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Markets, Institutions and Policies

# Baseline Scenario of **Rainy Season Pearl Millet Economy in Rajasthan**

N Nagaraj, IP Singh, Surajit Haldar, Cynthia Bantilan,
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International Crops Research Institute
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# Abstract

Pearl millet is the staple food and fodder crop in Rajasthan, with about 60 percent of farmers following the *Bajra*-Buffalo-Cow-Sheep combination (BBCS). The HOPE project endeavors to help small farmers in target areas in Rajasthan increase pearl millet productivity and alleviate food insecurity and poverty by introducing the latest technologies and management practices. A baseline survey was conducted in the primary project intervention area (HOPE), where improved technologies were introduced, and in matching control villages with comparable agroecological and market conditions in non-intervention area (non-HOPE). Income from crops forms about 74% of the total, followed by wage and nonfarm income (11%). Pearl millet yield is about 1.7 t $ha^{-1}$ under irrigated conditions, and 0.76 t $ha^{-1}$ under rainfed conditions without irrigation. The total cost of cultivation is about ₹ 8073 per ha, with human labor forming 50% of the variable cost. Both HOPE clusters and non-HOPE areas showed a high rate of adoption of pearl millet hybrids. The yield gap of improved hybrids of pearl millet in low management farms was 186% compared to the potential yield, which shows further scope for improvement. Farmers prefer hybrids due to their higher productivity, short duration, drought tolerance, and pest and disease resistance and as they fit into the cropping system. Low productivity and long duration are the main constraint in adoption of public hybrids. Pearl millet cultivation is skewed towards male labor participation. The highest involvement of women labor is in weeding, harvesting and threshing which involve a lot of bending. Sowing and marketing, the two crucial activities, do not involve women, perhaps due to high day temperatures and cultural factors.

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This work has been undertaken as part of the CGIAR Research Program on Dryland Cereals

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## Summary

The HOPE (Harnessing opportunities for productivity enhancement of sorghum and millets in sub-Saharan Africa and South Asia) project endeavors to help small farmers increase dryland cereal crop yields in specific target areas in four states of India to alleviate food insecurity and poverty. HOPE seeks to discover, develop and deliver improved technologies for producing sorghum and millets to increase productivity beyond subsistence level in a sustainable manner.

The project has been implemented in three states in western India – Gujarat, Rajasthan and Haryana – by introducing the latest pearl millet technologies and management practices in the targeted clusters. A baseline survey was conducted in the primary project intervention area (HOPE) where improved technologies have been introduced and in matching control villages with comparable agroecological and market conditions in non-intervention areas (non-HOPE), where improved technologies have not been introduced. This enables the collection of baseline data from participating and non-participating farmers that help identify comparable counterfactual outcomes in impact evaluation.

The baseline survey was conducted with an objective of appraising the existing situation in the targeted cluster villages of Rajasthan with respect to the status of resource endowments; socioeconomic profile of farmers; cropping pattern, improved hybrids and practices adopted; yield gaps; input-output levels and the profitability of crop production; technology and trait preferences of farmers; income and consumption levels; labor participation and earnings; marketing channels and costs; and gender participation. The key findings of the survey are as follows:

The results revealed that pearl millet is the staple food and fodder crop in Rajasthan, supporting poor smallholders and livestock. The BBCS is followed by around 60% of farm families. Backward castes constitute a significant proportion of farm households, followed by scheduled castes (SCs) and scheduled tribes (STs) with an average family size of six members, with only a few years of schooling of 4-6 years. About 45% are medium and large holdings with a holding size of 6 ha. More than 60% of the farmers are about 45 years old. The proportion of irrigation is 37% in HOPE and 44% in Non-HOPE areas.

Most farmers possess farmhouses, residential houses, two-wheeled vehicles, radios and fans/air coolers. More than 65% of farmers possess irrigation pump sets, an indicator of the importance of irrigation in this arid state. More than 35% possess tractors, signalling an increasing economic scarcity of labor and resultant lack of timely sowing. Income from crops forms about 74% of the total income (₹ 1,63,000), with wage and nonfarm income at 11%, income from dairy (5%), income from livestock (2.4%), savings and money-lending (2.1%) and so on. Income per ha from crops is about ₹ 21,244. The non-HOPE area shows a similar trend. Per capita income in both the areas is around ₹ 26,000 $yr^{-1}$.

No single crop dominates during the rainy season (*kharif*) as two crops are grown – pearl millet occupies 22% and cotton 24% of the total rainy season area; while in the postrainy season (*Rabi*), mustard occupies 29% and wheat 24%. Pearl millet yield is about 1.75 t $ha^{-1}$,

depending largely on irrigation conditions, and averages at 0.76 t $ha^{-1}$ under rainfed conditions. Productivity in a year with above-normal rainfall is 40-60% higher than that achieved with normal rainfall; and 75% lower in a year with below-normal rainfall. The total cost of cultivation is about ₹ 7,900 $ha^{-1}$, with human labor comprising 50% of the variable cost, and machine labor constituting an additional 7%. In HOPE clusters, a high rate of adoption of pearl millet hybrids is evident, where public-bred hybrid (HHB 67 Improved) covers 20% and proprietary hybrids 48% of total area. In the non-HOPE area, Public bred (HHB 67 Improved) covers only 7% of total area, while the adoption rate of proprietary hybrids is to the tune of 65%.

Return-to-cost ratios (shown in parentheses) showed that sesame (3.0), cluster bean (4.3), green gram (2.9) and moth bean (1.47) are the major competing crops of pearl millet (1.7) in rainfed areas. But cotton (2.5) and castor (6.3) are remunerative crops, competing with pearl millet in the irrigated areas. The return-to-cost ratios indicated that the competing crops generated more revenue per rupee of expenditure. The yield gap of improved hybrids of pearl millet was estimated as 186% as compared to potential yield, which shows further scope for improvement in productivity levels by the introduction of the recommended package of practices along with improved hybrids.

About 70% of the pearl millet produced is consumed at home in both HOPE and non-HOPE areas. About 25% of families reported an increase in pearl millet consumption due to increased family size. The crop that is likely to replace pearl millet is wheat.

Farmers have indicated that they prefer hybrids due to their higher productivity, short duration, drought, and pest and disease resistance and as they fit into the cropping system. On the demand (or consumption) side, farmers feel that hybrids taste better (32.8%), cook faster (30-46%) and possess higher keeping quality (31-43%). In terms of market trends, a higher proportion of farmers have indicated that hybrids are in relatively higher demand, fetch higher prices, have lower price fluctuations and relatively larger grain size.

Hybrids are performing better on the counts of both production and consumption. They are also giving higher fodder quantity (23-30%), better palatability (36-45%) and storability (42%). Thus, the demand for hybrids is high, as expressed by 37-38% of the farmers. Cultivation of pearl millet is skewed towards male labor participation in Rajasthan. Female labor is not involved in land preparation, sowing, watch and ward, irrigation or marketing. The highest involvement of women labor is in weeding (100%), harvesting and threshing which involve a lot of bending activity. Sowing and marketing, the two crucial activities are devoid of women labor; perhaps due to high day temperatures and cultural factors. Low productivity has been the main constraint in public hybrids, followed by their long duration, low recovery and small grain size.

# I. Significance of the study

Pearl millet is a crop with the potential to cope with harsh agroclimatic conditions and is cultivated largely by poor and marginal farmers on nearly 9 million ha of infertile lands. It contributes to both food (grain) and feed (fodder) and can grow under high temperature and low and erratic rainfall conditions on soils with poor water holding capacity. The potential productivity of millet in the rainfed marginal environments varied from 1.8 t $ha^{-1}$ to 2.9 t $ha^{-1}$ across states, whereas the current productivity levels varied from 0.8 to 1.8 t $ha^{-1}$, indicating a yield gap of 53% to 175% across major production states. The HOPE project has been implemented in order to reduce this yield gap and increase household income and food security,. The objectives chosen were market chain and delivery, constraints/opportunities, genetic and production systems and better targeting. Under better targeting, this baseline survey was undertaken to study the existing scenario in the targeted clusters and develop a database to track the changes in adoption and impact of crop management, improvement and market access on food, fodder, and income security.

