Hossain *et al. CABI Agriculture and Bioscience* (2024) 5:53
https://doi.org/10.1186/s43170-024-00257-8

CABI Agriculture and Bioscience

RESEARCH Open Access

Women-led community institutions as a potential vehicle for the adoption of varieties and improved seed practices: an impact case from India

Mosharaf Hossain[1*], Swati Nayak[2], Subhasmita Mohapatra[1], Pooja Trivedi[3] and Showkat A. Waza[4]

Abstract

Rice–wheat rotation is the principal cropping system in South Asian countries. Increasing productivity under this cropping system in Northern India is not only a policy priority but also an important component towards ensuring food and nutritional security for the major portion of the Indian population. The objective of enhanced productivity is being pursued through innovative extension models focusing on the adoption of modern varieties and community-led seed production. The present experimental study (a randomized control trial) was conducted in Uttar Pradesh (India) to evaluate the efficacy of community institutions [e.g., women self-help group (WSHG)] based seed interventions in promoting the adoption of improved varieties amongst farmers. Besides, the impact on the implementation of quality seed production practices, adoption of seed quality measures, and participation in capacity-building trainings were also evaluated. The findings infer that implementing seed scaling programs through community institutions leads to a significantly higher rate of technological adoption than that executed through non-collectivized ways. Besides, farmers from WSHGs have more tendency towards learning new technologies and participating in training programs about improved crop management practices. The study also explains that WSHG-based programs are not a contributory factor in advancing farm technologies that are already in practice, such as seed cleaning and germination tests. This validated model can be suitably replicated for accelerated dissemination of seed-related innovations.

Keywords Innovative extension, Randomized control trial (RCT), Women self-help group (WSHG), Varietal adoption, Quality seed production (QSP)

Introduction

Rice–wheat cropping sequence is the world's largest agricultural production system and the lifeline for billions of people in South Asia. This system is India's most widely adopted cropping pattern prevalent in the Indo-Gangetic plains of the country (Bhatt et al. 2016). It acts as a source of food and nutritional security for millions of people, besides being one of the major contributors of foreign exchange through exports. The productivity under this cropping system largely determines the nation's food security and the general welfare of the farmers (Mahajan

*Correspondence:
Mosharaf Hossain
s.hossain@irri.org
[1] International Rice Research Institute, Varanasi, India
[2] International Rice Research Institute, Los Banos, Philippines
[3] Catalyst Management Services, Bengaluru, India
[4] MCRS Sagam, SKUAST Kashmir, Jammu and Kashmir, India

and Gupta 2009). Although the green revolution technologies have significantly contributed towards enhancing the yields, the productivity under this system is still lower than its actual potential, thereby making it relatively less remunerative. With more than 50% of India's population engaged in agriculture, the rice–wheat cropping system warrants evaluating and adopting all sustainable farm innovations for enhancing productivity and profitability (Dar et al. 2020a, b, c). Advancement of research programs in India has introduced several productivity-boosting scientific innovations, but most revolve around developing and disseminating crop varieties. Thus, a major share of scientific efforts to raise crop productivity is about farmers' enhanced access to quality seeds of improved cultivars (Dar et al. 2020a, b, c). However, the efforts to improve seed security and its availability to farmers have yielded mixed results. The interventions aimed at improving access to quality seed by farmers as a productivity-enhancing measure have not shown uniform and positive results across the setups (Kiptot et al. 2006). Development, subsequent transfer, and availability of the technology cannot ensure its adoption, and consequently, cannot achieve maximal benefits to its end users. Appropriate extension models and the recipients' characteristics often play a crucial role in stimulating farmers' adoption decisions for a new technology like a crop variety (Brennan and Byerlee 1991). Besides, the adoption of improved varieties results from an intricate interplay of a range of technical and socio-economic factors which are constantly evolving in developing countries like India (Kumar et al. 2021). Therefore, farmers' adoption challenges are often multidimensional, thus requiring an in-depth analysis to formulate the appropriate policy and planning strategies (Bannor et al. 2018). Some of the strategies require capital-intensive measures like investment in infrastructure and research and developmental activities. India has taken several transformative approaches [including establishing Krishi Vigyan Kendras (KVKs), Agriculture Technology Management Agency (ATMA), etc.] to fast-track its technology adoption programs amongst the farming community (Kumar et al. 2019). Nevertheless, a streamlined and innovative extension approach can accelerate the adoption of new technology in the target geography (Tin et al. 2001).

In recent times, the role of women farmers has been greatly emphasized for faster diffusion of agriculture innovations (Singh et al. 2018). Besides, it has been observed that the extension programs implemented through collectivized and non-collectivized women farmers show differential adoption rates (Tanellari et al. 2014). Technological interventions such as capacity building for quality seed production when channelled through group-based women farmers result in enhanced technical know-how and improved adoption of the improved varieties (Dar et al. 2019). However, there are only a few studies that have been conducted to test this hypothesis and have not been evaluated scientifically and neither the processes nor the outcomes have been documented sufficiently. Despite several research efforts toward understanding the adoption dynamics across different conditions and contexts, a research gap exists in building empirical knowledge about seed diffusion through collectivized women-focused extension models (Manzanilla et al. 2014). A science-based evaluation methodology appropriately attributing the measurable impacts to such specially designed interventions needs to be employed for conclusive research findings (Diiro et al. 2018).

In this context, a randomized control trial (RCT) based experiment was conducted in Eastern Uttar Pradesh to evaluate the efficiency of the WSHG-based extension strategy towards enhancing varietal awareness. Besides, the adoption of improved varieties for demonstrated rice–wheat cropping systems, implementation of other seed technology practices, and consequential enhancement in yield were also investigated. The impacts of WSHG-based extension on implementing quality seed production practices, adopting seed quality measures, and participating in capacity-building trainings were also evaluated. RCT-based evaluation is nowadays widely being used to quantify and attribute the desired impact of extension programs (Ban et al. 2020).

Materials and methods

The study area and design

The study was carried out in 100 Gram Panchayats (GPs) uniformly distributed across four districts of Eastern Uttar Pradesh (Varanasi, Jaunpur, Ghazipur, and Chandauli) where rice–wheat rotation is the most prevalent cropping system. In the experimental area, rice is grown in the wet season followed by wheat as the dry season crop. The study area is characterized by the dominance of traditional rice and wheat varieties with very low adoption of improved cultivation practices. Observational pieces of evidence suggest that farmers in the study area use farmer-saved seeds of traditional varieties, thus realizing very low crop yields. The lack of technical know-how among the farming community seems to be the major reason for the usage of farm-saved seeds of traditional varieties. Besides, appropriate and systematic efforts for strengthening the farming systems were not visible among farmers in the study area. Further, farmers in the present study were almost similar concerning their technical know-how and cultivation practices.

