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# The adoption and impact of an improved drought-tolerant, dual-purpose groundnut variety in Southern India

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**Abstract:** This paper looks at the adoption and impact of an improved groundnut cultivar in Anantapur district, Andhra Pradesh, India. Despite positive results in farmer-participatory varietal selection, adoption was extremely low despite promotional efforts of a local NGO. The few farmers who adopted the variety generated significant benefits. They earned higher profits per hectare and their agricultural asset portfolios (a measure of wealth) increased significantly more than those of non-adopters. This raises the question of why, if the variety is beneficial, adoption is so low. Some possible explanations and their implications for future varietal development and dissemination are discussed.

## 1. Introduction

There were many reasons to expect that the groundnut variety ICGV91114, released officially in 2006, would be widely adopted in Anantapur district in the state of Andhra Pradesh in southern India. The variety was bred for drought tolerance as well as for high yields, and it was screened for the quantity and quality of the haulms (stems), a major source of feed for livestock. ICGV91114 was developed by research and development organisations through a participatory process with extensive farmer involvement (Nigam et al, 2005). Experimental data from farmers' fields consistently showed that ICGV91114 outperformed traditional varieties (Nigam et al, 2005). In addition, reports on seed production and sales data were indicated large-scale dissemination in the district. A recent impact study comparing adopters and non-adopters found that adopters had significantly higher groundnut income than non-adopters (Birthal et al, 2011).

This study originally intended to improve understanding and measurement of the impact of ICGV91114 in several ways. The first was by looking more carefully at the extent of diffusion and at the determinants of adoption at the household level. The second was to look at the impacts on livestock, specifically dairy production, and the third was to assess whether the distribution of the benefits and costs associated with the variety was gendered.

Early on in the field work, it became clear that adoption levels were dramatically lower than anticipated. Only a handful of adopters could be found in the sample hamlets, which had been selected, based on the location of the dissemination activities of the main NGO promoting the variety in the district. Qualitative evidence suggested that varietal performance may have been an issue (Neumeister, 2011). However, another possible explanation is that seed for other major varieties was sold by government at a subsidized price. ICGV91114, on the other hand, was distributed in limited quantities by an NGO that encouraged recipient farmers to share or sell seed to other farmers. As a result of these preliminary findings, the objectives of the study were adjusted to focus on the small population of adopters in order to understand who they are, why they are adopting, and what benefits they receive from the variety. Possible reasons for non-adoption by the majority of groundnut farmers are also explored, and the implications of the findings for future dissemination efforts as well as for varietal development processes are discussed.

The remainder of the paper is structured as follows: An outline of the background to the development of ICGV91114 is followed by a short overview of the data and methods employed for this study. Subsequently, the presentation of results first characterises the role of groundnuts in the local farming systems with a special emphasis on the varieties being grown. Secondly, the impact of adopting ICGV91114 on farm productivity, both in terms of cropping and livestock, is explored, which is followed by a discussion of the results and possible reasons for the low observed adoption rates given the apparent benefits of the variety

## 2. Background

### 2.1. The impact of drought-tolerant, dual-purpose crop varietal improvement

The benefits of high-yielding crop varieties (HYVs) have been widely documented (eg Evenson and Gollin, 2003). Relatively less evidence is available on the adoption and impact of improved groundnuts (Tripp, 2011) though some studies have documented productivity and poverty impacts (Birthal et al, 2011; Kassie, Shiferaw, Muricho, 2010; Bantilan, Deb and Nigam, 2003; Deb, Bantilan, and Nigam, 2005). Theoretical frameworks and empirical approaches for evaluating the *ex post* economic impacts of HYVs are well established (Walker et al, 2008), and have advanced in recent years with the methodological innovations in the area of program evaluation (De Janvry et al, 2011).

It is increasingly recognized that varietal traits that help farmers manage risk as well as increase average yield are especially important in developing countries, where most farmers are poor and have few resources with which to manage risk or cope with shocks (Marra et al, 2003). This is especially relevant in dry areas where drought regularly leads to complete crop failures. While there are fewer studies documenting these impacts (Marra et al, 2003) that number is likely to grow as more resources are invested in this area (Lybbert and Bell, 2011). Assessing the impact of improved varieties that reduce risk is more methodologically challenging than for varieties whose main benefit is improved yield. Studies that look only at average yield run the risk of underestimating the benefits of risk reduction both in terms of production and household welfare ( Gollin, 2006; Johnson and Klass, 2001; Marra et al, 2003). While technologies that reduce risk should be especially attractive to vulnerable farmers, risk aversion is generally associated with lower rates of adoption of new technology (Hurley, 2010). In addition, some risk-reducing traits may be more "adoptable" than others because of the way risk reduction occurs or the ease with which farmers can observe and learn about the benefits of the new varieties (Lybbert and Bell, 2011). Despite its importance, Lybbert and Bell (2011) suggest that drought resistance may be an especially challenging trait.

It is also increasingly recognized that farmers produce crops and livestock in integrated systems, and that they are interested in the productivity, profitability and stability of the system as a whole rather than the individual components. There any many ways that crops and livestock are linked in mixed systems (Wright et al, 2011) however one of the principle ones is that crop residues are used as animal feed. An implication of this is that farmers choose varieties based not only on grain characteristics (eg yield, yield stability, quality) but also on fodder characteristics. This has always been the case but has been growing in recent years as increasing demand for livestock products has pushed up the relative value of fodder as compared to grain (Blummel and Rao, 2006). While the need to consider food and feed characteristics in crop improvement has been recognized for a long time, it still accounts for a small portion of total breeding resources and has been focused mainly in drylands where feed is scarce (Erenstein et al, 2011). Several studies have documented adoption and economic impact of dual purpose legumes in West Africa and Asia (eg Kristjanson et al, 2006). Despite the explicit focus on dual purpose crops, most studies emphasise plant productivity gains (grain and fodder) and do not measure changes in livestock production practices or productivity on farm.