# II. Importance of pearl millet in India

Pearl millet, a dual purpose crop cultivated for human consumption and for fodder, is an excellent livestock feed. Pearl millet is the third most important food grain in India, grown both as a rainy-season crop from June to October and as a summer crop from February to May. Pearl millet possesses the inherent capacity to survive under extremely high temperatures. Therefore, it is widely distributed in arid zone and semi-arid tropics. The primary pearl millet growing state in India are Rajasthan, Maharashtra, Gujarat, Uttar Pradesh, Haryana, Karnataka and Madhya Pradesh which together account for 96% of the total pearl millet area (8.69 million ha) and production (10.05 million t) in 2011-12. Pearl millet accounted for about 4.68% of the gross cropped area in 2009-10.

# III. Importance of pearl millet in Rajasthan

Rajasthan falls under the arid (60%) and semi-arid (40%) regions of India. In the arid region, the average rainfall is below 400 mm and in the semi-arid region the average rainfall ranges from 500-800 mm.

The annual precipitation in Rajasthan is insufficient, causing regular agricultural droughts even when a meteorological drought is not declared. Even under these conditions, pearl millet is a lifeline for farmers and cattle. In Rajasthan, pearl millet is cultivated mainly as a rainfed crop during the rainy season. The area under irrigated pearl millet was modest (6.1% in 2007-08). During 2011-12, rainy season pearl millet was cultivated on 5.02 million ha in Rajasthan with a production of 4.59 million t, and a productivity of 915 kg $ha^{-1}$. Within Rajasthan, Jodhpur district accounted for about 12% of area and 6% of production (407 kg $ha^{-1}$ yield in 2008-09), while Nagaur district accounted for 9% area and 11% of production (992 kg $ha^{-1}$ in 2008-09) of pearl millet. The Desi pearl millet in Rajasthan is utilized primarily for food because of its superior quality as compared to Hybrid pearl millet and this is reflected in its higher grain price compared to Hybrid pearl millet.

Pearl millet is grown for both food grain and fodder purposes. The fodder is used for cattle, buffaloes and small ruminants. Pearl millet grain is also gaining importance as a cheap source of starch for fine quality brewing and other diversified food uses.

A baseline survey was carried out in the project area depicting the existing situation, enabling decision makers to obtain information about resource and infrastructure endowments. This appraisal of the existing conditions in the project area is crucial before the commencement of the action research HOPE project.

# IV. Methodology

## 1. Sampling

The baseline survey was conducted in Jodhpur and Nagaur districts with a total sample size of 180 farmers, 90 from each district. Two villages were chosen as adopted or HOPE beneficiary villages from each district – Laverakhurda and Mahalana from Jodhpur, and Gotan and Talanpur from Nagaur. Kajanavkalan (Jodhpur district) and Harsolav (Nagaur district) were selected as Control or non-HOPE area villages. Therefore, 120 HOPE area farmers and 60 non-HOPE area farmers were sampled using stratified random sampling based on probability proportional to farm size method. The sampling framework is depicted in Figures 1 and 2.

# V. Results and discussion

## 1. General characteristics of sample farmers

Backward castes constitute a major portion of the farming population in Rajasthan, followed by SCs and STs, in both HOPE and non-HOPE areas. About 40-45% of the holdings are medium and large holdings of average size about 6 ha, with agriculture as the primary occupation. Small and marginal farmers constitute 55-60% of the sample. The irrigated area forms around 40-45% of the total holding. In Rajasthan, the connotation of small and marginal holdings needs to be viewed with caution. Due to extreme aridity, the size of the land holding does not directly imply the size of the farm income and/or wealth. Most of the farmers in both HOPE and non-HOPE areas have about 6 ha of land, and about 60% are about 55 years old. The family size is around six members per family, but with only about 4-6 years of schooling, in both HOPE and non-HOPE areas (Table 1).

