F_1 Hybrid Rice in Eastern India: Silver Bullet or Capitalist Ploy?*

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Introduction

This paper questions the role agricultural scientists are playing in addressing the problem of how rice production should be improved and increased, an issue that continues to be hotly debated and contested in both academic and civil society spheres. Public debate is sharply polarised between two paradigms: the agro-industrial (conventional farming) model and the agro-ecological (alternative farming) model (Roy 2010).[1] One contributing factor to the standoff between advocates of these paradigms, highlighted by Glover (2014, 185), is the division of labour within the agronomy profession itself. Agronomists think about crop yields in terms of several deficits, which are usually termed "yield gaps" and "yield ceilings." The yield ceiling expresses the theoretical maximum yield that can be produced by a given crop in a given context. Yield gaps can be defined in different ways, for example, as the gap that exists between yields produced on a farm and those achieved in agricultural research stations, or between yields achieved on average farms and those achieved by large, resource-rich farmers. In the present day, funding is disproportionately made available to plant breeders and genetic engineers whose chief goal is to raise yield ceilings. Although the development of flood-, pest-, and disease-resistant seeds can contribute to closing yield gaps, little emphasis is placed upon extension work or upon systemic issues such as land tenure or irrigation, fertiliser or credit access. Glover concludes that without an attendant emphasis on improving cultivation practices, agricultural research that focuses solely on raising yield ceilings may merely widen yield gaps (192).

Yet the biotech industry and its academic allies maintain a continued fixation on yield increases, rationalised by abstract policy calculations that compare steadily declining crop yield growth with rapidly increasing population growth. Such rhetoric allows the development and commercialisation of genetically modified (GM) crops to be pushed as a form of "pro-poor"

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* The Gene Campaign, India and the German Federal Ministry of Education and Research (BMBF) supported this work. Aditya Kumar assisted in field research and Tambo Justice in the quantitative data analysis.
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[1] Both Roy (2010) and Glover (2014) argue that there is a certain convergence of views between the proponents of both models. For example, the advocates of both the System of Rice Intensification (SRI) and of genetic improvement (including engineering) stress the genetic and physiological characteristics of the rice plant with less emphasis given to spatially and temporally situated knowledge and management skills of farmers (Glover 2014).

technology, its advocates overlooking the economic and political contexts and institutional frameworks that shape outcomes for the poor, while invoking poverty as a moral platform on which a series of assertions about the biotechnology are made (Glover 2009). The case of GM Bt cotton in India is illustrative. Shah (2011, 37) argues that only resource-rich farmers have profitably cultivated Bt cotton, and that its cultivation has led to significant environmental degradation while producing and reproducing newer forms of injustice and inequality. Stone (2012, 63) contends that by 2003 both proponents and opponents of Bt cotton had, using their respective authentication systems ("industry-journal" and "reciprocal NGO"), simultaneously claimed technological triumph and abject failure of the technology. Herring (2006, 467), who earlier argued that "Operation Cremate Monsanto" failed in India because of the opposition movement's "egregious inaccuracies of framing" (which ultimately weakened their case for environmental and social justice), contests Stone's narrative. To Herring (2013), farmers' near universal adoption of Bt cotton challenges the narrative that support for Bt cotton in India comes mainly from economists, the biotech industry, and their academic allies.

Indeed, Shah shows that "while experts and activists question the [Bt cotton] technology in the name of farmers' interests and a greater democratic future, the farmers on the contrary are voting with their feet in favour of the technology" (Shah 2005, 4629). To Shah, the cultivation and multiplication of the Bt cotton seed in Gujarat was aided by the fact that GM seed technology required no paradigmatic change in the agricultural practices and agrarian relations shaped by the earlier Green Revolution, which had privileged and consolidated the social power of resource-rich farmers (Shah 2005, 2011). Stone shows how farmers in Andhra Pradesh select cotton seed varieties by both environmental learning (empirical assessment of the benefits) and social learning (emulation of others). He argues that the Bt cotton technology's characteristics have disrupted the environmental learning that should enable farmers to renew their knowledge and skills, leading to "agricultural deskilling," a phenomenon that was less marked in the earlier Green Revolution (Stone 2007, 97). Roy, Herring, and Geisler (2007) find that Gujarati farmers (n=45) actively experiment when choosing which cotton seeds to grow, have naturalised the transgenic Bt varieties, and are unconcerned with larger ideological constructions behind transgenic seed (171). Returning to rice, Feuer provides a perspective that perhaps explains why farmers might adopt new crop types with such zeal. Focusing on the materiality of rice, he distinguishes between informal and flexible ideological standards (e.g., taste, suitability of straw for fodder) held by farmers and the oversimplified technical standards (e.g., crop yield) deemed worthy of institutionalisation, commercialisation, and regulation by agricultural scientists. "In the end, the more intrusive the technical standard, the more material facets of rice are fixed and removed from ideological interpretation and material encounter" (Feuer 2011, 457).

