HEIDELBERG UNIVERSITY
DEPARTMENT OF ECONOMICS

UNIVERSITÄT
HEIDELBERG
ZUKUNFT
SEIT 1386

Trials and Tribulations: High-Yielding Varieties and Small Farmers in Bihar, circa 1970

Clive Bell

AWI DISCUSSION PAPER SERIES NO. 761
January 2025

Trials and Tribulations: High-Yielding Varieties and Small Farmers in Bihar, circa 1970

Clive Bell *

Universität Heidelberg, Voßstraße 2, D-69117 Heidelberg, Germany

clive.bell@urz.uni-heidelberg.de ORCID: 0000-0002-7098-2252

This version: January, 2025

*Sections 3 and 4 draw heavily on Sections IV and V of Chapter 7 of Bell (1976). All data have been checked anew and much more extensive use made of them, chiefly in Section 5. I am much indebted to Shanta Devarajan for valuable comments and suggestions. All responsibility for surviving errors of omission and commission is mine alone.

Abstract

This paper recounts an early attempt to promote the adoption of high-yielding varieties (HYVs) of rice and wheat by small farmers. The instrument was a package not only of inputs, extension advice and supervision, but also – addressing risk aversion – a guaranteed net revenue. The scheme was implemented by the newly-created Small Farmers' Development Agency, a parastatal body. The paper examines how and why the scheme failed, and analyses the data yielded by the trials. The chief causes of its failure were a lack of incentives within the public sector and the Agency's weakness within the larger administrative system. Despite all manner of difficulties, the participants in the trials obtained levels of valued added per acre thrice those of their contemporaries cultivating local varieties and crop yields from two-thirds to four-fifths of those achieved by their grand children's cohort circa 2020.

Keywords: high-yielding varieties, credit-insurance scheme, Small Farmers Development Agency, Bihar

JEL Classification: N55, O12, O13, Q12, Q16

1 Introduction

Like most innovations, the introduction of high-yielding varieties (HYVs) of rice and wheat in the Indian subcontinent in the mid 1960s was something of a mixed blessing. Coinciding with the severe droughts of 1965-66 and 1966-67, the second of which led to famine in Bihar, it promised to banish hunger. It also threatened to exacerbate rural inequality. Cultivating these varieties requires not only assured irrigation, thus favouring particular regions and localities, but also certified seed and heavy doses of fertilizer for a full yield response. HYVs are also generally more susceptible than local varieties to plant diseases and pests, a hazard strengthened by the dense plant populations on fields so cultivated, thus making treatment with pesticides essential. Cultivating an acre of an HYV efficiently therefore demands an investment of variable capital of a wholly different order than cultivating an acre of a local variety. In all likelihood, therefore, big farmers would be at an advantage over small farmers in three ways. First, in the regulated system supplying the inputs, including extension advice, they had better connections to the administration. Secondly, they were better able to finance such cultivation, in part through those connections. Thirdly, they were arguably more able and willing to bear the risks involved.

In 1970, the Indian government established the Small Farmers Development Agency (SFDA), presumably with some of those concerns in mind. The SFDA was a parastatal body whose function was to co-ordinate the actions of other departments, so as to promote small farmers' welfare as producers. The branch in Purnea District, Bihar, was just the second in India, and it was hoped that it might serve as a test bed for ideas and projects to be applied elsewhere. One such project was a scheme combining a package not only of inputs, extension advice and supervision, but also a guaranteed net revenue. It was called the Crop Guarantee Scheme (CGS). Small-scale trials were conducted in the winter and summer seasons of 1970-71 and 1971-72. This paper tells the story of this rather ill-fated enterprise. It describes the scheme's design, examines

how and why it failed, analyses the data yielded by the trials, and draws some lessons.

Turning to the vast literature on the diffusion of HYVs over the following two decades or so, and how that process involved the systems of public administration, a few citations must suffice. At the outset, the distinguished scientist M. S. Swaminathan (1968a,b) laid out a course for HYVs to effect India's agricultural transformation. For a compact account of the development and adoption of HYV rice and wheat in less developed countries, see Dalrymple (1985), and for a fuller one of rice, Dalrymple (1986). That HYVs were a mixed blessing in those countries was vigorously argued by Lipton and Longhurst (1989), who advanced various proposals to mitigate their ill effects. Ghosal (1973) called the SFDA a failure not long after its founding. A notable attempt to promote diffusion through a specialized extension agency was the Training and Visit (T&V) system, which the World Bank promoted enthusiastically from 1974 until the mid 1990s. Feder and Slade (1986) assessed its impact in India; Anderson et al. (2006) wrote its obituary. Binswanger (1980) employed an experimental approach to measure attitudes towards risk, using subjects drawn from ICRISAT's villages. Binswanger and Sillers (1983) examined the relative roles of credit constraints and risk aversion as influences on farmers' investment decisions, particularly concerning seeds and fertilizers. It is noteworthy that Cole et al. (2013) find that other factors, especially lack of trust, are as important as price in explaining Indian farmers' lack of interest in commercial index insurance against rainfall risk.

There is already a hefty catalogue of well-intentioned, but largely or wholly unsuccessful government schemes to improve the lot of the poor. A leading cause of these failures is a failure of incentives within government (World Bank, 2003), which can be exacerbated by political pressures; for an example of the government failing where an international NGO succeeded, see the study of contract teachers by Bold et al. (2018). An account of CGS ought to do more, therefore, than provide a salutary warning from another important domain and an earlier age. The scheme involved two factors that deserve close attention, especially with reference to the literature on impact evaluation.

The first was participants' trust that the government would honour its obligations under the terms of any guarantee and, it might be added, impose penalties if they failed to comply. For having rights in principle is one thing, but enjoying them is another, as emphasized by Dutta et al. (2014) in their analysis of the National Rural Employment Scheme (NREGS) in Bihar. The second is that when households participate, they often learn, even if the scheme itself subsequently fails; and some of this knowledge may then spread more widely through the usual social channels.

The plan of the paper is as follows. Section 2 sketches the setting. Section 3 describes the scheme's design and the plan to implement it, and Section 4 how it actually operated. Section 5 analyses and discusses the trials' quantitative results. The aftermath is treated in Section 6, which goes on to compare a few key features of cultivation at that time with those ruling recently. The chief conclusions are drawn together in Section 7.

2 The Setting

At that time, what is now Purnea Division was a large, populous, single district, bounded to the north by Nepal, to the east by West Bengal, to the south by the Ganges, and to the west by undivided Saharsa district, whose western boundary was the river Kosi, an important tributary of the Ganges. The Kosi canal system delivered water to 10,000 acres on an experimental basis in 1964-65. The effective command rose to about 300,000 acres by the late 1960s, and then to just over 400,000 acres in 1971-72. *Aghani* paddy, which is transplanted in the monsoon months and harvested from mid-November to early January, was by far the most important crop. Wheat, pulses and oilseeds were grown in the winter (*rabi*) season, followed by jute, maize and *badai* paddy in summer, a fiercely hot season that rounds off the annual cycle.[1]

This was the early stage of the promised 'green revolution', whereby the government

[1]For an account of Purnea's agrarian structure, see Wood (1973), of agricultural wages, Rodgers (1975), and of rural contracts, Bell (2018).

was to ensure adequate supplies not only of certified seeds, fertilizers and pesticides, but also of the credit farmers would need to finance such cultivation. A complementary initiative was the child of the All-India Rural Credit Review Committee, constituted in 1969, with B. Venkatappiah as chairman. Its aim was to ensure that small farmers would gain access to, and profit from, these opportunities. The instrument to accomplish this aim was the SFDA; the target group was households owning between 2.5 and 5 acres. The Purnea branch was inaugurated by Venkatappiah himself in March 1970. Its overall target was to coordinate Rs100 million in long-, medium- and short-term credit to some 50,000 small farmers over a period of five years. This was an ambitious programme, so there was a need for projects. There begins the present tale; but first, a preamble.

