Prospects for R*ainy Season(kharif)*and *Summer* Pearl Millet in Western India

A.Amarender Reddy, P.Parthasarathy Rao, OP Yadav, SK Gupta, Rajan Sharma, Sawargaonkar GL, IP Singh, Ardeshna, KK Kundu

International Crops Research Institute for Semi-Arid Tropics (ICRISAT/Hyderabad)

Abstract

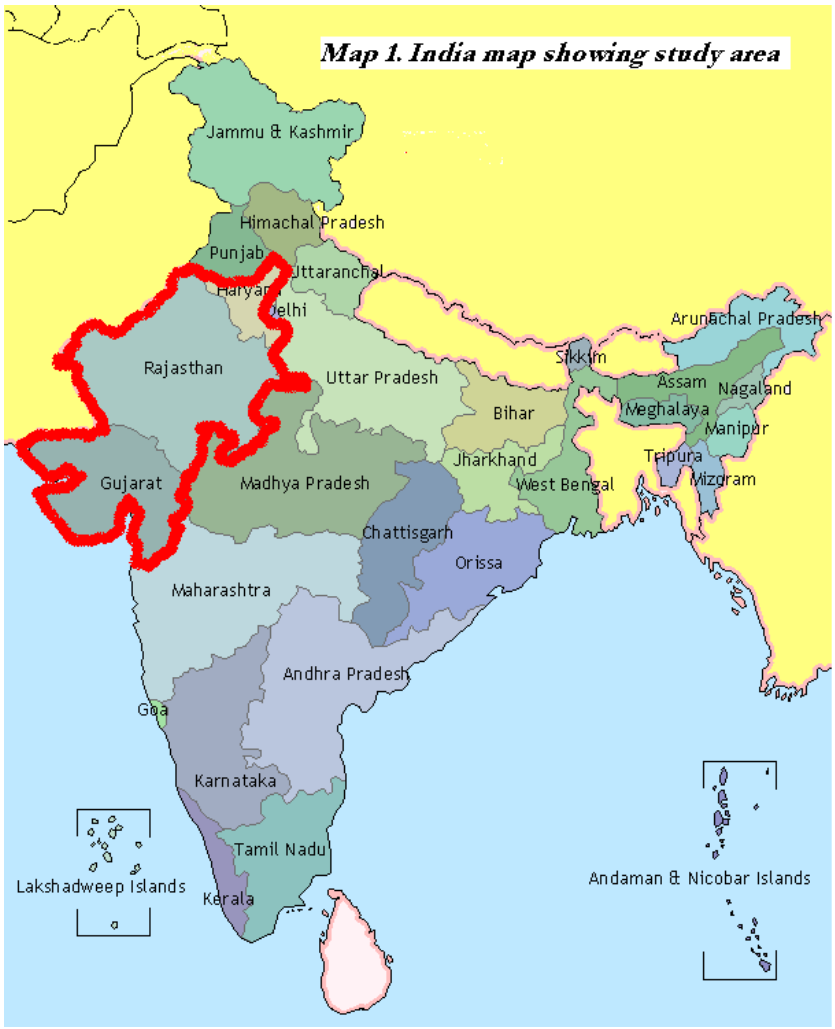
Pearl millet is a major cereal crop in north western India. The crop is grown in most harsh arid and drier climatic areas under high temperature and low and erratic rainfall. Its use as food is declining but use as cattle feed, poultry feed and source of starch in alcohol industry are increasing. Its fodder is an important source of animal feed particularly in dry months when alternative sources of feed are not available. In the last decade, pearl millet is also grown under irrigation in summer months. Gujarat state has the highest area under summer pearl millet not only among the north western states but also at all-India level. In this paper we have analyzed the productive potential of both *kharif (rainy season)* and summer pearl millet particularly in Gujarat state. *Kharif* pearl millet still contributes bulk of the pearl millet production in western India although its yields are relatively low. To compete with competing crops like *guar, green gram*, cotton etc both grain and fodder yields of *kharif* crop need to be increased. With the adoption of improved cultivars and low-cost improved technology, yields can be increased by 20-30% from the existing levels. Yields of summer pearl millet are much higher since it is grown under irrigation and its grain quality is also superior. It is grown as a commercial crop with bulk of the crop sold domestically, and also exported to nearby countries. There is a need to explore opportunities to expand area under summer pearl millet particularly in areas where irrigation is available and the fields are vacant during summer season.

Introduction

Pearl millet is the most drought tolerant warm season cereal grown on 27 million ha in some of the harshest arid and drier semi-arid tropical environments of south Asia and sub-Saharan Africa. It is more tolerant to higher temperatures than any other cultivated cereal. The best temperature for the germination of pearl millet seed is from 23 to 32 ^{0}C. The optimum rainfall requirement of pearl millet ranges between 500-800 mm but it can also be successfully grown in areas, which receive less than 500 mm of annual rainfall. However, prolonged intra-seasonal spells of warm, rain free period may be detrimental to its growth and may lead to reduced crop yields. Although pearl millet can respond to good moisture supplies during its growth, it is nevertheless one of the toughest, drought tolerant crops available and has a distinct advantage over its competing crops in the regions where there is scanty and erratic rainfall and high temperatures. The ability of the crop to grow in drier environments is due to a number of physiological and morphological characteristics viz., (i) rapid and deep root penetration (root depths of 3.6 m have been recorded); (ii) fast growth and development; and (iii) high tillering capacity.

India has the largest area (about 8.5 million ha) under pearl millet which is at third rank after rice and wheat among cereals. Although the crop is grown in several states of the country it is major crop in the dry areas of north-western India which comprises of parts of Gujarat, Rajasthan and Haryana

(Map 1). It is valued for both its grain and stover. Its grains have high protein content, balanced amino acid profile, and high levels of iron, zinc and insoluble dietary fiber and is the major source of dietary carbohydrates of human diet. Its stover is an important component of livestock ration during the dry period of year.



Pearl millet is cultivated in both *kharif* and *summer* seasons in north western India. The recent spurt in prices of food grains especially of coarse cereals indicates supply-side constraints to meet their growing demand from non-food uses mainly from poultry, cattle feed, alcohol and starch industry. Further, with the higher prices of wheat, rice and maize in recent years, cattle and poultry feed and alcohol industries are looking for cheaper alternative sources like pearl millet. It is also noted that, demand of pearl millet from health-conscious food products industry is increasing as it contains more fibre and is good for diabetic and heart patients. However, due to the high instability in grain yields and decline in prices of pearl millet, farmers might shift to other competing crops. The cultivation of pearl millet during summer might reduce the instability as the crop is grown under irrigated conditions, which also fetch higher yields and returns. The area under summer pearl millet is still low

relative to *kharif* pearl millet but is expanding in Gujarat state. Pearl millet is also an important fodder crop in the summer season, as most other crops cannot withstand hot temperatures. However there are some abiotic and biotic constraints in cultivation of pearl millet, like downy mildew, stem borer, shoot fly, drought, extreme heat and moisture stress**.**

Keeping the importance of pearl millet in *kharif* season in terms of area and production and the scope for expanding area in *summer* due to significant higher yields, this paper besides looking at area and production trends of pearl millet in India and north western India (particularly Gujarat)attempts to examine the comparative economics of pearl millet in both *kharif* and summer seasons in order to (i) assess competitiveness of *kharif* and summer pearl millet in western India (ii) examine possibility of enhancing overall yield by expanding area under *summer* season (iii) explore scope for further increasing yield, reducing instability and increasing competitiveness of *kharif* pearl millet.