The study involves a total of five groups which were compared to evaluate the impact of the interventions

(Table 1). 100 selected GPs were randomly assigned to three treatment (T1, T2 and T3) and two control (C1 and C2) groups. Two of the three treatment groups (T1 and T3) comprised WSHG farmers and T2 had non-WSHG farmers. The two control groups consisted of WSHG farmers (C1) and non-WSHG farmers (C2). A total of 1000 women farmers, 10 from each GP were randomly selected, considering their association or otherwise with WSHGs. In the treatment GPs, a total of 600 women farmers (one from each household) were selected and randomly classified into three experimental groups of 200 each. Similarly, in the control GPs, a total of 400 women farmers were randomly allocated into two groups of 200 each. Throughout the data collection phase, 45 respondents were unavailable, resulting in their exclusion from the study. Table 1 displays the count of valid respondents accordingly. Only the T1 group received seed-based interventions, and no such interventions were realized by any other group. In the present study, two-stage randomization, one at the level of Gram Panchayats and the other at the level of WSHGs/non-WSHGs groups was carried out to evaluate the impact of the interventions. In 2018, the baseline study recorded relevant key indicators of the experimental groups and subsequently, the intervention was implemented for two cropping seasons during 2018–19. In 2019–20, the endline survey was carried out and the attainment of predefined indicators was assessed in an RCT framework. This study wanted to establish the effect of collective-based interventions in comparison to non-collectivized women farmers. So, the experiment highly emphasized the importance of collectivization to promote good agricultural practices like improved seed management activities.

Intervention implementation

The experiment consists of three major interrelated interventions (treatments) viz., awareness regarding improved varieties of rice and wheat, providing the seed of rice varieties as mini-kits, and training on farmer-centered quality seed production to orient the farmers to produce quality seed on their farms. In quality seed production training, the thematic areas like seedbed preparation, seed treatment, germination test, roughing, seed drying, and scientific seed storage were the major training components. The study has analysed the key seed-related practices important for production and productivity enhancement. However, when farmers are not capacitated, the adoption of these practices is very low, limiting productivity. This experiment specifically wanted to explore how quickly farmers can learn and adopt these essential seed practices if and when they are exposed to training and knowledge enhancement programs.

Varietal awareness programs were organized before the onset of sowing seasons, and the potential benefits of improved varieties over the popular traditional cultivars, such as Moti, Damini, and Swarna in rice, were communicated to the target farmers. Keeping in view the high frequency of droughts of varying degrees in the study area, the cultivation of Sahbhagi Dhan (a recently bred drought-tolerant variety of rice) was advocated and distributed amongst the target farmers. On the other hand, PBW-343, an improved wheat variety was provided to the farmers for better yield and rust resistance. This wheat variety was considered a better alternative to popular wheat varieties such as Safed Bali, HD-2285, and Lal. The program allocated mini kits of 10 kg to each of the selected farmers. Subsequently, the same farmers received three-day long quality seed production (QSP) trainings to understand the importance of quality seeds and the practical know-how regarding their output. The first training was conducted before the onset of the sowing season followed by a refresher training before harvesting each rice and wheat crop. Seed treatment, germination test, roughing, seed drying, and scientific seed storage were the major training components. The participants were capacitated to produce quality seeds and market them locally to fellow farmers who otherwise used to plant farm-kept seeds of poor standard. All these interventions were bundled into one program and implemented amongst the target farmers

Table 1 Experimental groups and their description

Group	No. of respondents	Nature of the group	Intervention
T1	194	WSHG households in treatment GPs that were randomly selected to receive intervention	Awareness of modern rice and wheat varieties, distribution of rice seed mini-kits, and training in QSP
T2	187	Non-WSHG households in treatment GPs	None
T3	197	WSHG households in treatment GPs without intervention	None
C1	188	WSHG households in control GPs	None
C2	189	Non-WSHG households in control GPs	None

in the above-mentioned framework. The objective was to understand if the intervention and its mode of implementation, i.e., through WSHGs is significantly impactful. The experiment was initiated in the kharif season of 2018 and continued till the end of rabi 2018–19.

The randomization process occurred prior to the implementation of interventions. Initially, the gram panchayats (GPs) participating in the study were randomly assigned to either the treatment or control group. Subsequently, a secondary randomization was conducted within the treatment GPs. Within these treatment GPs, households belonging to self-help groups (SHGs) were either randomly chosen to receive the intervention or designated as part of the control group. Moreover, members of the treatment group were selected randomly for program participation.

A larger sample size increases the statistical power of the assessment of a treatment. When the effect size is seemingly small, a large sample size is required to get a given level of power. A program evaluation experiment with low take-up needs a larger sample. The study followed this statistical principle in calculating a tenable sample size.

Before the introduction of the interventions, it was ensured that there were no pre-existing differences in the experimental groups. The baseline survey collected several characteristics for each household in the sample. These include ownership of a BPL card, housing structure, number of migrant members, land holdings, and many others like seed production practices, seed treatment, management practices, and adoption of modern varieties for staple cereals, i.e., rice and wheat. It was done through an informal survey/interaction in the selected gram panchayats (both intervened and non-intervened ones).

Impact evaluation framework

The impact evaluation was carried out for the farmers' collectivization (i.e. WSHG vs. non-WSHG) and technological intervention. Comparing the outcomes will help evaluate the impact of the interventions and suggest measures to enhance the impact.

Comparison of T1 and C1

The comparison estimates the direct impact of the treatment on intervened WSHG households.

Comparison of T1 and T2

The comparison helps to understand the impact of farmers' collectivization (WSHGs) on technological adoption in intervened GPs.

Comparison of T3 and C1

The comparison measures the spillover impact on non-intervened WSHG households in the treatment GPs.

Comparison of T2 and C2

The comparison estimates the treatment effect on non-WSHG households within the treatment GPs.

The performance of the seeds and varieties is important for farm income. The experiment laid much emphasis on capacity-building initiative and their impact on the adoption of improved varieties, the practice of quality seed production, the adoption of seed-saving practices, and seed quality maintenance, like seed treatment, and seed cleaning. The study also investigated if group-based intervention affects the farmers' participation in the capacity-building programs.

