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THE ECONOMIC BOTANY OF ORGANIC COTTON FARMS IN TELANGANA, INDIA

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*Organic agriculture projects have advanced biodiversity as a key goal and outcome of their methods, in part by encouraging non-chemical inputs and non-genetically modified seeds. In India, organic cotton agriculture has been marketed as a specific alternative to genetically modified cotton (*Gossypium hirsutum*), India's only legal GM crop. However, previous work has shown that the same production pressures that drive GM agriculture to lack biodiversity do not necessarily apply to Indian cotton farms. On organic farms in the Adilabad district of Telangana, India, organic farmers are growing nearly 100 semi-managed foods, trees, and medicines belonging to 37 botanical families. However, organic groups target farmers that may be more inclined to cultivate agrobiodiversity anyway. This paper draws on household surveys, field interviews, and ethnographic research among ethnic Gond farmers participating in a corporate organic program to suggest that such alternative agriculture schemes find ways to reward farmers for biodiverse fields. Organic cotton farms contain significantly greater numbers of economic plants than GM cotton farms in Telangana and organic organizations ensure that this economic botany becomes institutionalized.*

Keywords: *organic agriculture, agrobiodiversity, India, farmer decision-making, sustainability*

Introduction

Agrobiodiversity is a key element in smallholder agriculture, helping farmers maintain a resilient crop base in the face of variable ecological conditions and shifting economic and subsistence needs. Agrobiodiversity provides a wellspring of germplasm that farmers can rely on when necessary as well as the knowledge required to manage these variables successfully (Brookfield 2001; Netting 1993; Wilken 1987). Agrobiodiversity can suffer under conventional industrial agriculture[1] because of the imperative to produce cash crops, grow monocultures, and buy seeds bred to grow best when given the right cocktail of chemical fertilizers, pesticides, and irrigation (Altieri 2000; Kloppenburg 2004). Since the late 1990s, organic agriculture has emerged for Indian farmers as an alternative to this input-intensive agricultural development. Research in this paper shows that organic cotton (*Gossypium hirsutum*) farmers in Telangana, India, are maintaining a biodiverse agriculture, especially when compared to Telangana farmers who plant genetically modified (GM) Bt[2] cotton. Bt[2] cotton produces proteins from the *Bacillus thuringiensis* (Bt) bacteria, which is fatal to major cotton pests in the Lepidoptera order. However, it is argued that this difference in economic botany stems less from the inherently low-input technology of organic agriculture than from the institutional reward structure of the particular organic corporation managing their production. For these organic farmers, agrobiodiversity is a

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function of a social relationship with organic program managers rather than an inherent feature of their agriculture. This distinction is necessary to understand the conditions under which agrobiodiversity, food security, and botanical knowledge are preserved in this context.

This study draws on the economic botany of 70 farmers participating in an organic cotton program in the Adilabad district of Telangana, India. Data were collected between May and August 2014 as part of a doctoral dissertation that involved 12 months of ethnographic fieldwork and an additional survey of the economic botany of 62 farmers growing genetically modified (GM) cotton in the Warangal district. Through farmer ethnography, key informant interviews, freelisting, voucher specimen collection, walking interviews, and field surveys, this study provides a view of the plants regularly used and cultivated on the farm fields by organic cotton farmers participating in the Prakruti Organic[3] program. Because the organic program recruited entire villages, this sample draws on the agrobiodiversity of five hamlets ranging from 10 to 50 households. In each hamlet, either the entirety or the vast majority (~80%) of organic-planting households were interviewed to gain a representative sample.

Neither this survey nor a previous survey of persistent agrobiodiversity of GM cotton farmers (Flachs 2015) was designed to record wild plants and animals on farm fields or a complete knowledge of forest products, home gardens, or other plants used by particular individuals. Rather, both studies record the typical economic botany of farmers' fields to document how different modes of cotton production, here GM and certified organic agriculture, are impacting the everyday agrobiodiversity of cotton agriculture. As described in the caveats section below, these data cannot be used to compare the agrobiodiversity of all GM and all organic cotton farmers in India. However, these village case studies can highlight the ways that different economic and institutional incentives impact agrobiodiversity. This difference does not arise because organic or GM cotton agriculture inherently promote or suppress biodiverse agriculture, but because organic programs underwrite the production costs of agrobiodiversity while GM cotton agriculture incentivizes lower biodiversity in favor of cash cropping. In order to contextualize this study and to clarify the comparative reward structures of GM and organic cotton agriculture, it is important to understand the different political, regulatory, and economic trajectories of these two modes of cotton production.

Organic Agriculture as a Biodiverse Alternative

In India, the development of certified organic agriculture has taken place against the backdrop of GM cotton production. Commercially released in 2002, GM cotton is regulated by a complex bureaucracy including several committees designed to accommodate business interests, anti GM-activists, and concerned farmers (Scoones 2006). GM cotton's rise in India has been a complex journey. While adoption as a whole has been rapid and overwhelming (Cotton Corporation of India Ltd. 2014), there is uncertainty regarding the selection of particular seeds (Stone et al. 2014). Indian cotton yields have increased since

GM cotton's introduction (Kathage and Qaim 2012), yet there is uncertainty over the role that GM seeds played in this increase because the spread of GM seeds was so quick that there was no on-farm counterfactual to Bt cotton; that is, we have no way of knowing how yields would have risen in the absence of GM seeds over this period (Crost et al. 2007). Additionally, strong national controls on the spread of the GM technology (Kudlu and Stone 2013) were initially incapable of preventing the spread of illegal or spurious seeds (Herring 2007; Sahai and Rehman 2004). Despite the government's attempts to satisfy various civil society stakeholders through a regulatory structure that slowed corporate and national agribusiness interests, GM cotton and the agricultural future it represents continues to be protested and questioned (Herring 2015; Parsai 2012). Although calls for a unified approach to organic and GM agriculture have been made (Ronald and Adamchak 2008; The Hindu 2008), the uncertainties related to GM cotton provided an opportunity for an alternative agriculture to gain popularity.

Whereas GM regulation preceded GM production by 13 years (Heinemann 2012; Newell 2003), India's organic regulation did not coalesce until 2000, sixteen years after the first NGO-sponsored organic conference (Narayanan 2005). As with GM seeds, organic proponents tout its potential to cure India's chemical overuse, stop poverty, and bring Indian products to new markets (da Costa 2012; Panneerselvam et al. 2012). To satisfy ethical consumers mainly based in North America and Europe, organic regulation in India sought to maintain equivalency with organic regulations first established in the United States and later adopted internationally. Seeing that environmental organizations received groundswells of support during GM debates in the 1990s (Schmid 2007), environmentally minded policymakers, especially in Europe and the United States, saw the advantages of positioning organic agriculture as an alternative to genetic modification and the kind of production it represented to consumers (Jasanoff 2005). By the late 1990s, anti-GM activists saw organic agriculture and its regulation as an opportunity to align themselves with environmentalist consumer demand and growing skepticism of anti-biotechnology. This opportunistic alliance between agricultural regulators and anti-GM interests led American regulators to ban GMOs from organic production while the growth of global organic supply chains led to GMO bans in all subsequent national and international legislation to maintain global consistency. Following this international trend, Indian organic guidelines have been adopted from USDA protocols and deny certification "when use of [GM] products is detected at any stage" (Department of Commerce 2005:92). In aligning themselves with extant regulation, GM and organic cotton producers became legally opposed and have come to represent two mutually exclusive alternative agricultures. This opposition is especially ironic for Bt cotton biotechnologists, who selected Bt specifically because of its longstanding use as a certified organic pesticide in the US (Charles 2001).

To its Indian proponents, organic agriculture is a distinctly Indian form of production, one that served Indians before the interference of colonialism, was brought to the West after British officer Albert Howard lived in India, and was destabilized by the Green Revolution (Conford 2011; INORA 2012; Narayanan

2005). Its popularity in the larger world thus presents both an example of foreigners capitalizing on Indian knowledge and an opportunity that threatens to leave India behind. To become certified and label their products as organic, farmers must contact certifiers accredited by the Agricultural and Processed Food Products Export Development Authority (APEDA) and the National Programme on Organic Production (NPOP). NPOP, run through APEDA, defines organic standards, criteria for accreditation, and certification procedures (APEDA 2012). This structure mirrors the USDA and other international standards (APEDA 2012; Narayanan 2005), a decision crucial for exporting to coveted markets in the US and Europe. This equivalency has allowed the organic cotton industry to boom in India, providing 74% of the global organic cotton spun in 2012 (Textile Exchange 2013).

Organic cotton production in India has emphasized low-level inputs, increased wages, and biodiversity, among other social and environmental benefit, to emphasize the type of agriculture that environmentalist or ethical consumers wanted to support (Franz and Hassler 2010; Guthman 2009). Organic agriculture proponents (Chetna Organic 2013; Gene Campaign 2008) claim that certified organic agriculture is one way of maintaining biodiversity, particularly by encouraging the use of fewer herbicides, pesticides, chemical fertilizers, and monoculture practices. Some additionally blame GM cotton for suicide (Shiva et al. 2002), question its role in sustaining biodiversity because it promotes less biodiverse commodity farming (Conner et al. 2003; Kloppenburg 2004), or charge it with exacerbating agricultural inequalities with roots in the Green Revolution (Shiva 1993, 1997). Others (Deshpande and Arora 2010; Plewis 2014) place cotton farmer suicides or underproduction within a broader narrative of agrarian crisis, arguing that this context has more to do with social and economic vulnerability or access to credit systems than with seeds themselves.

