pantnagar
Niger					
30	KBN-1, JNC1, JNC6, JNC9	ACZ-IV, V, VI	Central, Eastern, Southern Dry Zone	Karnataka	GKVK, UAS(B)/ KSSC / NSC
31	PNS-6, JNC1, JNC6, JNC9	ACZ-I	Marathwada Region	Maharashtra	VNMKV, Parbhani
			Vegetables		
Ash gourd					
1	Kashi Dhawal		North Eastern Plain Zone	Uttar Pradesh, Bihar, Delhi	IIVR, Varanasi
Bottle gourd					
2	Kashi Ganga		North Eastern Plain Zone	Uttar Pradesh	IIVR, Varanasi
Brinjal					
3	GJB-2 AND GJB-3	ACZ-I, II, III, IV, V, VI, VIII	South, Middle & North Gujarat, North West Arid, South Shurashtra	Gujarat	VRS, JAU, Junagadh
4	PKM-1	ACZ-VI	Southern zone	Tamil Nadu	HC & RI, Periyakulam
5	PPI-1	ACZ-VII	High rainfall zone	Tamil Nadu	HRS, Pechiparai

Sl. No.	Varieties	Zone	Sub-Zone	State	Source of seed availability
6	Kashi Sandesh, Kashi Taru			Uttar Pradesh, Bihar, Jharkhand	IIVR, Varanasi
Cauliflower					
7	Pusa Sharad, Pant Gobi-4, Pant Shubra, Pusa Dipali, Daina	ACZ-I, II	New Alluvial Zone, Red and Laterite Zone	West Bengal	BCKV, Kalyani
Chillies					
8	Kashi Anmol		North Eastern Plain Zone, Central Zone, Southern Zone	Uttar Pradesh, Bihar, M.P., Karnataka	IIVR, Varanasi
9	KKM-1, K-1	ACZ-VI	Southern zone	Tamil Nadu	AC & RI, Kilikulam
Clusterbean					
10	RGC 936, RGC 1002, RGC-1003	ACZ-I & II-A	North West Plain Zone-1B of Rajasthan, Fatehpur (Sikar)	Rajasthan	NSC, RSSC, NSP, Rajasthan
11	RGC-936, RGC-1017	ACZ-I-A & I-C	Arid Western Plains & Hyper arid	Rajasthan	RSSC, NSC, SKRAU, Bikaner
Colocasia					
12	Panchmukhi	ACZ-III	Bastar Plateau	Chhattisgarh	IGKV, Jabalpur
Cowpea					
13	IT-38956-1, PKB-4	ACZ-IV, V	Central, Eastern Dry Zone	Karnataka	GKVK, UAS(B)/ KSSC / NSC
14	RC-19, RC-101	ACZ-II-A	Fatehpur (Sikar)	Rajasthan	RSSC, Rajasthan
Cucurbits					
15	Rajmata	ACZ-III	Coastal Saline Zone	West Bengal	BCKV, Kalyani
Elephant foot yam					
16	Bidhan Kusum, Gajendra	ACZ-I, II	New Alluvial Zone, Red and Laterite Zone	West Bengal	AICRP Tuber Crops, Kalyani Centre, BCKV
17	NDA-9	ACZ-III	Bastar Plateau	Chhattisgarh	IGKV, Jabalpur
French beans					
18	YCD-1	ACZ-V	High altitude zone	Tamil Nadu	HRS, Yercaud
Indian bean					
19	GJIB-11, GJIB-2	ACZ-III	Middle, South and North Gujarat	Gujarat	VRS, JAU, Junagadh

Sl. No.	Varieties	Zone	Sub-Zone	State	Source of seed availability
Okra					
20	Arka, Anamika, Azad, Sonal, Avantika	ACZ-II, III	Red and Laterite Zone, Coastal Saline Zone	West Bengal	BCKV, Kalyani
Onion					
21	N-53	ACZ-II-A	Transitional Plain of Inland Drainage, Fatehpur	Rajasthan	NSC & RSSC
Tapioca					
22	CO3, CO4	ACZ-III	Western Zone	Tamil Nadu	TC &RS, Yethapur
23	CO4	ACZ-VII	High rainfall zone	Tamil Nadu	HC & RI, TNAU
Tomato					
24	JT-3	ACZ-VI	South Shurashtra	Gujarat	VRS, JAU, Junagadh
25	Paiyur-1	ACZ-IV	North Western zone	Tamil Nadu	RRS, Paiyur
Yam bean					
26	RM-1	ACZ-I	New Alluvial Zone	West Bengal	BCKV, Kalyani

