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RESEARCH ARTICLE

Impact of *Rabi* maize in paddy fallow through farmers' participatory adoption

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Abstract

Maize is a staple food grain in the eastern Himalayas of India, traditionally grown only during the *Kharif* seasons using local cultivars. The cultivation of *Rabi* maize is a relatively new concept in the hills; however, favourable agro-climatic conditions offer potential for higher economic returns and proper utilisation of paddy fallow. A study was conducted in the adopted cluster villages (05 villages), Ri-Bhoi district, Meghalaya, covering a 15-hectare area, using a participatory approach to investigate the adoption of improved maize cultivars during the *Rabi* season. The results showed that DA 61 A and RCM 75 had promising growth and yield performances (5.2-5.8 green cob MT/ha). Prior to intervention, all the respondents grew only local varieties, and the growing seasons were mainly *Kharif* (76.67 %) and *Zaid* (23.33 %), with none cultivating during the *Rabi* season. In the post-intervention period, most respondents partially adopted *Rabi* maize cultivation technology, with a 60.0 % overall adoption level. Partial adoption was mainly due to a preference for high-value vegetables (ranked first at 100 %) and non-availability of varieties (96.67 %). The highest gross return, net return and benefit-cost ratio were recorded in improved cultivars (DA 61A and RCM 76). A negative correlation (r = -0.547*) was observed between disease incidence and *Rabi* maize yield. Adoption of *Rabi* maize cultivars shows promise for enhancing the socio-economic status and livelihoods of participating farmers.

Keywords: impact studies; partial budgeting; participatory approach; *Rabi;* maize

Introduction

Maize (*Zea mays* L.) is one of the most significant cereal food crops in the world, contributing 19.5 % to global caloric intake from all sources (1). Maize is also extensively used as animal feed and in the industry for the manufacturing of baby corn, corn oil, starch and biofuel. Out of total maize production in India, 48 % for poultry feed, 12 % for starch and oil production through wet milling, 11 % for other animal feed and 1 % for seed. Maize, ranked third in food crops in India after rice and wheat, occupied an area of 10.1 million hectares and produced 34.61 million MT during 2022–23 (2).

It is common practice in India's Eastern Himalayas to grow maize only during the *Kharif* season due to limited soil moisture availability in upland regions. Maize is considered the most a potential rainy-season crop in the region (3). However, the productivity is 1.50 t/ha in the region, which is half of the national average (3.4 MT/ha). This was primarily due to insufficient plant nutrition, adoption of local cultivars and high incidence of insect pests and weeds in *Kharif* crop. The steady rise in temperature and other parameters of climate change over recent decades has created more congenial climatic conditions for *Rabi* maize in the Eastern Himalayas region. It was also observed that a negligible incidence of insect pests, diseases and weeds during *Rabi* season (3). Furthermore, the photo-thermo-insensitive traits of maize indicate that it can be grown throughout the year, hence the term 'queen of cereal'.

Generally, the land used in the post-harvest of paddy remains fallow and unused. However, it is well established that paddy fallow offers residual soil moisture and nutrients, which are sufficient to raise several short-durations crops (4). In addition, the introduction of a subsequent crop after the preceding paddy raised cropping intensity and could transform lowland paddy farming into a profitable enterprise. Therefore, improved varieties of maize were introduced along with a package of practices for the cultivation of *Rabi* maize in the paddy fallow to enhance the livelihood of the farmers.

Materials and Methods

Description of the site

A demonstration was conducted for two consecutive years (2021 and 2022) in the adopted villages of Marngar cluster, Ri Bhoi District, Meghalaya by Indian Council of Agricultural Research (ICAR); Research Complex for Northeastern Hill Region, Umiam under the project "livelihood improvement of hill farmers through sustainable farming systems in northeastern hill region (Farmers' FIRST Program)". The study was conducted on paddy fallow land surrounded by hillocks in Marngar areas located at altitudes (900-1100 m amsl), a latitude of 25.8897866° N and a longitude of 91.922131° E. The agro-climate is characterized as sub-tropical, with an average temperature (minimum 10.2 °C and maximum 23.0 °C) and rainfall (22.2 mm) during the *Rabi* cultivation period. The soil in the study site is typic paleudalf, clay loam, acidic pH (5.0-5.5), available nitrogen (253.7 kg ha^{-1}), available phosphorus (11.2 kg ha^{-1}) and available pottasium (259.9 kg ha^{-1}).