Despite the demonstrated success of crop improvement programs in many contexts, there are still many examples of limited adoption of improved varieties, especially among resource-poor farmers in marginal environments (Ashby, 2003). One possible explanation is that the varieties may have performed well on breeders' fields according to their criteria but were not developed with a good understanding of farmers' preferences and constraints. Participatory plant breeding (PPB), in which farmers are actively involved in the varietal development process, emerged in the 1980's as a potential solution to the problem (ibid).

**2.2. Development of ICGV91114 and of AF dissemination**

Livelihoods in the drought prone district of Anantapur, Andhra Pradesh (AP) depend largely on groundnut which is cultivated on 70 to 80% of the district's cropped area, covering 800 000 ha and supporting more than 300 000 small-holders. Though Anantapur is the highest groundnut producing district in AP, productivity is low due to the dry climate which is characterized by low (550mm/year on average) and variable rainfall (Prasad et al, 2006). To mitigate risk and diversify income opportunities, groundnut cropping is integrated with livestock which depend on groundnut haulms for feeding during the dry season. While home consumption and informal marketing were major characteristics of the state's dairy sector, lately renewed co-operative activity and private sector involvement have led to an above-national growth of the dairy sector in Andhra Pradesh (De Luca et al., 2010; Garcia et al., 2006).

The district has traditionally been dominated by a traditional groundnut cultivar – TMV2 – and despite multiple attempts no new cultivars have been adopted to any significant extent,. A new cultivar – ICGV 91114 – was developed for superior food and fodder (i.e. haulm, the residue after pod harvest) traits by collaborative work between crop improvement (ICRISAT) and livestock nutrition (ILRI) scientists with active participation a local NGO (Rural Development Trust/Accion Fraterna).

As part of an IFAD project on farmer participatory breeding, on-farm trials by farmers using their own management practices were conducted in three villages over three years (rainy seasons 2002, 2003, 2004) during which severe droughts occurred. The results showed that in general ICGV 91114 outperformed TMV2 by about 15% in pod and haulm yield (Nigam et al 2005). In addition, dairy animals fed haulms from ICGV 91114 gave about half a litre more milk/day than animals fed with the same amount of TMV2 haulms because of the superior fodder quality of the new cultivar (Blummel et al 2005). Farmers stressed that these additive effects (pod yield plus fodder yield plus fodder quality) were the driving factor in their demand for the new cultivar.

Transition from on-farm trials to adoption of the cultivar outside the research framework started around 2003 when farmers began producing seed for their own use and to sell to other farmers. In 2005 (post rainy season), 111 farmers in 23 villages in Anantapur were producing seed (Nigam et al, 2005). Despite this initial interest by farmers and the efforts to produce seed for broader dissemination, it quickly became clear that scaling up would be a challenge due to deficiencies in the seed system (Prasad et al, 2006), a concern that has been raised more generally about legumes (Tripp, 2011). An actor analysis was conducted which reaffirmed the importance of drought as the main constraint faced by farmers but also highlighted several market-and processing-related concerns. As a result, greater effort was placed on understanding aspects of demand for new varieties beyond the farmer level (Prasad et al, 2006).

Based on its performance in 2002-2004, NGO Rural Development Trust/Accion Fraterna (RDT/AF), a partner in the IFAD project, and its associated farmers decided to make a collective effort to scale up the variety after the project ended. In 2005, RDT/AF farmers agreed to produce exclusively for seed, and to sell to other farmers to expand the cropped area. In 2005, it was estimated that 285 ha were planted to ICGV 91114 in 41 villages. In 2009 RDT/AF estimated that about 10 000 to 12 000 ha are now cultivated with ICGV 91114.

## 3. Data and methods

### 3.1. Village survey and census

In Anantapur district villages are not the smallest settlement unit. A village generally comprises several hamlets, the actual settlement, and is more of an administrative unit. Thus, for the purpose of this study, hamlets are the community unit used in selection and analysis although the term village is used in regard to tools and methods.

The first step of sample selection resulted in the selection of 32 hamlets through stratified random sampling. The NGO Accion Fraterna (AF) had been actively promoting the new groundnut variety ICGV91114 in 8 sub-districts (mandals) of Anantapur district (which contains 63 mandals in total). In addition, 8 adjoining mandals were also identified to control for the impact of AF activities. Furthermore, AF had categorised activity and adjoining mandals by relative rainfall into equal classes of "dry" and "wet" mandals. From within their activity mandals, AF provided a list of 129 hamlets where according to their records ICGV91114 was being cultivated. 16 hamlets were randomly selected from this list – 8 hamlets from "dry" and 8 from "wet" mandals. Furthermore, 8 hamlets not on the ICGV91114 list were also randomly selected from within the 8 AF activity mandals (equally from "dry" and "wet" mandals). Finally, 8 hamlets were randomly selected from the 8 adjoining mandals (again equally from "dry" and "wet" mandals).

In order to obtain an initial overview of farming systems and the distribution of groundnut varieties a village survey was implemented. Data were collected through a questionnaire focussing on village characteristics such as infrastructure, land use, technology adoption, social indicators and prices. In each selected hamlet a group of 7-15 farmers was assembled which provided the requested information. Discussion was generally encouraged during this process.

Two hamlets from "wet" adjoining mandals were shown to grow only a very limited amount of groundnuts and were therefore excluded from further data collection.

Subsequently, village census data were collected from each selected hamlet. Local assistants based in the selected hamlets collected information on 20 variables from each household. These centred on identification of groundnut growers, including adopters of ICGV91114, and included some demographic variables and information on major land and livestock assets as well.

Because within the randomly selected hamlets only 14 households were currently growing ICGV91114 according to the village census results, 6 additional hamlets were selected for their high number of ICGV91114 adopters according to information provided by AF. The village survey and village census were also carried out in these hamlets, which resulted in a further 66 adopting households being identified. The extent of adoption of ICGV91114 in the various hamlet selection categories is shown in Table 1. Figure 1 illustrates the distribution of survey mandals and hamlets within Anantapur district.

