CP 322

Ind. Jn. of Agri. Econ.
Vol 41, No. 3, July-Sept. 1986

RESEARCH AND TECHNOLOGY FOR DRYLAND FARMING IN INDIA: SOME ISSUES FOR THE FUTURE STRATEGY

N.S. Jodha*

Dryland farming is broadly defined to cover rainfed agriculture dominated by low water requiring crops in the arid and semi-arid tropical (SAT) regions of India. Accounting for nearly a half of the country's gross cropped area, this is one of the major sectors of Indian agriculture which has been bypassed by the development process (Jodha, 1984). "Science and Technology" which helped to transform agriculture in the areas well endowed with water and simultaneously accentuated regional inequalities is also recognised as a potential source for inducing growth of dryland agriculture (Swindale, 1981; Swaminathan, 1982).

The development of new technologies for dryland farming has remained a neglected area until recently. Only since the early 1970s, some increase in research resource allocation to dryland agriculture has taken place. The research strategy, which has had 15 years to show its potential and shortcomings, in generating relevant technologies may now require a fresh look particularly in the context of rapidly changing agricultural situation in the country. In this paper, we examine that strategy. The circumstances emanating from the major characteristics of natural resource base of dry regions, emerging scenarios about problems and performance of dryland agriculture and experience of past work on technology development constitute the broad framework for discussion on issues for future R and D (Research and Development) for dryland agriculture.[1] The discussion is confined to issues relating to agricultural research and technology. Hence, our focus may appear rather narrow to someone concerned with larger issues of rural development in dry regions.

---

* Senior Economist, International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru P.O., Andhra Pradesh 502 324, India. The author is thankful to different scientists at ICRISAT and the Central Research Institute for Dryland Agriculture (CRIDA) for valuable comments on an earlier draft of this paper. The views expressed in the paper are the author's own and do not necessarily reflect ICRISAT's position.

1. The issues discussed in this paper are elaborated and supported by detailed evidence in a position paper under preparation (Jodha, 1986 a).

I

THE CONTEXTS

Imperatives of the Natural Resource Endowment

Notwithstanding the intra-regional differences, the key features of the natural resource base of dry regions are: low and variable rainfall; heterogeneity, and in some areas extreme fragility of their land resource base (AICRPDA, 1981).

The key technological imperatives of such a resource base include generation of resource use-cum-production options which *(i)* help in raising and stabilising agricultural productivity through well adapted crops and farming systems, *(ii)* offer multiple and diversified resource use opportunities to match the spatial and temporal heterogeneity of resources and *(iii)* are conducive to protection of fragile resource base.

Traditional farming systems, evolved over generations, contained a number of elements which helped to satisfy these imperatives.[2] The traditional farming systems and their underlying technologies evolved under low population pressure. Agriculture was subsistence oriented. They were resource extensive, involved low input use, and had low productivity. Changes in the circumstances, reflected through a rise in population pressure on land, operation of market forces and side effects of different technological and institutional changes, are eroding the viability of traditional farming systems.

Emerging Scenarios

The strains on traditional farming systems caused by the changed circumstances and the policy responses to the worsening situation of dryland agriculture are reflected through the following:

Uncertain future and stagnation of dry crops: The traditional crop varieties, because of their characteristics like long duration, low yield, high stalk grain ratios and indeterminate habit, suited well to extensive type of mixec farming system. But these very attributes make them less suitable for inten sive cropping systems necessitated by rising pressure on land (Rao, 1982) Moreover, stagnation of production and productivity has also been observec in all the major food crops of dryland agriculture (Sawant, 1983).

