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Adoption level, yield and constraints in Indian barley (*Hordeum vulgare*) cultivation: Insights from baseline data for identifying livelihood prospects

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ABSTRACT

Barley (*Hordeum vulgare* L.) is an important nutritious cereal in India with growing demand for malt preparation, brewing and food industries. Over years, declining acreage along with distorted production becomes a major concern in spite of increasing yield. A baseline study was conducted (2013-14 and 2014-15) to analyse the extent of adoption, yield variations and constraints in cultivation across four major states, viz. Haryana, Madhya Pradesh, Rajasthan and Uttar Pradesh so as to identify the livelihood options and explore possibilities for increasing the crop acreage. Socio-economic analysis indicated that farmers allotted less area to the crop owing to poor market facilities barring Rajasthan and a majority restricted their cultivation to feed the livestock. A significant number of farmers were growing old varieties and replaced the seed once in more than three years indicating the lack of awareness on improved varieties, non-availability of latest varieties seeds and technologies. Reasons for barley cultivation were analysed and it was found that higher income led to production in Haryana and Rajasthan, whereas feed for livestock invited crop acreage in the case of Madhya Pradesh and Uttar Pradesh. Around 71% perceived that barley is more suitable for cultivation under changing climate scenario owing to its high adaptability. Regression analysis indicated that enrolment in contract farming, source of seed, seed replacement frequency and farm size influenced the crop yield. The baseline findings suggest for strengthening the complete value chain in barley production with targeted capacity building programs for farmers and extension workers especially in Madhya Pradesh and Uttar Pradesh along with policy interventions to link producers with market.

Key words: Adoption, Barley, Baseline data, Contract farming, Malt production

Barley (*Hordeum vulgare* L.), an important cereal, is globally ranked next to maize, wheat and rice both in acreage and production (FAO 2017). Despite declining crop area in India, its productivity has undergone rapid strides since 1950 to sustain the level of production and domestic demand. The average productivity has increased by 241.20% between 1950-51 and 2016-17 against the acreage decline by 78.60% and currently hover around seven lakh ha with production estimated at 17.4 lakh tonnes (DES 2017). Traditionally, barley is a poor man's cereal in India and its cultivation requires low input with better adaptability to different stresses like drought, salinity and alkalinity, and marginal lands. It has a wide range of utility such as cattle feed, human food and industrial raw material for malting and brewing. Currently, its utilization as a food (mainly huskless type) is restricted to the tribal areas of hills and plains in India. Under semi-arid conditions, it is also used for dual purpose *viz.,* green fodder and grain/ straw production from the crop re-growth (Ceccarelli and Grando 2010).

Consistent increase of domestic demand for malting has led to the development of cultivars with superior malting quality (Nagarajan and Verma 2000). By 2050, India needs around 2.5 million tonnes (Vision 2050, 2015), but the current level of production will not be sufficient to meet the projected target. Farm level data on barley report stagnation in farmers yield in the recent years as measured under the best possible growing conditions and even some indications that average yields were hovering around 2500 kg/ha and plateaued in many regions (ICAR-IIWBR 2017). *Inter alia,* yield gaps have been attributed to old varieties, production constraints, variations in management, site and inputs usage (Sendhil *et al.* 2014). Prevalence of yield gap and its skewed distribution is a matter of serious concern considering barley's growing demand for malting and

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brewing industries as well as its preference as a health safety food. In order to upscale technologies, prioritize research strategies for addressing the production constraints coupled with drawing polices for increasing the crop acreage as well as potential yield levels, a baseline study in major barley growing regions gains significance. An attempt has been made to analyse the adoption behaviour on barley genotypes, spatial variations in yield and their attributes, and constraints in production so as to ascertain the livelihood options through barley cultivation in four important barley growing states in India.

MATERIALS AND METHODS

The present study was accomplished through farm household survey with the aid of structured pre-tested interview schedule. Baseline data on socio-economic and crop production particulars were collected during 2013-14 and 2014-15 from a randomly selected 400 barely producing farmers across Haryana, Madhya Pradesh, Rajasthan and Uttar Pradesh. From each state, two districts with maximum area under barley were selected and the final sample size of respondents was achieved from a cluster of blocks and villages since the crop cultivation is restricted to only certain regions (Table 1). Apart from conventional tools like percentage, graphs and frequency analysis; regression analysis was done to identify the factors influencing the yield. For analyzing the reasons for barley cultivation, ranks were converted into scores to list the preferred parameters.