Heat stress

The continuous exposure of plants to high temperatures or heat stress during crop growth cycle is a major impediment to agricultural production and cause an array of morpho-anatomical, physiological and biochemical changes in plants, which affect plant growth and development eventually reducing economic yield. Heat stress is often defined as the rise in temperature beyond a threshold level for a period of time sufficient to cause irreversible damage to plant growth and development. In general, a transient elevation in temperature, usually 10–15°C above ambient, is considered heat shock or heat stress. The adverse effects of heat stress can be mitigated by developing thermo-tolerant crop varieties through genetic improvement and when coupled with various adaptation and mitigation strategies can counter production losses. Heat tolerance is generally defined as the ability of the plant to grow and produce economic yield closest to its genetic potential under high temperatures. The heat-threshold level that the plant can withstand without adverse effects varies considerably at different developmental stages in different crops. For instance, during seed germination, high temperature may slow down or totally inhibit germination. High temperature, in general adversely affects photosynthesis, respiration, water relations and membrane stability production of ROS (Reactive Oxygen Species) and

anti-oxidants, accumulation and adjustment of compatible solutes etc. In addition, plants intrinsically respond to high temperature stress by triggering a cascade of events and adapt by switching on numerous stress-responsive genes.

The genetic resources, especially land races and wild relatives from areas where past climates mimicked the projected future climates for agriculturally prime areas, could serve as the starting genotypes for breeding crops for heat tolerance. Some successful attempts have been made by conventional breeding methods in evolving plants with improved heat tolerance. However, the key to evolve heat tolerant crops lies in an integrated approach combining both traditional and molecular breeding techniques. Marker-assisted selection for heat tolerance as well as cloning and characterization of underlying genetic factors could be highly useful in this context. Major food, vegetable and horticultural crop varieties with tolerance to heat stress released by various Institutes/ Universities are given in Table 3.

Table 3: Crop varieties suitable for cultivation under heat stress

Sl. No.	Varieties	Zone	Sub-Zone	State	Source of seed availability
			Cereals		
Wheat					
1	Lok-1, Vidisha, GW-173, Arpa	ACZ-II	Northern Hills	Chhattisgarh	IGKV Jabalpur / Private sector
2	RSP 561	ACZ-II	Intermediate Hill Zone	Jammu & Kashmir	SKUA&T-Jammu
3	MP 4010, RVW 4106	ACZ-I	Vindhya Plateau Zone, Bundelkhand, Malwa Plateau Zone, Nimar Valley, Jhabua Hill Zone	Madhya Pradesh	RVSKVV, Gwalior
4	PBW 658, PBW 590	ACZ-I, II, III, IV, V	NWPZ	Punjab	PAU, Ludhiana
5	RAJ 3777, RAJ 3765, RaJ 3077	ACZ-I, IVA	North West Plain Zone-1B of Rajasthan	Rajasthan	NSC, RSSC, NSP, ARS, Durgapura
6	RAJ 3777, RAJ 3765, RAJ 3077, RAJ 4037, RAJ 4083	ACZ-I-B	North Western Plane	Rajasthan	NSC, RSSC, NSP
7	RAJ-3777, Raj-3765, MP-3288, HI-1500	ACZ-IV B	ARS Banswara	Rajasthan	RSSC, RSSC, MPSSC, MPSSC
8	RAJ-4037	ACZ-IV A	Sub-humid southern plains and Aravali Hills	Rajasthan	ARS, Durgapura, Jaipur

