# Dimensions of Problems in Rainfed Agriculture—Problems & Prospects of Fertiliser Use in Development of Arid and Semi-Arid Areas*

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**Abstract**

*The importance of rainfed area in India in agriculture production has been emphasised. Various constraints of crop production in the rainfed areas have been identified. The strategy for increasing production through integrated and efficient management of soil moisture, plant nutrients and HYV has been highlighted. Potential of crop production in the area is 3 to 5 times greater than the present production. What is required is the use of appropriate technology.*

The importance of dryland agriculture in feeding the world population and improving their nutrition can hardly be over emphasised. Nearly 61 per cent of the cultivated area of the world, which falls in the arid and semi-arid regions, suffers from moisture stress for many months in a year. Most of these areas are in the tropical and subtropical climatic belt. In India the semi-arid and arid dry lands cover nearly 80 per cent of the cultivated area. The areas where moisture stress is serious for 5 to 10 months in a year excluding the irrigated areas is nearly 65 per cent in the country. Even if all the plans to develop irrigation to the maximum extent materialise in the next two decades, still more than 55 per cent of the area in India will remain unirrigated, practising rainfed agriculture.

It has been estimated by various authorities that nearly 90 per cent of sorghum, millets, pulses, and oilseeds are produced from the rainfed conditions in the arid and semi-arid areas of India. Their yields are low, ranging from 200 to 900 kg/ha and fluctuation in yields is rather high, which makes agriculture a gamble in monsoons. It is no wonder that the country faces shortage of many commodities, particularly of pulses and oilseeds. Though there is a good deal of evidence that modern agricultural technology has been able to blunt the edge of aberrant weather, drought and floods, but its full impact is not felt because of low spread of technology in rainfed areas. Some statistics indicate that India is spending nearly Rs. 700 crore on import of groundnut oil alone. Thus, the bill of vegetable oil parallels the bill on the import of fuel oil. The prices of pulses which were considered as the poor man's meat are putting them beyond the reach of the common man. The escalation of the price index in India is attributable to a considerable extent to the rise in prices of oils of vegetable or of petroleum origin.

The Sixth Five Year Plan aims at increasing production of groundnut from 6.1 to 7.3 million tonnes by 1985. Likewise, the pulses production is proposed to be increased from 11.6 to 14.5 million tonnes. When one considers this Plan along with the best performance and normal rate of growth in the Fourth and Fifth Five Year Plans, one feels concerned about the future possibilities. However, there is no reason to be pessimistic as there are sufficient indications that a new technology is becoming available which can bring a spectacular increase in production provided the right technology and right pricing policies are followed. The researches at ICRISAT have shown that even under rainfed conditions the yield of sorghum, pearl millet, chickpea and pigeonpea yields under rainfed conditions on Vertisols and Alfisols can be increased to 300-500 per cent. The results of the All India Coordinated Project for Dryland Agriculture have also confirmed that the potential for increasing production in the drylands of the country is 200 to 400 per cent of their present level. The analysis of yields on farmers' actual fields with traditional technology, demonstration results with improved technology and experimental station results show a very wide gap. Rastogi (4) from AICRPDA has reported that the ratio for cereals as 1:4:7, for oilseeds 1:1.8:5.0 and for pulses 1:2.2:4.2. This shows that there is a wide scope for bridging this gap.

## Problems of Dryland Agriculture

For developing suitable strategy for increasing production from dryland agriculture, we must diagnose the problems or constraints to increasing crop yields.

The problems can be grouped into 4 categories—(i) climatic constraints, (ii) soil constraints, (iii) technological constraints, and (iv) socio-economic constraints. I will touch upon briefly some aspects of these constraints.

