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Technological and Institutional Interventions in Enhancing Livelihood of Farmers in Semi-Arid Tropics (SAT) Areas: Experience of ICRISAT-HOPE Project

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ABSTRACT

The semi-arid tropics (SAT) are characterised by their poor natural resource base, high day temperatures, high evapo-transpiration, poor market linkages, low returns, risk bearing ability and repayment capacities. These areas shelter 75 per cent of the poor and accordingly deserve prime attention from the technologists and policy makers. This paper highlights the impacts of the innovative HOPE (Harnessing Opportunities for Productivity Enhancement of Dry Land Cereals) project of ICRISAT in addressing the poverty and related issues in the SAT states of Rajasthan, Gujarat, Haryana and Maharashtra. With key technological and institutional interventions the project has provided fillip to the integrated farming system characterised by the time tested crop-livestock combination in Maharashtra, and pearl millet-buffaloes combination in Gujarat, Rajasthan and Haryana. Thus, with diffusion of innovations, provision of quality seeds, efficient input delivery and market linkage, more than 75 per cent of the farmers benefitted through bridging the productivity gaps and thereby enhanced incomes in both crop and livestock sectors. The welfare gains accrued to the farming community are evident due to cost effective technologies in harsh agro climatic conditions. These have nullified the vicious circle of poverty through effective and appropriate institutional interventions and infrastructure tailor made for semi-arid areas. It is crucial that the sorghum and pearl millet sector be supported by strong governmental policies and programmes, for food, fodder and better nutrition through value addition and demand creation, as they are the prime crops supporting food and fodder in dry land areas.

Keywords: agricultural technologies, crop management

JEL: Q13, Q15, Q16, Q55

PRELUDE

In semi-arid areas, dry land agriculture is the hope as the opportunity for expansion of irrigated area is limited. Dry land agriculture accounts for 58 per cent of the net sown area in India and contributes significantly to pulses, oilseeds and millets, which is not contributed by irrigated agriculture (CRIDA, 2011). Thus, even though dry land contributes to a modest 40 per cent of the foodgrains and a significant 80 per cent of the pulses and oilseeds, it plays a complementary role and has no substitute,

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as the irrigated areas do not produce those crucial dry land crops which provide vital proteins (pulses and millets) and calcium rich grains (ragi, for instance). While the potential of irrigation especially that of groundwater irrigation has been reached, the ultimate potential of dry land agriculture is yet to be harnessed, due to poor technology outreach, lack of post-harvest technologies, information asymmetry, economic scarcity of labour and poor market linkage and infrastructure.

KEY PREDICAMENT IN DRY LAND AGRICULTURE

Agricultural development in drylands is constrained by shrinking natural resource base (land, water, common property resources (CPRs), irrigation tanks), vagaries of nature, low efficiency in natural resources management, low productivity, poor integration of farming systems, frequent crop failures due to droughts, low income, low level of education, low social mobilisation, poor market linkages and value addition, lack of adequate purchasing power and frequent economic losses. These have resulted in unemployment, widespread poverty, malnutrition, indebtedness and migration of population. Thus, the dryland areas are fret with vicious circle of poverty characterised by high risk, low investment, poor technology uptake, low production and value addition. Hence, the development of dryland/rainfed farming systems assumes importance and immediate relevance.

CRITICAL GAPS IN TECHNOLOGY

Technologies have been generated at research institutions but, these are hardly reaching the farmers in time due to lack of effective extension efforts and often are not adopted due to risk and uncertainty in dry land agriculture, lack of capital, infrastructure support, poor market linkage and policy support. 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 dry land agriculture continue to exist. However technology per se cannot help the farmers towards producing marketable surpluses, 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 (Nagaraj, 2009). The most common complaint of small farmers in rural India is lack of access to stable markets. Thus the twin problems in dry land 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 among producers, processors and consumers, meager bargaining power and poor transportation links.

ICRISAT- HOPE PROJECT INITIATIVES

The HOPE project is operating in Rajasthan, Haryana, Maharashtra and Gujarat since 2009 with a hypothesis that the combination of improved technologies (crop varieties and management) with institutional interventions that increase market access and demand will drive adoption and increase production of sorghum and pearl millet. This improves household food and nutritional security and facilitates transition to market-oriented and viable sorghum and millet economies that enhance livelihoods of the poor. In this paper, the economic impact of technological and institutional interventions on farmers is assessed. A synthesis of evidences and lessons learned from ICRISAT HOPE project is presented here to provide empirical evidence on productivity and income enhancement for dryland farmers.