Data and methodology

The secondary data at district/state level on area, production and yield is taken from the Directorate of Economics and Statistics (DES), Ministry of Agriculture, Government of India. Data on annual prices of major crops in India is drawn from FAOSTAT price archives from 1961 to 2010 to measure trends in real prices. Prices were deflated by consumer price index (CPI) for agricultural labourers with 1986/87 base year to get real prices. Cost of cultivation data for pearl millet iscompiled from DES, Government of India. Since the DES does not provide separate data for *kharif* and summer pearl millet the secondary data collected is supplemented by primary data collected in the year 2009/10 and 2010/11 under the project titled 'Harnessing Opportunities for Productivity Enhancement of Sorghum and Millets in Sub-Saharan Africa and South Asia (HOPE)' of ICRISAT. Seasonal trends in market arrivals and price trends of pearl millet are collected from Agricultural Marketing Produce Committees (APMCs) in Radhanpur, Tharad, Palanpur, Deesa, Patan and Ahmadabad under HOPE project in western India. The simple averages, triennium ending averages, trends, instability index, and cost benefit ratios are used for analysis of the data.

Results

Trends in area, production and productivity

All-India

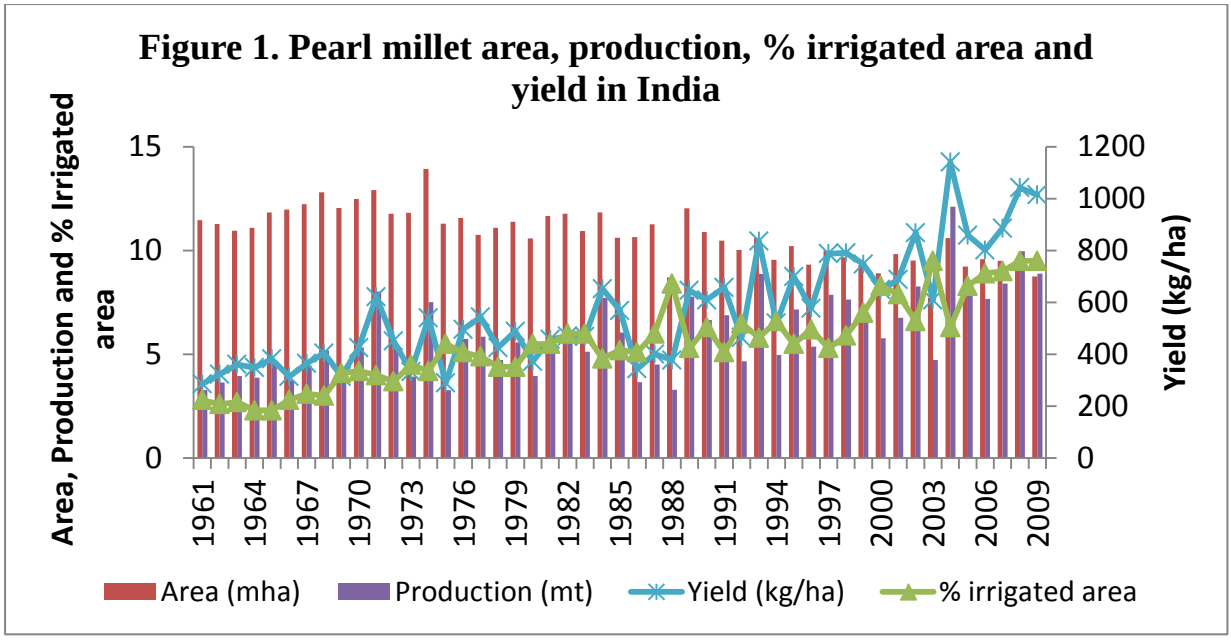
At the all-India level between 1961 and 2009 despite a decline in area under pearl millet, the faster increase in yield from about 400 kg /ha to more than 1000 kg/ ha helped to increase production from 3.28million ton (mt) in 1961to 8.89 mt in 2009 (Figure 1).The significant yield increase was achieved despite the fact that bulk of the crop is grown under rainfed conditions. The irrigated area under the crop increased slowly from around 3% in the sixties to around 10% in 2009. Much of yield increase

can be attributed to improved cultivars (varieties and hybrids) with higher yields compared to traditional land races. In north western India except area in western Rajasthan bulk of the area is under improved cultivars.

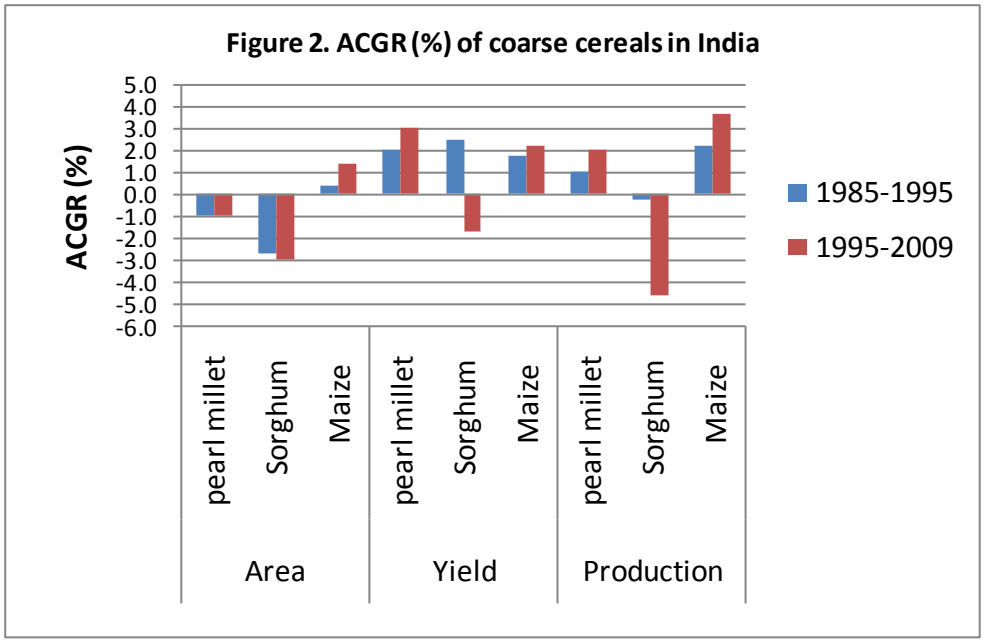
Among the coarse cereals growth in area under sorghum and pearl millet decreased, while area under maize increased between 1985 and 2009 (Figure 2). However, the decline in area is slower in pearl millet than sorghum. The growth of pearl millet yield is higher than both sorghum and maize during 1995-2009. Thus, the average yield of pearl millet in early 1960s was less than sorghum, but by 2009 it was slightly higher (981 kg/ha for pearl millet compared to 943 kg/ha for sorghum) in 2009 (Table 1). Pearl millet yields were however, still about half of that of maize yield (2251 kg/ha) and 1/3rdof that of wheat (2806 kg/ha) due to their higher initial yield levels.

Besides yields, prices also determine the competitiveness of crops. The real prices for pearl millet decreased by 17.4% from 1969 to 2009 while the decrease is less for wheat and sorghum. For some competing crops like pulses real prices actually increased during the same period (Table 1). This reduced competitive position of pearl millet in the cropping systems.

Table 2 presents the mean and instability index (II) for area, yield, production and % area under irrigation with respect to pearl millet from 1961-70 to 2000-2009 and few selected crops. The area under both sorghum and pearl millet declined, while maize and wheat increased (Pray and Nagarajan2009). However, it is to be noted that the instability of area, yield, and production of pearl millet increased significantly, whereas for other crops like maize, sorghum and wheat it decreased. The instability is higher in pearl millet mainly because it is grown under rainfed conditions in harsh environments. The instability is higher than that for sorghum since sorghum is grown under somewhat better rainfall regimes. For crops like maize and wheat as its area under irrigation increased instability in production declined. Hence there is a need for development of biotic and abiotic stress tolerant varieties and expansion of area under more favorable summer season under irrigation to stabilize yields.