Sl. No.	Varieties	Zone	Sub-Zone	State	Source of seed availability
9	Raj-4037, Raj-4083, RAJ 3765, RAJ 3077	ACZ-III-A	Semi-arid Eastern Plains, Jaipur	Rajasthan	RSSC, Rajasthan
	NIAW 34		Penninsular Zone	Karnataka	UAS, Dharwad
Maize					
10	Suwan	ACZ-I	North eastern plain zone	Bihar	BAU, Sabour / RAU, Pusa
11	Suwan	ACZ-II, III	North western plain zone, Southern alluvial zone	Bihar	BAU, Sabour / RAU, Pusa
12	PMH-7	ACZ-III	Central Plain Zone	Punjab	PAU, Ludhaiana
Pearl millet					
13	GHB-558, GHB-732 and GHB-538	ACZ-III, IV, V, VI, VII & VIII	Middle Gujarat, North Gujarat, South Shurash-tra, North Shurashtra	Gujarat	JAU, Jamnagar
			Pulses		
Chickpea					
1	JG-14, Indira Chana, JG-315, JG-11	ACZ-I	Chhattisgarh Plains Zone	Chhattisgarh	IGKV Jabalpur
2	JAKI 9218, JG 6	ACZ-I, II, III, IV, V, VI	Vindhya Plateau Zone, Bundelkhand, Malwa Plateau Zone, Jhabua Hill Zone	Madhya Pradesh	RVSKVV, Gwalior
3	RSG 888, GNG 663	ACZ-I-B	Semi-arid Eastern Plains, Jaipur	Rajasthan	NSC, RSSC, NSP
4	Pant G 186	ACZ-II	North Western Plain Zone	Uttarakhand	GBPUA&T, Pantnagar
Greengram					
5	Narendra Mung 1	ACZ-I, II, III, IV	Vindhya Plateau Zone, Gird Zone, Bundelkhand, Malwa Plateau Zone	Madhya Pradesh	RVSKVV, Gwalior
6	IPM2-3, IPM2-14, LGG460, LGG410	ACZ-I	North West Plain Zone-1B of Rajasthan	Rajasthan	NSC, RSSC, NSP, IIPR KANPUR
Moth bean					
7	RMO-40, RMO-225, RMO-425, RCG1033	ACZ-I-A, I-C	Arid Western Plains, Hyper arid and Western Plains	Rajasthan	RSSC, NSC, SKRAU, Bikaner

Sl. No.	Varieties	Zone	Sub-Zone	State	Source of seed availability
Pigeonpea					
8	Bahar, Rajeev Lochan, UPAS-120	ACZ-I, ACZ-III	Chhattisgarh Plains	Chhattisgarh	IGKV, Jabalpur
			Oilseeds		
Brassica (Rapeseed & Mustard)					
1	Urvashi, RGN13, Pusa Mustard 25	ACZ-III-B	Navgaon (Alwar)	Rajasthan	ARS, Navgaon RSSC
2	RGN 13	ACZ-IV A	Sub-humid southern plains and Aravali Hills	Rajasthan	ARS, Ganganagar (Rajasthan)
3	Pant Rai 19, Pant Rai 20	ACZ-II	North Western Plain Zone	Uttarakhand	GBPUA&T, Pantnagar
4	NRCDR601, RGN 229, RGN 236, RGB 298, Divya-33		North Western Plain Zone, Northern Hill Zone	Delhi, Haryana, J&K, Punjab, Rajasthan	IARI, New Delhi; ARS, Ganganagar; M.R. Seeds Pvt. Ltd.
5	RH 0119		North Western Plain Zone	Haryana	CCS HAU, Hisar
Linseed					
6	R-552, RLC-78, RLC-81, RLC-92	ACZ-I	Chhattisgarh Plains Zone	Chhattisgarh	IGKV, Jabalpur
Soybean					
7	JS-335	ACZ-I	Chhattisgarh Plains Zone	Chhattisgarh	IGKV, Jabalpur
Sunflower					
8	DRSF 113	ACZ-IV, VI	Central, Southern Dry Zone	Karnataka	GKVK, UAS(B)/ KSSC / NSC
			Fibre Crops		
Cotton					
1	RST-9	ACZ-I & ACZ-I-B	North Western Plane	Rajasthan	NSC, RSSC, NSP
Jute (*C. capsularis*)					
2	NDC-2008, JRC-532,JRC-517, Bidhan Pat- 1,2,3	ACZ-II, III,IV	North Western Plain Zone	Assam, North Bengal, UP	CRIJAF, Barrackpore

