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Participatory research approaches rapidly improve household food security in Nepal and identify policy changes required for institutionalisation

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ABSTRACT

The introduction, testing, promotion and release of a rice variety, BG 1442, in Nepal were examined in relation to existing policies governing these procedures and to how more participatory approaches could benefit food security. From 1998 to 2006, participatory varietal selection (PVS) was used to test BG 1442 and other candidate rice varieties in the spring (*Chaite*) rice-growing season (February to June) and in the main season (June to November). The testing of BG 1442 commenced 11 years after it was first introduced into Nepal in 1987 by the national rice research programme (NRRP). Following its initial acceptance by farmers, it was widely disseminated from 1998 by non-governmental organisations (NGOs) in the low altitude region of Nepal called the *terai* in projects funded by the Department for International Development (DFID), UK. This dissemination was done using a method termed informal research and development (IRD) where many small packets of seed were distributed without fertiliser or pesticides, the only additional input being a description of varietal characteristics on an enclosed leaflet. From 2001 to 2008, various assessments were made of its extent of adoption and its impact on livelihoods. In a randomised survey of households in 10 districts, BG 1442 increased from not being used at all in 1997 to being grown by about 20% of the surveyed rice farmers by 2008. It was grown both in the *Chaite* and the main season and was well adapted to the rainfed-upland and medium-land rice ecosystems. The variety was grown from the far west to the far east of low-altitude Nepal by resource-poor farmers. IRD was important in accelerating adoption and improving food security as it was by far the most important external source of seed for farmers. Prior to the adoption of BG 1442, farmers who did not harvest sufficient rice to last their households for 12 months increased rice self sufficiency by over 2 months (25% more). Those households that sold surplus grain and who grew BG 1442 increased grain sales by 600 kg (25% more) in the *Chaite* season and by 370 kg (24% more) from main season cultivation.

Compared with the conventional on-station variety testing and release, PVS can significantly reduce the time needed for testing and increase the benefits from plant breeding. However, the greatest impact of using more client-oriented approaches was not from PVS but from the subsequent IRD given that it was the major source of seed resulting in its wide use by 2008. This popularity certainly influenced the decision by the national programme to eventually release the variety. This demonstrated how the extent of adoption could be a useful criterion for release, particularly when experimental data has previously failed to establish the superiority of a variety. The benefits from using PVS and, particularly, IRD were very large as they reduced the time needed for variety testing and popularization and hence reduced the time needed to improve food security. However, NGOs cannot sustainably finance the use of IRD and if it is to become a routine part of the national research and extension system then government needs to change policies to routinely use PVS and IRD. The regulatory framework needs to pay more attention to farmers' preferences and make the process of official release or registration simpler and faster. The diversion to NGOs of some of the resources currently allocated solely to governmental organisations would allow NGOs to participate sustainably in varietal testing and dissemination.

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1. Introduction

Participatory varietal selection (PVS) allows farmers and other stakeholders, such as seed producers and traders, researchers and extension workers, to evaluate the suitability of a wide range of new varieties, both released and unreleased, in trials conducted by farmers' in their own fields using their own management (Joshi and Witcombe, 1996; Witcombe et al., 1996). This research approach for identifying superior varieties is relevant for remote and marginal areas as well as for high potential production systems (Joshi and Witcombe, 2002). PVS has been used in many crops and countries, and more recent examples include Witcombe et al. (2003) in maize, Ferrara et al. (2007) in wheat, and Tiwari et al. (2009) in maize. There are many examples of PVS on rice (*Oryza sativa* L.) including: Joshi and Witcombe (1996), Joshi et al. (1997), Witcombe et al. (2001), Gridley et al. (2002), Joshi and Witcombe (2002), and Joshi et al. (2007).

PVS, apart from identifying varieties that farmers prefer to grow, accelerates varietal adoption and spread and enhances food security through the improved yield and stress tolerance of the new varieties (Joshi and Witcombe, 1996; Joshi et al., 1997, 2005; Witcombe et al., 1999). Informal research and development (IRD), is a much-simplified and less intensive approach. It was initiated at the Lumle Agricultural Research Centre, Nepal in 1990 (Joshi and Sthapit, 1990) at a time when conventional breeding followed by extension had not benefited smallholders in remote, marginal and difficult areas. This approach emphasised increased varietal adoption rather than data collection for research and was particularly suitable for increasing the flow of new genetic materials to areas lacking an effective formal seed supply system (Joshi and Sthapit, 1990; Joshi et al., 1997).

Although there are many papers on PVS most concentrate on the PVS process itself. Very few of such papers have examined the socioeconomic or institutional impacts of participatory research or how it is constrained by the regulatory framework for variety testing and release. Lilja and Erenstein (2002) describe how evidence from these approaches is important for strategic decision makers in overcoming resistance by national systems to adopt participatory research methods. Tiwari et al. (2010) reported that PVS can greatly contribute to improved food security by addressing the issues of social exclusion and discrimination based on gender, ethnicity and caste and that it can have important institutional impacts in making the research and development process more inclusive and demand-driven.