Based on the aforesaid comparison criteria, sample statistics were calculated for each relevant indicator across the five experimental groups. A positive difference between the comparison groups was considered to be a change and therefore may be attributed as a possible impact of the collectivization and/or intervention. Subsequently, such indicator-wise changes among different groups were tested for their significance using appropriate statistical tests, depending on the variable type and the distribution. The significance of the difference for a specific parameter across experimental groups was calculated using the arithmetic mean and its subsequent validation through the two proportion Z tests (using crosstabs and Chi-Square test). Data processing and analysis were carried out using IBM SPSS software. To understand the program's effect on ensuring the participation of farmers in the trainings, the fixed effect regression model as given below was employed.

$$Y = \alpha + \beta_1 \text{ treatment arm} + \varepsilon,$$

where Y is the outcome expressed as a binary (participation or non-participation) variable and β_1 is the regression coefficient of the treatment group and ε is the error term.

Results and discussion

Adoption of the improved varieties of rice and wheat

A comparison of the endline adoption rates of the improved varieties of rice and wheat revealed that WSHGs in the treatment group (T1) had the highest level of adoption viz., 27.8% for Sahbhagi Dhan (rice) and 21.8% for improved PBW-343 (wheat) (Figs. 1 and 2, respectively). Interestingly, C1 (WSHG farmers in the control group) had an adoption rate of only 2.8% for

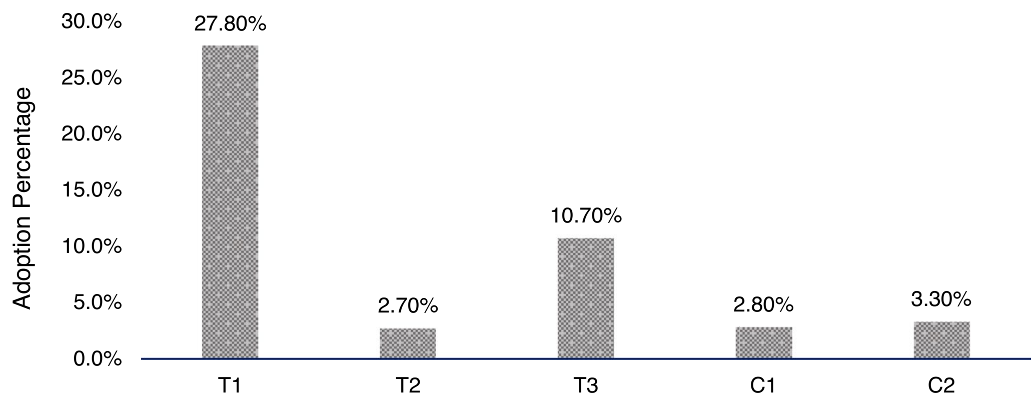

Fig.1 Adoption of Sahbhagi dhan (improved rice variety) across the experimental groups

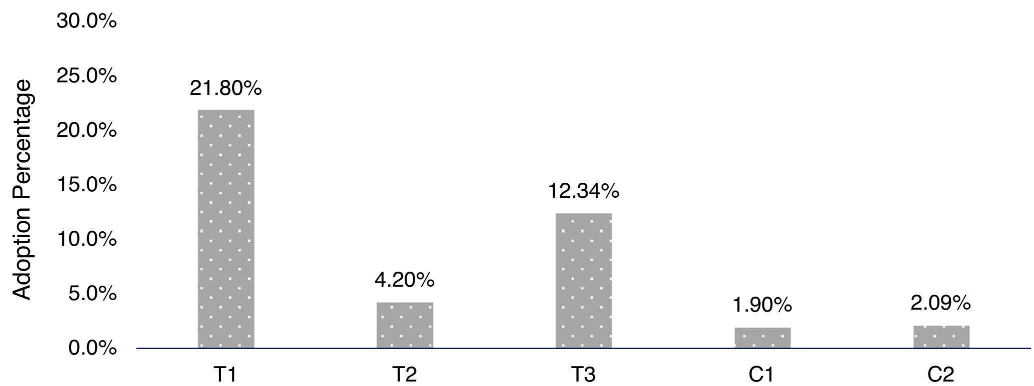

Fig. 2 Adoption of improved PBW-343 (improved wheat variety) across the experimental groups

Sahbhagi Dhan. The difference of 25% between the two groups was found to be statistically significant. In the case of wheat, the difference between T1 and C1 was found to be 19.9% which was also statistically significant. These findings suggest that when farmers' collectives (WSHGs) were used as units of intervention for varietal dissemination, the impact was substantial and noticeable. Without intervention exposure, even WSHG farmers fail to adopt a good variety on the desired scale.

The results of the comparison between T1 and T2 to evaluate the WSHG effect were also significant. The difference in adoption rates was 25.1% and 17.6% for rice and wheat, respectively. Both statistically significant values underline the effect of WSHGs in promoting the adoption within the intervened GPs. T2 represents non-collectivized farmers and shows low adoption rates for both rice and wheat varieties. The findings support the better effectiveness of the farmer's collectives in varietal dissemination. Likewise, the comparison between adoption rates of T3 and C1 measures the spillover effect of the interventions on collectivized farmers. The difference in adoption rates for rice and wheat was 7.9% and 10.4%, respectively. The values are statistically significant and show the importance of WSHGs in technology dissemination. T3 farmers were not directly intervened but they existed in close vicinity of the intervened farmers. Similarly, the insignificant differences between adoption rates of T2 and C2 plausibly explain that the intervention is not satisfactorily effective when undertaken with non-WSHG farmers even if they reside in the vicinity of the intervened farmers. The findings have been presented in Figs. 1 and 2.