Sl. No.	Varieties	Zone	Sub-Zone	State	Source of seed availability
			Fodder Crops		
Forage Cowpea					
1	UPC 9202, UPC 628	ACZ-III	Central Zone	Uttarakhand	GBPUA&T, Pantnagar
			Fruits		
Aonvla					
1	Francis Chakkia	ACZ-III-A, III-B	Semi-arid Eastern Plains, Jaipur, Navgaon (Alwar)	Rajasthan	CIAH, Bikaner
Apricot					
2	Badami, Inzhirnyl and Rannil	ACZ-II	Intermediate Zone	Jammu & Kashmir	SKUA&T-Jammu
Banana					
3	Shrimanti and Grand Naine		Southern Zone	South A.P. and Karnataka	NRC Banana, Trichy
4	Poovan, Karpura valli		All India	TN, Kerala, A.P., Karnataka, Bihar, W.B.	NRC Banana, Trichy
Peach					
5	Flordasun and Sunlet	ACZ-II	Intermediate Zone	Jammu & Kashmir	SKUA&T-Jammu
Sweet Orange					
6	Mosambi	ACZ-I	Sub-Tropical Zone	Jammu & Kashmir	SKUA&T-Jammu
Water Melon					
7	Durgapura, Madhu, Durgapura kesher & local	ACZ-II-A	Transitional Plain of Inland Drainage, Fatehpur (Sikar)	Rajasthan	NSC & RSSC
			Vegetables		
Bottle gourd					
1	Thar Samridhi	ACZ-I & ACZ-I-C	Northern Zone	Rajasthan	CIAH, Bikaner

Sl. No.	Varieties	Zone	Sub-Zone	State	Source of seed availability
Brinjal					
2	Kashi Sandesh, Kashi Taru		North Eastern Plain Zone	Uttar Pradesh, Bihar, Jharkhand	IIVR, Varanasi
Cauliflower					
3	Sabour Agrim	ACZ-I, II	North eastern plain zone	Bihar	BAU, Sabour
Clusterbean					
4	RGC-197, RGC-936	ACZ-II-A	Transitional Plain of Inland Drainage, Fatehpur (Sikar)	Rajasthan	RSSC, Rajasthan
5	RGC-936	ACZ-I-A	Arid Western Plains	Rajasthan	RSSC, NSC, SKRAU, Bikaner
Cowpea					
6	Kashi Kancha, Kashi Nidhi		North Eastern Plain Zone	UP, Bihar, Jharkhand, Odisha, M.P.	IIVR, Varanasi
Okra					
7	Kashi Pragati, Kashi Kranti		North Eastern Plain Zone	Uttar Pradesh, Bihar, Jharkhand, Chhattisgarh	IIVR, Varanasi
Onion					
8	NP53	ACZ-III-B	Navgaon (Alwar)	Rajasthan	CIAH, Bikaner
9	Raseedpura local	ACZ-II-A	Transitional Plain of Inland Drainage, Fatehpur (Sikar)	Rajasthan	NSC & RSSC
Pea					
10	Matar Ageta-6	ACZ-IV	North Western Plain Zone	Punjab	PAU, Ludhiana
11	Azad Pea G 10	ACZ-III-A	Semi-arid Eastern Plains, Jaipur	Rajasthan	RSSC, Rajasthan
Tomato					
12	Arka Meghali, Arka Vikas	ACZ-I, II, III	Chhattisgarh Plains Zone, Northern Hills, Bastar Plateau	Chhattisgarh	Private sector
13	Varkha Bahar-1 & Varkha Bahar-2	ACZ-IV	Vegetable Crops	Punjab	PAU, Punjab

Cold stress

Major food crops, maize (*Zea mays*) and rice (*Oryza sativa*) are very sensitive to low temperatures, the growth of these crops are severely affected in terms of their growth and development by temperatures below 10°C resulting in considerable yield loss or even crop failure. When the temperature decreases to less than 5°C for more than three consecutive days it is considered as cold wave/stress in areas where normal temperature remains 10°C or above, while in areas where normal temperature is below 10°C, if temperature goes below 3°C for more than three days it is considered as cold wave (Venkateswarlu et al., 2011). Many plants, especially those, which are native to warm habitat, exhibit symptoms of injury when subjected to low non-freezing temperatures. These plants including maize, soybean, cotton, tomato and banana are in particular sensitive to temperatures below10–15°C. Various symptoms in response to cold/chilling stress include reduction of leaf expansion, wilting, chlorosis and necrosis. In chilling stress, primary injury is the initial rapid response that causes a dysfunction in the plant, but is readily reversible if the temperature is raised to non-chilling conditions (Kratsch and Wise 2000). Major food, vegetable and horticultural crop varieties with tolerance to cold stress released by various Institutes/ Universities are given in the Table 4.

