

New agronomic approaches

for abiotic stress management

Yogeshwar Singh^{1*}

Rani Lakshmi Bai Central Agricultural University, Jhansi, Uttar Pradesh 284 003

Climate change with negative effects outweighing the positive inducing stressors is abiotic in nature, and imposes stress on different plant species. These abiotic plant stressors are reducing average yields for most major crop plants by more than 50%. Renewed demands in this regard add new dimensions to the challenges for agriculture, which is already constrained by the depleting natural resources and is threatened by adverse effects of climate change. Innovations in agronomic approaches have always been important and will be even more vital in the context of climate change for climate resilient sustainable agriculture.

Keywords: Abiotic stress, Climate resilient agriculture, Sustainable agriculture

THE impact of climate change and variability on crop production, with negative effects outweighing the positive, is reported from all parts of the world. It is a matter of great concern for a country like India, where more than 52% of its population is dependent on agriculture for employment. The individual climate change inducing stressors are abiotic in nature, and impose stress on crops. Abiotic factors cause 50% yield losses worldwide and they include high temperature (20%), salinity (10%), drought (8%), low temperature (7%), multi-nutrient deficiency and others (5%). Environmental stresses such as erratic and insufficient rainfall, extreme temperatures, salinity, alkalinity, aluminium toxicity, acidity, stoniness and others limit yield and productivity of many cultivated crop plants. Approximately 120.8 million ha (36.5%) area in India is affected by one or other type of edaphic stresses which include soil erosion, salinity/alkalinity, soil acidity, water logging, etc. In addition, about 68% of the cultivated area in the country is prone to drought. The atmospheric CO₂ concentration is about to cross 415 ppm, methane

concentration increased from 800 to 1891 ppb and nitrous oxide concentration increased from 270 to 320 ppb. These alarming events that potentially contribute to abiotic stress impact on agriculture needs to be addressed comprehensively to achieve the targeted food production.

It is need of the hour to develop climate smart agriculture for ensuring the food security. Hence, the focus of research across the agricultural organization is on 'genetic improvement' and 'crop management' with the help of advance scientific tools and third generation machines as the reliable option for making the crops resilient. Here the role of agronomist become more paramount important to manage the available natural resources so as to achieve the target of sustainable agriculture production under changing climatic scenario.

Agronomic approaches for abiotic stress management: Holistic system biology approach should be adopted to minimize the adverse effect of abiotic stresses. Following technologies should be considered to make the agro-ecological conditions more suitable for climate resilient sustainable agriculture.

Weather-based management decisions in major rainfed crops of India: Improved crop management strategies by using a decision support system involving data mining, site specific requirement, automation, and so on can help in climate resilient agriculture. The dynamic crop weather calendar with improved weather forecasts should be used for making the agriculture more climate resilient.

Crop diversification for abiotic stress management: New Traits, Varieties & Crops

The diversification of crop systems can take many forms, involving different crop species and/or varieties (intra and/or inter-specific diversification), different spatial scales (landscape, farm, individual fields and/or crop) and different time frames. Several new varieties and traits help in better tolerance to drought, heat, salinity etc. Climate change also leads to new pest and disease pressures. Crops, varieties and traits that are resistant to pests and diseases will improve producers' ability to adapt to climate change. It will reduce the need for pesticides, carbon emissions by decreasing

pesticide demand as well as the number of in-field applications.

Adoption of soil and water conservation techniques:

It has been estimated that the current demographic trends and projected growth in global population (around 9 billion by 2050), will result in a 60% increase in demand for food, feed and fibre by 2050. In the year 2015, the United Nations General Assembly adopted the 2030 Agenda for Sustainable Development that includes 17 Sustainable Development Goals (SDGs). Out of 17 SDGs, six are directly associated with agriculture (Fig. 1). Utmost care should be given on soil and water conservation to achieve the SDGs.

Successful production especially of rainfed crops largely depends on how effectively soil and water conservation techniques be adopted. Surplus runoff should be harvested, stored and recycled for supplemental/ life saving irrigation and soil moisture should be conserved *in-situ*. Several promising soil and water conservation measures depending on the amount of rainfall received in the area as suggested by Venkateswarlu *et al.* (2015), are presented in the Table 1.

Depending on the rainfall and soil characteristics, 10-50% of the runoff can be collected in farm pond. There is a potential to harvest about 24 million ha-m of rainwater through small-scale water-harvesting structures in different rainfall zones of India, of which, about one-fourth can be harvested in zones receiving rainfall <1,000 mm/year. With this, an additional foodgrain production of about 60-65 million tonnes can be easily realized, along with multitude of physical to social benefits like enhancing crop productivity, food supply and income, increasing water and fodder for livestock, increasing rainfall infiltration, thus recharging shallow groundwater sources.

