Grassroots Solutions to Overcome Abiotic and Biotic Environmental Stress in Agriculture

Pawan Kumar Singh, Vivek Kumar, Nitin Maurya, Hardev Choudhary, Vipin Kumar, and Anil K. Gupta

Abstract

Agriculture systems, the world over, are evolving at a fast pace to meet various challenges like fluctuating precipitation pattern, warmer climate, depleting ground water resources, declining soil fertility, insect and pest resistance, etc. Fighting such challenges amid uncertainty, farmers have been continuously devising ingenious solutions. These are a testimony to their experimental efforts. Mostly derived from locally available resources, such solutions are low cost, frugal and easily replicable. These include improved crop varieties, agricultural practices for plant protection and production, or eco-friendly farm practices. This contribution of farmers for coping with environmental stresses and addressing food security problems is now slowly being recognised globally by scientific researchers. It is hoped that formal scientific institutions will try to build upon the coping strategies of creative farmers further, add value and develop innovative products and practices. Such a blending of the best of formal and informal science can only ensure a sustainable future for all by mitigating present and imminent agricultural challenges.

P.K. Singh • H. Choudhary
Value Addition Research and Development Department, National Innovation Foundation-India, Satellite Complex, Premchand Nagar Road, Ahmedabad 380015, Gujarat, India

V. Kumar
Scouting and Documentation Department, National Innovation Foundation-India, Satellite Complex, Premchand Nagar Road, Ahmedabad 380015, Gujarat, India

N. Maurya
Dissemination and Social Diffusion, National Innovation Foundation-India, Satellite Complex, Premchand Nagar Road, Ahmedabad 380015, Gujarat, India

V. Kumar
National Innovation Foundation-India, Satellite Complex, Premchand Nagar Road, Ahmedabad 380015, Gujarat, India

A.K. Gupta (✉)
Centre for Management in Agriculture, Indian Institute of Management, Ahmedabad and Executive Vice Chairperson, National Innovation Foundation-India, Satellite Complex, Premchand Nagar Road, Ahmedabad 380015, Gujarat, India
e-mail: anilg@iimahd.ernet.in; anilgb@gmail.com

S.B. Singh et al. (eds.), *Translational Research in Environmental and Occupational Stress*,
DOI 10.1007/978-81-322-1928-6_2,

Introduction

Stresses caused by the increasing fluctuations in the climatic and edaphic conditions have to be dealt with by either enhancing the resilience of the agricultural ecosystems or inducing human interventions for the purpose. Many farmers and local communities have met these challenges through (a) in situ conservation of varieties developed through careful selection, (b) development of coping strategies by manipulating agronomic or general management conditions and (c) by controlling biotic stresses such as pests and diseases through herbal plant protection innovations. Honey Bee Network has been tracking and pooling such examples of farmer creativity for the last 25 years. This paper comprises specific examples where we have documented and shared the creative coping strategies with or without value addition [1]. In both formal and informal sectors, experiments for improving existing crop genetic resources and developing sustainable practices have begun to attract added attention in the recent years.

National Innovation Foundation – India (NIF), an autonomous institution of the Department of Science and Technology, Govt. of India, provides institutional support to such farmers and other grassroots innovators. NIF tries to ensure that they receive due acknowledgement for their efforts and that such innovations diffuse widely through commercial and/or non-commercial channels generating incentives for farmers/innovators and others involved in the value chain. NIF, with the help of the Honey Bee Network (HBN), has been able to document thousands of farmers' developed agricultural practices and plant varieties from different parts of the country.

Coping with Stress

The practices deal with the biotic factors like weeds, pest diseases and plant pathogens and abiotic factors such as salinity, drought and extreme cold or hot temperature. Several sociological processes also help in coping with risk such as intra-household risk adjustment strategies, inter-household strategies, common property or pool resources-based alternatives and public interventions [2–4]. However, the scope of this paper is restricted to technological innovations, and it does not provide any insight to these practices.