In this paper, we use the rice variety BG 1442 as a case study to examine the social impacts of PVS and IRD, particularly on food security, and present and future institutional impacts on release policy and varietal testing and popularisation. BG 1442 was chosen because it was the most widely adopted rice variety of more than 50 varieties that had been tested by PVS in Nepal, despite it having not been released by the National Rice Research Programme (NRRP) after a decade of evaluation. We examine the social impact of PVS and IRD by assessing the extent to which they have influenced the adoption of BG 1442 and the significance of this adoption on food security and improved livelihoods. For institutional impacts, we review how participatory research has impacted on official policy, including the eventual release of BG 1442, and discuss the further policy changes needed to facilitate the sustainable use of participatory research and extension.

2. Materials and methods

2.1. Introduction, testing and promotion of BG 1442 in Nepal by the national research system

The testing and promotion of BG 1442 by the national government programme were reviewed from the available literature, particularly from the data included in the release proposal for this variety by NRRP (Anonymous, 2004, obtained from National Seed Board (NSB)). Other sources were two NGOs: the Local Initiatives for Biodiversity, Research and Development (LI-BIRD) and the Forum for Rural Welfare and Agriculture Reform for Development (FORWARD). The variety was also tested by the Lumle Agricultural Research Centre (LARC) at the same time as the earlier years of testing by NRRP (the early nineties). No data were available from LARC following a major reorganisation in 1997 so we relied on the knowledge of scientists who worked in this institution.

2.2. Evaluation and promotion of BG 1442 by participatory research projects in Nepal

The Department for International Development (DFID) Plant Sciences Research Programme (PSP) funded projects from 1996 to 2006 in Nepal in two complementary themes; Participatory Crop Improvement (PCI) and the Promotion of Rainfed *Rabi* Cropping (RRC) in rice fallows of India and Nepal. The lead organisations were LI-BIRD for the PCI project and FORWARD for the RRC project. Scientists from the Centre for Advanced Research in International Agricultural Development (CARIAD), Bangor University, UK (at that time called CAZS) supported both projects. They covered districts in the low altitude region called the *terai* (Fig. 1) and in some of these both PVS and subsequent IRD were done ('intensive districts') and in others only IRD was employed ('extensive districts'). Several District Agriculture Development Offices (DADOs) of the Department of Agriculture (DoA) and other NGOs, e.g., the Social Upliftment through Participatory Programmes, Research and Training (SUPPORT) Foundation and the Community Development and Research Centre (CDRC) also collaborated in popularising BG 1442.

The PVS trials (Table 1) included mother trials that consisted of all the new test entries in single replicates of a randomised complete block design using the most widely grown farmers' variety as a control (mostly CH 45 but also Chaite 4 and Bagari). The farmer decided the agronomic management of the trial and the plot size varied with the land available. Researchers collected quantitative data including yield. In each village, a matrix ranking of important varietal traits was done jointly with participating and other interested neighbouring farmers when the crop was near to maturity. Post-harvest interviews with the participating farmers were done to include traits such as milling recovery, cooking and eating qualities, and market price.

2.3. Promotion of BG1442 through IRD

In the IRD (Table 1), BG 1442 was promoted along with several other rice varieties also identified by PVS. Farmers received either a 1 kg or 2 kg bag of seed (this varied with the organisation involved and seed availability) that usually contained a leaflet that described the varietal characteristics. Seed was distributed to farmers in villages that were chosen according to priorities established in the projects. In each village, the NGO handed over the seed bags to farmers' groups who distributed them to their members. The DADOs supplied the bags to government agricultural service centres that distributed them to farmers on a first-come, first-served basis. In all cases records were kept of the recipient farmers.

2.4. Impact assessment by Monitoring Impact and Learning (MIL) of the DFID Research into Use Programme (RiUP), 2008

Two studies included an assessment of the adoption and impact of rice variety BG 1442, and were done in 2008, through the MIL component of the RiUP, across 10 districts of the *terai* (Fig. 2). Both the studies were done from July 2008 to January 2009. The design of the survey and quality control of the field surveys by NGOs was