Both the agro-industrial and agro-ecological camps have conducted research on F_1 hybrid rice. Authenticated by the "industry-journal" system, the former supports its arguments by abstract projections of national-level rice yields, advocating monopolisation by the private sector (particularly multinational corporations) and the future introduction of GM as a "pro-poor" technology; it portrays F_1 hybrid rice as a silver bullet that can solve the problems of low yields and farmer poverty. The agro-ecological camp is more a dispersed network, its non-peer-reviewed publications often in the format of briefs authenticated by the "reciprocal NGO" system. This camp focuses its attention on environmental and social justice concerns—such as biodiversity, sovereignty, privatisation, and climate change—but (to its disservice) rarely engages with farm economics. The industry-journal literature makes evident that farmers are purchasing and sowing F_1 hybrid rice seed in an attempt to raise their yields. However, many aspects remain unclear, not least because agricultural scientists design their studies and frame their results in ways that support their ideological preferences. If, as the critics' claim, F_1 hybrid rice seed does not yield particularly well and is innutritious as a food grain, why are farmers purchasing and growing it? Are they merely being duped by advertising ploys?

Rice Research in India

Rice is the most extensively cultivated crop worldwide, and the staple of about half of humanity. By 2010 rice occupied 24 percent of India's gross cropped area and contributed 42 percent of its total food grain production (CRRI 2011). Oryza Sativa's two sub-species are Indica, grown in monsoonal South and Southeast Asia, and Japonica, grown in more temperate Japan, Korea, North China, and in parts of Europe, America, and Australia. While Indica are hardy, resistant to disease, and can tolerate unfavourable conditions producing a fair yield, Japonica have short stiff stalks, resist lodging, and respond well to heavy fertiliser doses (Navdanya 2006). Over millennia Indian farmers cultivated and bred an estimated 110,000 to 200,000 varieties of Indica rice (Alvares 1986; Navdanya 2006). Rice breeding by scientists began in undivided India in 1911 in Bengal and in 1912 in Madras. The Indian Council of Agricultural Research (ICAR) was founded in 1929 and established rice research projects across the country. By 1950 some 445 improved Indica rice varieties had been released by 82 public sector research stations located across the country. Using pure line selection, rice varieties were developed for all rice ecologies, suitable for specific stress situations or for resistance to particular diseases (Alvares 1986; DRD 2002).

With the popularisation of synthetic fertilizers post-World War II (see Alvares 2009, 8-9), efforts were made to identify rice varieties that responded to heavy doses of fertilisation (DRD 2002). In the early 1950s a Food and Agriculture Organization (FAO)-India programme was established. Attempts were made to create inter-racial hybrids so as to transfer the high-yielding capacity and response to higher use of fertiliser from exotic Japonica varieties into local Indica varieties while preserving the latter's in-built adaptation to local conditions and tolerance to pests and diseases (Dalrymple 1978; DRD 2002). ICAR started a parallel project, as did the public sector Central Rice Research Institute (CRRI) in 1960. Taichung Native I (TN-I) was developed in Taiwan in 1956, and released in 1960 (Dalrymple 1978, 25). Under a project launched by ICAR in 1965, an inter-racial hybridisation programme of semi-dwarf Taiwanese types and Indica led to the release of the Padma and Jaya semi-dwarf (high-yielding) varieties of rice in India. In the 12 years thereafter, 123 high-yielding fertiliser-responsive varieties (HYV) were released (DRD 2002).

Research to develop F_1 hybrid rice seed began in India in 1970, but there was little success for two decades. Hybrid vigour, or heterosis, is the increase in yield of cultivated crops that results from the genetic contributions derived from the crossing of distinct parental lines. The yield gains conferred by heterosis decline dramatically after the first generation (F_1), which compels farmers to purchase new F_1 seed each season to continue to realise the yield gains (Spielman, Kolady, and Ward 2013). This differentiates F_1 hybrids from high-yielding (HYV) and traditional varieties of rice, in which the harvested grain can be stored and used as seed the following year. In 1989, with an eye on the development and widespread adoption of F_1 hybrid rice technology in China, the ICAR initiated a national programme to develop and promote F_1 hybrid rice. The programme involved public sector agencies and private sector companies, with technical support from the International Rice Research Institute (IRRI)[2] and FAO, and financial support from the United Nations Development Programme (UNDP), the Indian firm Mahyco (Maharashtra Hybrid Seeds Company Ltd),[3] a World Bank funded project, and an IRRI/Asian Development Bank project (Viraktamath 2011, 2-3). In the same year the US government exerted extreme bilateral pressure on the Indian government to concede to expanded negotiations of the Trade-Related Intellectual Property Rights Agreement (TRIPS) (Plahe 2009). This is significant because the commodification

[2] According to Dr Richharia, director of the Central Rice Research Institute (CRRI) from 1959, the Rockefeller Foundation had approached the Government of India seeking to take over CRRI to establish IRRI. However, Indian scientists resisted this. Shortly afterwards, IRRI was established in the Philippines (Alvares 1986).

[3] The year before, in 1998, Mahyco partnered with Monsanto to produce a joint venture: Mahyco-Monsanto Biotech Ltd (MMB) (Roy, Herring, and Geisler 2007, 172, endnote 2).

of seed germplasm comprises two components: advances in seed technology and concurrent changes in the legal treatment of plant genetic resources (Aoki 2003 cited in Plahe 2009, 1205).