Performance of Sahbhagi Dhan and improved PBW-343

Any new variety to be introduced must possess certain features for its acceptance and adoption amongst the farmers. One of the most preferred characteristics of rice and wheat varieties is yield potential. Okello et al. (2019) in similar studies observed that adopting new crop varieties depends upon seed quality. The significant yield advantage of a variety acts as a strong trigger for its adoption. Selecting an appropriate extension model is important for obtaining maximum benefits from the innovation (Veerabhadraiah 2012). In this study, the

Table 2 Productivity of the improved varieties distributed amongst the farmers

Rice		Wheat	
Variety	Yield (t/ha)	Variety	Yield (t/ha)
Sahbhagi Dhan	4.18	Improved PBW 343	5.4
Traditional varieties	3.77	Traditional varieties	4.51
Yield gain	0.41[a]	Yield gain	0.89[a]

[a] Significant at 5% level of significance

Table 3 Seed production in rice by different experiment groups

Treatment group	Proportion of farmers who produced rice seeds (%)	P-value (at α = 0.05)	If difference is significant
T1	8.2	0.003	**
C1	1.6		
T2	5.9	0.028	**
C2	1.6		
T3	4.6	0.093	NS
C1	1.6		

**Significant at a 5% level of significance, NS = not significant

Table 4 Seed production in wheat by different experiment groups

Treatment group	Proportion of farmers who produced wheat seeds (%)	P-value (at α = 0.05)	If difference is significant
T1	8.2	0.000	**
C1	0.5		
T2	5.9	0.061	NS
C2	2.1		
T3	4.7	0.012	**
C1	0.5		

**Significant at a 5% level of significance, NS = not significant

Table 5 Average seed production by a farmer across the experimental groups

Treatment group	Rice (kg)	Wheat (kg)
T1	106.6	114
T2	46.7	82
T3	55.6	111
C1	76.7	75
C2	56.7	94

average yield advantage of the new rice and wheat varieties across all the groups was observed to be considerable and statistically significant (Table 2). However, the adoption rate is skewed towards the intervened WSHG farmers. The findings of this study imply that introducing new technologies through collectivizations such as WSHGs is a much more effective extension model for enhancing the adoption of new technologies than through non-collectivized farmers. Since Sahbhagi Dhan is a drought-resilient variety of rice and improved PBW-343 is a rust-resistant wheat variety, their adoption will help the farmers cope with environmental stress more efficiently. Even after knowing the superiority of the varieties, their adoption may remain low when non-WSHG extension models are employed.

Impact on seed production

The intervention implemented was intended to encourage the farmers to quality seed production to meet their seed requirements as well as the requirements of their fellow farmers. Overall, 4.4% of farmers produced rice seeds while maintaining the minimum quality standards as taught in the QSP training program. In line with the afore-discussed comparative trend, T1 showed the highest proportion of farmers who produced rice seeds (8.2%). While comparing T1 with C1, T1 reported 6.6% more cases of seed production than C1, and the differential effect was significant. Similarly, T2 has 4.3% more seed producers than C2. This difference is statistically significant and suggests that non-WSHG farmers in the treatment GPs have been influenced by the WSHG farmers as well as by the intervention. However, the estimated difference of 3% between T3 and C1 is statistically insignificant, suggesting that the spillover effect of QSP trainings is inconsequential (Table 3).

In the case of wheat, the difference between T1 and C1 was found to be 7.7%, which is significant enough to support the claim that WSHG-based intervention is an efficient pathway in promoting seed production activities. However, the difference in the proportion for T2 and C2 farmers was insignificant indicating the program's inefficiency when implemented through non-WSHG mode. This further suggests that even though T2 farmers were in the intervened GPs, the indirect impact was not significant. Unlike in rice, a significant difference of 4.2% was observed between T3 and C1 farmers in the case of wheat (Table 4). It explains a spillover effect on non-intervened WSHG farmers, residing in the neighbourhood of the T1 farmers and indirectly exposed to the interventions. The different trends in the spillover effects of the two crops may be attributed to a relatively lower proportion of farmers of C1 farmers producing wheat seeds.

The average quantity of rice seed produced by an individual farmer in a cropping season was estimated to be 106.6 kg in T1, while it was less than 77 kg for the other groups (Table 5). In the case of wheat as well, T1 farmers produced the highest average quantity of seeds

(114 kg). It indicates the impact of collectivization on initiatives such as seed production.

Share of varieties in seed production

The study has observed the substantial adoption of improved rice and wheat varieties viz., Sahbhagi Dhan and improved PBW-343. The adoption was also reflected in seed production, where farmers could choose several other existing varieties. The majority of the farmers who opted for seed production selected these two varieties. For rice, 45.2% of the farmers selected Sahbhagi Dhan for seed production; while the proportion of farmers who chose improved PBW-343 for this activity was 39%. The next most preferred variety for rice was Ganga Kaveri (26.2%) and for wheat was Safed (29.3%). The cultivation of other varieties for seed production has been presented in Fig. 3.

The experiment also made a comparative assessment between baseline and end-line data on seed production practices amongst the different groups. It revealed a substantial increase in the proportion of farmers producing seeds over the baseline data. For instance, T1 registered a 5.1% increase in the number of seed-producing farmers (Fig. 4). Such a deviation validates the positive impact of WSHG-led seed intervention in encouraging the farmers to quality seed production. Moreover, this finding is indicative of the effectiveness of the training program in motivating the farmers