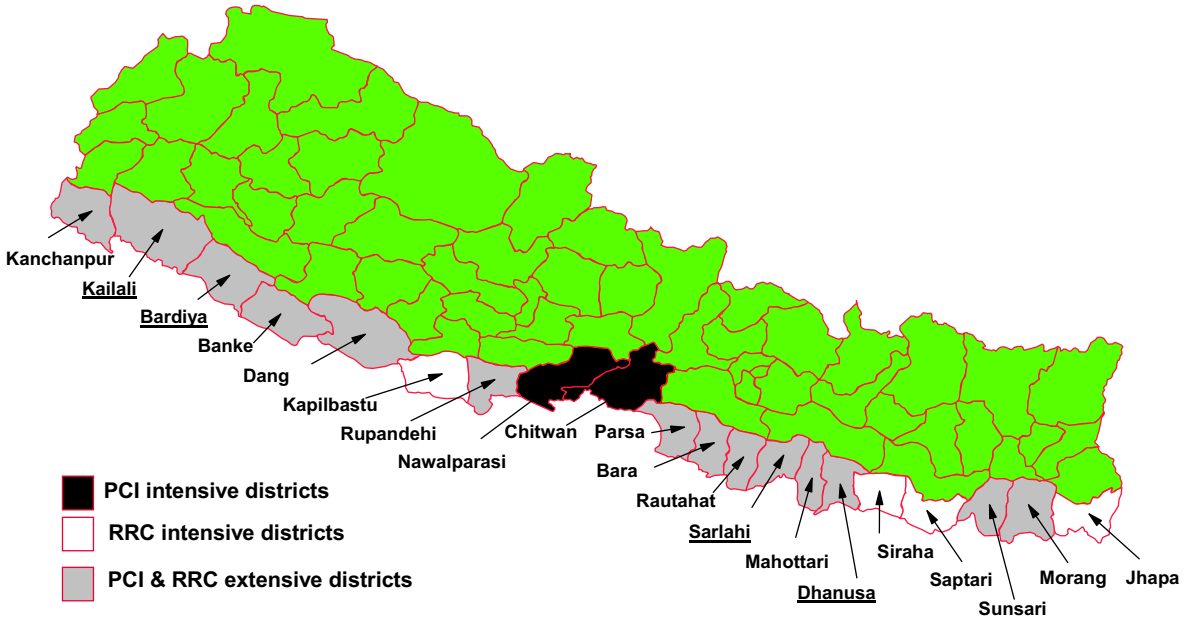

Fig. 1. Districts where the PCI and RRC projects worked in the Nepal *terai*. The resources used by the projects varied by district (indicated by shading).

Table 1
Verification and promotion of BG 1442 in participatory research projects in Nepal, 1998–2004.

Year	Organisation	PVS mother trials or IRD	Number of		
			Locations for PVS/IRD	PVS trials	IRD
1995	LARC	PVS	2	10	0
1998	LI-BIRD	Mother trial (MT)	3	9	0
2000	LI-BIRD	IRD	9		100
2001	LI-BIRD	MT, IRD	4	20	300
2000	DADO Chitwan	IRD	27		300
2001	DADO Chitwan	IRD	27		600
2001	CBOs	IRD	20		280
2002	CBOs	IRD	10		150
2002	LI-BIRD	MT, IRD	3	3	900
2003	LI-BIRD	MT, IRD	3	13	590
2002	FORWARD	MT, IRD	3	3	650
2003	FORWARD	IRD	4	0	800
2004	FORWARD	IRD	4	0	500

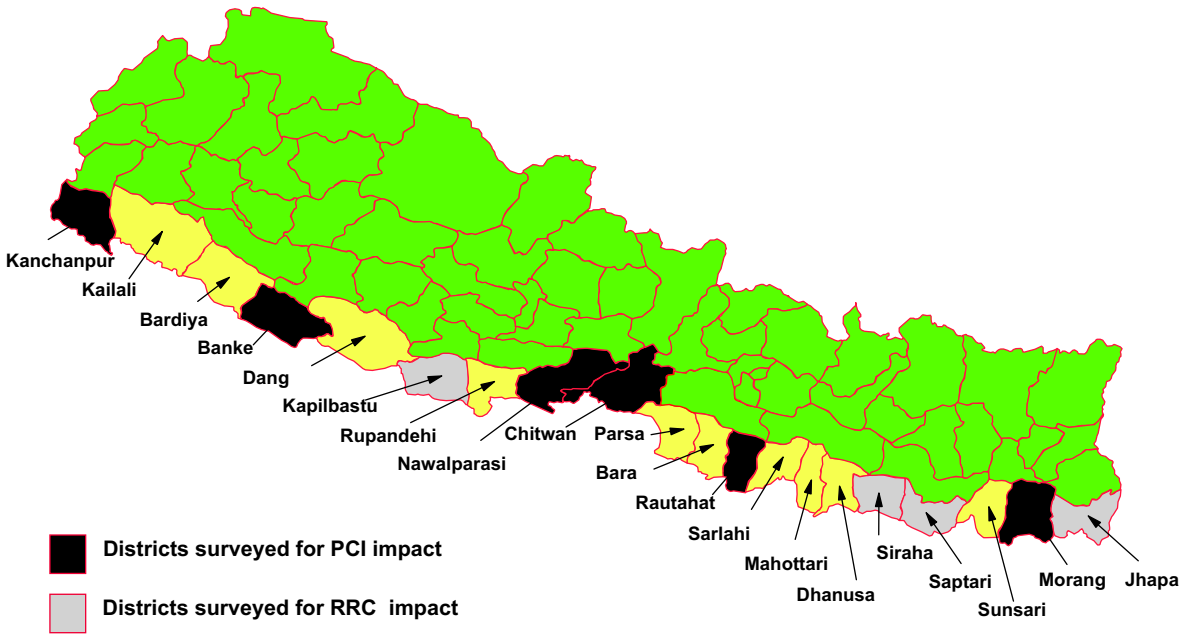

Fig. 2. Impact assessment for PCI and RRC projects in the selected districts of *terai*, 2008.

done by scientists from the MIL component, and CARIAD scientists analysed the survey data.

2.4.1. Assessment of PCI project (COB and PVS projects)

Surveys were made in six villages in each of six selected districts (Fig. 2) where rice varieties, either identified using PVS or bred in Nepal using participatory client-oriented breeding (COB) (Witcombe et al., 2005, 2006) were evaluated and promoted by the projects. In each village, group discussions were conducted by enumerators from LI-BIRD with key informants and household members. The boundary for the village was set by the participants according to where they collectively had sufficient information to answer questions on the rice crop and rice varieties. A sketch map of the village was drawn on paper and households were listed by name along each village path. The group then identified households along the paths where at least one of the members lived, either as users (grew one or more of 14 COB and 4 PVS rice varieties in either the Spring of 2007 or in the main season of 2008 or both) or as non-users (grew none of them). Across all of the 36 villages, that had to have at least 12 users to be included in the analysis, this produced a list of 2222 rice-growing households of which 1022 were identified as users and 1200 as non-users.