Precision leveling: Precision land leveling is gaining popularity and increases land area up to 2-3%, increase in cropping intensity and crop productivity, improve crop establishment, reduces weed problem, saving in irrigation water. As per the available source for field



Fig. 1. SDGs associated with agriculture.

leveling, different precision land leveling techniques could be adopted to improve the water productivity of crops which saves the water by 15-30% in different crops and increase in crop yields by 5-20%.

Crop establishment techniques

Selection of suitable planting

method as per the agro-ecological condition will facilitate better crop yield coupled with minimizing the probability of drought or flood.

Conservation Agriculture: Reduced or no tillage agriculture often results in soil carbon gain and usually lower N₂O emissions. Advances in weed control methods

Table 1. *In-situ* soil and water conservation measures for various rainfall zones

Seasonal rainfall (mm)			
<500	500-700	750-1000	>1000
Contour cultivation with conservation furrows	Contour cultivation with conservation furrows	Broad bed and furrow (vertisol)	Broad bed and furrow (vertisol)
Ridging	Ridging	Conservation furrows	Field bunds
Sowing across slopes	Sowing across slopes	Sowing across slopes	Vegetative bunds
Mulching	Scoops	Tillage	Graded bunds
Scoops	Tied ridges	Lock and spill drains	Level terrace
Tied ridges	Mulching	Small basins	
Off-season tillage	Zigg terrace	Field bunds	
Inter-row water harvesting	Off-season tillage	Vegetative bunds	
Small basins	Broad bed and furrow	Graded bunds	
Contour bunds	Inter-row water harvesting	Zing terrace	
Field bunds	Small basins		
	Modified contour bunds		
	Field bunds		

and farm machinery now allow many crops to be grown with minimal or without tillage. In addition, recycling crop residues tends to improve soil carbon, while burning of residues promotes emissions of aerosols and GHGs. Zero tillage is reported to save irrigation water by 20–35% in the wheat crop compared to conventional tillage, reducing water usage by approximately one million l/ha.

Furrow irrigated raised bed planting technique (FIRB): Raised bed planting saved irrigation water by up to 40% with additional yield advantages over the flat plantings. Moreover, as many crops like maize, soybean, cotton, chickpea etc. are sensitive to water logging. So raised beds offer the potential to reduce water logging stress through improved surface drainage and the opportunity to diversify to water logging sensitive crops.

Direct seeded rice: Realizing the upcoming scarcity of water for irrigation purpose and adverse affect of puddling on ground water recharge focus has been shifted towards direct seeded. Jat *et al.* (2009) have reported that compared with CT systems, double ZT (DSR-rice-ZT-wheat) consumed 12–20% less water with almost equal system productivity and demonstrated higher water productivity.

Aerobic rice: Aerobic rice is gaining popularity in India and Southeast Asia, particularly in drought-stricken or upland areas. Under frequent drought occurrence circumstances, aerobic production can ensure that a community has rice to eat, while the paddied plants wither away.

Brown manuring: Brown manuring is recommended for direct seeded/aerobic rice to address the problem of weeds and in overcoming the adverse effect of early season drought due to smothering effect of sesbania.

Pre-sowing seed priming: Seed priming with Potassium Nitrate and Gibberellic Acid enhances the performance of several crops. The rapid and uniform emergence with early vigor can lead to uniform and good crop establishment, crucial for

attaining full yield potential and suppressing weeds especially in direct seeded rice and other rainfed crops.

Precise nutrient management:

The current status of nutrient use efficiency is quite low in case of P (15–20%), N (30–50%), S (8–12%), Zn (2–5%), Fe (1–2%) and Cu (1–2%). Delineation and mapping of macro and micro nutrient deficiencies using GIS and GPS tools and also simulation modeling is receiving attention to aid in nutrient management decisions. Soil fertility evaluation, monitoring and precise fertilizer recommendations has taken priority for ensuring sustainable agriculture production. Application of nitrogenous fertilizer on the basis of LCC and Green seeker is also well documented and is in the upsacing phase to increase the NUE. Development of fortified and other controlled released fertilizers and efficient utilization of organic wastes, indigenous minerals and industrial byproducts in agriculture has become focus areas. Commercial availability of nano-urea and other formulations will not only increase nutrient use efficiency but also reduce the cost of cultivation. Integrated Nutrient Management and Site-Specific Nutrient Management have the potential to mitigate effects of climate change.