Participatory farmer's and technology demonstrated

A series of trainings, interactions and demonstrations were conducted in the adopted cluster villages for the cultivation of *Rabi* maize in paddy fallow. Based on the feedback obtained from stakeholders, *Rabi* maize cultivation was introduced in a scientific manner for the first time in the adopted cluster villages. The technical details of cultivation, management practices and the efficient utilisation of paddy fallow were thoroughly demonstrated to the participant farmers.

Quality seeds of maize varieties suitable for *Rabi* cultivation, namely RCM-75, RCM-76 and DA-61A, including local lines as a checked variety were used for the study. Approximately 1.0 kg of seeds (250 g of each variety) was distributed to each farmer, covering about 3.5 ha of area under adopted trials in Marngar cluster villages (Lalumpam, Borgang, Borkhatsari and Purangang villages). The cultivation of *Rabi* maize in the farmer's field was demonstrated and closely monitored during the study period. A random sampling technique was adopted for this study. The cluster villages were purposefully selected based on their long-standing traditional practices of maize cultivation in the *Kharif* season. About 60 participatory farmers were selected using the probability proportional to size sampling method.

Package of practices and layout

Rabi maize was sown directly in the paddy fallow during the second quarter of January with a spacing of 50 cm row to row and 25 cm plant to plant. Well-decomposed farmyard manure (FYM) containing 0.5 % nitrogen (N) and 0.2 % phosphorus (P_2O_5) was applied as basal based on N equivalent to meet the requirement (60:60:40 kg N, P_2O_5 and potash (K_2O)/ha) and the phosphorus (P) requirement was supplemented through rock phosphate. The gross plot size was 5.0 m × 4.0 m. A recommended package of practices was followed as described previously (5).

Observations for growth and yield parameters

About five plants from each plot were randomly selected and tagged. Plant height was measured from the base of the stem to the tip of the longest tassel branch. The yield parameters of maize, such as cob weight, were recorded at harvest.

$$\text{PDI} = \frac{\text{Sum of individual ratings}}{\text{No. of plants examined x maximum disease scale}} \text{ X } 100 \qquad \text{(Eqn.1)}$$

The disease intensity, including turcicum leaf blight (*Exserohilum turcicum*), maydis leaf blight (*Drechslera maydis*) and rust in maize (*Puccinia sorghi* and *Puccinia polysora),* was assessed using a key (6, 7). The percent disease index (PDI) was worked out by using the formula given (8).

Socio-economics analysis

The age of the respondents was measured in terms of years from birth to the time of the interview. A unit score was assigned for each year of one's age. Based on age (years), the farmers of the study area were classified into three groups, namely young, middle and old.

To measure the extent of the education level of the respondents, an index was developed based on their literacy level. The respondents were asked to respond to each item of education level with respect to the extent of education on a four-point continuum, namely, illiterate was operationalized as a person who can't read and write (0), literate was operationalized as a person who can read and write (1), educated was operationalized as a person with an education level up to 10 + 2 level (3) and highly educated was operationalized as a person who had graduated and above (4). Based on the responses to each item, the total score of individual farmers was computed by summing up the scores. As a result, the education score that a person received represented their overall score.

To measure the extent of social participation among the respondents, the social participation scores assigned to each respondent were totaled and the mean scores of social participations (*x*) and standard deviation (SD) were computed. Social participation was categorized into three levels, such as (i) low level, indicating the total score of an individual respondent was below the mean-SD; (ii) medium level, when the score varied from the mean-SD to the mean + SD and (iii) high level, indicating the individual score was above the mean + SD.

To know the knowledge level on *Rabi* maize production technologies of the respondents, the knowledge level scores assigned to each respondent were totaled and the mean scores of knowledges (*x*) and SD were computed. Three categories were used to classify respondents' knowledge levels as social participations.

Furthermore, the knowledge index was also computed as given below:

$$\text{Knowledge index (KI)} = \frac{\text{Total score obtain}}{\text{Maximum possible score}} \text{ x } 100 \qquad \text{(Eqn.2)}$$

Adoption level

To measure the extent of adoption of improved *Rabi* maize production technologies in paddy fallow conditions, an index was developed by following the recommended procedures. The respondents were asked to provide their response to every question on the adoption of these varieties and recommended practices on a three-point continuum: complete adoption (2), partial adoption (1) and non-adoption (0), with corresponding weightages assigned. The full adoption was opera- tionalized as the adoption of stated practices completely and regularly in each season. Partial adoption was operationalized as the adoption of only a part of the recommended practice in each season. The non-adoption means that those recommended practices were not at all adopted by the farmer.

Based on the responses to each item, the total score of individual farmers was computed by summing up the scores. Thus, the total score secured by an individual was the adopted score. Each respondent's adoption quotient was calculated using the following quotient and it served as their adoption score. Each respondent's adoption scores were summed up and mean (x) and SD were calculated. Adoption behaviour was categorized into three levels as social participations). The entire schedule was subjected to pre-testing before being administered to the actual respondents.