Individual interviews of household heads or their spouses were then made of 10 randomly selected users and four randomly selected non-users. A member (or members) of each of 344 user households and 139 non-user households were interviewed (fewer than the targeted 360 and 144, as no substitutions were made if a farmer could not be interviewed) to complete a structured questionnaire that provided detailed information on the rice varieties grown, on seed transactions including quantities, recipients and types of transaction. Users and non-users were asked if they knew about any of the COB and PVS varieties they were not growing and, for those they knew about, whether they intended to grow them or not.

Farmers were asked what their rice self-sufficiency and grain sales were both currently and prior to any adoption of a PVS or COB variety. To avoid any possible confounding effects of other PVS and COB varieties on the impact of BG 1442 the analysis presented in the 'Results' was done for BG 1442 growers who had not adopted any of the other PVS and COB varieties. An analysis of all BG 1442 growers was also made as a check (but not presented in the 'Results') and it gave very similar results to the analysis of the exclusive growers of BG 1442.

2.4.2. Assessment of rice-fallow rabi cropping (RRC) project

Using the same methods as the PVS and COB survey, group discussions were held in the four districts where the RRC project had been implemented from 2002 to 2006 (Fig. 2). Six villages where RRC project activities had started in 2004 were randomly selected per district except in one where only four villages were surveyed because there were insufficient users in the other two. The group discussions identified users and non-users, where the users were of RRC technologies: any one of 7 rice varieties, of 7 chickpea varieties, or 2 mungbean varieties, or one of the RRC-promoted agronomic techniques such as seed priming or improved composting.

Across the 22 villages 1381 households were identified in the group discussions, of which 646 were defined as users and 735 as non-users. From the lists for each village 12 users and 5 non-users were randomly selected for interview. In total, 287 user households and 96 non-users were interviewed compared with an expected 308 and 108 because substitutes were not used. The households provided detailed information on the rice varieties grown and their seed distribution.

Unlike the PCI project survey, questions were not asked on rice grain sales and rice self-sufficiency, but there were questions on the adoption of BG 1442 and the source of seed for that adoption.

2.5. Source of BG 1442, its production, distribution and sale

Annual records were collected of seed of BG 1442 produced and distributed or sold by the NRRP, PCI and RRC projects and compared with the original source of seed of BG 1442 identified in the PCI and RRC impact studies (above).

2.6. Rice variety release process in Nepal

The history of the rice variety release process and the number of varieties released per 5 years in Nepal was obtained from published data and related to the introduction of participatory research and PVS.

3. Results

3.1. Testing by NRRP and NGOs

BG 1442 was introduced from Sri Lanka in 1987 through the International Network for Genetic Evaluation of Rice (INGER) coordinated by the International Rice Research Institute (IRRI). The variety would have been tested in at least some of the years of 1987–1992 but no data were available. On-station research on BG 1442 by NRRP was reported from 1993 to 2004 in the variety release proposal that was only available from the National Seed Board on request (Table 2).

This testing followed the broad outlines of the scheme generally employed by NRRP (Fig. 3). On-station yield testing started with an initial evaluation trial (IET), followed by a coordinated varietal trial (CVT) having more test locations. Data were collected in the IET and CVT trials on distinctness, uniformity and stability (DUS). After this, BG 1442 was evaluated in on-farm trials called farmers' field trials (FFT) but was not promoted to the usual farmers' acceptance test (FAT). Normally, disease- and insect screening commences before or in the same season as the IET, and continues even after the release of a variety (Fig. 3), but no data were presented on the disease and insect resistance of BG 1442 until several years after it was first tested (Table 2).

Following this scheme (Fig. 3), the NARC research system requires at least 15 years to breed a new variety, to generate data to prove its distinctness, uniformity and stability, and to establish its value for cultivation and use (VCU). At least 9 years are needed for varietal testing under the current system even if a variety, such as BG 1442, is bred elsewhere and introduced into Nepal for testing. However, the national system took 17 years to release BG 1442 if 1987 is considered as its year of introduction.

The on-station yield trials conducted by NRRP in 1993, 1994, 2000 and 2001 all showed statistically significant differences between the test entries but the yield of BG 1442 did not differ significantly from that of the check varieties, CH 45 or Radha 4 (data not shown).

3.2. Testing and popularisation through IRD by NGOs

The PVS mother trials in 1998, 2001, 2002 and 2003 also failed to show any significant difference between BG 1442 and either CH45 or the best available alternative that the farmer used (data not shown).

Unlike the on-station research, the PVS trials facilitated the evaluation of multiple traits by farmers who could trade off the traits with each other, for example lower yield against higher grain quality, higher market price, disease resistance or earlier maturity.

Table 2
Introduction and testing of BG 1442 in on-station research by NRRP in Nepal, 1993–2003.