On the demand front, the major crops, *i.e.*, coarse cereals like sorghan and pearl millet are faced with a rather alarming scenario. Their low valu status restricts their absorption capacity for yield-enhancing high cost input like chemical fertilisers. Furthermore, they are faced with competition fror

2. Such elements are reflected through the choice of well adapted cultivars with var ing attributes, mixed farming involving crops and livestock enterprises, mixed croppi combining crops of divergent attributes, a range of crop and resource specific agronom practices, and a number of institutional arrangements to guide the usage of the sub-ma ginal lands. These elements vary according to agro-climatic conditions of specific tract For details, see Mirchandani (1971), Jodha and Mascarenhas (1985).

superior cereals like wheat and rice, which, in some areas, through public distribution system, are available at prices lower than that of coarse grains. The technological advancement and government policies relating to input subsidies, price support and procurement have, in their respective ways, contributed to this. Hence, unless the competitiveness of coarse grains is improved through increased productivity and augmented demand, they may further stagnate (Jodha and Singh, 1982). As of today, the demand and price situation regarding other food crops, namely; oilseeds and pulses, is the opposite to that of coarse cereals. However, traditionally these crops, particularly pulses, have a secondary status in a 'cereal first' type of semi-subsistence farming. Improved technology may help change their status (Sharma and Jodha, 1982).

Debasement of livestock component: The population growth led to the decline in traditional grazing areas including rural common property lands, and periodically fallowed crop lands (Jodha, 1986 *b*). These resources helped to sustain livestock as well as associated activities, and ensured benefits of complementarity of crop and livestock at the household level. The change has adversely affected mixed farming systems and has curtailed the range of multiple options they offered to the dryland farmer.

Increasing infeasibility of traditional technologies: Traditional technologies of dry farming, reflected through choice of crops and agronomic and other resource use practices, helped in maintaining soil fertility and in controlling weeds and insect-pests. They also offered flexibility to adjust to to weather variability (Jodha and Mascarenhas, 1985; Walker and Jodha, 1985). However, many of these practices which were possible under 'resource extensive' agriculture are either infeasible or ineffective under the changed circumstances.[3]

Rising natural resource scarcity: Population growth, besides reducing the per capita availability of land, has led to over-exploitation and, therefore, erosion and degradation of crop and grazing lands. The qualitative decline of land resources has set into motion a process of environmental degradation in the dry tropics (ICAR, 1977; Jodha, 1986 *b*).

A time for dryland agriculture: The emerging trends described above have become a matter of serious concern for the policy makers and planners. This in turn has generated yet another qualitatively different scenario. Dryland agriculture has of late received specific attention in the development plans. The widening regional inequalities between irrigated and dry regions; adverse effects of stagnation of dryland crops like pulses and oilseeds on national

3. Practices, like long fallowing, crop-fallow rotation, staggered planting, topo-sequencing of cropping and to an extent intercropping based on crop varieties with long maturity period and high stalk-grain ratios, have been adversely affected by increased pressure on land.

food budget (and foreign exchange); rising cost of managing the 'back lash' of stagnant agriculture in drylands (in terms of environmental degradation, sustaining people through relief, etc.); and some hopes of repeating green revolution in dry areas, are some of the factors responsible for this change (Jodha, 1984). Most of the special programmes like those for promoting production of oilseeds and pulses and development schemes based on natural watersheds have placed a heavy emphasis on technology components to make them a success.

The circumstances discussed above have established an agenda for future R and D for dryland agriculture. High priority should be attached to *(i)* increasing the productivity and competitiveness of dryland crops; *(ii)* strengthening the range of multiple options; *(iii)* conserving and rehabilitating degraded lands; and *(iv)* generating technology options for incorporation into new development programmes.

II

RESEARCH AND TECHNOLOGY: PAST EFFORTS

Until recently, agricultural research in drylands has remained a neglected area. The extent of neglect and possible reasons thereof are discussed elsewhere (Jodha, 1979, 1983). The present discussion is confined to the foci and achievements of past research efforts, particularly their implications to guide future R and D strategies for dryland agriculture.