Innovative Agricultural Practices

Harbhajan Singh (Haryana) combats water stress by sowing cotton crop on two-foot-wide ridges which are separated by six feet. Irrigation of alternative row reduces water requirement to half without affecting yield. In addition, the pest and weed control expenses also lessen. Plants require moisture and not water [5]. Frequent or heavy irrigation causes succulence in plants which in turn renders pest attack. Numerous farmers have adopted this irrigation pattern which reduced their irrigation and seed costs while increasing the yield. Scientific studies also confirm that alternate row irrigation of cotton field has great potential in reducing the uses of water without compromising the yield of lint [6]. The use of lady's finger as a border crop around the cotton fields is another interesting example of economical grassroots experiment performed by few farmers in Maharashtra, India, for controlling pests. The lady's finger's flowers are similar to cotton but it blossoms earlier than cotton's flower. Hence, it attracts the pests and reduces the burden on the main crop [7]. Despite of the availability of such non-expensive practices, it is tragic that we still encounter increasing rate of suicides in large-scale farmers of the cotton-growing regions, as these non-monetary practices to reduce cost and increase resilience of the cropping systems were never publicised and most of the farmers are not aware of such practices. Farmers also manage and maintain some weeds, which are used for the biological control of various pests, hedge, etc. [8]. Weeds are controlled by creative communities by growing *berseem* (*Trifolium alexandrium*) or other such fodder crops in weed-infested fields. Once in 3 years or so,

farmers grow such crops, harvest them intermittently to feed livestock and thus prevent weeds to grow to maturity, set seeds and increase their seed load in soil. Thus in subsequent years, there are much lesser weeds. Two lady farmers from Tamil Nadu, Ariyammal and Pushpam, developed purple-coloured *Chinnar* 20 paddy variety using selection method from ADT-46 paddy variety. The plants have purple pigmented leaves and culm; hence, differentiation between weed and crop becomes easier. Weeds can thus be removed saving time and labour cost and preventing loss of the crop [9].

Farmers have developed growth promoters and herbal pesticides by studying the properties of various weeds as well as other plants and fruits. Haribhai Narola from Bhavnagar, Gujarat, provides a basal treatment to the soil with the week-old flour of pearl millet as an alternative to chemical fertilisers. With the above treatment, improvement in the growth and yield was recorded in wheat, cotton, chilli, brinjal and other vegetable crops. In 1995, he conducted a systematic study to compare the effects of 'bajra' flour with those of chemical fertiliser, diammonium phosphate (DAP) on wheat. He obtained a yield of 250 kg/ha in the plots treated with 'bajra' flour. Haribhai also observed small patches of rust in DAP-treated plot, while the plots treated with 'bajra' remained healthy. The growth and boll setting was much better when the cotton was sown in the same plot in which wheat was grown with 'bajra' flour treatment in the previous season [10].

M A. Chinnathambi had developed a pesticide by using the aerial parts of cactus kodikaali (*Euphorbia nivulia*) or madakalli or thirugukalli (*Euphorbia tirucalli*), cut into pieces, immersed in water and fermented for 15 days. After fermentation the extract is then filtered and sprayed on the crops. The pesticide effectively controls the leaf curl disease in chilli and brinjal, the mosaic disease in lady's finger, jassids in paddy and sucking pests in cotton [11]. Pravinsinh Jadeja, Kutch, Gujarat, suggested a remedy for protection of wheat crop from termites by placing crushed 'kharsadi' (*Euphorbia tirucalli*) and 'thor' (*Euphorbia neriifolia*) plants in watering grooves within the field [12].

Germplasm Conservation

Conservation and development of high yielding and disease-resistant crop varieties is also one of the ways farmers overcome environmental stress conditions. A round chilli variety has been conserved by a community in Bihar. This variety bears fruit for 5–6 years continuously. The main features of the variety are high pungency, ability to grow under shade and tolerance to common diseases and pests [9]. Kir community from Jaipur region of Rajasthan, India, has preserved and propagated a traditional tinda (round gourd) variety for the past 35 years for its superior yield. For conserving this variety, they selected two main characters, i.e. big size of fruits and dark green colour with hairy skin. The fruits of this traditional variety of tinda are tender, delicious in taste and flat round in shape and weigh about 100–200 g at the time of harvesting. Fruits of this variety are famously known as 'Sahapur tinda' in Jaipur and surrounding areas [13].

