Vol XLI
No. 4

ISSN 0019-5014

CONFERENCE NUMBER

**PART II
OCTOBER-
DECEMBER
1986**

INDIAN JOURNAL OF AGRICULTURAL ECONOMICS

INDIAN SOCIETY OF
AGRICULTURAL ECONOMICS,
BOMBAY

Ind. Jn. of Agri. Econ.
Vol. 41. No. 4, Oct.-Dec. 1986

TECHNOLOGY POLICY FOR DRYLAND AGRICULTURE: SOME ISSUES AND APPROACHES

P. Rangaswamy*

It is now well-recognised that the development of dryland agriculture is a crucial means for achieving the Plan objectives of redressing regional imbalances, alleviating poverty and increasing the production of pulses and oilseeds which are in short supply. It can, thus, help to meet the demands of both growth and social justice and provide the much needed correction to the earlier strategy which concentrated on a few well-endowed regions for augmenting food production. The Seventh Five Year Plan document shows a clear recognition of this need and puts the prime emphasis on regional dispersal of growth along with special programmes to assist the weaker sections to contribute to as well as gain from growth.

TECHNOLOGY DESIGN

A technology policy is or should be an integral part of total policy framework designed to achieve the above ends. Technology is the main source of growth but it can also promote equity if it is designed to cater to the requirements of all categories of farmers, namely, big, medium and small and also adapted to the varying agro-climatic conditions of different regions. The development of dryland technology itself illustrates this possibility. In the mid-sixties when the high-yielding varieties (HYV) programme was launched, some hybrid and improved varieties of jowar and bajra were also released along with those of wheat and rice but their performance widely varied across locations. Realising the need for evolving packages of practices specific to various agro-climatic regions, the Indian Council of Agricultural Research (ICAR) established in the early seventies, the All India Coordinated Research Project for Dryland Agriculture (AICRPDA) with 23 co-ordinating centres.

These centres initially developed high cost packages with the primary emphasis on bio-chemical and mechanical inputs but there were problems with regard to diffusion of these practices in the project areas, especially the problem of relapse to traditional practices once the project support is withdrawn (Sanghi and Vishnu Murthy, 1983). In order to evaluate the technoloy under farmers' management conditions and to identify the gaps and constraints in its adoption, the ICAR in collaboration with the Government

* Agricultural Economics Research Centre, University of Delhi, Delhi-7. This paper is based on part of the work done by the author at the Perspective Planning Division of the Planning Commission, Government of India. He is grateful to Dr. C. H. Hanumantha Rao and Dr. D. P. Chaudhri for valuable comments on earlier drafts of the paper and to S/P. Gupta and Padam Singh for their help in this work. The views expressed are those of the author.

of Canada set up during 1976 Operational Research Projects (ORP)' in five centres of AICRPDA. These centres organised trials on the farmers' fields to measure the contributions to yields of different inputs or practices. They also carried out farm household surveys to identify their socio-economic and other constraints. One important consequence of these as well as other studies has been the attempt to adapt the technology to the resource constraints of dryland farmers, especially the small land holders (Singh, 1983; ICRISAT, 1980). More attention is now being paid to the development of low cost cultural or management practices which will increase the efficiency of fertiliser use, help to avoid pest attacks and drought spells, etc.

TECHNOLOGY TRANSFER

The immediate need is an effective transfer of the proven technology to the farmers' fields. Besides AICRPDA which has developed improved techniques for several crops in the red and black soil areas, the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) has designed techniques for jowar, bajra, gram, *arhar* and groundnut specially suited to deep vertisols with assured rainfall (above 750 mm.). These techniques have made their impact in the respective project areas of these centres but their diffusion outside those areas is not known, except for HYVs of jowar, bajra and maize as mentioned above. As a first step towards wider diffusion, it is necessary to conduct on-farm verification trials and demonstrations in the different agro-climatic zones of the country outside the project areas.