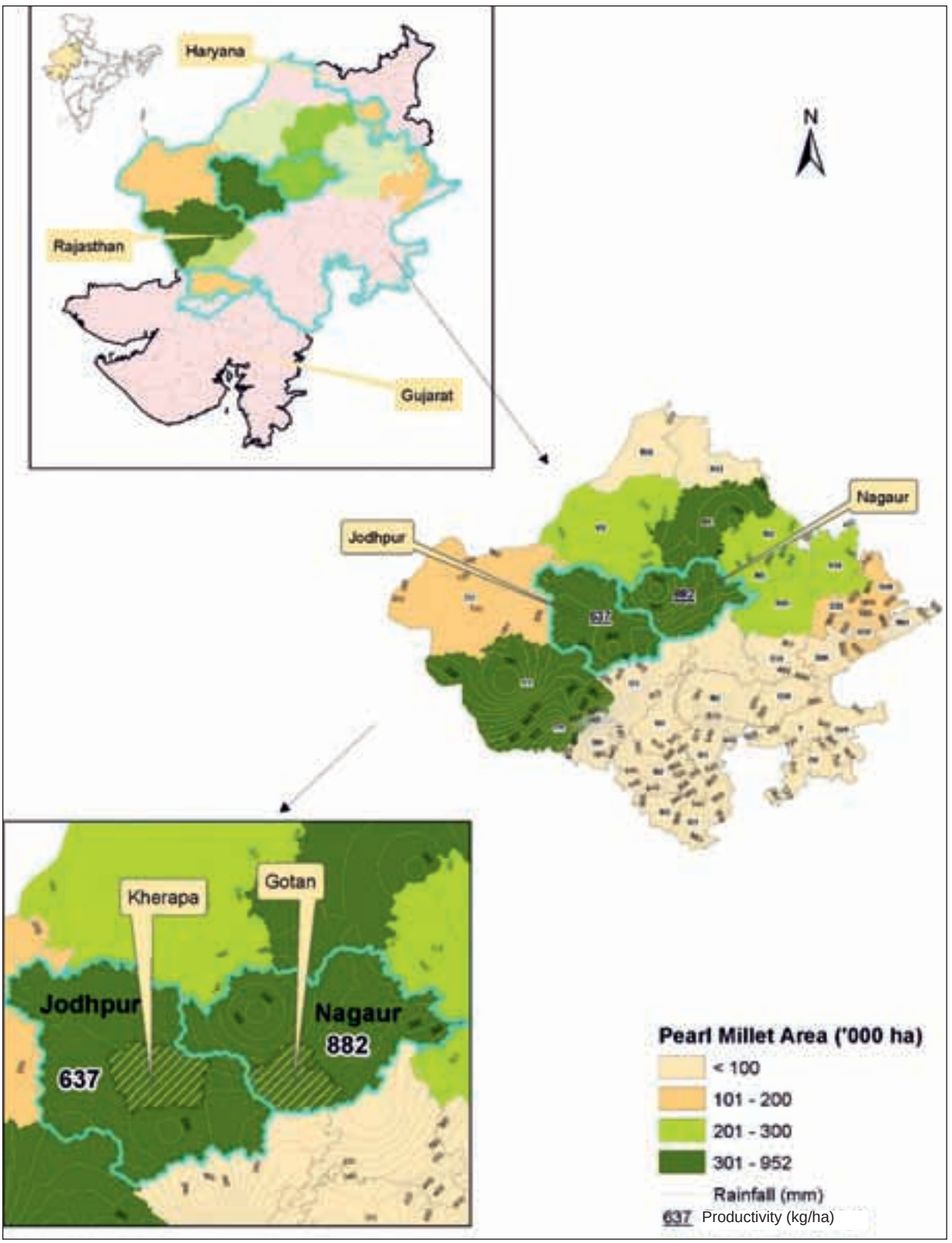


*Figure 1. Map of the study area.*

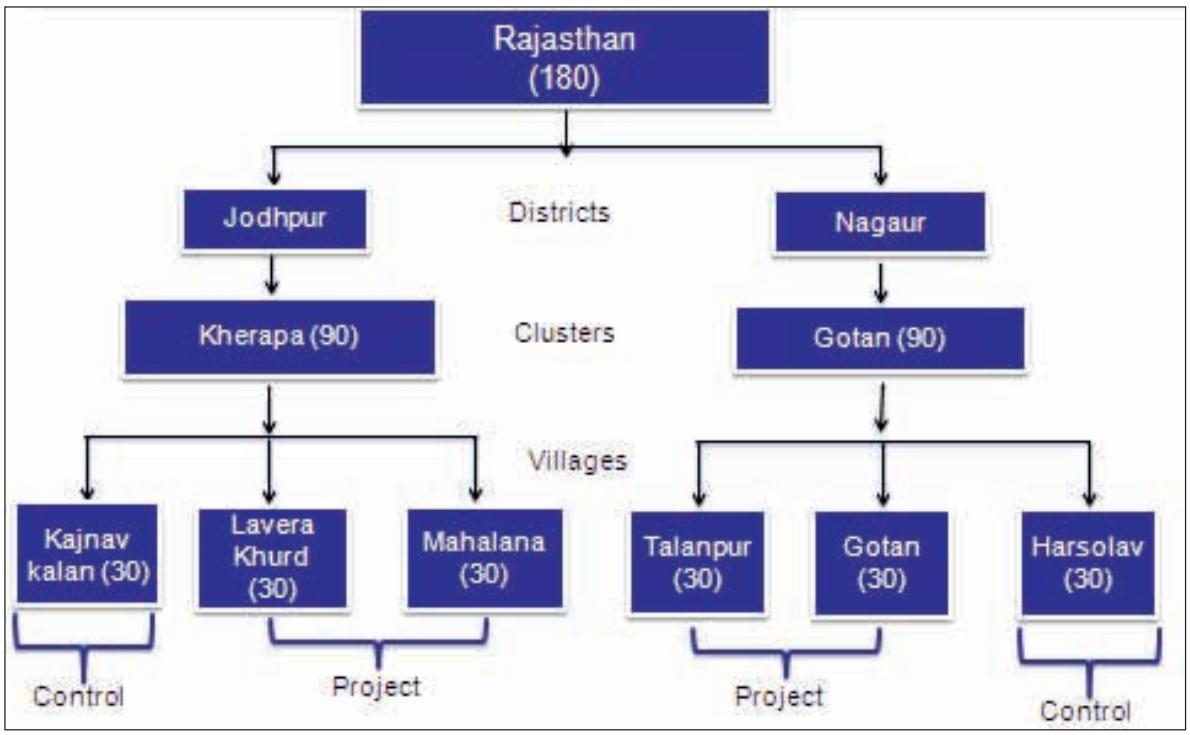


*Figure 2. Sampling framework.*

**Table 1. Characteristics of sample households in Rajasthan state in 2010.**

| Characteristics | HOPE project area | non-HOPE project area |
|---|---|---|
| Family size (no.) and | 6.2 | 6.4 |
| Average literacy (years of schooling) | 5.6 | 4.3 |
| **Social classification (% of farmers)** | | |
| SC + STs (%) | 10.8 | 23.3 |
| Backward (%) | 57.5 | 71.7 |
| Others (%) | 31.7 | 5.0 |
| **Size/class of holding** | | |
| Small and Marginal <2ha (%)<br>Size of the holding in ha | 55<br>2 | 60<br>1 |
| Medium and large holdings >2.01 ha (%)<br>Size of holding in ha | 45<br>6 | 40<br>6 |
| Agriculture as the primary occupation | 100 | 100 |
| Age of farmers | | |
| 1.Young (< 35) years | 5 (30%) | 15 (27%) |
| 2. Middle aged (35-55 years) | 77 (43%) | 63 (46%) |
| 3. Aged farmers (> 55 years) | 18 (62%) | 22 (65%) |

## 2. Land holding pattern

The average operating size of the holding is around 5.2-5.3 ha in HOPE and non-HOPE areas and the proportion of irrigation is 39% in HOPE and 45% in non-HOPE areas. Leasing in and leasing out is rare (Table 2, Figure 3).

**Table 2. Pattern of land holding among sample farmers in Rajasthan.**

| | HOPE project area | | non-HOPE project area | |
|---|---|---|---|---|
| Particulars | Area (ha) | Proportionate to total | Area (ha) | Proportionate to total |
| **Own land** | | | | |
| Dry | 3.3 | 58 | 2.8 | 53 |
| Irrigated | 2 | 37 | 2.3 | 44 |
| Fallow | 0.3 | 5 | 0.2 | 3 |
| Total | 5.6 | 100 | 5.3 | 100 |
| **Leased in land** | | | | |
| Dry | 0.03 | 1 | 0.14 | 3 |
| Irrigated | 0.1 | 1 | 0.1 | 2 |
| Total | 0.1 | 2 | 0.2 | 4 |
| **Leased out land** | | | | |
| Dry | 0.1 | 3 | 0.2 | 3 |
| Irrigated | 0.1 | 1 | 0.1 | 2 |
| Total | 0.2 | 4 | 0.3 | 5 |
| **Operating land** | | | | |
| Dry | 3.1 | 59 | 2.8 | 53 |
| Irrigated | 2.1 | 39 | 2.3 | 45 |
| Fallow | 0.1 | 2 | 0.1 | 1 |
| Total | 5.3 | 100 | 5.2 | 100 |

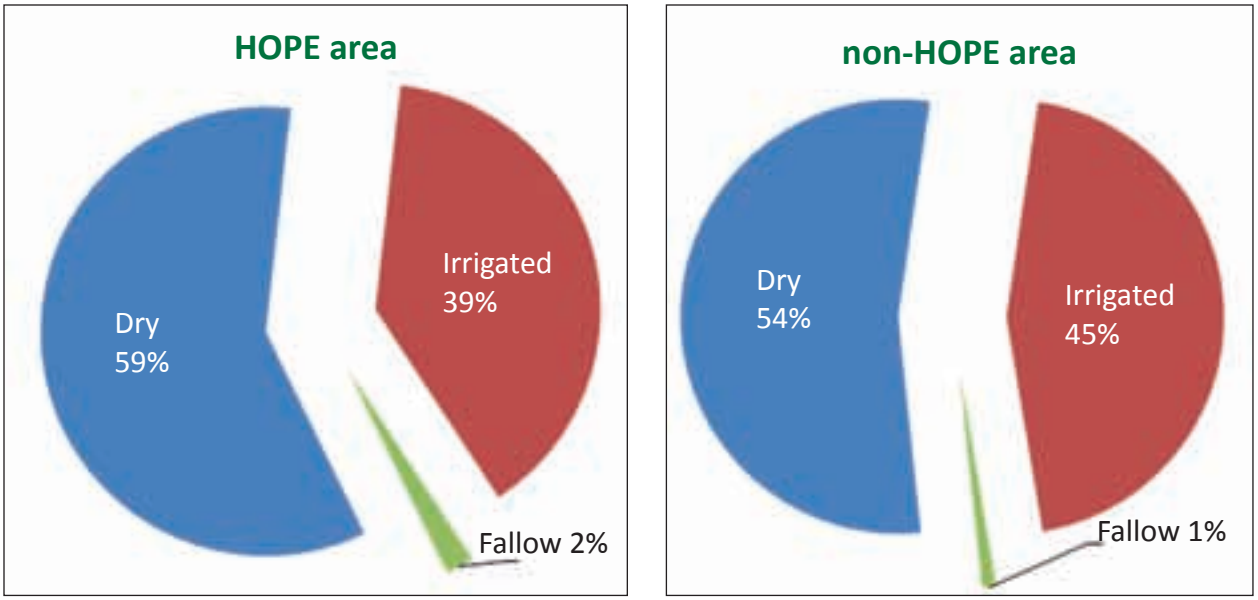


*Figure 3. Land holding pattern among sample farmers in Rajasthan.*

## 3. Pattern of livestock holding

Crop-livestock complementarity is evident in Rajasthan – at least 60% of the farm families in both HOPE and non-HOPE areas possess livestock such as local cows, she buffaloes and small ruminants such as sheep and goats. These are the *prima facie* indicators of both the diversity of farming and the strength of the integrated farming system drawing synergies between crop and livestock systems effectively to address the harsh climatic and economic conditions of arid agriculture of Rajasthan. The integration of crops and livestock in Rajasthan is described as BBCS, the prime characteristic of an average farm situation (Table 3).

