Economics of demonstrating wheat production technology under rain-fed ecosystems

**Pawan Kumar Sharma[1]*, Pardeep Wali[1], Parveen Kumar[1],
Rakesh Sharma[1], Rajbir Singh[2], and V P Chahal[3]**

[1]Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu,
Chatha 180 009, Jammu & Kashmir
[2]ICAR-Agricultural Technology Application Research Institute, Ludhiana 141 004, Punjab
[3]Krishi Anusandhan Bhawan, New Delhi 110 012

*Corresponding author: pawanvatsya@gmail.com

Abstract The recommended wheat production technology—including variety, seed rate, and fertilizer dose—was demonstrated under the Farmer FIRST programme of the Indian Council of Agricultural Research, New Delhi during the *rabi* season of 2017 and 2018. The difference in average yield was statistically significant between the demonstration plots (15.70 quintals per hectare ± 1.27) and local check plots (11.93 quintals per hectare ± 1.45). The variation in productivity was less at demonstration plots and the net return was higher (by INR 3,042 per hectare). Adopting the recommended production technologies can enhance wheat production in rainfed areas and make it sustainable.

Keywords Wheat, technology demonstration, rainfed

JEL codes Q12, Q16

Kandi (rainfed) areas have unique agroecological features and cropping systems; the organic matter is restricted, as is the efficiency of water and nutrient use (Ghuman and Sur 2001). Crop and livestock production is completely dependent on rainfall, and returns are difficult to sustain. Wheat is an important crop for the livelihood security of farmers in rainfed ecosystems, and researchers worldwide have attempted to analyse the factors of wheat production, efficiency, and profitability.

Chapagain and Good (2015) analyse 10 years' data to understand yield variability and input efficiency and the yield potential under optimal management for closing yield gaps of wheat. Edreiraa et al. (2018) combine local weather, soil, and agronomic data, and crop modeling in a spatial framework to determine gaps in water productivity and found the gap for wheat to average 10 kg per ha per mm. On the other hand, wheat plants treated with a combination of plant growth promoting rhizobacteria and salicylic acid showed significant increases in leaf protein and sugar content, and these maintained higher chlorophyll content, chlorophyll fluorescence (fv/fm) and performance index under rainfed conditions (Khan and Bano 2019).

Efficiency studies of wheat production under rainfed ecosystems have been carried out. In the rainfed zone of Punjab, Pakistan, the mean technical efficiency of wheat production, 47.1%, signifies the scope of increasing wheat productivity with the same level of technology and input use (Hussain et al. 2012). Al-Feel and Al-Basheer (2012) estimate the mean technical efficiency of wheat production at 63% and suggest that the technical efficiency of wheat production can be improved by using improved varieties and by preparing and irrigating the land at the optimum time.

Mburu et al. (2014) estimated the technical, allocative, and economic efficiencies of wheat farmers in Nakuru

District, Kenya, and find that efficiency is strongly influenced by formal education, extension advice, and farm size. The technical efficiency of wheat production in Ethiopia is determined by sex, age, distance to all-weather roads, livestock holding, group membership, farm size, farm fragmentation, tenure status, and investment in fertilizers (Uma 2017).

All these studies focus on the influence of socio-economic factors on the efficiency of wheat production. Therefore, the demonstration of recommended scientific technologies on farmers' fields is considered to be an effective method for improving the technical efficiency and economic return of crops.

Under the Farmer FIRST (Farm, Innovations, Resources, Science and Technology) programme, an initiative of the Indian Council of Agricultural Research (ICAR), demonstrations of scientific wheat production in *kandi* areas were conducted in Samba district of the Jammu region of Jammu and Kashmir Union Territory by Sher-e-Kashmir University of Agricultural Sciences and Technology (SKUAST), Jammu. The demonstrations of scientific technologies and improved practices yielded better results than the existing practices (Dhaka et al. 2010; Pal and Saroj 2019).

Technology and credit are considered to be the crucial factors for improving farm incomes in rainfed regions (Rao et al. 2014). This paper attempts to find out the economics of the recommended wheat production technologies demonstrated in the *kandi* areas of Jammu and Kashmir under the Farmer FIRST programme.