The prime candidate for short-term credit programmes was the cultivation of HYV wheat and paddy, presumably displacing local varieties. How well did these alternatives match up in terms of average net returns and riskiness? Cultivation of paddy in summer has two advantages over *aghani* paddy: first, there is much more sunlight; secondly, pests and plant diseases are less troublesome in summer, which is important in view of HYVs' greater susceptibility, *Taichung Native* 1 (TN1) being notably so. The trials therefore involved summer paddy.

Bihar's *Annual Season and Crop Reports* provide estimates of the total acreage under, and aggregate output and yields of, virtually all crops in each district. The yields are based on crop-cutting experiments. The unit of measure at the time was *maunds* per acre, the *maund* defined as 37.32kg. Farmers, traders and officials in Purnea, however, almost invariably spoke of 40kg-*maunds*, doubtless inspired by the fact that there are 40 *seers* to a maund. In what follows, all weights are reported in kilos.

Data for wheat and *badai* rice were available for the years 1954-55 through 1969-70. Noting that cultivation of HYV wheat had become quite widespread in 1968-69, inspection of the series for 1954-55 through 1966-67 revealed no obvious trend in that

sub-period. The same held for *badai* paddy for the whole period, in keeping with the fact that the cultivation of HYV paddy in *badai* had made no inroads. Converting dry paddy to rice at the rate 1/0.662 (NSSO, 1966: 5), the mean yields of wheat and summer paddy during the said periods were 215 and 284 kg per acre, respectively, with standard deviations of 78 and 65 kg per acre. The corresponding coefficients of variation of 0.363 and 0.228 suggest that cultivating local varieties of wheat and summer paddy was far from yielding the 'sure thing'. Be that as it may, these summary statistics provided certain benchmarks for cultivating HYVs under CGS.

3 The Scheme: Design and Plan

While assessing small farmers' needs for short-term finance, it was argued that some form of insurance would be a necessary part of the package. The extension officers agreed that, in their experience, small farmers generally applied little, if any, fertilizer to HYV wheat and their fear of incurring heavy debts deterred all but a few from trying out HYV paddy. The farmers' behaviour was seen to be motivated by 'safety first'. Participants would be assured, therefore, of a minimum net income for each acre cultivated under the scheme.

The basis of this minimum was the alternative of cultivating local varieties. A premium was added to the associated net income to reflect, first, the fact that innovation claims much more of the farmer's time and secondly, that there should be a perceptible difference between the net incomes yielded by the two options in order to induce innovation. This step involved guesswork, complicated by the fact that cultivating local varieties is also risky. If these factors are ignored, the farmer's opportunity cost is simply the expected value of net income per acre when cultivating local varieties. As it turned out, this choice treated participants generously, a point taken up in Section 5.

Net income for the purposes of the scheme was defined to be the excess of the value of the crop over the cost of intermediate inputs and hired labour: equivalently, the value of the returns to the household's productive factors thus employed. It was assumed that family labour and bullocks would supply all inputs for ploughing and 50 percent of those for transplanting and weeding. Inputs supplied by the household were excluded from financing. Harvest labour was self-financed; for the regional practice was to pay harvest labourers a fixed share, usually one ninth, of the crop. The cost of hiring labour for other operations was set, rather generously, at Rs3 per person-day; fertilizers, pesticides and canal irrigation were valued at current farm prices. Output prices were taken to be those for state procurement of foodgrains: about Rs30 and Rs20 per *maund* (40kg) for wheat and paddy, respectively. If market prices rose above these levels, then the participants would enjoy a windfall gain.

The provision of some credit in the form of cash to finance hired labour demands comment. The evidence from various field surveys in Purnea refuted the not uncommon belief that small farmers carried out all the work of cultivation with family labour, and so required credit only for inputs in kind. Although family males almost invariably did the ploughing, hired labour predominated in weeding and transplanting operations, even on small farms. One reason for this is that the timing of such operations is important. For example, wheat should be given its first weeding between 20 and 25 days after sowing. Even if there were no other calls on their time (especially for ploughing), few small-farm families could supply the 25 or so person-days needed to clean an acre thoroughly. Transplanted HYV summer paddy requires significantly more labour than the local varieties thus displaced, the latter being broadcast.

Turning to the agronomic treatments, cultivation of local varieties provided the control, T_0, the estimates for which were largely derived from recent field studies, whose gross yields were somewhat higher than those reported in the *Annual Crop Season Reports* (see Section 5). Farmers sowed part of their retained output from the previous year. The resulting opportunity cost of adopting HYVs, as defined above, was 300kg

less Rs.74 for wheat and 290kg less Rs.64 for summer paddy: at procurement prices, Rs.151 and Rs.81 per acre, respectively.

The HYVs were classified into two types, namely, very high yielding and highly variable, and less dramatic, but more reliable. For wheat, these were represented by S227, and S308 and RR21, respectively; for paddy, by TN1 and Padma, and Nagina, respectively. Since it was unclear what treatment would be best for the scheme, the first types were to be given three fertilizer treatments (T_1, T_2, T_3) of increasing intensity, the second type only T_1 and T_2. T_3 was very close to the recommended dose, namely, nitrogen, phosphorous and potassium, in the form of 60kg of urea, 50kg of diammonium phosphate, and 30kg muriate of potash per acre. T_1 and T_2 represent half- and three-quarter doses. Combining the foregoing assumptions yields the cost structures in Tables 1 and 2. It is important to note that the investments of working capital range from 70 to 115 percent of the mean gross revenues yielded by 'the local alternatives. With the modest treatment T_1 of wheat and full repayment of the loan of Rs169, the household would need a net yield of 425kg in order to obtain the defined opportunity cost of Rs151. With T_3, it would need 560kg. In order to strengthen the incentive to participate, the repayment schedule comprised, first, a complete remission of the loan and interest for all realized net yields not exceeding 400kg, together with a reimbursement in the amount of any shortfall, so as to reach Rs151. The value of any net yield over 400kg would be due as repayment, up to the full value of the amount due. Gross yields were to be determined by official crop-cutting. The provisions for paddy were decided later and were less generous, but with analogous calculations. All schedules are set out in Tables 1 and 2.

Under these arrangements, the institution financing the scheme stands to accumulate a steadily mounting deficit; for every time the net yield fails to reach the level at which repayment is complete, some remission of debt occurs. It was therefore decided to levy a cess at the rate of 20 per cent on yields in excess of the level at which repayment would be complete, up to a maximum of Rs40 per acre. In order to limit the loss to the

Table 1: Financed inputs and loan repayment schedules: wheat (per acre)

Variety	local	S227			S308/RR21	
Treatment	T_0	T_1	T_2	T_3	T_1	T_2
Financed inputs (Rs)						
Seed	25	70	70	70	70	70
Weeding	39	39	39	39	39	39
Fertilizers, pesticides, irrigation	10	60	110	160	60	110
Total	74	169	219	269	169	219
Net yield[a] (kg)	300					
Net income (Rs)	151					
Repayment schedule:						
begins at net yield		400	400	400	400	400
complete at net yield		625	690	750	625	690

Author's calculations.