The following regression function was formulated to identify the factors influencing the yield. The functional form is specified as:

$$Y_{Bi} = b_0 + b_1X_{1i} + b_2X_{2i} + b_3X_{3i} + b_4X_{4i} + b_5X_{5i} + b_6X_{6i} + b_7X_{7i} + b_8X_{8i} + U_i \text{ for i= 1 to n farmer.}$$

where, Y_i is the yield of barley for the i^{th} farmer (kg/acre), X_{1i} is the experience of the i^{th} farmer in agriculture (years), X_{2i} is the dummy variable for education level of the i^{th} farmer, X_{3i} is the seed rate of the i^{th} farmer (kg/acre), X_{4i} is the dummy variable on contract farming by the i^{th} farmer, X_{5i} is the dummy variable on source of seed by the i^{th} farmer, X_{6i} is the dummy variable on replacement of seed by the i^{th} farmer, X_{7i} is the dummy variable on sowing time by the i^{th} farmer, X_{8i} is the farm size of the i^{th} farmer (acres), b_0 is the intercept, U_i is the stochastic disturbance term, b_1 to b_{10} are the partial regression coefficients to be estimated by the ordinary least squares method. To know the goodness of fit, the adjusted multiple coefficient of determination ($\overline{R}^2$) was calculated using the following formula:

$$\overline{R}^2 = \left[1 - (1 - R^2) \times \left(\frac{n-1}{n-k}\right)\right]$$

F test was used to test the overall significance of the regression equation and is given by,

$$F = \frac{R^2 / (k-1)}{\left(1 - R^2\right) / (n-k)}$$

where, R^2 is the multiple coefficient of determination, n is the number of sample observations and k is the number of parameters estimated from the sample including intercept.

Table 1 Sampling design adopted for baseline data collection

State	District	Block/ Village	Number of respondent
Haryana	Bhiwani	Cluster	50
	Sirsa	Cluster	50
Madhya Pradesh	Bhind	Cluster	50
	Chatarpur	Cluster	50
Rajasthan	Chomu	Cluster	50
	Jaipur	Cluster	50
Uttar Pradesh	Bulandshahar	Cluster	50
	Etah	Cluster	50
			400

RESULTS AND DISCUSSION

Landholding and barley production particulars: Farm size is one of the major variables that decide the livelihood of the farmers. Information on operational holdings and allotment of area to barley provides a clue on the crop importance given by the farmers. Analysis of holding size indicated a huge difference among states (Table 2). Uttar Pradesh had the lowest operational area (5.80 acres) which is almost one-third of Haryana. Around 18 acres has been under cultivation (area owned + leased-in) by the respondents in Haryana. Out of which, only 3.14 acres (17.70%) devoted for barley production which is just one-sixth of total operational holdings. The highest share was found in Rajasthan (44.88%) indicating the importance of crop in comparison to other selected states. Further, less crop acreage in other regions implied that the competing crops grown during the *rabi* season like wheat and mustard had ample market support with well-structured procurement by the Government inviting large area under them. Despite support price exist for barley (CACP, 2017), the procurement arrangements from central/ state agencies are negligible with exception like HAFED in Gurugram (Haryana) that procures for its own malting plant, though farmers may retain some part for use as feed for livestock.