Some observers (Pearson 2006; Stone 2002) have argued that publications and studies on GM cotton can be more politically than scientifically motivated. The political tempestuousness of GM crops aside, scientific studies generally affirm that organic agriculture has a positive effect on species richness and abundance when compared to conventional agriculture (Altieri 2000; Bengtsson et al. 2005; Hole et al. 2005; Maeder et al. 2002). In the field, these benefits can be difficult to attribute to a specific pattern of regulation or certification so much as a reduction in biocide application and a de-emphasis on monoculture. Furthermore, Guthman's (2004) study of California organic farmers shows that organic agriculture is not inherently more biodiverse or less industrialized. When regulation becomes too expensive or the scale of production increases, this pressure can price out smaller organic farmers and lead the remaining farmers to resemble conventional agribusiness in their farming practices.

Although some (Krishna et al. 2014) have argued that the diversity of GM cotton hybrids, now manifesting in more than 1,000 possible seed brands, provides a necessary biodiversity to safeguard cotton farmers against agricultural risk, this would account only for different strains of cotton, not for a species-level biodiversity. A diverse set of crops managed by farmers provides different kinds of insurances. Agrobiodiversity diffuses a farmer's risk that individual crops will fail and leave them without a product to sell at the market or food to eat. Agrobiodiversity is agronomically useful as well, because a diverse set of crops is less likely to be ruined by a catastrophic pathogen or pest attack that affects a single type of plant. These agricultural practices also allow farmers to retain knowledge about these plants, their interactions and uses, and their management through daily practice (Altieri 2000; Barthel et al. 2013; Netting 1993). As farmers change their management strategies and manage fewer subsistence and market crops in their field, they also risk losing the knowledge that accompanies this agrobiodiversity.

On Telangana cotton farms, the organic/conventional divide is defined by the seeds used. As GM Bt cotton seeds cannot be certified organic under current regulations, GM cotton farmers have no incentive to grow Bt cotton under organic conditions. Instead, most farmers who plant non-GM cotton in an area defined by over 90% GM adoption (The Hindu Business Line 2013) are participating in an alternative agriculture program. Indeed, non-Bt seeds are virtually impossible to find otherwise.

Despite concern that GMs represent a threat to biodiversity (Altieri 2005; Fitting 2006; Garcia and Altieri 2005), previous work has shown that GM-planting farmers also plant a surprising diversity of crops in their small fields (Flachs 2015). GM cotton farmers in the Warangal district of Telangana maintained an average of 17 economically useful semi-managed plants belonging to 100 species and 39 families. The reward structure of GM cotton cash-cropping incentivizes high investments in the name of large yields and large profits, and those farmers would never intentionally thin their cotton crop to make room for non-cash crops. This agrobiodiversity was a product of chance or crop failure on valuable land in which farmers invested resources. When cotton failed to germinate on farm fields, farmers opportunistically planted other crops or encouraged wild plants or trees to grow on field edges as a means of encouraging greater food security, access to medicines, or access to firewood. That study showed that economic plant counts were greater among more marginal, poorer members of the Lambadi Scheduled Tribe (ST), a census category referring to historically marginalized farmers ethnically distinct from the local caste system, who live in a hamlet outside the town proper rather than among members of the Telugu caste system in the village.

While GM cotton agriculture in India can be at least somewhat biodiverse, organic agriculture makes biodiversity part of its brand. The differing institutional rewards of GM agriculture and organic agricultural development in Telangana provide an opportunity to compare the economic botany of these groups as a function of different agricultural reward structures, although this comparison must be considered in light of the caveats listed below. The comparative economic botany of these two sites will be further detailed in the discussion. As part of the perpetual backdrop of and opposition to GM, organic cotton producers in India are comfortable claiming a greater biodiversity than conventional farms. This is, in part, a testable hypothesis.

Methods

This study is concerned with the economic use of plants as part of everyday agroecology in farm fields in Telangana, India. To collect information on plants regularly used on farm fields by most people, all or the vast majority (~80%) of the households practicing organic agriculture in each village cluster were sampled. This was relatively easy given the small size of the villages. Only active farmers were interviewed about plants on or bordering their farm lands, defined as the area where farmers are actively cultivating crops for market or food stores, as well as the edges of those fields. Due to the focus on agrobiodiversity specifically, this study does not investigate forests or home gardens located next to houses outside of field areas. The research is not a full ethnobotanical study, but rather an accurate view of managed agrobiodiversity. Plant counts are relatively low because of this research design. This paper replicates a number of different methodologies developed in a previous agrobiodiversity study of GM cotton farmers (Flachs 2015). By maintaining a consistent data collection strategy, this research can compare plant counts between GM and organic farmers. First, key informants and talkative farmers freelisted commodity, home-need, volunteer, useful wild, medicinal, ornamental, tree, and other plants found on or near their farms. These and other plants were identified as part of walking interviews (De Leon and Cohen 2005) and further probes designed to counteract respondent forgetfulness and fatigue (Quinlan 2005). This was used to develop a final plant checklist that was presented to 70 farmers in the Addabad and Japur village areas. Plant counts determined by each farmer and by farmers in the previous GM study were used to compare the relative counts of both kinds of farmers using one-way analysis of variance (ANOVA). Although the final list included 65 plants, farmers added an additional 32 others. Farmers were asked if the given plants were present or not present in their fields, were given an opportunity to add plants to the master list, and were asked to add to these lists after their initial interview. This final economic botany count (97) represents the species richness on Adilabad organic farms. Vouchers were collected for each plant with farmer informants and all farmers consented to participate in the study and provide plant material.

This project received IRB approval from Washington University in St. Louis and was conducted under an Indian research visa, following the code of ethics outlined by the Washington University in St. Louis IRB and the American Anthropological Association. All farmer participants gave prior informed consent for plant collection and participated in voucher collection. All vouchers (for ID numbers see Appendix A) were delivered to Dr. R. Ganesan of the Ashoka Trust for Research in Ecology and the Environment (ATREE) in Bangalore, Karnataka, and high-resolution photographs were taken of mounted plant specimens collected in this study. No plant specimens were removed from India and all specimens collected in this study remain in the care of ATREE. All data used in this study were collected between May and August 2014. These field counts and collections were intended to give a perspective on agrobiodiversity as

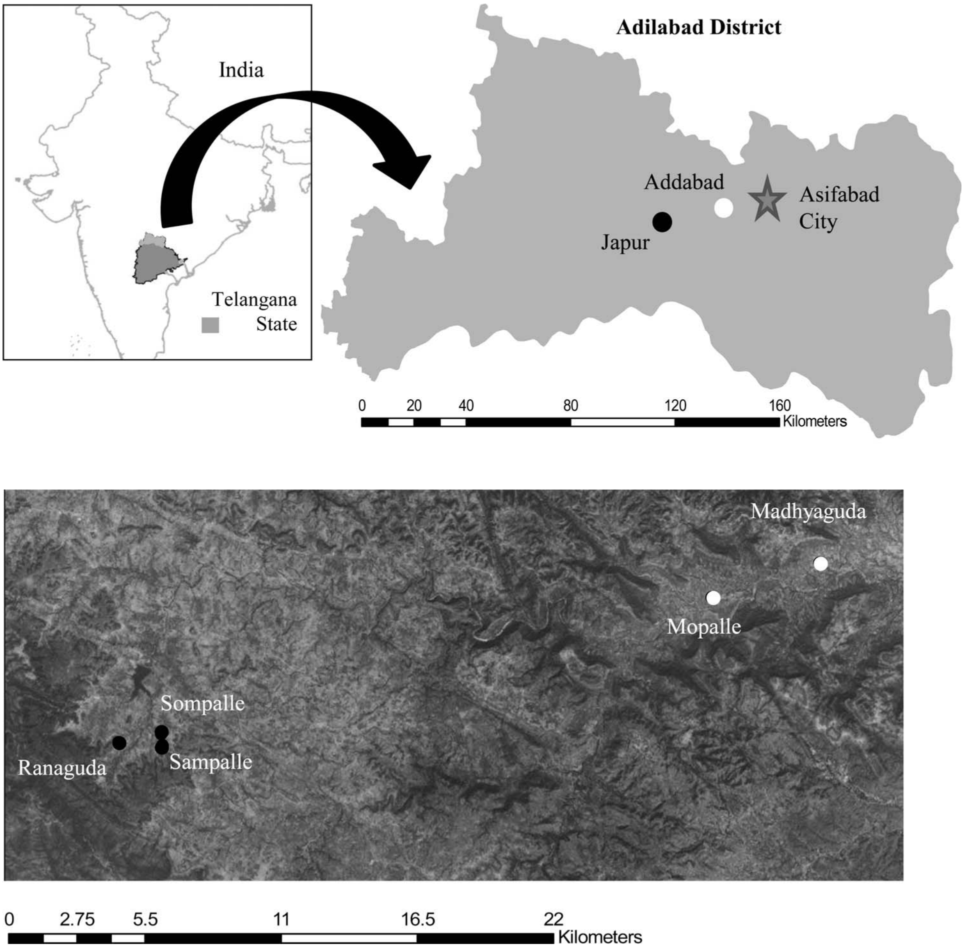


Figure 1. Map of Organic Sites.

a function of species richness, or total botanical diversity, rather than their evenness or distribution. Statistical analysis and graphs were calculated using Minitab 17 (Minitab Inc. 2010).

Site Description

This study was conducted as part of a doctoral dissertation project conducted between May and August 2014 among five clusters of households in the Adilabad District of Telangana (Figure 1). These villages were recruited to participate in a certified organic scheme in part because they are far from town centers, the farmers belong to the historically marginalized Gond Scheduled Tribe, and they have relatively poor access to resources. Gond people have lived in the Adilabad district for centuries (Mehta 1984), but their language and customs are different from the Telugu caste majority and their *thandas*[4] tend to be well removed from villages proper and their infrastructure. This study takes place in two *thanda* clusters in the Adilabad district: Addabad and Japur. Addabad is composed of two smaller hamlets, Madhyaguda (~8 households, all practicing organic agriculture) and Mopalle (~40 households, half of which practice organic agriculture). Nearby Asifabad is a small city with a lively market and bus station, but the *thandas* themselves have only intermittent access to buses and auto rickshaw. It can take over an hour during the rainy season to reach the *thanda*s from Asifabad and local buses often refuse to make the trip citing a lack of interest.