Agricultural research and technologies are often grouped into two rather interrelated categories: *(i)* resource-centred research/technology, and *(ii)* crop- or seed-centred research/technology The former in the case of dryland agriculture includes soil and moisture conservation practices and their efficient use. The latter covers the work related to crop improvement through breeding, selections, adaptations, etc. More systematic and focussed research covering the above aspects began only since the 1960s. In the early 1970s the All India Coordinated Research Project on Dryland Agriculture (AICRPDA) and several other co-ordinated research projects for a number of dryland crops were initiated (ICAR, 1979). Their work was complemented by the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) established in 1972 near Hyderabad.

If one goes by the inventory of recommended improved crop varieties/hybrids (CRIDA, 1985), and soil moisture conservation/water harvesting techniques (ICRISAT, 1981 *b*; El-Swaify, *et al*, 1985), the achievements of past R and D seem to be quite impressive. Unless one is governed by the inflated expectation generated by the green revolution in the irrigated areas, which is difficult to repeat in dry areas due to harshness of environment and location-specificity (Jodha, 1983), the farm level impact of these technologies, particularly the seed-centred ones, is not discouraging (Walker and Singh, 1983). However, the impact of resource-centred technologies is much less visible. Furthermore, for a variety of reasons, there is a considerable gap between their performance at experimental stations and at the farm level (Rastogi, 1983).

III

LESSONS AND IMPLICATIONS

An evaluation of past research to identify the issues for future R and D for dryland agriculture is attempted largely by highlighting the specific attributes of new or prospective technologies emerging from the past research.

Major Achievement: Potential for High Productivity Arable Farming

The major achievement of past research is generation of potential for high productivity arable farming particularly in the crops in relatively dependable rainfall parts of dry tropics. The factors contributing to this are discussed below.

New cultivars: The lynchpins of the new technologies are the hybrids or modern varieties of major dry crops, mainly cereals. They have recorded substantially higher yields compared to local varieties. Besides their high genetic potential for grain yield, the other attributes of the new cultivars contributing to their performance and stability are: (*a*) their responsiveness to high input use, particularly chemical fertilisers and improved agronomic practices; (*b*) their higher grain-stalk ratios, and (*c*) photo-period insensitivity and short maturity period in most cases (CRIDA, 1985). The first two attributes provide considerable scope for manipulation of grain yield through changing input use and management practices. The last one helps in extracting maximum benefit from the short growing season characteristic of the dry regions. Earliness enhances their potential in raising cropping intensity and widens the scope for their adaptation to different situations (ICRISAT, 1981 *a*; Rao, 1982).

Complementarity with resource-centred technology: New cultivars perform better and absorb more yield-enhancing inputs under assured moisture situations. The performance of individual crops or temporally extended cropping systems based on these cultivars can, therefore, be further improved by increasing effective availability of moisture or extension of growing season through the use of various moisture conservation techniques (ICRISAT, 1981 *b*; Walker *et al.*, 1983).

Potential of slack resources: The availability of new cultivars which occupy lands for shorter duration, and the possibility of prolonging the growing season through moisture conservation and drainage management technologies reveal considerable extent of slack resources for increasing crop production in the dry tropics. The possibility of having two instead of one crop in traditionally *kharif* fallow regions is one example (ICRISAT, 1981 *b*).

Implications

The above account indicates that despite slow progress in developing high-yielding varieties (HYVs) for pulses and oilseeds and also cereals to suit the *rabi* tract, new technologies do have some potential to redress the situation reflected by the agricultural scenarios discussed earlier. In view of its achievements and availability of ample genetic variation for dry crops,[4] the HYV-based approach could be profitably pursued in the future. Of course, the existing imbalance between cereals and oilseeds/pulses, an outcome of the research priorities of the past, should be corrected.

However, the future R and D for dryland agriculture needs to be sensitive to the problems of sustainability and robustness of HYV-based technologies as well as to certain facets of dryland agriculture largely ignored in the past. Factors crucial to sustainability of new technologies are: (*a*) moisture conservation or rainwater management, (*b*) new cultivars' protection against yield reducers like insect-pests and diseases, and (*c*) the breaking of persistent yield barriers for specific dryland crops. The robustness or effective use of new technologies at the farm level is limited by attributes like (*a*) high degree of precision, (*b*) their strong dependence on non-technical (institutional) factors, (*c*) the mismatch between their resource requirements and the farmers resource position, (*d*) location-specificities, and (*e*) relatively narrow range of options offered by them.