METHODOLOGY

This study was conducted under HOPE project aiming at improving the productivity by 30-40 per cent over the baseline in 6 clusters in Maharashtra (*rabi* sorghum), 2 clusters in each of Gujarat, Haryana and Rajasthan (*kharif* pearl millet). The selected clusters are predominantly dry land with low and uneven rainfall with large area under *rabi* sorghum (Maharashtra) and *kharif* pearl millet (Rajasthan, Gujarat and Haryana). The clusters are characterised by low productivity, high concentration of livestock and large number of small and marginal farmers. The farmers were sampled from clusters using probability proportional to farm size (PPS) method.

Data Base: The baseline survey was conducted in the primary project intervention area (HOPE) where improved technologies have been introduced and are matched with control villages with comparable agro-ecological and market conditions in the non-intervention area (non-HOPE), where improved technologies have not been used. Baseline data was collected from 36 villages in 12 districts of Maharashtra, Gujarat, Haryana and Rajasthan. A monitoring and evaluation survey was also conducted during the (post-rainy) season of 2011-2012, in which 540 farmers in Marathwada and western Maharashtra were surveyed. Similarly 180 farmers in each of the pearl millet-producing states of Rajasthan, Gujarat and Haryana were surveyed. The data relating to adoption of improved technologies, productivity of grain and fodder, marketed surplus, cost of production and the key constraints in adoption of improved technologies were collected and analysed.

Baseline Scenario

According to the baseline survey in Maharashtra, 50 per cent of the farmers are smallholders with 8 years of literacy with family size of six. Sorghum productivity in HOPE and non-HOPE areas is 790 kg/ha and 900 kg/ha, respectively. More than 75 per cent of the farmers possess two draught animals and two milch animals. The strong livestock sector (as in sorghum-buffalo-cow combination) sustains sorghum in Maharashtra. The annual per capita income in the HOPE area is Rs. 32,039 while that in non-HOPE area is Rs. 40,669. Thus, per capita income in these clusters is lower than the national per capita income of Rs 53,000 in both Western Maharashtra and Marathwada regions. In HOPE project areas, farmers received a net return of Rs.3,515 per hectare, compared to non-HOPE farmers of Rs. 2,528 after accounting for paid out costs. The grain yield gap of sorghum was 80 per cent (as per recommendation the grain yield is 2,000). Gram and onion are the major competing crops in Maharashtra for *rabi* sorghum.

In Rajasthan, 45 per cent of the farmers had a holding size of 6 hectares. More than 60 per cent of the sample farmers were under the age of 45 with an average family size of 6, with 4-6 years of schooling. The average pearl millet yield is 1,100 kg/ha, compared to a potential yield of 2,200 kg/ha; the yield gap ranges from 50-100 per cent. After accounting for paid out costs of Rs.7,900, farmers realised a net return of Rs. 8,800 per hectare. The integrated farming of pearl millet with a buffalo-cow combination sustained millet cultivation in Rajasthan. Cluster bean is the competing crop for pearl millet in Rajasthan, which is more profitable than pearl millet.

In Gujarat, smallholder farmers comprised 80 per cent of the total sample with literacy commensurate with 3 years of schooling. A majority of the sample farmers (more than 85 per cent) have three she-buffaloes, and only 10 per cent of them have draft animals. The HOPE farmers realised a grain yield of 1,050 kg/ha, compared to non-HOPE farmers' average yield of 960 kg/ha. The yield gap of pearl millet with farmers practice was estimated to be 130 per cent considering the potential yield of 2,400/ha under recommended practice and normal rainfall. After accounting all the paid out costs (Rs. 11,000/ha) the net income per hectare of pearl millet is Rs. 4,200. In both HOPE and non-HOPE areas, the crucial competing commercial crop is castor, which fetched a three times higher return. Around 53 per cent of farmers in Haryana are marginal smallholders with an average farm size of 1.3 hectare with average schooling of 7 years. The productivity of pearl millet in the dry spells in Haryana is 1,540 kg/ha of grain and 2,600 kg/ha of fodder, with a yield gap of 58-101 per cent. The net income per hectare of pearl millet is Rs 4,400 but Bt-cotton fetches two to three times higher return from pearl millet in HOPE and non-HOPE areas. The pearl millet-buffalo combination is practiced by more than 90 per cent of the farm families *(Baseline Reports of Rabi Sorghum and Pearl Millet, 2013).*