Table 4: Crop varieties suitable for cultivation under cold stress

Sl. No.	Varieties	Zone	Sub-Zone	State	Source of seed availability
			Cereals		
Pearl millet					
1	GHB-538	ACZ-III, IV, V, VI, VII & VIII	Middle Gujarat, North Gujarat, South Shurashtra, North Shurashtra & Bhal costal region	Gujarat	JAU, Jamnagar
Rice					
2	Bhrigudhan, Varun Dhan	ACZ-III	High Hills Temperate Wet Zone	Himachal Pradesh	CSK HPKVV, Palampur
3	HPR2143, HPR1068, RP2421, Palam Basmati-1, Bhrigudhan, Varun Dhan	ACZ-II	Mid Hills Sub-Humid Zone	Himachal Pradesh	CSKHPKV, Palampur

Sl. No.	Varieties	Zone	Sub-Zone	State	Source of seed availability
4	Gizza-14	ACZ-II	Intermediate Hill Zone	Jammu & Kashmir	SKUA&T, Jammu
5	K-39, K-343, K-448	ACZ-III	Temperate & Warm tTemperate Zone	Jammu & Kashmir	SKUA&T, Jammu
7	Pant Dhan 11	ACZ-I	Northern Hill Zone	Uttarakhand	Pantnagar
8	NE Megha Rice 1, NE Megha Rice 2		High Hills	Meghalaya	ICAR Barapani
Wheat					
9	RSP 561	ACZ-I	Sub-Tropical Zone	Jammu & Kashmir	SKUA&T, Jammu
10	Shalimar wheat-I	ACZ-III	Temperate & Warm Temperate Zone	Jammu & Kashmir	SKUA&T-Kashmir
11	Buland	ACZ-I	Sub-mountain Undulating Zone	Punjab	PAU, Ludhaiana
Barley					
13	BHS352	NHZ	Northern Hill Zone	HP & Uttarakhand	IARI, Shimla
Pulses					
Chickpea					
1	PDG 4	ACZ-II	North Western Plain Zone	Uttarakhand	GBPUA&T, Pantnagar
Oilseeds					
Brassica (Brown Sarson)					
1	KBS-3	ACZ-II	Mid Hills Sub-Humid Zone	Himachal Pradesh	CSK HPKVV, Palampur
2	RGN-73	ACZ-IV A	Sub-humid southern plains and Aravali Hills	Rajasthan	ARS, Sri Ganganagar
Soybean					
3	RGN-73	ACZ-IV B	ARS Banswara	Rajasthan	MPSSC, MPSSC

Sl. No.	Varieties	Zone	Sub-Zone	State	Source of seed availability
			Fodders		
Anjan grass/ Buffalo grass					
1	Bundel Anjan-1	All Zone	All Zone	All over India	IGFRI, Jhansi
Dhaman grass/ Bird wood grass					
2	Bundel Dinanath-2	All Zone	All Zone	All over India	IGFRI, Jhansi
Rye grass					
3	Pb. Ryegrass No.1		North Western Plain Zone	Punjab	PAU, Ludhiana
Setaria grass					
4	Setaria-92, S-18		Northern Hill Zone	Himachal Pradesh, Uttarakhand	CSK HPKVV, Palampur
5	PSS-1, Nandi		Northern Hill Zone	Himachal Pradesh	CSK HPKVV, Palampur
			Fruits		
Banana					
1	Poovan, Karpura valli		North Eastern Plain Zone, Southern Zone	Tamil Nadu, Kerala, A.P., Karnataka, Bihar, W.B.	NRC Banana, Trichy
Cashew					
2	Indira Cashew	ACZ-III	Bastar Plateau	Chhattisgarh	IGKV Jabalpur
Sweet Orange					
3	Indira navin	ACZ-III	Bastar Plateau	Chhattisgarh	IGKV Jabalpur
			Vegetables		
Berseem					
1	BL-180		North Western and Hill zone	Punjab	PAU, Ludhiana
Carrot					
2	Ooty-1	ACZ-V	High altitude zone	Tamil Nadu	HRS, Ooty

Sl. No.	Varieties	Zone	Sub-Zone	State	Source of seed availability
Cumin					
3	RZ-223, RZ-209	ACZ-II-B	Transitional Plan of Luni Basin, Jaipur	Rajasthan	RSSC, Rajasthan