Source: Directorate of Economics and Statistics (2011)



Source: Directorate of Economics and Statistics (2011)

Table 1. Trends in real prices (Rs/quintal) of food grains in India

Crop	% change in real prices Between 1969-2009	% change in production between 1969 and 2009	Yield TE 2009 (kg/ha)
Pearl millet	-17.4	91	981
Sorghum	-6.3	-24.5	943
Maize	-18.9	214	2251

Wheat	-10.2	405	2806
chickpea	42.0	37.6	834
Pigeon pea	32.9	63.4	715

Source: FAOSTAT (2011); prices were deflated by CPI for agricultural labourer with 1986/87 base year

Table 2. Changes in mean and instability Index (II) of major cereals in India

		Area (mha)		Yield (kg/ha)		Production (mt)		% irrigated area	
Crop	Year	Mean	II	Mean	II	Mean	II	Mean	II
Pearl millet	1961-70	12.5	0.04	426	0.18	5.3	0.20	4.2	0.14
	2000-09	9.3	0.15	981	0.29	9.1	0.43	9.3	0.23
Sorghum	1961-70	18.6	0.02	522	0.14	9.7	0.15	4.1	0.07
	2000-09	7.9	0.03	942	0.10	7.4	0.08	8.5	0.09
Maize	1961-70	5.9	0.03	968	0.07	5.7	0.09	18.2	0.25
	2000-09	8.1	0.03	2220	0.12	17.9	0.14	22.8	0.06
Wheat	1961-70	16.6	0.06	1208	0.13	20.1	0.17	51.1	0.08
	2000-09	27.9	0.04	2806	0.04	78.4	0.07	90.7	0.01

Note: Instability index(II) = Standard deviation of natural logarithm (Yt+1/Yt) where, Yt is the area / production / yield in the current year and, Y t+1 is for the next year. This index is unit free and very robust, and it measures deviations from the underlying trend (log linear in this case). When there are no deviations from trend, the ratio of Yt+1/ Yt is constant and thus standard deviation is zero. As the series fluctuates more, the ratio of Yt+1 and Yt also fluctuates more, and standard deviation increases.
Source: Directorate of Economics and Statistics (2011)

North Western India

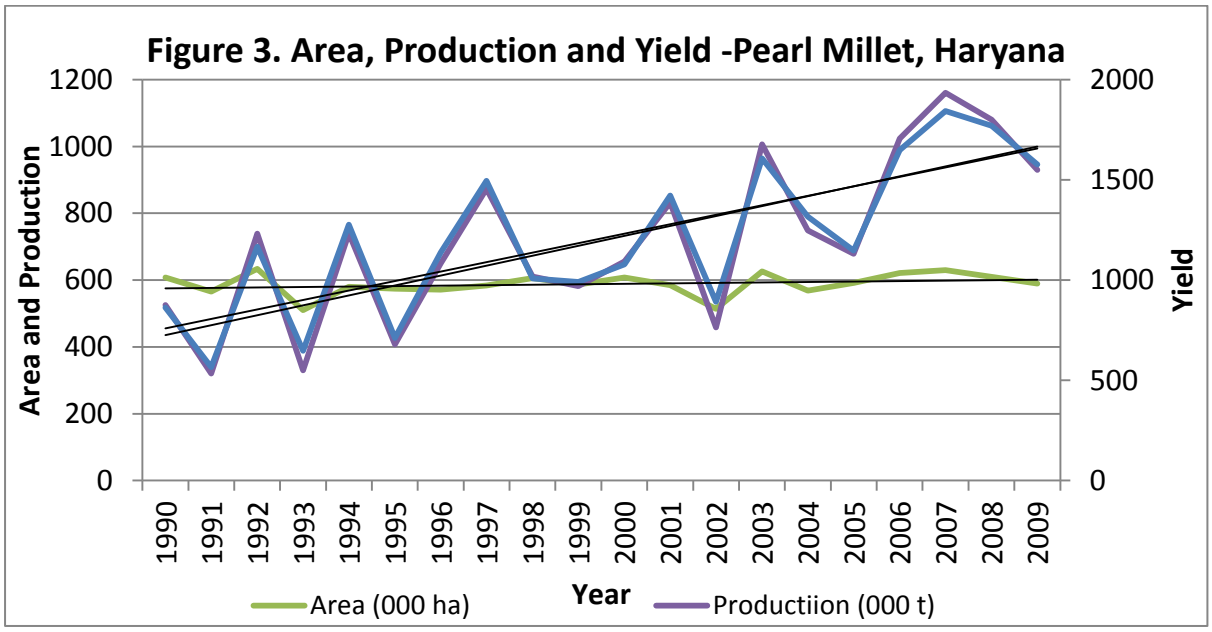
The north Western India accounts for 72% of all-India area under pearl millet and 66% of its production (Table 3).The yield levels are modest at 860 kg / ha that is slightly lower than the all – India average yield levels. Within north Western India, Rajasthan accounts for bulk of the area and production followed by Gujarat and Haryana. Yield levels are the lowest in Rajasthan (650 kg /ha) while it is 1300 and 1700 in Gujarat and Haryana respectively. High yield rates in Haryana are because more than 40% area under pearl millet is irrigated. In Gujarat bulk of the summer pearl millet area is irrigated that contributes to high over all yields. Also, in both the states improved cultivars have replaced local land races. In Rajasthan, in contrast bulk of pearl millet is grown in rainfed conditions and land races still account for close to 50% of the total area in western Rajasthan. Between 1990 and 2009 area under pearl millet is declining in Gujarat and is stagnant in Haryana and Rajasthan. In contrast, production is increasing in both Haryana and Rajasthan by more than 4% / annum. The major driver of production growth is yield increase in both the states. Also in Gujarat despite declining area production is holding on due to yield growth. There is considerable fluctuation

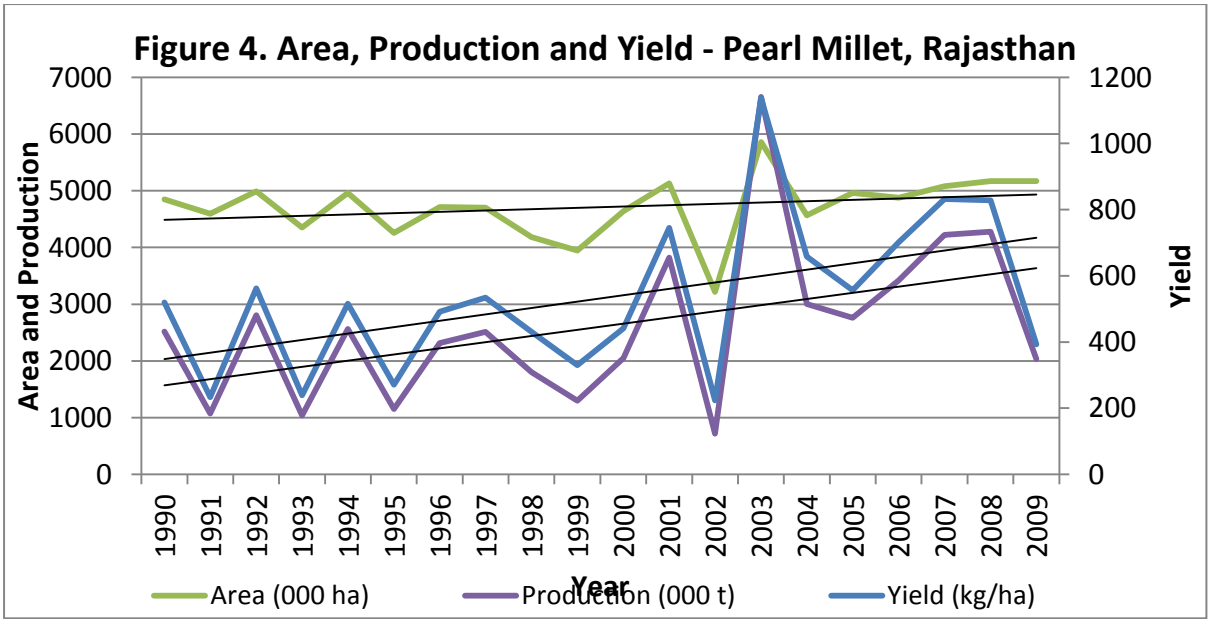
in pearl millet yields .western India and there is also a high correspondence between year to year fluctuations in yield and production levels (Figures 3, 4, 5).