Demonstrations are the chief means of convincing and educating the farmers about the improved practices. They should be organised on farms of different size-groups—small, medium and big. While the farmers' practices may be followed on the control plots at the respective average input levels of each group, the improved practices may be adopted in two different combinations as follows:

Size-group	Input levels		
	Chemical	Mechanical	Labour
Big	High	High	Intermediate
Small and Medium ..	Intermediate	Intermediate	High

The intermediate levels of chemical and mechanical inputs on the small and medium farms can, to a certain extent, be compensated by more intensive improved cultural practices. These will be in accordance with the resource endowments of the farm categories, though efforts should be made to neutralise their differential access to institutional credit and inputs. Some adoption studies of AICRPDA, in fact, indicate these differences in the rates of adoption (see, for instance, AICRPDA/Birsa Agricultural University, 1981). The demonstrations organised in IADP areas used only uniform input levels on the demonstration/control plots which were somewhat unrealistic.

Demonstrations need to be effectively combined with other extension methods like farm visits, farmers' training camps, mass media, etc. There should be an organic link between these methods so as to achieve a common goal or target. This requires effective planning by the extension agency and also proper training for the extension workers. In this respect, the Training and Visit (T & V) system of extension seems to have fared better than the earlier system in several areas.

TECHNOLOGY COMPONENTS AND CONSTRAINTS TO ADOPTION

Variety

Of the several components of the improved dry farming technology (see ICAR, 1982 *b*), the variety or genotype is probably the basic. It is generally a low cost input (with some exceptions) compared to fertiliser or pesticides. So the adoption rates for the former are observed to be usually higher than those for the latter in areas where higher profitability of new varieties compared to the local ones is well established (Rastogi and Annamalai, 1981; Rangaswamy, 1982 *a*). This is revealed by the adoption studies conducted by AICRPDA in 16 centres over four years 1976-80 (see Table I). It implies

TABLE I. PER CENT OF FARMERS ADOPTING IMPROVED DRYLAND PRACTICES IN 16 LOCATIONS OF INDIA OVER FOUR YEARS (1976-80)

Crop	Improved seed	Fertiliser	Plant protection	Interculture and weeding
(1)	(2)	(3)	(4)	(5)
1. Groundnut	66	49	20	96
2. Cotton	54	38	38	96
3. Castor	58	23	17	88
4. Jowar (*kharif*)	22	25	25	86
5. Jowar (*rabi*)	87	41	27	95
6. Bajra	48	28	8	83
7. Wheat	68	59	23	40
8. Upland paddy	57	31	7	62
9. *Setaria*	7	4	3	5
10. Maize	17	4	5	84
11. *Ragi*	62	69	8	—
12. Gram	34	19	5	25

Source: Rastogi and Annamalai (1981).

that many farmers are using the new varieties at low levels of chemical inputs. This could be attributed not only to resource or credit constraints but also to the riskiness of investment. However, there are several constraints to the widespread adoption of new varieties. The most important of them are possibly their susceptibility to pests and diseases as well as drought conditions. The lack of ready and timely availability of seeds is also a factor limiting their coverage. While the development of disease-free and drought-tolerant varieties should receive high priority in research, great care needs to be bestowed on the selection and release of genotypes from the on-going breeding trials for farmers' use. High average yield cannot be the sole criterion, even though it is quite important. Weightage should be given also to other criteria such as their stability of performance especially in years of droughts and floods, resistance to diseases, fodder yields and response to low to moderate doses of fertiliser, as compared to the local varieties. These are of obvious importance to the dryland farmers and can influence their adoption rates significantly.

It will be difficult, of course, to incorporate all the desirable features in *one* variety of a crop. A trade-off will certainly be involved between the several traits as, for instance, between drought-resistance and yield, fodder and grain yields, etc. This problem can be resolved by assigning suitable weightage to the different traits in accordance with the farmers' preferences and by offering a choice of varieties with different characteristics. A continuous interaction between the extension and research agencies is essential so that the latter may be alive to the field needs and problems and the former can be familiar with the latest findings of research. The Operational Research Projects in the five centres of AICRPDA mentioned above have, in fact, provided valuable feed back to the Research Stations (see Sanghi and Vishnu Murthy, 1983) and similar projects need to be established in other centres also.