Within five years half a dozen F_1 hybrids were developed and in 1994 four were released. By 2011, 46 F_1 hybrid varieties (29 public, 17 private) had been released for cultivation across India (Viraktamath 2011, 7). By 2012, 31 public and 28 private F_1 hybrids had been notified (Siddiq 2012), and a further 30-40 "truthfully labelled" private-sector F_1 hybrids were being cultivated (Shobha Rani et al. 2012, slide 41). Hybrid rice research initially targeted the south Indian rice-rice systems and north Indian rice-wheat systems—the irrigated areas that were the focus of the Green Revolution. However, farmers in these regions did not accept the technology. Thus, in 1994-1995 eastern India was targeted for the expansion of F_1 hybrid rice cultivation (Janaiah 2002, 4322). Presently, an estimated three-quarters of the area under hybrid rice in India falls in Uttar Pradesh (39 percent), Bihar (17 percent), Chhattisgarh and Jharkhand (10 percent each) (Siddiq 2012, slide 6). Seed for an estimated 90 percent of the area under hybrid rice is supplied by the private sector (Baig 2009).

Science and Technology as Agents of Capital

Agricultural scientists have sought to encourage the uptake of F_1 hybrid rice technology in India. Janaiah, an agricultural economist who worked for ICAR from 1991 to 2005, with a stint at IRRI as a postdoctoral fellow between 1999 and 2002, has published widely on the topic. In 2002 he examined the reasons for the dramatic uptake of F_1 hybrid rice in China, showing that:

> … it was reported that political pressure from government was the major factor that contributed to rapid adoption of hybrid rice in China… Government agencies produced and supplied hybrid rice seeds for free to farmers supported with subsidies on fertilisers and plant protection chemicals… Therefore, it was the nature of the political set-up and other socio-economic factors that were behind the rapid diffusion of hybrid rice in China, and not the inherent economic superiority of hybrid rice over the existing HYVs. (Janaiah 2002, 4321-4322)

Furthermore, after economic liberalisation, in the 1990s China's area under hybrid rice declined as farmers and consumers started to express their own preferences (Janaiah 2002, 4322). Certain aspects of Janaiah's narrative change markedly eight years later, as he wrote for IRRI. He omits mention of political pressure: "China's miraculous success in the popularization of hybrid rice technology in the late 1970s and the 1980s motivated countries in tropical Asia to invest more resources for hybrid rice R&D in the 1990s" (Janaiah and Xie 2010, 6). By 2012, at IRRI's 6th International Hybrid Rice Symposium in Hyderabad, the narrative of the "Chinese miracle" had been instilled in Indian public sector scientists (e.g. Shobha Rani et al. 2012).

The International Food Policy Research Institute (IFPRI), part publicly funded and closely allied with IRRI, claims to work towards "sustainable solutions for ending hunger and poverty." To this end, they support the growth of the private sector over the public sector, and have a particular liking for multinational corporations. For example, a 2011 IFPRI discussion paper, parts of which were published in 2013 in Springer's *Food Security* and in 2014 in Elsevier's *Food Policy*, contains an analysis that does not consider India's public sector or small farmers (Spielman et al. 2011, 2), but yet concludes that "technological innovation in India's seed and agbiotech industries is primarily a private-sector phenomenon" (Spielman et al. 2014, 97). Hybridisation "provides innovators with the ability to recoup their investments in research…" (Spielman, Kolady, and Ward 2013, 651), and even though "data suggest that most hybrid rice adopters tend to be relatively wealthy" (657), and studies have shown hybrids in India are only marginally higher-yielding (by 10-12 percent) than popular inbreds (HYV), the scientists recommend "creative approaches" to privately funding hybrid rice research for the benefit of "poor farmers in India" (663). They also have no qualms in stating that F_1 hybrid rice has long-term value "as a practical platform for launching GM traits in rice" (661).[4] Conspicuously missing from their research is any examination of how small farmers—who are the majority in India—actually benefit from growing F_1 hybrid rice.

Hybrid Rice in Eastern India: A Case Study from Jharkhand

The author and an assistant undertook field research in Jharkhand in the 2009 wet season (July-September). Our aim was to investigate the uptake of F_1 hybrid rice varieties by farmers and to gauge the benefits of F_1 hybrid rice cultivation vis-à-vis HYV and traditional varieties. Figure 1 shows the study sites located in five blocks (Mandar, Ormanjhi, Namkom, Karra, and Kuru), in three of Jharkhand's centrally located districts (Ranchi, Khunti, and Lohardaga).[5] In the study sites the proportion of Adivasis[6] to the general population is about 50 percent, literacy rates are less than 50 percent, and average household landholdings vary between 0.75 to 2.0 hectares (GoI 2005).

[4] Recent data indicate that the private sector accounted for three-fifths of 20 imports into India of transgenic material for rice from 1997 to 2008 (Randhawa and Chhabra 2009, 127-128), with Mahyco-Monsanto and Bayer Crop Science being the lead importers of GM rice (Spielman et al. 2011, 11).
[5] Khunti district was carved out of Ranchi district in 2007.
[6] Adivasis are India's indigenous people: most are classified as Scheduled Tribes (ST).