Rainwater management: Due to the strong complementarity between moisture conservation and crop-centred technologies, the non-availability of widely acceptable technology in the former may prove a bottleneck to the success of HYV-technology. Technology development in this area is handicapped because of logistics and high cost of experimentation and location-specificity, on the one hand, and institutional constraints emerging from the lack of convergence between property boundaries and physical contours of land, on the other (Jodha, 1979). Furthermore, the focus of this research in the past has been too much diffused and ad hoc. Hence systematic research in this area for different soil-rainfall zones should form an important part of the agenda for future R and D.

---

4. Germplasm available at ICRISAT includes 24,600 lines of sorghum, 17,080 lines of pearl millet, 13,820 lines of chickpea, 10,100 lines of pigeonpea, and 11,490 lines of groundnut, collected from all over the world (ICRISAT, 1985).

Yield reducers: The new cultivars are generally more susceptible to yield reducers like insect-pests and diseases than traditional varieties. Increased cropping intensity and in some situations year round cropping made possible by new technologies provide a suitable environment for the survival and spread of insect-pests. This calls for high priority to maintenance research to keep up defences against yield reducers, especially as old sources of resistance break down. The collapse of the hybrid pearl millet-based green revolution in the early 1970s is an example. In view of high cost and adverse ecological consequences of chemical control measures, avoidance of pest and disease through resistant breeding, biological controls and crop rotations should be the long-term strategy.

Yield Barriers and Competitiveness of Dry Crops

A mention of yield barriers soon after the discussion of high growth potential of arable farming due to new technologies may sound contradictory. However, this may not be so. The limits to yield growth of dry crops stem from harshness and fluctuations of the environment as well as ecological limits of dry crops as plants. Beyond certain limits, an experimentally feasible yield improvement may become an economically non-viable option. Such limits to productivity tend to operate much earlier for the low value coarse grains like sorghum and pearl millet.

Higher inputs and improved management practices can raise crop yields. But this tends to make the crop-centred technologies costly. By implication, higher costs deter the resource poor farmer from adopting such technologies. They also reduce the competitiveness of dry crops in general and low value crops in particular.

Possible approaches: Thus, raising productivity and by implication the competitiveness of dryland crops should constitute a key task for future R and D. The possible steps involving both technological and policy measures may include the following.

(i) Increasing the use efficiency of yield-raising (high cost) modern inputs like fertiliser. Developing appropriate cultivars, enhancing precision in input use, ensuring complementary use of moisture supply, and perhaps some elements of organic farming can contribute in this respect.

(ii) Emphasis on the total cropping system rather than individual crops, especially low value coarse cereals can help raise overall productivity and returns. This underscores the need for breeding crop varieties which perform better as components of the system (*e.g.,* one suited to intercropping as against sole cropping) and for developing cropping systems appropriate to new cultivars.

(iii) More emphasis should be assigned to improving varietal food quality, particularly for low value coarse grains. This implies greater attention to consumer taste and to other attributes of crops to make them suitable for processing and diversified uses to increase their demand and competitiveness.

(iv) To harness the benefits of increased yield potential and new attributes of crops, technology has to be complemented by more effective price support, marketing and processing facilities, etc.

(v) An additional approach involving a major policy shift, to enhance the competitiveness of dryland drops is to increase the emphasis on high value crops like oilseeds and pulses (besides the traditional cash crops like cotton in some areas), which do not suffer handicaps faced by coarse cereals. Similarly, concentration on high potential areas, where productivity of dry crops including that of coarse cereal is quite high, can raise the latter's competitiveness significantly.