Table 1: Adoption of ICGV91114 in various hamlet categories

| hamlet category | | random selection | | purposive |
|---|---|---|---|---|
| | AF-mandal ICGV-hamlet | AF-mandal non ICGV-hamlet | non AF-mandal non ICGV-hamlet | selection ICGV-hamlet |
| hamlet no. | 16 | 8 | 6 | 6 |
| ICGV91114 share of groundnut area [%] | 0.5 | 0.1 | 0.0 | 7.8 |
| ICGV91114 area [ha] | 40.4 | 2.8 | 0.2 | 139.8 |
| ICGV91114 share of groundnut growing hh [%] | 0.3 | 0.1 | 0.1 | 9.4 |
| ICGV91114 growing hh [no.] | 11 | 2 | 1 | 66 |

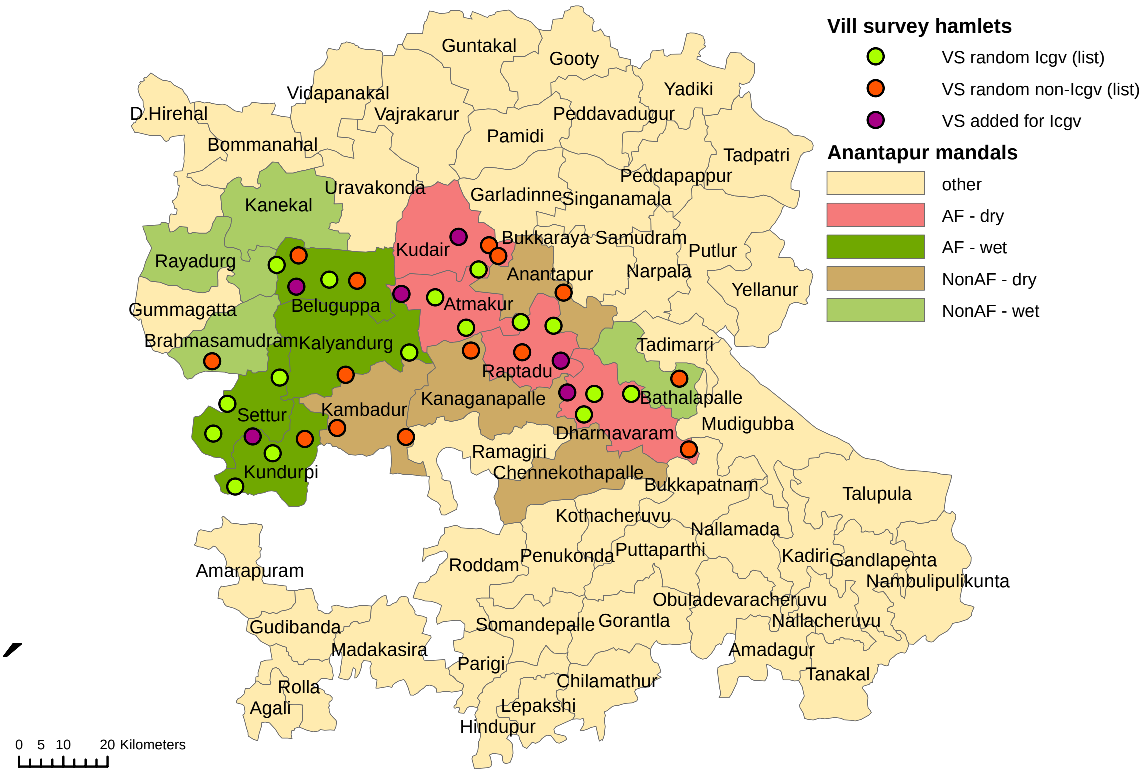



Figure 1: Location of selected hamlets within Anantapur district

Only 14 out of the 7036 (0.2%) of ground-nut growing households in the randomly selected hamlets were cultivating ICGV91114 according to the village census. The true adoption rate is lower still since half of these hamlets were specifically chosen for dissemination activities. Adopters appear to differ from non-adopters in many ways (Table 2). They are younger, own and cultivate more land and plant more groundnut than non-adopters. They own more cross-bed cattle, buffalo and draft animals, but fewer small ruminants.

Table 2: Mean values (standard errors) of key household characteristics in sample hamlets

| Adoption status of ICGV 91114 | | Adopters | Non-adopters in adopting hamlets | Non-adopters in non-adopting hamlets |
|---|---|---|---|---|
| Households | [no.] | 75 | 2294 | 5357 |
| Age Hh head[1] | [y] | 45.0 (1.4) | 45.9 (0.3) | 46.7 (0.2) |
| Hh size | [no.] | 4.9 (0.2) | 4.7 (0.0) | 4.6 (0.0) |
| Land owned | [ha] | 5.2 (0.6) | 2.7 (0.1) | 2.6 (0.0) |
| Land cultivated | [ha] | 5.3 (0.6) | 2.6 (0.1) | 2.6 (0.0) |
| Groundnut area | [ha] | 3.6 (0.5) | 2.2 (0.0) | 2.2 (0.0) |
| ICGV91114 area | [ha] | 2.1 (1.6) | 0.0 (0.0) | 0.0 (0.0) |
| Dairy cattle, local | [no.] | 0.5 (0.1) | 0.7 (0.0) | 0.6 (0.0) |
| Dairy cattle, cross-bred | [no.] | 0.7 (0.1) | 0.2 (0.0) | 0.1 (0.0) |
| Buffalo | [no.] | 1.2 (0.2) | 0.3 (0.0) | 0.4 (0.0) |
| Donkey | [no.] | 0.0 (0.0) | 0.0 (0.0) | 0.0 (0.0) |
| Goat | [no.] | 0.1 (0.0) | 0.6 (0.1) | 0.6 (0.2) |
| Sheep | [no.] | 0.4 (0.3) | 3.3 (0.5) | 2.7 (0.2) |
| Draft animals | [no.] | 1.5 (0.1) | 0.7 (0.0) | 0.7 (0.0) |

Data source: Village census; only groundnut-growing households

[1] some missing values in "Age Hh head" and "ICGV91114 area"