Data and methodology

Study area

The Farmer FIRST Programme, conducted in three panchayats of Nud block in Samba district, covered 12 villages: Sarna, Raith, Badla Deonian, Badla Brahmna, Kayani, Patyari, Nangal, Satah, Sarain, Toond, Dheora, and Balore. Each demonstration was conducted on an area of 0.4 hectare. The farmers were provided free critical inputs as per the scientific package of practices recommended by the SKUAST-Jammu. The baseline data for the year 2016–17 and subsequent data for 2017–18 regarding socio-economic characteristics, wheat production, etc. were gathered from sites of demonstration plots and neighbouring local check plots.

Before the recommended scientific interventions were implemented, all the farm families in the selected village clusters were interviewed, and existing farm-level cost-–returns data were collected for the major crops. Out of 755 wheat-growing families, 500 families were selected as the experimental (treatment) group, and the recommended wheat production technology was demonstrated. After the wheat had been harvested, the data were collected again from all 755 families, including the 255 comparison group farmers, to compare the productivity and profits of the check and demonstration plots.

Analytical framework

The double difference method—or difference in differences method—controls for time-invariant characteristics while comparing the beneficiaries and non-beneficiaries of a technology, scheme, or programme (Palanisami et al. 2014). We employ the double difference non-equivalent control group design to identify the difference in productivity between beneficiaries and non-beneficiaries of the Farmer FIRST programme (Table 1).

The specification of the double difference (DD) model is

$$DD = \left[\left\{ \frac{1}{b} \sum_{i}^{b} \left(\bar{Y}_{dt} - \bar{Y}_{dt+1} \right) \right\} \left\{ \frac{1}{nb} \sum_{j}^{nb} \left(\bar{Y}_{lt} - \bar{Y}_{lt+1} \right) \right\} \right]$$

Table 1 Differences in productivity

Particulars	Participants	Non-participants	Difference across groups
Group I Treated (with demonstrations)	D_1	C_1	$D_1 - C_1$
Group II Control (without demonstrations)	D_0	C_0	$D_0 - C_0$
Difference across time	$D_1 - D_0$	$C_1 - C_0$	Double difference $(D_1 - C_1) - (D_0 - C_0)$

where,

DD = the difference between mean changes in wheat yield for beneficiaries and non-beneficiaries;

$\bar{Y}_{dt} - \bar{Y}_{dt+1}$ = difference of mean wheat yield of beneficiaries before & after implementation of project, respectively;

$\bar{Y}_{lt} - \bar{Y}_{lt+1}$ = difference of mean wheat yield of non-beneficiaries before & after implementation of project, respectively;

b = number of beneficiaries; and

nb = number of non-beneficiaries

A positive mean double difference indicates that the demonstrations had a constructive impact on beneficiaries, while a negative mean double difference indicates no impact. The modified form of difference in differences regression involving the personal and socio-economic characteristics of beneficiaries and non-beneficiaries is

$y_{gt} = \beta_0 + \beta_1 Treat_g + \beta_2 Post_t + \beta_3(Treat_g \times Post_t) + \beta_i Socioec_i + \varepsilon_{gt}$

y_{gt} = observed outcome in group s in period t;

$Treat_g$ = dummy variable is '1' if observation is from 'treatment' group in either time period

$Post_t$ = dummy variable is '1' if observation is from post treatment group in either time period

$Treat_g \times Post_t$ = estimation of treatment effect (difference across groups)

$Socioec_i$ = socio-economic variables related to groups

Production efficiency and yield gaps

The production efficiency and yield gaps were assessed using the formulas given by Samui et al. (2000).

$$Production\ efficiency = \frac{Yield\ of\ a\ particular\ crop\ on\ the\ given\ farm}{Average\ yield\ of\ that\ crop\ in\ the\ locality} \times 100$$

Technology gap = Potential yield – Demonstration yield

Extension gap = Demonstration yield – yield from traditional plots

$$Technology\ index = \frac{Potential\ yield - Demonstration\ yield}{Potential\ yield} \times 100$$

Other researchers use similar methodologies to assess the gaps in production efficiency and yield (Sharma et al. 2015; Vaid et al. 2017; Arora and Sharma 2019; Kumar et al. 2019).