To measure the reasons for not cultivating *Rabi* maize, an index was developed by following the recommended procedure. The respondents were asked to respond to each of the items of the reason for not adopting *Rabi* maize in a rank-wise manner. The response to each item was then calculated percentagewise. Thus, the item which secures the highest percentage comes under the 1st rank and vice versa.

The formula given below are some of the analyses used for the present study:

i) Adoption

Adoption index (AI) =

$$\frac{\text{Total score obtain}}{\text{Maximum possible score}} \times 100 \qquad \text{(Eqn.3)}$$

Overall adoption level in the area was also worked out by calculating the arithmetic mean of the adoption quotient of all the respondents as below:

Overall adoption level =

$$\frac{\Sigma AQ}{N} \times 100 \qquad \text{(Eqn. 4)}$$

Where, AQ = adoption quotient for the respondents, N = total number of respondents

ii) Percentage

Percentage =

$$\frac{\text{Number of observation}}{\text{Total number of observations}} \times 100 \qquad \text{(Eqn. 5)}$$

Garrett's ranking technique

The primary constraints to maize cultivation as perceived by farmers were identified using Garrett's ranking technique. The specific issues that the respondents faced were asked to be ranked in order according to their individual perceptions and subsequently transferred into Garett scores. As a result, the mean score for each issue was ranked by arranging them in decreasing order.

Economics of production

The economics of cultivation were measured based on return analyses such as gross return (value of the main crop and by product), net return (gross return – total cost of production) and benefit cost ratio (gross return/total cost of production).

A partial budget is used to assess the economic viability of the adoption of *Rabi* maize over *Kharif* maize (9). The partial budgeting technique was employed to determine the profitability of specific changes in the operations between the two seasons of cultivation (10). It emphasised only the changes in variable costs incurred and profit that would result from adopting between two alternative interventions and thus all aspects of farm expenses and profits that are unchanged by the decision can be safely ignored (11).

Data collection

For the present study, several surveys were conducted in the adopted cluster villages with the support of a pre-structured interview schedule. The primary data required for the study were collected from the selected sample respondents. The schedule included questions related to the seasons of cultivation of maize, variety used, reason for not adopting the improved variety and income generated from maize.

Statistical analysis

The experiment was laid out in a randomized block design with each cultivar were replicated thrice, consisting of five plants. The replicated data were analysed using statistical package for the social sciences (SPSS) (version 14.0) software and the data were presented as mean ± SE using one-way analysis of variance (ANOVA) ($p < 0.05$) of HSD Tukey's Test. The possible relationship among growth, yield attributes and economics of maize cultivation was analysed through Pearson's correlation coefficient.

Results and Discussion

Growth and yield of maize varieties

A significant difference was obtained for growth and yield characteristics among cultivars of maize grown during the *Rabi* season (Table 1). The highest plant height was recorded in RCM 1 -75 (248.43 ± 1.6^{a} cm) and the lowest in DA 61A (215.52 ± 2.8^{c} cm). The shortest duration taken for green cob formation was recorded in RCM 76 (78.48 ± 1.7^{b} days), followed by RCM 75 (80.74 ± 2.1^{b} days) and the longest in Local Yellow (104.93 ± 2.02^{a} days). It is a common characteristic of local landraces that they usually take a longer period to mature compared to improved varieties. Our results were corroborated by the findings of previous studies (12, 13). This is mainly due to varietal differences and the genetic characteristics of the variety or cultivar (14).

The green cob length was maximum in DA 61A (16.67 ± 0.05^{a} cm), followed by RCM 75 (15.03 ± 0.49^{b} cm), while the minimum was recorded in RCM 76 (14.31 ± 0.52^{b}). The green cob weight was the highest in DA 61 A (216.7 ± 4.91^{a}g per cob), followed by RCM 75 (207.4 ± 7.42^{ab}g per cob) and the minimum was obtained in Local Yellow (191.4 ± 2.05^{c} per cob). DA 61 A had the highest yield (5.19 ± 0.12^{a}) t/ha, which was significantly superior over other varieties, followed by RCM 75 and RCM 76. This was probably due to the higher green cob length and weight in these high-yielding varieties, as supported by a strong correlation of yield with green cob length (0.72**) and weight (0.88**) (Fig. 1). Similar associations of cob traits with yield were also highlighted in recent studies from India, where yield per plant showed a strong positive correlation with cob length and cob weight (15).