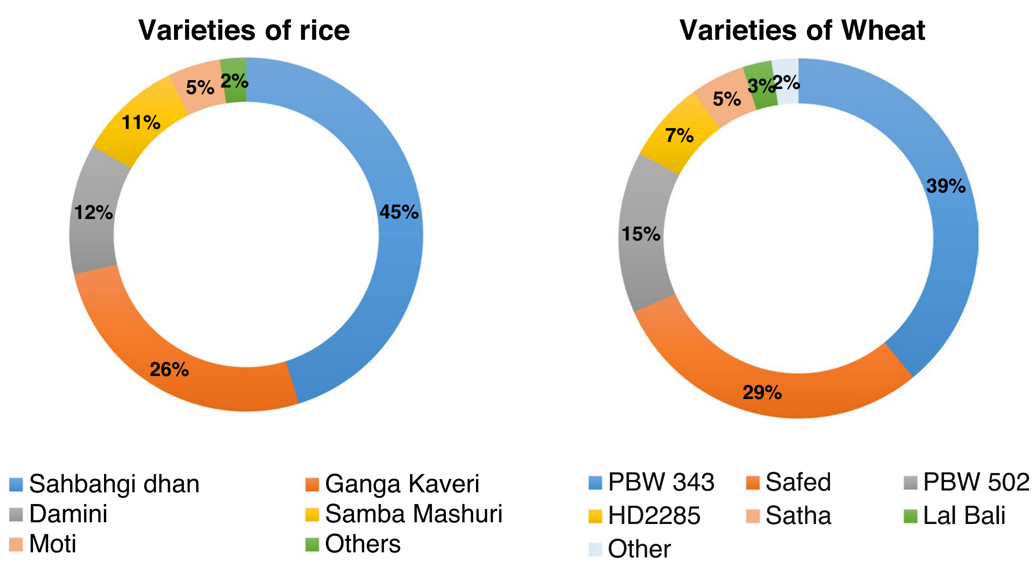

Fig. 3 Share of varieties adopted for seed production in rice and wheat

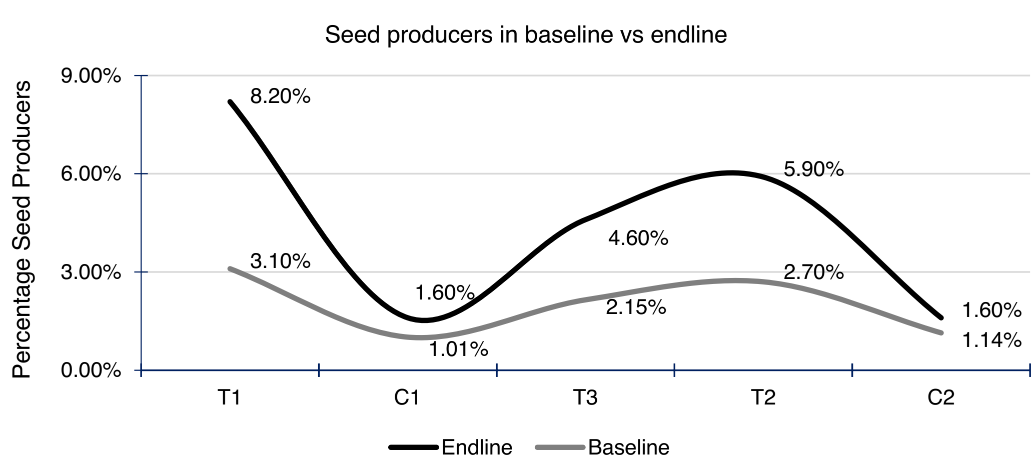

Fig. 4 Comparative data on seed production in baseline and endline surveys

to quality seed production. A significant impact of the training programmes on quality seed production has also been demonstrated in the studies by Bahtiar et al. (2021). Seed production can be a complex practice depending on the access to early-generation seeds, strict field monitoring and certification processes, and assured market for the produce. So, the number of farmers who opted for seed production was small.

Seed saving practices

The measure of the success of the awareness creation strategies for a new variety in a specific market segment and the subsequent adoption of that variety by farmers is determined by the actual number of farmers who opt to grow the variety in subsequent seasons. This emphasizes the importance of seed-saving practices by the farmers who are exposed to the improved varieties. Seed saving by farmers not only strengthens an uninterrupted adoption but also promotes varietal dissemination since farmer-to-farmer seed sharing and exchange is a common phenomenon among Indian farmers (Coomes et al. 2015). The average quantity of seed saved per farmer for own usage ranged from 3 to 9 kg in rice and 4–12 kg in wheat (Fig. 5). Generally, farmers in treatment groups tend to retain relatively larger quantities of seed than the farmers in control GPs. T1 farmers retained about 5 kg and 7 kg of rice and wheat, respectively than C1 farmers. This highlights the effectiveness of WSHGs in mobilizing farmers towards seed saving. Seed saving can also help disseminate improved varieties (Boef et al. 2021). Surplus seed (over and above the saved quantity) was either shared or sold to other farmers, mostly in the same GP.

Source of seed

Considering all the treatment groups together, retail seed shops were the most preferred source for seed procurement (42.6%). The other common sources were general shops and farmer-to-farmer exchanges. Together, these three sources provided seeds to 80% of the farmers. However, a significant proportion (29.1%) of T1 farmers reportedly sourced their seed requirement from the WSHG-run seed scaling program. A large extent of seed sourcing from WSHGs in T1 experimental groups demonstrates a strong intra-group seed transaction, indicating the possibility of seed self-sufficiency when WSHGs are programmatically targeted. Before the program (intervention), WSHG farmers sourced merely 2.2% of their seed requirement (Fig. 6) from any other similar WSHG arrangement. Such outcomes fairly indicate that a seed scaling program launched can substantially increase the seed supply by the WSHGs in the interest of the farming community. Boef et al. (2021) demonstrated that the involvement of WSHGs in seed systems increases access to new varieties for poor farmers. The statistical significance of the differential effect among the studied groups has been presented in Tables 6 and 7.

Seed quality maintenance

The seeds procured, irrespective of the sources (formal or informal), must go through certain easy-to-do farmer-level practices to minimize the quality-linked yield losses. However, farmers often do not strictly follow these physical tests and practices. As part of the quality seed production training program, target farmers were trained on the importance and procedures of the three critical seed quality boosting practices i.e., seed cleaning, seed treatment, and germination test. As per the experimental plan, the effectiveness of the intervention was analyzed after four seasons by comparing the baseline and endline