To assess the validity of the improved efficiency of demonstrated plots compared to the local ones, we apply the independent two-sample t-test under these hypotheses:

H_0: μ_1 - μ_2 = 0 (the difference between the two population means is 0)

H_1: μ_1 - $\mu_2 \neq$ 0 (the difference between the two population means is not 0)

After the project was implemented, to compare the change in productivity of the local check and demonstration plots, we apply the paired two-sample t-test under these hypotheses:

H_0: μ_t - μ_{t+1} = 0 (the difference between the two population means is 0)

H_1: μ_t - $\mu_{t+1} \neq$ 0 (the difference between the two population means is not 0)

The impact estimator was considered to be the intention to treat effect, as all the farmer partners were supposed to adopt the recommended interventions and, accordingly, the data of all the beneficiaries was considered for comparison with the control group.

The study involves the impact assessment of technology in a cluster of villages using the data of two consecutive years. No separate data for pre-periods was available for treatment and control groups, and the testing of parallel trends was difficult. Both treatment and control villages were part of the same block for which the yield data were recorded by the revenue authorities, and a parallel trend was assumed.

Results and discussion

Table 2 presents the details of wheat demonstrations conducted and some of the major differences between the practices adopted under frontline demonstrations and traditional farms.

Description of technology

The demonstrations comprised recommended technologies, including improved variety WH-1080 and nutrient application as per package of practices. Traditionally, farmers use farm-saved seeds and the broadcast method of sowing, which resulted in a high

Table 2 Demonstrations

Crop	Particulars	Traditional practices	Frontline demonstrations
Wheat	Area (ha)	107.175	295.45
	Number of farms	255	500
	Variety	PBW-343	WH-1080
	Sowing	Broadcasting	Line sowing
	Nutrient Management(N:P:K)	70:00:00	60:30:20
	Seed rate (kg/ha)	125	100

seed rate per hectare. The farm yard manure available at the local check plots was sufficient and urea the only chemical fertilizer used (Table 2).

In demonstration plots, farmers were provided with an improved variety, WH-1080, recommended for *kandi* areas. The seed was sown in lines and the optimum seed rate of 100 kg per hectare was used. Under demonstrations, sowing was performed with seed-cum-fertilizer drill to ensure proper spacing in line sowing. The application of chemical fertilizers was in the ratio of 60:30:20 N:P:K. Nitrogen was applied in three split doses (half as basal and rest half at 'crown initiation' and 'ear initiation' stage), and phosphorus and potash were applied in full during sowing as basal dose.

Socio-economic and maize production variables

Table 3 presents the descriptive statistics of socio-economic characteristics—age of household head, formal education, farming experience, operational holding, area under wheat, and family size—of wheat growers at the local check plots and at the demonstration plots. The respondents at the local check and demonstration plots are statistically indifferent from each other in respect of age, education, and family size, but statistically different in respect of farming experience, operational holding, and area under wheat crop. The beneficiaries at the demonstration plots had more farming experience, total operational area, and area under wheat than those at the local check plots. At the local check plots, the operational holding was 0.49 ha and the area under wheat 0.29 ha. At the demonstration plots, the operational holding was 0.62 ha and the area under wheat 0.20 ha.

At the local check plots, the mean age of farmers was 51.76 years, the formal education of the household head 5.63 years, the farming experience 28.96 years, and the family size was 4.54 members. At the demonstration plots, the mean age of farmers was 52.36 years, the

Table 3 Socio-economic variables (descriptive statistics)

| Particulars	Local check plot	Demonstration plot	t-value	p-value	d.f.
Age of household head (years)	51.76 (±0.66)	52.36 (±0.52)	-0.691	0.490	753.00
Formal education of household head (years)	5.63 (±0.21)	5.53 (±0.18)	0.340	0.734	753.00
Farming experience of household head (years)	28.96*** (±0.69)	31.63 (±0.37)	-3.726	0.000	753.00
Operational holding (ha)	0.49*** (±0.03)	0.62 (±0.03)	-2.86	0.004	752.93
Average area under wheat (ha)	0.29*** (±0.009)	0.20 (±0.002)	12.606	0.000	753.00
Family size (number)	4.54 (±0.06)	4.60 (±0.03)	-0.908	0.364	753.00