Application of foliar nutrition:

The spraying of K and Ca induces drought tolerance in arable crops. Spraying of micronutrients and secondary nutrients improves crop yields and quality. Anti-transpiration coatings have been found effective for maintaining quality through control of water loss. The energy input can be reduced by increasing plant reflectivity by using effective chemicals like zinc oxide, kaolinite, etc alone or in combination with other anti-transpirants. Water loss can also be restricted by applying chemicals (phenyl mercuric acetate, Decenyl succinic acid, Atrazine and Sodium azide) which facilitate stomatal closure.

Use of plant growth regulators:

Plant bio-regulators (PBRs) play an important role to control the physiological metabolic activities in crops under stress conditions. The

beneficial role of PBRs and other plant hormones in enhancing the crop yields through the regulation of physiological processes and plant–water relation has recently been reported by many researchers. Use of PBRs like thiourea, salicylic acid, potassium nitrate, gibberellic acid and ortho-silicic acid improved the grain yields of several crops and 25.2–49.7% of irrigation water could be saved without yield penalty.

Use of Beneficial microbes:

Some of the microorganisms are capable of enhancing plant growth and development, which are generally called as Plant growth promoting rhizosphere microorganisms. They can facilitate plant growth directly by facilitating the uptake of nutrients from the environment, by influencing phytohormone production (e.g., auxin, cytokinin, or gibberellin), and/or by enzymatic lowering of plant ethylene levels. In addition to facilitating the growth of plant, these microorganisms can protect plants from the deleterious effects of flooding and drought. These mycorrhizal plants are often more competitive and better able to tolerate environmental stresses.

Water management: It is estimated that by 2050, about 22% of the total geographic area and 17% of the population will face water scarcity. Adding climate change to it further intensifies the water use demands in agriculture and farmers with no access to irrigation are most vulnerable to precipitation volatility.

Regulated deficit irrigation: It is an optimization strategy in regions where water resources are restrictive. It can be more profitable for a farmer to maximize crop water productivity instead of maximizing crop productivity. With dwindling water supplies, such deficit irrigation techniques will become increasingly important. Under limited water situations, water-saving irrigation methods like alternate furrow irrigation or widely spaced furrow irrigation and drip irrigation systems can be adopted. Drip or Sub-surface drip irrigation can be adopted in wider spaced arable/fruit crops. Sub-surface drip irrigation is gaining popularity especially in sugarcane and

other wide spaced crops which helps in increasing water and crop productivity beside minimizing the weed problem. Open ditches are preferred because they are relatively cheaper and suitable to all types of soil.

Conjunctive use of canal and groundwater: Where freshwater is in short supply, groundwater of marginal quality could be advantageously used in combination with good-quality water for irrigations.

Hail control mechanisms and its management

Artificial hail control is an important measure in disaster prevention. Cloud seeding for hail is postulated to reduce hail severity. Another concept is to create shock waves which can prevent the formation and growth of hail by melting altogether. Acetylene or

butane gas is used to generate hail disruptive shockwaves. Protective screens termed as anti-hail nets above the crop can be appropriately utilised especially for high value crops.

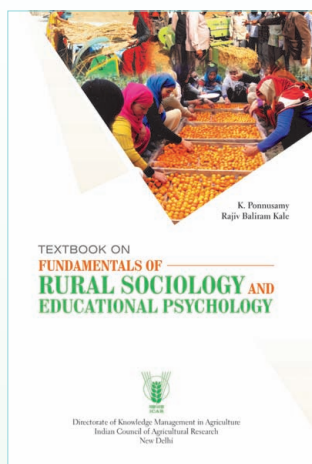
Integrated Farming system: IFS has great scope to meet out the requirement of climate resilient sustainable agriculture especially in stressed prone areas. In order to minimize the adverse effects of frequent crop failures due to drought, farmers may evolve some combined protective-productive systems by integrating perennials fruit/timber trees and livestock in farming as per the location and situation. IFS seems to be an important option to ensure nutritional security, profitability, gainful employment and environmental security in arid and semi-arid regions. There is also dire need to upscale implementation of IFS to the desired extent and harness the full potential of IFS.

SUMMARY

As climate change affects input availability, especially water in many places, input use efficiency must increase with the productivity. Innovations in agriculture have always been important and will be even more vital in the context of climate change. Diffusion of the appropriate agricultural technologies will be crucial in enabling an effective technological response. Seeing the reliance of the poor on agriculture and the sensitivity of agriculture to climate change, the agricultural research should maintain its pace to provide the need based suitable technologies to achieve the goals of sustainable development.

¹Professor, Department of Agronomy, Rani Lakshmi Bai Central Agricultural University, Jhansi, Uttar Pradesh. *Corresponding author's e-mail: singhyogeshwar@gmail.com

Textbook on Fundamentals of Rural Sociology and Educational Psychology



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TECHNICAL SPECIFICATIONS

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