Salinity stress

Salinity is a major environmental stress and is one of the chief constraints to crop production. Increased salinization of arable land is expected to have devastating effects on agricultural production in many countries including India. High salinity causes both hyper-ionic and hyper-osmotic stress and can lead to plant death. Salinity in a given land area depends on the amount of evaporation in relation to the amount of precipitation leading to increase in salt concentration. Intrusion of sea water also is another major cause for increase in salinity. Sodicity is a secondary result of salinity in clay soils, where leaching washes soluble salts into the subsoil, while sodium is left bound to the negative charges of the clay (Wang *et al.,* 2003). Agricultural lands that have been heavily irrigated are becoming highly saline, while in drier areas there is extensive water loss through a combination of both evaporation as well as transpiration. High salt concentration (Na+) deposited in the soil alter the basic texture of the soil resulting in decreased soil porosity, reduced soil aeration and water conductance. While, several crops are sensitive to salinity, rice can thrive relatively better on salt-affected soils as standing water helps in leaching salts from topsoil. A number of mapping studies have been attempted to identify QTLs located on different chromosomes for salinity tolerance in rice. A major QTL designated as 'SALTOL' was mapped on chromosome 1 which accounts for more than 40 per cent of the variation in salt uptake. Several lines containing SALTOL QTL were developed through marker assisted breeding. Major cereals varieties with tolerance to salinity stress released by various Institutes/ Universities are given in the Table 5.

Table 5: Crop varieties suitable for cultivation under salinity stress

Sl. No.	Varieties	Zone	Sub-Zone	State	Source of seed availability
			Cereals		
Rice					
1	Basmati CSR 30, CSR 36, CSR 27		Inland saline	Haryana	CSSRI, Karnal
2	CSR 23		Inland Saline	Uttar Pradesh	CSSRI, Karnal
3	CST 7-1	ACZ-III	Coastal Saline Zone	West Bengal	CSSRI Station, Canning Town
4	Jarva		Coastal Saline Zone	West Bengal, Kerala	DRR, Hyderabad
5	VTY-8		Coastal Saline Zone	Kerala	RRS(KAU), Vyttila
6	Panvel 3		Coastal Saline Zone	Maharashtra	Kharland Research Station, Raigad, Panvel
7	Luna Suvarna, Luna Sampad, Luna Sankhi		Coastal Saline Zone	Orissa	CRRI, Cuttack

Flooding and submergence

Water logging which is also called as flood submergence, anoxia, hypoxia etc., is one of the major harmful abiotic stresses limiting crop yields. Generally, the flooding in the field can be either water logging in which root and some portion of the shoot under water are complete submergence where the whole plant is under water. Lack of oxygen supply for the plant is main cause of damage in water logging conditions, because of which plant shifts its metabolism from aerobic to anaerobic mode. Aerenchyma formation, greater activity of glycolate pathway, involvement of anti-oxidative defense mechanism are some of the adaptive mechanisms to cope with flooding tolerance. Ethylene contributes in induction of the genes associated with the adaptive mechanism of flood tolerance (Alamgir and Uddin 2011). Major food, vegetable and horticultural crop varieties with tolerance to flooding stress released by various Institutes/ Universities are given in the Table 6.