Synthesis of Interventions

HOPE project enabled to establish both upstream and downstream linkages in order to deliver the critical inputs at the right time and place including the market information and linkage. Activities include increasing farmers' access to information on crop management and new varieties, increasing availability and use of seeds and fertilisers, and increasing access to markets and credit. Leaflets and brochures in local languages, radio talks, and videos were provided to the farmers. The HOPE project has successfully completed three years and the project implemented all the targeted interventions listed in Table 1.

Area and Farmers Coverage Under Improved Technologies and Institutional Interventions

In Maharashtra state, 25,200 farmers were reached with improved sorghum technologies in six clusters covering an area of 1080 ha in 181 villages over a period of 3 years. Similarly, improved pearl millet hybrids were delivered to the selected farmers in Gujarat (7838), Haryana (8110) and Rajasthan (8233) covering an area of over 3135, 3244 and 3293 ha in 53, 32 and 71 villages, respectively.

Technological Interventions

The technological interventions implemented with the institutional support from the partner institutions both for *rabi* sorghum and pearl millet are provided in Table1.

TABLE 1. TECHNOLOGICAL INTERVENTIONS

Particulars (1)	Sorghum (2)	Pearl Millet (3)
Improved variety	Phule Vasudha, Phule Anuradha, Phule Chitra, Phule Yashoda, Phule Revati, Akola Kranthi, Parbhani Moti, Parbhani Jyoti	HHB 67, RHB 121, GHB 538, GHB 744, HHB 197, HHB 223, Tejas, 9444, 86M66, Bio-8494, MP7792
Fertiliser application	40kg N, 20kg P_2O_5 per ha	40-60 kg N, 20-30 kg P_2O_5 per ha
Wide row spacing	45 cm between rows and 12-15 cm between plants	45 x 10-15 cm
Seed treatment	70 WS Thiomethaxam @ 2.1 a.i. kg^{-1} seed	Metalaxyl@ 2.0 g a.i. kg^{-1} seed
Optimum seed rate	10 kg ha^{-1}	3.75 kg ha^{-1}
Recommended depth of sowing	10-12 cm for rainfed and 5-8 cm for irrigated crop	2.5 cm – 3 cm deep
Micro nutrient application	10 kg ha^{-1} of $ZnSO_4$	20 kg/ha of $ZnSO_4$
Insect and pest management	Spray Endosulphan 35 EC 0.05 per cent to control shoot fly and Thiomethaxam 25 WG 0.0075 per cent for aphid management	-
Weeding	Pre-emergence spraying of Atrazine 50 per cent WP (1.0 kg/ha immediately after sowing)	Atrazine (1.0 kg/ha) at sowing

Key Institutional Interventions

The key institutional interventions introduced in all the clusters in order to implement the planned activities are enlisted in Table 2. The institutional landscape comprised scientists from ICRISAT and NARS, KVK's, village level institutions like