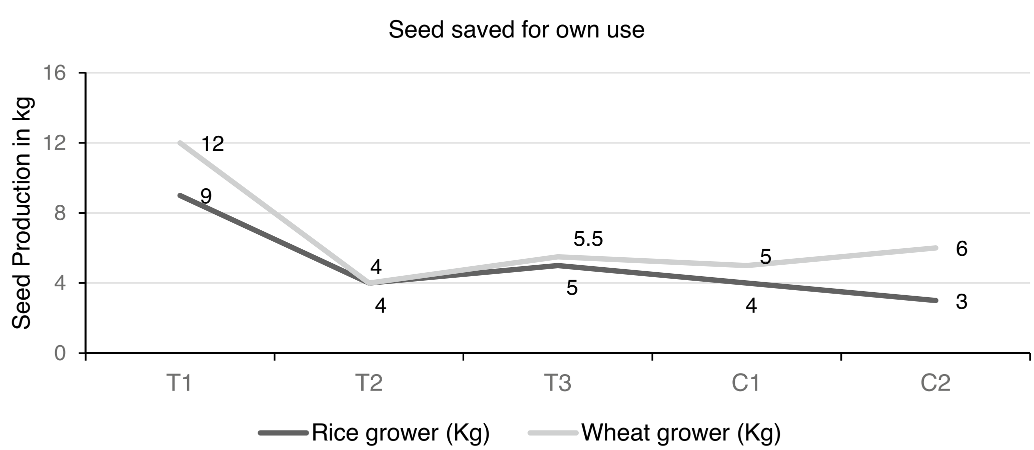

Fig. 5 Seeds saved for own use by farmers

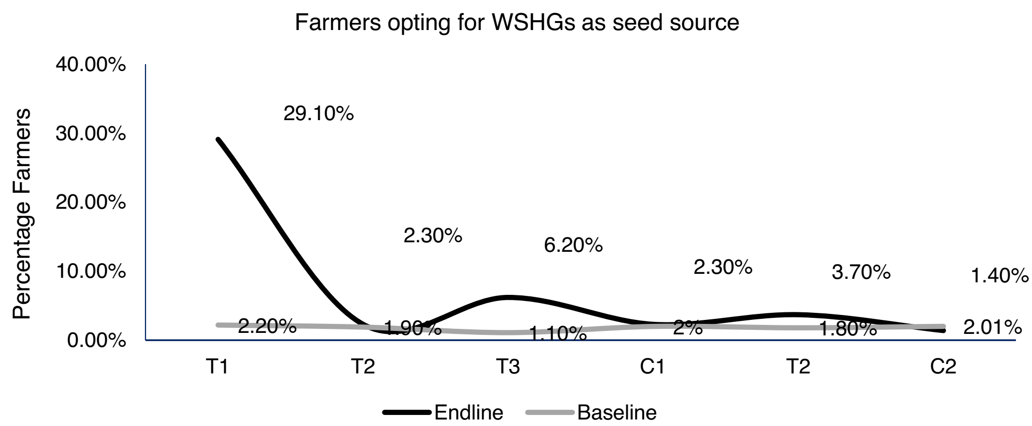

Fig. 6 Proportion of farmers opting for intervened WSHGs as the source of seed

Table 6 Proportion of farmers across different experimental groups with WSHG-based seed program as a source of rice seeds

Treatment group	Farmers with WSHG scaling program as a source of their seed (%)	P-value (at α = 0.05)	If difference is significant
T1	29.1	0.000	**
C1	2.3		
T2	3.7	0.135	NS
C2	1.4		
T3	6.2	0.041	**
C1	2.3		

**Significant at a 5% level of significance, NS = not significant

Table 7 Proportion of farmers across different experimental groups with WSHG-based seed program as a source of wheat seeds

Treatment group	Farmers with WSHG scaling program as a source of their seed (%)	P-value (at α = 0.05)	If difference is significant
T1	27.3	0.000	**
C1	0.5		
T2	1.1	0.153	NS
C2	0.0		
T3	10.9	0.000	**
C1	0.5		

**Significant at a 5% level of significance, NS = not significant

data as well as the inter-group statistics obtained from the endline data.

Seed cleaning

Pre-sowing practice is recommended to clean the seeds of all physical impurities. Baseline findings revealed that the number of farmers who adopted the practice was quite high and ranged from 84.2 to 90.0%. However, a noteworthy increase was reported in T1 as the percentage of farmers in this group who adhere to the seed cleaning practices rose by 14.2%. The difference in the proportion of farmers undertaking the activity in baseline and endline surveys, across other experimental groups, was not very high except for T1 (14.2%) (Fig. 7). Such an outcome establishes the fact that the seed cleaning initiative, as a part of the WSHG-led QSP program, is highly effective in persuading more farmers to adopt this important practice.

Seed treatment

Unlike seed cleaning which was a widely adopted practice across the groups, even prior to the intervention, chemical treatment of seeds was followed only by small proportion of the farmers. Following the seed program, there was a substantial increase in the proportion of farmers who adopted this seed quality assuring measure. An increase in 26.8% was observed among the T1 farmers who recognized chemical treatment of seeds as an essential practice (Fig. 8). The number of farmers conducting seed treatment was significantly higher by 33% higher in T1 than in C1 after the intervention. Similarly, the number of farmers undertaking the activity in T3 was substantially higher (14.5%) as compared to those in C1, thus indicating a possible spill over effect from intervened WSHGs to non-intervened WSHG farmers. However, difference between T2 and C2 was insignificant, thereby suggesting that mere intervention may not result in desirable outcomes, if it is not targeted through the appropriate route.

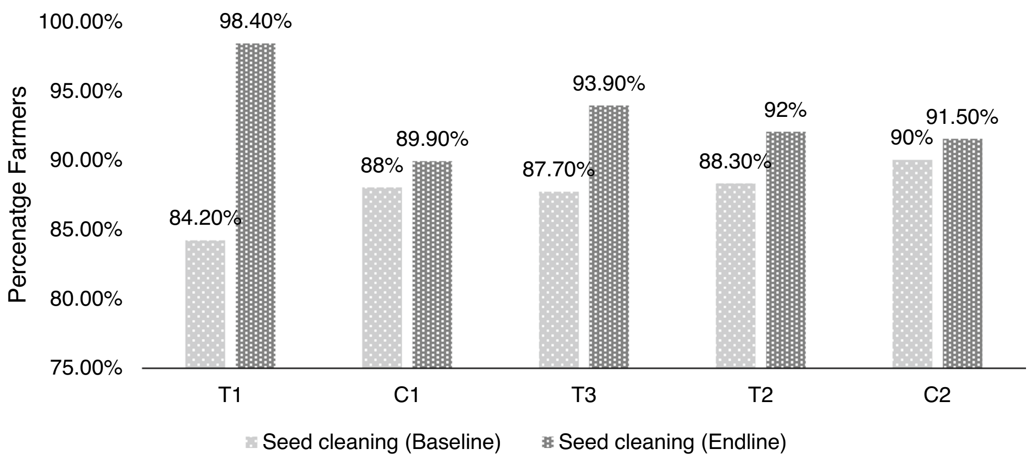

Fig. 7 Practice of seed cleaning across experimental groups

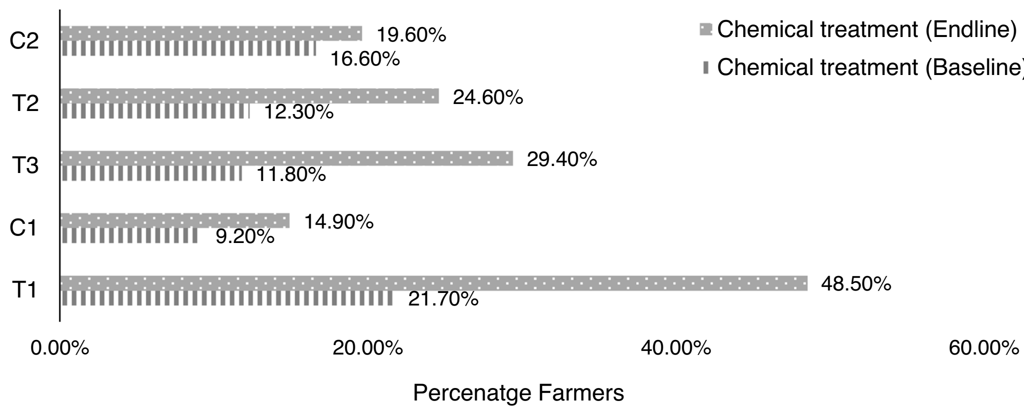

Fig. 8 Practice of chemical treatment of seed across the experimental groups

Germination test

Germination test is a highly recommended practice to ensure that farmers sow the seeds with an acceptable level of germination for a good harvest. In this study, this simple but crucial test was found to be a popular practice across all the groups. The WSHG based program resulted in a marginal increase in terms of the proportion of farmers who followed the germination test (Fig. 9), with an insignificant difference between treatment and control groups. The large number of farmers practicing germination testing could partly explain the minimal increase (in a treatment group), leaving a little scope for its further increase.