The Crucial Role of Institutional Components in New Technologies

In the case of moisture conservation/water harvesting technologies, requirements like adherence to physical contours or use of mini-watershed as a unit of land management are not satisfied because the property boundaries on land do not coincide with the physical contours. This makes the adoption of resource-centred technologies difficult (Jodha, 1979).

The solution lies in *(i)* making resource-centred technologies so divisible that they could be adopted on individual holdings and *(ii)* making these technologies highly profitable so as to induce farmers' group action to facilitate adoption of indivisible components of technologies (Doherty and Jodha, 1979).

However, since it is essentially an institutional problem, the solution lies in government policies relating to land use. Lack of this support constrains, besides financial back-up, most of the resource-centred technologies including the ones directed to promote alternative land uses for sub-marginal lands.

Precision and High Management Intensity

New technologies involve minor but complex adjustments in agricultural operations, their sequence, timings and input combination, etc. An important element in the whole process of raising cropping intensity and productivity through adapting plants to micro environment (*i.e.,* field conditions) in dry areas and vice versa, is precision in operations. Significant differences in yields were found associated with small deviations from the recommended level of precision in operations (Singh and Das, 1984).

However, such a degree of precision does not match with the experience of the farmer as well as extension/support services personnel, who are accustomed to resource extensive low yield agriculture, where precision/timeliness did not matter. This highlights the need for some reorientation of extension services and skill formation at the farm level. Addition of specific features to the design of farm equipment can also partly help in this respect.

Cost Factor

Besides management skill, the farmer may need strong resource support as the high productivity technologies are costly also (Walker *et al.*, 1983). In the context of historically low and unstable income and general state of under-investment in dryland agriculture, this fact assumes greater significance.

Location-specificity: Heterogeneity of the resource base which makes a given agricultural activity or a practice suitable for one area/location and unsuitable for the other, also makes the new technology highly location-specific. The involved degree of precision makes it more so. The resource-centred technologies are more location-specific than the crop-centred (Binswanger *et al.*, 1980; Walker *et al.*, 1983). Location-specificity restricts the area of applicability and impact of technologies, and finally reduces the range of options generated by technology. Hence, no single technological breakthrough can help transform dryland agriculture on a large scale. Future R and D for dryland agriculture, therefore, should strive at reducing the location-specificities of prospective technologies.

Besides encouraging the current approach towards wider adaptability of technologies through multi-location testing and on farm verification, this calls for demarcation of homogeneous tracts called recommendation domains within the dry tropics and conduct of problem-focussed research accordingly. This will imply considerable restructuring and widening of research network for dry regions.

Short Range of Options

Viewed in the context of overall farming systems, the range of potential options offered by high cropping intensity due to new technologies is quite narrow to be able to match the heterogeneity of the resource base. In the first place, HYV technologies ensuring high cropping intensity may not extend to the moisture-wise low potential areas and to resource poor farmers. Secondly, emphasis on crops and that too on raising grain yield, ignoring the importance of stalk; low attention to minor crops, thereby ignoring the range of diversity offered by them; and insistence on standardised operational norms and precision, reducing the scope for flexibility, tend to shorten the range of options available to the adopters of new technologies.

In order to widen the range of options, the future R and D should give greater attention to minor crops which have their own ecological niche and place in the farming systems. Livestock support system at farm levels is another area requiring greater attention. Research in these areas will help to extend the benefit of modern science and technology to areas and people bypassed by R and D in the past, as shown by the experience of *ragi*, a minor crop, in Karnataka.

IV
SYNTHESIS

Despite very late start, persistent environmental constraints and only modest increase in resource allocation, the R and D effort in dryland agriculture has generated a number of technologies which indicate the potential for more productive and stable farming in dry areas. However, the past approach had its own limitations also.