[a] Net of payments to harvest labour, at 1/9th of the gross yield.

The seeding rate for local varieties, 25kg per acre. S227 is very high yielding and highly variable; S308 and RR21 are less dramatic, but more reliable. Interest charges, at 10 per cent p.a. with a 6-month turnover, have been omitted as very small.

Table 2: Financed inputs and loan repayment schedules: paddy (per acre)

Variety	local	TN1/padma			Nagina	
Treatment	T_0	T_1	T_2	T_3	T_1	T_2
Financed inputs (Rs)						
Seed	25	20	20	20	20	20
transplanting	0	18	18	18	18	18
Weeding	39	39	39	39	39	39
Fertilizers, pesticides	0	60	110	160	60	110
Total outlays (Rs)	64	137	187	237	137	187
Net yield[a] (kg)	290					
Net income (Rs)	81					
Repayment schedule:						
begins at net yield		360	360	360	360	360
complete at net yield		640	740	840	640	740

Author's calculations.

[a] Net of payments to harvest labour, at 1/9th of the gross yield.

TN1 and Padma are the counterparts of S227, and Nagina that of S308 and RR21. Padma, TN1 and Nagina are transplanted; hence, the relatively small expenditures on seed.

SFDA that could result, the trial's scale was kept small, but sufficient to gain realistic experience. It was to cover two consecutive seasons, *rabi* and summer 1970-71, with 25 randomly selected small farmers. To ease the problem of supervision, it was decided to choose one block, limiting participants to five villages, which would be in some broad sense representative types. If each of the participants put half an acre under each of two treatments in both seasons, 10 observations would be available for each treatment. This was considered adequate to establish which crop-treatment combination would be the most promising for extending the scheme on a larger scale.

4 The Scheme in Operation

The scheme raised issues beyond changes in cultivation techniques: (i) the capacity and willingness of all levels of the administration to implement it while dealing with other tasks; (ii) the role and authority of the SFDA; (iii) the efficiency and timeliness of input deliveries; and (iv) the farmers' responses. These are taken up when examining the more qualitative aspects of the trials, which comprise two *rabi*-summer pairs.

4.1 1971

The *rabi* trial was not conducted according to specifications, a fate suffered by most plans. First, only 21 farmers were recruited as participants. Secondly, there was haphazard variation in treatments: nearly all used the full recommended dose of fertilizer, close to T_3, but only five obtained cash. While the failure to execute exactly a rather complicated treatment design when the agents are farmers was understandable, the failure to fulfil a quota of 25 participants and to ensure some systematic variation in treatments pointed to serious administrative problems and boded ill for attempts to scale up CGS in the future. These concerns assumed a sharper form after the participants had been interviewed in depth later on.

Deviations from the design aside, implementation faced other problems. Not all participants obtained seed and fertilizers in good time, and the performance of the Irrigation Department was particularly troubling. Providing water ought to have been straightforward, but the *modus operandi* imposed externalities. Water was not contractually supplied to individual cultivators, reasonably enough. Instead, a majority of all farmers whose land was served by a particular watercourse had to present a written demand for irrigation greater than that of the crops displaced – a demand known as *satta* – before the opening of the canal system for the season. Failing *satta*, no individual or minority group served by that watercourse would receive water. Thus, would-be cultivators of HYVs who depended on the canal system were also dependent on their neighbours' decisions.[2] The position is summarized in Table 3.

Table 3: Timeliness of input deliveries in rabi 1971, 21 participants

Inputs	on time	late	unclear/n.a.
Seed	15	3	3[a]
Fertilizers	17	3	1
Pesticides	3	2	16
Cash	5	2	14[b]
Irrigation	5	16	0

[a] In one case, seed had to be bought from other farmers; the other two are uncertain.

[b] Five belonged to a village whose COOP was defunct; five were previous defaulters on COOP loans; one was not a COOP member; the other cases are unclear.

Doubts also arose about the extension part of the package. The Village Level Worker (VLW) was to supervise the application of fertilizer to ensure that none destined for CGS plots was diverted to others or simply sold off. It was not clear that VLWs had been present in all cases, and a suspicion that diversion had occurred remained. In

[2] A few years later, there was an important change: all owners of plots commanded by the system were charged at the relevant seasonal rate, whether they used the water delivered or not.

contrast, verifying yields went well: only two farmers complained about the results of the crop-cutting experiments.

Despite these problems, the results were encouraging, with gross yields ranging from 720 to 1080kg per acre. All participants were therefore contractually obliged to repay their loans in full and the SFDA would obtain cess payments ranging up to the maximum of Rs40, a limit attained by 10 participants. Sadly, there was one more problem in store. The heavy and wholly unseasonal rains that followed destroyed the greater part of the harvest on the threshing floor, leaving a post-harvest average of merely 240kg. A detailed, quantitative account is provided in Section 5.

The post-harvest rains also aborted the summer part of the combined trial. Seven of the 21 participants were prepared, in principle, to stick with the scheme; the remainder withdrew for fear that the formal agreement would not be honoured and that they might then increase their debts by risking HYV cultivation a second time. Of the seven stalwarts, two waited in vain for irrigation and five for fertilizer. Two of the latter got fertilizer after more than a month's delay and eventually realized yields of 1200kg per acre; two went ahead and transplanted without it, and averaged 500-600kg per acre; and one gave up in disgust. No spraying equipment was available, and estimated losses ranged between 20 and 30 per cent.

There remains the matter of the scheme's efficacy to induce small farmers to sow and apply heavy doses of fertilizers to HYVs if they had not done so before, or to keep them within the fold if they were about to drop out. Such a small trial is a slender reed on which to rest firm conclusions, but it is worth summarizing the findings. First, although only five of the 21 participants were growing HYV wheat for the first time, 14 had never applied fertilizer at a rate more intensive than a half dose (about 35kg of nutrients per acre). This was in keeping with the prevailing pattern of wheat cultivation at that time. F2 and F3 HYV seed was freely available in village markets and, even without fertilizer and irrigation, this would normally outperform local varieties if cultivated in

the same way; but whereas varietal adoption was widespread, heavy fertilizer use was not. Virtually all participants indicated that in the absence of the scheme, they would have grown less wheat and kept fertilizer intensity low. Indeed, some said that they would have avoided growing wheat altogether, and others that they would not have used fertilizer at all. Secondly, the heavy drop-out after the *rabi* trial is in some ways more striking. The participants had the firm offer of access to resources, but most of them declined because there were no credible indications at the time that CGS's provisions would cover post-harvest losses. Thirdly, the onus of initial recruitment fell on the VLWs, who probably favoured those small farmers with whom they had dealt previously. Such clients tended to be more adventurous than other small farmers; thus, the participating group probably had greater experience of HYV cultivation than their peers. These factors indicate that the insurance component of CGS was not redundant.

4.2 1972: a revised plan

After the experience with the first trial had been digested and assessed, it was decided to subject the scheme to a more searching test in *rabi* 1971-72. The prime aim of the second trial was to get a clearer idea of the administration's ability to manage CGS routinely. In an attempt to simulate the conditions prevailing in a district-wide scheme covering a few thousand farmers, it was planned to select 100 cultivators from each of two blocks. These were to make up compact groups, giving each of the selected VLWs responsibility for 10 to 15 farmers, this being deemed a reasonable load for a VLW to shoulder in addition to his other duties. It was also hoped that the eightfold increase in the number of participants would provide a more solid basis for deciding whether such a scheme could be both self-financing and attractive. The groundwork for the extension input into this *rabi* trial was completed in September 1971. The nature and details of CGS were explained to, and discussed with, the extension staff of both the blocks involved. Later, a Document of Agreement was drawn up, the contents of which

were to be explained to participants, and it was decided that all 200 farmers should sign the agreement by mid-October.