Generally, high-yielding varieties, owing to their genetic makeup, play a very significant role in determining yield performance. However, in most cases, local landraces are relatively inferior in terms of yield, as seen in our results. The importance of genetic progress in maize contributing to substantial yield enhancement has also been emphasized in recent literature, underscoring that differences among cultivars largely stem from genetic improvement programs (16). The differences in the yield of different varieties may be attributed to the existence of differences in the cultivars in terms of their reactions to external

Table 1. Plant growth and yield characteristics of *Rabi* maize varieties in paddy fallow condition.

Cultivars	Plant height (cm)	Duration (days) to green cob	Green cob length (cm)	Green cob weight (g)	Green cob (t/ha)	Disease incidence
RCM 75	248.43 ± 1.6^{a}	80.74 ± 2.1^{b}	15.03 ± 0.49^{b}	207.4 ± 7.42^{ab}	4.63 ± 0.11^{b}	2.22 ± 0.51^{a}
RCM 76	224.37 ± 3.1^{b}	78.48 ± 1.7^{b}	14.31 ± 0.52^{b}	199.5 ± 5.47^{bc}	4.71 ± 0.14^{b}	1.33 ± 0.33^{b}
DA 61A	215.52 ± 2.9^{c}	82.35 ± 2.03^{b}	16.67 ± 0.05^{a}	216.7 ± 4.91^{a}	5.19 ± 0.12^{a}	0.56 ± 0.12^{c}
Local Yellow	225.69 ± 2.7^{b}	104.93 ± 2.02^{a}	14.22 ± 0.59^{b}	191.4 ± 2.05^{c}	3.67 ± 0.08^{c}	1.11 ± 0.19^{b}

Superscripts (**a**, **b**, **c**) within a column indicate statistically significant differences among means as per Tukey's HSD test at $p < 0.05$.