The Imbalances

An important feature of past R and D in dryland agriculture is a sort of imbalance in the approaches towards different crops and different areas of research. For instance, until recently much higher priority was given to major coarse cereals compared to other crops like oilseeds and pulses. The consequence is development of a large number of HYVs for coarse cereals and very limited success in other crops in this respect. The same argument extends to minor crops and to resource-centred technologies when compared to major coarse cereals.

Responses to Agricultural Scenarios

Without belittling the progress achieved, it may be stated that the effectiveness or suitability of technological achievements, as responses to agricultural scenarios discussed earlier, is also influenced by the above imbalances. This is clear from the following:

(i) Competitiveness of dryland crops as a group is severely handicapped due to lack of HYVs in oilseeds and pulses; and inability to exploit complementarity between seed-centred and resource-centred technologies due to non-availability of remunerative moisture conservation techniques.

(ii) The imbalance generated by concentration on major crops and on grain production mainly has not helped in strengthening the range of multiple, high productivity options particularly those involving livestock.

(iii) Due to rather casual approach and limited effort, there is very little in terms of viable technological options, which can help conservation and upgrading of the depleted sub-marginal lands.

(iv) The availability of technology options to complement the government's increased concern for dryland agriculture is also adversely affected by the above imbalances in past R and D. The special drives to enhance cereal production could be helped by HYVs of sorghum and pearl millet, but the same is not the case with pulses and oilseeds. Similarly, for major area-based programmes like National Watershed Development Project, past R and D do not offer many options which are viable enough.

Default on the Institutional Front

It is also true that even the available back-up from technologies for public programme is not fully utilised. It seems as if the policy makers expect technology to act as substitute for institutions and public policies. Looking to the lack of institutional and other support, one gets the impression that technologies are expected to take care of all problems, namely, specificities of natural resource endowment, the farmer's weak resource position, and constraints emanating from the absence of institutional, and infrastructural support required for adoption and operation of any productive technology. This is more so in the case of resource-centred technologies where the state's land use policies can play a more important role than further refinements in techniques of moisture conservation.

Issues for Future and Question of Priorities

The issues emerging from the review of past R and D constitute an agenda for the future work. They can be regrouped according to their primary foci such as their role in sustaining the HYV-based approach, easy transferability of technology, etc. The relative priorities to them will depend on the weightage given to their primary foci and their implications in terms of promoting productivity, efficiency, equity, etc. The relevant details are summarised in Table I, which is self-explanatory.

(i) To sustain the recently initiated high productivity arable farming, the emphasis should be laid on HYV-based cropping system (rather than on individual crops); improvement in the use efficiency of modern inputs like fertilisers, maintenance research for new cultivars' protection against yield reducers like pests and diseases; and finally institutional and technical mechanisms for more efficient management of rain water.

(ii) To facilitate development of widely applicable and robust technologies for dryland agriculture, some restructuring of research infrastructure (to handle the problem of location-specificity), and reorientation of extension services (to take care of precision and high management skill), will be essential. Problem-focussed demarcation of homogeneous tracts called recommendation domains should be emphasised as a research tool. The resource support to the farmer to encourage adoption of new technologies is a well emphasised issue to need a repetition.

(iii) For raising income and not just crop production of dryland agriculture the emphasis should be laid on: (*a*) high value food crops such as oilseeds and pulses besides the traditional cash crops; (*b*) high potential areas; and (*c*) promoting alternative uses of dry crops including through processing. Science and technology can help inject relevant characteristics into crops to suit the above purposes, but development of processing and marketing infrastructure is the responsibility of the planners.