### 3.2. Household survey

In order to better understand the reasons for the low levels of adoption, we focused the household survey on adopters and a "matched" sample of non-adopters. This would allow us to see whether the variety delivered benefits to users as compared to comparable non-users, a first step in understanding the challenges of the varietal development and dissemination process. The non-adopter sample was obtained through propensity score matching using variables from the village census. Adopting households were matched with 2 types of non-adopting households: households from within adopting hamlets and households from non-adopting hamlets. The reason for selecting two matches is that each presents a different empirical challenge. Households from the same hamlets are likely to face similar agro-ecological, social, and market conditions. However because they had the opportunity, at least in theory, to adopt the variety and chose not to, there is clearly an issue of selection bias that needs to be addressed. Households in hamlets where adoption was not found and where AF did not work had less opportunity to adopt the variety which means that there is no selection bias issue at the household level. However, there may be bias at the hamlet level depending on how AF chose its sites, and different conditions between the AF and non-AF hamlets may make them difficult to compare. Although the household characteristics of non-adopters in both hamlet types appeared very similar (see Table 2) and socio-economic as well as climate characteristics did not vary greatly within mandals, we could not *a priori* say which problem is likely to be more significant. Therefore, we opted for including both types of households in the sample in order to compare the results.

The variables employed in the logit model for calculating the propensity scores were "total land cultivated", "local cattle", "buffaloes" and "draft animals", selected according to their significant coefficients (Table 3). Subsequently, "matching" households amongst the non-adopters, both in adopting and non-adopting villages were identified by their similarity in propensity scores. Table 4 shows the results of the matching process, including. "Land owned", a variable not employed for matching.

Table 3: Results or logistic regression

| | | | | | |
|---|---|---|---|---|---|
| Number of obs | = | 3186 | LR chi2(4) | = | 92.65 |
| Prob > chi2 | = | 0.0000 | Pseudo R2 | = | 0.1290 |
| Log likelihood | = | -312.68149 | | | |

| IcgvAdopHh | coefficient | standard error | z | P>z |
|---|---|---|---|---|
| LandCultAc | .051 | .010 | 4.79 | 0.000 |
| CtlLcl | -.282 | .117 | -2.42 | 0.016 |
| Buff | .203 | .077 | 2.64 | 0.008 |
| Draft | .526 | .101 | 5.19 | 0.000 |
| Constant | -4.584 | .187 | -24.47 | 0.000 |

Table 4: Results of propensity score matching

| | | adopters | non-adop., adop. hamlet | | | non-adop, non-adop. hamlet | | |
|---|---|---|---|---|---|---|---|---|
| Variable | sample | mean | controls | diff. | s.e. | controls | diff. | s.e. |
| LandCultAc | unmatched | 13.07 | 4.97 | 8.10 | 0.75 | 4.83 | 8.24 | 0.70 |
| | ATT | 13.07 | 13.32 | -0.25 | 2.27 | 10.76 | 2.31 | 1.94 |
| LandOwnAc | unmatched | 12.89 | 5.23 | 7.66 | 0.80 | 5.03 | 7.87 | 0.70 |
| | ATT | 12.89 | 13.69 | -0.80 | 2.23 | 11.18 | 1.71 | 1.89 |
| CtlLcl | unmatched | 0.49 | 0.59 | -0.10 | 0.21 | 0.37 | 0.12 | 0.12 |
| | ATT | 0.49 | 0.36 | 0.13 | 0.17 | 0.47 | 0.01 | 0.18 |
| Draft | unmatched | 1.51 | 0.58 | 0.93 | 0.11 | 0.59 | 0.93 | 0.12 |
| | ATT | 1.51 | 1.41 | 0.11 | 0.19 | 1.75 | -0.24 | 0.20 |

Due to some changes in adoption category between the village census and the household survey, the final household survey dataset includes 80 adopters, 91 non-adopters in adopting hamlets and 102 non-adopters in non-adopting hamlets. The selected households are located in 11 adopting hamlets and 6 non-adopting hamlets. Their location is shown in Figure 2.