Hitherto, 95 barley varieties have been released for

Table 2 Particulars of land holdings in acres by sample farmers

State	Average land holding			Area under barley
	Area owned	Area leased-in	Operational area	
Haryana	13.06	9.83	17.74	3.14 (17.70)
Madhya Pradesh	7.55	0.30	7.75	1.78 (22.97)
Rajasthan	5.40	0.46	5.86	2.63 (44.88)
Uttar Pradesh	4.04	1.76	5.80	1.16 (20.00)

Figures within parenthesis indicate the per cent to operational area

different production conditions and for the study region, around 60 varieties were released by the state and central varietal release committees for cultivation (Kumar *et al.* 2017). Despite a huge varietal spectrum, only a bunch of varieties were popular among farmers and being under cultivation or in seed chain. In Madhya Pradesh, local or *desi* varieties were grown by 81% of the respondents (Table 3), followed by JB1 (9%). BH 393 was more popular among Haryana farmers, whereas in Rajasthan and Uttar Pradesh, RD 2715 and K 508, respectively were cultivated by 46% and 24% of the respondents. The analysis indicated the regional preference of varieties based on their use and cultivation of old varieties despite availability of latest and improved varieties. For instance, farmers in Madhya Pradesh were not much particular about varieties because of the intention of feed to livestock and hence cultivated the locally available varieties. On the contrary, farmers in Rajasthan preferred RD 2715, a six-row dual purpose barley variety released in 2008 for irrigated cultivation under timely sown conditions (Kumar *et al.* 2017), due to its dual uses as forage and grain/ straw importance for their large livestock population in this water deficit state. The acute shortage of green fodder in lean period (December–February) is being addressed by such dual purpose varieties which are providing good source of green forage during this period. Shockingly, farmers in Uttar Pradesh were growing varieties which are more than forty years old.

Perusal of Table 4 indicates that the average area under barley varieties in the study region was highest in the case of DWRUB 52 (5.27 acres) in Haryana, followed by RD 2660 (3.70 acres) and RD 2715 (2.51 acres) in Rajasthan. The survey also indicated that the sample respondents started growing barley since 1996 in Haryana, 1995 in Madhya Pradesh, 1970 in Rajasthan and 1980 in Uttar Pradesh. However, the year of peak adoption in the study region was reported as 2010, 2010, 2009 and 2005 respectively in Haryana, Madhya Pradesh, Rajasthan and Uttar Pradesh.

In continuation of information pertaining to varieties, farmers were asked to report on the frequency of seed replacement. Surprisingly, a majority reported that they have replaced their seeds once in more than three years indicating the need for awareness programs. Only a few replaced every year and they are from Haryana (37%) and Rajasthan (28%) (Fig. 1). The scenario was worst in Madhya Pradesh since 75% of the respondents from the state reported that they replaced seed only once in more than three years. The concern here is that there are research institutes/KVKs near to these areas; even then the farmers have no or little access to latest information on barley crop cultivation. This is mainly because the extension personnel with those organizations have little interest in this crop being grown on marginal land and only in those conditions where wheat is not an easy option. Clearly, it is not only the farmers but also the extension personnel needs to be trained on the recent technological interventions and innovations in crops like barley.

Table 3 Cultivation of barley varieties by the sample farmers and year of release

State	Preferred barley varieties and year of release			
Haryana	BH 393	DWRUB 52	BH 902	Others
	77 (2001)	22 (2007)	1 (2010)	
Madhya Pradesh	Local/ Desi	JB1	Others	
	81	9 (2008)	10	
Rajasthan	RD 2715	RD 2660	RD 2052	Others
	46 (2008)	25 (2006)	18 (1991)	11
Uttar Pradesh	K 508	Jyoti	NB1 (NDB 209)	Others
	24 (1996)	18 (1969)	18 (1999)	40

Table 4 Particulars of area under barley varieties

State	Average area under barley varieties (in acres)		
Haryana	DWRUB 52	BH 393	BH 902
	(5.27)	(2.49)	(1.00)
Madhya Pradesh	Local/Desi	JB1	
	(1.75)	(1.50)	
Rajasthan	RD 2660	RD 2715	RD 2052
	(3.70)	(2.51)	(1.83)
Uttar Pradesh	K 508	Jyoti	Narendra1
	(1.80)	(1.05)	(1.04)