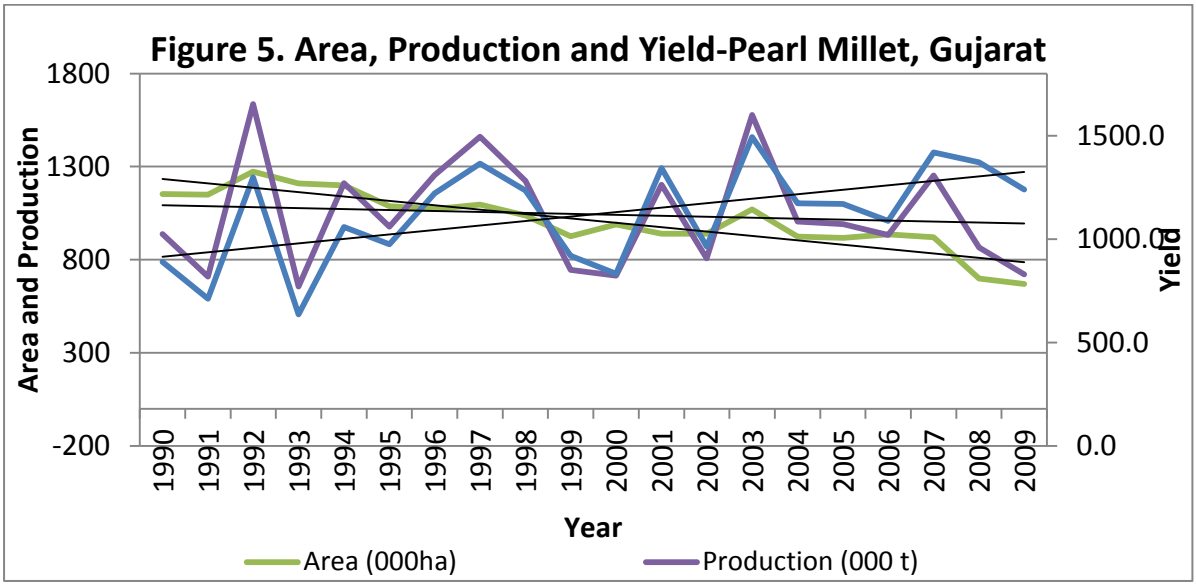
Table 3: Pearl millet area, production and yield, 2007-09 and their compound annual growth rates, 1990-2009

Region/ State	Area		Production		Yield	
	(000 ha)	Growth rate (%)	(000 tons)	Growth rate (%)	(kg/ha)	Growth rate (%)
Western India	6,513 (72)	0.003	5,600 (66)	3.12	860	3.1
Gujarat	764 (8)	-2.4	1,032 (12)	-0.3	1352	2.15
Haryana	610 (7)	0.25	1,057 (13)	4.49	1733	4.24
Rajasthan	5,139 (57)	0.45	3,511 (42)	4.17	683	3.7
All India	9,080	-0.62	8,455	1.82	931	2.46

Note: Figures in parenthesis indicate share to all-India







Area and production under summer pearl millet

Summer pearl millet is an emerging niche area for pearl millet production in north Western India grown under irrigated conditions during April –June when other crops are not commonly grown. Within the north Western states of India the area under summer pearl millet has expanded rapidly in Gujarat and also accounts for bulk of the area and production in the region. In Gujarat between 2004-05 and 2008-09 the share of summer pearl millet area in total pearl millet area increased from 16% to 25% while share of *kharif* pearl millet declined (Table 4). However, the production share of summer pearl millet is 44% in total

pearl millet production since its yields are more than twice that of *kharif* pearl millet (Table 5).

Table 4: Pearl millet area and production in Gujarat during summer, and *kharif* seasons

Year	Summer	Share (%)	*Kharif*	Share (%)
	Area ('000 ha)			
2004-05	145.0	16	770.1	84
2005-06	164.4	17	781.6	83
2006-07	183.4	20	742.3	80
2007-08	193.4	21	728.2	79
2008-09	174.6	25	528.7	75
	Production ('000 t)			
2004-05	303.1	28	785.9	72
2005-06	374.5	31	831.3	69
2006-07	428.5	45	528.4	55
2007-08	454.9	35	851.7	65
2008-09	426.1	44	535.2	56

Table 5: Pearl millet yield (kg/ha) in Gujarat during summer and *kharif* seasons

	Summer	*Kharif*	Total
2004-05	2,090	1,021	1,190
2005-06	2,278	1,064	1,275
2006-07	2,337	712	1,034
2007-08	2,352	1,170	1,418
2008-09	2,440	1,012	1,367

Within Gujarat 8 districts account for more than 75% of the area and production of pearl millet with highest area and production in Banaskanta district. These same districts account for almost 90% of the area and production under summer pearl millet. .For summer pearl millet also Banaskanta is the leading district with more than 40% of the area and production followed by Anand and Kheda (Table 6).Yield of *summer* pearl millet is 2 times higher than that of the *Kharif* pearl millet. As summer pearl millet is cultivated as irrigated crop, yield fluctuations are also less. The district level data indicates that there is a negative relationship between % area under pearl millet cultivation and the rainfall of the district. But, there is a positive relation between % area under *summer* pearl millet and % area under irrigation. Considering farmer's willingness to invest more money for cultivation of *summer* pearl millet because of higher profits, private sector is active in marketing hybrid seeds for *summer* cultivation; hence improved varieties/hybrids are popular in *summer*. A few fodder varieties are also developed to meet the growing demand for fodder. The forage types are much taller (7-8 feet), having good succulency and fodder value and mostly grown in sub-urban areas.