***Significant at 1% level
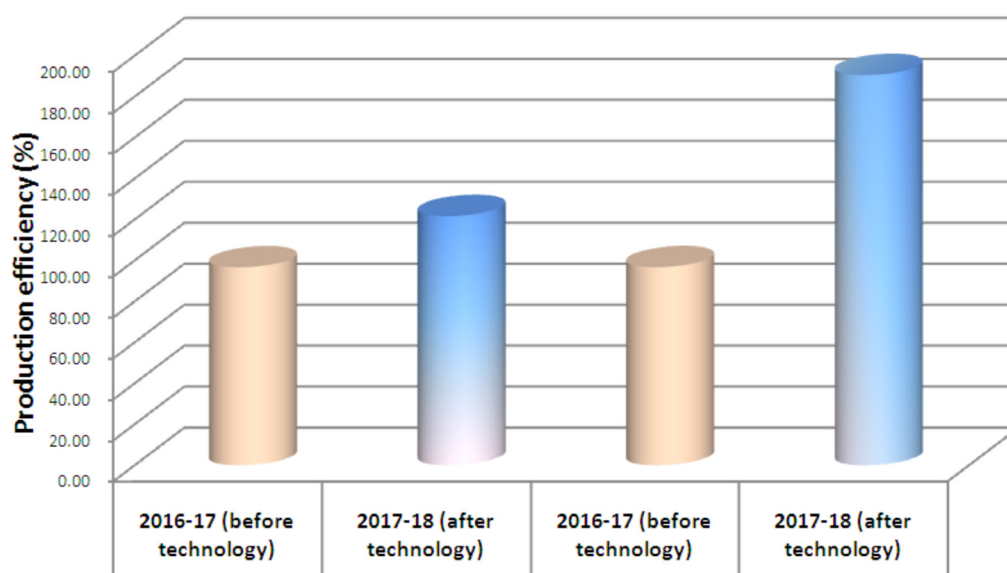
Figure 1 Comparison of production efficiency

formal education of the household head was 5.53 years, the farming experience 31.63 years, and the family size was 4.60 members.

Production efficiency

The production efficiency was assessed at two time periods—before the technology was introduced and afterwards. The efficiency was estimated by considering the average yield in the *kandi* areas of the district recorded in 2015–16 (10.93 quintals per hectare). The production efficiency was 96.61% at the local check plots and 96.68% at the demonstration plots in the base year, 2016–17; these percentages increased, respectively, to 121.68% and 190.48% in 2017–18 (Figure 1).

Physical performance of demonstrations

At the demonstration plots, applying the recommended scientific practices yielded 20.82 q per ha of wheat on average; under traditional practice, the yield was 13.30 q ha. The yield at the demonstration plots was 56.54% higher than in the traditional plots (Table 2). Implementing the project raised production efficiency at the demonstration plots (by 93.50%) and at the local check plots (by 25.95%) (Figure 1). The variance in productivity fell at the demonstration plots from 1.85 in the baseline year to 1.38 but rose at the local check plots from 1.70 in the base year to 2.50. The rise can be attributed to the spillover effect of technology

demonstrations at some of the nearby farms (Table 3).

Descriptive statistics of wheat productivity

The overall variations in productivity at the demonstration plots and local check plots across two time periods are depicted as box and whisker plots (Figure 2).
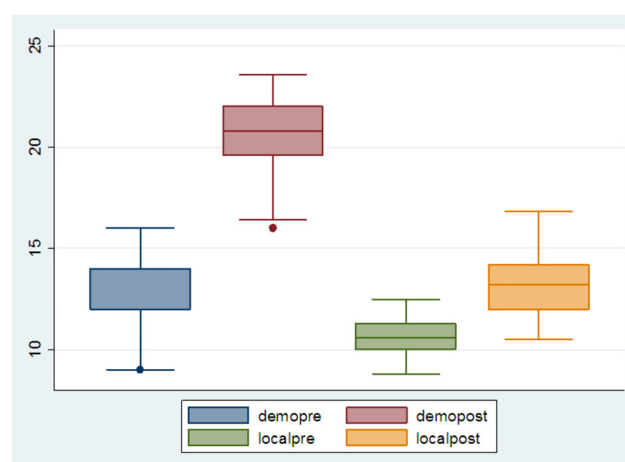