A farm economics survey was undertaken with 46 farmers of different *jaati* (caste or community), having different-sized landholdings. The sample was purposively random because farmers were very busy at this time of year. Nevertheless, the 46 farmers have an average landholding of 1.34 ha (median 1.03 ha) as compared to the Indian average of 1.2 ha (Janaiah and Xie 2010, 10), meaning that in terms of farm size the sample is perhaps close to representative.[7] Farmers faced difficulties recalling their expenses and yields for the year 2008-2009, as (most) subsistence farmers do not keep records. As a result, a subset (n=29) of the 46 sampled farmers is used to calculate cost-returns. An agricultural economist assisted with the data analysis. Semi-structured qualitative interviews were conducted with an additional 20 farmers (some individual, some with groups of farmers). These interviews focused on farmer experiences with all three rice seed types. To understand how F_1 hybrid seed is procured from companies and sold to farmers, 11 seed vendors were interviewed in block headquarters and in Ranchi. Finally, the Research Director and a Chief Scientist (Rice) were interviewed at Ranchi's Birsa Agricultural University.

[Figure 1 near here]

In an assessment of rural India, Jharkhand state was recently classified the most food-insecure state (MSSRF and WFP 2008). Before *and* after Indian independence little to no investment was made in agriculture while the region was exploited for its mineral resources and labour (Sengupta 1982). The Green Revolution, which targeted the north-west and southern regions of India, was less pronounced in eastern India and almost entirely bypassed Jharkhand (Table 1). Indeed, 5 of the 17 districts in India that maintained *the lowest growth* (<1.5 percent) of agricultural output during the 1960s, 1970s, and 1980s were in Jharkhand (Bhalla and Singh 2001, 124-125).

[Table 1 near here]

Field research confirmed that the Green Revolution did indeed bypass central Jharkhand: government supply of HYV seed (IR36, Mansuri, IR64) began only in the late 1990s, as did the supply of F_1 hybrid rice seed by the private sector. During field research farmers named a total of 13 HYV and 88 varieties of traditional rice, while the F_1 hybrid rice seed of a confirmed 26

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7 One cannot imagine that any small sample in an agro-ecologically varied setting can be representative (Roy, Herring, and Geisler 2007, 162).

companies were identified, with 58 different varieties named. One farmer aptly stated "our heads are spinning because there are so many companies and seeds."

Seed Vendors Promoting F_1 Hybrid Rice

The interviewed seed vendors, each of which specialises in the sale of the profitable F_1 hybrid vegetable seeds, identified eight brands of F_1 hybrid rice as the most popular (Table 2).[8] Seven of these are owned by the six largest companies/groups in the Indian seed and agbiotech industry for 2001-2011 (Spielman et al. 2014, 94); in 2013 Syngenta bought Frontline from the Belgian multinational corporation Devgen, which has collaborated with Monsanto in the past.[9] The seed companies employ different methods to encourage farmers to buy their seed. Three-fifths of the surveyed farmers purchased DuPont's Pioneer rice seed (PHB71)—the most expensive F_1 hybrid—in 2008. A vendor in Ormanjhi, who started business in 1994, showed us a 2 kg Pioneer packet upon which was written "MRP 520 Indian Rupees;" he had been instructed to sell it at 420 Rupees. Pioneer has a different advertising scheme each year: in 2007 they gave away umbrellas, in 2008 they added silver and gold coins to seed packets, and in 2009 they gave away coupons to farmers buying six kilograms of seed, each coupon allowing another farmer to purchase six kilograms (the amount required for one acre) for 60 Rupees. Syngenta's Frontline pursued an identical strategy in 2009. Pioneer's advertisements were everywhere: posters were tacked to trees along main roads, and flags and posters decorated the fronts of vendors' stores.

[Table 2 near here]

Vendors have an incentive to sell F_1 hybrid rice because the small 2 kg packets can be returned to the company if it is not sold, whereas HYV seed is supplied in large, open sacks that cannot be returned. Most seed vendors are themselves farmers. They carefully monitor yields, preferring "branded" companies and shunning newcomers. Though branded companies' pay less commission, their seed is more trust worthy, so in the medium to long term it is in the interest of the vendor to promote and sell branded seed varieties. A vendor at Block Chowk in Ormanjhi, who started business in 1995, explained the system: "There is a scale for commission. For example, if I sell 100 kg, I'll receive 10 Rupees/kg, for 200 kg 11 Rupees/kg, and for 500 kg 12 Rupees/kg. Companies like Mahyco give less commission because they are "solid," whereas "loose" companies

[8] In 2009 Limagrain formed a 51:49 percent joint venture with Atash Seeds, a subsidiary of Avesthagen. See http://www.business-standard.com/article/companies/groupe-limagrain-closing-in-on-second-buy-in-india-112070300057_1.html

[9] See http://www.thehindubusinessline.com/companies/syngenta-completes-acquisition-of-devgen/article5462422.ece

like VNR might give 30-35 Rupees/kg. For example, if I sell 10 kg at 35 Rupees/kg, I'll make only 350 Rupees, but if I sell 500 kg at just 5 Rupees/kg, I'll make 2500 Rupees." When asked why farmers buy and sow F_1 hybrid rice seed, several vendors gave these responses: for increased yield, due to small landholdings, to sell the harvest, and because they can afford it. We also asked the vendors why farmers do not purchase F_1 hybrid seed. Over half of the vendors reported that the hybrid grain lacks taste. Several emphasised that it is not always due to a lack of cash or credit. Large landholdings, habit, and adequacy of yield from HYV seeds were also mentioned.