TABLE 2. INSTITUTIONAL INTERVENTIONS AND INFRASTRUCTURAL FACILITIES

Institutional interventions (1)	Gujarat (2)	Haryana (3)	Rajasthan (4)	Maharashtra (5)
Institutional interventions				
Outreach strategy developed	Information about new hybrids suited to target ecology, management practices provided through flyers, meetings, field days and training. Seed of best suited hybrid provided through test kits.			Training materials like flyers, brochures, leaflets on improved crop cultivars, management practices, processing methods and marketing developed and farmers trained in all these aspects. Seeds of improved cultivars supplied to all project farmers.
Breeder seed produced (kg)	105	114	73	1,400
Foundation seed produced (kg)	11230	11730	11990	121000
Seed supply (mini packs of seeds)	7838	8110	8233	25200 (3kg seed to each of these farmers')
Farmers associations	Farmers in the cluster villages were linked to soil testing facilities and fertiliser suppliers in each district.			Farmer's associations (6) were linked with the input suppliers in target areas and ensured that there is no short fall in fertilizer or pesticides availability
Frontline demonstrations	30	30	30	178
Fertiliser supplied for demonstration trails	32,200 kg DAP (2010); 60,000 kg of DAP (2011); 72,000 kg of DAP (2012)	40,450 kg DAP (2010); 60,000 kg of DAP (2011); 72,000 kg of DAP (2012)	40,325 kg DAP (2010); 120,000 kg SSP fertiliser (2011); 72,000 kg DAP (2012)	
Training and capacity building				Farmers groups (6, 60 members in each), women's self-help groups (2 in each region, 50 members in each) and KVK field staff (8) trained in crop management, varieties seed production and grain and stover marketing.
Credit facilities	3 financial institutions were identified in Haryana, 3 in Rajasthan, and 4 in Gujarat and informed of business opportunities along the pearl millet value chain			Interactive meetings were organized to network the financial institutions and farmers associations to have increased flow of credit.
Market linkage	Farmers were linked to identified retail market chains, wholesalers and feed manufacturers by providing information about these markets.			Retail market chains were identified and Post-rainy sorghum grain 'Mahostava' was organised where farmers sold their grain produce directly to the consumers from city area.
Farmer visits organised	One field day and exposure visit organised in each state every year.			Field days (2 in each region) and exposure visits (3 in each region) were organised every year (400 farmers from each region)
Infrastructural Facilities				
Seed storage				One warehouse in MAU region

Source: George (2012).

farmer clubs/associations/groups, Community Based Organisations (CBOs,) representatives from Department of Agriculture, the commercial banks, co-operative societies and input suppliers. At the village level, the entry points for introducing interventions are farmer groups linked to input agencies. Further, the public-private sector partnership enabled to produce the required quantity of truthfully labeled seeds to meet the targeted area and farmers. Thus the institutional framework created in the HOPE project have been largely responsible for producing quality seed, delivering support services, market information and linkage to the households cultivating *rabi* sorghum and millet. The ICRISAT made modest initiative to bring these stakeholders together on a common learning and action platform. The focus was on *rabi* sorghum and pearl millet production that enabled in establishing a working group of institutional actors responsible to bring about desirable changes in the production, processing, value addition and market linkage. Establishment of crop based working groups formed an effective mechanism for problem solving. Similarly capacity building of the farmers in critical focused areas was another hallmark of the institutional intervention. The farmers' clubs have been linked to soil testing labs and the farmers are trained in soil sample collection. Based on the nutrient status in the soils, optimum dose of fertiliser application has been advocated. Further, seed-cum-fertiliser drills to ensure optimum population and fertiliser use have been promoted. At least one farmer's rally in each cluster per season has been organised in order to disseminate technologies on a larger scale.

TABLE 3. IMPACT INDICATORS OF HOPE PROJECT IN THE STUDY REGIONS FROM 2010-13

Impact indicators	*Rabi* sorghum	Pearl millet		
	Maharashtra	Gujarat	Haryana	Rajasthan
(1)	(2)	(3)	(4)	(5)
Households directly reached	25200	7838	8110	8233
Total acreage (ha) under HOPE project clusters	10080	3135	3244	3293
Change in yield (per cent)	-37 *(19)	103	14	35
Change in production (per cent)	-25 (19)	148	42	59

Note: *indicate percentage change of improved varieties with local varieties.

Extent of Technology Spread

The adoption surveys revealed that in Maharashtra, adoption of improved varieties was 100 per cent. With respect to seed drilling with fertiliser, 80 per cent of the HOPE farmers adopted the practice in its entirety, opening of furrow was adopted by 25 per cent of farmers, wide row spacing was adopted by 50 per cent of farmers and adoption of seed treatment technology reached 85 per cent. The farmers fully adopted all the recommended practices in Rajasthan and Haryana. In the Gujarat clusters, 98 per cent of farmers adopted the improved varieties, 34 per cent adopted seed and fertiliser drill technology, and 51 per cent partially adopted the recommended optimum depth of sowing (Figure 1) (Nagaraj *et al.*, 2012).