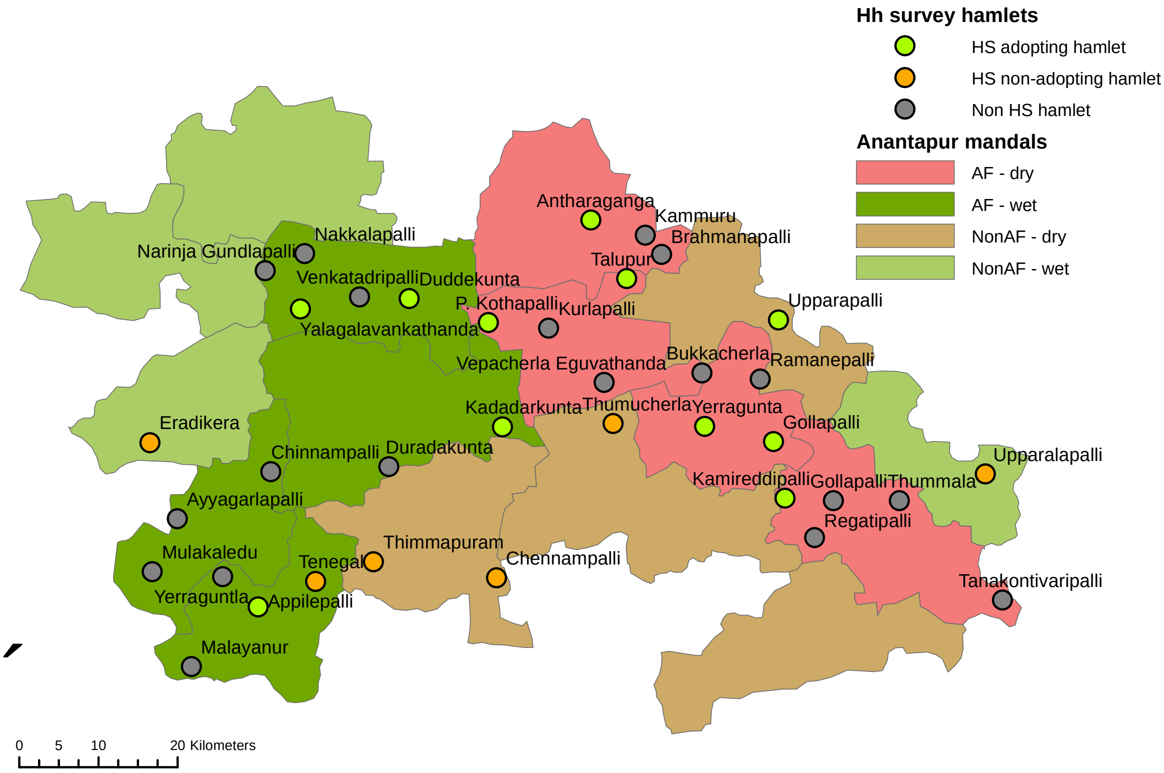



Figure 2: Location of selected hamlets by household survey category

The mean values of key characteristics for sample households are presented in Table 5 by adoption category. After matching households by basic assets the comparison shows that in general, household heads of adopting households are younger and more educated. They have larger share of irrigated land and more non-land assets than matched non-adopters. They also live closer to towns and output markets but further from input markets. Adopters do not own more livestock (in TLUs) than non-adopters but they do have higher milk production and sell a greater share of it. Adopters have higher income and expenditure than non-adopters which suggests that they are better off. The only variables for which we have baseline (recall) data are asset levels. Data were collected on a range of agricultural and non agricultural assets which were combined to form indices (Njuki et al, 2011). Adopters had higher levels of agricultural and non-agricultural assets in both 2008 and 2011. Nevertheless, adopters saw their assets grow relatively more (annually 17% and 10%, respectively) than both non-adopters in adopting hamlets (16% and 6%) and in non-adopting hamlets (12% and 1%). This could be interpreted as an indicator of positive impact of ICGV91114 on household welfare.

Table 5: Key household characteristics from the matched sample by adoption category

| Variables | | Adopters (n=80) | | Non-adopters (adopting hamlet) (n=91) | | Non-adopters (non-adopting hamlet) (n=102) | |
|---|---|---|---|---|---|---|---|
| | | Mean | SE | Mean | SE | Mean | SE |
| Sex of hh head (male=1, female=0) | | 0.99 | 0.01 | 0.97 | 0.02 | 0.96 | 0.02 |
| Age of hh head | [y]** | 46.0 | 1.4 | 51.0 | 1.4 | 50.2 | 1.3 |
| Edu of hh head | [y schooling]*** | 6.6 | 0.6 | 4.7 | 0.5 | 4.2 | 0.4 |
| Hh size | [no.] | 5.4 | 0.3 | 5.0 | 0.2 | 5.6 | 0.2 |
| Labor available (15-59 years) | [no.] | 3.6 | 0.2 | 3.4 | 0.1 | 3.6 | 0.2 |
| Total land owned | [ha] | 5.2 | 0.6 | 5.1 | 0.5 | 4.9 | 0.5 |
| Irrigated land owned | [%]*** | 39 | 3 | 20 | 3 | 15 | 2 |
| Cultivated land owned | [ha] | 5.7 | 0.6 | 5.4 | 0.5 | 5.0 | 0.5 |
| Cultivated irrigated land | [%]*** | 34 | 3 | 19 | 2 | 15 | 2 |
| Milk production | [l/d]*** | 3.5 | 0.4 | 2.6 | 0.4 | 1.6 | 0.3 |
| Milk marketed | [%]*** | 52 | 4 | 33 | 4 | 26 | 4 |
| Milching cattle local | [no.] | 0.5 | 0.1 | 0.4 | 0.1 | 0.4 | 0.1 |
| Milching cattle xbreed | [no.]*** | 0.5 | 0.1 | 0.3 | 0.1 | 0.0 | 0.0 |
| Milching buffalo local | [no.] | 0.7 | 0.1 | 0.8 | 0.1 | 1.2 | 0.3 |
| Milching buffalo imprvd | [no.]*** | 0.2 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 |
| Draft animal | [no.] | 1.4 | 0.1 | 1.4 | 0.1 | 1.3 | 0.1 |
| Small ruminant | [no.] | 1.5 | 0.6 | 1.5 | 0.9 | 4.5 | 2.1 |
| Total Adult animals | [TLU] | 4.2 | 0.3 | 3.5 | 0.3 | 4.4 | 0.6 |
| Annual income | [INR] | 173,955 | 23,492 | 112,295 | 9,362 | 138,028 | 28,954 |
| Annual Food Expenditure | [INR]** | 36,994 | 1,775 | 32,342 | 1,079 | 32,716 | 1,229 |
| Annual Non-Food Expenditure | [INR] | 65,514 | 4,251 | 63,008 | 5,187 | 58,955 | 5,521 |
| Distance Local input market | [km] | 13.7 | 0.9 | 12.1 | 0.8 | 13.5 | 1.2 |
| local output market | [km] *** | 13.7 | 0.9 | 12.1 | 0.8 | 31.9 | 2.2 |
| town | [km]*** | 14.4 | 1.0 | 20.4 | 0.8 | 20.9 | 1.0 |
| machinery repair shop | [km]*** | 14.3 | 1.0 | 13.7 | 1.1 | 18.6 | 1.1 |
| ag knowledge center | [km]*** | 13.5 | 0.6 | 12.5 | 0.8 | 18.6 | 1.1 |
| microfinance institution | [km]*** | 0.6 | 0.2 | 0.2 | 0.1 | 0.0 | 0.0 |
| nearest commercial bank | [km]*** | 10.5 | 0.6 | 11.1 | 0.7 | 6.1 | 0.5 |
| Non-agri asset index 2011 | | 81.2 | 15.0 | 47.0 | 8.4 | 50.5 | 13.9 |
| Agri asset index 2011*** | | 493.3 | 53.4 | 303.2 | 54.2 | 279.9 | 50.6 |
| Non-agri asset index 2008 | | 50.5 | 11.7 | 30.0 | 8.1 | 35.5 | 13.5 |
| Agri asset index 2008 | | 373.6 | 44.1 | 254.7 | 44.1 | 269.5 | 53.0 |
| Change in agri-assets index*** | | 119.8 | 41.2 | 48.5 | 19.1 | 10.4 | 13.0 |
| Change in non agri-asset index* | | 30.8 | 9.8 | 17.0 | 3.0 | 15.0 | 3.3 |

Asterisks indicate that differences in means are significant at ≤.1(*), ≤.05(**), or ≤ .01(***)

Data source: Household survey

## 4. Role of ICGV91114 in groundnut production and crop-livestock systems

To better understand the contribution of ICGV91114 to improved outcomes such as income and assets, we compared crop and livestock production practices among the three adoption categories.