**Table 3. Pattern of livestock holding among sample farmers in Rajasthan.**

| | | HOPE project area (N=120) | | | non-HOPE project area (N=60) | | |
|---|---|---|---|---|---|---|---|
| S. No. | Particulars | No. per family | % of farmers owning | Current Value | No. per family | % of farmers owning | Current value |
| 1 | Draft animals | 1.2 | 10.8 | 6423 | 1 | 10.0 | 13167 |
| 2 | Local Cows | 1.6 | 64.2 | 10688 | 1.6 | 58.3 | 9800 |
| 3 | Crossbred cows | 3.7 | 2.5 | 23333 | - | - | - |
| 4 | She buffaloes | 1.8 | 79.2 | 35453 | 2 | 76.7 | 32587 |
| 5 | Sheep and goats | 5.6 | 86.7 | 12162 | 2.6 | 85.0 | 4624 |
| 6 | Young stock and Others | 1.5 | 14.2 | 7882 | 1.3 | 6.7 | 6000 |

## 4. Pattern of farm machinery and household items

In both HOPE and non-HOPE areas, almost all farmers possess farmhouses, residential houses, two-wheeled vehicles, radios and fans/air coolers. Furthermore, the fact that more than 65% of sample farmers in both HOPE and non-HOPE areas possess irrigation pump sets is an indicator of the necessity for supplementary irrigation. Interestingly more than 35% of the farmers in both the sample areas possess tractors. This reiterates the increasing scarcity of labor for timely sowing and the role of mechanization in farm operations including marketing (Table 4).

**Table 4. Farm machinery and equipment holding among sample farmers in Rajasthan.**

| | | HOPE project area (N=120) | | non-HOPE project area (N=60) | |
|---|---|---|---|---|---|
| S. No. | Particulars | Current value (₹) | % of farmers | Current value (₹) | % of farmers |
| 1 | Flour making equipment | 2666 | 8 | - | - |
| 2 | Farmhouse | 18420 | 100 | 8483 | 98 |
| 3 | Harvester | 33954 | 18 | 18500 | 17 |
| 4 | Irrigation pump set | 18013 | 64 | 19024 | 68 |
| 5 | TV | 8118.2 | 46 | 7030 | 65 |
| 6 | Residential house | 137125 | 100 | 129000 | 100 |
| 7 | Radio/tape recorder | 579 | 83 | 635 | 57 |
| 8 | Tractor | 225000 | 35 | 237727 | 38 |
| 9 | Two wheeled vehicle | 14713 | 80 | 19974 | 78 |
| 10 | Sprinkler set/drip irrigation set | 21411 | 14 | 13333 | 5 |
| 11 | Rice mill | 5000 | 8 | 4600 | 8 |
| 12 | Broadbed and furrow | 3687 | 7 | 4533 | 5 |
| 13 | Bullock cart | 4236 | 9 | 5500 | 7 |
| 14 | Manual/power sprayer | 1814 | 18 | 900 | 15 |
| 15 | Fridge | 9062 | 7 | 6750 | 7 |
| 16 | Fan/air cooler | 1422.1 | 100 | 1704 | 100 |

## 5. Assessment of various sources of income

The average income per ha from crops is ₹ 22,851 in HOPE and ₹ 31,984 in non-HOPE areas, which are at modest levels. The income from all sources per farm is around ₹ 1.6 lakhs in both HOPE and non-HOPE areas. However, the income per capita drops to around ₹ 26,000 per year, which is only about 50% of India's per capita income (₹ 53,000) (Table 5).

Income from crops accounts for 74% of the total income in the HOPE area, followed by wage and nonfarm income (11%), income from dairy (5%), income from livestock (2.4%), and savings and money lending (2.1%). In the non-Hope area, too, the income from crops accounts for 75% of the total, followed by wage and nonfarm income (10%), dairy income (6%) and livestock income (1.4%). Table 5 and Figure 4 show that the livestock component does not significantly contribute to the total income, which needs to be strengthened.

**Table 5. Sources of income for sample farmers in Rajasthan.**

| Sources of income | HOPE project area | % of farmers | non-HOPE project area | % of farmers |
|---|---|---|---|---|
| Total size of holding (ha) | 5.3 | | 5.2 | |
| Irrigated land (ha) | 2.1 | 100 | 52.3 | 100 |
| Family size | 6 | | 6 | |
| Income from crops | 121108 | 100 | 126317 | 100 |
| Wage income and nonfarm income | 17951 | 68 | 17114 | 73 |
| Income from dairy | 7940 | 90 | 10000 | 88 |
| Wage income from hiring bullock labor | 3100 | 6 | 5000 | 2 |
| Income from livestock | 3901 | 83 | 2474 | 63 |
| Income from water market for irrigation | 5846 | 22 | 3357 | 23 |
| Income from custom hiring | 12069 | 24 | 10786 | 23 |
| Rent from land, building and machinery etc. | 8706 | 14 | 2750 | 13 |
| Business | 33000 | 15 | 65833 | 10 |
| Regular salaried jobs | 138333 | 5 | 120000 | 5 |
| Interest on savings and money lending | 3543 | 41 | 3500 | 45 |
| Income from all sources per farm | 162683 | | 167175 | |
| Income from all sources per capita | 26064 | | 26327 | |
| Crop income per ha | 22851 | | 31984 | |

## 6. Crop production, cropping pattern and yields

In the HOPE area, in both the rainy and postrainy season, no single crop dominates the cropping pattern. However, while generalization is not easy, it can be inferred that in the rainy season, as pearl millet occupies 22% of the area and cotton 24%, these two are the major crops in the area. In the postrainy season, similarly, mustard occupies around 29% and wheat occupies 24% of the area (Table 6; Figures 5, 6). Similar trends were observed in the case of the non-HOPE area as well.