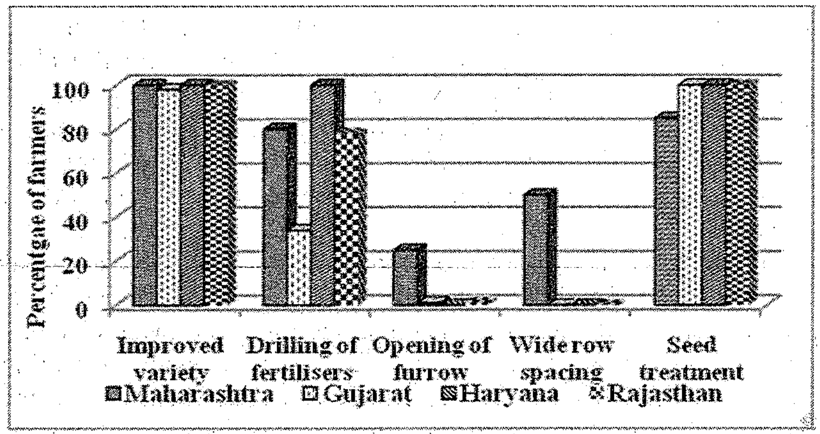

Figure 1. Extent of Adoption of Technology

Major Constraints Expressed by the Farmers

The main constraints to post-rainy season sorghum production include moisture stress during sowing and/or terminal drought, scarcity of labour, shortage of fertiliser and farmyard manure, lack of credit, lack of quality seed, and lack of appropriate machinery for harvesting. Similarly for pearl millet, the key constraints include scarcity of labour during harvesting, high wage rates, moisture stress, and lack of appropriate machinery in all the three states.

Priority Interventions

Economic analysis of improved technologies indicated that the additional cost of replacing the local variety with the improved variety is Rs. 3,413, yielding a net gain of Rs. 6,088 per ha with incremental returns to cost ratio of 1.78. The incremental income is Rs. 2,675. Similarly, the additional cost associated with replacing variety along with improved management practices is Rs. 4,083 with an incremental cost to return ratio of 3.51. With supplementary irrigation, the net gain increased to the tune of Rs. 14,418 per ha with incremental returns to cost ratio of 3.78. Thus, the contributing factors towards improved productivity in case of *rabi* sorghum are management practices such as nutrient management, supplementary irrigation and improved production technology. In case of pearl millet, in all the study regions on an average, additional cost of replacing the local variety with the improved variety is Rs.1,708 yielding a net gain of Rs.2,746 per ha with incremental returns to cost ratio of 1.61. Similarly, the additional cost associated with replacing variety along with improved management practices is Rs.2,032 with an incremental cost to return ratio of 1.59. With supplementary irrigation, the net gain increased to the tune of Rs.5939 per ha with incremental returns to cost ratio of 2.02 (Figure 2).

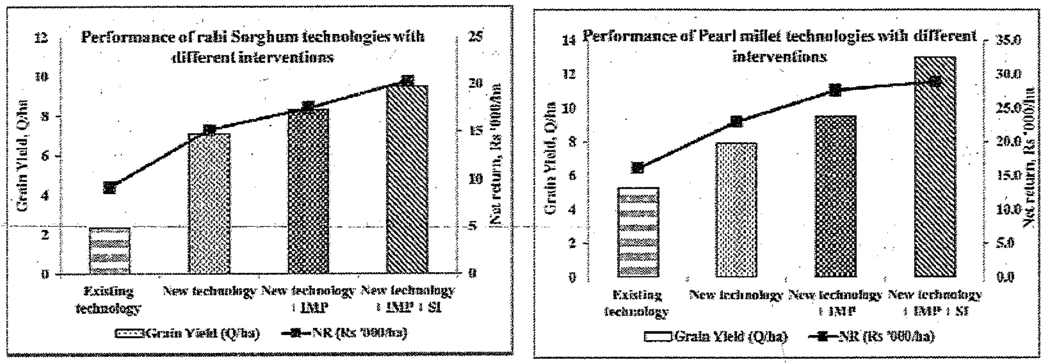

Figure 2. Performance of Technologies with Different Interventions

Productivity Differential Between Baseline, Monitoring and On-farm Trails in the Study Regions

As discernible from the table, the productivity gain differed from state to state and it varied from 14 to 100 per cent. During base year, the pearl millet grain yield in Gujarat, Haryana and Rajasthan was 1.06 t/ha, 1.54 t/ha and 1.7 t/ha respectively (Table 4). Due to interventions of HOPE project, there has been significant productivity gain to the tune of 103 per cent in Gujarat, while the productivity gain has been modest in Rajasthan (34 per cent) and Haryana (13 per cent). This is mainly due to low rainfall in Haryana and Rajasthan. With respect to fodder, there has been marginal gain compared to the base line.