Fertiliser

The causes for the current low levels of fertiliser consumption in many of the dry farming areas are low percentage of irrigated area and HYV area, the riskiness of hybrid varieties, the high fertiliser-product price ratios, inadequacy of institutional credit, sale outlets, etc. (see Desai, 1983). Available evidence suggests gross under-investment in fertiliser for the dryland crops in the sense that there is a wide gap between expected profit-maximising doses and the average doses used by the farmers. Even though fertiliser investment is subject to risk of loss in bad years, it is profitable on an average for two or three years (unless they are consecutively drought years). In fact, riskiness of investment and risk-aversion of farmers explain only a small part of the investment gap. The major part of the gap can be attributed only to other factors such as credit constraints, difficulty of access to inputs, knowledge, etc. (Rangaswamy, 1982 *b*). This gap can be bridged by removing the constraints mentioned above.

Any attempt to raise or conserve moisture levels in the dryland areas is bound to result in more fertiliser absorption not only directly, *i.e.*, in the areas already covered by HYVs but also indirectly via inducing more area coverage under HYVs which are more responsive to fertiliser. Table II shows the close relationship between these factors. States like Tamil Nadu, Haryana, Uttar Pradesh and Andhra Pradesh which have high percentage of irrigated area, have also high levels of HYV coverage and fertiliser consumption in comparison to other States. Thus, the development of groundwater resources wherever feasible and harvesting of run-off water in community ponds or tanks in other areas will lead to widespread adoption of the bio-chemical inputs. The Integrated Watershed Development Programme

TABLE II. FACTORS ASSOCIATED WITH FERTILISER CONSUMPTION IN INDIAN STATES

States	Fertiliser consumption (kg./ha.) 1983-84	Per cent of rainfed areas* to GCA	Per cent of irrigated area to GCA 1981-82	Per cent of HYV area to GCA 1983-84	Short-term co-operative credit per ha. 1982-83	GCA per sale point of fertiliser 1983-84
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1. Karnataka	43·4	46·5	16·0	18·4	107	1435
2. Maharashtra	31·5	72·4	13·2	32·0	169	2222
3. Gujarat	46·1	40·4	23·1	22·1	137	1573
4. Rajasthan	11·3	45·1	20·0	15·5	66	4312
5. Madhya Pradesh ..	14·5	70·7	11·5	18·7	72	2995
6. Andhra Pradesh.. ..	69·6	12·4	35·9	32·4	98	1403
7. Uttar Pradesh	66·2	4·9	46·9	41·0	120	1219
8. Haryana	56·0	0	59·3	45·7	470	1922
9. Tamil Nadu	84·9	0·8	49·6	41·5	217	467
10. Bihar	27·4	35·3	33·7	42·3	32	1714
11. Orissa	11·8	44·2	22·9	18·4	95	1574
12. West Bengal	49·8	53·1	23·4	31·6	58	439
All-India	43·5	35·7	29·1	31·5	136	1353

Sources: 1. Government of India (1985 *b*).
2. Fertiliser Association of India (1985).
*With 15 per cent or less of irrigated area, GCA=Gross cropped area.

initiated in the Sixth Plan and to be followed up in the Seventh Plan will be the first major step to harvest run-off water in ponds and utilise it for critical irrigation. Successful execution and maintenance of these works will go a long way in absorbing more of modern inputs, raising the profitability of dryland crops and reducing risks of crop losses due to long drought spells in the rainy season.

It should be noted, however, that Gujarat, Karnataka, Maharashtra and West Bengal have achieved higher levels of fertiliser consumption (resulting in higher yields) in spite of low irrigation ratios. This can be attributed to better availability of co-operative credit among other factors in the first three States and easier access to sale points in West Bengal (Table II). In contrast, Rajasthan, Madhya Pradesh and Orissa have low levels of fertiliser consumption associated with low levels of other inputs including HYVs, co-operative credit and sale points. These facts highlight the need to strengthen institutional infrastructure relating to extension, credit and input delivery in the last three States as well as Bihar.

There is need to cut down costs on chemical fertilisers and pesticides. A balanced use of NPK, farmyard manure and bio-fertilisers based on soil tests can reduce costs and at the same time achieve greater efficiency both in the short and long run. Intercropping/sequences of cereals and legumes (which fix nitrogen in the soil) reduce the need for nitrogenous fertiliser and are already practised by the farmers in several areas. The use of pest-resistant varieties and chemically treated seeds can minimise the chances of pest attacks and cut down costs on pesticides. Early sowing can avoid incidence of pests and diseases like shootfly in the case of jowar and ergot in regard to hybrid bajra.