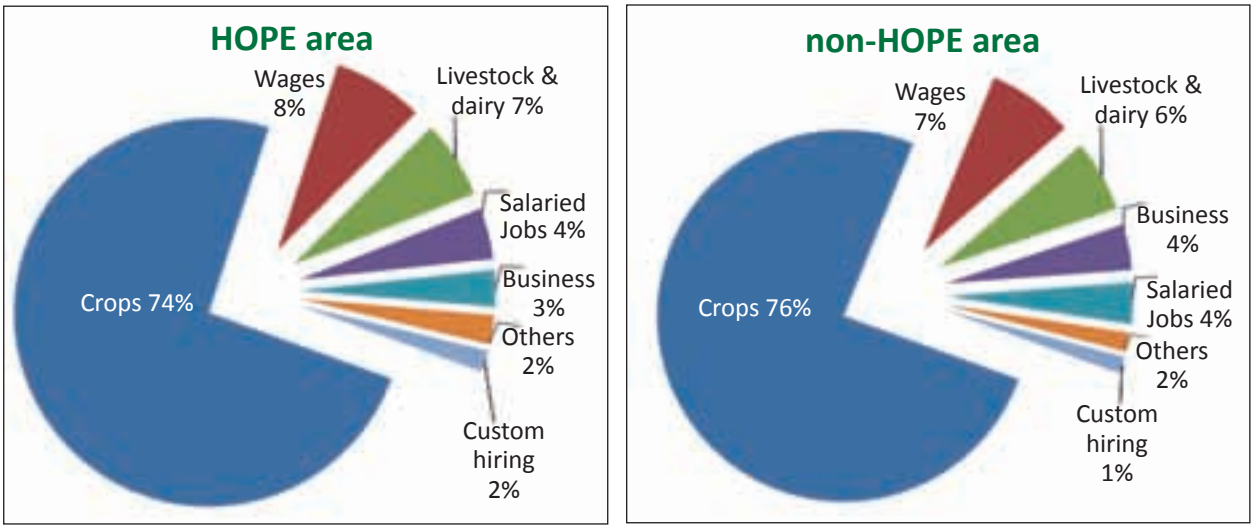


*Figure 4. Different sources of income among sample farmers in Rajasthan.*

**Table 6. Choice of crops among sample farmers in Rajasthan.**

| | HOPE project area | | | | non-HOPE project area | | | |
|---|---|---|---|---|---|---|---|---|
| Crops including fodder | Area (ha) | % of GCA | % of season area | Yield (t ha$^{-1}$) | Area (ha) | % of GCA | % of season area | Yield (t ha$^{-1}$) |
| **Rainy season crops** | | | | | | | | |
| Pearl millet | 2.1 | 13 | 22 | 1.46 | 5.1 | 13 | 21 | 1.45 |
| Cotton | 2.4 | 15 | 24 | 2.03 | 6.1 | 15 | 25 | 1.95 |
| Sesame | 1 | 6 | 10 | 0.7 | 2.5 | 6 | 10 | 0.63 |
| Cluster beans | 1.1 | 7 | 11 | 0.8 | 2.7 | 7 | 11 | 0.85 |
| Moth bean (*Vigna aconitifolia*) | 1.1 | 7 | 12 | 0.65 | 3 | 8 | 13 | 0.6 |
| Green gram | 1.2 | 8 | 13 | 0.65 | 3 | 8 | 12 | 0.6 |
| Castor | 0.8 | 5 | 8 | 2.03 | 2 | 5 | 8 | 1.95 |
| Total rainy season crops | 9.7 | 61 | 100 | 8.32 | 24.4 | 62 | 100 | 8.03 |
| **Postrainy season crops** | | | | | | | | |
| Wheat | 1.5 | 10 | 24 | 3.7 | 3.7 | 9 | 24 | 3.75 |
| Mustard | 1.8 | 11 | 29 | 1.88 | 4.6 | 12 | 30 | 1.5 |
| Cumin | 1.5 | 9 | 24 | 0.48 | 3.7 | 9 | 24 | 0.5 |
| Psyllium (*Plantago ovata*) | 0.9 | 7 | 17 | 0.8 | 2.5 | 6 | 16 | 0.75 |
| Onion | 0.4 | 2 | 6 | 1.6 | 0.8 | 2 | 6 | 1.5 |
| Total postrainy season crops | 6.1 | 39 | 100 | 8.46 | 15.3 | 38 | 100 | 8 |
| Gross cropped area | 15.8 | 100 | | | 39.7 | 100 | | |

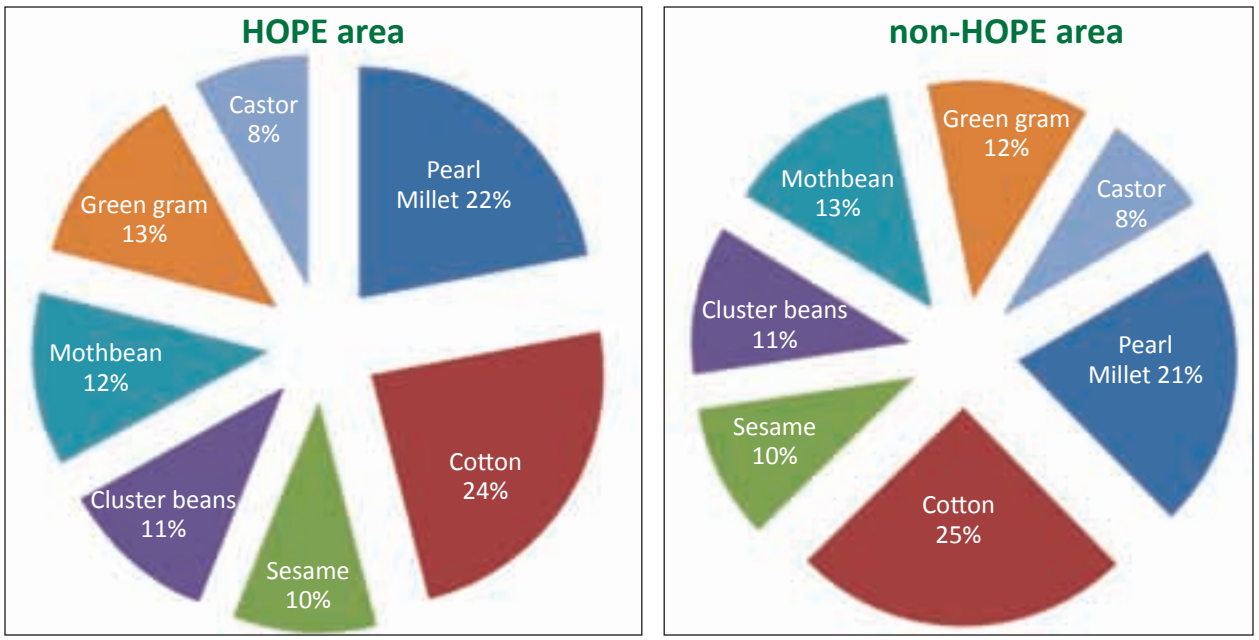


*Figure 5. Choice of crops during the rainy season in Rajasthan.*

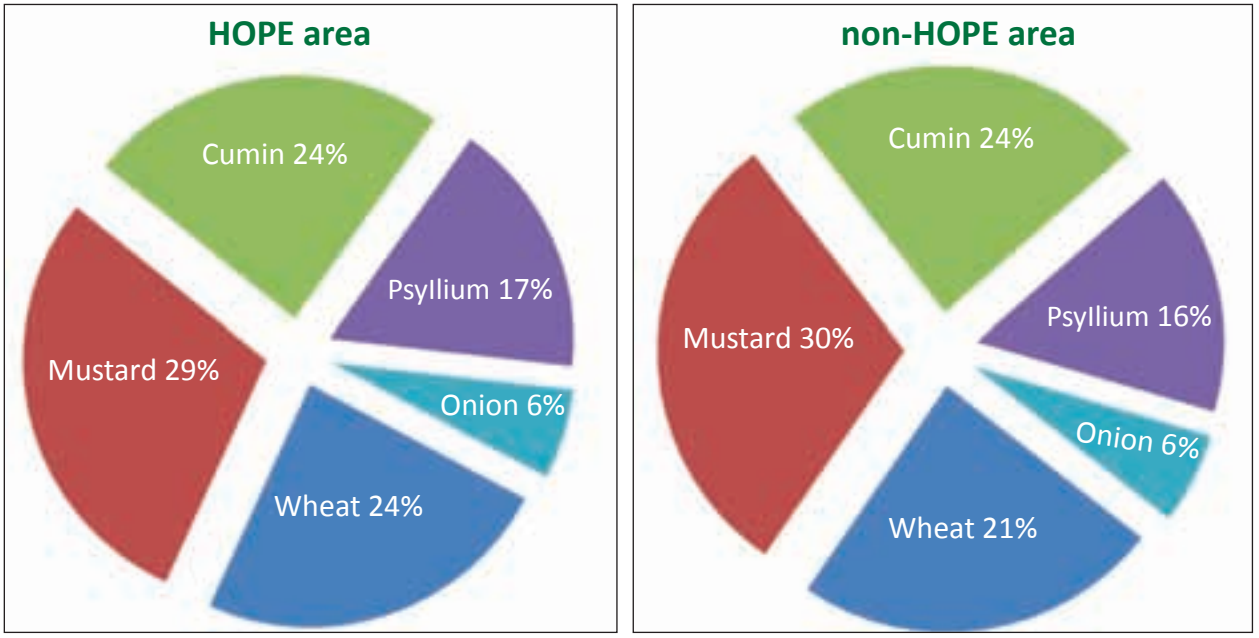


*Figure 6. Choice of crops during the postrainy season in Rajasthan.*

Agronomic performance of pearl millet is strongly a function of rainfall in Rajasthan. The performance of hybrids in irrigated and dry conditions in HOPE and non-HOPE areas are comparable in a normal year. Similarly they are comparable in below normal and above normal years. However the productivity in the above normal year is 40-60% higher than the normal year performance (Table 7, Figure 7).

Similarly, the productivity in a below normal year is around 75% lower than that in a normal year. This further reiterates the crucial and vital link between rainfall and pearl millet productivity. This then affects livestock and dairy performance, since the buffaloes and cows are strongly dependent on the fodder from the main crop. It is crucial to find ways and means of improving the performance of livestock and income contribution to farm income in Rajasthan, as pearl millet, which is a major rainy season crop, is a preferred fodder by livestock.