TABLE 4. PRODUCTIVITY DIFFERENTIAL BETWEEN BASELINE, MONITORING AND ON-FARM TRIALS IN THE STUDY CLUSTERS

Particulars		*Rabi* sorghum	Pearl millet		
		Maharashtra	Gujarat	Haryana	Rajasthan
(1)		(2)	(3)	(4)	(5)
Baseline	Grain yield (t/ha)	1.12	1.06	1.54	1.7
	Fodder yield (t/ha)	2.29	3.54	2.6	2.6
	Yield gap	79	108	43	29
On farm trials (average)	Grain yield (t/ha)	1.75	2.3	1.94	1.78
	Fodder yield (t/ha)	4.58	7.53	3.76	3.4
	Yield gap	14	-4	13	24
Monitoring (Average)	Grain yield (t/ha)	0.71 (0.60)	2.15	1.75	2.3
	Fodder yield (t/ha)	2.69 (2.0)	5.1	2.95	3.5
	Yield gap		2	26	-4
Percentage change of on-farm trials with baseline	Grain yield (t/ha)	56	130	26	5
	Fodder yield (t/ha)	100	113	45	31
Percentage change of monitoring with baseline	Grain yield (t/ha)	-36 (19)	103	14	35
	Fodder yield (t/ha)	17 (35)	44	13	34
Reduction of grain yield gap		82	104	69	20

Notes: * Figures in parentheses are the yield of local variety,
** Figures in parentheses are the percentage change of HOPE over local variety.

Productivity gains from the whole package of improved practices in the Maharashtra state for *rabi* Sorghum is around 56 per cent from the trial yield data (based on large samples). However, compare to baseline, the productivity is relatively lower in clusters of Maharashtra, (as it is based on small sample size) due to severe drought conditions prevailed during monitoring years. Even under severe drought conditions, the productivity increased by 19 per cent over local varieties and practices. Further, there has been reduction of yield gaps to the tune of 40-100 per cent for pearl millet and increase in the yield gap over 82 per cent for *rabi* sorghum over baseline productivity.

Income Gain

There has been an improvement in the income levels of the farmers over base line for sorghum to the extent of 240 per cent in Maharashtra even under terminal drought conditions. In case of *kharif* pearl millet, the improvement in the income levels of farmers over baseline is 260 per cent in Gujarat, 16 per cent in Haryana and 50 per cent in Rajasthan. This increase in income is apportioned partly due to change in the price of grain and partly due to enhanced grain and fodder productivity. As evident from Table 6, the increased price from base year to monitoring years is 127 per cent and productivity of improved varieties is increased by 25 per cent compared to local varieties even under drought conditions in Maharashtra (Table 5). Similarly, in case of pearl millet farmers, the percentage change due to increase in price is 18, 5, 2 and

TABLE 5. INCOME GAIN BY THE FARMERS BETWEEN BASELINE AND MONITORING YEARS IN THE STUDY CLUSTERS

Particulars (1)	Maharashtra Baseline (2)	Maharashtra Monitoring (3)	Gujarat Baseline (4)	Gujarat Monitoring (5)	Haryana Baseline (6)	Haryana Monitoring (8)	Rajasthan Baseline (9)	Rajasthan Monitoring (10)
Cost of cultivation (ha)	13851	14161	11732	13083	10739	13686	8073	11723
Gross income (ha)	16854	23250	15946	28315	14349	17868	16809	24836
Net return (ha)	3003	9090	4213	15233	3610	4182	8736	13114
Benefit to cost ratio	1.22	1.64	1.36	2.12	1.34	1.30	2.08	2.12
Per cent change in net income over baseline/ha	-	237	-	262	-	16	-	50
Per cent change in increased price	-	127	-	18	-	5	-	2
Per cent change in increased yield	-	-19 (25)	-	58	-	14	-	36

Note: Figure in parenthesis is the percentage change in increased yield of improved varieties compared to local varieties.

percentage change due to increase in yield is 58, 14, 36 in Gujarat, Haryana and Rajasthan respectively from base year to monitoring years. Thus farmers realised additional income through technological and institutional interventions.