Quantum of production which decides the income level is a major criterion for livelihood assessment and interest to sustain the farm business. The survey indicated that regional differences exist in yield, production as well as quantity sold for barley (Table 5). On an average, the productivity was highest in Rajasthan (1975 kg/acre), followed by Haryana (1666 kg/acre) and Uttar Pradesh (1334 kg/acre). Farmers always perceive that barley gives low yield as they always compare with the competing crop, wheat and respond to the question on yield parameter. The divergence in productivity between high yielding and low yielding region was to the tune of 782 kg/acre. Despite highest productivity in Rajasthan, the average production per farm turned marginally less than Haryana (5231 kg) due to difference in holding size (Table 2). The reason for high production in Haryana was due to high acreage allotment (3.14 acres) in comparison to others. Marketed surplus shows the extent of harvested produce sold in the market after retaining for seed, food, feed etc. It ranged from as high as 99.60% (Haryana) to as low as 27.84% (Uttar Pradesh). The analysis indicated that a majority of the produce from Haryana and Rajasthan have been disposed in the market, while a considerable share has been retained by farmers in Madhya Pradesh and Uttar Pradesh. A majority of the respondents with marketed surplus sold their harvested barley in village market, local mandi and at farm gate with no procurement support from the government.

Seed is one of the crucial inputs for better farming and its availability and access influence largely the adoption of a variety. Farmers in the study region used mostly their

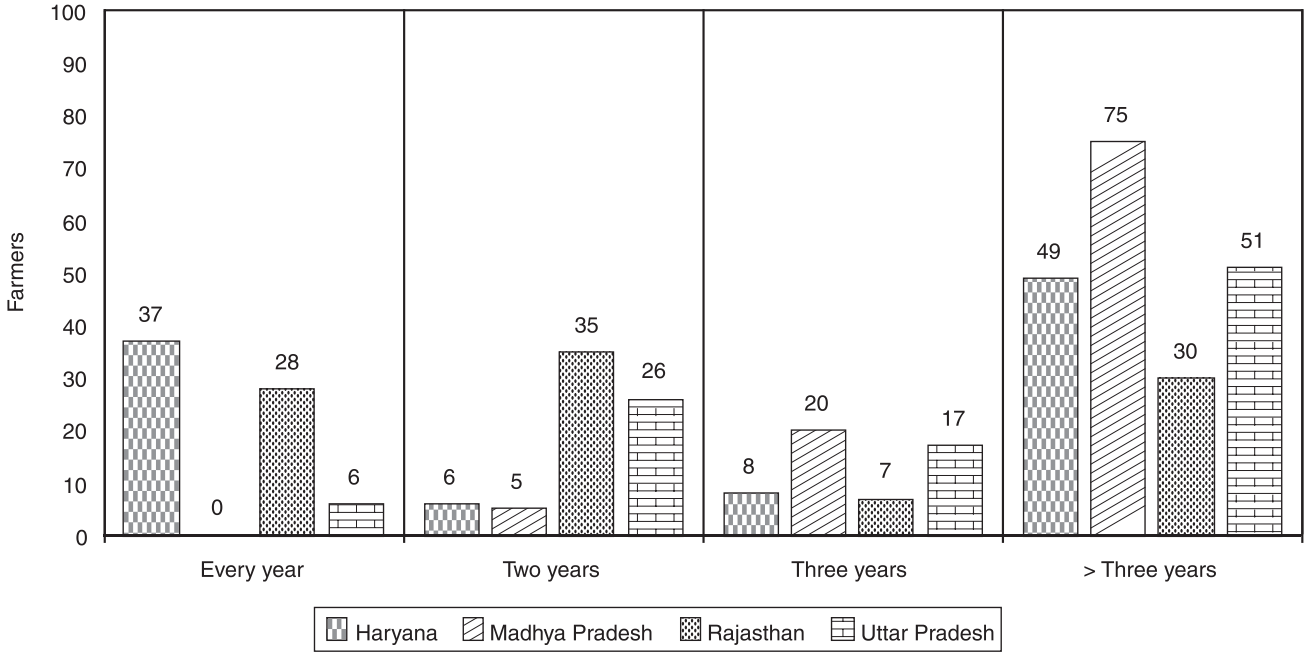

Fig 1 Replacement rate of barley seeds among sample farmers

Table 5 Production and marketed surplus of barley

State	Yield (kg/acre)	Average total production (kg)	Average quantity sold (kg)
Haryana	1666	5231	5210
Madhya Pradesh	1193	2093	1467
Rajasthan	1975	5188	4926
Uttar Pradesh	1334	1638	456

own seed, either higher/lower than the recommended dose (40 kg/acre), and if purchased, it was from seed dealers as they ensure timely availability. Apart from seed replacement rate, dose and source of purchase, time of sowing is more important for targeting better yield. A majority of the barley growers opted for timely/normal sowing and it was highest in Uttar Pradesh, followed by Madhya Pradesh, Haryana and Rajasthan (Table 6). Interestingly, the association between time of sowing and yield shows that farmers opting for timely sowing harvests more than farmers who are undergoing either late sowing or early sowing.