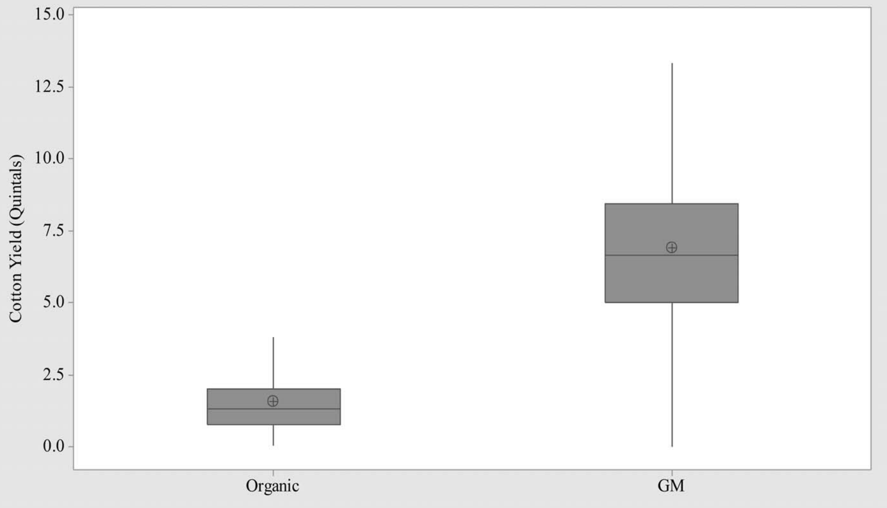
Sompalle (~10 households, all practicing organic agriculture), Sampalle (~10 households, all practicing organic agriculture on some of their land), and Ranaguda (~20 households, practicing organic agriculture on some of their land) compose the Japur *thanda* cluster and are similarly difficult to reach by bus or auto rickshaw. In both village clusters in the Adilabad district, farmers work hilly, rocky soil that pools water and erodes quickly. Their proximity to forest areas provides an additional risk of pig and parrot predation, which farmers manage by sending family members, often, but not exclusively, young men, to sleep in bamboo stilted houses (*manda*) from which they sling stones at attacking pests. These Adilabad district organic farmers additionally lacked irrigation facilities and so relied entirely on rain for crop watering, with the exception of a few farmers who rigged motors to nearby seasonal streams. Farmer cotton yields in this area are predictably lower as a result, regardless of their organic imperatives to grow without chemical inputs or GM seeds. Farmers tended to grow heirloom sorghum (*Sorghum bicolor*) rather than wet rice (*Oryza sativa*), although a few farmers cultivated a dry, non-irrigated rice variety (*Oryza sativa*). Due to their close relationship with organic NGOs, as well as their geographic and social distance to input shops, most Adilabad district organic farmers procured seeds through organic programs or their own stores.

This research was conducted in villages associated with Prakruti Organic, an organic and fair trade cotton intervention program. Based in Secunderabad, they work with farmers in Telangana, Orissa, and Maharahstra. Prakruti works as a two-tier program. As a development NGO and cooperative, they secure international funding, apply for grants, partner with national and international development initiatives, and promote education and local entrepreneurship, in addition to farming workshops. As a corporation and cooperative, they organize farmers into village, district, and state buying and selling groups that partner with other cooperatives and companies to buy and sell certified organic cotton. Prakruti's corporate arm asks that farmers turn profits and sell to organic buyers. The NGO arm ensures that grants and government loan programs can help to soften profit imperatives while providing avenues for more general development. The corporate and development motivations of this company are often synergistic, as organic cotton buyers tend to publicize the ways in which their products contribute to socioeconomic growth, education, modernization, and village livelihoods, broadly defined. Because farmers sell certified organic cotton, they must submit to periodic field inspections for organic compliance and they procure seeds almost exclusively through the company and its partner groups.

Caveats

To understand the biodiversity found on different kinds of cotton farms, this study and any comparisons to other farmers must be framed within a series of caveats. The first caveat deals with the geographic and ethnicity politics that make these Adilabad District farmers attractive to organic groups in the first place. In the Warangal district of Telangana, ethnic Lambadi farmers were seen to manage nearly twice as many crops in their fields as the nearby caste farmers in a previous study (Flachs 2015). Gond farmers belong to a different ethnic group, but the role that agrobiodiversity plays in providing extra crops and filling in gaps in the cotton fields is similar. Thus, we might expect Gond farmers to cultivate, at minimum, a similarly biodiverse farm field. As the Gond farmers are even more geographically isolated by hills and poor roads than the Lambadi farmers, it is reasonable to expect that Gond field agrobiodiversity would be higher to further compensate for their reduced access to market goods and foods. Furthermore, this study does not survey GM cotton farmers near the organic villages in the Adilabad district and so it is not intended as a direct comparison of organic versus GM farming itself, a study of Gond agrobiodiversity versus ethnic Lambadi or Telugu caste agrobiodiversity, or a study of hill area fields versus lowlands. Owing to the diverse ways in which organic agriculture manifests in India, including state-sponsored, corporate, and NGO-driven projects, this study is not presented as a referendum on agrobiodiversity in India generally. Rather, it aims to complicate and contextualize the role of agrobiodiversity in organic cotton production using these particular farmers as case studies.

The agrobiodiversity differences in these two groups are not inherent to production methods so much as encouraged by differing economic and social incentives. In addition to ethnic and geographic reasons, the rewards and constraints of certified organic cotton production in these villages lead farmers to cultivate agrobiodiversity: the organic program offers a limited number of free vegetable seed; farmers are instructed to frequently rotate crops and intercrop rows of non-commodity crops; and, because food security is a stated goal of the program, farmers are asked to keep seed stores of crops including landraces of pulses and sorghum (*Sorghum bicolor*). Even without these institutional pushes, farmers would likely value stores of non-cash crops. Working on uneven, rocky soil in the foothills of the Eastern Ghats with virtually no access to irrigation and without the use of chemical fertilizers and pesticides, organic cotton yields in these fields are much lower than those of their lowland counterparts in the Warangal district (Figure 2). Organic farmers plant fewer seeds in each field to make room for intercropping with legumes and other species and therefore have fewer plants from which to harvest cotton in the first place. Finally, because non-GM cotton (*Gossypium hirsutum*) seeds are so difficult to find in Telangana, organic farmers in this program plant GM refugia[5] seeds, produced by GM seed companies to respond to the suite of water, fertilizers, and pesticides found on conventional farms. Lacking these inputs, farmers manage suboptimal environments in which these cotton plants grow.



Statistics	Organic	GM
N	69	218
Mean	1.5595	6.8988
StDev	1.0548	2.8641
Minimum	0.05	0
Maximum	4.1667	18

Figure 2. Organic Adilabad District and GM Warangal District Cotton Yields, 2013. Circled plus symbol indicates the mean.

These caveats contextualize this research and temper conclusions about these farmers and organic agriculture generally. The farmers in this study represent corporate-sponsored organic agriculture in this area. As such, they provide some insight into the types of communities targeted by organic projects and the ways that farmer agroecologies work within the rewards and constraints of organic institutions. While organic agriculture will look different in each particular project, this case study examines how marginal farmers planting organic cotton compare to other organic farmers in the literature and to their GM cotton farmers both socially and ethnobotanically.

Results

Seventy organic farming households were surveyed to elicit 1866 individual plants managed within these organic cotton fields. This agroecology consists of 37 plant families and 96 distinct plant species growing on farm fields (Appendix A). Although these farms show a considerable range in the number of economic plants per farm, most farms contained more than 17 useful managed plants (Figure 3) and farms contained a mean of 27 plants and a median of 22.5 plants. The incidence of these plants as observed and listed by farmers can be found in Appendix A. Fabaceae, Poaceae, Solanaceae, and Malvaceae species together