Overall, farmers in the targeted clusters benefited through adoption of improved cultivars and practices along with efficient use of resources and this was possible due to synergy of institutional and technological interventions implemented in the cluster villages.

Lessons Learnt

Some of the lessons learnt in the process of project implementation are summarised as: dryland farmers tend to under invest in improved capital-intensive technologies because of risk and uncertainty, including the vagaries of monsoon rains and scarcity of labour. It was observed that the farmer's response to investment in soil and moisture conservation technologies is poor due to the large investments required, lack of capital, small holdings and limited crop choices. In spite of popularising the use of seed drills to maintain the required row spacing, farmers hardly follow the recommended spacing. The demand for fodder often drives out the desire to maintain the higher plant population than is recommended. With respect to post-rainy sorghum, farmers tend to prefer stover quality to improved varieties along with grain quality besides higher yields. It was noted that the farmers' response has been encouraging towards mechanical threshing due to scarcity of labour. In case of pearl millet, public hybrids are more popular in harsh agro-climatic ecologies, while private hybrids are more popular in irrigated areas. A strong livestock economy is the driving force for adopting the improved varieties/hybrids of pearl millet and *rabi* sorghum farmers.

Access to Credit

In spite of having a wide network of financial institutions, many dryland farmers remain excluded from financial services, as financial institutions are shy to lend to dry land farmers due to high transaction cost and risk associated in production. In order to adopt improved technologies in the dry land conditions, this distortion need to be corrected through a holistic approach to lending covering new loan services such as pledge loan, marketing credit, loans against warehouse receipt. Further, bankers' knowledge of dryland agriculture need to be strengthened in order to increase the flow of credit.

Risk Mitigating and Social Safety Net Mechanisms

Monsoons decide the productivity of dry land crops especially the intensity and distribution of rainfall. Further, the risk due to long dry spell and recurrent droughts coupled with increasing day temperatures are a major predicament. Investment in R and D is a crucial part of mitigating these risks and uncertainties in promoting dry land cereals crops which are in a way climate change ready crops. In the dry land agriculture farmers need to be offered, schemes/programmes that enhance the risk bearing ability so that the farmers are willing to take risk and invest in capital intensive technologies. The focus is to shift from technology driven to management driven using diversification and integrated farming system approach with livestock for income generation. In this endeavour, weather based crop insurance need to be expanded on a wider scale covering most dry land crops which contribute to income security (Chengappa, 2010). Currently, MNREGA and watershed programmes are the only schemes for the benefit of dry land farmers compared to vast number of programmes in the irrigated area. In addition to insurance, farmers need to be de-risked through efficient land and water management, rain water conservation and watershed development. Hence, innovative programmes such as Bhuchetana (applying micronutrients to soil), expanding micro-irrigations in dry land for protective irrigation need to be heralded. In order to ensure the required inputs and appropriate implements in dry land agriculture, convergence of different agencies for providing efficient delivery of services and information to the farmers is most crucial.

Dryland crops are suffering from the policy bias towards procurement and in offering support prices which needs to be corrected. Reorientation of public policies and better targeting of development interventions to dryland farmers for augmenting agricultural productivity, commercial orientation and competitiveness of dryland agriculture are required. Hence, institutional innovations, building partnerships, linkages and capacity are crucial (Bantilan *et al.*, 2006).

CONCLUSIONS

Synergies among technologies, institutional interventions, access to information, quality seed production and supply, efficient input delivery and market linkage enabled to reach large number of farmers and greatly contributed to bridge the productivity gaps and in enhancing the income of the farmers. The economic gains accrued to the farming community are evident due to implementation of cost effective technologies in harsh agro climatic conditions. Thus, the vicious circle of poverty with low investment, poor technology and low production in dry land agriculture has been nullified to certain extent in the targeted regions. This emphasises the critical role of institutions and infrastructure in agricultural development of semi-arid areas. In order to scale up these technologies on a wider scale to benefit the farming community in dry lands, the institutional interventions and infrastructure play a pivotal role. It is crucial that the sorghum and millet sector be supported by strong governmental policies and programmes, for food, fodder and better nutrition through value addition and demand creation, as they are the prime crops in dry land areas.

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