### 4.1. Role of groundnuts in cropping systems

Groundnut is the dominant crop in *kharif* season; nearly all households, adopters and non-adopters, planted groundnut on most of their land in that season (Table 6). Paddy was a distance second in terms of area (<10%). However, in terms of households two-thirds of the households planting ICGV91114 were also growing paddy. Amongst the households not growing ICGV91114 in *kharif* nearly half were growing paddy. During *rabi* fewer households plant crops because of the need for irrigation.. Cropping patterns also differed between adopters and non-adopters in *rabi* with adopters planting a higher proportion of their land to groundnut and relatively less to paddy and other cereals. Adopters and non-adopters did not differ much in regard to growing pulses, fruits and vegetables.

Table 6: Distribution of area and households under different crops by households' ICGV91114 status in that season[1]

| | Rabi (2009-10) | | | | | | Kharif (2010) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | planted ICGV91114 | | no ICGV91114 (adopting hamlet) | | no ICGV91114 (non-adopting hamlet) | | planted ICGV91114 | | no ICGV91114 (adopting hamlet) | | no ICGV91114 (non-adopting hamlet) | |
| | area 29ha [%] | hh n=15 [%] | area 97ha [%] | hh n=71 [%] | area 92ha [%] | hh n=70 [%] | area 319ha [%] | hh n=56 [%] | area 598ha [%] | hh n=115 [%] | area 492ha [%] | hh n=102 [%] |
| Groundnut | 62 | 100 | 35 | 42 | 21 | 29 | 84 | 100 | 81 | 98 | 89 | 100 |
| Paddy | 20 | 47 | 33 | 61 | 46 | 69 | 10 | 68 | 8 | 49 | 8 | 45 |
| Other cereals | 0 | 0 | 6 | 11 | 5 | 9 | 0 | 2 | 2 | 6 | 0 | 3 |
| Pulses | 0 | 0 | 1 | 1 | 0 | 0 | 3 | 9 | 5 | 6 | 1 | 3 |
| Fruits | 18 | 13 | 21 | 17 | 20 | 6 | 2 | 7 | 4 | 13 | 1 | 2 |
| Vegetables | 0 | 0 | 2 | 3 | 3 | 9 | 0 | 4 | 0 | 3 | 0 | 2 |
| Other | 0 | 0 | 2 | 3 | 5 | 6 | 0 | 5 | 1 | 6 | 0 | 2 |

[1]In this table we do not use the categories "adopter" and "non-adopter" since it is possible that a household which planted ICGV91114 in one season did not plant it in another but still planted groundnut.

Adopters reported higher groundnut pod (grain) and haulm yields compared to non-adopters in *kharif* but not in *rabi* (Table 7). They also reported higher yields for paddy – in both seasons. Average area planted to groundnut and to paddy did not differ very much between adoption categories in either season though there were some differences in the less common crops (Table 8).

Table 7: Grain and haulm yield [t/ha] of different crops by households' ICGV91114 status in that season

| | Rabi (2009-10) | | | | | | Kharif (2010) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | planted ICGV91114 (n=15) | | no ICGV91114, adopting hamlet (n=71) | | no ICGV91114, non-adopting hamlet (n=70) | | planted ICGV91114 (n=56) | | no ICGV91114, adopting hamlet (n=115) | | no ICGV91114, non-adopting hamlet (n=102) | |
| | grain | haulm | Grain | haulm | grain | haulm | grain | haulm | grain | haulm | grain | haulm |
| Groundnut | 1.7 | 2.7 | 1.2 | 2.6 | 1.3 | 3.9 | 0.8 | 1.7 | 0.3 | 1.1 | 0.3 | 1.3 |
| Paddy | 4.0 | 2.5 | 3.7 | 4.4 | 3.1 | 4.1 | 4.7 | 4.3 | 3.4 | 4.1 | 4.0 | 4.8 |
| Other cereals | 0.0 | 0.0 | 1.3 | 2.3 | 1.3 | 3.4 | 1.0 | 1.2 | 0.9 | 2.6 | 2.4 | 4.1 |
| Pulses | 0.0 | 0.0 | 0.5 | 0.1 | 0.0 | 0.0 | 0.1 | 0.1 | 0.5 | 0.3 | 0.1 | 0.4 |
| Fruits | 0.0 | 0.0 | 5.6 | 0.0 | 0.5 | 0.0 | 8.3 | 0.0 | 4.5 | 0.0 | 6.5 | 0.0 |
| Vegetables | 0.0 | 0.0 | 3.0 | 0.0 | 2.5 | 0.0 | 4.6 | 0.0 | 5.4 | 0.0 | 6.2 | 0.0 |
| Other | 0.0 | 0.0 | 0.4 | 0.2 | 0.5 | 0.0 | 0.0 | 7.9 | 1.4 | 2.6 | 0.4 | 0.0 |
| Total | 2.3 | 2.4 | 2.9 | 2.9 | 2.3 | 3.4 | 2.4 | 2.6 | 1.6 | 1.9 | 1.6 | 2.3 |