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i. *Climatic constraints*

Uncertainty and variability of rain both in space and time is one of the biggest problems affecting agricultural production under rainfed farming. Droughts and floods are common phenomenon affecting crop production sometimes in the same year and in the same region and often in the same field. No doubt the weather modification techniques have not become feasible so far, but we have not also made use of the weather data which is available for about 100 years in this country. There are new possibilities which the agricultural climatological researches have shown for planning agriculture. To mention just one example—dry sowing of crops in deep black soils of medium rainfall areas (750-1250 mm) keeping in view the probable dates for onset of monsoons can transform many million hectares of these soils into double cropped areas. The agroclimatological information is also valuable for making right choice of varieties, cropping system, water harvesting and crop modelling for targetting production.

ii. *Soil constraints*

The major soil problems of the rainfed farming areas are low soil fertility (nutrient stress), soil erosion, drainage, low water intake rate in some soils and too much percolation and low rententivity in others. The soil salinity, alkalinity and aluminium toxicity are other soil problems, limiting crop production in drylands. There is general lack of realisation that both *moisture stress* and *nutrient stress* are the two most serious problems of dry lands limiting production. The contour bunding technique which has become synonymous with soil conservation seems to have more serious limitation as soil water conservation practices for increasing crop production in rainfed black and red soils which cover more than 50 per cent of the entire dry farming cropped area of the country.

(a) *Moisture Stress*: Out of the climatic constraints, moisture stress is the most serious one and its removal has been accepted as Priority I task by all planners. There are three ways of removing the moisture constraint—(1) moisture conservation and better rain water management, (2) harvesting runoff water and its utilisation for life saving irrigation, and (3) extension of irrigation systems to provide partial supplemental irrigation to drylands.

So far as the third alternative is concerned, this is already receiving the highest priority by the planners. The country hopes to double the irrigated areas in the next five years which would mean extension of the irrigation to more of the drylands. As mentioned above, despite all the efforts to increase irrigation, most of the areas in the country will still remain rainfed. Hence the only possibility of removing the moisture constraint remains confined to moisture conservation, water harvesting and its reuse. Techniques have been developed in the last 10 years for better moisture conservation and rain water management in the black soils and the red soil areas of the country. It is observed that if these techniques are properly utilised, they can reduce the runoff loss of water, loss of soil and increase the productivity of the land. The concept of small watersheds and the broad bed and furrow (BBF) system for increasing rainwater use efficiency *in situ* and harvesting runoff water by storing it in tanks and using it for life saving irrigation is an excellent one. Extensive trials with BBF system and new technology in deep black soils or Vertisols which cover 28 million ha of cropped area in the country out of which about 12 million ha remain uncropped during monsoon season in Madhya Pradesh, Maharashtra and Andhra Pradesh can produce about more than 4,000 kg/ha without irrigation as against 500-800 kg at present. There is enough evidence that by reorienting the philosophy of water conservation from these areas, agricultural production can be increased manyfold. But this would require substantial use of fertiliser and use of high yielding varieties and better management techniques. Probably 2.8 million tonnes of nutrients will be required for this area alone, which is at present receiving only a fraction of it. In the last few months, ICRISAT, ICAR, and Agricultural Universities have launched a programme for introducing this technology to dependable rainfall areas (750-1,250 mm) of deep black soils in India. We hope this can transform these lands.

In the Alfisols, the scope for harvesting and reuse of runoff water is high and it can stabilize and increase production from many drylands. Likewise, AICRPDA has developed techniques for better management of the rainwater in alluvial region which can transform agriculture of the rainfed areas of these regions. It needs hardly emphasise that availability of water can act as a catalyst for transforming agriculture of the drylands.

(b) *Nutrient stress*: Nutrient stress is probably the most serious limiting factor for crop production in dryland agriculture but unfortunately its importance has been overlooked and underestimated. If one wants to consider only one factor which can substantially improve productivity of drylands without irrigation, it is the removal of nutrient stress. Balanced use of fertilisers and manures tailored to soil moisture status and cropping system, should get the highest priority in any strategy for increasing crop production from drylands. There is no doubt that most of the low production from the drylands is attributable to nutrient deficiency. Nitrogen deficiency is almost universal. Recent estimates by Ghosh and Hassan (1) have shown that more than 65 per cent soils in the country are ~~low in available nitrogen. Probably~~ the deficiency in the drylands is even more severe. The deficiency of phosphate specifically in the black soils, red soils and the laterites, which the modern taxonomists call Vertisols, Alfisols and Oxisols is very pronounced. The micronutrients deficiency particularly zinc deficiency is very pronounced.