Years	Trial	Rice season and domain	Locations[a]
1993	Initial Evaluation Trial (IET) Early	*Chaite* rice (spring rice)	1
1994	Coordinated Varietal Trial (CVT) Early	*Chaite* rice	4
1996	Farmers' Field Trial Early (FFTE)	*Chaite* rice	1
1997	Farmers' Field Trial Early (FFTE)	*Chaite* rice	2
2000	IET Rainfed Lowland Early (RLE)	Main season rainfed lowland	2
2001	CVT RLE	Main season rainfed lowland	2
2001–2003	Disease and insect screening nurseries	Main season lowland early	1

[a] Three replicates at each location and one trial per location, except for the disease and insect screening nurseries that had a total of seven trials in one location over 3 years.

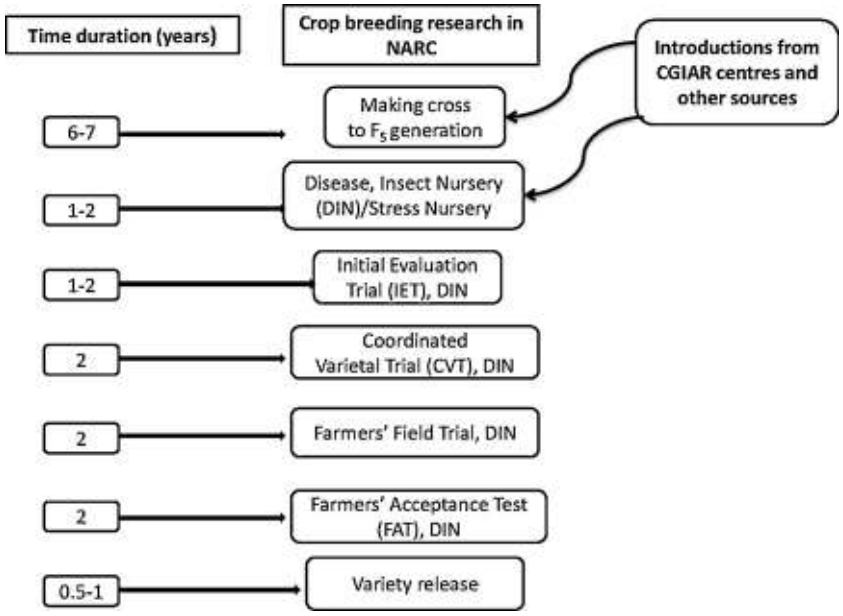

Fig. 3. Steps in crop breeding and variety testing research by the Nepal Agricultural Research Council.

However, in the matrix rankings the farmers' preferences for BG 1442 differed little from the widely grown CH 45. Prior to these trials participatory research at the Lumle Agricultural Research Centre (LARC) had shown that farmers liked BG 1442 for its good agronomic- and post-harvest traits in the low hills at the villages of Arghaun (900 masl), in Kaski district and at Yampaphant (475 masl) in Tanahun district.

Some of the researchers in the PCI and RRC projects had worked at LARC, were aware of these results, and so started the wider promotion of BG 1442 in these two projects. LI-BIRD, from 1998, and FORWARD, from 2002, encouraged community-based seed producer (CBSP) groups to produce substantial quantities of seed of BG 1442 (about 180 t over an 8-year period) to promote the variety through IRD across the *terai* (Fig. 1 and Table 1). These CBSPs were based in the districts of Kapilvastu (one), Chitwan (three), Saptari (two), and Jhapa (two).

The IRD began in Nawalparasi and Chitwan districts and the DADO in Chitwan distributed IRD sets in 27 villages in collaboration with LI-BIRD. IRD seeds were distributed in 20 villages in 2001 and 10 villages in 2002 in Nawalparasi district by three community-based organisations (CBOs) in collaboration with LI-BIRD. In total there were over 5000 IRD sets distributed by 2004.

3.3. Seed produced by NGOs and NRRP and seed sources used by farmers

The seed produced by CBSPs groups and distributed by the PCI and RRC projects was sufficient to plant 3500 ha of rice. Data for seed produced and distributed by NRRP were available only after 2003 and the potential area that could have been covered from this seed was over 800 ha (Fig. 4). The lower volume of seed production and distribution by NRRP was because it only produces breeder and foundation seeds and not certified seed.

The PVS and COB and RRC surveys of 2008 showed that these projects were the first source of seed for over half of the farmers that were growing BG 1442. In contrast to the NGO seed supply,

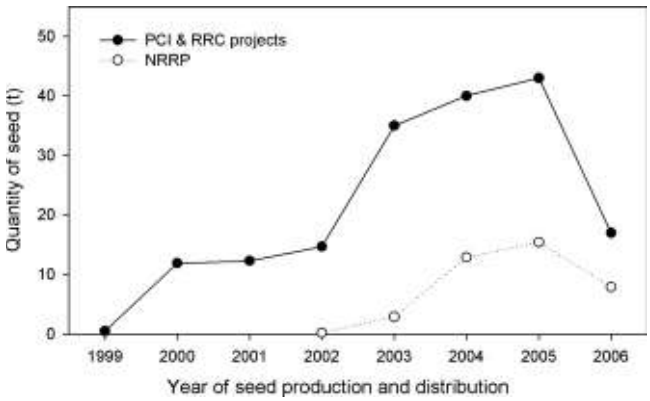

Fig. 4. Quantity of seed of BG 1442 produced and distributed by the NRRP, 2003 and 2006 and the PCI and RRC projects, 1999–2006. Data were unavailable from NRRP from 1999 to 2001.
Source: FORWARD, LI-BIRD and NRRP unpublished data.