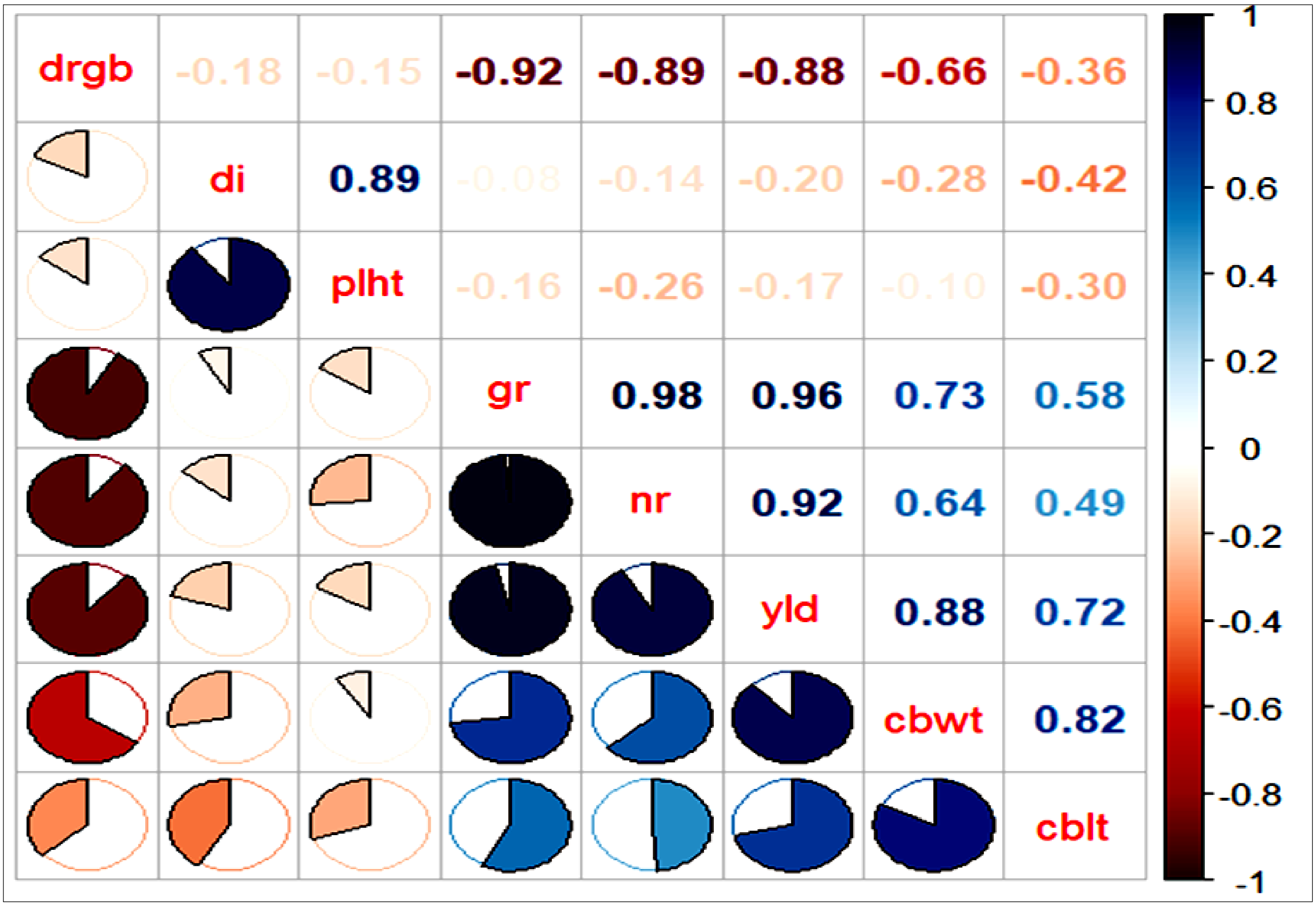

Fig. 1. Correlation among growth, yield attributes and economics of maize cultivation. (**drgb**, duration to green **cob**; di, disease incidence; **plht**, plant height; **gr**, gross return; **nr**, net return; **yld**, yield of green cob; **cbwt**, green cob weight; **cblt**, green cob length).

factors and utilisation of soil and water resources, which also have a significant effect on the yield and other agro-morphological parameters.

Disease incidence

The study also indicated a significant difference in the disease response of maize varieties under *Rabi* cultivation (Fig. 2). The minimum disease incidence was recorded in DA 61 A (0.56 ± 0.12^{c} %), followed by RCM 76 (1.33 ± 0.33^{b} %) and Local Yellow (1.11 ± 0.19^{b} %). While RCM 75 had the highest percentage of disease incidence (2.22 ± 0.51^{a} %), which might be responsible for its low yield, as clearly indicated by a negative correlation (-0.20) of disease incidence with yield (Fig. 1). The cultivars DA 61A, RCM 76 and Local Yellow might have some degree of tolerance to diseases, which ultimately helps in obtaining better yields. These findings are corroborated with the previous report that maize cultivars, including DA 61A, RCM 76 and Hemant, showed tolerance to diseases occurring under organic cultivation (17). However, in all the varieties, the degree of infestation of insect pests and diseases in our study (0.56-2.22 %) was very low as compared to those of summer crops (12.5-19.5 %) in the same varieties (17). This might be due to the unfavourable agro-climatic conditions, such as low temperature, precipitation and humidity, in *Rabi* season for the incidence of insect pests and diseases, resulting in a negligent incidence of diseases and insect pests. It was earlier reported that *Rabi* maize has a higher yield than *Kharif* maize and is free of insect pests and diseases (18). Recent Indian evidence further supports this observation, highlighting that *Rabi* maize faces very low pest and disease incidence due to the cooler and drier season, leading to comparatively higher yields (19).

Socio-economics characteristics

The socio-economic profile of the respondents represents personal and socio-economic attributes like age, education, social participation, knowledge level and adoption (Table 2). The age distribution of respondents provides insights into the proportion of economically productive vs. dependent individuals in the household. It was clearly evident that the highest number of respondents in terms of age is 50 % in the age group of 35*50 years, whereas the age group of less than 35 years is found to have the lowest number (16.67 %). Most of the respondents are literate (65 %), whereas about 3.3 % of the respondents are highly educated (graduates and above). Education plays a vital