Table 6: Crop varieties suitable for cultivation under flooding and submergence

Sl. No.	Varieties	Zone	Sub-Zone	State	Source of seed availability
			Cereals		
Wheat					
1	UP 2338, UP 2425, UP 2526, UP 2565	ACZ-II	North Western Plain Zone	Uttarakhand	GBPUA&T, Pantnagar
Rice					
2	Swarna Sub1		North Eastern Plain Zone	Orissa, West Bengal, AP	CRRI, Cuttack
3	MTU 1010, MTU1001, MTU1140		North Eastern Plain Zone, Central Zone	Chhattisgarh, Odisha	ANGRAU, Hyderabad
4	CR Dhan 500, Jalamani, Jayantidhan, CR Dhan 505		North Eastern Plain Zone	Orissa, West Bengal	CRRI, Cuttack
Maize					
5	Pragati	ACZ-III	North Eastern Plain Zone	Uttarakhand	GBPUA&T, Pantnagar
			Pulses		
Chickpea					
1	DCP92-3, Pusa240, GNG16	ACZ-I	Chhattisgarh Plains Zone	Chhattisgarh	IGKV farm/ Private sector
2	DCP92-3, Pusa240, GNG16	ACZ-I, II, III, IV, V, VI	Vindhya Plateau Zone, Gird Zone, Bundelkhand, Malwa Plateau Zone, Nimar Valley, Jhabua Hill Zone	Madhya Pradesh	RVSKVV, Gwalior
			Sugar Crops		
Sugarcane					
1	Co 8371, Co Tl 88322, Co 99006, Co 0124, Co 0237 and Co 0239	Flood prone areas in the country		All states	SBI, Coimbatore
			Fibre Crops		
Jute (*C. capsularis*)					
1	JRC-321, JRC-212, Shyamali, JRC-80, JRC-7447	ACZ-II, III,IV	North Eastern Plain Zone	Assam, North Bengal, UP	CRIJAF, Barrackpore
2	NDC 2008	ACZ IV	North Eastern Plain Zone	UP	NDUAT, Faizabad, UP

Sl. No.	Varieties	Zone	Sub-Zone	State	Source of seed availability
3	JRC 532, JRC 517	ACZ II, III, IV	North Eastern Plain Zone	Assam, North Bengal, UP	CRIJAF, Barrackpore
4	Bidhan Pat 1, 2, 3	ACZ II, III, IV	North Eastern Plain Zone	North Bengal, Assam, UP	BCKV, Kalyani, West Bengal
Mesta Kenaf (*H. cannabinus*)					
5	JBM 81, HC 583, AMC 108, JBM 2004 D	ACZ II, III, IV, XI	North Eastern Plain Zone	West Bengal, Bihar, Odisha, Tripura	CRIJAF, Barrackpore
Fodder Crops					
Anjan grass/ Buffel grass					
1	Marwar Anjan (CAZRI-75)		Northern zone	Arid and semi-arid areas in the country	CAZRI, Jodhpur
Cowpea (Forage)					
2	UPC-4200		Northern Zone	Tropical hu-mid and sub humid region	GBPAUA&T, Panthnagar
Fruits					
Guava					
1	Allahabad Safeda, Lucknow-49		Sub-tropical Zone	U.P., Bihar, W.B.	CISH, Lucknow
Vegetable Crops					
Colocasia					
1	Indira Arbi-1	ACZ-III	Bastar Plateau	Chhattisgarh	IGKV seed farm
Swamptaro					
2	BCST-1, BCST-3, BCST-5	ACZ-I	New Alluvial Zone	West Bengal	AICRP Tuber Crops, Kalyani Centre, BCKV

Strategies for ensuring access to resilient crop varieties

The changing climate is a major impediment in sustaining agricultural productivity especially to small and marginal farming communities, where the event of loss of even a single crop can lead to starvation or malnutrition of the family. In case of early season stress, the loss of standing crop at initial stages could be compensated by re-sowing immediately. However, there may not be sufficient seed left with the

farming community for re-sowing. Moreover it would be difficult for the public and private seed sectors to meet the demand of seeds to farmers specially those residing the far areas from seed source. To overcome such a situation it may useful to develop community seed banks to meet local seed demand as a contingency measure. There is a need to supply the quality seeds of climate resilient crop varieties to the farming communities. Rainfed agriculture which is more vulnerable to climate change, needs a robust decentralized seed system that is able to provide quality seed of diverse crops and varieties at affordable prices at right time to improve productivity and can buffer contingencies of climate risks such as repeat sowing in case of crop failure for enhanced resilience. There is also need to ensure conservation of the local agro biodiversity which has inbuilt tolerance to various stresses.

It is necessary to improve the seed quality of farm saved seeds for enhancing crop productivity as in our country farmers often use these for subsequent crops. The need to replenish diversity in agricultural systems will encourage farming communities to build up community seed banks that facilitate the revival and distribution of traditional and stress-tolerant crops and varieties. The various aspects of seed production, seed distribution and storage condition have to be improved and strengthened at the farmers' level under a community based seed system by making a cluster of villages or block as a seed village to cater the quality seed requirement of specified area. The implementing agencies which can play a pivotal role in further strengthening the seed village concept are State Departments of Agriculture, State Agriculture Universities, Krishi Vigyan Kendras, State Seeds Corporation, National Seeds Corporation, State Farms Corporation of India (SFCI), State Seeds Certification Agencies etc. in a coordinated effort.