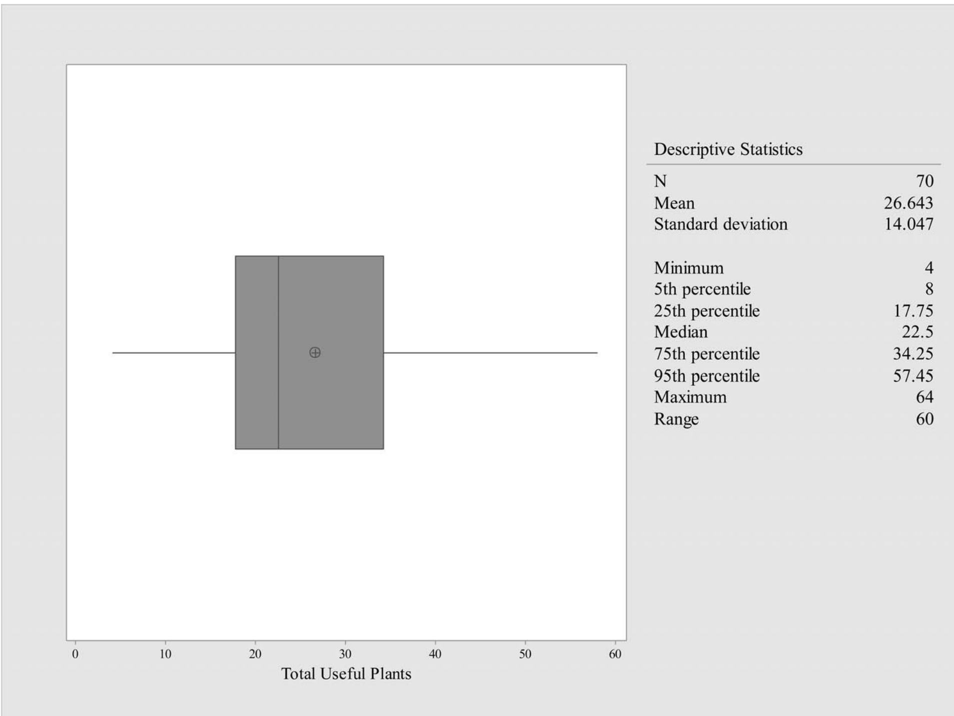


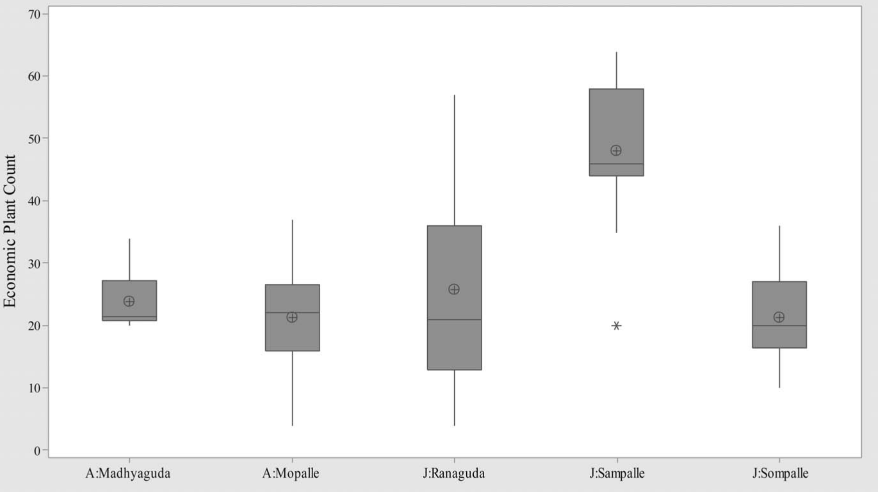
Figure 3. Boxplot of Total Useful Plants per Farm. Circled plus symbol indicates the mean.

account for 58.25% of the 1866 economic plants reported, with Fabaceae species alone accounting for more than 30% of the economic botany of these farms. On these farms, more than 90% (63 out of 70) of farmers planted subsistence sorghum (*Sorghum bicolor*), tomato (*Solanum lycopersicum*), cotton (*Gossypium hirsutum*), and pigeon pea (*Cajanus cajan*). Nearly every organic farmer in this area grows cotton for the market and sorghum as a subsistence grain, while tomatoes and pigeon pea are common food crops. More than half of the respondents additionally planted ten food crops, a trap plant intended to lure pest insects, three useful trees, and an ornamental flower.

All five village hamlets reported roughly similar uses of economic botany, with the notable exception of Sampalle, which reported nearly twice as many plants as the rest (Table 1). Charted as a boxplot (Figure 4), Sampalle appears far

Table 1. Farm economic botany by village hamlet.

Village hamlet	Household N	Total plant count	Average plant count	Average acreage	Average age
Addabad - Madhyaguda	6	143	23.8	11.5	33.8
Addabad - Mopalle	29	617	21.2	8.4	40.7
Japur - Ranaguda	15	329	25.7	8.1	40.7
Japur - Sampalle	11	529	48.1	10	34.9
Japur - Sompalle	9	248	21.2	11.4	46.6



Statistics	A:Madhyaguda	A:Mopalle	J:Ranaguda	J:Sampalle	J:Sompalle
N	6	29	15	11	9
Mean	23.833	21.241	25.733	48.091	21.222
StDev	5.2694	7.5529	15.845	12.888	7.6775
Minimum	20	4	4	20	10
Maximum	34	37	57	64	36

Figure 4. Boxplot of farm economic botany by village hamlet. Star indicates outliers, while the circled plus symbol indicates the mean.

above the range of variation in economic plants found in the rest of the villages. A one-way ANOVA test suggests that this difference is significant ($F = 13.71$, $p < .001$).

Age and acreage are two other possible confounds on economic botany. Older people and people with more acres to manage might be expected to maintain greater numbers of useful plants in their fields, both because older people tend to use greater reservoirs of ethnobotanical knowledge and because larger farms have more space to grow plants. To measure the impact of age and acreage, households were split into three terciles for each category (Table 2). In

Table 2. Farm economic botany by farmer age and farm acreage tercile.

Age tercile	N	Range (years)	Average of plant count
1	18	20–34	24.1
2	26	35–44	29.8
3	26	45–70	25.2
Acreage tercile	**N**	**Range (acres)**	**Average of plant count**
1	26	3–6	24.6
2	22	7–9	26.8
3	22	10–40	28.9

this schema, three represents the largest farms and oldest farmers, while one represents the smallest farms and youngest farmers. The range of variation in each case is relatively small and a one-way ANOVA test revealed no significant differences in plant counts for ages or acres.

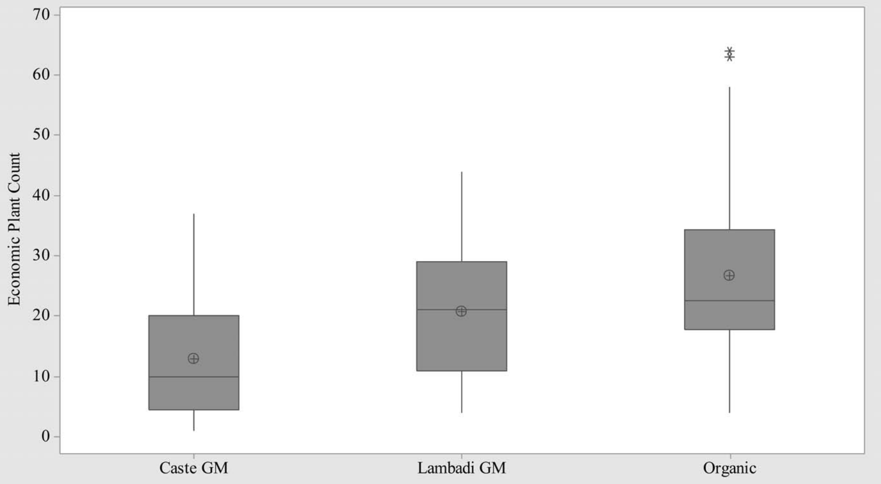
Additionally, we may expect to see gendered differences in plants managed. Although this survey was designed to gather information at the household level, male and female respondents may give different responses. Owing in part to the author's own position as a foreign, male researcher with male research assistants, this study does not survey a representative number of female respondents. Of 70 respondents, 53 (76%) were male, 13 (19%) were female, and 4 (6%) were interviewed as husbands and wives. It is methodologically interesting to note that the male respondents, with whom the researcher established the best rapport, divulged larger counts of economic plants than women or men and women interviewed together as a household.

Plant use was divided into ten categories corresponding with the Missouri Botanical Garden's Tropicos ethnobotany use categories (Kuhlman and Salick 2014): Food-Human, Food-Animal, Medicines-Human, Veterinary, Fuels, Fibres, Cultural Uses, Construction and Structural Materials, Environmental, and Other. This paper added a category for Cash crops to better describe several plants' roles, including cotton, in the agricultural economy. Given that many plants cross use boundaries, such as castor (*Ricinus communis*), used as a pest control plant and for its medicinal oil, or numerous trees used as firewood and construction materials, they are listed here by their primary use as reported by the farmers. The most meaningful way to describe the variation between these farms in terms of economic botany is by village (Table 3). All uses reported by respondents are listed in Appendix A and Tropicos codes for each village are listed in Appendix B. Food plants account for the largest category by far in each village (70% of the total). The overwhelming presence of food plants in these farms likely results from a combination of the organic institution's emphasis on food security, free seeds distributed through a state horticultural program, and a practical response to relatively low yields from cotton cash-cropping. It is worth noting that the second-largest category refers to plants primarily cultivated for pest control. This includes trap plants such as castor, intended to lure insects away from cash crops, as well as plants such as *Lantana camara*, whose leaves are included in a homemade organic pesticide developed in tandem with the organic program known locally as "top ten" because it includes up to ten locally accessible ingredients.

The range in variation of the economic botany of the farms in this study is higher (Figure 5) than both the Telugu caste GM cotton farmers and the Lambadi GM cotton farmers surveyed in an earlier study (Flachs 2015). To test the influence of differing social, economic, and institutional pressures on these cotton farmers, a one-way ANOVA test compared the average economic botany plant counts on these three types of farms. Organic farmers on average managed more plant species than the other groups, differences that are significant ($F = 11.30$, $p < .001$). These differences stem from the way in which the organic program provides social incentives for agrobiodiversity and are discussed below.

Table 3. Farm economic botany incidence by use category.

Village	Cash crop	Fertilizer	Fodder	Food	Fuel	Lumber	Medicinal	Ornamental	Pest control	Religious	Tools	Total
Addabad - Madhyaguda	9	2	2	101	1	6	3	4	14	1		143
Addabad - Mopalle	41	8	8	436	2	33	13	17	48	8	3	617
Japur - Ranaguda	27	2		242	1	18	5	8	24		2	329
Japur - Sampalle	28	9	2	349	10	48	16	18	40	4	5	529
Japur - Sompalle	18	4		188	1	9	3	7	17		1	248
Total	**123**	**25**	**12**	**1316**	**15**	**114**	**40**	**54**	**143**	**13**	**11**	**1866**



Statistics	Caste GM	Lambadi GM	Organic
N	25	37	70
Mean	12.88	20.703	26.643
StDev	10.895	10.903	14.047
Minimum	1	4	4
Maximum	37	44	64

Figure 5. Comparative economic botany of: Warangal Telugu caste GM cotton farmers, Warangal Lambadi GM cotton farmers, and Adilabad Organic farmers. Stars indicate outliers while the circled plus symbol indicates the mean.