Table 8: Average area per household [ha] and no. of households under different crops by households' ICGV91114 status in that season

| | Rabi (2009-10) | | | | | | Kharif (2010) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | planted ICGV91114 | | no ICGV91114 (adopting hamlet) | | no ICGV91114 (non-adopting hamlet) | | planted ICGV91114 | | no ICGV91114 (adopting hamlet) | | no ICGV91114 (non-adopting hamlet) | |
| | area | hh | area | hh | area | hh | area | hh | area | hh | area | hh |
| Groundnut | 1.2 | 15 | 1.1 | 30 | 1.0 | 20 | 4.8 | 56 | 4.3 | 113 | 4.3 | 102 |
| Paddy | 0.8 | 7 | 0.7 | 43 | 0.9 | 48 | 0.8 | 38 | 0.9 | 56 | 0.9 | 46 |
| Other cereals | 0.0 | 0 | 0.7 | 8 | 0.8 | 6 | 0.8 | 1 | 1.6 | 7 | 0.5 | 3 |
| Pulses | 0.0 | 0 | 0.8 | 1 | 0.0 | 0 | 2.1 | 5 | 4.1 | 7 | 1.8 | 3 |
| Fruits | 2.5 | 2 | 1.7 | 12 | 4.6 | 4 | 1.9 | 4 | 1.6 | 15 | 3.6 | 2 |
| Vegetables | 0.0 | 0 | 1.0 | 2 | 0.5 | 6 | 0.5 | 2 | 0.3 | 3 | 0.3 | 2 |
| Other | 0.0 | 0 | 0.8 | 2 | 1.2 | 4 | 0.2 | 3 | 0.5 | 7 | 0.9 | 2 |

### 4.2. Groundnut varieties

In addition to growing ICGV91114, more than a third of the adopting households also grew the traditional variety TMV2 and nearly a quarter grew another improved variety, K6 (Table 9). TMV2 is still by far the most common variety among non-adopters in kharif. Non-adopters in adopting hamlets are more likely to use other improved varieties than non-adopters in non-adopting hamlets, which could mean that adopting hamlets have better access to information and improved technology. Amongst the few adopters who adopted ICGV91114 in rabi, other groundnut varieties were hardly grown.

Table 9: Area and household distribution of various groundnut varieties by households' ICGV91114 status in that season

| | Rabi (2009-10) | | | | | | Kharif (2010) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | planted ICGV91114 | | no ICGV91114 (adopting hamlet) | | no ICGV91114 (non-adopting hamlet) | | planted ICGV91114 | | no ICGV91114 (adopting hamlet) | | no ICGV91114 (non-adopting hamlet) | |
| | area 18ha [%] | hh n=15 [%] | area 34ha [%] | hh n=30 [%] | area 20ha [%] | hh n=20 [%] | area 268ha [%] | hh n=56 [%] | area 481ha [%] | hh n=113 [%] | area 436ha [%] | hh n=102 [%] |
| ICGV 91114 | 90 | 100 | 0 | 0 | 0 | 0 | 57 | 100 | 0 | 0 | 0 | 0 |
| TMV2 | 3 | 7 | 61 | 57 | 74 | 80 | 32 | 38 | 80 | 84 | 92 | 90 |
| K6 | 7 | 7 | 37 | 37 | 26 | 20 | 10 | 23 | 17 | 27 | 6 | 12 |
| JL24 | 0 | 0 | 1 | 3 | 0 | 0 | 1 | 2 | 3 | 5 | 1 | 1 |
| Other | 0 | 0 | 1 | 3 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 |

Data source: Household Survey

Overall, yields were considerably higher in rabi. ICGV91114 performed well in both seasons, considering grain and haulm yields together. But because yields were highly variable across varieties and adopter categories and because household numbers are very small in some cells there is no evidence of a clear yield advantage (Table 10 and Table 9).

Table 10: Grain and haulm yields [tons/ha] of different groundnut varieties by by households' ICGV91114 status in that season

| | Rabi (2009-10) | | | | | | Kharif (2010) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | planted ICGV91114 | | no ICGV91114 (adopting hamlet) | | no ICGV91114 (non-adopting hamlet) | | planted ICGV91114 | | no ICGV91114 (adopting hamlet) | | no ICGV91114 (non-adopting hamlet) | |
| | grain | haulm | grain | haulm | Grain | haulm | grain | haulm | grain | haulm | grain | haulm |
| ICGV 91114 | 1.7 | 2.7 | | | | | 0.9 | 1.9 | | | | |
| TMV2 | 2.1 | 1.2 | 1.2 | 2.3 | 0.9 | 3.7 | 0.3 | 1.3 | 0.3 | 1.1 | 0.3 | 1.2 |
| K6 | 0.5 | 2.9 | 1.3 | 3.0 | 2.9 | 4.3 | 0.5 | 1.7 | 0.5 | 1.3 | 0.9 | 2.1 |
| JL24 | | | 1.4 | 4.0 | | | 0.5 | 1.3 | 0.2 | 1.1 | 0.1 | 0.5 |
| Other | | | 0.7 | 3.0 | | | 3.0 | 3.5 | | | | |
| Total | 1.7 | 2.6 | 1.2 | 2.6 | 1.7 | 4.2 | 0.7 | 1.7 | 0.3 | 1.1 | 0.3 | 1.3 |

Data source: Household Survey

In kharif, the proportions of groundnut varieties did not differ strongly between farm size classes within the household survey sample (Table 11). TMV2 covered over two thirds in all three categories. However, ICGV91114 was somewhat more popular amongst small farmers and K6's share was highest amongst medium farmers. In rabi this trend considerably stronger with small farmers growing ICGV91114 over half of their groundnut area compared to a quarter on large farms.. It appears large farmers were more reluctant to move to new varieties compared to households in the smaller farm size categories in both seasons. However, these results have to be treated with some caution, firstly household numbers are limited, especially in rabi. Secondly, the household sample is not representative of groundnut farmers in general as illustrated in Table 2. These results do indicate though that when small farmers do decide to adopt a new variety they may well switch faster, although this may also be determined by the number of plots.