4.3 Rabi 1972: actual operation

Early in February 1972, field interviews with some 25 farmers who had been approached to take part revealed that they had only a hazy understanding of the nature of the scheme and the details of its guarantee. Most knew that there would be compensation if yields fell below a certain level, but not one had the details right. A decision had been taken in October to produce a pamphlet about the scheme for distribution to interested farmers. That this did not happen must surely have weakened the scheme's official and contractual standing. No written agreements had been entered into, for the Government of India had formally approved the scheme only just before the interviews.

Although, at the time of those interviews, the farmers concerned regarded themselves as having agreed to participate, and the administration was treating its commitment to CGS as firm, the preceding period appears to have been a scene, first, of confusion, and then of extreme haste, as attempts were made to contract in the target number of farmers. One VLW claimed that after the meetings in September, he received instructions only early in December, well past the November 30 deadline for sowing. Thus, the farmers he supervised knew of the scheme only *after* they had sown wheat. Here, and in other villages, there were instances of unirrigated plots, late sowing, and little – if any – application of fertilizers.

The Government of India formally sanctioned the money for the trial in January, some six weeks after the optimal sowing period, a delay in part attributable to the fact that CGS was not an established expenditure item. Even so, the SFDA was informed in good time that it should proceed with the trial, and that the formalities would be concluded without fuss subsequently. Yet VLWs could offer only verbal understandings at ploughing time. With formal contractual agreements, all parties

would have been persuaded that the scheme was serious, and farmers would have been clear about their rights and obligations. It was a misfortune also that the Kosi Commissioner (and ex officio Chairman of the SFDA) departed to take up a new post at the beginning of December. This inevitably involved some loss of overall supervision and authority in the period immediately before his move. From December to mid-February, other senior officers not resident in the district assumed additional charge of the Kosi Commissioner's post, and there was no resident officer with sufficient authority to take final responsibility for the conduct of the trial. The scheme therefore suffered a virtually complete loss of administrative authority during a critical period. This suffices to explain the lack of commitment at the block level, which was communicated in turn to the VLWs in the form of late or inadequate directives from, and an absence of supervision by, senior block officers.

By February, it was clear that the only way of salvaging the situation was to seek detailed information on the cultivation practices actually followed by the nominal participants and to relax somewhat the conditions for eligibility. A questionnaire was drawn up for this purpose, and 94 farmers were enumerated in both blocks. Of these, only 12 had applied the revised minimum dose of 45kg of nutrients per acre. Despite careful planning in advance, this trial, too, had to be aborted.

Problems with the availability of inputs merit discussion in their own right. First, whereas the supply position regarding fertilizers and seed had been largely satisfactory in the *rabi* trial of 1971, that prevailing in 1972 was not. There was virtually no bulk supply of fertilizers for cultivation until early December. Under the conditions of CGS, this was already later than the last admissible sowing date for S227 and borderline for S308. There was a general problem with fertilizer supply in Bihar at that time, stemming from the dislocation of transport services due to heavy monsoonal flooding and impending hostilities with Pakistan. The position concerning seeds was similar. Certified seed ought to be sown at least every other year, but CGS was stricter, participants being required to sow F1 seed. The post-harvest rains in *rabi* 1971 had

caused such widespread and serious losses that arrangements were made to ship large quantities of S227 procured from farms in the Punjab, now for use as seed. In view of the uncertain state of the certified seed supply, it was decided to relax the CGS stipulation to include this "Pantnagar seed".[3] These difficulties notwithstanding, fertilizer and F1 seed were available in overwhelming quantities relative to the requirements of the trial. With 200 farmers, these amounted to a mere 30 tonnes of fertilizer and 7 tonnes of seed. Yet the obstacles confronting small farmers were such that only 12 of the 94 participants initially listed for the second trial had applied the (subsequently) reduced standard of a 45kg dose. Had administrative authority not lapsed towards the end of 1971, there should have been little difficulty in making a priority allocation of these inputs so as to fulfil a necessary condition for the trial's success.

Secondly, there was a replay of untimely irrigation. In the *rabi* 1972 trial, no canal irrigation was made available before January 20 owing to farmers' alleged failure to enter into *satta*, a reluctance that may have reflected their unwillingness to order water when there was no fertilizer. Had any farmer applied a heavy dressing of fertilizer in the second half of November, it is likely that his crop would have been badly burned by the time water began to flow. With a lower fertilizer dose, delayed irrigation became somewhat less critical.

Thirdly, as noted above, small farmers need liquidity to hire labour for timely and thorough transplanting and weeding operations. Yet, important as cash credit was for CGS, it was virtually unobtainable. The two Project Executive Officers (PEO) concerned reported that they had extreme difficulty in finding any, let alone 100, small farmers in their respective blocks who were eligible for, and able to obtain, institutional credit in a form other than inputs supplied in kind against permits issued by the Block Office. There were several reasons for this. First, senior block officers could issue permits against inputs in kind, but not in cash, so farmers had to resort to the State Bank of India, commercial banks, or the co-operatives. The commercial

[3]This was sold at Rs1 a kg; the price of certified F1 seed was Rs2 a kg.

banks' procedures were so stringent and bureaucratic as to deter most farmers, big and small alike, from even making an application. The reluctance of the commercial banks to get involved in the scheme was puzzling, since the liabilities for credit advanced to participants were underwritten by the SFDA. Overdues had rendered many co-operatives defunct; many members of others were debarred from taking new loans because they had defaulted on old ones; and some small farmers were not members.

4.4 Summer 1972

In view of the woes that had beset the *rabi* trial, and in the full expectation (amply justified as it turned out) that the dozen accepted participants would get poor results, there was an understandable hesitancy to proceed in summer. After receiving sanction to proceed, however, it was decided to try once more. The scale was reduced to make the undertaking more manageable: 100 farmers in all were to be recruited from four blocks (participants in the *rabi* trial of 1971 were excluded) and each was to grow half an acre of HYV paddy (TN1 or Padma). Generally speaking, the cultivation of these varieties in the summer season – or any season for that matter – was something outside the experience of the region's small farmers. The canal system had been closed for desilting during the *badai* seasons of 1969 and 1970. For other reasons, HYV *aghani* paddy had never gained the general acceptance won by HYV wheat. Nevertheless, the fragmentary evidence from the previous summer trial was encouraging.

The input story began in a familiar way. Seed was not readily available, and there were delays in obtaining supplies from other parts of the State. The Irrigation Department scrupulously observed its custom – quite unconnected with the trial – of releasing water into the canal system several weeks later than promised, with the result that at transplanting time, the seedlings raised by many participants were a good deal older than optimal.

Despite this unpromising start, the extension officers exerted themselves to make the

trial work. Participants signed agreements with the SFDA at the outset, the VLWs supervised on the spot, and the PEOs made special efforts to secure the necessary inputs, as well as taking a closer interest than hitherto in cultivation itself. They recruited 37 participants, who did rather well: all but four were liable to pay a cess (most the limit of Rs40 per acre), and only three suffered disastrous outcomes. Ironically, the last trial to be staged provided arguably cogent grounds for continuing the project.