Table 3
Primary sources of seeds of BG 1442 (% of all BG 1442 users) as reported in the PVS and COB study and the RRC study, 2008.

First source of BG 1442	PVS and COB study (% of 105 BG 1442 users)	RRC study (% of 106 BG 1442 users)
LI-BIRD	47.1	
FORWARD		53.6
SUPPORT Foundation	4.9	
CDRC	3.9	
Neighbours and other farmers	28.4	43.6
Relatives	4.9	
Market	10.8	0.9
Government farm		1.8

seed came from a Government agency only in the RRC survey and at a low frequency (Table 3). Neighbours and relatives accounted for nearly all of the remainder showing the variety had spread from farmer to farmer on a significant scale.

3.4. Adoption of BG 1442

BG 1442 was adopted across nine of the 10 study districts from the Far West to the Far East, the only exception being Banke (Table 4). This variety was adopted by 22% of all of the 2222 households in the group discussions in the six districts surveyed in the PVS and COB impact assessment. This is high given that the project had worked extensively in only two of the six districts. In the four RRC districts that were surveyed, where the project had worked intensively, 17% of all 1381 households in the group discussions grew BG 1442. However, this adoption was uneven with by far the highest adoption in Jhapa district where 83% of households grew it as a *Chaite* crop on an average of 0.46 ha compared with an average landholding size of only 0.8 ha.

BG 1442 was by far the most popular of the new varieties introduced from COB or PVS by the two projects in both the upland and medium land ecosystems (data not shown). The importance of seed multiplied by CBSPs and supplied using IRD by the NGOs varied greatly across districts but in all districts with high adoption it was an important source. Only in Rautahat district was there significant adoption without substantial seed supply by IRD among the users that were surveyed (Table 4).

Knowledge of BG 1442 had also spread. For households that were growing at least one PVS or COB variety but not BG 1442, 89% had heard of the variety and a third intended to grow it. Awareness was lower among the households that did not grow any of the new varieties but still 61% had heard of BG 1442, and 70% of them were intending to try it.

Table 4
The adoption of BG 1442 across the 10 study districts related to the importance of seed supplied using IRD by NGOs, from the PVS and COB and RRC surveys, 2008.

Source of data	District	Adoption of BG 1442 across both seasons (%)	IRD first seed source (%)
PCI and PVS survey	Kanchanpur	16	41
	Banke	0	0
	Nawalparasi	52	82
	Chitwan	19	77
	Rautahat	39	0
	Morang	12	24
	Overall	22	56
RRC survey	Kapilbastu	5	86
	Siraha	1	0
	Saptari	6	30
	Jhapa	83	52
	Overall	17	54

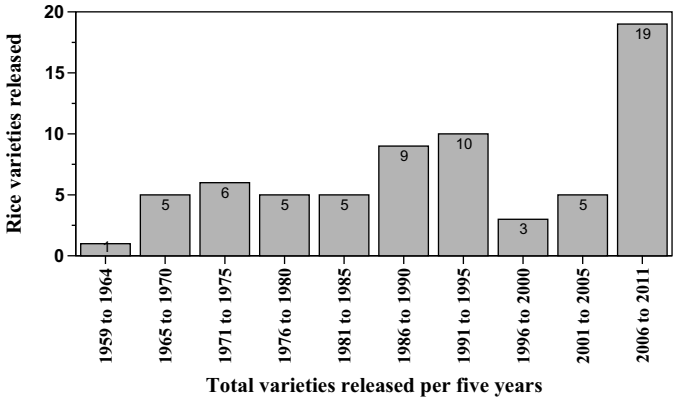

Fig. 5. Summary of rice varieties released in Nepal between 1959 and 2011. Figures displayed on the bar represent the number of released varieties per 5-year period except for 1959–1964 and 2006–2011, where the number of released varieties per 6 years is given.

3.5. Contribution of PVS and IRD to household food security

Farmers most commonly grew BG 1442 in the *Chaite* season and they reported substantial impacts. Previously rice-deficit households reported an increase in rice self-sufficiency of over 2 months (a 25% improvement). Grain-surplus households increased grain sales by 900 kg (a 24% improvement). However, about a third of farmers in the *Chaite* season reported there was no impact. They had, on average, grown BG 1442 for 2 years longer than those that reported benefits and the longer farmers had grown BG 1442 the more likely they were to report no benefit (e.g., 72% of farmers report no benefit who had adopted first in 2004 or earlier but 21% who first adopted after 2004). However, even if there was no benefit they were still preferring to grow it over alternatives and farmers may have found it more difficult to answer a question on benefits when the 'before' scenario was in the more distant past.

Advantages in the main season were very similar to those in the *Chaite* in relative gains, but in absolute terms the gains were lower; rice yields are lower in the rainfed main season compared with the *Chaite* season when crops receive more solar radiation and where water can be better controlled. Main season growers were more recent adopters than those in the *Chaite* season, by an average of a year (2006 compared with 2005) (Table 5).