Figure 2 Box and whisker plots of wheat yield

The performance of demonstrations was better in marginal landholdings (56.86%) than at small (55.87%) and medium landholdings (45.28%). A similar trend was witnessed at local check plots (Figure 3).
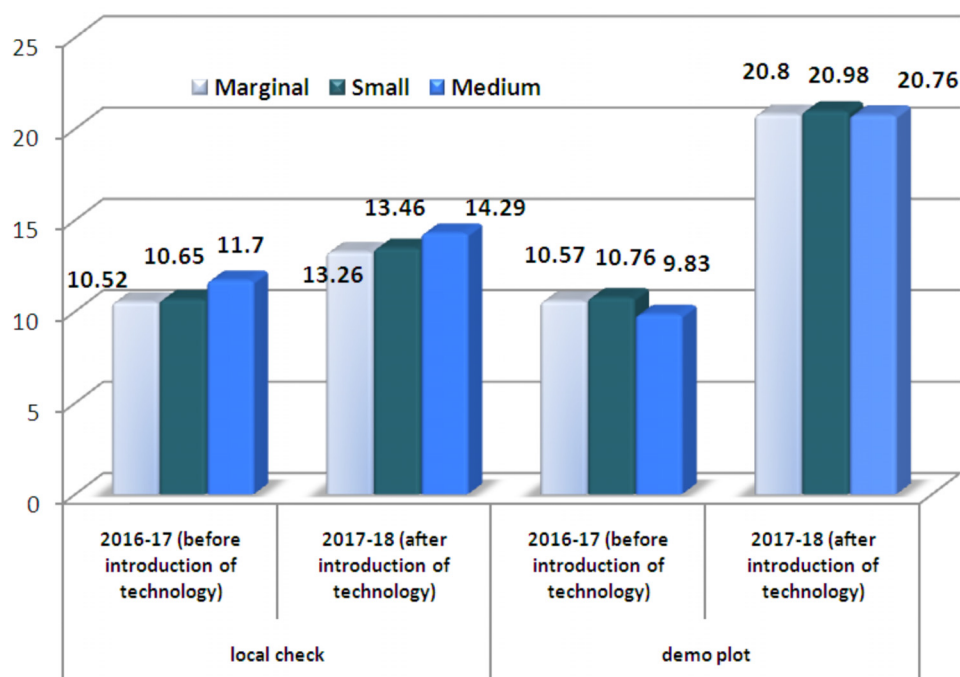
Figure 3 Size of holding and productivity change

Statistical differences in yields and testing of hypothesis

The statistical differences were evaluated by employing the independent two sample t-test and the paired two sample t-test for comparing the yields between the local check plots and the demonstration plots (Table 4) and the base year with the demo year (Table 5), respectively.

The independent two sample t-test revealed that the yield at the local check plots was not statistically different from that of demonstration plots (p=0.860) before the project was implemented; afterwards, however, the yields differed significantly (p=0.000) (Table 4). The paired two-sample t-test revealed statistically different yields (p=0.000) for the base year

Table 4 Wheat productivity, descriptive statistics

Particulars	2016–17 (Baseline)		2017–18		Average of 2 years	
	Local check	Demonstration plots	Local check	Demonstration plots	Local check	Demonstration plots
Mean	10.56	10.58	13.30	20.82	11.93	15.70
Standard error	0.08	0.06	0.10	0.05	0.09	0.06
Median	10.50	10.20	13.50	20.80	12.00	15.50
Mode	10.00	10.00	14.00	20.80	12.00	15.40
Standard deviation	1.31	1.36	1.58	1.18	1.45	1.27
Sample variance	1.70	1.85	2.50	1.38	2.10	1.62
Kurtosis	"0.29	2.88	"0.03	"0.58	"0.16	1.15
Skewness	0.24	1.58	"0.19	0.15	0.03	0.87
Range	5.60	7.00	9.00	7.00	7.30	7.00
Minimum	8.00	9.00	8.00	17.60	8.00	13.30
Maximum	13.60	16.00	17.00	24.60	15.30	20.30
Sum	2692.80	5289.10	3391.50	10410.00	3042.15	7849.55
Count	255	500.00	255	500	255.00	500.00