Preference and awareness survey: The survey on mode of selling indicated that local traders and commission agents dominated in purchasing the commodity from the farmers and the choice in selection of buyers is based on some criteria like price quote, immediate cash settlement, closer to farm etc (Table 7). A majority of the farmers prefer buyers (if sold) who gives higher price. The response was higher in Rajasthan (90%), followed by Madhya Pradesh (41%) and Haryana (35%). Even 69% of the respondents from Uttar Pradesh and 15% from Madhya Pradesh have not responded to this investigation which might be due to retaining of barley for self consumption either as food or feed to livestock.

Farmers face circumstances nearly each and every day in which the outcomes are risky and uncertain. They not only face production risk but also price risk. Contract farming is a proven technique and highly recommended to overcome the price risk. Survey suggested that around 97%

Table 6 Sowing time of respondents and crop yield

State	Seed rate (kg/acre)	Normal sown (Nov 1 to Nov 25)		Late or early sown (before Nov 1 and Nov 26 onwards)	
		Frequency	Yield (kg/acre)	Frequency	Yield (kg/acre)
Haryana	32.58	60	1715	40	1603
Madhya Pradesh	58.60	89	1194	11	1185
Rajasthan	50.85	58	1999	42	1669
Uttar Pradesh	38.88	99	1336	1	1067

Table 7 Farmers preferences towards buyers

Parameter	Haryana	Madhya Pradesh	Rajasthan	Uttar Pradesh
Gives higher price	35	41	90	16
Provides advance when needed	21	5		6
Immediate settlement	17	16	5	3
Accepts small quantities	13	3	4	2
Accepts large quantities	3	2	1	1
Close by	9	12		3
No other option to sell	2	6		
No response		15		69