Discussion

I will highlight two important conclusions from this study of organic agrobiodiversity. First, this survey highlights the potential of organic projects to promote biodiversity and food security. Second, although the organic and previously surveyed GM farmers are from different districts and belong to different ethnic groups, this project provides another case study in cotton agrobiodiversity. The economic botany of these organic farmers tends to be far above the Warangal GM farmers—not because organic agriculture is inherently more agrobiodiverse, but because the social and economic reward structure of the organic program encourages them to grow a variety of food and pest control crops.

Only five farmers in the sample managed fewer than 10 economic plants in their cotton farms. Compared to the cotton cash-cropping farmers in Warangal this number is relatively high. Two institutional imperatives contribute to the presence of economically useful plants on these farms: intercropping and underwriting. Among GM-planting farmers in Warangal, previous work attributed agrobiodiversity, largely to opportunism in the field, including taking advantage of field holes where cotton failed to germinate and allowing useful

Figure 6. Organic employees bag free food crop seeds provided through a government assistance program.

plants to grow so long as they did not interfere with cotton production. Among these organic farmers, part of their certification specifies a particular legume intercropping pattern whereby ten rows of cotton are interspersed with two rows of pigeon pea. This intercropping plays a role in reducing overall yields (Figure 2) by taking roughly $1/6^{th}$ of the land out of cotton production and it forces farmers to compensate for lower cash crop yields by diversifying their agriculture with food crops or other market crops such as sunn hemp (*Crotalaria juncea*).

To ease the burdens of planting biodiverse fields, Prakruti Organic, like many such programs, connects farmers to programs that provide free seeds or seeds sold at zero-interest loans (Figure 6). Presented with cheap seeds, most farmers elect to plant them. Farmers are also asked to cultivate organic pesticides and fertilizers, including nitrogen fixing trees. This practice is better characterized as institutional underwriting than intercropping. In 2014, farmers cultivated 168 plants as organic fertilizers or pesticides, representing nine percent of the plants managed on the farm and six species. In addition to the food crops (Table 4), these plants form a baseline agrobiodiversity of plants in the local organic agroecology. Not only are these farmers inclined to cultivate a variety of crops to fill gaps in their household economy, the organic program underwrites the cost of planting certain crops by providing them free of charge. This institutional push is by design. The company CEO actively works to discourage a strict cash-cropping

Table 4. Foods, fertilizers, and pest control plants encouraged by the organic program.

Food crops	Incidence of households planting
Abelmoschus esculentus	61
Aegle marmelos	18
Allium sativum	1
Amaranthus dubius	21
Anacardium occidentale	25
Annona reticulata	1
Annona squamosa	15
Arachis hypogaea	5
Artocarpus heterophyllus	3
Borassus flabellifer	5
Brassica juncea	20
Cajanus cajan	69
Capsicum annum	61
Carica papaya	5
Cicer arientinum	50
Citrus limetta	13
Citrus sinensis	1
Coccinia grandis	3
Coriandrum sativum	6
Cucumis sativus	20
Curcuma longa	1
Cyamopsis tetragonoloba	3
Diospyros melanoxylon	14
Ficus racemosa	10
Hibiscus cannabinus	12
Lablab purpureus	54
Lagenaria siceraria	11
Luffa acutangula	33
Macrotyloma uniflorum	24
Madhuca longifolia	45
Mangifera indica	26
Manilkara zapota	3
Momordica charantia	30
Moringa oleifera	2
Oryza sativa	23
Phaseolus vulgaris	2
Phyllanthus emblica	2
Psidium guajava	17
Punica granatum	2
Semecarpus anacardium	22
Sesamum indicum	19
Solanum insanum	1
Solanum lycopersicum	63
Solanum melongena	55
Solanum tuberosum	1
Sorghum bicolor	63
Spinacea oleracea	22
Syzygium jambos	4
Tamarindus indica	26
Trigonella foenum-graecum	3
Triticum aestivum	13
Vicia faba	51

Table 4. Continued.

Food crops	Incidence of households planting
Vigna mungo	55
Vigna radiata	57
Vigna unguiculata	57
Zea mays	52
Ziziphus jujuba	20
Zizyphus oenoplia	8
Zizyphus oenoplia	7
Fertilizer and pest control crop	**Incidence of households planting**
Azadirachta indica	43
Gliricidia sepium	25
Lantana camara	24
Millettia pinnata	15
Ricinus communis	52
Vitex negundo	9

system in favor of what he sees as a more sustainable agriculture. "We need to encourage resilience," he stated in one interview, "and, in smallholder farming, resilience means subsistence agriculture." He maintains this goal even as his efforts endure criticism from a local politician who accuses him of blocking a more cash-based form of agricultural development.

One village in particular stands out in the counts of economic plant use. Sampalle's unusually high plant count stems, directly and indirectly, from the efforts of organic program employees and Sampalle farmer Shivaram. Shivaram draws a small salary from the organic program as a field officer, has been given loans for a small poultry farm, cultivates a small orchard of perennial tree crops, and creates signage to ensure that the other villagers know exactly what he is planting. Shivaram influences the agrobiodiversity of his hamlet in two major ways. First, as a representative of Prakruti Organic, he ensures that his fellow villagers, many of whom are in his immediate family, follow intercropping best practices. This includes agreeing to devote land to the program's food security initiatives as well as participating in tree-planting to curb erosion. As a watchdog and a trusted member of the community, Shivaram's good faith encourages farmers to devote more of their land to non-cash crops. Shivaram also ensures that his friends and family members, as well as he, have a first pick of free or inexpensive plants. Through him, Sampalle farmers benefit from insider knowledge about the best new seeds, transplants, horticultural loans, and program assistance. Shivaram's mother secured her favorite fruit tree varieties free of charge through an organic donation program, while Shivaram receives free plants as long as he maintains visible signs labeling them in the field. Through this synergy, Sampalle farmers have negotiated an organic agrobiodiversity that fits their needs.

This study is cautious in making direct comparisons between Warangal district GM cotton farmers and these organic farmers because ethnic differences and the organic farmers' comparative geographic isolation likely lead the latter to have a higher incidence of economic plant use in the first place. Instead, this study emphasizes the ways in which these GM and organic agricultures provide opportunities for agrobiodiversity. Organic farmers surveyed in this project participate in a corporate organic cotton project and also participate in a variety of NGO and state-sponsored development schemes. Some of these development programs are targeted at small farmers while others are focused on development in tribal communities. As such, these farmers respond to different reward structures in their farm management than the Warangal GM cotton farmers, who are more directly exposed to the cotton market and must produce cash crops to recoup their investments. The differences in economic botany are therefore suggestive of the ways in which farmers in similar agroecological conditions respond to different agricultural and economic needs.

Previous work (Flachs 2015) suggested that the difference in agrobiodiversity between Lambadi and caste GM cotton farmers is due in part to local differences in infrastructure and household economic security. The comparatively wealthier Telugu caste farmers live in a town serviced by bus routes, with paved roads, reliable electrical connections, a farm input shop, and a successful NGO-run school, while the comparatively poorer Lambadi farmers lack paved roads, have no local seed store, and live adjacent to their farm fields in hamlets outside the town proper. Beyond the Lambadi farmers, Gond farmers participating in this organic program are further removed from town centers and live on more marginal, hilly land comparatively ill-suited to agriculture. Their historical ethnic and geographic marginalization in part makes them attractive for organic and fair trade cotton marketing in the first place.

Because the comparatively more marginalized Gond organic farmers need to fulfill food security needs and income gaps from relatively poor cotton yields, it makes sense that they would tend to manage more crops. Their economic plant use may represent an extreme on the spectrum of farmers managing household and market needs. The organic program enables this by underwriting or requiring a measure of agrobiodiversity. In doing so, Prakruti eliminates some of the market imperative to produce as much of the cotton cash crop as possible. The Warangal Lambadi farmers have no such intervention and thus tend to plant fewer non-cash economic plants in favor of cotton, while the Warangal caste farmers with better access to village infrastructure are even more inclined to plant small-scale commercial GM cotton. The organic farmers discussed in this paper show an alternative economic plant management strategy largely within the range of variation reported by the Lambadi farmers and largely above the caste farmers. This suggests that different institutional pressures, including market incentives and organic regulation, have a large impact on agrobiodiversity.

Conclusion

Organic projects like Prakruti Organic can maximize agrobiodiversity by recruiting relatively poor farmers living with relatively poor access to markets. This organic company guarantees that their farmers will have a biodiverse agriculture irrespective of the organic methods farmers use by stressing food security as part of the program and then providing access to free vegetable seeds.

Ninety percent of these organic farmers managed fields more diverse than the average caste Telugu GM farmer of the Warangal district, and 70% had fields as or more diverse than the average Lambadi GM farmer from Warangal. This does not prove that organic agriculture causes agrobiodiversity, but it does suggest that organic farmers can maintain higher levels of agrobiodiversity than many of their GM cotton-planting peers through a combination of institutional and practical incentives. Furthermore, while the persistent agrobiodiversity found among GM farmers in the Warangal district indicates that GM cash cropping does not totally replace the need for household food security, the economic botany of organic farmers shows that cotton farmer agrobiodiversity could be much higher.

As different organic programs work through different NGO, state, and corporate actors and require differing levels of regulatory oversight, differing effects on agrobiodiversity are expected. Moreover, many alternative agriculture projects develop mutually beneficial relationships like the one observed in Sampalle. In that case, agrobiodiversity stemmed largely from a well-trusted local employee who encouraged the village to see regulation and agrobiodiversity in their interest. While the economic botany is certainly larger and more complex than those observed on GM cotton farms, it is not clear to what extent that managed diversity depends on the subsidizing efforts of this particular program and how much agrobiodiversity we might expect to see anyway. The high counts in this study merit further study in the economic botany of other kinds of alternative agriculture among Indian smallholders. If the range in economic plant use across these different types of farmers can be understood as a response to market or regulatory incentives, then more alternative agriculture groups should be studied in this way to better understand how the reward structures of local markets or alternative agriculture programs impact economic botany in the field.