It may not be out of place to mention that on ICRISAT farm of 1,400 ha most of the Vertisol and Alfisols are low in N, P and Zn and in some of them even after addition of about 1,000 kg of $P_2O_5$ in the last 8 years the available P has not gone beyond medium levels. Even today 75 per cent Vertisol fields test low in P and 9 per cent low to medium. Likewise, 90 per cent Alfisols test low to medium in P. Thus it has become necessary for us to apply phosphates year after year to get good crops. In our operational scale on-farm trials on cultivators fields in Tadanapalle village in Vertisols and Aurapalle in Alfisols, the nutrient deficiency was so pronounced that we had to apply not only N but also a good dose of P and Zn.

Our experience shows that many of the problems of low production are more due to severe deficiency of these nutrients. It may also be of interest that many plant diseases such as *Char coal rot* and *Striga* of sorghum become more severe in the soils of low fertility. The interaction of removal of moisture stress and nutrient stress produces synergistic effect but even under moisture stress situation, adequate supply of nutrients through fertilisers and manures produces most spectacular effect on crop yields. Thus fertiliser application becomes the lynch pin of the strategy for increasing crop production in rainfed conditions of arid and semi-arid tropics.

iii. *Technological problems*

Rainfed farming has suffered from neglect both from the researches and planners in the past. Even the farmer, because of the greater risks inherent in rainfed farming, gives preferential treatment to irrigated crops, consequently the rainfed crops get less allocation of agricultural inputs, of which fertiliser is most conspicuous.

It is only in the last 15 years that researchers in India have started paying attention to rainfed agriculture. There are too many problems of technological nature which need attention as the technology suited for irrigated farming is not well suited for rainfed farming because of numerous uncontrollable variables and inherent risks.

A few of the technological constraints are:

1. Lack of genotypes capable of giving high and stable yields under rainfed conditions and the presence of yield reducers.

2. Lack of more fertiliser responsive varieties in many crops particularly pulses and oilseeds.

3. Lack of more remunerative cropping system than the existing ones.

4. The pest and disease problems of intercropping system of rainfed farming are different from those of sole cropping system in many ways and have not been adequately researched. A technology based on use of pesticide umbrella is also not likely to attract the dryland farmer because of the poorer returns, and great risks.

5. Weeds are a serious competiter for nutrients and moisture in dryland farming but not much attention has yet been paid to the development of technology of an integrated weed management. Thus for alleviating moisture and nutrient stresses and improving efficiency of fertilisers, weed management is a critical factor.

6. Lack of appropriate and viable resource management technology for some of the drylands is a common complaint. Lack of suitable implements for seeding and fertiliser application at the proper depths and in proper amounts is a serious handicap for obtaining good results from rainfed farming. Some techniques which have potentiality of producing demonstrably good results have not gone beyond the research stations. Likewise some of the implements which seem to be suitable for dry farmers, have not yet come in mass production and the farmers as well as the development agencies fail to take advantage of these innovations. Those involved in fertiliser promotion may like to note this problem as it is a serious limitation for extending use of fertiliser.

iv. *Socio-economic constraints*

Lack of capital, lack of price incentives for producers of dryland crops, marketing facilities, credit, etc. are numerous socio-economic constraints which seriously affect the morale and condition the attitude of the dry land farmer, but I hardly need to emphasise that the dryland farmer is as much attracted to substantial and stable returns as his counterpart in irrigated farming.

I don't wish to go into the details of these factors. Suffice to say that even when with the available technologies farmers are capable of producing high yields, these socio-economic constraints act as barriers to production.

The list of the problems and constraints to production in ranfed farming is formidable and it has led to slow rate of progress in rainfed farming areas. Use of traditional technology, subsistance farming, intercropping system, low intensity of cropping, low yields and fluctuation in yield are the common features of the dry farming areas.

As a consequence, many of the dryland farmers look for other avenues of gainful employment which leads to vicious circle of untimely farm operations, poor farming and poor yields.

## Strategy for Increasing Crop Production under Rainfed Farming

Now let us look at the strategy for increasing crop production in rainfed farming areas. No doubt the removal of all these constraints will create an ideal situation for a dry land farmer, but it is unthinkable that all these constraints can be removed all at once. Some pragmatic approach is necessary to alleviate some of them which may be most seriously affecting production. Thus a strategy for increasing quantum jump in yield from rainfed farms must identify the key factors.