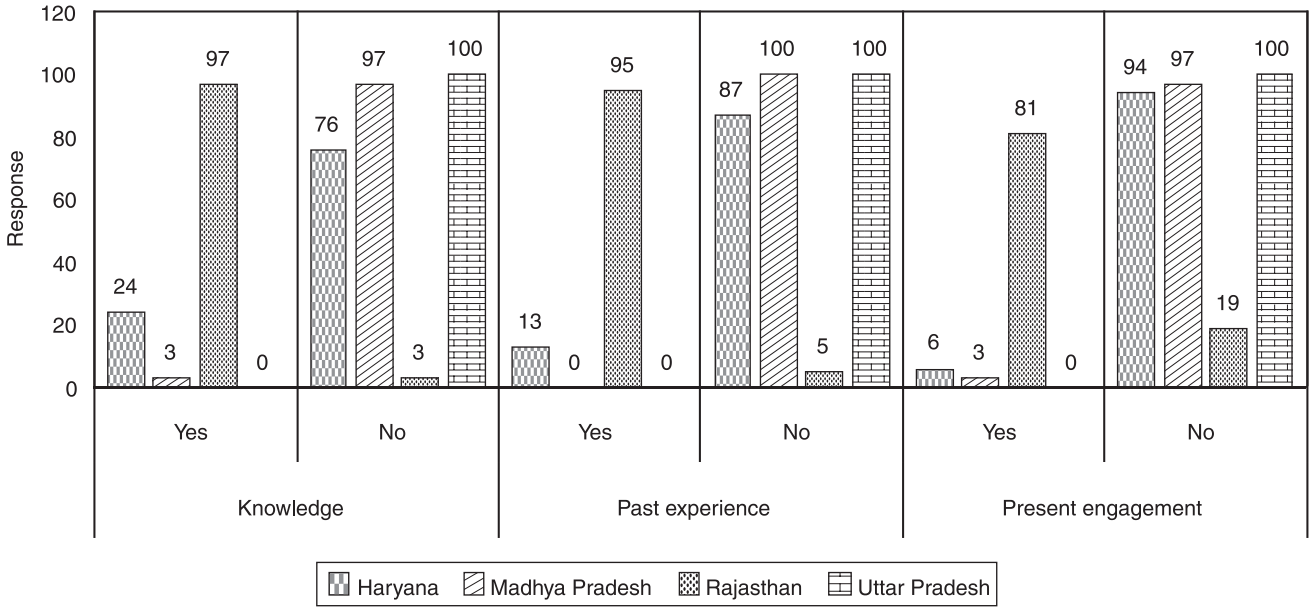

Fig 2 Knowledge, past experience and present engagement with contract farming

of the respondents in Rajasthan were having knowledge on contract farming, whereas only 3% and none were aware of contract farming respectively in Madhya Pradesh and Uttar Pradesh (Fig. 2). Interestingly, 95% of the respondents in Rajasthan had past experience and out of them 81 farmers are availing the contract facility presently. In Madhya Pradesh, only 3 respondents were aware of contract farming and they were engaged in price risk aversion technique. Clearly, the analysis indicated the importance of markets for better livelihood by trouncing the price instability during harvest. The concern here is lack of market interventions and price support instruments like contract farming prevailing in Haryana-Rajasthan borders wherein around 95% of the malt industries exist.

The reasons for cultivation of barley in the selected states despite popularity of other competing crops during the season like wheat in those regions were probed and reported in Table 8. The scoring analysis (1-10) revealed that higher income led to cultivation in Haryana and Rajasthan which might be due to the involvement of contract agencies, whereas, in the case of Madhya Pradesh and Uttar Pradesh, feed for livestock invited more acreage under barley. Apart from these, low production cost, lack of irrigation facilities and easy crop management have been ranked as major factors influencing barley cultivation. The analysis supports the fact that barley is a preferred crop for marginal lands as well as adapted crop to changing climatic scenario.

Preferences for different traits (Table 9) were asked from the respondents (n=400) and they reported that high yield (254 responses), requirement of less water for irrigation (178) and short duration (108) were the major parameters considered for barley production. For consumption, better taste (72), less cooking time (46) and high keeping quality (35) were preferred. Similarly, for fodder production, more number of leaves per plant (150), palatability (94) and storability (68) were preferred. In the case of marketing

Table 8 Ranking of reasons for barley cultivation

Parameter	Haryana	Madhya Pradesh	Rajasthan	Uttar Pradesh
Higher income	1.76	5.31	1.85	6.20
Low production cost	2.22	5.01	2.73	3.45
Easy management	2.38	3.59	3.29	4.35
Fits well into the cropping system	3.17	5.76	4.15	3.56
Resistant to pests/ drought tolerant	3.18	6.98	3.64	5.83
Lack of irrigation facilities	3.82	6.04	2.46	2.94
Best suited to my land and climate	3.83	4.93	3.91	4.15
Adaptive to saline/ alkaline soil	3.98	9.03	3.17	6.33
Food/ home consumption	4	2.71	3.00	2.14
Fodder/animal consumption	4	1.40	2.69	1.32

(grain), demand for the marketed produce, high price and low price fluctuation were the highly preferred parameters. For fodder marketing, high price was the preferred trait. The analysis gives a clue on the preferences which has to be translated into the crop for wider adoption.

Perception on climate change: The perception of the respondents on climate change with respect to barley production have been inquired and presented in Fig 3. Around 52% of the total respondents (n=400) reported that temperature is rising during the past three decades, and, on the contrary, 30.50% perceived that the temperature has been declining. On the other hand, 42.75% reported that the quantity of rainfall has been decreasing. A mixed response

Table 9 Preferences for different traits in barley (frequency analysis)