5 Quantitative Analysis

Let x_{it} denote a measure of performance on plot i in period t, and let it be linear in three components:

$$x_{it} = u_i + v_{it} + w_t, \tag{1}$$

where u_i is time-invariant and reflects the plot's and farmer's characteristics and how the plot is cultivated, v_{it} is an idiosyncratic, time-varying shock, and w_t is a shock common to all plots in period t. Let the time-varying components be i.i.d. and stationary, with $\mathbb{E}_t[V_{it}] = \mathbb{E}[W_t] = 0$. It is assumed that when a sample of plots is drawn, no farmer appears more than once.

In period t, the staff draw a random sample of size n_t from the district's population of all plots, perform the crop-cutting experiments, and subsequently report the mean yield, $\bar{q}_t$, for that district:

$$\bar{q}_t = \frac{1}{n_t}\sum_{i=1}^{n_t} q_{it} = \frac{1}{n_t}\sum_{i=1}^{n_t}(u_i + v_{it}) + w_t. \tag{2}$$

If, over a run of periods and under the above assumptions, the sample sizes are sufficiently large, then virtually all fluctuations in the mean yield will arise from those in the common component w_t. In fact, the samples in question for Purnea district (and doubtless for most others) were surely small, so that fluctuations in the mean of the idiosyncratic variate $U + V_t$ were far from negligible and fluctuations in the mean yield

cannot be largely ascribed to the variate W_t. In support of this claim, the National Sample Survey (1966) dealt with land utilisation and crop-cutting experiments in 1962-63. The numbers of experiments for wheat and summer paddy in Bihar were 494 and 97, respectively (Tables 9.3 and 4.3). At that time, Bihar comprised 17 districts, so the numbers performed in Purnea must have been about 30 and 6, respectively. It is inconceivable that Bihar's Directorate of Statistics would have conducted many more during the period under consideration.

With this much established, the preliminary comparison is that between the Directorate's estimates and those for the two village surveys in 1968-69, whose full summary statistics are presented in Table 4. The 95% confidence limits for wheat are 199 to 291, for paddy 237 to 369 kg per acre, which comfortably enclose the Directorate's averages reported in Section 2. Although the latter themselves lie in a 95% confidence band that is not especially narrow, it seems safe to conclude that cultivation in the two villages, which belong to the same block as those selected for the *rabi* trial of 1971, was fairly representative of that practised in the district.

In making the comparisons that follow, it needs no emphasis that several confounding factors are work. First, the years differ and their common components cannot be estimated. Secondly, whereas the HYVs were cultivated under some supervision by agricultural extension workers and necessarily irrigated, local varieties were not; indeed, the canal system was closed in the summer of 1969. Thirdly, HYV summer paddy was transplanted, but local varieties were broadcast. Fourthly, wheat and summer paddy must be grown in different seasons and are not, in this sense, close substitutes in cultivation. It is possible, however, to grow both in the same cycle, provided wheat is sown early enough, a fact that entered into the scheme's original design. Concerning HYV wheat, the discussion deals mostly with the crop-cutting results; those following the unprecedented and ruinous post-harvest rains are treated only as needed.

Beginning with yields, it should be recalled that paddy must be husked to produce

Table 4: Wheat and summer paddy cultivation, summary statistics (per acre)

	mean	st.dev.	min	max	skew	obs.
Wheat						
Yield (kg)						
Local[a]	245	76	110	410	0.27	13
HYV[b], crop cutting	875	89	720	1080	0.63	21
HYV[b], post harvest	241	42	160	320	0.01	21
Value added (Rs)						
Local[a]	155.9	55.6	57.9	272.8	0.24	13
HYV[b], crop cutting	423.0	57.7	330.0	540.0	0.19	21
Net income (Rs)						
Local[a]	147.8	57.8	31.1	251.6	−0.27	13
HYV[b], crop cutting	314.1	48.7	246.2	423.3	0.63	21
HYV[c], crop cutting	241.1	55.2	159.0	375.8	1.14	21
HYV[d], post harvest	−52.0	57.7	−155.0	75.0	0.41	21
Paddy						
Yield (kg)						
Local[a]	302	189	0	700	0.43	35
HYV[e]	1037	459	92	1960	−0.22	37
Value added (Rs)						
Local[a]	165.8	118.8	−25.0	409.8	0.40	35
HYV[e]	481.9	292.1	−91.5	1080.2	−0.09	37
Net income (Rs)						
Local[a]	140.1	124.3	−25.0	409.8	0.61	35
HYV[e]	376.4	249.3	−98.8	903.2	0.04	37

[a] Two survey villages, 1968-69. For wheat, revenue is net of actual outlays on hired labour. The 35 observations for summer paddy were contributed by 32 farmers.
[b] CGS, *rabi* 1971, net of cash credit for labour hire.
[c] CGS, *rabi* 1971, net of actual outlays on hired labour.
[d] CGS, *rabi* 1971, net of cash credit for labour hire.
[e] CGS, *badai* 1972, net of cash credit for labour hire.

rice, the conversion factor being 0.662. Judged by their means, HYVs greatly outperformed local varieties,[4] but the distributions also differed strongly in other ways. Whereas the standard deviations for wheat were essentially the same, that for HYV summer paddy was roughly two and a half times that of local varieties, and the latter was about twice that of wheat. The distribution for HYV paddy also exhibits negative skewness. Plots of the four cumulative distributions yield a revealing picture (see Figure 1). One striking feature is that HYV wheat first-order stochastically dominated (FOSD) local varieties of both wheat and summer paddy. HVY summer paddy dominated local varieties of paddy, but neither type of wheat (the distribution functions intersect). Even after the husking conversion, the distributions for paddy exhibited dispersions of a wholly different order from those for wheat. In this connection, recall from Section 2 that the standard deviations of the mean yields of wheat and summer paddy over the period 1954-55 to 1969-70 were a modest 78 and 65 kg per acre, respectively. These are dwarfed by the shifts in the distributions of yields in Figure 1.

[Figures 1 and 2 about here.]

The salient difference in the techniques of cultivation was the intensive use of intermediate inputs on CGS plots, which indicates that value added per acre is a far better measure of performance. The picture is essentially the same (see Figure 2), except that a few poor outcomes with HYV summer paddy now deny it FOSD over local varieties. The means of the HYVs are about thrice those of their local counterparts and the samples are evidently drawn from quite different populations. The Kolmogorov-Smirnov (K-S) test yields the following result for summer paddy: the critical value of $N^{1/2}D$ for a test of size 0.001 is 1.95, the actual value is 2.47. Whatever be the differences in the time-varying components in (1), the radical shifts in the pairs of distributions clearly stem overwhelmingly from a profound change in the hypothesized stationary distribution of the variate U, which reflects plots' quality and how they are cultivated.

[4]Throughout the following, t-tests of differences in these means are superfluous; the t-values are off the charts.

Not all value added accrued to the participants. Hired hands did nearly all the harvesting, not only under CGS, but also in the survey villages. The same held for weeding and transplanting, but the data for HYV summer paddy were not made available. On the basis of the crop-cutting experiments, all participants in *rabi* 1971 would have been liable for cess payments, ranging from Rs23.8 to the maximum of Rs40; just 4 of the 37 in summer 1972 were free of cess payments and 26 were liable for the maximum.