From the foregoing, it becomes evident that the management of soil moisture, nutrients and crop is the key to increasing production in dry land agriculture. All the three of them are important but the contribution by fertilisers accounts for the largest increase in production under any given system. Thus, any strategy for increasing production from rainfed farming must aim at increasing consumption and improvement of efficiency of use of fertiliser and manures under rainfed conditions. The failure to recognize this factor has resulted in poor results.

## Fertiliser the King Pin of the Strategy for Increasing Production under Rainfed Conditions

The Sixth Five Year Plan targets for fertiliser consumption indicate that India hopes to increase consumption of fertilisers from 5.3 to 9.7 million tonnes. No doubt it is also proposed to double irrigated areas as well as substantially increase area under high yielding seeds, but these targets will be achieved only if the fertiliser consumption in rainfed areas is increased markedly.

Let us now analyse the existing situation of fertiliser use under rainfed agriculture. Analysis of fertiliser consumption in the country shows that Kharif crops which account for 70 per cent of cropped area and cover most of the dry farming area in the country, receive only 40 per cent of the entire fertiliser consumed in the country. Bulk of the fertiliser use, i.e., 60 per cent is in Rabi crops which account for 30 per cent of the cropped area. Looking at the picture differently, we find that while about more than 4 million tonnes of nutrients are used for cash crops, irrigated crops like wheat, rice, sugarcane, cotton, etc., hardly 1 million tonnes of nutrients is available for about 100 million ha of cropped area under rainfed farming situation.

Jha and Sarin (2) made an extensive study on fertiliser use in Indian SAT and found that the average consumption of fertiliser per ha of cropped area was less than 10 kg/ha out of 114 predominantly non-irrigated SAT districts. In 12 districts the fertiliser consumption exceeded 40 kg/ha though in these cases also most of it was used for cotton, groundnut, chillies, tobacco and high yielding varieties of cereals. The low fertiliser using districts are concentrated in Madhya Pradesh, Maharashtra, Rajasthan, and Gujarat which was the major dryland tract of the country.

These authors also observed that in 57 per cent of the nonirrigated districts the annual rate of increase in consumption of NPK was less than 1 kg/ha though in 10 per cent of them it exceeded 5 kg/ha. The authors concluded that irrigation and assured rainfall, high value crops, market incentives and technological advances, govern the rate of growth of fertiliser consumption on these SAT lands. Thus viable technology holds the key to spread of fertiliser.

Jha *et al.* (3) have also concluded that most of the farmers who cultivated high yielding varieties of sorghum and millets used fertilisers under unirrigated conditions also as extensively as under irrigated conditions. This was particularly more pronounced in sorghum hybrids than in pearl millet hybrids growing districts under rainfed conditions of SAT. Judging from the analysis of these data the authors concluded that model classes for application rates of N, $P_2O_5$ for HYV of sorghum was 21-40, 21-30, and 11-20 kg and for HYV of pearl millet 21-40, less than 20 kg and less than 10 kg respectively under unirrigated conditions. These rates were almost double under irrigated conditions. The data clearly lend support to the hypothesis that if gains from adoption were high and stable, the farmers in the SAT as elsewhere did not lag behind in adopting the fertiliser use. This is a clear indication of the importance which the farmers attach to fertilisation of high yielding varieties even for rainfed farming. Thus the surest way to increase consumption of fertiliser in rainfed areas will be increasing area under high yielding varieties.

In cereals, the sorghum, millets, maize and wheat—have the high yielding seeds available which are equally well suited to dryland farming. In pulses, improved varieties of pigeonpea, chickpea and *mung* bean are available but they do not posses the high fertiliser responsiveness which is a serious constraint in the way of increasing use of fertilisers in these crops. However, there is plenty of evidence that on the farmers' fields these crops respond to moderate doses of fertiliser and give economic yield advantages. In oilseeds such as groundnut, soybean and rape seeds also the situation is similar. Thus for enhancing production of these crops, use of fertilisers is essential. Rhizobial cultures can help in reducing the N requirements of these crops to a certain extent. It is expected that the developing technology in the next decade would provide the genotypes which would be more responsive to fertilisers.