Preferences	Haryana	Madhya Pradesh	Rajasthan	Uttar Pradesh	Total
Production					
High yield	80	46	92	36	254
Require less water/irrigation	50	47	50	31	178
Short duration	48	9	49	2	108
Fits into cropping system	41	9	24	33	107
Drought resistance	36	5	33	3	77
Disease resistance	30	3	33	1	67
Pest resistance	29	3	28	2	62
Improves soil fertility	10	3	12	4	29
Consumption					
Better taste	15	21	31	5	72
Less cooking time	20	12	9	5	46
High keeping quality	20	2	8	5	35
Fodder					
More leaves per plant	44	40	47	19	150
Palatability (quality/taste)	18	25	33	18	94
Storability	14	16	22	16	68
Marketing (grain)					
High demand	68	45	81	18	212
High price	62	38	67	16	183
Low price fluctuations	52	29	46	12	139
Bigger grain size	26	12	31	13	82
Marketing (fodder)					
High demand	52	50	37	15	154
High price	51	38	20	16	125
Low price fluctuations	32	41	11	11	95
Less thickness of stem	16	20	-	10	46

prevailed with respect to crop acreage across regions. It is clearly evident from the survey that around 71% perceived that barley is more suitable for cultivation under changing climate scenario owing to its high adaptability.

Determinants of yield: Multiple linear regression analysis resulted in a low 'goodness of fit' ($\overline{R}^2$) value but turned significant at 1% level of probability. Among the included eight variables in the model, only four showed significant coefficients (able 10). *Ceteris paribus,* enrolment of the farmer in contract farming, on an average, increases the crop yield by 444.02 kg/acre. Similarly, if the farmer uses own seed, the yield on an average reduces by 192.95 kg/acre. The dummy variable on seed replacement indicates that if the farmer not replacing the seed every year, then the yield on an average declines by 188.77 kg/acre in comparison to others. The analysis indicated a negative causal relationship between untimely sowing and yield, however, the coefficients were not significant. Farm size had a positive relation with the crop yield indicating that as the farm size increases, yield of barley also increases which might be due to the capacity of large farmers for high input application. Overall, the analysis indicated that variables associated with the farmer as well as farm influenced the crop yield.

Constraints in barley production: Agriculture is a biological activity with inherent production risks and hence an analysis on constraints in barley production was carried out (Table 11). Barring a few major constraints, the rest were region specific. Low yield (58.75%), followed by low market price (58%), and less rainfall (30%) were reported as the major constraints. Analysis on constraints provides a clue for researchers and policy makers to address through proper interventions. Clearly, the baseline study indicates

Table 10 Estimated coefficients from the multiple linear regression model Dependent variable: Yield of the farmer in kg/acre (Yi) ($\overline{R}^2$): 0.24*

Parameter	Estimated coefficients		't' value	Significance
	'b' coefficient	Standard error		
Intercept	1508.56*	142.74	10.57	0.00
Experience of the farmer in years (X_{1i})	-1.47	1.66	-0.89	0.37
Education level (X_{2i}) (0 for illiterate and 1 for literate)	-44.91	54.69	-0.82	0.41
Seed rate in kg/acre (X_{3i})	-0.97	1.81	-0.54	0.59
Contract farming enrolment (X_{4i}) (0 for no and 1 for yes)	444.02*	56.54	7.85	0.00
Source of seed (X_{5i}) (0 for own seed and 1 for others)	192.95*	62.04	3.11	0.00
Seed replacement (X_{6i}) (0 for every year and 1 for others)	-188.77*	57.90	-3.26	0.00
Sowing time (X_{7i}) (0 for timely sowing and 1 for others)	-77.48	58.74	-1.32	0.19
Farm size (X_{8i})	7.53*	2.26	3.34	0.00

Note: * indicate the significance at 1% level of probability.