Agronomic Practices

There are several other improved agronomic practices—labour intensive, low cost inputs—which have proved their worth not only in Research Centres but also in operational research trials and demonstrations on farms (see ICAR, 1982 *a*). Hence the adoption rates for these practices (like interculture and weeding) are quite high (see Table I). Practices including off-season tillage, interculture, maintenance of optimum plant population, proper inter-row and intra-row spacing, etc., have significant positive impact on yields. They positively interact with the modern bio-chemical inputs making the package effect greater than the sum of contributions of individual components.

Mid-Season Corrections

The AICRPDA has devised some strategies to deal with weather aberrations like sowing alternative crops and varieties for normal and delayed monsoons, *e.g.*, sorghum for normal onset of monsoon and sorghum fodder for late onset in Bellary; rice and transplanted finger millet for the two situations in Chotanagpur. If the farmers were to change crops or varieties in the mid-season, it is necessary that the seed supply agencies keep adequate stock of seeds of alternative crops and varieties.

The above are the important components of the technology designed by the AICRPDA. The technology developed by the ICRISAT is specially suited to deep vertisols with dependable rainfall. The technology is carried out in small watersheds ranging from 5 to 25 hectares. The basic elements of the ICRISAT package are:

(*i*) Post-harvest cultivation after the *rabi* crop.
(*ii*) Land-levelling and shaping, construction of field and community drains and the use of graded broad-beds and furrows.
(*iii*) Dry seeding before the monsoon.
(*iv*) Use of improved varieties and moderate amounts of fertiliser.
(*v*) Proper placement of seeds and fertiliser.
(*vi*) Timely plant protection.

Most of the above practices are carried out with the help of a bullock-drawn wheeled tool-carrier. These practices have been found to be generally profitable in deep vertisols except in drought years (Walker *et al.*, 1983). The broad-bed and furrow system facilitates drainage, but where drainage is not a problem, this method has no advantage over flat sowing. The wheeled tool-carrier is too expensive (around Rs. 10,000) for an average farmer and so a cheaper substitute needs to be found (NABARD *et al.*, 1984). It also requires heavy draft animals which the small farmers cannot afford. In the absence of summer showers, preparatory cultivation and dry seeding have been found difficult.

The techniques developed so far by the AICRPDA and ICRISAT seem to be suited for the medium and high rainfall areas. A serious gap is the technology for low rainfall areas (below 750 mm.). Further, the techniques are found to be more profitable in the deep to medium deep black soil areas than in the red soil or shallow black soil areas due to the higher moisture-holding capacity of the former. For areas with shallow red or black soils (which are not very productive) and with low rainfall, suitable crop techniques have to be evolved. Further, priority should be given to the strengthening of other supplementary enterprises like dairy, agro-forestry, sylvi-pasture, etc. in these areas, as crop production alone will not be sufficient for the farmers' sustenance.

There is a clear need to strengthen and expand the activities of the Dry Farming Research Centres set up under AICRPDA. More Adaptive Research Centres for coarse cereals, pulses and oilseeds have to be set up in the different agro-climatic zones. Highly motivated and qualified staff have to be appointed with the assurance of regular promotional avenues. Frequent transfers of staff should be scrupulously avoided since they have seriously affected the continuity of work in these centres. More funds will be required for the above purposes. The resources now devoted to dryland research are incommensurate with the share of dryland area to total area (Jodha, 1983). There is urgent need to step up the allocation for dryland research.

THE NEW STRATEGY FOR DRYLAND FARMING

The strategy for the development of dryland farming based on the watershed approach has been evolved after consultations between the Central and State Governments and agricultural scientists. Under this scheme, selected watersheds are being treated with dry farming practices according to a phased programme. Simultaneously, work is also being carried out in the areas outside the watersheds for promoting adoption of available techniques like the use of improved seeds, fertiliser, seed-cum-fertiliser drill, etc.

The watershed approach offers an excellent opportunity for an organised and integrated management of drylands. It can facilitate an optimal use of the available resources including soils and water. It can lead to greater diversification of dryland farming by promoting animal husbandry, agro-forestry, agro-horticulture, sylvo-pastural system, etc., which would generate more employment and income-earning opportunities and also reduce the risks inherent in crop-centred activity.