Notes

[1] Industrial here refers to Barlett's (1989) general criterion for input intensive agriculture: capital-intensive, using machinery and purchased inputs to replace human and animal labor, state-endorsed, producing to satisfy market requirements, and driven by innovations to increase capitalistic productivity.

[2] Bt cotton refers to plants genetically modified to contain the genes from Bt bacterium that code for insecticidal proteins.

[3] All village and interlocutor names have been changed.

[4] Scheduled Tribe household clusters outside the village proper.

[5] Bt cotton seeds include a small package of non-GM seeds that are to be planted in rows surrounding the field such that 20% of the field provides a non-Bt refuge for insects. These seeds are genetically identical to the GM seeds and come from the same hybrid stock, but lack the Bt-producing gene as a mechanism to slow selective evolutionary pressure for Bt-resistant cotton pests.

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References Cited

Altieri, M. A. 2000. Ecological Impacts of Industrial Agriculture and the Possibilities for Truly Sustainable Farming. In *Hungry for Profit: The Agribusiness Threat to Farmers, Food, and the Environment*, edited by F. Magdoff, J. B. Foster, and F. H. Buttel, pp. 77–92. Monthly Review Press, New York.

Altieri, M. A. 2005. The Myth of Coexistence: Why Transgenic Crops are Not Compatible with Agroecologically Based Systems of Production. *Bulletin of Science, Technology & Society* 25:361–371. DOI:10.1177/0270467605277291.

APEDA-Agricultural and Processed Food Products Export Development Authority. 2012. National Programme for Organic Production (NPOP). [web page] URL: http://www.apeda.gov.in/apedawebsite/organic/index.htm. Accessed on April 2, 2012.

Barlett, P. F. 1989. Industrial Agriculture. In *Economic Anthropology*, edited by S. Plattner, pp. 253–291. Stanford University Press, Stanford, CA.

Barthel, S., C. L. Crumley, and U. Svedin. 2013. Biocultural Refugia: Combating the Erosion of Diversity in Landscapes of Food Production. *Ecology and Society* 18:71. DOI:10.5751/ES-06207-180471.

Bengtsson, J., J. Ahnström, and A.-C. Weibull. 2005. The Effects of Organic Agriculture on Biodiversity and Abundance: A Meta-Analysis. *Journal of Applied Ecology* 42:261–269. DOI:10.1111/j.1365-2664.2005.01005.x.

Brookfield, H. C. 2001. *Exploring Agrodiversity*. Columbia University Press, New York.

Charles, D. 2001. *Lords of the Harvest: Biotech, Big Money, and the Future of Food*. Basic Books, New York.

Chetna Organic. 2013. About Chetna Organic. [web page] URL: http://www.chetnaorganic.org.in/about-us. Accessed on April 9, 2013.

Conford, P. 2011. *The Development of the Organic Network: Linking People and Themes, 1945-95*. Floris Books, Edinburgh.

Conner, A. J., T. R. Glare, and J.-P. Nap. 2003. The Release of Genetically Modified Crops into the Environment. *The Plant Journal* 33:19–46. DOI:10.1046/j.0960-7412.2002.001607.x.

Cotton Corporation of India Ltd. 2014. 44th Annual Report 2013-2014. Annual Report 44. Cotton Corporation of India Ltd, Mumbai.

Crost, B., B. Shankar, R. Bennett, and S. Morse. 2007. Bias from Farmer Self-Selection in Genetically Modified Crop Productivity Estimates: Evidence from Indian Data. *Journal of Agricultural Economics* 58:24–36. DOI:10.1111/j.1477-9552.2007.00076.x.

da Costa, A. 2012. Organic Farming Promises to Yield a Sustainable Future for India's Rural Poor. *The Guardian*, March 15, sec. Global development. Available at: http://www.guardian.co.uk/global-development/poverty-matters/2012/mar/15/organic-farming-india-rural-poor. Accessed on April 1, 2012.

De Leon, J. P., and J. H. Cohen. 2005. Object and Walking Probes in Ethnographic Interviewing. *Field Methods* 17(2):200–204.

Department of Commerce, Government of India. 2005. *National Programme for Organic Production* (NPOP). Government Report. Ministry of Commerce and Industry, New Delhi.

Deshpande, R. S., and S. Arora. 2010. Editor's Introduction. In *Agrarian Crisis and Farmer Suicides*, edited by R., S. Deshpande and Saroj Arora, Vol. 12:1–42. Land Reforms in India Sage Publications India Pvt Ltd, New Delhi.

Fitting, E. 2006. Importing Corn, Exporting Labor: The Neoliberal Corn Regime, GMOs, and the Erosion of Mexican Biodiversity.

Agriculture and Human Values 23:15–26. DOI:10.1007/s10460-004-5862-y.

Flachs, A. 2015. Persistent Agrobiodiversity on Genetically Modified Cotton Farms in Telangana, India. *Journal of Ethnobiology* 35:406–426. DOI:10.2993/etbi-35-02-406-426.1.

Franz, M., and M. Hassler. 2010. The Value of Commodity Biographies: Integrating Tribal Farmers in India into a Global Organic Agro-Food Network. *Area* 42:25–34. DOI:10.1111/j.1475-4762.2009.00893.x.

Garcia, M. A., and M. A. Altieri. 2005. Transgenic Crops: Implications for Biodiversity and Sustainable Agriculture. *Bulletin of Science, Technology & Society* 25:335–353. DOI:10.1177/0270467605277293.

Gene Campaign. 2008. Bt Cotton or Organic Cotton? Available at: http://www.genecampaign.org/Publication/Article/BT%20Cotton/Bt-cotton-or-organic-cotton.html. Accessed on April 4, 2012.

Guthman, J. 2004. *Agrarian Dreams: The Paradox of Organic Farming in California*. University of California Press, Berkeley.

Guthman, J. 2009. Unveiling the Unveiling: Commodity Chains, Commodity Fetishism, and Ethical Food Labels. In *Frontiers of Commodity Chain Research*, edited by J. Bair, pp. 190–206. Stanford University Press, Stanford, CA.

Heinemann, J. 2012. Suggestions on How to Apply International Safety Testing Guidelines for Genetically Modified Organisms. Centre for Integrated Research in Biosafety, Christchurch, New Zealand.

Herring, R. J. 2007. Stealth Seeds: Bioproperty, Biosafety, Biopolitics. *Journal of Development Studies* 43:130–157. DOI:10.1080/00220380601055601.

Herring, R. 2015. State Science, Risk and Agricultural Biotechnology: Bt Cotton to Bt Brinjal in India. *The Journal of Peasant Studies* 42:159–186. DOI:10.1080/03066150.2014.951835.

Hole, D. G., A. J. Perkins, J. D. Wilson, I. H. Alexander, P. V. Grice, and A. D. Evans. 2005. Does Organic Farming Benefit Biodiversity? *Biological Conservation* 122:113–130. DOI:10.1016/j.biocon.2004.07.018.

INORA. 2012. Welcome To INORA (Institute of National Organic Agriculture). [web page] URL: http://www.inoraindia.com/index.htm.

Jasanoff, S. 2005. *Designs on Nature: Science and Democracy in Europe and the United States*. Princeton University Press, Princeton, NJ.

Kathage, J., and M. Qaim. 2012. Economic Impacts and Impact Dynamics of Bt (*Bacillus Thuringiensis*) Cotton in India. *Proceedings of the National Academy of Sciences* 109(29):11652–11656. DOI:10.1073/pnas.1203647109.

Kloppenburg, J. 2004. *First the Seed: The Political Economy of Plant Biotechnology 1492-2000*. University of Wisconsin Press, Madison.

Krishna, V., M. Qaim, and D. Zilberman. 2014. Transgenic Crops, Production Risk, and Agrobiodiversity. ZEF-Discussion Papers on Development Policy, 186. University of Bonn, Bonn.

Kudlu, C., and G. D. Stone. 2013. The Trials of Genetically Modified Food: Bt Eggplant and Ayurvedic Medicine in India. *Food, Culture, and Society* 16:21–42.

Kuhlman, A., and J. Salick. 2014. Database Standards for Biocultural Collections. In *Curating Biocultural Collections*, edited by J. Salick, K. Konchar, and M. Nesbitt, pp. 141–158. University Of Chicago Press, Chicago.

Maeder, P., A. Fliessbach, D. Dubois, L. Gunst, P. Fried, and U. Niggli. 2002. Soil Fertility and Biodiversity in Organic Farming. *Science* 296(5573):1694–1697. DOI:10.1126/science.1071148.

Mehta, B. H. 1984. *Gonds of the Central Indian Highlands*. Concept Publishing Company, New Delhi.

Minitab Inc. 2010. Meet Minitab 17. Manual.

Narayanan, S. 2005. Organic Farming in India: Relevance, Problems, and Constraints. Occasional Paper 38. Department of Economic Analysis and Research National Bank for Agriculture and Rural Development, Mumbai.

Netting, R. McC. 1993. *Smallholders, Householders: Farm Families and the Ecology of Intensive, Sustainable Agriculture*. Stanford University Press, Stanford, CA.

Newell, P. 2003. Biotech Firms, Biotech Politics: Negotiating GMOs in India. IDS Working Paper 201. Institute of Development Studies, Brighton.

Panneerselvam, P., N. Halberg, M. Vaarst, and J. E. Hermansen. 2012. Indian Farmers' Experience with and Perceptions of Organic Farming. *Renewable Agriculture and Food Systems* 27:157–169. DOI:10.1017/S1742170511000238.