Program effect on participation in the trainings

Besides the training program in quality seed production, the WSHG program has organized several trainings for the farmers in the treatment groups specific to rice and wheat crop management practices. Since the WSHGs as social units supposedly empower women members in the areas of health and nutrition, they also conducted quarterly trainings in the two areas. To analyse the effect of an intervention on participation in the trainings, a simple regression model was used. In the model, the dependent variable indicates participation in the trainings (Table 8). The dependent variable (participation) is binary, where 1 corresponds to participation and 0 to non-participation. The regression output reveals that participation in all training themes like rice, wheat, health and nutrition is significant for WSHG farmers with the intervention. Therefore, if any programmatic intervention with a strong training component is executed through WSHGs, the outcomes will be desirable (Kalra et al. 2013).

Conclusions

The WSHG-based seed program was mainly intended to promote the adoption of improved varieties and encourage the practice of quality seed production. The

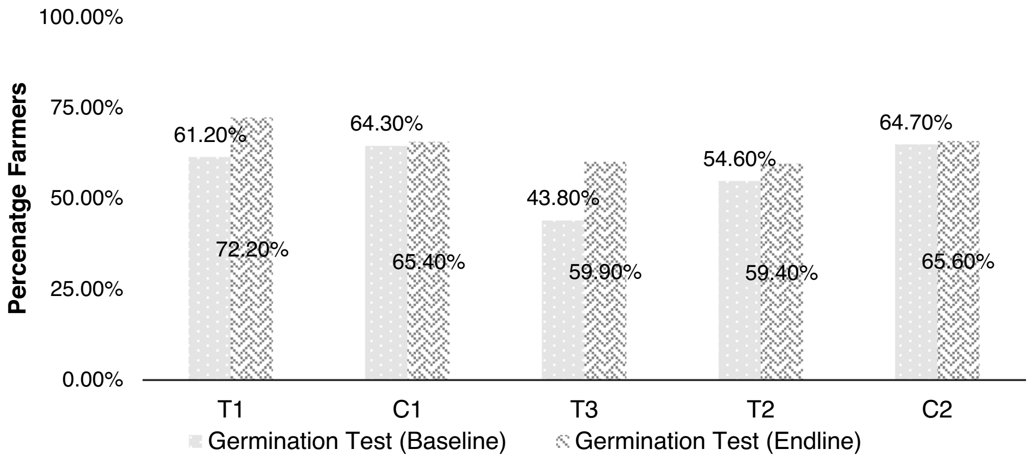

Fig. 9 Practice of germination test across the experimental groups

Table 8 Intervention effect on participation in different training programmes

Treatment	Group type	Training theme/subject matter			
		Rice	Wheat	Health	Nutrition
T1	WSHG farmers in treatment GPs with intervention	0.323***	0.251***	0.282***	0.103***
T2	Non-WSHG farmers in treatment GPs with intervention	−0.00678	0.0244	0.0554	0.0360*
T3	WSHG farmers in treatment GPs without intervention	0.0357	0.0574	0.0526	0.0196
C2	Non-WSHG farmers in control GPs	−0.0713	−0.0299	−0.0351	0.0209

***Significant at 1% level of significance

*Significant at 10% level of significance

incremental differences for various parameters, viz., varietal adoption, seed production, and seed quality enhancement measures were significant between intervened WSHGs in the treatment and control groups. With the RCT-based empirical analysis, such positive changes conclusively imply the advantage of using WSHGs for program delivery. Therefore, the results encouragingly recommend the diffusion of new and improved agro-technologies through WSHGs. Comparison between non-intervened WSHGs in the treatment GPs and WSHGs in the control GPs, which explains the spillover impact of WSHG farmers, was an important research objective in the present study. Adoption of the varieties, sourcing seeds from WSHGs, and chemical treatment of seeds were the cases in which a significant spillover impact was observed. These research findings validate the notion that even if WSHG farmers are not programmatically intervened but are located in the vicinity of the intervened recipients, substantial crossover benefits of the program may be ascertained. This assumption can be an important guiding principle for program design and implementation. Moreover, the present findings suggest that if a program intends to increase the participation of farmers in various capacity-building activities, implementation through the WSHG model can be significantly effective. These findings can help formulate training outreach programs. Further, any attempt towards popularizing the technology that is already in practice (e.g., seed cleaning, germination test, etc.) may not show a further enhancement in adoption even through the WSHG-based interventions. Such findings suggest carefully considering the baseline data and exploration of the different dissemination strategies.

Acknowledgements

The authors are highly appreciative of the respondents who provided their time and occupational information to the researchers.

Author contribution

In producing the manuscript, all five authors conceptualized the study. MH, and SN collected, analyzed, and built the first draft of the manuscript. SM, PT, and SAW read the first draft and second draft of the manuscript. All the authors were engaged in the revisions of the manuscript.

Funding

The experiment was originally grounded with funding support from a non-government organization RGMVP (Rajiv Gandhi Mahila Vikas Pariyojna) for carrying independent evaluation of their initiatives with WSHGs. However, the expanded research study and detailed analysis and interpretations were further supported through CGIAR IRRI SeedEqual initiatives (Grant No. A-2021-136).

Availability of data and materials
The dataset used in this experiment is shared as supplementary materials in Excel format.

Declarations

Ethics approval and consent to participate
Due consent was obtained from the competent authority and respondents to participate in the experiments and survey. The authors further confirm that this work has been conducted with the ethical approval of the relevant bodies.

Consent for publication
The authors confirm that the manuscript has been read and approved by all the named authors. The order of the authors listed in the manuscript has been approved by all.

Competing interests
The authors confirm that there are no known conflicts of interest associated with this publication and there is no significant financial support for this work, apart from the mentioned donor, that could have influenced its outcome.