Table I. Summary of Issues for Future R and D for Dryland Agriculture as Revealed by Review of the Past Work*

Issues requiring greater emphasis under future R and D	Implications' relating to broader objectives: Productivity/Stability				Equity		Logistics		
	Competitiveness of dryland crops	Use of comparative advantage	Wider range of options	Resource conservation/upgrading	Inter-regional	Intra-regional/Inter-group	Chances of quick success	Easy transfer of technology	Key role of institutional factors
A. For productivity gains									
. Continuation of HYV approach	✓				✓		✓		
. Cropping systems (not individual crops)	✓		✓						
. Use efficiency of new inputs	✓								
. high potential areas/crops	✓		x		✓	x	✓	✓	
B. To face demand price constraints									
. Work on quality aspects of HYVs (for alternative uses/processing also)	✓				✓				
. Concentrate on high value crops (oilseed/pulses)	✓	✓			✓	x			✓ ✓
C. For spread and sustainability of technology									
. moisture management research	✓		✓	✓					
. crop protection research	✓								
. wider adaptability research	✓								
. area/problem focussed research	✓	✓						✓	
. skill formation/extension for precision farming	✓					✓	✓	✓	
. policy/logistic support								✓	✓
D. For flexibility					✓			✓	✓
. Minor crops			✓						
. Livestock support system			✓	✓	✓		x	✓	✓
. Alternative land uses			✓	✓	✓				✓

* Mark (✓) indicates positive role of specific option for specific objectives; while mark (x) indicates some degree of contradiction between the two.

(iv) Emphasis on minor crops (including high value minor crops) and strong livestock support is required for generating multiple options which has equity implications also. This is one way to extend benefits of science and technology to areas/groups by-passed by the past R and D.

(v) The development, diffusion and performance of dryland technologies are constrained by (*a*) poor infrastructure and general under-investment in dryland agriculture both at the farm level and regional level; (*b*) inadequate support system, a product of historical neglect; (*c*) existing land and water use policies which permit *laissez-faire*, even if it means gross under-utilisation or misuse of natural resource potential. In some areas such as resource conservation, appropriate land use/water use policies can do more than technologies can do.

Given clearer idea of weightage by the policy makers to specific implications of new technologies and detailed projections about future demand and supplies of major inputs, including fertilisers, draft power, water, and crop output, more precise guidelines for future R and D could be worked out.

Finally, it may be added that owing to the small size of holding, on the one hand and ecological limitations of dryland agriculture, on the other, the latter even with strong support of new technologies, may not prove a total answer to the problem of low income of those who depend on dryland farming. The need for non-farm activities as a part of rural development programme, therefore, cannot be over-stated. New farm technology can at best serve as an important component of the development strategy.

REFERENCES

All India Coordinated Research Project for Dryland Agriculture (AICRPDA): Improved Agronomic Practices for Dryland Crops in India, Hyderabad, Andhra Pradesh, 1981.

H. P. Binswanger, S. M. Virmani and J. Kampen: Farming Systems Components for Selected Areas in India: Evidence from ICRISAT, Research Bulletin No.2, ICRISAT, Patancheru, Andhra Pradesh, 1980.

Central Research Institute for Dryland Agriculture: Efficient Management of Dryland Crops, Hyderabad, Andhra Pradesh, 1985.

V. S. Doherty and N. S. Jodha, "Conditions for Group Action among Farmers", in J. Wong (Ed.): Group Farming in Asia: Experience and Potential, Singapore University Press, Singapore, 1979, pp.207-223.

S. A. El-Swaify, P. Pathak, T. J. Rego and S. Singh, "Soil Management for Optimised Productivity under Rainfed Conditions in Semi-Arid Tropics", *Advances in Soil Science*, Vol.1, No.1, 1985.

Indian Council of Agricultural Research (ICAR): Desertification and Its Control, New Delhi, 1977.

ICAR: 50 Years of Agricultural Research and Education, New Delhi, 1979.

ICRISAT: Proceedings of International Workshop on Intercropping, January 10-13, 1979, Hyderabad, Patancheru, Andhra Pradesh, 1981 *a*.

ICRISAT: Improving the Management of India's Deep Black Soils: Proceedings of the Seminar on Management of Deep Black Soils for Increased Production of Cereals, Pulses, and Oilseeds, May 21, 1981, New Delhi, Patancheru, Andhra Pradesh, 1981 *b*.

ICRISAT: Annual Report 1984, Patancheru, Andhra Pradesh, 1985.