Table 5 Independent two-sample t-test

	Levene's test for equality of variances		t-test for equality of means		
	F	Sig.	T	df	Sig.(2-tailed)
Comparison of local check (base year) with demo (base year)					
Equal variances assumed	0.590	0.442	−0.176	753	0.860
Comparison of local check (demo year) with demo (demo year)					
Equal variances not assumed	27.685	0.000	−67.105	401.161	.000

and project year at both the local check and demonstration plots (Table 5), indicating that implementing the project raised the yield for both control and treatment groups.

The difference in mean yield between the local check and demonstration plots was statistically non-significant (p=0.860) before the demonstrations were conducted, but statistically significant afterwards. However, the difference in wheat yield before and after demonstrations was statistically significant (p=0.00) at both the local check and demonstration plots.

Technology and extension gaps

The yield of wheat under frontline demonstrations was compared to its potential yield to estimate the technology gap (23.18 q per ha) and the extension gap (7.52 q per ha) (Hiremath et al. 2009).

The large technology gap—attributed mainly to the rain-fed conditions of the district and to the dissimilarity in soil fertility status and landholding size (Table 6)—resulted in the high value of the technology index (52.68%). Lower the value of the technology index, greater the feasibility of the improved practices at the farmer's field.

The extension gap was quite low, due to the demonstration of the complete package of practices for the wheat crop. Educating farmers through various extension means and helping them adopt scientific wheat cultivation practices would narrow the gap further (Table 6).

Medium-size landholdings recorded the highest increase in productivity (111%), followed by marginal (96.78%) and small (94.98%) landholdings (Figure 3).

Economics of frontline demonstrations

Table 7 compares the economics of the recommended wheat production technologies under frontline demonstrations with that of local check plots. The economic analysis considers the variable costs of cultivation: cost of land preparation, seed, fertilizers, labour, agrochemicals, harvesting, and threshing for wheat crop.

The gross returns were calculated by combining the income from grains and straw at the prevailing market price. The gross returns were higher for demonstration plots (INR 33,103 per ha) than at traditional plots (INR 21,014 per ha), as was the B:C ratio (0.727 per hectare at the demonstration plots and 0.534 per hectare at the traditional plots).

Table 6 Paired two-sample t-test

	Paired differences		t-test		
	Mean (SD)	Std. Error Mean	t	df	Sig. (2-tailed)
Comparison of yield under local check during base year with demo year					
Demo year yield – Base year yield	2.74 (±1.36)	0.852	32.138	254	0.00
Comparison of yield under demonstrations during base year with demo year					
Demo year yield – Base year yield	10.24 (±1.81)	0.809	−126.48	499	0.00

Table 7 Technology and extension gaps

Potential	Yield (q/ha)		% increase over local	Technology gap (q/ha)	Extension gap (q/ha)	Technology index (%)
	Demonstration	Traditional Plots				
44.00	20.82	13.30	56.54	23.18	7.52	52.68

Table 8 Economics of wheat at local check and demonstration plots

Particulars	2016–17 (Base year)		2017–18	
	Local check plot	Demonstration plot	Local check	Demonstration plots
Cost of production (INR/ha)	12213.88 (±96.90)	12874.84 (±75.87)	13854.42 (±89.22)	19228.78 (±50.47)
Yield (q/ha)	10.56 (±0.08)	10.58 (±0.06)	13.30 (±0.06)	20.82 (±0.06)
Gross return (INR/ha)	16790.40 (±107.50)	16819.34 (±96.74)	21014.00 (±156.40)	33103.80 (±102.22)
Net return (INR/ha)	4576.52 (±168.26)	3944.50 (±120.09)	7159.58 (±182.69)	13875.02 (±111.70)
B:C ratio	0.399 (±0.01)	0.33 (±0.01)	0.534 (±0.016)	0.727 (±0.006)

The net returns were INR 6,717 higher per hectare at demonstration plots (INR 13,875 per ha) than at the traditional plots (INR 7,159 per ha). Implementing the project raised the net returns at both the demonstration plots (by 81.53%) and the local check plots (by 56.44%), and it reduced the variation in net returns at the demonstration plots. The B:C ratio increased 120% at demonstration plots and 33.83% at local check plots.

