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Cost-Effective Production Technologies through Engineering Interventions

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Food is a physiological necessity for the survival of human being, the highest form of life on the planet earth. Eating food is a source of pleasure and it, therefore, demands quantity, quality and variety. Food is derived from agriculture which traps and transforms solar energy into chemical energy in the form of biomass which is processed and utilized for food, feed, fibre and fuel. Engineering interventions in the form of appropriate tools and technology facilitate in maximizing agricultural productivity and profitability on sustainable basis and with a minimum drudgery to farm workers, especially to women.

Present scenario of Indian agriculture

The agriculture and allied sector continues to be pivotal to the sustainable growth and development of the Indian economy. Not only does it meet the food and nutritional requirements of 1.3 billion Indians, it contributes significantly to production, employment and demand generation through various backward and forward linkages. Moreover, the role of the agricultural sector in alleviating poverty and in ensuring the sustainable development of the economy is well established. Agriculture is an important part of the Indian economy and about 65% of Indian population depends directly on agriculture. Over 70% of the rural households depend on agriculture and it contributes about 17% to the total GDP and provides employment to over 60% of the population. Even though food production has touched new highs in recent years it hasn't kept pace with the exponential jump in the population. Although industrialized agriculture has been successful in producing large quantities of food, the future of food production is in jeopardy due to many problems in agriculture.

The critical issues that plague Indian agriculture at present are the knowledge deficit and infrastructure deficit, especially in the rural areas and problems related to irrigation infrastructure, market infrastructure and transport infrastructure adding significant cost to farmers' operations especially for small and marginal landholding farmers. There are a number of schemes aimed towards developing agriculture but again the problem is in effective delivery mechanisms that can translate those into effective facilitation at the ground level, in terms of increasing productivity or decreasing cost or increasing price realization. To resolve these issues, new policy reforms were introduced re-organizing the production system in the form of corporate and contract farming. These production systems are well adopted in Farmer Producer Organizations/Producer Co-operatives overcoming many issues. However, these are dependent on Government subsidies and the forethought to ensure that these are transformed into self-sustaining, economically viable entities seems to be lacking. Thus, farming is becoming a 'dead' profession with many marginal farmers opting to leave their lands barren and migrating into the cities in the hope of a better life.

The growth of the agriculture and allied sector at the state level differs from that at the national level. For instance, at the national level, the GDP from the agriculture and allied sectors grew at the rate of 4.7% in 2013-14 (at constant 2004-05 prices), but the states of Gujarat, Madhya Pradesh and Himachal Pradesh registered double-digit growth during the same period. Almost 50 per cent of the states were estimated to have experienced more than 5% growth in the agriculture and allied sectors during 2013-14.

Requirement of technical interventions in Indian agriculture

The first and foremost goal of agricultural development should be to raise the income of farmers to a higher level than what it is at present to provide them a sense of well being. As of now, there are about 820 million people in developing countries, who go hungry every day and 70% of them are in Asia. The investment in agriculture

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and allied sectors promises greater return than that made in other sectors by the national/state governments. Small and marginal farmers, whose potential, if harnessed properly, can bring about a substantial positive change in the agricultural scenario of the country. The farmer welfare-centred approach to agricultural development can empower the rural masses with higher income and employment and make balanced development a reality.

The high cost input technologies are not popular with small holders due to their low investment capacity and poor risk bearing ability. Thus, the gaps between the actual and potential yields in dryland agriculture continue to exist. However technology per se cannot help the farmers towards producing marketable surplus, unless institutional, infrastructural and market gaps are adequately addressed. Moreover, the critical gaps in (i) input supply, (ii) access to credit, (iii) access to input and output market, (iv) value addition (v) access to services such as insurance, market information, (vi) access to natural resources are crucial to be addressed in enhancing the economic and social security of farmers. The most common complaint of small farmers in rural India is lack of access to stable markets. Thus, the twin problems in dryland agriculture are (1) production inefficiency due to use of obsolete technologies, input constraints, over or under use of inputs, or inadequate access to information or training, (2) market inefficiency due to unorganised markets, lack of information, superfluous middlemen, poor vertical coordination amongst producers, processors and consumers, meagre bargaining power and poor transportation links.

At present, agriculture has to fulfil diverse objectives: it needs to be internationally competitive, produce agricultural products of high quality, while meeting sustainability goals. In order to remain competitive, agricultural producers need rapid access to emerging technologies. Farmers are faced with many more constraints and also more opportunities. In addition to being profitable, they need to meet environmental standards and regulations, as well as deal with direct and indirect consumer and lobby group pressures. They may also be flooded with information from various government and industry sources that make choosing appropriate technologies more difficult. Farmers also need to change their production and management practices in response to agricultural policies that include environmental conditions and I am confident that farmers have the capacity to do so.