Results of the Farm Economics Survey

In this section the results of the farm economics survey of 46 farmers are compared with those obtained from a study conducted in the neighbouring state of Chhattisgarh by two international scientists working for IRRI. The results indicate that under farmers' conditions, yields obtained from F_1 hybrid rice are not significantly higher than those gained from growing HYV rice.

Of the 46 surveyed farmers, 15 percent held Bachelor of Arts degrees, 22 percent had passed their class 10 or 12 exams, 28 percent were partly educated (class 3 to 9), and 35 percent illiterate. The credit scenario was dire: 82 percent of farmers availed no credit, and so self-financed. One-third of the 46 farmers grow only rice, whereas two-thirds also grow combinations of *maduwa* (a cereal), maize, potato, green vegetables, wheat, mustard, tomato, onion, and *gram* (pulse). Farmers sow combinations of different rice types: traditional, high-yielding, and F_1 hybrid varieties. For example, in 2008 seven farmers sowed all three types, seven sowed solely F_1 hybrid varieties, and the remainder sowed other combinations. Two-thirds of the farmers growing F_1 hybrid rice sowed only one variety in 2008, while the remainder sowed two, three, or four varieties. 37 farmers (80 percent of the total) grew F_1 hybrid in 2008, a number that has steadily risen from four farmers in 1999. Over the same period 14 of the farmers have stopped sowing traditional varieties altogether. Yet traditional rice varieties continue to be planted on a greater area (48 percent) of the total farmland area under rice, and on average per farmer (0.65 hectares), as compared to F_1 hybrid and HYV rice (Table 3).

[Table 3 near here]

A subset of the data (n=29) was used to analyse the performance of F_1 hybrid and HYV rice types. Following the method used by Janaiah and Xie (2010, 7-12), the analysis applied various measures of central tendencies (mean, percentage) to calculate intended outcome indicators. The difference was then tested for statistical significance by estimating paired-t values. Farmers' costs of production were found to be very low, which is indicative of the lack of credit, hence inputs utilised. Just six of the 27 F_1 hybrid rice farmers, and one of the 10 HYV rice farmers, had sold a part of their rice harvest; with five of these doing so at the rate of 7 Rupees/kg.[10] Therefore, a market price for the final produce of 700 Rupees per quintal is used in the calculation. The results show that there is no significant difference between the cost of production, the net returns, and the yield gain of F_1 hybrid as compared to HYV (Table 4).

[Table 4 near here]

In an IRRI study conducted in Chhattisgarh—a state with similar political and socio-economic characteristics to Jharkhand—Janaiah and Xie (2010) sampled 61 farmers from eight villages during the 2008-2009 wet season (7), purposively selecting only those households "that had adopted hybrid rice on a considerable land area along with regular existing inbred [HYV] varieties" (6). Their sample is not representative—by average farm size or by farmers' field conditions—yet they claim "Hybrid rice outyielded the existing inbred varieties by about 36% in Chattisgarh… under farmers' field conditions… which is a phenomenal increase under rainfed uplands" (11). In this study the yield gain of F_1 hybrid rice over HYV was 4 percent (Table 5).

[Table 5 near here]

Farmers' Perceptions of F_1 Hybrid Rice

The 20 semi-structured interviews revealed a host of concerns regarding F_1 hybrid rice. Without prompting, in half of the interviews it was said that hybrid lacks taste, in one-third that hybrid is insufficiently nutritious, and in several that hybrid has poor cooking and keeping quality. Similar findings are highlighted in Janaiah and Xie (2010, 14-15). To cite one example, the large farmer Deonath Pahan, who owns eight hectares of land, explained that for the past five years he sowed F_1 hybrid on four hectares of *khet* (irrigated lowland) and HYVs on his *tanr* (unirrigated upland), and had only had good experiences. He also grows the traditional rice variety Dhusri, both for comparison of yields and because it does not require chemical fertiliser. The rice of traditional varieties is sweet and tasty, but when consuming F_1 hybrid rice he and his family

[10] In 2008-2009 the Minimum Support Price for rice was set at 900 Rupees per quintal (Sharma 2012, 9). Janaiah and Xie (2010, 12) state that the market price of HYV and F_1 hybrid was 7.4 and 7.1 Rupees/kg for Uttar Pradesh and 12.1 and 10.8 Rupees/kg for Chhattisgarh, respectively.

members crave vegetables. He links an increase in the rate of illnesses to conventional (agro-industrial) farming, and laments the gradual disappearance of coarse, early maturing crops like Gorha paddy and the reduction in size and catch of fish found in paddy fields.