The results of the difference in differences estimator revealed that the coefficient of post (time) term was statistically significant at 1% level of significance and had a positive sign. This means that wheat yield was trending up over time. The coefficient of the treatment term had a negative coefficient, which indicates that the wheat yield at the demonstration and local check plots was the same before the project was implemented.

The coefficient of the interaction term (treat × post) had a positive coefficient of 7.502, and it was statistically significant at 1% level of significance. That indicates that the project has increased the yield of wheat in the cluster of villages where the project had been implemented.

The coefficients of age, education, and family size had negative signs, but the coefficients of farming experience, size of holding, and area under wheat had positive signs. However, only the coefficients of age and farming experience were significantly related to wheat yield in selected cluster of villages.

Difference in differences

The double difference regression model was employed to analyse the impact of wheat production technology demonstrated under the Farmer FIRST programme (Table 8). The regression estimates supported the double difference estimates along with the inclusion of growers' socio-economic variables for relaxing the stringent parallelism assumption associated with simple differences.

The coefficient of the treatment variable (β_1= -4.763) estimated the mean difference in wheat yield between the treatment and control groups prior to the implementation of project. Therefore, β_1 represents whatever "baseline" differences existed between the groups before the intervention was applied to the control group.

Similarly, the coefficient of post variable (β_2 = -7.485) provides the expected mean change in outcome from before to after the start of the project among the control

Table 9 Difference-in-differences estimator using ordinary least square (OLS)

Variable	Coefficients	Standard error	t-value
Constant	16.005***	0.458	34.933
Treat	–4.763***	0.231	–20.582
Post	–7.485***	0.215	–34.852
Treat × post	7.502***	0.134	56.033
Age of household head	–0.015***	0.004	–4.399
Formal education of household head	–0.004	0.009	–0.429
Farming experience of household head	0.011***	0.004	2.718
Family size	–0.060	0.041	–1.462
Operational holding	0.030	0.043	0.685
Average area under wheat	0.224	0.363	0.616
F value	2350.19***		
Adjusted R^2	0.933		

***Significant at 1% level

group. Therefore, β_2 reveals the pure effect of time in the absence of the actual intervention. The coefficient of treat × post ($\beta_3 = 7.502$) represents the difference in differences estimator, which reflects the expected mean change in outcome in the two groups before and after project implementation.

Conclusions

Rain-fed farming is entirely dependent on timely, adequate rain; therefore, production risks and uncertainty cause large variations in productivity in the same agroecological situation, and farmers are reluctant to adopt new interventions. Considering the vagaries of rain-fed farming, demonstrations on the recommended wheat production technology were conducted on farmers' fields under the Farmer FIRST programme. The results of the difference in differences estimator revealed a significant increase in the wheat yield of demonstration plots, and the consistent implementation of the recommended technology minimized the variation in yield under similar agroecological situations. Extension agencies should adopt a cluster approach and focus on the horizontal expansion of rain-fed technologies across different farms. Reducing the variation in yield in a cluster in rain-fed ecosystems helps in building the confidence of farmers in adopting innovative methods and practices.

References

Al-Feel, M A, and A A R AL-Basheer. 2012. Economic efficiency of wheat production in Gezira scheme, Sudan. *Journal of the Saudi Society of Agricultural Sciences* 11 (1): 1–5. https://doi.org/10.1016/j.jssas.2011.08.001

Chapagain, T, and A Good. 2015. Yield and production gaps in rainfed wheat, barley, and canola in Alberta. *Frontiers in Plant Sciences* 6: 990. 10.3389/fpls.2015.00990.