In the past most of the high yielding varieties have been extended to irrigated areas. This is the case with wheat and rice but in case of sorghum and pearl millet, extension of high yielding varieties in Maharashtra, Madhya Pradesh, and Andhra Pradesh is taking place in rainfed situations. In pearl millet, these high yielding varieties are spreading in Gujarat, Punjab and Haryana. In case of pulses and oilseeds, the spread of high yielding varieties is rather weak, though there are indications of the spread of these varieties in Punjab, Haryana, Uttar Pradesh, Bihar, Gujarat and Andhra Pradesh. The future hope lies in research and extension and the Government policies regarding marketing and pricing incentives for the cultivation of these crops. The role of the Fertiliser Industry in promotion of balanced use of fertilisers under rainfed farming assumes special importance in future. The use of organic manures, green manures and inclusion of legumes in the crop rotation along with phosphates and Rhizobial cultures should be recognized as an integral part of the crop production strategy for rainfed areas. Unfortunately, this aspect has ben neglected in the past. Conjunctive use of organic manures and inorganic fertilisers needs more emphasis.

The promotional measures will be successful if the high yielding seed, fertiliser and soil and rainwater management are linked up together in one system.

Some of the factors which account for low consumption of fertiliser in Kharif crops are listed below and unless we are able to increase fertiliser use in Kharif crops we cannot attain fertiliser consumption goals in the next 5 years.

1. Large area under rainfed crops with greater risks and low returns.
2. More extensive area under rainfed rice, with no water control, hence with poor efficiency of nitrogen. It hardly needs to be emphasised that unless fertiliser consumption in rainfed rice growing areas of Assam, Bihar, Bengal, Orissa and Madhya Pradesh shows rapid increase in the fertiliser consumption, the fertiliser use targets are difficult to achieve.
3. Lower recovery of nutrients or lower degree of response in Kharif than in Rabi.
4. More weed infestation, which reduces fertiliser efficiency.
5. Greater incidence of disease and pests which reduces fertiliser responses.
6. Imbalanced use of fertiliser which affects the efficiency of the fertiliser applied because of the limiting nutrient.
7. Lack of suitable implements for fertiliser application at the right time in right doses and at right depth.
8. Lack of timely availability of fertiliser and lack of credit.
9. Lack of information on relationship between the soil moisture status and fertiliser need for the crop and soil.

10. Lack of appreciation that water alone is not enough and it is the *combined effect of soil and rain* water management, fertiliser management, crop management which can produce quantum jump under rainfed farming.

### Potentials and Prospects of Fertiliser Use in Arid and Semi-arid Tropics

I have tried to survey the problems and prospects of increasing crop production under rainfed farming conditions of arid and semi-arid regions of India. There is no doubt that there is evidence of appropriate technology for increasing production from these areas but a strategy is to be based on integrated use of soil and rainwater management, use of high yielding varieties of crop and efficient use of fertiliser. The dry land is capable of producing 3 to 5 times more food and the major contribution will come from efficient use of fertiliser but to convince the farmers about the potential of production and maximization of returns, it is necessary to use an integrated approach, *based on removing moisture* stress, nutrient stress an exploitation of the potential of the environment.

Even 12 million ha of deep black *soils in the heartland of India are* capable of producing additional 36 million tonnes of food per annum but they need an application of many tonnes of N, P. Same is the situation with the red, alluvial and laterite soils which also need many million tonnes of nutrients to give satisfactory crop production.

It hardly needs to be stressed that the potential of these nearly 100 million ha of cropped areas of rainfed farms is very vast and remains unexploited. They are producing less than 1/5th of what they are capable of producing. Even an application of 20 kg nutrient per ha will mean an increased consumption of 2 million tonnes of nutrients per year which can produce more than 60 million tonnes of additional grain. If the fertiliser use is combined with best soil and rainwater management, *high yielding varieties and efficient* crop management, the additional production could be many times more. But this will need a change from the traditional technology and subsistance farming to improved technology and market oriented farming system. I may conclude that the future of the rainfed arid and semi-arid tropical lands lies in the use of improved technology.

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