In one-third of the interviews farmers said that they sow F_1 hybrid because of increased yield. Yet this disguises the fact that most farmers simultaneously sow several seed types. Mahdu Mahato of Ranchi district owns 0.24 hectares of land, share crops another 0.16 hectares, and has bought seed from the same vendor for the past 10 years. In 2009 he purchased a "loose" F_1 hybrid seed (company Manisha), however, half of the seedlings died. In its place he purchased Lalat, an HYV. The previous year he had purchased and sown Mahyco F_1 hybrid and IR36 HYV seed. He keeps the traditional variety Lal Dhan for what he terms "insurance"—in case the F_1 hybrid seed fails or he cannot afford seed.

In the interviews farmers had more to say about why they do not sow F_1 hybrid seed than why they do. Lack of cash and credit for the purchase of inputs was raised in half of the interviews, and the high cost of F_1 hybrid seed was mentioned in one-third. One interview took place in the early morning in an Adivasi village in Khunti district. When riding down a lane we stumbled upon a weekly meeting attended by c. 50 men. We were told that for the past ten years all the villagers had purchased and sown at least 3-6 kg of F_1 hybrid seed, getting a high yield. Prior to F_1 hybrid they had sowed HYV seed. They complained that F_1 hybrid seed was expensive and that most villagers could not avail formal credit and were unwilling to take informal loans for fear of crop failure. They also said excessive use of chemicals was ruining the land, that F_1 hybrid grain cannot be stored for even a year due to pest infestation, and that its straw is of no use for feeding their livestock because of its short length. They listed many traditional varieties of rice and discussed their uses. For example, Karaini rice was mentioned as used to treat jaundice. F_1 hybrid rice does not serve such purposes.

Other responses regarding why farmers were not using F_1 reported in more than one interview included: preference for use of cow dung over chemical fertiliser, unwillingness to spray chemical pesticides on grain grown for food, livestock's dislike of the straw of F_1 hybrid, and limited support (extension) from government. Jagdesh Munda, an Adivasi farmer, explained why, with only one hectare of land and 16 family members, he sows HYV and traditional varieties (Hardimuri and Chaina Gora). Harvesting enough rice to last just 6-7 months, he believes that HYV seed requires less chemical fertiliser than F_1 hybrid seed, and that F_1 hybrid rice digests too fast and is laced with pesticide. Besides this, he need only purchase new HYV seed every fourth year. Six farmers of Lohardaga district said that all of their village's households—regardless of *jaati*—have annually sown 4-6 kg of F_1 hybrid seed for the past four years. The block office has never distributed F_1 hybrid seed. HYVs have been sown for the past ten years, however its seed is available in limited and insufficient quantities at the block office.

Conclusion: F_1 Hybrid Rice as Silver Bullet or Capitalist Ploy?

By the late 2000s the uptake of F_1 hybrid rice by farmers in central Jharkhand is widespread, although farmers have a clear preference for traditional and high yielding varieties of rice. Up until the 1990s the majority of farmers grew traditional varieties of rice because the Green Revolution had had no impact in this region. HYV seed is not provided to farmers in the required quantities, and while non-governmental organisations provide trainings in villages (e.g. on the SRI technique), not a single farmer could say that government extension workers had provided them with support. Their knowledge of conventional farming (i.e., how and when to apply inputs) inadequate, a majority of farmers are self-funding anyhow, having no credit facilities to avail, and are therefore unable to purchase inputs.

There appears to have been little progress made in the 2000s. The need to provide HYV seed, fertiliser, institutional credit, and appropriate extension services for India's eastern region are highlighted by Bhalla and Singh (2001, 209-210). As such, agrarian conditions greatly differ from those of China during the 1960s to 1980s, when the government produced and supplied hybrid rice seeds for free to farmers, and supported them with subsidies on fertilisers and pesticides. They differ also from those experienced by Indian farmers in the Green Revolution states (with the most favourable conditions for farming), who were provided with subsidised seed-fertiliser technology. For their selection of seed, the Jharkhandi farmers encountered in this study were for the most part reliant on information gleaned from seed vendors more inclined—due to profit margins—to sell F_1 hybrid than HYV seed.