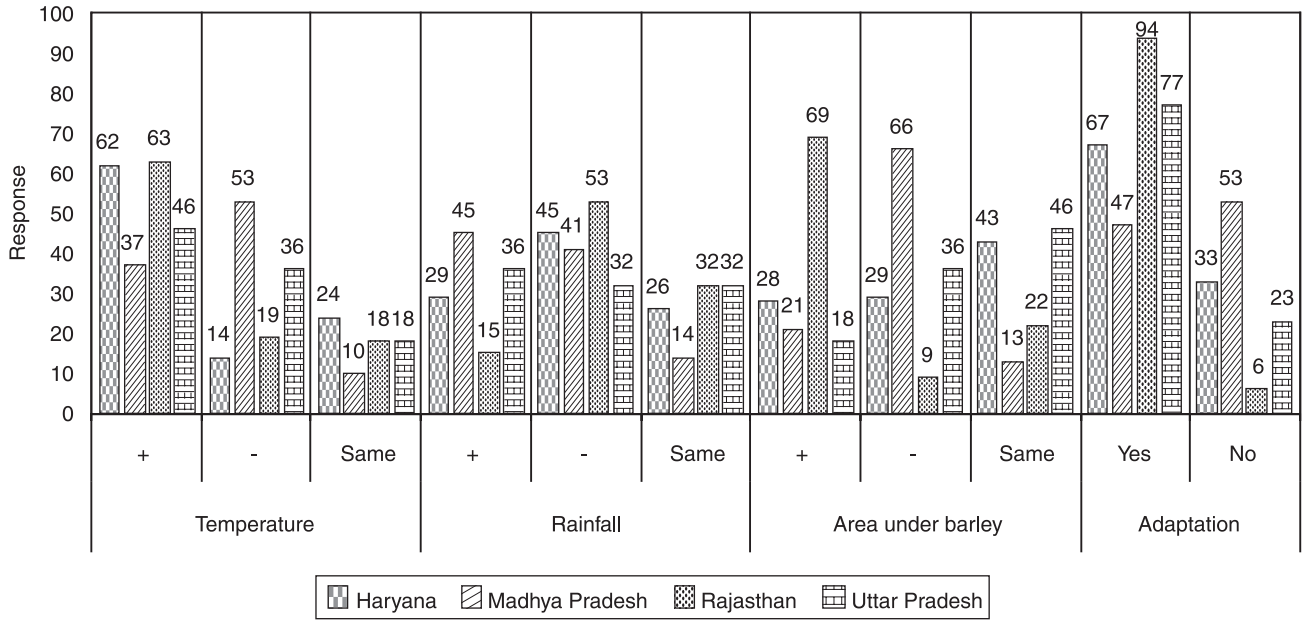

Fig 3 Impact of climate change on barley production

Table 10 Constraints in barley production (frequency analysis)

Parameter	Haryana	Madhya Pradesh	Rajasthan	Uttar Pradesh	Total
Low yield	57	61	46	71	235
Low market price	59	51	57	65	232
Less rainfall	13	26	46	35	120
Low malt recovery	23		10	1	34
Long duration	19				19
Unattractive color	17		4		21
Susceptible to storage pests	16	2	10		28
Poor fodder quality	14	3	1		18
Weeds	14	1			15
Poor taste	13	1			14
High disease incidence	13	1	2	1	17
Small grain size	12	1		2	15
High pest incidence	12		14		26
Doesn't fit into cropping system	10		12		22

the region wise priorities for carrying out research so as to tackle the existing and emerging challenges in barley production.

Despite increased trend in yield over years, the area under barley showed a declining pattern which shall be attributed to the replacement of crop post green revolution with high yielding semi-dwarf wheat varieties and later on with oilseed crops like mustard due to obvious reasons. Further changing consumption pattern from coarse cereals to wheat and rice, and more remunerative competing crops aggravated the problem of declining area. Overall, the baseline survey in Haryana, Madhya Pradesh, Rajasthan and Uttar Pradesh indicates that there is a huge scope for increasing the crop acreage in the changing climatic scenario. Providing an assured market support and genotypes adapted to prevalent biotic and abiotic stresses could greatly help in the process. The demand from malting and brewing industries is increasing owing to the better nutritional content (energy drinks for infants) and improved malting traits of this industrial cereal and it can be fulfilled only by increasing the productivity as well as enhancing area resulting in overall production escalation. The findings of the baseline survey indicate the weak value chain especially in Uttar Pradesh and Madhya Pradesh which requires interventions across all core process (production to marketing) for strengthening the value chain. Hence, the efforts should capitalize the collaborative research of barley varietal improvement which has to be taken to different stakeholders at all levels through targeted capacity building programs not only for farmers but also to the extension workers who gives least priority to the coarse cereal despite its rich nutrition value and high adaptive capacity to harsh environments.

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