The success of this project, however, depends on several factors including close co-operation among the farmers and project officials, co-ordination of the activities of several departments, building up of the required infrastructure for the various services including credit, input delivery system and marketing. All these cannot be accomplished in the short run. Hence this will be a phased programme. To begin with, crop enterprises can be taken up for which technology is available. Gradually, other programmes may be taken up depending on the local needs, farmers' skills, resource availability, land use capability, infrastructure facilities, etc. Proper planning of each activity taking into account all the above factors and with the active involvement of the farmers will be crucial for its success. Close co-ordination between watershed development and poverty alleviation programmes like Integrated Rural Development Programme (IRDP), National Rural Employment Programme (NREP), Training of Rural Youth for Self-Employment (TRYSEM) and Rural Landless Employment Guarantee Programme (RLEGP) will be mutually beneficial, since the types of activities covered by them are similar. This will avoid duplication of effort and help in the pooling of resources—both men and materials—for their more effective utilisation.

REFERENCES

All India Coordinated Research Project for Dryland Agriculture (AICRPDA)/Birsa Agricultural University: Report on Adoption and Diffusion of Recommended Technology, Ranchi, 1981.

Gunvant M. Desai, "Fertiliser Use in India's Unirrigated Areas: A Perspective Based on Past Record and Future Needs," Paper presented at the Seminar on Technology Options and Economic Policy for Dryland Agriculture: Potential and Challenge, Indian Society of Agricultural Economics, Bombay and ICRISAT, Patancheru, A.P., 1983.

Fertiliser Association of India: Fertiliser Statistics, 1984-85, New Delhi, 1985.

Indian Council of Agricultural Research: A Decade of Dryland Agricultural Research in India, 1971-80, AICRPDA, Hyderabad, 1982 *a*.

Indian Council of Agricultural Research: Improved Agronomic Practices for Dryland Crops in India, 1971-80, AICRPDA, Hyderabad, 1982 *b*.

ICRISAT: Yield Gap Analysis, Patancheru, Hyderabad, 1980.

Government of India: Seventh Five Year Plan 1985-90, Vols. I and II, Planning Commission, New Delhi, 1985 *a*.

Government of India: Indian Agriculture in Brief, 20th Edition, Directorate of Economics and Statistics, Ministry of Agriculture and Rural Development, New Delhi, 1985 *b*.

N. S. Jodha, "Dry Farming Research: Issues and Approaches", Paper presented at the Seminar on Technology Options and Economic Policy for Dryland Agriculture: Potential and Challenge, Indian Society of Agricultural Economics, Bombay and ICRISAT, Patancheru, A. P., 1983.

National Bank for Agriculture and Rural Development (NABARD), ICAR and ICRISAT: Watershed-based Dryland Farming in Black and Red Soils of Peninsular India, ICRISAT, Patancheru, A.P., 1984.

P. Rangaswamy, "Improved Technology for Coarse Grains : Some Constraints," *Indian Journal of Agricultural Economics*, Vol. XXXVII, No. 3, July-September 1982 *a*.

P. Rangaswamy, "Risk Aversion and Investment Gap", *Indian Economic Review*, Vol. XVII, No. 2-4, April-December 1982 *b*.

B. K. Rastogi and V. Annamalai: A Study on the Adoption and Diffusion of Recommended Technology in Dryland Areas, AICRPDA, Hyderabad, 1981.

N. K. Sanghi and T. Vishnu Murthy, "Analysis of Constraints in Transfer of Dryland Technology: An Operational Research Experience", Paper presented at the Seminar on Technology Options and Economic Policy for Dryland Agriculture: Potential and Challenge, Indian Society of Agricultural Economics, Bombay and ICRISAT, Patancheru, A.P., 1983.

R. P. Singh, "Technology Options for Small Dryland Farmers in India", Paper presented at the Seminar on Technology Options and Economic Policy for Dryland Agriculture: Potential and Challenge, Indian Society of Agricultural Economics, Bombay and ICRISAT, Patancheru, A.P., 1983.

T. S. Walker, J.G. Ryan, K. G. Kshirasagar and R. Sarin, "The Economics of Deep Vertisols Technology Options: Implications for Design, Testing, and Transfer", Paper presented at the Seminar on Technology Options and Economic Policy for Dryland Agriculture: Potential and Challenge, Indian Society of Agricultural Economics, Bombay and ICRISAT, Patancheru, A.P., 1983.