Gangaram Kir of the same community has been continuously trying to improve a traditional variety of brinjal through successive or recurrent selection. The criteria used for selection are pests and disease-free plant with more spiny fruits per plant. The variety has features like strong spininess of calyx of fruit, larger fruits, high yield and less number of seeds per fruit as compared to other varieties, with sweet taste and better cooking quality [9].

Improved High Yielding Varieties

Farmers make selections in the available diversity produced through natural mutations, mixtures or outcrossing. Sometimes, diversity may increase due to natural stresses, which creates selection pressure. This provides opportunity for less common characters to become noticeable.

Chunni Lal from Rajasthan has developed an improved variety of ridge gourd (*Luffa acutangula*) by selecting the seeds from a traditional variety with particular attributes. The developed variety is tolerant to powdery mildew

disease. The vine climbs the trees of height of 9–10 m and bears 15–20 fruits per vine with fruit size of 3–7 ft. The fruits contain very less number of seeds as compared to conventional varieties [9]. Santosh Pachar, a lady farmer from Rajasthan, has developed a high yielding variety of carrot. Sixteen years back, she had collected some carrots for consumption, which had good colour, taste and no forked roots. She adopted the root-to-seed method of planting at her farm to produce seeds from the above carrots. She collected the seeds from first year plants, sowed them again in the field and adopted the same selection method continuously for 5 years. The carrot variety is now stable in yield and has desirable traits. The length of carrot is up to 1.5 ft, with less or no forked roots; the carrot is sweet in taste and adapted to high temperature [14].

Prakash Singh Raghuvansi from Varanasi, Uttar Pradesh, has developed various improved plant varieties of wheat, paddy, mustard, pigeon pea, etc. He developed three wheat varieties, namely, Kudrat 5, Kudrat 9 and Kudrat 17 (developed from Kalyan sona and RR21 varieties), which have higher yield (65–70 q/ha), lengthy spikes, robust stem and water lodging resistance with high protein content. Paddy variety Kudrat 1 developed from HUVR-2-1 gives high yield (60–70 q/ha) with higher number of tillers (30–35/plant) and seeds (280–290 seeds/tiller) as compared to other locally popular varieties. The pigeon pea variety developed by him gives high yield (30–34 q/ha), has bold seeds, robust stem and bears more number of pods per plant. The variety is also tolerant to common pest and disease of the crop. The variety of mustard has bunchy siliquae, bears about 40 seeds per siliqua, contains higher oil content (42.3 %) and shows synchronous maturity. Farmers of many states are cultivating their varieties with commercial intention [15]. Rajkumar Rathore from Madhya Pradesh has developed an improved variety of pigeon pea *Richa* 2000, which is very famous in his area. It has low seed rate (3–4 kg/acre) and contains pods in bunch at apical region, with double harvest (December and April) and higher yield (24 q/acre) [16].

Disease-Resistant Varieties

Jagdish Prasad Pareek from Sikar, Rajasthan, developed a high yielding variety of cauliflower, which grows in all the seasons, is tolerant to hot temperature, is resistant to disease and is less susceptible to insect attacks. The fruit weighs up to 12 kg [17]. A wilt-tolerant groundnut variety, 'Dhiraj-101', was developed by Thummar Dhirajbhai Virjibhai from Gujarat [18]. The yield of this wilt-tolerant variety is higher than locally cultivated varieties (GG 20 and GG 2) with higher oil content (52–55 %). Only 0.47 % stem rot incidence has been found in Dhiraj-101 as compared to 16.37 % in the check variety (GG 20), reported in the trials conducted at Oil Seed Research Station, Junagadh Agricultural University.