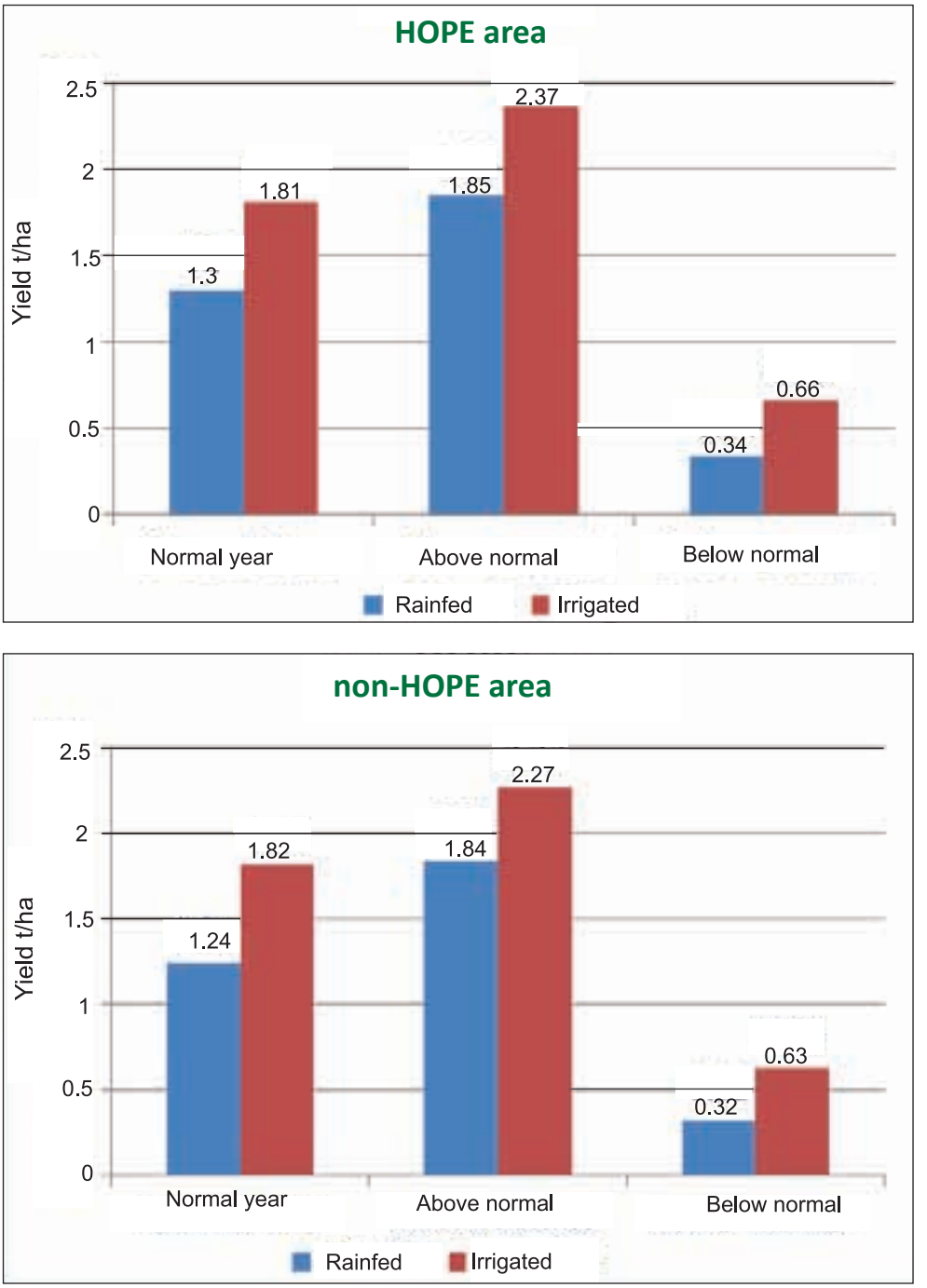


*Figure 7. Crop productivity in pearl millet among sample farmers in Rajasthan.*

**Table 7. Crop productivity (t ha$^{-1}$) in rainy season pearl millet in Rajasthan (Opinion survey of farmers).**

| | HOPE project area | | non-HOPE project area | |
|---|---|---|---|---|
| | Rainfed | Irrigated | Rainfed | Irrigated |
| **Normal Year (650 - 750 mm)** | | | | |
| Average yield | 1.3 | 1.81 | 1.24 | 1.82 |
| **Above normal (> 750 mm)** | | | | |
| Average yield | 1.85 | 2.37 | 1.84 | 2.27 |
| **Below normal (< 650 mm)** | | | | |
| Average yield | 0.34 | 0.66 | 0.32 | 0.63 |

In HOPE clusters, high rate of adoption of pearl millet hybrids is evident, where public bred hybrid (HHB 67 Improved) covers 20% and proprietary hybrids 48%. Similarly, in the case of non-HOPE areas, the adoption rate of proprietary hybrids is to the tune of 65% whereas public bred (HHB 67 Improved) is only 7% of the total area (Table 8).

**Table 8. Area adoption (ha) of improved and local pearl millet varieties/hybrids in Rajasthan.**

| Particulars | HOPE project area | non-HOPE project area |
|---|---|---|
| Public hybrids (HHB 67 Improved) | 64 (20%) | 9 (7%) |
| Local variety | 104 (32%) | 37 (28%) |
| Proprietary hybrids | 156 (48%) | 86 (65%) |

Note: figure in parentheses are percentage to total

The yield gap of pearl millet was estimated as 186% (the recommended grain yield is 2.2 t ha$^{-1}$ as per the package of practices) for the improved hybrids, which shows a further scope for improvement in productivity level with the introduction of recommended package of practices along with improved hybrids.

## 7. Economics of pearl millet according to input use and relative profitability

The total cost of cultivation is ₹ 8,070 per ha in HOPE and ₹ 8,160 per ha in non-HOPE areas, while the gross returns are around ₹ 16,800 per ha. The grain and fodder yields in both HOPE and non-HOPE areas is around 1.7 t $ha^{-1}$ and 2.7 t $ha^{-1}$. The net returns in both the areas area ₹ 8,700 per ha, yielding a return-to-cost ratio of 2.1 (Table 9). Expenditure on human labor forms 50% of the variable cost in both the areas. Threshing and harvesting dominate the cost of production, which constitutes 28%, followed by input cost (20%), irrigation cost (13%) in both HOPE and non-HOPE areas.

**Table 9. Economics of pearl millet in sample farmers of Rajasthan (per ha).**

| | HOPE project area | | non-HOPE project area | |
|---|---|---|---|---|
| Particulars | Value (₹) | Proportion to total (%) | Value (₹) | Proportion to TC (%) |
| Input cost | 1588 | 20 | 1584 | 19 |
| Land preparation | 554 | 7 | 521 | 6 |
| Sowing | 775 | 10 | 815 | 10 |
| Fertilizer application | 119 | 1 | 113 | 1 |
| FYM application | 283 | 4 | 273 | 3 |
| Irrigation | 1058 | 13 | 1057 | 13 |
| Weeding | 794 | 10 | 789 | 10 |
| Harvesting and threshing | 2295 | 28 | 2297 | 28 |
| Bird scaring | 150 | 2 | 250 | 3 |
| **Variable Cost** | **7616** | 94 | **7699** | 94 |
| Interest on variable cost @ 6% per annum | 456.96 | 6 | 461.94 | 6 |
| **Total cost** | **8073** | 100 | **8161** | 100 |
| Main product yield (t) | 1.7 | | 1.72 | |
| Value of main product (₹ $t^{-1}$) | 7950 | | 7990 | |
| Byproduct yield (t) | 2.7 | | 2.7 | |
| Value of byproduct (₹ $t^{-1}$) | 1220 | | 1160 | |
| Total return | 16809 | | 16875 | |
| Net return over total cost | 8736 | | 8714 | |
| Return-to-cost ratio | 2.08 | | 2.07 | |

The input usage pattern by high management group (HMG) farmers has improved grain yield over low management group (LMG) in both HOPE and non-HOPE areas. The grain yield under HMG was substantially higher (2.22 t $ha^{-1}$) as compared to LMG (0.76 t $ha^{-1}$). Nevertheless, the HMG farmers cultivated hybrids with protective irrigation that boosted the grain as well as fodder yield, whereas LMG farmers cultivated mostly public bred hybrids under residual moisture condition only. This increased grain and fodder yield due to proprietary hybrids and supplemental irrigation ultimately improves the net returns realized by HMG farmers to four fold (₹ 12500) that of LMG farmers (₹ 2300) (Table 10).