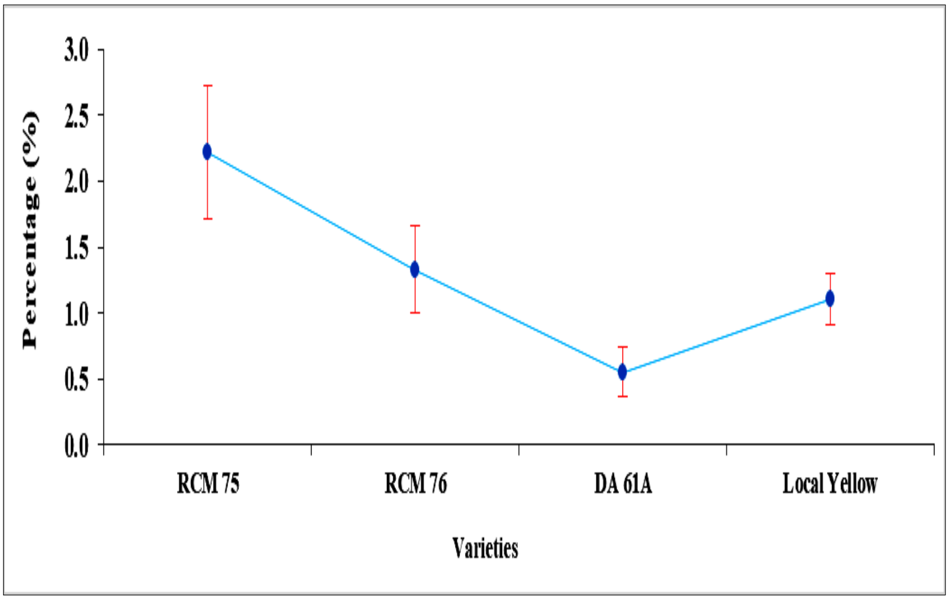

Fig. 2. Disease incidence (%) in different varieties of *Rabi* maize.

Table 2. Distribution of respondents based on socio economic parameters of growers (n ≈ 60).

Attribute	Category	Frequency	Respondents (%)
Age	< 35 years	10	16.67
	35-50 years	30	50.00
	> 50 years	20	33.33
Education	Illiterate	13	21.67
	Literate (can read and write)	39	65.00
	Educated (Up to 10 + 2 level)	6	10.00
	Highly educated (graduate and above)	2	3.33
Social participation	Low (<0.25)	15	25.00
	Medium (0.25-2.11)	40	66.67
	High (>2.11)	5	8.33
Knowledge	Low (<3.05)	14	23.33
	Medium (3.05-11.24)	38	63.33
	High (>11.24)	8	13.33
	Knowledge index (KI)	-	44.69

role in the socio-economic development of society. Educated people can easily make any decision quicker and better than uneducated people. The positive aspect of education is that it boosts the confidence level of the farmer or individual, which helps them take their own decisions without hesitation.

The social participation data showed that most of the respondents had a medium level (66.67 %) of involvement and only 8.33 % of the respondents had a high level of social participation. Social participation is defined as involvement in activities that allow for connections with people within the community or in society. The majority (63.33 %) of the respondents had a medium level of knowledge regarding the cultivation of improved *Rabi* maize varieties, whereas only 13.33 % of the respondents had a high level of knowledge on cultivating *Rabi* maize. The knowledge index was found to be 44.69 %. Knowledge is frequently interpreted as factual awareness or practical abilities, but it can also represent familiarity with things or circumstances.

Adoption of technology intervention

Technology adoption refers to the process of accepting, integrating and using new technology in society. The status of respondents with respect to *Rabi* maize cultivation before intervention is presented in Table 3. The results showed that most of the respondents (100.00 %) grew only local varieties of maize; however, the growing seasons were mainly *Kharif* (76.67 %) and *Zaid* (23.33 %), with none cultivating during the *Rabi* season prior to the intervention. The cultivation of landrace varieties was due to the easy accessibility of seeds.

Table 3. Distribution of respondents based on cultivation of *Rabi* maize before intervention (n ≈ 60).

Attribute	Category	Frequency	Respondents (%)
Varieties	Local	60	100.00
	Other	0	0.00
Seasons	*Kharif* (July-Oct)	46	76.67
	Rabi (Oct-April)	0	0.00
	Zaid (March-June)	14	23.33

Responses regarding the adoption of *Rabi* maize cultivation practices in the post-intervention period are presented in Table 4. It was found that the many of the respondents have partially adopted the recommended practices for *Rabi* maize and interestingly, harvesting time was fully adopted by 48.33 % of the respondents. It was further shown that a majority (60.00 %) of the respondents had a medium level of adoption, whereas 20.00 % had a high adoption level, as indicated in Table 5. The adoption index was also found to be 46.04 %, with a mean adoption of 7.37, whereas the standard deviation was found to be 4.51. Furthermore, the findings showed that the partial adoption during the *Rabi* season was due to numerous reasons, as shown in Table 6. The ranking showed that high-value crops (100 %) were ranked first, followed by the non-availability of suitable varieties of *Rabi* maize (96.67 %), the lack of short-duration varieties of rice that could facilitate timely sowing of *Rabi* crops (93.33 %) and other reasons for partial adoption of *Rabi* maize. The preference for high-value crops, such as cole crops and other winter-season vegetable crops, was due to the negligible incidence of insect pests and weeds, the minimum labour requirement attributed to favourable agro-climatic conditions during *Rabi* season. In addition, crops such as broccoli and cauliflower fetch a higher price as compared to *Rabi* maize (Rs. 90 per kg to Rs. 60 per kg).

Table 4. Distribution of respondents based on adoption of recommended practices for *Rabi* maize after intervention (n ≈ 60).