Parsai, G. 2012. Protests Mark 10th Anniversary of Bt Cotton. *The Hindu*, March 27, sec. Science & Technology. Available at: http://www.thehindu.com/sci-tech/agriculture/article3248530.ece. Accessed on April 4, 2012.

Pearson, M. 2006. 'Science', Representation and Resistance: The Bt Cotton Debate in Andhra Pradesh, India. *The Geographical Journal* 172:306–317.

Plewis, I. 2014. Indian Farmer Suicides: Is GM Cotton to Blame? *Significance* 11:14–18. DOI:10.1111/j.1740-9713.2014.00719.x.

Quinlan, M. 2005. Considerations for Collecting Freelists in the Field: Examples from Ethobotany. *Field Methods* 17:219–234. DOI:10.1177/1525822X05277460.

Ronald, P. C., and R. W. Adamchak. 2008. *Tomorrow's Table: Organic Farming, Genetics, and the Future of Food*. Oxford University Press, New York.

Sahai, S., and S. Rehman. 2004. Bt-Cotton, 2003-2004: Fields Swamped with Illegal Variants. *Economic and Political Weekly* 39:2673–2674.

Schmid, O. 2007. Development of Standards for Organic Farming. In *Organic Farming: An International History*, edited by W. Lockeretz, pp. 152–74. CABI, Cambridge.

Scoones, I. 2006. *Science, Agriculture and the Politics of Policy: The Case of Biotechnology in India*. Orient Blackswan, New Delhi.

Shiva, V. 1993. *The Violence of the Green Revolution: Third World Agriculture, Ecology, and Politics*, 2nd edition. Third World Network, Atlantic Highlands, NJ.

Shiva, V. 1997. *Biopiracy: The Plunder of Nature and Knowledge*. South End Press Collective, Boston.

Shiva, V., A. H. Jafri, A. Emani, and M. Pande. 2002. *Seeds of Suicide*, 2nd edition. Research Foundation for Science, Technology, and Ecology, New Delhi.

Stone, G. D. 2002. Both Sides Now: Fallacies in the Genetic-Modification Wars, Implications for Developing Countries, and Anthropological Perspectives. *Current Anthropology* 43:611–630.

Stone, G. D., A. Flachs, and C. Diepenbrock. 2014. Rhythms of the Herd: Long Term Dynamics in Seed Choice by Indian Farmers. *Technology in Society* 36:26–38.

Textile Exchange. 2013. Farm and Fiber Report 2011-2012. Annual Report. Textile Exchange. [online] URL: http://farmhub.textileexchange.org/upload/library/Farm%20and%20fiber%20report/FarmFiber%20Report%202011-12-Small.pdf. Accessed on January 6, 2014.

The Hindu. 2008. Swaminathan Calls for Harmonising Organic Farming and New Genetics. *The Hindu*, January 9, Online edition. [online] URL: http://www.thehindu.com/todays-paper/tp-national/tp-tamilnadu/swaminathan-calls-for-harmonising-organic-farming-and-new-genetics/article1175193.ece. Accessed on April 3, 2012.

The Hindu Business Line. 2013. Production Dips Even as 90% Land is under Bt Cotton Cultivation: Mahant. *The Hindu Business Line*, March 15. [online] URL: http://www.thehindubusinessline.com/industry-and-economy/agri-biz/production-dips-even-as-90-land-is-under-bt-cotton-cultivation-mahant/article4512380.ece. Accessed on February 25, 2014.

Wilken, G. C. 1987. *Good Farmers: Traditional Agricultural Resource Management in Mexico and Central America*. University of California Press, Berkeley.

Appendix A: Incidence of Economic Plants on Adilabad Organic Farms.
In two cases, *C. sativus* and *Z. oenoplia*, farmers identified two variants as belonging to different ethnotaxa. This paper lists these as separate species although they are botanically identical to better represent the economic botany as managed and understood by local farmers.

English common name	Telugu name	Family	Latin name	Use determined by informants	ATREE voucher ID	Count
Pigeon pea	Kamdulu	Fabaceae	Cajanus cajan (L.) Huth	Edible seeds	1672	69
Cotton	Patti	Malvaceae	Gossypium hirsutum L.	Fruits contain spinnable fiber	1684	65
Tomato	Tomato	Solanaceae	Solanum lycopersicum L.	Edible fruit	1622	63
Sorghum	Juna	Poaceae	Sorghum bicolor (L.) Moench	Edible seeds	1620	63
Okra	Bemdakaya	Malvaceae	Abelmoschus esculentus (L.) Moench	Edible fruit	1642	61
Chili	Mirchi	Solanaceae	Capsicum annum L.	Edible fruit	1621	61
Mung bean	Pesarlu	Fabaceae	Vigna radiata (L.) R. Wilczek	Edible fruit	1617	57
Cowpea	Bubbarlu	Fabaceae	Vigna unguiculata (L.) Walp	Edible fruit	1645	57
Eggplant	Vamkaya	Solanaceae	Solanum melongena (Mill.) Dunal	Edible fruit	1698	55
Black gram	Minimulu	Fabaceae	Vigna mungo (L.) Hepper	Edible fruit	1676	55
Hyacinth bean	Anumulu	Fabaceae	Lablab purpureus (L.) Sweet	Edible fruit	1618	54
Castor	Amundum	Euphorbiaceae	Ricinus communis L.	Pest trap plant, oil plant	1643	52
Maize	Makajuna	Poaceae	Zea mays L.	Edible fruit	1646	52
Broad bean	Chikkudukaya	Fabaceae	Vicia faba L.	Edible fruit	1659	51
Chickpea	Shenigallu	Fabaceae	Cicer arientinum L.	Edible legumes	1688	50
Mahua	Ipa	Sapotaceae	Madhuca longifolia (J. Koenig ex L.) J.F. Macbr.	Flower used to make alcohol	1667	45
Neem	Vepa	Meliaceae	Azadirachta indica A. Juss.	Twigs for dental health, fruits as insecticide, leaf juice as a topical cure for chicken pox and other sores, can be drunk as a tonic for health, bark should be ingested for a fever	1696	43

Appendix A: Continued.

English common name	Telugu name	Family	Latin name	Use determined by informants	ATREE voucher ID	Count
French Marigold	Banti	Asteraceae	Tagetes patula L.	Ornamental, trap plant, flowers grow taller than the chilis, evil eye (desti) sees flowers and leaves chilis unaffected	1611	40
Teak	Teak	Verbenaceae	Tectona grandis L. f.	Lumber	1692	36
Ridge gourd	Beerakaya	Cucurbitaceae	Luffa acutangula (L.) Roxb.	Edible fruit	1657	33
Soy	Soya	Fabaceae	Glycine max (L.) Merr.	Edible fruit	1641	31
Bitter gourd	Kakkadakaya	Cucurbitaceae	Momordica charantia L.	Edible fruit	1673	30
Sunn hemp	Janumulu	Fabaceae	Crotalaria juncea L.	Fibers for cordage	1668	27
Mango	Mamidi	Anacardiaceae	Mangifera indica L.	Edible fruit	1606	26
Tamarind	Chimta	Fabaceae	Tamarindus indica L.	Edible fruit, leaves for tamarind soup	1660	26
Cashew	Jidi	Anacardiaceae	Anacardium occidentale L.	Fruits, oil can be used as an antiseptic for minor cuts and applied topically in small amounts to soothe headaches	1670	25
Gliricidia	Biomass	Fabaceae	Gliricidia sepium (Jacq.) Kunth ex Walp.	Leaves used for organic compost	1648	25
Wild Sage	Bommakura	Verbenaceae	Lantana camara L.	Leaves used in top 10 organic pesticide, edible fruits	1644	24
Horsegram	ulavalu	Fabaceae	Macrotyloma uniflorum (Lam.) Verdc.	Edible fruit	1695	24
Rice	Wari	Poaceae	Oryza sativa L.	Edible seeds	1631	23

Appendix A: Continued.

English common name	Telugu name	Family	Latin name	Use determined by informants	ATREE voucher ID	Count
Milkweed	Jilledu	Apocynaceae	Calotropis gigantea (L.) W.T. Aiton	Put on swelling, cuts to remove heat and bloodclots/expedite healing of scabs, brings down lymph node swellings when applied topically as well as when "gas" from the flowers is inhaled. Ingest liquid from the root to mitigate snakebite, leaves can be used to attract insects away from cotton and then kill it, a la trap plant. Flowers used in prayers (pujjas).	1649	22
Oriental cashew	Muri/Serka	Anacardiaceae	Semecarpus anacardium L. f.	Edible cashew-like fruits	1607	22
Spinach	Palakura	Amaranthaceae	Spinacea oleracea L.	Edible leaves	1619	22
Amaranth (broad leaf variety)	Pedda Totorkura	Amaranthaceae	Amaranthus dubius Mart. ex Thell.	Edible leaves	1685	21
Mustard	Avallu	Brassicaceae	Brassica juncea (L.) Coss	Edible leaves, seeds	1654	20
Bamboo	veduru	Poaceae	Dendrocalamus strictus (Roxb.) Nees	canes, staffs, baskets	1699	20
Jujube	Regi Pandu	Rhamnaceae	Ziziphus jujuba (L.) Gaertn.	Edible fruit	1687	20
Sesame	Nuvullu	Pedaliaceae	Sesamum indicum L.	Oil seeds	1679	19
Bengal quince	Billopatri	Rutaceae	Aegle marmelos (L.) Correa	leaves and flowers used for Ganesh pujjas, Hanuman pujjas, edible fruits	1613	18
Guava	Jamma	Myrtaceae	Psidium guajava L.	Edible fruit	1669	17
Cucumber (Lemon cultivar)	Dosakaya	Cucurbitaceae	Cucumis sativus L.	Edible fruit	1662	16
Custard Apple	Sitapaluka	Annonaceae	Annona squamosa L.	Edible fruit	1689	15
Sali mara	Salimara	Burseraceae	Boswellia glabra Roxb.	firewood, lumber, matchsticks	1705	15

Appendix A: Continued.