Table 6: Shares of pearl millet area and production in districts in Gujarat (%)

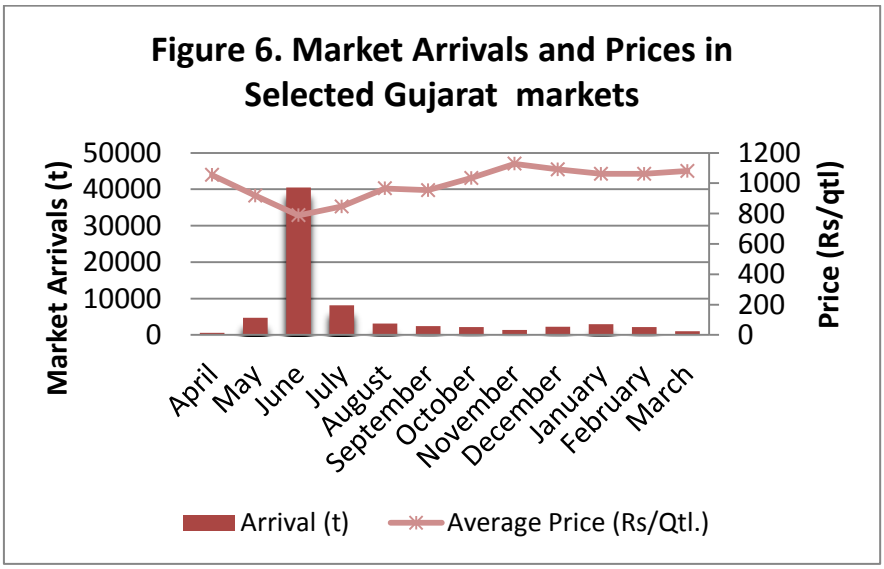
District	**Share in total pearl millet area**	**Share in total pearl millet Production**	**Share in summer pearl millet area**	**Share in summer pearl millet production**
Banaskantha	29.1	21.4	42.8	40.9
Patan	8.97	5.79	2.69	3.0
Bhavnagar	6.8	11.3	2.0	2.01
Mehsana	8.4	9.9	8.13	8.72
Kheda	9.1	9.8	11.16	11.31
Anand	6.9	9.7	11.26	12.03
Gandhi Nagar	3.46	4.87	5.32	5.86
Sabarkantha	1.92	2.66	4.92	5.04
Total	**74.6**	**75.4**	**88.2**	**88.8**

Relative profitability of *Kharif* and summer pearl millet compared to competing crops

As discussed the area under pearl millet is marginally declining or stagnant and there is a probability of further decline in area under *kharif* pearl millet due to expansion of area under pulses and oilseeds (like green gram, black gram, sesamum, guar etc.,) which fetch higher profit as the prices and demand of these crops increased more relative to that of pearl millet in the last decade. Further expansion of irrigated area also leads to replacement of pearl millet with other crops like cotton which is highly remunerative under irrigated conditions. Hence, the scope of expanding the area under *kharif* pearl millet exists only in low rainfall districts with little scope for expanding irrigation facilities. However, still large pearl millet area is under *kharif* season in western India, it is important to increase pearl millet production through all the best possible interventions in this season. For example, the existing low yields can be tackled by adoption of improved cultivars and improved package of practices that will enhance yield even in marginal environments.

Expanding area pearl millet area under *summer* season under irrigated condition is another option. Presently bulk of the summer pearl millet area is in Gujarat and efforts should be made to further expand the area here. Our market survey in Agricultural Marketing Produce Committees (APMCs) in Radhanpur, Tharad, Palanpur, Deesa, Patan and Ahmadabad shows that the *summer* pearl millet is cultivated mostly as a commercial crop in Gujarat with almost 100% of production marketed just after harvest with peak market arrivals in the month of June(Figure 6). However, major problem in expanding the summer pearl millet area and production is finding niches with irrigation facilities, low storability of summer harvest due to on-set of monsoon in the month of July-August, just after harvest that might spoil the grain quality under ordinary storage condition. Bulk of the summer pearl millet is shipped outside the growing area to neighboring districts / states for food use. Second quality grain

goes for cattle feed. Greyish white grain with elongated shape has a good export market (mainly gulf countries) for use in poultry feed and other such uses. The stalk of summer pearl millet is also valued for its thin stem.



Output and Input Markets

In western India, input and output markets are reasonably developed. All states have regulated markets for grain while only some states are having regulated markets for fodder. However the fodder trade is mostly done in informal markets with few commission agents facilitating the trade between sellers and buyers. Input (seed, fertilizer, pesticides, credit etc.) marketing is done by both private and public agencies. In Gujarat, the *Taluka* (which is an intermediate administrative unit comprising 50 to 60 villages) level cooperative purchase and sale units under the umbrella organization of Gujarat State Cooperative Marketing Federation (GSCMF) sells fertilizer, seed and pesticide etc., and procures agricultural commodities at minimum support price (MSP). Although a number of seed companies are involved in marketing seed requirements of *kharif* pearl millet they are more interested in seed marketing of commercial crops like cotton and high-volume business crops. The private seed companies are more actively involved in meeting hybrid-seed requirements of *summer* pearl millet as farmers are willing to invest more to purchase the high-cost seed and other inputs (including irrigation) due to assured higher yields. However, some farmers complain about the poor quality of the seed and authenticity of the numerous small seed companies, even though they are satisfied with seed supplied from large private companies. It is interesting to note that in Gujarat in 2010 about 96% of pearl millet area is under High Yielding Varieties (HYVs), mainly the expansion occurring in the last decades, as a result there is spectacular growth in yield of pearl millet from 817 kg / ha in 1990 to 1215 kg/ha in 2010 (Table 7).These are average yields for both kharif and summer pearl millet. At local level, *Taluka* level cooperatives distribute the seed procured from public/private agencies to farmers with a commission of 5% for public sector seed companies and 10% commission for the

private seed companies. The retail prices of private company hybrid seeds are about 3 times higher (Rs 153/kg) than that for the public sector companies (Rs 53/kg). The low (5-6 kg/ha) seed rate also helped farmers to adopt higher-priced seed which is affordable even for small farmers given higher yields.

Table 7. Area under HYVs for different cereals in Gujarat

Indicator	Year	TE 1990	TE 2010	% change
Area under HYVs (%)	Rice	73	87	14
	Wheat	80	87	8
	Maize	41	62	21
	Pearl millet	**73**	**96**	**23**
Yield (kg/ha)	Rice	1267	1631	29
	Wheat	1971	2379	21
	Maize	1076	1440	34
	Pearl millet	**817**	**1216**	**49**

Source: Directorate of Economics and Statistics (2011)

The GSCMF also undertakes government procurement operations at Minimum Support Price (MSP) on behalf of government agencies for pearl millet. However, in most of the years, farm harvest price is above the MSP, hence there was very little procurement operations in pearl millet grain. In most of the years, even though recommended MSP by state government is higher than cost of production, central government fixed MSP lower than cost of production based on Commission for Agricultural Costs and Prices (CACP) recommendation (Table 8).

Table 8. Cost of production and Minimum Support Price of pearl millet.

Year	Cost of Production (Rs/q)	MSP recommended by Haryana government (Rs/q)	MSP recommended by CACP (Rs/q)	MSP fixed by Govt. of India (Rs/q)
TE 1999	455	470	350	353
TE 2005	605	607	502	505
TE 2011	896	1033	853	853
2010-11	938	1050	880	880

Source: Cost of Cultivation Scheme(2011), Haryana Agricultural University

Cost of production and profitability of pearl millet in Gujarat

Cost of cultivation data was obtained from DES, Government of India but they do not separate the data for kharif and summer pearl millet. Hence, the cost of cultivation data reported in Table 9 is average values for the two seasons. More than 50% of the total cost of production is accounted by labor i.e., human, bullock and machine labor. This is followed by other costs like interest charges and rental value of own land (24%), fertilizer and manure costs (11%), irrigation charges 6%. Over the years fertilizer use per ha has increased significantly while bullock labor has declined giving way to machine labor. Seed rate in pearl millet is about 4-5 kg/ha, because of the lower seed rate, it becomes easy for farmers to purchase high-priced private company seed and thus adoption rates are higher. The profitability of pearl millet has been fluctuating over the years, however more recently (2007-08 and 2008-09) there is a general rise in profitability due to higher yields and rising prices of grain and fodder. One interesting point of observation is that, the share of value of by-product in total value (grain and fodder) ranges between 22.9% and 29.3%, which suggests that, the relative price of fodder increased more compared to that of grain. It also suggests for higher share of research and development efforts are required towards increasing quality and yield of fodder from the pearl millet cultivation.