Using grafting technique, R.G. Hegade from Karnataka has developed a drought-resistant black pepper variety NP 77, which has about 30 % higher yield than the prevalent varieties. It contains about 80–100 spikes per plant and 100–120 berries per spike, and the plant height reaches up to 50–60 cm. The yield of dark black-coloured berries is about 3,000 kg per acre with high dry recovery percentage, early maturity and resistance to quick wilt. It also contains heightened flavour and aroma [9]. An improved variety of paddy 'HMT' has been developed by Dadaji Ramaji Khobragade, of Maharashtra, which is now included as a standard reference for thinness by Protection of Plant Variety and Farmers' Right Authority (PPV&FRA). This variety has an average yield of 40–45 q/ha with short grains, high rice recovery (80 %), better smell and cooking quality in comparison to the parent ones. He also developed another improved paddy variety 'DRK', which gives average yield of 60–80 q/ha. The grains are short, slender, white in colour and aromatic and have good cooking quality. The most important feature of this variety is its ability to tolerate biotic and abiotic stress conditions [19].

Varieties with an Ability to Withstand Drought and Salinity

Sabu Varghese from Kerala has developed a cardamom variety, *wonder cardamom*, which is known to have drought-resistant characters and can be grown along with the rubber plantations. The variety was developed using seeds collected from a morphologically different plant. The plants were propagated by vegetative multiplication. The other specialty of this variety is its branched panicles, which have attracted interest from the scientific community due to its better adaptability at lower altitudes and lower rainfall regions. Traditionally, these areas are not known for cardamom production and generally used for the cultivation of rubber [20]. Another farmer from Kerala, KJ Baby, has developed a white flowered variety of cardamom from *Vazhuka* type of cultivars through mass selection method, which took about half a decade. The variety bears white flowers and has high productivity compared to other commonly grown cardamom varieties. It can be grown in waterlogged areas as well. It has wider adaptability to different shade conditions apart from having higher production with good quality than other locally popular *Mysore* and *Vazhuka* cultivars, viz. *Njallani*, Green-bold, *Palakkudi* and *Veeraputhara* varieties. It has sturdy plants, robust tillers and deep root system, which also makes it resistant to various biotic and abiotic stresses [21]. *Alakhpura* selection, an improved chilli variety, has been developed through mass selection method by Balwan Singh from Haryana. He started the selection in the year 1984 based on the criteria of fruit length, diameter, dark red colour, pungency, etc. The variety is known to perform extremely well under saline conditions and is also tolerant to extreme heat and humidity. The yield of the variety is 400 q (green) and 40 q (dry) per hectare and is known to fetch high market price due to its skin colour [9].

Water shortage inspired Manaram Choudhary, Rajasthan, to breed an onion variety requiring less irrigation. He succeeded in developing a highly productive, early maturing and drought-resistant variety of onion, which gradually became famous in Haryana, Delhi, and Rajasthan for its delicious taste. This onion variety, known as *Rashidpura*, can be cultivated as a winter crop due to adaptability in varying climatic conditions. It has higher yield (40,000 kg/ha) as compared to normal yield (25,000–30,000 kg/ha). It also matures early (110–115 days) with less irrigation and hence gives good result in drought conditions [22]. Drought conditions cause reduction in the yield, and also the higher frequency of irrigations may lead to excessive vegetative growth in heavy soils [23]. Sundaram Verma, also from Rajasthan, has been experimenting on the arid crops varieties. He has successfully developed and conserved several cultivars of plant varieties during his many years of farm research. He has developed a *kabuli*-type bold-seeded chickpea variety, which gives very good yield in drought conditions. The potential yield of the variety is about 28 q/ha, which is higher than other commercially cultivated varieties and fetches good market price due to the seed boldness [9].

Conclusion

Farm practices, herbal pesticides and stress-resistant crop varieties discussed illustrate the enormous potential that exists for learning from farmers and partnering with them to develop solution to deal with various stresses in the environment. Such solutions, also referred as frugal innovations or Gandhian innovations, are incredibly economical and eco-friendly and help the crops to withstand biotic or abiotic stress conditions. These grassroots innovations can revolutionise sustainable food security solutions. Being improvement in locally adapted varieties or practices, farmer innovations often tend to have a robustness and frugality which may elude in many externally developed solutions. Respect, recognition and reward for grassroots innovations, Honey Bee Network has argued, can pave the bridge between formal and informal science and technology system and increase mutual trust and reciprocity.