3.6. Rice variety release in Nepal

Rice varietal improvement in Nepal has largely depended on the introduction and testing of finished varieties bred in other countries. About two thirds of all the varieties released since the early sixties and still recommended for cultivation were introduced from IRRI and other national programmes. In more recent years, from 2005 to 2011, the number of rice releases substantially increased (Fig. 5). A higher proportion of these more recently released varieties had been bred in Nepal and, for the first time, some were bred by actors other than NRRP. Three varieties were released from a COB programme jointly implemented by LI-BIRD and CARIAD, Bangor University with some support from NRRP while two were released from the in situ crop conservation project jointly implemented by LI-BIRD, NARC and Bioversity International. During this period another rice variety from COB, Barkhe 1027, was proposed by FORWARD, LI-BIRD and CARIAD and registered by the National Seed Board, rather than following the full release process that requires substantially more data and time.

Table 5
Effect on rice self-sufficiency and grain sales of BG 1442 of farmers who grew it in either the *Chaite* or the main season across four categories of improvement as reported by households, PVS and COB survey, 2008.

	BG 1442 growers reporting on rice self sufficiency and grain sales:			
	No improvement	Self sufficiency improved	Self sufficiency and grain sales improved	Grain sales improved
Chaite season crop				
Proportion of BG 1442 growers (%)[a]	32	34	6	27
Rice self-sufficiency before (months)		8.3	11.3	
Rice self-sufficiency after (months)		11.1	17.3	
Rice self-sufficiency increase (%)		25	53	
Grain sales before (kg)			0	3790
Grain sales after (kg)			475	4690
Grain sales increase (%)				24
Main season crop				
Proportion of BG 1442 growers (%)[a]	6	75		19
Rice self-sufficiency before (months)		7.2		
Rice self-sufficiency after (months)		8.6		
Rice self-sufficiency increase (%)		20		
Grain sales before (kg)				1490
Grain sales after (kg)				1860
Grain sales increase (%)				25

[a] In the *Chaite* season, the proportion of 65 farmers who grew BG 1442 in the *Chaite* season but grew no other PVS or COB variety in any season; in the main season, the proportion of 36 farmers who grew BG 1442 in the main season but not in the *Chaite* season and who also grew no other PVS or COB variety in either season.

4. Discussion

4.1. Adoption as a criterion for release

Of all of the possible ways of assessing the potential worth of a cultivar, i.e. its value for cultivation and use (VCU), the determination of the extent of adoption is the only one that directly measures farmers' and users' acceptance. Given that both on-station testing and PVS trials failed to clearly demonstrate the advantages of BG 1442, proving that many farmers had adopted it was valuable information. However, although adoption data were useful in this particular case, making it a routine criterion for official release would demand resources for the initial scaling up of more varieties than would eventually be released, and would also significantly delay the larger-scale dissemination that only takes place after release.

If adoption data are used to identify varieties that could not be identified by other, more conventional, methods (a surprisingly frequent occurrence in rice) it will be cheaper to do so when adoption is higher after there has been more time for farmer-to-farmer spread. The higher the adoption the fewer the resources needed to determine the level of adoption with some accuracy, as a smaller sample of households is needed. The survey itself can provide additional information to support the case for release through simple questions on why farmers have chosen to grow the variety and its possible impacts on livelihoods. Such questions added little expense to the surveys on adoption presented here but provided valuable information for BG 1442 on its impacts on food security, household income from grain sales, and the areas and rice domains in which it was grown.

4.2. Implications of delays in the variety release process

In many developing countries National Research Systems can spend, as was the case for BG 1442, nearly two decades in establishing the value for cultivation and use of a crop variety. For example, in Bangladesh BRRIdhan 29 met with similar delays and was released only after 22 years of rigorous testing (M.A. Salam, personal communication). However, plant breeding research incurs a huge investment and returns are realised only when farmers grow and use its products. Hence, there are obvious advantages to reducing the long breeding cycle (Pandey and Rajatasereekul, 1999) and accelerating variety promotion by using more rapid participatory approaches.

The release of BG 1442 would have been considerably delayed, or even prevented, without the higher adoption levels created by participatory research and dissemination. By the time the variety was proposed for release, scientists in NRRP knew of its widespread acceptance following the distribution of many IRD sets, through their involvement in monitoring visits, workshops, and interactions with the PCI and RRC project scientists. Hence, NRRP would have considered BG 1442 as a safe bet for release but, as there was no mention of farmer adoption in the release proposal or of the IRD programme of the NGOs, the evidence for its importance in the release of BG 1442 is indirect;

- Usually the trial data in a release proposal are for the recent past (for the last 3–5 years) while most of the data reported in the BG 1442 proposal were from the 1990s.
- Unlike most, if not all, previously released varieties, it was never promoted to the farmers' acceptance test (FAT) and this was despite it being tested in the FFTs.
- In the variety release proposal the yield of BG 1442 was never superior to the control varieties. Usually NSB and NARC use increased yield as the deciding factor.
- Widely adopted varieties originating from NRRP have not been released when no other organisations championed them. Nearly 9% of the total rice area in the Nepal *terai* was covered by such varieties in 2008, e.g., Kanchhi Masuli, Radha 17, and RP1017, that had spread from farmer to farmer (Witcombe et al., 2008).

We conclude that the promotion of BG 1442 by the PCI and RRC researchers helped overcome the resistance to releasing a variety that had an apparent fault that would have prevented its release – BG 1442 did not yield more than the control varieties in trials.