S. No.	Recommended practices	Status of technology adoption					
		No adoption		Partial adoption		Full adoption	
		F	P	F	P	F	P
1	Soil management	14	23.33	37	61.67	9	15.00
2	Variety	12	20.00	32	53.33	16	26.67
3	Sowing time	15	25.00	33	55.00	12	20.00
4	Spacing	9	15.00	37	61.67	14	23.33
5	Manuring	17	28.33	31	51.67	12	20.00
6	Integrated pest management	35	58.33	20	33.33	5	8.33
7	Disease management	32	53.33	22	36.67	6	10.00
8	Harvesting time	7	11.67	24	40.00	29	48.33

Table 5. Distribution of respondents based on overall level of adoption after intervention (n ≈ 60).

S. No.	Adoption level	Percentage
1	Low (<2.85)	20.00
2	Medium (2.85-11.89)	60.00
3	High (>11.89)	20.00
4	Adoption index (AI)	46.04
5	Mean	7.37
6	Standard deviation	4.51

Economics of cultivation

The adoption of varieties has significantly improved the yield and economics of production of *Rabi* maize as compared to traditional practices and cultivars (Fig. 3). Among the cultivars, the highest gross return was recorded in DA 61A (Rs. 131785 ± 1972[a]), followed by RCM 76 (Rs. 129791 ± 638.0[b]), while the lowest was obtained in Local Yellow (Rs. 104275 ± 375.02[d]). Similarly, the net return was highest in DA 61A (Rs. 71270 ± 1927.32[a]), which was statistically at par with RCM 76 (Rs. 69276 ± 638.01[a]), while the lowest was observed in Local Yellow (Rs. 43760 ± 402.00[c]). Furthermore, the highest benefit-cost ratio was obtained in variety DA 61A (2.81 ± 0.08[a]), followed by RCM 76 (2.14 ± 0.06[b]) and the minimum was obtained in Local Yellow (1.72 ± 0.06[d]). The highest economic returns in varieties DA 61A and RCM 76 were probably due to their higher yield and the lower incidence of diseases and insect pests in these improved varieties as compared to traditional varieties. This was evidenced by a negative correlation between the incidence of insect pests and diseases and the yield of *Rabi* maize (-0.20*), as shown in Fig. 1.

Partial budgeting analysis revealed changes in cost accrued and profit and a significant impact on the economics of production due to the *Rabi* maize intervention (Table 7). The cost of cultivation was higher under *Kharif* maize (Rs. 74065/ha) than *Rabi* (Rs. 60515/ha). In contrast, the gross return was higher in *Rabi* maize (Rs. 131785/ha) than in *Kharif* maize (Rs. 116148/ha).

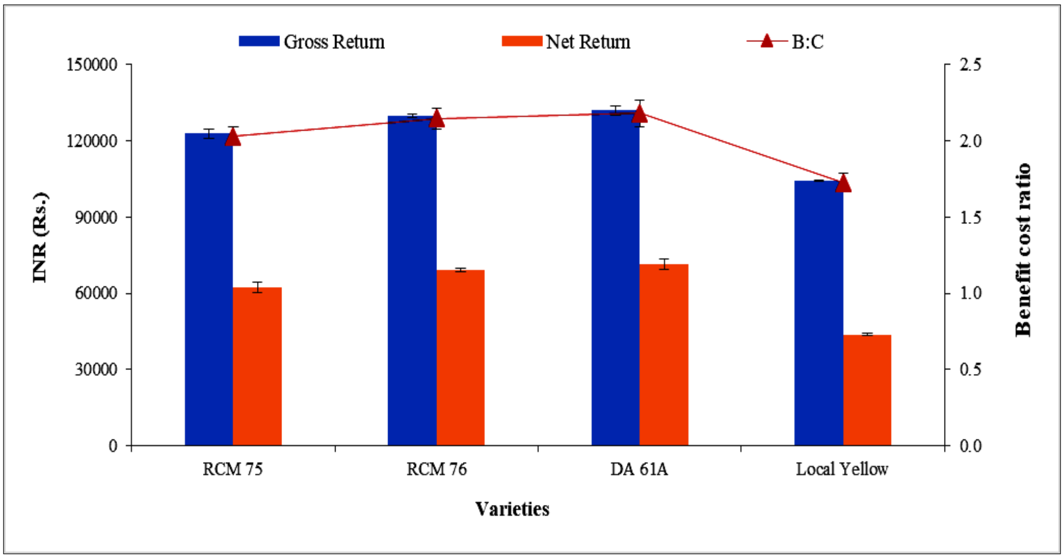

Fig. 3. Economics of production of different varieties of *Rabi* maize.