Table 9. Changes in cost of cultivation of pearl millet in Gujarat

Items	**TE 1995**	**TE 2001**	**TE 2004**	**2007-08**	**2008-09**
Seed (Kg/ha)	5	6	6	6.87	6.74
Fertilizer (Kg/ha)	44	80	70	94.49	104.44
Manure (q/ha)	17	18	29	17.54	23.07
Human Labour (Man hrs/ha)	541	606	627	655.10	655.87
Animal Labour (Pair hrs/ha)	44	37	37	21.49	11.59
Yield (q/ha)	15	15	16	19.47	25.07
Break-up of Cost of Cultivation (Rs./ha)					
Human labour (Rs/ha)	1813 (31.8)	3602 (35.1)	4162 (36.4)	5224 (33.5)	6252.87 (30.01)
Bullock Labour (Rs/ha)	610 (10.7)	591 (35.1)	949 (8.3)	647 (4.1)	537.81 (2.58)
Machine Labour (Rs/ha)	-	1157 (11.3)	1482 (13.0)	2432(15.6)	3214.2 (15.43)
Seed (Rs/ha)	142 (2.5)	311 (3.0)	374 (3.3)	715(4.6)	833.25 (4.00)
Fertilizer & manure (Rs/ha)	371 (6.5)	1188 (11.6)	1377(12.0)	1742(11.2)	2000.56 (9.6)
Insecticides (Rs/ha)		0 (0.0)	2 (0.1)	11(0.1)	49.13 (0.24)
Irrigation Charges (Rs/ha)		752 (7.3)	575 (5.0)	949(6.1)	1624.3 (7.80)
Interest charges, depreciation rental value of own land (Rs/ha)	2772 (48.6)	2647 (25.8)	2514 (22.0)	3873(24.8)	6233.26 (29.92)
Total Cost C2 (Rs/ha)	5708 (100)	10248 (100)	11435 (100)	15593(100)	20836.18 (100)
Cost of Production (Rs/q)	380.5	514	496	611	615.0
Value of Main Production (Rs/ha)	5591 (77.1)	9033 (73.3)	8270 (70.7)	15164(77.4)	21053.47 (74.5)
Value of By-Production (Rs/ha)	1661 (22.9)	3287 (26.7)	3429 (29.3)	4418(22.6)	7178.31 (25.5)

Net profit over C 2 (Rs/ha)	1544	2072	264	5224	7395.6
Cost-benefit ratio	1.27	1.20	1.02	1.25	1.35

Note : Cost (C2)= all actual expenses in cash & kind incurred in production by farmer, plus interest on value of owned capital assets (excluding land), plus rental value of owned land & rent paid for leased-in-land, plus imputed value of family labour
Source: Directorate of Economics and Statistics (2011) Cost of cultivation scheme, Govt of India

Cost structure and profitability of *kharif* and *summer* pearl millet

Since separate data for kharif and summer pearl millet are not available from published sources the cost structure of kharif and summer pearl millet was collected under the HOPE project under recommended resource management regime for year 2009/10 and 2010/11 and shown in Table 10. The standard cost principle is used to calculate cost A and cost C2. The significant difference in cost structure of *Kharif* and summer peal millet is cost of irrigation which is about 27% of cost C2 in *summer*, while it is only 1.6% in *Kharif* season. Due to multiple irrigations, and also higher seed cost (Hybrid seed purchased from private companies) cost A is higher (Rs.23326/ha) for *summer* crop compared to *Kharif* crop (Rs.14517 /ha). Interestingly under recommended resource use the grain yield difference between kharif and summer pearl millet is about 62%. The net returns of over cost A is Rs.11279/ha in summer and Rs.7935/ha in kharif. It is interesting to see that under both kharif and summer human labour constitutes about 23% of cost-2 in summer and 28% of cost-C in kharif. In terms of cost A share of human labour is 31% summer and 40% in kharif respectively. The figures indicate that the summer crop is more profitable under non-constrain resource environment.

Table 10. Profitability of *Kharif* and summer pearl millet under recommended resource management (average of 2009/10 and 2010/11)

Items	summer		kharif	
	Physical unit	Value Rs. (% to total cost C2)	Physical unit	Value Rs. (% to total cost C2)
Human labour (man days)	73	7251(23.3)	66	5888 (28.0)
Bullock labour (pair days)	3	972(3.1)	4	981(4.7)
Seeds (kgs.)	7	1225(3.9)	6	652(3.1)
Manures (carts)	1542	1279(4.1)	8	2029(9.6)
Chemical fertilizers (kgs)	124	1681(5.4)	60	824(3.9)
Irrigation		8389(27.0)		335(1.6)
Insecticides/pesticides		74(0.2)		2(0.0)
Miscellaneous costs		2458(7.9)		3808(18.1)
Cost A		**23326(75.0)**		**14517(68.9)**
Depreciation cost		313(1.0)		247(1.2)
Interest on working capital		815(2.6)		468(2.2)
Rental value of owned land		3448(11.1)		3587(17.0)
Interest on owned fixed capital		358(1.2)		325(1.5)

Management cost		2826(9.1)		1914(9.1)
Cost C2		**31085(100)**		**21057(100)**
Yield:Main product (qt/ ha)	26.2		16.2	
Yield: By-product (qn/ha)	41.3		30.4	
Farm harvest price of main product (Rs/qn)		973		1044
Farm harvest price of by-product (Rs/qn)		220		184
Gross income: main product + by-product (Rs/ha)		**34604**		**22452**
Cost -Benefit Ratio (Cost A)		1.48		1.55
Cost -Benefit Ratio (Cost C)		1.11		1.07
Net Returns over cost A (Rs/ha)		11279		7935
Net Returns over cost C (Rs/ha)		3519		1394

Note: Cost A= all cash and kind expenses plus family labour; Cost C2= Cost A+ depreciation cost+ interest on working and fixed cost+ Rental Value of land+ Management cost; Source: Data collected from HOPE project, Gujarat State

An attempt is made to look at the profitability of pearl millet and its competing crops in the three states in north western India for the year 2007-08 and 2008-09 (Table 11). In all the states there is considerable fluctuation in profits across the two years and hence firm conclusions cannot be drawn. In Rajasthan, pearl millet is competitivewith sorghum, and maize (black gram and sesamum in 2008-09), In Haryana, pearl millet is not competitive with cotton but is grown for its fodder value and its grain for industrial uses. Also the cost of cultivation of pearl millet is about one half of cotton making it affordable for small scale farmers. In Gujarat pearl millet is competitive with groundnut and sesame in 2008-09. Interaction with farmers revealed that summer season pearl millet competes quite well with sesamum.