There are successful implementation of seed village and seed banks concept in different parts of the country which can further upscaled to cope with climate variability such as, community seed banks for flood tolerant rice varieties of Bihar and Bengal, saline-resistant rice varieties of Orissa (Wajih 2008).

Conclusions

The need for stress tolerant cultivars has become paramount in the present context of climate change apart from various adaptation and mitigation strategies to feed the ever increasing population in the country. Concerted efforts of the National Agricultural

Research System (NARS) during the last few decades resulted in development of stress tolerant varieties in several crops and efforts are further being strengthened to develop varieties tolerant to various abiotic stresses individually as well as those with multiple stress tolerance. These stress tolerant cultivars can play an important role in coping with climate variability as well as enhancing the productivity. Location specific conservation techniques, water harvesting and efficient management of water resources and other adaptation strategies as well as enabling policies on crop insurance, along with robust early warning system and weather-based advisories will further facilitate enhancing the resilience of Indian agriculture to climate change and climate variability.

Way forward

Enhancing resilience of the farming community to climate risks to ensure sustainability over a period has to be focused on climate resilient agriculture in the country. Thus, the focus is on adaptation to climate variability, which entails appropriate strategies to contingent situations. In this context, climate resilient crop varieties are one the most important resources. Improved and tolerant varieties along with the proper management practices can enhance the coping ability through risk reduction in vulnerable environments. Ensuring seed availability of the resilient varieties in various crops at the appropriate time to the farmers is an important challenge to be addressed immediately. Issues related to managing trade-off between risk and expected returns in vulnerable areas to weather aberrations including drought, flood, heat and cold waves etc., also need urgent attention. Participatory approach to consolidate the involvement of village institutions will go a long way in ensuring the seed availability of resilient varieties locally. These resilient varieties need to be included in contingency plan implementation linking with national programme such as RKVY, NMSA etc. Another important dimension of utilizing the present information on climate resilient varieties is that, these could be utilized as potential genetic resources for further advancement using tools of both conventional as well as marker assisted selection and other cutting edge science tools.

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Contributors

Additional Director General, Field and Fodder Crops, ICAR

Additional Director General, Horticulture Sciences, ICAR

Additional Director General, Seeds, ICAR

Additional Director of Research, PAU, Ludhiana, Punjab

Assistant Director of Research, ZARS, Kolhapur, Maharashtra

Director of Research, BAU, Bhagalpur, Bihar

Director of Research, BCKV, Kalyani, West Bengal

Director of Research, CSK HPKVV, Palampur, HP

Director of Research, IGKV, Raipur, Chhattisgarh

Director of Research, JAU, Gujarat

Director of Research, MPKV, Rahuri, Maharashtra

Director of Research, MPUAT, Udaipur, Rajasthan

Director of Research, Navsari Agricultural University, Gujarat

Director of Research, RVSKVV, Gwalior, MP

Director of Research, Sher-e-Kashmir University of Agriculture and Technology, Jammu, J&K

Director of Research, SKRAU, Bikaner, Rajasthan

Director of Research, UAS, Bangalore, Karnataka

Director of Research, University of Horticultural Sciences, Bagalkot, Karnataka

Director, Central Institute of Arid Horticulture, Bikaner, Rajsthan

Director, Indian Institute of Rice Research, Hyderabad, Telangana

Director, Indian Institute of Wheat and Barley Research, Karnal, Haryana

In-Charge, AINPJAF, CRIJAF, Barrackpore, West Bengal

Professor & Head, Dept. Vegetable Crops, Horticultural College & Res. Inst., TNAU, Coimbatore, TN

Professor, Department of Genetics and Plant Breeding, GBPUA&T, Pantnagar, Uttarakhand

Project Coordinator, AICRP on Forage Crops, Jhansi, UP

Project Coordinator, AICRP on Pearlmillet, Jodhpur, Rajasthan

Project Coordinator, AICRP on Sesame and Niger, Jabalpur, MP

Project Coordinator, AICRP on Tuber Crops, Trivandrum, Kerala

Project Director, Directorate of Groundnut Research, Junagarh, Gujarat

Project Director, Directorate of Onion and Garlic Research, Pune, Maharashtra

Zonal Director Research, ARS, Sriganganagar, Rajasthan