The next step, therefore, is to examine net income, as defined for the purposes of CGS, that is, also net of harvest labour costs, cash credit and any cess payable, where only 5 of the 21 participants obtained cash credit in *rabi* 1971, all in the amount of Rs100, and only 13 of 37 in summer 1972, in amounts ranging from Rs25 to Rs60. Cash credit for the cultivation of local varieties in the survey villages can be ruled out, leaving harvest labour costs as the sole item to be subtracted. The cumulative distributions are depicted in Figure 3. The only notable change from Figure 2 is that the values for HYV wheat are so reduced that, while its distribution of net income still exhibits FOSD over those of both local varieties, it barely does so for summer paddy. There is, nevertheless, an overwhelming rejection of the null according to the K-S test.

[Figures 3 and 4 about here.]

A brief comment on the actual outcomes following the post-harvest rains in *rabi* 1971 is now needed. The participants obtained, on average, not eight-ninths, but just over one quarter of their gross yields in the field, and all suffered in roughly the same degree, the coefficient of variation being 0.17. The SFDA incurred a loss for each and every participant, ranging from Rs76 to Rs306, with an average of Rs203. Only two participants fared well enough to incur an obligation to repay any of their debt, and then far from in full. All the rest were entitled to compensation in some measure, so as to obtain the contractual minimum net income of Rs151.

The final step is to net out all known expenditures on hired labour, which limits comparisons to HYV wheat and both kinds of local varieties (see Figure 4). There is no

longer FOSD of HYV wheat over local summer paddy, but the K-S test overwhelmingly rejects the null: for a test of size 0.01 with $N = 21 \cdot 35/(21 + 35) = 13$, $D_N = 0.433$, whereas $D = 0.800$. The corresponding values for HYV and local wheat are $N = 13 \cdot 21/(13 + 21) = 8$, $D_N = 0.543$, and $D = 0.615$.

5.1 Discussion

It is safe to conclude from Figures 3 and 4 that cultivating HYV wheat under the conditions actually prevailing was superior to cultivating local varieties. For differences in growing conditions in the years 1969 and 1971 or sampling fluctuation in farmers' husbandry abilities and land quality cannot plausibly explain lateral, rigid-body shifts of such a magnitude. Even with the large stakes in the form of variable capital, FOSD implies that HYVs were the better bet, whatever be farmers' risk aversion. This assertion must, of course, be qualified in the light of the damage wrought by the unprecedented post-harvest rains. Yet in one important respect, there was a silver lining: the guarantee was put to the test – and it was honoured. In September 1971, all 21 participants were assembled for an official gathering, at which they received certificates covering the value of both all due debt repayments and compensation under the terms of the contract. This step was essential to secure the scheme's credibility, and it was hoped that word of it would spread. Such an exceedingly rare caprice of nature notwithstanding, CGS would have been self-financing over the long run if pursued on a modest scale. The accompanying demonstrations of the superiority of HYVs, as cultivated under the wider conditions actually ruling, would have promoted their adoption in roughly that form by farmers outside the scheme itself, whereby the custom of patrilocal exogamy would have helped to spread the word.

The position for paddy is not quite so clear cut. First, FOSD did not hold, the shift in yields being proportional rather than lateral. Secondly, outlays on hired labour for transplanting and weeding HYVs, although not known, were surely a good deal

larger than those for weeding local paddy, a difference that is not reflected in Figure 3. The left-hand tail of the distribution of income net of all outlays on hired labour for HYVs was therefore somewhat thicker than that depicted therein. Inspection of the two distributions indicates, however, that a farmer would have to be very risk-averse indeed to prefer cultivating local varieties, even without any guarantee when cultivating HYVs. The experience with the summer trial of 1972 provides grounds for asserting that CGS for paddy on a modest scale would also have been self-financing over the long run.

The account in Section 4 reveals that the functioning of the administrative system confronted farmers with additional hazards. The operations of the Irrigation Department were a notable, seemingly unvarying source of trouble. Nor were the supplies of fertilizers, pesticides and certified seed especially reliable. As for cash credit, that was fairly reliably unavailable. In this regard, it cannot be said that the trials took place under conditions advantageous for the scheme's success.

There was, moreover, an inherent source of problems afflicting CGS and like projects, namely, the status of the SFDA within the larger structure of government. As constituted, it could only co-ordinate the contributions of other departments. It had no extension or other specialized functional staff of its own, and could not, therefore, implement unaided special or novel schemes. Above all, it lacked any de jure, let alone de facto, authority over the departments with which it had to deal. The Kosi Commissioner, as ex officio Chairman of the SFDA, could exercise his authority on the SFDA's behalf; but that was a matter of choice, and there must have been occasions on which his responsibilities were in conflict. The SFDA had to approach other departments for their services, not with bureaucratic authority, but rather as a supplicant.

The signal absence of RCTs from CGS also calls for some comment. As the Bayesian philosophers Howland and Urbach (1993: 279-80) note, randomization 'excludes, as illegitimate, retrospective trials using historical controls', such as those used in CGS.

The authors then proceed to a vigorous defence of their use. In the present setting, if traditional cultivation and its yields are well established, why bother to repeat it on a limited scale? If, further, HYV-cultivation with a guarantee is prospectively so much more attractive, then excluding the control-participants is surely unethical.

6 Aftermath

No more was heard of CGS after the summer trial of 1972. Small, special projects that demand lots of attention and effort face poor prospects in a culture of large-scale targets, so they normally need an internal advocate. At its founding in 1970, SFDA Purnea had one in its first Managing Director, an able and conscientious officer; but he was posted elsewhere shortly after the summer trial of 1972. His successor had no such personal connection to CGS. He ensured the collection and compilation of the data from that trial, and eventually succeeded in obtaining a report. Having wrapped up that matter, it is understandable that he then devoted his attention to others. For while continuing the scheme on a modest scale would have paid off in the form of wider adoption of intensively cultivated HYVs – and hence contributed to meeting overall targets – through its demonstration effects on farmers formally outside the scheme, such a pay-off must have seemed rather intangible and far off. Exploiting this possibility fully would have required, moreover, the effort of mounting a publicity campaign based on the trials' results.

As for the SFDAs, they fell into oblivion not long afterwards, being absorbed into the Integrated Rural Development Programme in 1980. Parastatals with a purely co-ordinating function, however worthy their purposes, must do more than add a layer of bureaucracy.

6.1 Later developments

Looking back half a century later, Swaminathan (2013) summarized the progress of wheat cultivation in India as follows: the gross output from about 29 million hectares sown was expected to come in at about 96 million tonnes, a quantity requiring at least 100 million hectares with the yields of 1963. It is striking that this proportional improvement is about the same as that in Table 4.

There were indeed remarkable improvements in Purnea. The five-year averages of the official estimates (Bihar, various years; India, 2023) of the yields of wheat and *badai* paddy for the period 2016-2017 to 2020-21 were 2.77 and 3.89 tonnes per hectare, respectively. Recalling Section 2, the corresponding averages over the decade or so preceding the introduction of HYVs were 0.53 and 0.70 tonnes per hectare, albeit for undivided Purnea before its reorganization into four districts in 1990.

All but three of the 58 participants in the two trials were drawn from blocks in the rump of Purnea District left by that reorganization, and thus provide another comparison of then with now. According to the crop-cutting experiments, the 21 participants in *rabi* 1971, who grew mostly S227, achieved on average 2.16 tonnes per hectare (see Table 4), i.e., almost 80 per cent of that generally ruling about 50 years later. The 37 participants in *badai* 1972, who grew mostly TN1, did a little less well relatively speaking, averaging 2.56 tonnes per hectare.