Table 6. Distribution of respondents based on their reason for not adopting *Rabi* maize.

S. No.	Reason for not adopting *Rabi* maize	Not relatable	%	Relatable	Percentage (%)	Mean score	Rank
1	Lack of short duration varieties of rice that could facilitate timely sowing of *Rabi* crops	4	6.67	56	93.33	0.93	III
2	Non-availability of *Rabi* varieties of maize	2	3.33	58	96.67	0.97	II
3	Lack of technical know-how	15	25.00	45	75.00	0.75	V
4	High-value crops such as cole crops, other vegetables	0	00.00	60	100.00	1	I
5	Non-traditional practices	15	25.00	45	75.00	0.75	VI
6	Non-availability of labor during peak season	12	20.00	48	80.00	0.8	IV
7	Inadequate irrigation facilities	22	36.67	38	63.33	0.63	IX
8	Disease and pest management constraints	18	30.00	42	70.00	0.7	VIII
9	Dependence on local traders for marketing	16	26.67	44	73.33	0.73	VII
10	Lack of institutional and extension support	25	41.67	35	58.33	0.58	X

Table 7. Partial budgeting for the adoption of *Rabi* maize over *Kharif* maize.

Cost		Benefit	
a) Added cost	**Amount (Rs)**	**a) Reduced cost**	**Amount (Rs)**
i) Labour cost	-	i) Labour cost	13400
ii) Input costs		ii) Input costs	
Nutrition cost	-	Nutrition cost	-
Irrigation	4800`	Irrigation	-
Plant protection	-	Plant protection	4950
Total	4800	Total	18350
b) Reduced return		**b) Added returns**	
Yield reduction	-	Added yield	15637
c) Total loss (a + b)	4800	**c) Total benefit (a + b)**	33987
Net income (total benefit- total loss)			29187

Added cost

The cost of cultivation in *Kharif* and *Rabi* maize cultivation is presented in Table 7. On the negative side, irrigation emerges as an additional cost associated with *Rabi* maize adoption. This is due to the requirement of supplement irrigation (Rs. 4800) to ensure the survival of *Rabi* maize during the dry season, unlike the rainfed *Kharif* maize.

Reduced cost

On the positive side, labour costs for weeding and plant protection, appears to be reduced by Rs 13400 under *Rabi* cultivation. Similarly, the inputs for plant protection were reduced by Rs 4950. This is due to the lower incidence of weeds and insect pests during *Rabi* season maize.

Added returns

Rabi maize produced an additional yield of 0.23 t/ha over *Kharif* maize, resulting in an extra return of Rs. 15637/ha.

Net income

The net income from the adoption of *Rabi* maize increases significantly when considering the total loss (negative side) of Rs. 4800 and the total benefit (positive side) of about Rs. 33987, resulting in a net income of Rs. 29187/ha. A positive net income indicates that adoption of *Rabi* maize increased profit and brought additional profit of Rs. 29187/ha.

Conclusion

Maize is an important food grain cultivated during the *Kharif* season in the region. Recently, the potential of growing *Rabi* maize in paddy fallows has emerged, owing to favourable agro-climatic conditions that enable improved resource utilisation, increased yield and enhanced livelihood. Improved varieties of maize along with a package of practices were introduced in the paddy fallow. It was found that varieties DA 61 A and RCM 75 showed higher growth and yield performance with the minimum disease incidence. Furthermore, the economics of production were higher for improved varieties as compared to traditional varieties. Most of the respondents have partially adopted the recommended practices for *Rabi* maize. Therefore, capitalizing on favourable conditions, *Rabi* maize technological intervention is considered the most promising production system for higher resource-use efficiency, yield, economic returns, optimal utilisation of paddy fallow and labour engagement during the lean season as compared to traditional practices and cultivars during the *Kharif* crop.

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Authors' contributions

HR performed the investigation and wrote the manuscript. NUS, TRB and RK are involved in the conceptualization, supervision and editing of the manuscript. NS, AY, PP, AR and AT were involved in the editing of the manuscript. All authors read and approved the final manuscript.

Compliance with ethical standards

Conflict of interest: Authors do not have any conflict of interest to declare.

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Declaration of generative AI and AI-assisted technologies in the writing process

The authors acknowledge the use of generative AI tools (such as ChatGPT by OpenAI) to assist in language refinement, grammar correction and paraphrasing during the preparation of this manuscript. AI tools were used for content generation, data analysis or intellectual contribution to the core ideas or findings. All content has been critically reviewed and approved by the authors to ensure accuracy, originality, and integrity.

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