References

1. Gupta AK (1988) Survival under stress in South Asia: a socio-ecological perspective on farmer risk adjustment and innovations. International Conference on Plant Physiology, New Delhi
2. Gupta AK (1984) Small farmer household economy in semi-arid regions: socio ecological perspective. Center for Management in Agriculture, Indian Institute of Management, Mimeo, Ahmedabad, p 452
3. Gupta AK (1985) Socio-ecological paradigm to analyse the problem of poor in dry regions. Eco-Dev News (Paris) 32:71–75
4. Richards P (1989) Agriculture as a performer: farmer first. Intermediate Technology Pub, London, pp 39–43
5. Cotton cultivation in water stress condition. http://nif.org.in/awards/profile/Cotton-cultivation-in-water-stress-condition/150
6. Subramani et al (2008) ag.arizona.edu/pubs/crops/az1513/az1513c.pdf
7. Gupta AK (2009) http://www.sristi.org/anilg/papers/Seduce_the_scientist.pdf
8. Altieri MA, van Schoonhoven A, Doll JD (1977) The ecological roles of weeds in insect pest management systems: a review illustrated with bean (Phaseolus vulgaris L.) cropping systems. Pests Articles News Summ (PANS) 23:195–205
9. NIF database. http://www.nif.org.in/
10. Gupta AK (ed) (1996) Bajra' flour: higher yield, lesser rust. Honey Bee 7(2):14
11. Gupta AK (ed) (2002) Cactus as pesticide. Honey Bee 13(2):8
12. Gupta AK (ed) (1999) Tradition of invention: simultaneous innovations across space and time. Honey Bee 10:4
13. Conservation of traditional variety of *Tinda* round gourd by Kir-community. http://nif.org.in/awards/profile/Conservation-of-traditional-variety-of-Tinda-round-gourd-by-Kir-community/74
14. Improved variety of carrot *Laxmangarh* Selection. http://nif.org.in/awards/profile/Improved-variety-of-carrot-Laxmangarh-Selection/631
15. Improved Varieties of Wheat, Paddy, Mustard and Pigeon pea. http://nif.org.in/awards/profile/Improved-Varieties-of-Wheat-Paddy-Mustard-and-Pigeon-pea/17
16. *Richa 2000* perennial pigeon pea variety. http://nif.org.in/awards/profile/Richa-2000-perennial-pigeon-pea-variety/387
17. Cauliflower variety of 12 Kg weight. http://nif.org.in/awards/profile/Cauliflower-variety-of-12-Kg-weight/185
18. Groundnut variety *Dhiraj 101* which is resistant to wilt due to stem rot. http://nif.org.in/awards/profile/Groundnut-variety-Dhiraj-101-which-is-resistant-to-wilt-due-to-stem-rot/19
19. *HMT* an Improved Paddy Variety. http://nif.org.in/awards/profile/HMT-an-Improved-Paddy-Variety/313
20. Wonder cardamom a new variety of cardamom. http://nif.org.in/awards/profile/Wonder-cardamom-a-new-variety-of-cardamom/358
21. White Flowered Cardamom Variety. http://nif.org.in/awards/profile/White-Flowered-Cardamom-Variety/354
22. Improved Onion variety. http://nif.org.in/awards/profile/Improved-Onion-variety/360
23. Gaur PM, Tripathi S, Gowda CLL, Ranga Rao GV, Sharma HC, Pande S, Sharma M (2010) Chickpea seed production manual. International Crops Research Institute for the Semi-Arid Tropics, Hyderabad, p 28

http://www.springer.com/978-81-322-1927-9

Translational Research in Environmental and Occupational Stress

Singh, S.B.; Prabhakar, N.R.; Pentyala, S.N. (Eds.)
2014, XIV, 274 p. 97 illus., 63 illus. in color., Hardcover
ISBN: 978-81-322-1927-9