Management of natural resources

Continuous degradation in natural resources under intensive agriculture to attain goals of food sufficiency is one of the reasons for declining factor productivity and stagnation in food grain production in the country. The health of soils has been impaired due to emergence of multi-nutrient deficiencies and falling organic carbon levels. The farmers are resorting to addition of more and more fertilizers to obtain yields similar to previous years. So, site-specific integrated nutrient management, envisaging precise use of chemical fertilizers including secondary and micronutrients, organic manures, composts/vermicomposts, bio fertilizers and green manures are ideal. This will maintain soil health, enhance nutrient use efficiency, provide sustained yields and ensure better economic returns to the farmers. It has been estimated that out of the total 140 million ha., nearly 120 million ha. of soil suffers from varying degrees of degradation. The quality of soil has deteriorated over time due to a combination of factors, such as injudicious use of fertilizer, accumulation of heavy metals and metalloids through various forms of emissions.

Enhancing input use efficiency

It is estimated that indiscriminate use of fertilisers and excessive irrigation have resulted in 12 million ha of land becoming water logged and 6.7 million ha rendered saline. A problem of soil erosion due to water is seen on 83 million ha and due to wind on 11.5 million ha. There is a need to transform our green revolution into an evergreen revolution which will be triggered by farming systems approach that can help produce more from the available land, water and manpower resources. The current whole-field management approaches ignore variability in soil-related characteristics and seek to apply crop production inputs in a uniform manner. With such an approach, the likelihood of over-application and/or under-application of inputs in a single field cannot be avoided, which results into higher cost of operation as well. Development of indigenous and affordable systems and devices for precise application of inputs is a challenge.

Land fragmentation

Increasing fragmentation of land holdings is a continuing cause for concern. Around 85% of the operational holdings in the country are small and marginal i.e. less than 2 ha. each. Between 2000-01 and 2010-11, the number of marginal holdings increased from 75.41 million to 92.83 million, a rise of 23% and number of small holdings increased from 22.70 million to

24.78 million (9%). By contrast, the medium holdings dropped by 3% and large holdings by almost 11%. Semi-medium holdings increased by 0.7%, while the number of medium holdings dropped by 3% and the number of large holdings declined by almost 11%. In terms of the proportion of area under different sized holdings, small and marginal holdings in 2010-11 accounted for 44.6% of the area, while semi-medium and medium holdings accounted for 44.8% of the area and the remaining 10.6 % by the large holdings. This is indicative of the significant fragmentation of operational holdings in India. Medium holdings are getting converted frequently into small and marginal holdings, and no signs of reversal can be seen in the foreseeable future.

Water management

Water is the most critical resource for agriculture, gaining primacy even over soil. India has only about four per cent of the world's freshwater resources. Thus, large tracts of land are dependent on seasonal rainfall for crop cultivation, which hampers productivity and the adoption of high yielding varieties and other inputs. Yields in rainfed areas remain low, and this low yield underscores the importance of irrigation in the country. The agriculture sector is going to face grim competition for supplies of fresh water in the wake of growing industrial and domestic sectors. The judicious management of water resources is, therefore, going to be crucial to sustain agricultural growth in the country. To focus on increasing the efficiency of water use, micro irrigation, which includes drip and sprinkler systems, considered better in terms of water use efficiency, should be promoted in different areas with the provision of subsidies. Drip and sprinkler systems are gaining popularity in high value crops, such as horticulture, plantations and sugarcane. It is estimated that about 50 per cent of water conservation can be done through the use of drip and sprinkler systems.

The share of irrigation water would come down due to the increasing competition from non-agricultural sectors and irrigation will suffer water scarcity. Water demand for irrigation would increase to feed an additional 2 billion people of the world by 2050. Lift irrigation would be limited by the conventional energy availability. At the same time enhanced pumping would be possible by using non-conventional energy sources. The challenge lies in achieving and maintaining higher water productivity in the changing scenario on sustainable basis.

To address the problem of ever increasing pollution loads in the rivers and other waterbodies, the following measures can be adopted:

a) Reuse of treated sewage for agriculture and horticulture purposes.

b) Use of sludge generated at sewage treatment plants which does not contain heavy metal as manure and soil conditioner.

c) Water use efficient technologies of drip irrigation, micro irrigation, sprinklers, etc. may be encouraged to reduce the pressure on water consumption by agricultural sector and reduce excessive withdrawal of groundwater.

Reducing post-harvest losses/Ensuring nutritional security

The demand for primary agricultural commodities is a derived demand, which is determined in part by wastage between producer and final consumer.

Huge wastage across the supply chain leads to lower level of processing and hence low value addition. On an average, post-harvest losses to the tune of 4 to 6 per cent in durables and 12 to 15% in case of fruits and vegetables have been documented. The challenge is in handling of fresh produce after harvest with emphasis on reducing losses, value addition, maintaining eating quality and marketing.