**Table 10. Economics of pearl millet according to input use pattern (low input management and high input management) in Rajasthan.**

| | HOPE project area | | non-HOPE project area | |
|---|---|---|---|---|
| | HMG (65%) | LMG (35%) | HMG (65%) | LMG (35%) |
| Grain yield (t $ha^{-1}$) | 2.22 | 0.76 | 2.22 | 0.77 |
| Grain price received (₹ $t^{-1}$) | 8110 | 7650 | 7950 | 8060 |
| Fodder yield (t $ha^{-1}$) | 2.80 | 2.44 | 2.69 | 2.62 |
| Fodder price received (₹ $t^{-1}$) | 1250 | 1170 | 1170 | 1130 |
| Total costs (₹) | 8625 | 6420 | 8313 | 6685 |
| Total return (₹) | 21537 | 8655 | 20834 | 9135 |
| Net return (₹) | 12912 | 2235 | 12522 | 2450 |
| Return-to-cost ratio | 2.50 | 1.35 | 2.51 | 1.37 |

HMG: High input use group, LMG: Low input use group

## 8. Relative profitability of crops in Rajasthan

With respect to other crops, in the HOPE area, sample farmers are earning relatively higher net returns in the form of cotton (42,051) than cluster beans (25,830) and the same trend is seen in non-HOPE areas also (Cotton ₹ 40,620 and cluster beans ₹ 28,313). From household nutritional point of view, sample farmers in both the areas are wise in cultivating cereals, millets and pulses (Table 11). However, the return-to-cost ratio of most crops in HOPE areas is higher than the corresponding crops in non-HOPE areas. Thus, HOPE area farmers have an edge in their management acumen over non-HOPE farmers.

**Table 11. Relative profitability of crops in Rajasthan.**

| | HOPE project area | | | | | | non-HOPE project area | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Crop | Pearl millet | Cotton | Sesame | Cluster bean | Moth bean | Green gram | Pearl millet | Cotton | Sesame | Cluster bean | Moth bean | Green gram |
| Total costs (₹) | 8073 | 28034 | 7008 | 7810 | 7508 | 7209 | 8161 | 27630 | 6768 | 7387 | 7400 | 7134 |
| Main product yield (t) | 1.7 | 2.03 | 0.7 | 0.8 | 0.65 | 0.65 | 1.72 | 1.95 | 0.63 | 0.85 | 0.6 | 0.6 |
| Price of main product (₹ $t^{-1}$) | 7950 | 35000 | 30000 | 42000 | 17000 | 32000 | 7990 | 35000 | 30000 | 42000 | 17000 | 32000 |
| Byproduct yield (t) | 2.7 | - | - | - | - | - | 2.7 | - | - | - | - | - |
| Price of by product (₹ $t^{-1}$) | 1220 | - | - | - | - | - | 1160 | - | - | - | - | - |
| Total return (₹) | 16809 | 70085 | 21025 | 33640 | 11064 | 20825 | 16875 | 68250 | 18900 | 35700 | 10200 | 19200 |
| Net return (₹) | 8736 | 42051 | 14017 | 25830 | 3554 | 13616 | 8714 | 40620 | 12132 | 28313 | 2800 | 12066 |
| Return-to-cost ratio | 2.08 | 2.5 | 3.0 | 4.3 | 1.5 | 2.9 | 2.07 | 2.5 | 2.8 | 4.8 | 1.4 | 2.7 |

## 9. Utilization of output (Grain and Fodder)

The exposure of pearl millet farmers to market differs between HOPE and non-HOPE areas. In both areas, about 3% of the farmers reported no sale (Table 12). Around 80% of the farmers in HOPE and non-HOPE area consume a little of their produce and sell the rest of the produce in regulated markets for ₹ 10-13 per kg. The remaining farmers in both areas sell their produce in village and weekly market.

In HOPE areas, 4% of farmers sold their produce in the village market for ₹ 15 per kg which was higher than the price in regulated market and 15% of farmers sold it in the weekly market where they get a similar price. This situation is reversed in the case of the non-HOPE areas, where 18% of farmers sold their produce in the village market at ₹ 16 per kg and 2% farmers sold it in the weekly market at a higher price of ₹ 20 per kg.

**Table 12. Utilization of pearl millet grain in Rajasthan.**

| | HOPE project area | | | | non- HOPE project area | | | |
|---|---|---|---|---|---|---|---|---|
| Particulars | No sale (3%) | Regulated (78%) | Village (4%) | Weekly (15%) | No sale (3%) | Regulated (77%) | Village (18%) | Weekly (2%) |
| Grain output (kg) | 1300 | 3933 | 1620 | 3803 | 955 | 2440 | 1214 | 3000 |
| Grain Consumed (kg) | 1000 | 513 | 600 | 572 | 725 | 478 | 436 | 800 |
| Other use (kg) | 225 | 290 | 375 | 194 | 185 | 215 | 120 | 100 |
| Future use (kg) | 50 | 64 | 13 | 22 | 45 | 46 | 14 | |
| Seed sale price (₹ $kg^{-1}$) | 15 | 10 | 15 | 14 | | 13 | 16 | 20 |
| Marketing cost (₹) | 0 | 38 | 22 | 96 | 0 | 31 | 7 | 42 |
| Marketable surplus | 25 | 3066 | 633 | 3014 | | 1701 | 643 | 2100 |
| Grain marketed | | 2984 | 622 | 3014 | | 1680 | 627 | 2100 |

Due to the presence of milch cattle on all the sample farms, around half of the fodder produced on the farm is retained for use by livestock (Table 13). Farmers sell their surplus fodder in the village market in both HOPE and non-HOPE areas for ₹ 2 per kg. Thus, pearl millet has the great capacity to meet both feed and fodder demand while being cultivated with low soil moisture under harsh climatic conditions.

**Table 13. Utilization of pearl millet fodder in Rajasthan.**

| | HOPE project area | | non- HOPE project area | |
|---|---|---|---|---|
| Particulars | No sale (40%) | Village (60%) | No sale (63%) | Village (37%) |
| Fodder production (kg) | 6100 | 8200 | 5000 | 5300 |
| Own use (kg) | 6100 | 4400 | 5000 | 3200 |
| Fodder sold (kg) | | 3800 | | 2100 |
| Sale price (₹ $kg^{-1}$) | | 2.01 | | 2.34 |

## 10. Production characteristics of technology and trait preferences of sample farmers

### 10.1. Constraints

In the HOPE area, low productivity has been the main constraint in public hybrids followed by their long duration, low recovery and small grain size. However in the case of private hybrids, poor taste of the hybrid, poor color, small grain size, and long duration are the deterring factors (Table 14). In the Non-HOPE area, in both public and private hybrids, the long duration of the hybrids, has been the deterring factor, followed by poor taste, long duration, poor color and small grain size. Thus, long duration of both public and private hybrids needs to be addressed as it has been the prime constraining factor listed by the majority of the farmers, and because of decreasing number of rainy days, increasing day temperatures and associated climate change impacts. Other factors such as poor color, poor taste, and small grain size, including low recovery, have been the chief characteristics of small millets by default, which need to be addressed along with the trait of 'long duration'. Long duration of pearl millet hybrids in relation to moisture is a major cause of concern for farmers.

**Table 14. Constraints in pearl millet in Rajasthan.**

| Characteristics/% of farmers who responded | HOPE project area | non-HOPE project area |
|---|---|---|
| Low yield | 1 | 1 |
| High pest incidence | 4 | 4 |
| High disease incidence | 9 | 9 |
| Long duration | 31 | 31 |
| Small grain size | 25 | 25 |
| Poor color | 27 | 27 |
| Low recovery/selling% | 3 | 3 |
| Low market price | 6 | 6 |
| Does not fit into cropping system | 2 | 2 |
| Susceptible to storage pests | 6 | 6 |
| Poor fodder quality | 11 | 11 |

## 10.2. Preferred traits

### Production characteristics

With regard to the production or supply side, farmers have indicated that they prefer proprietary hybrids due to their productivity and short duration, drought, pest- and disease resistance and because they fit into the cropping system. These are perhaps the lessons that should be learned for public hybrids from farmers' impressions and inputs (Table 15.1).