Received: 13 October 2023 Accepted: 28 May 2024
Published online: 10 June 2024

References
Bahtiar, Aqil M, Azrai M. The role of institutions in enhancing farmer motivation to carryout corn seed production under corporation system. IOP Conf Ser Earth Environ Sci. 2021;911: 012082. https://doi.org/10.1088/1755-1315/911/1/012082.
Ban R, Gilligan MJ, Matthias R. Self-help groups, savings and social capital: evidence from a field experiment in Cambodia. J Econ Behav Organ. 2020;180:174–200. https://doi.org/10.1016/j.jebo.2020.09.029.
Bannor RK, Kumar GA, Keyeremh HO, Wongnaa CA. Adoption and impact of modern rice varieties on poverty in Eastern India. Rice Sci. 2018;27(1):56–66. https://doi.org/10.1016/j.rsci.2019.12.006.
Bhatt R, Kukal SS, Busari MA, Arora S, Yadav M. Sustainability issues on rice–wheat cropping system. Int Soil Water Conserv Res. 2016;4(1):64–74. https://doi.org/10.1016/j.iswcr.2015.12.001.
Brennan J, Byerlee D. The rate of crop varietal replacement on farms: measures and empirical results for wheat. Plant Var Seeds. 1991;4:99–106. https://doi.org/10.1016/0305-750X(95)00162-6.
Coomes OT, McGuire SJ, Garine E, Caillon S, McKey D, Demeulenaere E, Jarvis D, Aistara G, Barnaud A, Clouvel P, Emperaire L, Louafi S, Martin P, Massol F, Pautasso M, Violon C, Wencélius J. Farmer seed networks make a limited contribution to agriculture? Four common misconceptions. Food Policy. 2015;56:41–50. https://doi.org/10.1016/j.foodpol.2015.07.008.
Dar MH, de Janvry A, Emerick K, Kelley EM, Sadoulet E. Endogenous Information Sharing and the Gains from Using Network Information to Maximize Technology Adoption. UC Berkeley: Center for Effective Global Action 2019. Retrieved from https://escholarship.org/uc/item/8qx7m4zq
Dar MH, Waza SA, Shukla S, Zaidi NW, Nayak S, Hossain M, Singh US. Drought tolerant rice for ensuring food security in Eastern India. Sustainability. 2020a;12(6):2214. https://doi.org/10.3390/su12062214.
Dar MH, Waza SA, Nayak S, Chakravorty R, Zaidi NW, Hossain M. Gender focused training and knowledge enhances the adoption of climate resilient seeds. Technol Soc. 2020b;63: 101388. https://doi.org/10.1016/j.techsoc.2020.101388.
Dar M, Dwivedi R, Nayak S. Creating market linkage and demand for new climate resilient rice varieties through innovative agriculture extension method. Int J Bus Glob. 2020c;1:1. https://doi.org/10.1504/IJBG.2020.10032640.
de Boef WS, Singh S, Trivedi P, Yadav KS, Mohanan PS, Kumar S, Yadavendra JP, Isaacs K. Unleashing the social capital of self-help groups for strengthening seed systems in Uttar Pradesh, India. Global Food Secur. 2021;29: 100522. https://doi.org/10.1016/j.gfs.2021.100522.
Diiro GM, Seymour G, Kassie M, Muricho G, Muriithi BW. Women's empowerment in agriculture and agricultural productivity: evidence from rural maize farmer households in western Kenya. PLoS ONE. 2018;13(5): e0197995. https://doi.org/10.1371/journal.pone.0197995.
Kalra RK, Anil B, Tonts M, Siddique KHM. Self-help groups in Indian agriculture: a case study of farmer groups in Punjab, Northern India. Agroecol Sustain Food Syst. 2013;37(5):509–30. https://doi.org/10.1080/10440046.2012.719853.
Kiptot E, Franzel S, Hebinck P, Richards P. Sharing seed and knowledge: farmer to farmer dissemination of agroforestry technologies in western Kenya. Agrofor Syst. 2006;68:167–79. https://doi.org/10.1007/s10457-006-9007-8.
Kumar A, Singh AK, Saroj S, Madhavan M, Joshi PK. The impact of India's farm science centers (Krishi Vigyan Kendras) on farm households' economic welfare: Evidence from a national farmers' survey". IFPRI Discussion Paper 1832. Washington, DC: International Food Policy Research Institute (IFPRI); 2019. https://doi.org/10.2499/p15738coll2.133226.
Kumar A, Tripathi G, Joshi PK. Adoption and impact of modern varieties of paddy in India: evidence from a nationally representative field survey. J Agribus Dev Emerg Econ. 2021;11(3):255–79. https://doi.org/10.1108/JADEE-11-2019-0198.
Mahajan A, Gupta RD. The rice–wheat cropping system. In: Integrated nutrient management (INM) in a sustainable rice—wheat cropping system. Dordrecht: Springer; 2009. https://doi.org/10.1007/978-1-4020-9875-8_7.
Manzanilla D, Paris TR, Tatlonghari GT, Tobias AM, Chi TTN, Phuong NT, Siliphouthone I, Chamarerk V, Bhekasut P, Gandasemtita A. Social and gender perspectives in rice breeding for submergence tolerance in Southeast Asia. Exp Aquac. 2014;50(2):191–215. https://doi.org/10.1017/S0014479713000409.
Okello DM, Bonabana-Wabbi J, Mugonola B. Farm level allocative efficiency of rice production in Gulu and Amuru districts, Northern Uganda. Agric Econ. 2019;7(1). https://doi.org/10.1186/s40100-019-0140-x
Singh G, Budhiraja P, Vatta K. Sustainability of farmer producer organisations under agricultural value networks in India: a case of Punjab and Gujarat. Indian J Agric Econ. 2018;73(3):370–85.
Tanellari E, Kostandini G, Bonabana-Wabbi J, Murray A. Gender impacts on the adoption of new technologies: the case of improved groundnut varieties in Uganda. Afr J Agric Resour Econ. 2014;9(4):300–8. https://doi.org/10.22004/ag.econ.197017.
Tin HQ, Berg T, Bjørnstad A. Diversity and adaptation in rice varieties under static (ex situ) and dynamic (in situ) management. Euphytica. 2001;122(3):491–502. https://doi.org/10.1023/A:1017544406975.
Veerabhadraiah V. Emerging Agricultural Extension Models. Indian Research Journal of Extension Education, special issue 2012.

Publisher's Note