Food safety will be the major concern of the production industry and the regulatory agencies. Maintenance and measurement of quality, especially flavour and nutritional content, and ensuring safety (avoiding chemical and microbial contamination) is a challenge and must be the focus of future research and extension activities.

Demand for new food (organic foods, nutraceuticals, health foods, age awareness and portion control products)

There is a need of economically viable technology that can turn this 'waste' into 'wealth'. The targets of food production will be governed by the population growth of India and the world in broader sense, considering India to be a global supplier of agricultural commodities after fulfilling its own demand. Land consolidation by sale/lease/contract etc. would demand mechanization of agricultural operations. Custom hiring of agricultural machinery will be a common scene by 2050, necessitating the research efforts in direction of developing bigger machineries and equipment.

Farmers often do not get remunerative prices for perishable fruits and vegetables that they grow. We need

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to develop suitable agro-processing technologies, on-farm storage and warehousing models for adoption by the farmers and create other post-harvest infrastructure in the rural areas.

The way forward consists in achieving targets of waste reduction, value addition and employment generation by:

a) Greater infrastructure development by involvement of State government and private sector for setting up food parks and cold chains.

b) Filling up institutional gaps for enabling contract farming, direct marketing, stocking and movement policies.

Towards realizing horticultural potential

a) Ensuring production and supply of quality planting material, with special emphasis on establishment of hi-tech nurseries having provision for mother or scion blocks of improved varieties, good quality rootstock banks and hi-tech green house, through accredited nurseries.

b) Establishing crop based Centres of Excellence in each state to serve as a hub for supply of planting material and dissemination of technology to farmers.

c) Covering more area under vegetable hybrids and export-oriented varieties of ginger, turmeric and chillies. High density planting and tree canopy management of orchards right from establishment stage need to be focused on to derive better yield.

d) Rejuvenation of old and unproductive orchards continue to be a focus area for enhancing productivity, profitability and sustainability.

e) Thrust on protected cultivation, particularly of high value crops.

Farm mechanization

Farm mechanization saves time and labour, cuts down crop production costs in the long run, reduces post-harvest losses and boosts crop output and farm income.

Steady growth was observed in manually operated tools, animal operated implements, and equipment operated by mechanical and electrical power sources in India. In manually operated equipment, the number of sprayers has almost doubled. After liberalization and with development of prototypes of machines, manufacturing got a big boost particularly in Haryana, Punjab, Rajasthan, Madhya Pradesh and Uttar Pradesh states of India. The Indian agricultural equipment market is experiencing a rapid growth with expected strong potential for future growth as well.

The overall mechanization level in India is only 40-45% even though 90% of the total farm power is contributed by mechanical and electrical power sources. However, all operations are not uniformly mechanized. Operation-wise level of mechanization varies from 42 % for soil management and seed bed preparation, 29 % for seeding and planting, 34 % for plant protection and 37 % for irrigation. In case of harvesting and threshing, the level of mechanization is 60-70 % for wheat and rice and less than five per cent for others crops.

The operation wise mechanization for harvesting, crop care and seeding are top priority for the farmers in India for cereals and horticultural crops. But mechanization of above operations is not up to the level of farmers' expectations till date. Farmers need complete mechanization package for major crops.

Zero-till drill, strip-till drill, raised bed planter, pre-germinated paddy seed drill, rice transplanter, high clearance self propelled sprayer, aero-blast sprayers, vertical conveyor reaper and combines are some of the successful recent introductions, which should be adopted for achieving timeliness in agricultural field operations, precision in metering and placement of inputs for best plant response and economy

The agricultural engineering inputs have played important role in increasing production, productivity and management of crops and commodities through technological inputs for timely field operations, rainwater harvesting, groundwater lifting, judicious application of water through on-farm interventions, soil and water conservation, land drainage, agro-processing etc.

Enhancing available energy use and reducing energy intensity

Efficient utilisation and management of commercial energy is a growing concern in the farm sector. Substitution with renewable energy sources and reduction of dependency on conventional power sources, which is highly interrupted.

Technologies/redesign machines are being developed for alternate energy sources such as bio-diesel, fuel cells, solar chips, multi-fuel options and portable energy sources for stationary and mobile operations to reduce carbon footprint.

To meet the demand of food grain production of about

293.5 million tonnes by 2020 as projected by ICAR, the productivity of food grain production at National level will have to be increased from the level of 1723 kg ha^{-1} (in 2001) to about 2300 kg ha^{-1} by 2020 for which, besides other things, the average farm power availability will have to be increased from the present level of about 1.35 to 2.00 kW ha^{-1} by 2020. Since the draught animal population is going down due to economic considerations and convenience point of view and availability of agricultural labourers will increase only marginally, the additional demand of farm power will come mainly from mechanical and electrical sources of power.

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