Preferred traits: Tables 15.1 - 15.4

**Table 15.1. Preferred traits: Production.**

| Characteristics/ % of farmers who responded | HOPE project area | non-HOPE project area |
|---|---|---|
| High yield | 35 | 45 |
| Short duration | 17 | 37 |
| Drought resistance | 15 | 33 |
| Pest resistance | 15 | 9 |
| Disease resistance | 15 | 2 |
| Fits into cropping system | 10 | 10 |
| Improves soil fertility | 1 | 0 |

### Consumption characteristics

Considering the demand side (or consumption), farmers said that proprietary hybrids have better taste, less cooking time and have higher keeping quality than public hybrids. Hence proprietary hybrids are performing better on the counts of both production and consumption (Table 15.2)

**Table 15.2. Preferred traits: Consumption.**

| Characteristics/% of farmers who responded | HOPE project area | non-HOPE project area |
|---|---|---|
| Better taste | 32 | 32 |
| Less cooking time | 29 | 46 |
| High keeping quality | 32 | 43 |

### Fodder characteristics

Considering fodder quality, farmers' opinion about proprietary varieties with regard to higher fodder quantity, palatability and storability is impressive. This is a lesson for public hybrids to improve upon fodder quantity, palatability and storability (Table 15.3).

**Table 15.3. Preferred traits: Fodder.**

| Characteristics | HOPE project area | non-HOPE project area |
|---|---|---|
| More fodder quantity with leaves | 29 | 23 |
| Palatability (quality/taste) | 37 | 45 |
| Storability of fodder (free from pest and diseases) | 1 | 42 |

**Marketing characteristics**

With regard to the marketing aspects, a higher proportion of farmers have indicated that proprietary hybrids are in relatively high demand, fetch higher prices, show low price fluctuations and have relatively larger grain size. These are lessons for breeders of public-bred hybrids who need to incorporate these traits in their breeding programs (Table 15.4).

**Table 15.4. Preferred traits: Marketing.**

| Characteristics | HOPE project area | non-HOPE project area |
|---|---|---|
| High demand | 37 | 38 |
| Fetches higher price | 15 | 37 |
| Low price fluctuations | 32 | 31 |
| Bigger grain size | 6 | 6 |

## 11. Consumption status

More than 60% of the total food grains consumed in both the HOPE and non-HOPE areas is millet, while wheat consumption is around 35% and rice 1-2%. It is important to note that policy support to rice, and especially to wheat, is influencing the consumption of pearl millet. This will directly affect the market for millets in the long run. Once the market for millets is on a downward trend, it becomes extremely difficult to sustain the millet economy which includes both food and feed (Table 16).

**Table 16. Per capita cereal consumption per annum in Rajasthan.**

| | HOPE project area | | non-HOPE project area | |
|---|---|---|---|---|
| Cereal/millet | Average quantity consumed as food and feed (kg) | % consumed | Average quantity consumed as food and feed (kg) | % consumed |
| Rice | 2 | 1 | 2 | 2 |
| Wheat | 49 | 36 | 43 | 35 |
| Pearl millet | 84 | 62 | 78 | 63 |
| Total food grain | 135 | 100 | 123 | 100 |

In Rajasthan, there is strong evidence of replacement of pearl millet by wheat, even though 70% of pearl millet produced is consumed at home. A mere 5% of the farmers in both HOPE and non-HOPE areas indicated that pearl millet consumption is increasing. Due to increase in family size, around 25% of the families reported that pearl millet consumption will increase in perspective. The crop which is likely to replace pearl millet is wheat. Thus, pearl millet is being sidelined and perhaps the trend will continue unless policies and programs are derived to check assured market demand of pearl millet in Rajasthan (Table 17).

**Table 17. Opinion survey on consumption of pearl millet in retrospect and prospect in Rajasthan.**

| Particulars | HOPE project area | non-HOPE project area |
|---|---|---|
| % of farmers reporting an increase in consumption | 5.0 | 3.33 |
| Due to family size increase | 24.17 | 28.33 |
| Crop replaced by pearl millet | Pearl millet is sustained | Pearl millet is sustained |
| % of farmers reporting decrease in consumption | 26.67 | 5.00 |
| Change in consumption habits | 10.00 | 3.3 |
| Crop by which pearl millet is replaced | Wheat | Wheat |

## 12. Gender involvement

Cultivation of pearl millet in Rajasthan is skewed towards male labor in both HOPE and non-HOPE areas. In cultural operations such as land preparation, sowing, watch and ward, irrigation and marketing, there is virtually no involvement of women. The highest involvement of women is in activities such as weeding, harvesting and threshing which involve a lot of bending activity. Sowing, a crucial physical and decision making activity, is totally devoid of women labor and at the other end, marketing, another crucial activity, is the same. However marketing activity is a function of marketable surplus. The reasons for modest involvement of woman labor in Rajasthan in pearl millet are: 1. High day temperatures, which women may not be able to withstand to the same extent as men; and 2. cultural factors that may deter women involvement in different aspects of cultivation (Table 18).

**Table 18. Gender involvement in pearl millet cultivation in Rajasthan.**

| | HOPE project area (Average crop area 1.67 ha) | | | non-HOPE project area (Average crop area 1.21 ha) | | |
|---|---|---|---|---|---|---|
| | Man days | Women days | % involvement of men, women | Man days | Women days | % involvement of men, women |
| Land preparation | 4 | 0 | 100, 0 | 2 | 0 | 100, 0 |
| FYM application | 3 | - | 100, 27 | 2 | - | 100, 16 |
| Sowing | 4 | 0 | 100, 0 | 2 | 0 | 100, 0 |
| Fertilizer application | 2 | 3 | 65, 18 | 1 | 2 | 65, 12 |
| Interculture/ weeding | 5 | 0 | 100, 100 | 4 | 0 | 100, 100 |
| Irrigation | 2 | - | 65, 0 | 2 | - | 65, 2 |
| Watch and ward | 1 | 5 | 100, 0 | 1 | 4 | 100, 0 |
| Harvesting | 10 | 3 | 100, 100 | 8 | 2 | 100, 100 |
| Binding | - | 2 | 0, 100 | - | 1 | 0, 100 |
| Threshing | 4 | - | 100, 100 | 3 | - | 100, 100 |
| Marketing | 2 | - | 100, 0 | 2 | - | 100, 0 |

## Conclusion and policy implications

Pearl millet is one of the staple food and fodder crops in Rajasthan, supporting poor smallholders and livestock in the harsh agroclimatic region. The baseline survey results reveal that pearl millet occupied one third of the total cropped area in the state. The average productivity of pearl millet in the low management farms is about 0.7-0.8 t $ha^{-1}$ as against the potential yield of 2.2 t $ha^{-1}$, leaving a yield gap of 186%. With respect to medium and high management farms, private bred hybrids perform better under protective irrigation facilities, leaving a yield gap of 50-80%. The local hybrids of pearl millet are still in use, occupying around 35% of the area. The most popular improved hybrids of pearl millet being cultivated include HHB 67 Improved, which occupies an area of 14-18% of the total. There is strong evidence of replacement of pearl millet by wheat, even though 70% of pearl millet produced is consumed in farmers' homes. A mere 5% of the farmers in both HOPE and non-HOPE areas indicated that pearl millet consumption is increasing. The marketed surplus was to the tune of 65-70% for grain and 25% for fodder. The traits farmers most preferred in public hybrids of pearl millet inter alia include more palatable grain and fodder quality and reduced disease-pest-moisture stress. The key constraints faced by the farmers in the adoption of improved hybrids are low productivity of public hybrids, followed by their long duration, low recovery and small grain size; untimely availability of fertilizer and quality seed. In order to improve productivity, besides targeting improved hybrids, targeting the key recommended technologies and management practices is vital as there is a significant yield gap between the baseline and the potential from

the improved cultivars. While minimum support price is announced for dryland cereals, none of them, including pearl millet grains, are procured. Hence, minimum support price should be followed by procurement to provide market support to farmers. Farmers preferred hybrids responding to low input usage, short duration with good quality of grain and fodder, and drought- and downy mildew tolerant attributes. Therefore these value-added attributes need to be incorporated into the breeding program of pearl millet.

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