Dhaka, B, B S Meena, and R L Suwalka. 2010. Popularization of improved maize production technology through frontline demonstrations in south-eastern Rajasthan. *Journal of Agricultural Sciences* 1 (1): 39-42. 10.1080/09766898.2010.11884652

Edreiraa, J I R, N Guilpart, V Sadras, K G Cassman, M K vanIttersum, R L M Schils, and P Grassini. 2018. Water productivity of rainfed maize and wheat: a local to global perspective. *Agricultural and Forest*

Meteorology 259: 364–373. https://doi.org/10.1016/j.agrformet.2018.05.019

Ghuman, B S, and H S Sur. 2001. Tillage and residue management effects on soil properties and yields of rainfed maize and wheat in a subhumid subtropical climate. *Soil & Tillage Research* 58: 1–10. https://doi.org/10.1016/S0167-1987(00)00147-1

Hiremath, S M, and M V Nagaraju. 2009. Evaluation of front line demonstration trials on onion in Haveri district of Karnataka. Karnataka *Journal of Agricultural Sciences* 22 (5): 1092–1093.

Hussain, A, A Saboor, M A Khan, A Q Mohsin, and F Hassan. 2012. Technical efficiency of wheat production in rainfed areas: a case study of Punjab, Pakistan. *Pakistan Journal of Agricultural Sciences* 49 (3): 411–417.

Khan, N, and A Bano. 2019. Exopolysaccharide producing rhizobacteria and their impact on growth and drought tolerance of wheat grown under rainfed conditions. *PLoS One* 14(9):e0222302.doi: 10.1371/journal.pone.0222302.

Kumar, S., V Mahajan, P K Sharma, and S Parkash. 2019. Impact of front line demonstrations on the production and productivity of moong (Vigna radiata L), mash (Vigna mungo L), rajmash (Phaseolus vulgaris L), lentil (Lens culinaris L) and chickpea (Cicer aeritinum L) under rainfed ecology in mid hills of J&K, India. *Legume Research* 42 (1): 127–133. doi: 10.18805/LR-3816.

Mburu, S, C Ackello-Ogutu, and R Mulwa. 2014. Analysis of economic efficiency and farm Size: a case study of wheat farmers in Nakuru district, Kenya. *Economics Research International* 802706. http://dx.doi.org/10.1155/2014/802706

Pal, B D, and S Saroj. 2019. Do improved agricultural practices boost farm productivity? The evidence from Karnataka, India. *Agricultural Economics Research Review* 32 (Conference): 55–75. https://doi.org/10.5958/0974-0279.2019.00017.X

Palanisami, K., C R Ranganathan, D Suresh Kumar, and R P S Malik. 2014. Enhancing the crop yield through capacity building programs: application of double difference method for evaluation of drip capacity building program in Tamil Nadu State, India. *Agricultural Sciences* 5 (1): 33–42. http://dx.doi.org/10.4236/as.2014.51003

Rao, C A R, J Samuel, S Kumar, B M K Raju, R Dupdal, and B Venkateswarlu. 2014. Role of technology and credit in improving farm incomes in rainfed regions in Andhra Pradesh. *Agricultural Economics Research Review* 27 (2): 187–198. 10.5958/0974-0279.2014.00023.8

Samui, S K, S Maitra, D K Roy, A K Mondal, and D Saha. 2000. Evaluation on frontline demonstration on groundnut. *Journal of Indian Society of Coastal Agriculture Research* 18 (2): 180–183.

Sharma, P K, and S Prakash. 2015. Economic Evaluation of Technology for Promoting Pulses Production in Poonch district of Jammu & Kashmir. *Journal of Community Mobilization and Sustainable Development* 10 (1): 29–33.

Uma, C. 2017. Determinants of technical efficiency of wheat production in Ethiopia: a review. *Journal of Economics and Sustainable Development* 8 (19): 11–15.

Vaid, A, P K Sharma, V Mahajan, B Ajrawat, A Jamwal, S Gupta, and V K Sharma. 2017. Economic impact of frontline demonstrations on basmati rice. *Agro Economist - An International Journal* 4 (2): 79–83. 10.5958/2394-8159.2017.00014.7