Table. 11. **Profitability of pearl millet and competing crops in north western India 2007/08 and 2000-09**

	2007-08			**2008-09**		
	Rajasthan					
Crops	Gross Return (Rs/ha)	Cost C_2 (Rs/ha)	Benefit Cost Ratio	Gross Return (Rs/ha)	Cost C_2 (Rs/ha)	Benefit Cost Ratio
Cotton	38,920	24,481	*1.58*	39,592	25,375	1.56
sorghum	66,15	7,297	0.90	10,117	9,293	1.08
P.millet a	97,87	8,527.	1.14	10,443	10,331	1.01
Green. gram	96,61	7,984	1.20	12,711	9,165	1.38
Black Gram	12,956	10,676	1.21	9,074	10,723	0.84
Soyabean	20,154	14,096	1.42	18,694	15,199	1.22

Sesamum	14,139	8,442	1.67	7,942	9,384	0.84
Maize	17,534	17,729	0.98	23,399	19,810	1.18
Haryana						
Cotton	42,125.	34,877	1.20	61,883	44,018	1.40
P.millet	14,002	15,803	0.88	19,642	18,716	1.04
Gujarat						
Cotton	43,445	29,107	1.49	56,206	42,070	1.33
P.millet	19,581	15,593	1.25	28,231	20,836	1.35
Maize	27,084	20,039	1.35	25,132	17,655	1.42
Pigeonpea	31,227	15,315	2.03	30,489	19,551	1.55
Groundnut	36,941	23,564	1.56	36,497	30,114	1.21
Sesamum	15,621	11,327	1.37	25,565	18,817	1.35

Source: Directorate of Economics and Statistics (2011) Commission for agricultural costs and prices, Department of agriculture & cooperation, Ministry of agriculture, GOI (2010-11), GOI (2011-12)

Yield gaps between improved and local practices

The results of frontline-demonstration and on-farm trials conducted in western India for *kharif* pearl millet revealed that, the responsiveness of *kharif* crop to high-cost inputs like high doses of fertilizers is low and farmers are also not willing to adopt higher doses of inputs keeping the high risk of crop failure due to frequent abnormal years. In recent years, yield of *kharif* pearl millet has increased, due to improved cultivars, but still large yield gaps exists between average yields on farmers fields and research station and on-farm demonstrations. Late varieties are having higher production potential than early varieties, but they required to be cultivated under irrigated conditions(Table 12).

Table 12. Potential of new varieties (*kharif*) in grain and fodder yield

Variety	grain yield (kg/ha)	Dry fodder yield (q/ha)	% increase over local (grain)	% increase over local (fodder)
Early	2169	51	21.2	23.6
Medium	2660	79	17.6	20.2
Late	3471	136	26.8	26.8

AICPMIP(2011)

There is significant difference in crop yields from different varieties in *kharif*, for example, grain and fodder yield of early varieties is less than medium and late varieties, but they are more suitable for resource poor condition (require less fertilizer dose NPK 40:20:0, while late varieties require 80:40:0)

and escape terminal floods and hence gives higher grain yield even during abnormal years. The response to supplementary irrigation is good, but farmers prefer to cultivate competing crops like guar, green gram, blackgram and sesamum when there is availability of irrigation facilities. However, there is scope for increasing the adoption rate of low-cost inputs like (i) application of 20 kg ZnSO4/ha as basal, (ii) similarly, application of atrazine @ 1.0 kg a.i. ha^{-1} as pre-emergence spray followed by atleast one hand weeding for combating weeds and thereby increasing grain and fodder yield of pearl millet to increase profitability, (iii) Dust mulching and spray of 0.1% thiouorea at tillering and flowering also helped to mitigate drought stress and reducing loss of crop and increase stability in profitability in *kharif* season, (iv) Seed treatment with neem oil 5ml/kg seed + spray of 5% N.S.K.E. (neem seed kernel extract) at 50% flowering was found effective treatment in controlling pest attack of pearl millet (AICRPM, 2011). The above agronomic practices are profitable both in *summer* and *kharif* crop. However, in case of summer pearl millet higher fertilizer doses (NPK 90:40:0), two weedings instead of one at 25 and 40 DAS and five to six irrigations recorded higher profitability (AICRPM, 2011). The economics of using these low cost inputs needs to be studied since without such data it would be difficultto introduce these on farmers field. Based on literature survey improvement in grain yield due to improved practices compared to farmers practices is shown in Table 13.

Table 13. Significance of Improved package of practices over conventional

Sr. No.	Farmers Practice	Improved practices	% improvement in grain yield over FP	Source
1	One hoeing at 30 DAS	Hand-weeding twice at 30 and 45 DAS or pendimethalin and oxadiazon each at 1.0 kg/ha supplemented with hand-weeding once at 45 DAS	15-17 %	Ram Baldev et al.,2005
2	One hoeing at 25-30 DAS	Oxyfluorfen + hand weeding at 25 DAS	24.96 %	Deshveer, C and Deshveer L. 2005.
3	Only Urea / SSP or both	10 kg Zn + RDF every year or 2.5 kg Zn + 5 t FYM ha + RDF alternate year	10-12 %	Chaube et al.,. 2007.
4	Only Urea / SSP or both	100 percent RD + vermi-compost and biofertilizers treatment Or 75 percent RD + vermin-compost + biofertilizer	10-12 %	Satyajeet et al,. 2007.
5	Only Urea / SSP or both	Application of 60+40 kg/ha of N + P_2O_5 along with 10 t FYM/ha and biofertilizers	15 %	Choudhary and Gautam. 2007
6	Only Urea / SSP or both	Aapplication of 5 tones of FYM + biofertilizer (Azospirilium + PSB @ 25 g kg^{-1} each) + 60:30:30 kg NPK ha^{-1}	12-15 %	Girase et al., 2010

Further, to ensure higher production and returns from pearl millet in abnormal years, different crops are recommended for intercropping with pearl millet in various states of the country. Suitable pearl millet based intercropping in north western India are Pearl millet + cluster bean/ mothbean/ sesame in Rajasthan, Pearl millet + Green gram/ sesame in Haryana, Pearl millet + Green gram/ sesame in Gujarat. Mostly pearl millet is rotated with sesame, guar, moong, moth and soybean in rainfed conditions. However, farmers widely practice pearl millet+guar as mixed crop and pearl millet +pigeonpea (2:1) as inter crop. In the field survey conducted in Rajasthan, farmers ranked food for home consumption as main reason for continuous cultivation of pearl millet followed by fodder for animal consumption, suitability to soil and climate and higher farm income in that order. Hence there is a need for development of dual purpose varieties with good grain and fodder quality for wider adoption of varieties in north western India.

A list of varieties suitable for *kharif* and *summer* pearl millet is given in Table 14. It shows there are large yield gaps between potential and farmers average yields both in *kharif* and *summer* seasons. However, the yield gaps are less in *summer*.

Table 14. Quality traits and grain and fodder yield potential of improved varieties

Variety	Varietal attributes	Season	Grain (q /ha)	Dry fodder (q/ha)
HHB-67 Improved	It is slightly taller (15–30 cm), later maturing (2–3 days) and has higher grain and stover yields (5–10%) than the original HHB 67, besides being more resistant to downy mildew. Recommended for the drier parts of Rajasthan, Gujarat and Haryana. Farmers expressed a clear preference	K	25-28	60
MH 1234 (GHB 715)	Ddeveloped by Junagadh Agricultural University, Jamnagar, identified for growing in rainfall scanty areas (less than 400 mm) of north-western parts of Rajasthan, parts of Haryana and Gujarat. it has shown high level of downy mildew resistance and high level of drought resistance. It has a synchronous tillering, bold grain size and attractive seed colour which would help farmers in getting better market price. It also has bristled	K	25	65