The private sector, dominated by several multinational corporations, has ample resources to advertise its F_1 hybrid rice varieties to farmers and enjoys the support of agricultural scientists working for international organisations such as IRRI, some of whom have been co-opted from the Indian public sector. Although ostensibly publicly funded—receiving a large proportion of funding directly (and indirectly) from OECD governments—in recent years IRRI has partnered with several multinational corporations. A 2010 report by a consortium of movements working to combat the corporate takeover of agriculture claims that it is not the performance of F_1 hybrid rice that is attractive to seed companies, but rather "the fact that farmers cannot save the seeds from these varieties, thus guaranteeing the companies a captive market" (GRAIN 2010, 9). They also note that "rice seed programmes are increasingly focused on hybrids, and support for developing inbred [HYV] varieties or improvement of native land races [traditional seed] that are more resilient to different agro-climatic conditions, is disappearing" (9). Janaiah's change in viewpoint, between when he worked in the Indian public sector and at IRRI, serves to highlight the co-option of public scientists. In 2002 he pointed out that resources diverted from conventional rice improvement programmes and invested in hybrid rice R&D had been wasted, and recommended that "regular replacement of quality seeds of existing HYVs of rice… can increase yields by 17-22 per cent without much extra investment" (Janaiah 2002, 4326). Yet in 2010, and based on his study of large farmers, he concludes that "in eastern India, where poverty and malnutrition persist widely, a considerable increase in yield through hybrid rice will have a major impact on household food security, income, and nutrition…" (Janaiah and Xie 2010, 18). Glover's insight holds well. The biotech industry and its academic allies use abstract notions of crop yield to package the development and commercialisation of new seed technologies as "pro-poor" (2009).

But does this explain why farmers are "voting with their feet" for the F_1 hybrid rice technology? In the absence of government-led systemic changes to the agrarian environment, farmers are experimenting with F_1 hybrid rice, in the short term gaining a boosted yield due to the heterosis effect. Yet given its overwhelmingly negative characteristics, the question of why farmers have naturalised the F_1 hybrid rice seed remains. Returning to the six farmers (n=29) who sold a part of their F_1 hybrid or HYV rice harvest, only three of these declared that they have an annual rice grain surplus; the other three sold a portion of their harvest (between 280 to 500 kg) with the knowledge that they would later have to purchase rice on the market. As the majority of farmers make production decisions oriented toward supporting their family and farm, and not to anonymous consumers in the market, why do they cultivate a grain they have no wish to consume? This is perhaps best explained by Feuer's insight that "the more intrusive the technical standard, the more material facets of rice are fixed and removed from ideological interpretation and material encounter" (2011, 457). Such a perspective explains why farmers provided (almost) solely with information that emphasises the importance of grain yield (*the* technical standard) learn to dismiss many of their ideological preferences (for agro-ecological cultivation), even to their own disservice.

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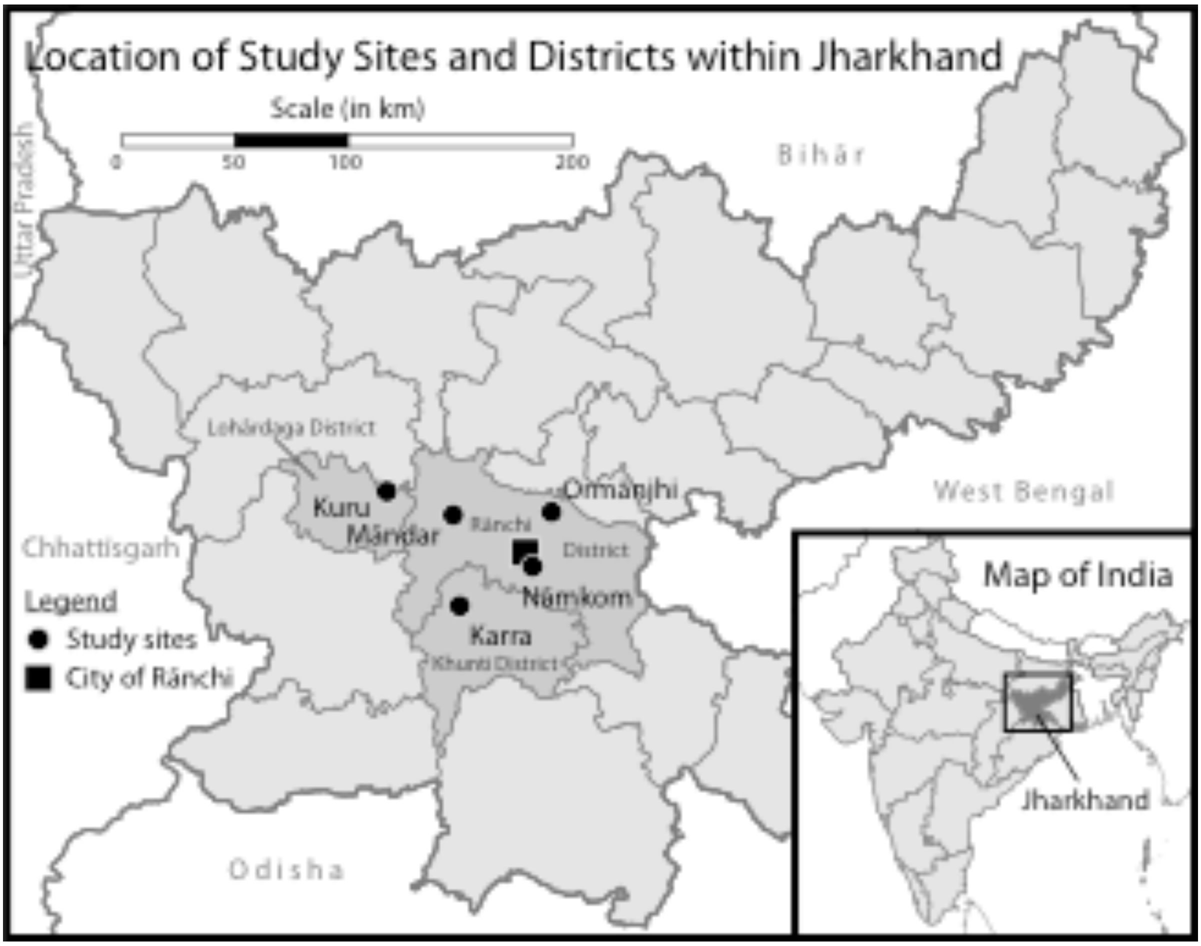

Figure 1. Location of the study sites and districts, within Jharkhand, India. Prepared by Carl Sack.