7 Conclusions

The scheme was a failure, in that it never got beyond two limited trials in a single district. That failure stemmed largely from the lack of incentives within the administrative system for its continuation in Purnea District, let alone its introduction elsewhere. As for scaling up, it was never intended that the scheme would provide blanket coverage for farmers registered with the SFDA. Rather the aim was to demonstrate to all of

them, through successively larger trials and spreading word of their results, that intensive cultivation of HVYs was an attractive option under the conditions ruling at that time. Despite all the difficulties they faced, the participants in those trials achieved yields of rice and wheat two-thirds to almost four-fifths of those achieved – with the advantage of yet newer varieties – by their grand children's cohort. This is cause for reflection on a possibly missed opportunity.

Be that as it may, and aside from the well-known importance of incentives in government, two salient lessons emerge for impact evaluation. First, establishing the government's credibility in any matter concerning guarantees needs careful consideration in advance; conducting preliminary, limited trials (without controls) is one possible instrument. Secondly, participants and those in their circle normally gain valuable knowledge from participation, perhaps for a specific purpose as in CGS, but if nothing else, then how better to deal with bureaucrats and officialdom.

References

Anderson, J.R., Feder, G., and Ganguly, S. (2006), 'The Rise and Fall of Training and Visit Extension: An Asian Mini-drama with an African Epilogue', World Bank Policy Research Working Paper 3928, Washington, D.C.

Bell, C. (1976), 'Technological Change, Output and Distribution in a Land-Scarce Economy', D. Phil. thesis, University of Sussex.

Bell, C. (2018), 'Labour and Tenancy in Retrospect: Two Bihari Villages in 1970', in: A. Mishra and T. Ray (eds.), *Markets, Governance, and Institutions in the Process of Economic Development*, Oxford: O.U.P.

Bihar, Government of (various years), *Annual Season and Crop Report*, Directorate of Statistics and Evaluation, Patna.

Bihar, Government of (various years), *District wise Area, Production and Yield*, Directorate of Economics and Statistics, Patna.

Binswanger, H.P. (1980), 'Attitudes Toward Risk: Experimental Measurement in Rural India', *American Journal of Agricultural Economics*, 62(3): 395-407. https://doi.org/10.2307/1240194

Binswanger, H.P., and Sillers, D.A. (1983), 'Risk Aversion and Credit Constraints in Farmers' Decision-Making: A Reinterpretation', *Journal of Development Studies*, 20(1): 5-21. https://doi.org/10.1080/00220388308421885

Bold, T., Kimenyi, M., Mwabu G., Ng'ang'a, A., Sandefur, J. (2018), 'Experimental Evidence on Scaling up Education Reforms in Kenya', *Journal of Public Economics*, 168: 1-20. https://doi.org/10.1016/j.jpubeco.2018.08.007

Cole, S., Giné, X., Tobacman, J., Topalova, P., Townsend, R., Vickery, J. (2013), 'Barriers to Household Risk Management: Evidence from India,' *American Economic Journal: Applied Economics*, 5: 104-135.

Dalrymple, D.G. (1985), 'The Development and Adoption of High-yielding Varieties

of Rice and Wheat in Developing Countries', *American Journal of Agricultural Economics*, Papers and Proceedings, December: 1067-1073.

Dalrymple, D.G. (1986), 'The Development and Spread of High-Yielding Rice Varieties in Developing Countries', Agency for International Development, Washington, D.C.

Dutta, P., Murgai, R., Ravallion M., van de Walle, M. (2014), *Right to Work? Assessing India's Employment Guarantee Scheme in Bihar*. Washington, DC: World Bank. doi:10.1596/978-1-4648-0130-3.

Feder, G., and Slade, R. (1986), 'The Impact of Agricultural Extension: The Training and Visit System in India', *World Bank Research Observer*, 1(2): 139-161.

Ghosal, S.N. (1973), 'Small Farmers: Why Have the Development Agencies Failed', *The Economic Times*, Mumbai, June.

Howson, C., and Urbach, P. (1993), *Scientific Reasoning: The Bayesian Approach*, 2nd ed., Open Court: Chicago, IL

India, Government of (2023), 'Crop Production Statistics for Selected States, Crops and Range of Year', https://aps.dac.gov.in/APY/Public-Report1.aspx (accessed 20.06.2024).

Lipton, M., and Longhurst, R. (1989), *New Seeds and Poor People*. Baltimore: Johns Hopkins University Press.

National Sample Survey Organisation (1966), *Tables with Notes on the Results of Land Utilisation and Crop-cutting Experiments, Eighteenth Round (July 1962-June 1963)* (Report No. 112). New Delhi.

Rodgers, G.B. (1975), 'Nutritionally Based Wage Determination in the Low Income Labour Market', *Oxford Economic Papers*, 27 (March): 81-106.

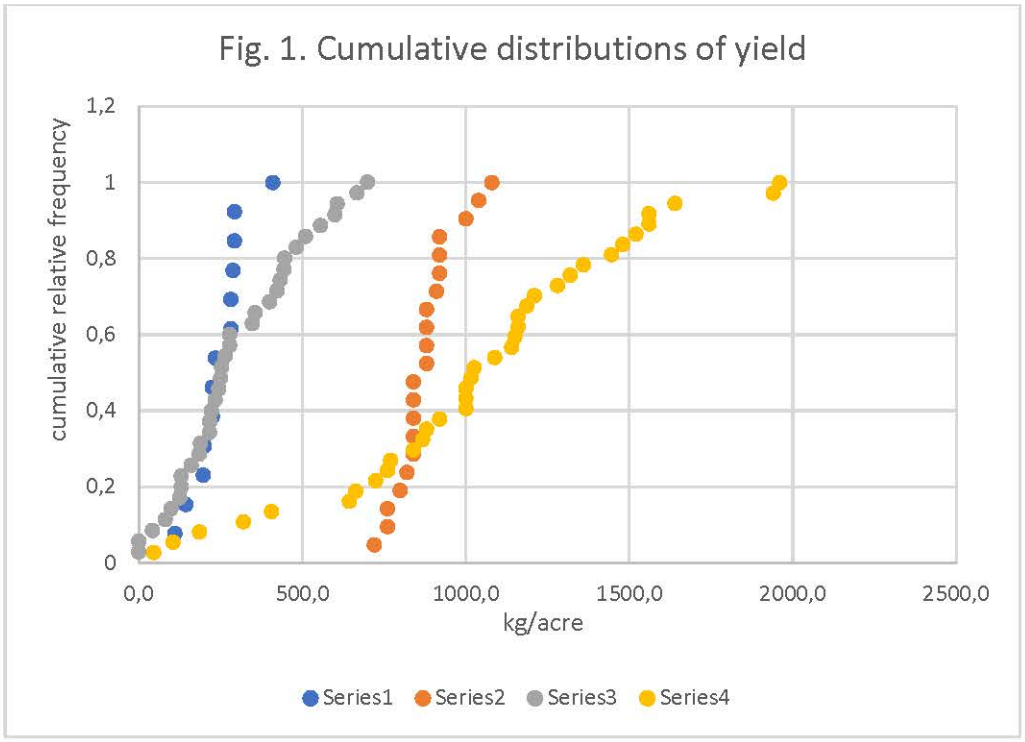
Swaminathan, M.S. (1968a,b), 'Agricultural Transformation: Parts I and II', *India News*, August 24 and September 7.