	earhead, which will be helpful in reducing bird damage.			
MH 1236 (GHB 719)	Identified for growing in rainfall scanty areas (less than 400 mm) of north-western parts of Rajasthan, parts of Haryana and Gujarat. It also shows similar characteristics like MH 1234 hybrid	K	24	62
GHB-526	Duration of 75-80 days, medium tall, good tillering, narrow leaves with greenish white mid-rib, good exertion, yellow anthers, compact conical earheads, obovate grey brown grain.	K	48-50	72
GHB-577	Duration of 70-75 days, tall, medium thick stem with basal pigmentation, semi-compact cylindrical earheads with slightly incomplete exertion and globular grains.	K	32-35	70
GHB-538	Early maturing, drought tolerant, hybrid showing, 27 and 23.8 per cent grain yield superiority over MH-169 and ICMH-356, respectively. Resistant to downy mildew and tolerant to stem borer and shootfly.	K	27-30	42
GHB-744	Early maturing (75-80 days)	K	30-32	70
9444	Maturing in 80-85 days, Very High Grain & Fodder Yield, Highly Adaptable Tolerant to Heat & Moisture Stress, Tolerant to Downy Mildew, Tall Dual Purpose Hybrid	K	40-45	65
MSH 155 (86 M 52)	Identified for growing under irrigated condition in Pearl Millet growing areas. It has broad leaves, wavy leaf margins and smooth surface, tall in height, stay green fodder quality, good standabilty and has high yield potential, tolerance to DM, very good grain size & color like desi PM, 80 to 85 Days Maturity	S	46	65
GHB-316	Higher grain & fodder yield during summer. Acceptable ear shape and plant type. Good quality grain.	S	43-45	75
GHB-558	Recommended for summer season. Average yield higher by 16.9 and 22.3 per cent over MH-169 and GHB-183, respectively.	S	47-48	76
GHB-538	It is early maturity and has shown temperature insensitivity for	S	48-50	60

	seed set under summer and pre-rabi seasons. Superior in grain yield under summer season over MH-169 (17.7%) in North Gujarat and Saurashtra and under pre-rabi condition over GHB-526 (8.7 %) in Saurashtra. High level of resistance to downey mildew and pest of pearl millet. The hybrid GHB-538 is endorsed for cultivation for summer/pre-rabi pearl millet growing areas of North Gujarat and Saurashtra region.			
9444 G	Tall Dual Purpose Hybrid, Maturing in 80-85 days, Very High Grain & Fodder Yield, Highly Adaptable, Tolerant to Heat & Moisture Stress, Tolerant to Downy Mildew, Good Tolerance against Termite	S	45-46	89

Source: AICPMIP (2011)

Conclusion and Recommendation

The paper examines the existing status of *kharif* and *summer* pearl millet, in the background of declining food demand for its grain and growing alternative demand from poultry, cattle feed industry and alcohol industry. To meet the demand from alternate industries like feed and brewery industry, it is important to decrease cost of production to make it competitive with maize, sorghum and broken rice. With this background, the paper examines the ways to increase production both in *kharif* and *summer* crop with focus on cost of production and profitability of improved technology. The production structure (input-output structure) and competitive environment of both *kharif* and *summer* crops is different. *Kharif*pearl millet is cultivated under rainfed conditions with low-input-low-output management, while *summer* pearl millet is cultivated under high-input-high-output management.

Even though *kharif* pearl millet yields are low it still occupies large area in north western India. Most of the *kharif* harvest is used for domestic purposes like food, feed, and in alternative uses like alcohol and poultry feed industry. In view of the importance of *kahrif* pearl millet in fulfilling food –feed security and its use in alternative uses, ways to enhance its yields should be identified and adopted widely. As it is mostly grown under rainfed conditions farmers follow different risk management strategies to cope with frequent droughts during crop growth period. In Rajasthan, the popular variety HHB-67 improved (early maturing cultivar) performed well during abnormal years of rain, even though its performance is less than high yielding private hybrid seeds. Keeping the high probability of abnormal years farmers widely grow HHB-67. There is severe shortage of certified seeds in *kharif* season and the adoption of publicly-released varieties especially for *kharif* season through large scale seed production and distribution by State Seed Corporations in Public-Private-Partnership mode needs to be promoted.

Summer pearl millet area is only 25% of total pearl millet area but contributes 44 % of production in Gujarat. For summer pearl millet the entire grain produced is marketed immediately after harvest. Its grain is consumed domestically for food particularly in the lean season in areas where summer pearl millet is not grown and the second and third grade grain is extensively used by poultry and alcohol industry. iIt is preferred grain for export to Gulf countries for poultry feed and other uses. Thus, summer crop is mainly cultivated as a commercial crop. In terms of cost composition, expenditure on irrigation and seed are higher in *summer* pearl millet than *Kharif,* but profitability is also higher due to doubling of yields of summer crop. There is thus a good scope for expanding area under *summer* pearl millet given its short duration (March–May) and since no other crop is suitable to grow given the high temperatures prevailing during this period. However, there is a need for sufficient irrigation facilities to cultivate the crop as also suitable cultivars that could further reduce the per unit cost of production.

For both kharif and summer pearl millet dual purpose varieties are a must since besides grain the fodder is an important source of animal feed contributing to feed security in the marginal and dry areas. .Besides dual purpose varieties, development and wider adoption of varieties suitable for non-food uses (feed, fodder and alcohol industry) need to be given priority to meet future demand growth.

References

1. AICPMIP. 2011. Annual Report 2011. All India Coordination Pearl Millet Improvement Project, Jodhpur
2. BALDEV RAM, G.R. CHAUDHARY, A.S. JAT AND M.L. JAT.2005 Effect of integrated weed management and intercropping systems on growth and yield of pearlmillet (Pennisetum glaucum) Indian Journal of Agronomy **50**(3): 210-213
3. Breese, W.A., Hash, C.T., Devos, K.M., Howarth, C.J., 2002. Pearl millet genomics: an overview with respect to breeding for resistance to downy mildew. In: Leslie, J.F. (Ed.), Sorghum and Millets Pathology. Iowa State University Press, Ames, Iowa, USA, pp. 243-246.
4. Chaube.A.K., Ruhela, R., Chakraborty, R., Gangwar, M.S., Srivastava, P.C. and Singh, S.K.(2007) Management of Zinc fertilizer under pearl millet – wheat cropping system in a Typic Ustipsamments. Journal of Indian Society of Soil Scienc:55(2):196-202.
5. CHOUDHARY RS AND R.C. GAUTAM. Effect of nutrient-management practices on growth and yield of pearl millet (Pennisetum glaucum) Indian Journal of Agronomy, **52**(1): 64-66
6. Cost of Cultivation Scheme 2011. Haryana Agricultural University, Hissar
7. Deshveer, C and Deshveer L. 2005. Indian Journal of Agronomy **37**(3 & 4): 212-215
8. Directorate of Economics and Statistics (2011) Ministry of Agriculture and Cooperation. http://dacnet.nic.in/eands/APY_96_To_06_lattest.htm

9. FAOSTAT, 2011. Food and agricultural organization statistics database (FAOSTAT). Available from http://faostat.fao.org/
10. Girase, P.P. and Wadile, S.C. and Sonawane, P.D. and et al, . (2010) Nutrient management for pearl millet (Pennisetum glaucum L.) in light soil of rainfed areas. Journal of Maharashtra Agricultural Universities, 35 (1). pp. 7-9.
11. Pray Carl E. and Nagarajan L. 2009. Pearl millet and sorghum improvement in India.Discussion paper No. 919. International Food Policy research Institute.
12. Satyajeet; Nanwal, R.K.; Yadav, V.K.; Kumar, P. 2007 Effect of integrated nutrient management on productivity and quality of pearl millet. Annals of Biology (India). (Jun 2007) v. 23(1) p.37-40
13. Yadav O P, Rai K N, Khairwal I S, Rajpurohit B S, and Mahala R S. 2011. Breeding pearl millet for arid zone of north-western India: Constraints, Opportunities and approaches. All India Coordinated Pearl Millet Improvement Project, Jodhpur, India. 28 pp.
14. Yadav OP and KN Rai (2011) Hybridization of Indian Landraces and African Elite Composites of Pearl Millet Results in Biomass and Stover Yield Improvement under Arid Zone Conditions, VOL. 51, September –October