Table 1. Key inputs to conventional agriculture: Ranchi district, compared with Indian regions. Source: Bhalla and Singh (2001).

Region	Number of tractors (per 000 ha net sown area)			No. pump-sets (per 000 ha net sown area)			Consumption of fertiliser (kg/ha net sown area)		
	1962-1965	1980-1983	1987	1962-1965	1980-1983	1987	1962-1965	1980-1983	1992-1995
Ranchi	0.04	0.4	1.5*	0.3	5.1	10.4*	1.2	7.1	26.1*
Eastern	0.2	0.8	5.3	0.6	27.6	51.5	2.6	26.1	74.3
North-west	0.8	11.9	34.4	2.5	76.9	106.4	4.3	91.0	163.6
Southern	0.2	2.0	4.6	10.1	77.8	93.3	8.3	55.9	115.3
All-India	0.3	3.7	11.7	4.6	49.2	64.9	4.3	42.6	89.1

* Ranchi data is for 1990-1993, not 1987 and 1992-1995.

Table 2. The most popular brands of F_1 hybrid rice as identified by seed vendors. Compiled from interview data.

Rank	Brand name	Company / Parent company (Country of origin)
1	Pioneer PHB71	Pioneer / DuPont (USA)
2	Advanta PAC-832, 801, 807	Advanta / UPL (India)
3	Arize PA 6444, 6129	Bayer (Germany)
4	Frontline RH 257, 664	Syngenta (Switzerland), formerly Devgen (Belgium)
5	US 312, 328	US Agriseeds (USA)
6	Sahyadri	Syngenta (Switzerland)
7	SRH 1, 302	Avesthagen-Limagrain (India/France)
8	Suruchi MRP 5629	Mahyco-Monsanto (India/USA)

Table 3. Cross-tabulation of farmland area, number of farmers, and rice type (n=46). Source: Author's own data and design.

Summary of quantitative survey findings	Rice type		
(for agricultural *kharif* season 2008-2009)	F_1 Hybrid	HYV	Traditional
Number of farmers growing rice type (n=46)	37 (80 percent)	16 (35 percent)	32 (70 percent)
Number of farmers who have grown rice type in past (n=46)	38 (83 percent)	26 (57 percent)	46 (100 percent)
Mean average farmland area (hectare) on which rice type is grown	0.49 (n=37)	0.27 (n=16)	0.65 (n=32)
Area of farmland (hectare) under rice type (n=46)	18.0	4.3	20.7
Percent of total farmland (hectare) under rice type (n=46)	42 percent	10 percent	48 percent

Table 4. Comparative cost-return profile for cultivation of F_1 hybrid and HYVs rice (n=29). ns = not significant. Source: Author's own data and analysis.

Performance indicators (for agricultural *kharif* season 2008-2009)	Rice type		
	F_1 hybrid (n=27)	HYV (n=10)	t-value
Total area (hectare) under rice type	12.88	2.47	-
Average area (hectare) under rice type per farmer	0.48	0.25	-
Average grain yield (metric tonnes per hectare)	4.73	4.56	0.254 (ns)
Gross returns (Indian Rupees per hectare)	33,129	31,941	0.255 (ns)
Total costs (Indian Rupees per hectare)	9,454	7,571	1.063 (ns)
Net returns (Indian Rupees per hectare)	23,676	24,369	-0.158 (ns)
Cost of production (Indian Rupees per metric tonne)	2,241	1,896	0.686 (ns)

Table 5. Comparison of findings between an IRRI study and this study. Source: Janaiah and Xie (2010 7, 10, 11); Author's own data and analysis.

Study authors	Janaiah and Xie 2010	This study (Hill)
Indian state / agricultural year	Chhattisgarh / 2008-09	Jharkhand / 2008-09
Number of farmers	61	46
Mean average landholding (ha)	6.6	1.34
Average rice area (ha)	5.7	0.93
Total area under rice (ha)	345	43
% under irrigated conditions	66%	Estimated ~12%
Total area under F_1 hybrid (ha) (%)	235 (68%)	18 (42%)
Total area under HYV (ha)	110 (32%)	4.3 (10%)
Total area under traditional (ha)	0	20.7 (48%)
Average yield of F_1 hybrid (mt/ha)	4.5	4.7
Average yield of HYV (mt/ha)	3.3	4.6
% Yield gain of F_1 hybrid over HYV	36.4	3.7