4.3. Contribution of IRD in acceleration knowledge and seed dissemination

In conventional breeding, it takes a long time to develop, evaluate and release varieties and there is an additional long period, typically of 5–6 years, after official release before appreciable adoption commences (Morris et al., 1992). A 20-year period is not unusual from the initiation of research to when farmers benefit fully from its results (Collinson and Tollens, 1994).

Reducing the delay between identifying a promising variety and promoting it increases the benefits from plant breeding. In the PCI and RRC projects, researchers avoided this delay. They took the client-oriented, participatory approach to its logical conclusion and helped to fund the extension of the most promising varieties. Seed production by CBSP groups was encouraged and IRD distribution, mostly funded by the research projects, quickly helped popularise the variety as IRD proved to be a major source of seed. Substantial amounts of farmer-to-farmer spread of seed and knowledge followed from the IRD distribution and accelerated its adoption. In the rice innovation system the extent of spread of information about new varieties precedes their future adoption and farmer awareness of BG 1442 was high.

About 10% of the seed produced was by NRRP but very few farmers reported government agencies as a source (Tables 3 and 4). However, the timing of seed supply is an additional factor as the sooner seed is supplied the sooner farmer-to-farmer spread begins that can lead to rapid adoption in rice (Witcombe et al., 1999, 2001; Joshi et al., 1997; Joshi and Witcombe, 2002). NRRP only distributed seed of BG 1442 in substantial quantities in 2004, the year of its release, several years after large scale supply by the NGO projects.

4.4. Institutional issues

BG 1442 was widely distributed using IRD by NGOs, often in collaboration with DADOs. However, this does not institutionalise the IRD approach because the donor-funded projects that drove the process lack long-term funding. The institutionalisation of IRD requires the government to support NGOs to do PVS and IRD, even though this might create a conflict with the funding of the government agencies. Government policy could also change to allow DADOs to use the IRD approach and distribute seed on a much wider scale.

The government should also consider further deregulation. The PVS approach dramatically reduces the time needed to popularise a variety because dissemination of seed can, as was the case for BG 1442, begin immediately researchers are convinced that farmers accept the new variety. This reduction in the time needed to bring the benefits of research to farmers is the greatest advantage of participatory research. However, this process is constrained by regulatory frameworks that insist that only seed of officially released or registered varieties can be distributed on a large scale. Currently, the time needed for the bureaucratic process involved in release and registration means that truthfully labelled or certified seed can only be produced years after the PVS results are available.

In the case of BG 1442 this delay was circumvented by the NGOs and CBSP groups, who were not officially allowed to sell truthfully labelled seeds of BG 1442, but distributed seed in the IRD sets that was not formally labelled. The government sector is even more constrained than NGOs in early promotion of new varieties identified by PVS. In all south Asian countries, Government agencies are responsible for administering the elaborate varietal release system and are unlikely to break their own regulations by undertaking the sale of unreleased varieties. Greater flexibility could be introduced by changing policy to allow speedier registration. For example, truthfully labelled seed production of 'pre-release' varieties could be allowed by an initial registration with the NSB that is simple to do. Varieties could later be considered for release or full registration. Unfortunately, current practice does not match the regulations – varietal registration has been made far more rigorous than needed and is almost as onerous as obtaining release.

In some countries, such as Bangladesh, the Seed Acts provide an even greater barrier as there is much over-regulation. The strictest regulations apply to important crops such as rice that are deemed to be 'notified' crops. For legal seed sales a variety of a notified crop has to be nationally listed through publication in the national gazette after approval by the National Seed Board (NSB) of Bangladesh. The new variety can be approved by the NSB only after it has passed the distinctness, uniformity and stability (DUS) tests (carried out by the Seed Certification Agency) and the technical committee of NSB has endorsed the results of multi-locational trials that have to be conducted by the Bangladesh Rice Research Institute (BRRI). This presents a barrier for private sector participation in plant breeding and the seed industry (Bødker et al., 2006). To have flexibility in the seed sector, major policy changes are needed to reduce what is effectively a government monopoly in plant breeding and varietal release.

In Nepal, the private sector provides an alternative route to the government and NGOs for seed supply. The latest Seed Act allows the private sector to register varieties but the process is not simple. Even if the private sector faced no regulatory barriers in registering varieties, business reasons may prevent the promotion of newer varieties. Witcombe et al. (2010) discuss how promoting new, almost unknown varieties over older ones that are already in demand not only adds costs in advertising but increases the risk of having unsold seed. This barrier would be reduced if government policy were changed to allow private sector companies to market seed of their own varieties without complex registration (as is done in India by the private sector who sell truthfully labelled seed of unregistered varieties as 'research varieties'). An additional step forward would be to change the extension message to recommend equally truthfully labelled and certified seed.

However, the private sector does have some reasons to promote newer varieties. One would be to establish a company reputation for providing better, new varieties although, until there is more competition in the seed sector in Nepal, currently the incentives to do so are weak. Another reason would be to achieve increased profit margins by selling new varieties with desirable traits at a premium price.

The direct benefits of new varieties are not often determined in a quantitative way. The impact assessment study on BG 1442 showed a 25% improvement in rice self-sufficiency and rice grain sales for most of the farmers who adopted it. Methods such as PVS and IRD bring such benefits more quickly to more farmers. If encouraged by government policy they are more likely to be used and hence have a significant impact on improving food security.

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