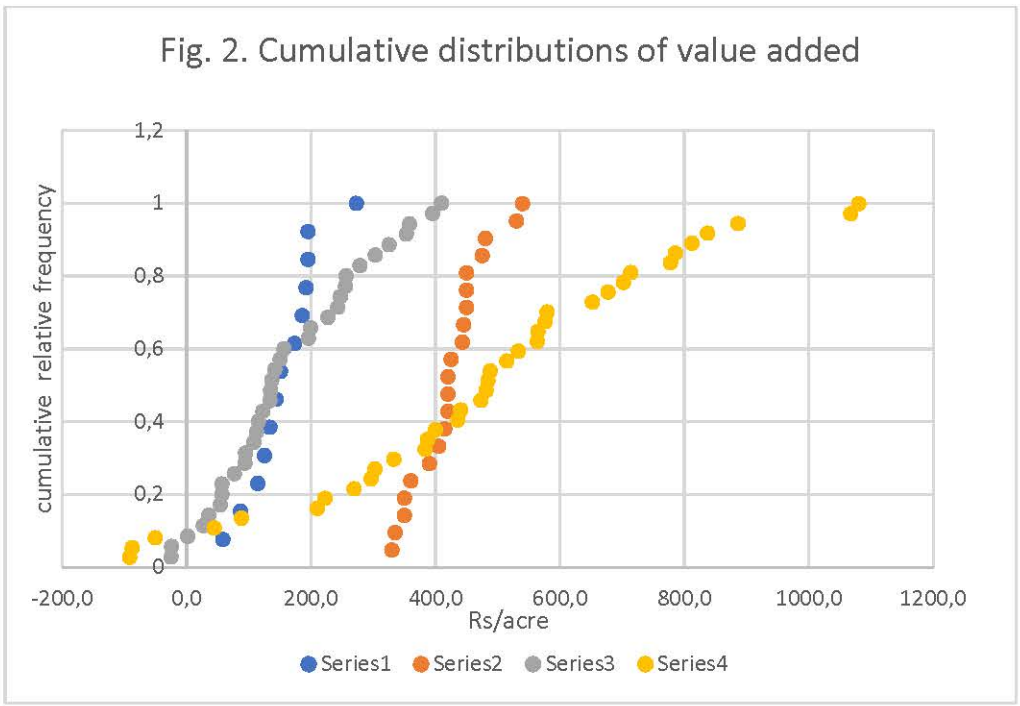
Swaminathan, M.S. (2013), 'Genesis and Growth of the Yield Revolution in Wheat

in India: Lessons for Shaping our Agricultural Destiny', *Agricultural Research*, 2: 183–188. https://doi.org/10.1007/s40003-013-0069-3

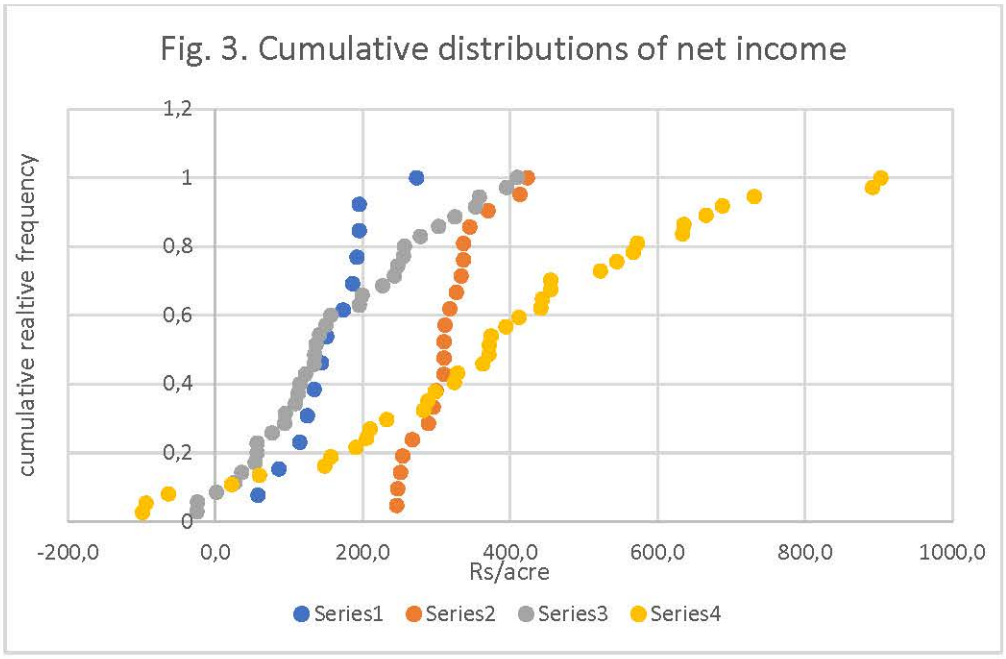
Wood, G. (1973), 'From Raiyat to Rich Peasant'. *South Asian Review*, 7 (October): 1-16.

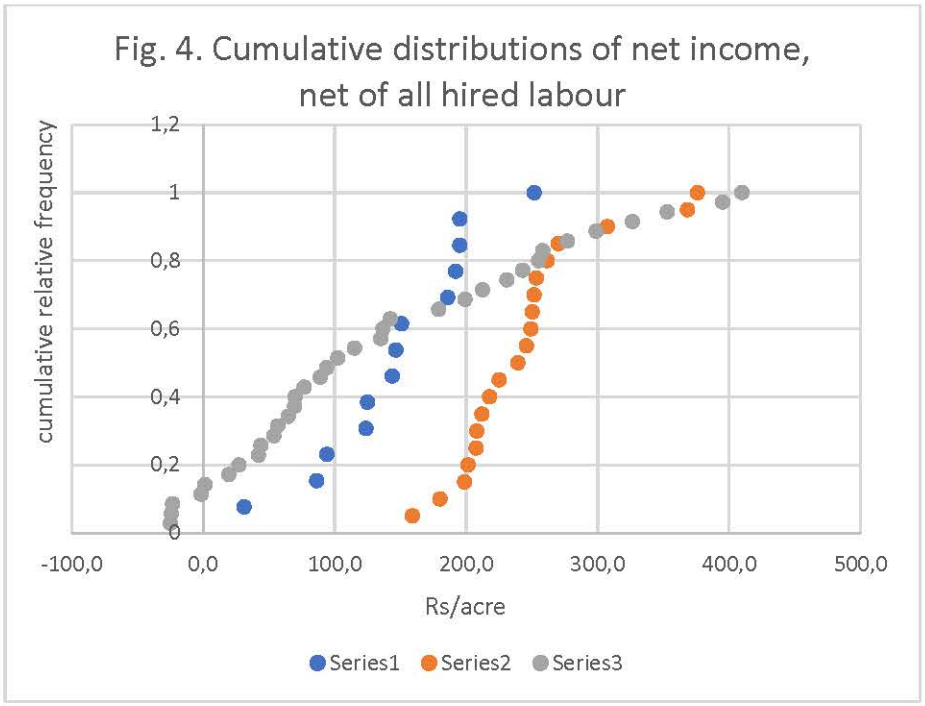
World Bank (2003), *World Development Report 2004: Making Services Work for Poor People*, Washington, DC: World Bank.





Series 1, local wheat; series 2, HYV wheat; series 3, local summer paddy; series 4, HYV paddy





Series 1, local wheat; series 2, HYV wheat; series 3, local summer paddy; series 4, HYV paddy