English common name	Telugu name	Family	Latin name	Use determined by informants	ATREE voucher ID	Count
Indian Beech	Kanuga	Fabaceae	Millettia pinnata (L.) Panigrahi	Leaves in top 10 organic pesticide	1650	15
Coamandel Ebony	Thuniki	Ebenaceae	Diospyros melanoxylon Roxb.	edible fruits, leaves for bidis, flowers used to make dyes for Holi festival	1601	14
Lime	Nimma	Rutaceae	Citrus limetta L.	Edible fruit	1678	13
Noni	Suhli	Rubiaceae	Morinda citrifolia L.	Medicinal bark, ground up and eaten with curd to cure a hangover or jaundice, edible fruits	1709	13
Tulasi	Mudera	Lamiaceae	Ocimum canum Sims	Seeds will give strength, the seeds smell like mint and make a good combination to a curry spice fry	1614	13
Wheat	Godama	Poaceae	Triticum aestivum L.	Edible seeds	1663	13
Kenaf	Gongura	Malvaceae	Hibiscus cannabinus L.	Leaves used in chutneys, pickles	1666	12
Johnsongrass	Avu juna	Poaceae	Sorghum halepense (L.) Pers	Fodder	1655	12
Vedema	vedema	Combretaceae	Terminalia coriacea Wright & Arn.	Sap makes a gum useful for sticking, goats like the leaves, firewood	1609	12
Flame of the forest	Mothu/Modugu	Fabaceae	Butea monosperma (Lam.) Taub.	plates, firewood	1610	11
Bottle gourd	Sorakaya	Cucurbitaceae	Lagenaria siceraria (Molina) Standl.	Edible fruit	1615	11
Fig	Medikaya	Moraceae	Ficus racemosa L.	Edible fruits	1626	10
Bodhi	Valimara/Ravi	Moraceae	Ficus religiosa L.	wood, leaves for pujjas	1639	9
Five leaved Chaste Tree	Vavila	Verbenaceae	Vitex negundo L.	used in sprays as part of top 10, leaves steeped in hot water will relieve cold syptoms if taken as a bath	1612	9

Appendix A: Continued.

English common name	Telugu name	Family	Latin name	Use determined by informants	ATREE voucher ID	Count
Gum Arabic	Thuma	Fabaceae	Acacia arabica (Lam.) Willd.	firewood, thorns	1625	8
Karra	Godayla	Euphorbiaceae	Cleistanthus collinus (Roxb.) Benth.	Fruits are poisonous, wood for firewood, goats like the leaves	1706	8
Forest jujube	Adavi Regi Pandu	Rhamnaceae	Zizyphus oenoplia L.	Edible fruit	1627	8
Rose	Gulabi	Rosaceae	Rosa L.	Ornamental	1665	7
Jackal Jujube	Pariki	Rhamnaceae	Zizyphus oenoplia L. (Mill)	Edible fruit	1680	7
Coriander	Kotmir	Apiaceae	Coriandrum sativum L.	Edible leaves, seeds	1671	6
Banyan	Mari	Moraceae	Ficus benghalensis L.	wood	1603	6
White leadtree	Subabol	Fabaceae	Leucaena leucocephala (Lam.) de Wit	firewood, fodder, lumber	1608	6
Peanut	Palli	Fabaceae	Arachis hypogaea L.	Edible legumes	1616	5
Toddy	Toddy	Arecaceae	Borassus flabellifer L.	palm wine, thatch leaves, edible fruits	1693	5
Papaya	Pappadakaya	Caricaceae	Carica papaya L.	Edible fruit	1681	5
Jasmine	Malle puvvu	Oleaceae	Jasminum officinale L.	Ornamental	1640	5
Cucumber (green cultivar)	Kheer dosakaya	Cucurbitaceae	Cucumis sativus L.	Edible fruit	1711	4
Rose apple	Ala Neeradi	Myrtaceae	Syzygium jambos (L.) Alston	Edible fruit	1638	4
Jackfruit	Panasa	Moraceae	Artocarpus heterophyllus Lam.	Edible fruit	1628	3
Cannabis	"Adavi Banti"	Cannabaceae	Cannabis sativa L.	Leaves fed to hens when they have digestion problems, smoked, thrown on fire to "calm the children when they have trouble sleeping"	1701	3
Gherkin	Dondakaya	Cucurbitaceae	Coccinia grandis (L.) Voigt	Edible fruit	1661	3
Cluster beans	Goru chikkudukaya	Fabaceae	Cyamopsis tetragonoloba Taubert	Edible fruit	1664	3

Appendix A: Continued.

English common name	Telugu name	Family	Latin name	Use determined by informants	ATREE voucher ID	Count
Suporta	Suporta	Sapotaceae	Manilkara zapota (L.) P. Royen	Edible fruit	1690	3
Fenugreek	Menthulu	Fabaceae	Trigonella foenum-graecum L.	Edible seeds	1675	3
Bauhinia	Tondera	Fabaceae	Bauhinia L: purpea or variegata	Firewood, fodder	1708	2
Sandan	Ser mara	Fabaceae	Desmodium oojeinensis (Roxb.) H. Ohashi	Especially strong lumber suited to plows or loadbearing	1710	2
Fig	Pakkadi	Moraceae	Ficus tsiela Roxb.	Firewood and lumber	1647	2
White teak	Krusi	Lamiaceae	Gmelina arborea Roxb. ex Sm.	Firewood and lumber	1707	2
Drumstick	Munuga	Moringaceae	Moringa oleifera Lam.	Edible fruit	1677	2
French Beans	Alchemta	Fabaceae	Phaseolus vulgaris L.	Edible fruit	1702	2
Indian Gooseberry	Usiri	Phyllanthaceae	Phyllanthus emblica L.	Edible fruit	1697	2
Pommegranate	Annar	Lythraceae	Punica granatum L.	Edible fruit	1653	2
Auri	Neelagiri	Fabaceae	Acacia auriculiformis A. Cunn. ex Benth.	Lumber, can be sold like teak	1704	1
Garlic	Velulli	Amaryllidaceae	Allium sativum L.	Edible bulb	1700	1
Custard Apple	Rama paluka	Annonaceae	Annona reticulata L.	Edible fruit	1686	1
Chrysanthemum	Chamanti	Asteraceae	Chrysanthemum indicum L.	Ornamental	1658	1
Orange	Bathai	Rutaceae	Citrus sinensis (L.) Osbeck	Edible fruit	1656	1
Kanakambaram	Kanakambaram	Acanthaceae	Crossandra infundibuliformis (L.) Nees	Ornamental	1674	1
Turmeric	Pasupu	Zingiberaceae	Curcuma longa L.	Edible rhizome	1682	1
Bt Cotton	Patti	Malvaceae	Gossypium hirsutum Bt L.	Fruits contain spinnable fiber	1683	1
Inca Berry	Parota	Solanaceae	Physalis peruviana L.	Edible fruit, roots are pounded and boiled in water to relieve lymph node swelling	1703	1

Appendix A: Continued.

English common name	Telugu name	Family	Latin name	Use determined by informants	ATREE voucher ID	Count
Eggplant (thorny variety)	Mullu Vamkaya	Solanaceae	Solanum insanum L.	Edible fruit, digestive aid for humans and cattle	1651	1
Potato	Aloo	Solanaceae	Solanum tuberosum L.	Edible tuber	1652	1
Bahera	Takha	Combretaceae	Terminalia bellirica (Gaertn.) Roxb.	Edible fruits, fruits cure dizziness brought on by fever	1691	1

Appendix B: Tropicos Ethnobotanical Use Codes.
Level one categories for use are listed across the top while level two categories are listed underneath each village. The bolded row indicates the total number of plants recorded in each level one category.

Village	A	B	C	E	F	G	H	I	Total
Addabad – Madhyaguda: Total	**101**	**2**	**3**	**1**	**9**	**1**	**6**	**20**	**143**
i	4	2	3	1	6		5		21
iii	50					1	1	2	54
iv	40				3			4	47
v	6								6
vi								14	14
vii	1								1
Addabad – Mopalle: Total	**436**	**8**	**13**	**2**	**41**	**8**	**36**	**73**	**617**
i	12	8	10	2	28		20		80
ii	15								15
iii	217		3			8	13	8	249
iv	159				13		3	17	192
v	27								27
vi								48	48
vii	6								6
Japur – Ranaguda: Total	**253**		**5**	**1**	**16**		**20**	**34**	**329**
i	12		2	1	11		17		43
ii	9								9
iii	105		2				1	2	110
iv	90				5		2	8	105
v	32								32
vi								24	24
vii	5								5
viii			1						1
Japur – Sampalle: Total	**360**	**2**	**16**	**10**	**17**	**4**	**53**	**67**	**529**
i	11	2	6	10	11		44		84
ii	16								16
iii	204		9			4	4	9	230
iv	100				6		5	18	129
v	20								20
vi								40	40
vii	9								9
xv			1						1
Japur – Sompalle: Total	**197**		**3**	**1**	**9**		**10**	**28**	**248**
i	6		1	1	9		6		23
ii	6								6
iii	97		2				3	4	106
iv	69						1	7	77
v	14								14
vi	1							17	18
vii	4								4
Total	**1347**	**12**	**40**	**15**	**92**	**13**	**125**	**222**	**1866**

All villages	A	B	C	E	F	G	H	I	Grand total
i	45	12	22	15	65		92		251
ii	46								46
iii	673		16			13	22	25	749
iv	458				27		11	54	550
v	99								99
vi	1							143	144
vii	25								25
viii			1						1
xv			1						1
Grand Total	**1347**	**12**	**40**	**15**	**92**	**13**	**125**	**222**	**1866**