Table 11: Distribution of area and households under different groundnut varieties by farm size category

| | Rabi (2009-10) | | | | | | Kharif (2010) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | small (< 2 ha) | | medium (2-4 ha) | | large (>4 ha) | | small (< 2 ha) | | medium (2-4 ha) | | large (>4 ha) | |
| | area 4.3ha [%] | hh n=6 [%] | area 16ha [%] | hh n=17 [%] | area 52ha [%] | hh n=42 [%] | area 41ha [%] | hh n=38 [%] | area 207ha [%] | hh n=94 [%] | area 938ha [%] | hh n=139 [%] |
| ICGV 91114 | 58 | 50 | 9 | 12 | 23 | 24 | 18 | 16 | 13 | 19 | 13 | 23 |
| TMV2 | 42 | 67 | 36 | 47 | 55 | 52 | 73 | 79 | 69 | 72 | 75 | 79 |
| K6 | 0 | 0 | 52 | 41 | 21 | 21 | 9 | 8 | 17 | 21 | 10 | 23 |
| JL24 | 0 | 0 | 0 | 0 | 1 | 2 | 0 | 0 | 1 | 1 | 2 | 5 |
| Other | 0 | 0 | 3 | 6 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |

Seed supply is an important issue in groundnut production, partly because of the comparatively high requirements, partly because of the strong government involvement in Anantapur district. Therefore, the study compares households' main sources of groundnut seed. Table 12 highlights the differences of seed sources between varieties. ICGV91114 seed is much more likely to come from other farmers, NGOs or farmers' own saved seed compared to other varieties. The main source for other varieties is the government, followed by other farmers. These results are consistent with both the role of government subsidies in influencing varietal adoption and AF being the major promoter of ICGV91114 in the area.

Table 12: Distribution of households [%] by their main source of different variety of seeds

| | ICGV91114 | K6 | TMV2 | JL24 | Other |
|---|---|---|---|---|---|
| farm saved | 20 | 6 | 7 | 0 | 0 |
| exchange | 0 | 3 | 0 | 0 | 0 |
| purchase from other farmers | 54 | 35 | 18 | 38 | 100 |
| purchase from market | 4 | 0 | 1 | 0 | 0 |
| provided by promoting agency/NGO | 21 | 0 | 0 | 0 | 0 |
| provided by govt. organisations | 1 | 57 | 73 | 63 | 0 |
| total (no. of hh) | 80 | 69 | 206 | 8 | 1 |

Source: Household Survey

Although adopters were using more seed coming from own production, there is little difference between adopters and non-adopters in regard to the share of groundnuts being saved for in-house use (Table 13). However, for this comparison the groundnut variety records referring to rabi 2011 have been excluded. These records (n=22) show an average share of in-house use of 68%. A reason for this high value might be that the rabi 2011 data is based only on households which started cultivating ICGV91114 in that season. Perhaps these households were especially interested in saving seed, either for later sale or for increasing their own ICGV91114 area in the following kharif season.

Table 13: Share of groundnuts [%] (n) saved for in-house use by variety and adoption status

| | adopters | non-adopters (adopting hamlet) | non-adopters (non-adopting hamlet) |
|---|---|---|---|
| ICGV91114 | 6 (54) | - | - |
| K6 | 6 (23) | 4 (24) | 5 (12) |
| TMV2 | 8 (34) | 7 (78) | 9 (92) |
| JL24 | 4 (4) | 0 (3) | 7 (1) |

Source: Household survey, household-variety records referring to rabi 2011 are excluded

Although only about a fifth of households growing ICGV91114 had received most of their seed from an NGO, nearly half of the adopters had some connections with AF (**Error! Reference source not found.**). Thus, more farmers were having links to AF than were receiving seed from AF, supporting the finding that the farmer-to-farmer distribution model supported by AF has become important.

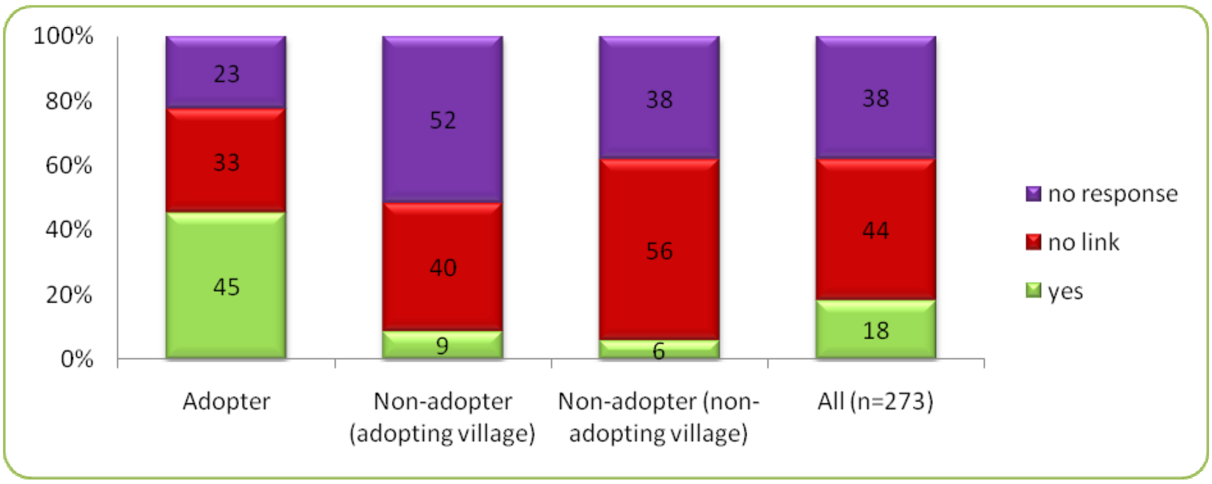
In regard to links with AF, it is also interesting to note that non-adopting households in adopting hamlets are more similar to households in non-adopting hamlets than to households in the same hamlets. It appears that AF extension activities are focussed more on individual households than on hamlets, allowing for more intensive interactions, but perhaps with reduced potential for further dissemination.

While the development of ICGV91114 has been continuing for about a decade it was interesting to note that most of the farmers in the household sample had only recently adopted the variety (Table 14). This also applies to K6, the variety developed recently be a state government research station.

Table 14: No. of households with their experience of cultivation by variety

| years of growing | ICGV | K6 | TMV2 | JL24 |
|---|---|---|---|---|
| 1 year | 46 | 30 | 0 | 0 |
| 2 years | 17 | 14 | 0 | 3 |
| 3 years | 7 | 13 | 0 | 1 |
| 4-10 years | 10 | 12 | 6 | 4 |
| >10 years | 0 | 0 | 200 | 0 |

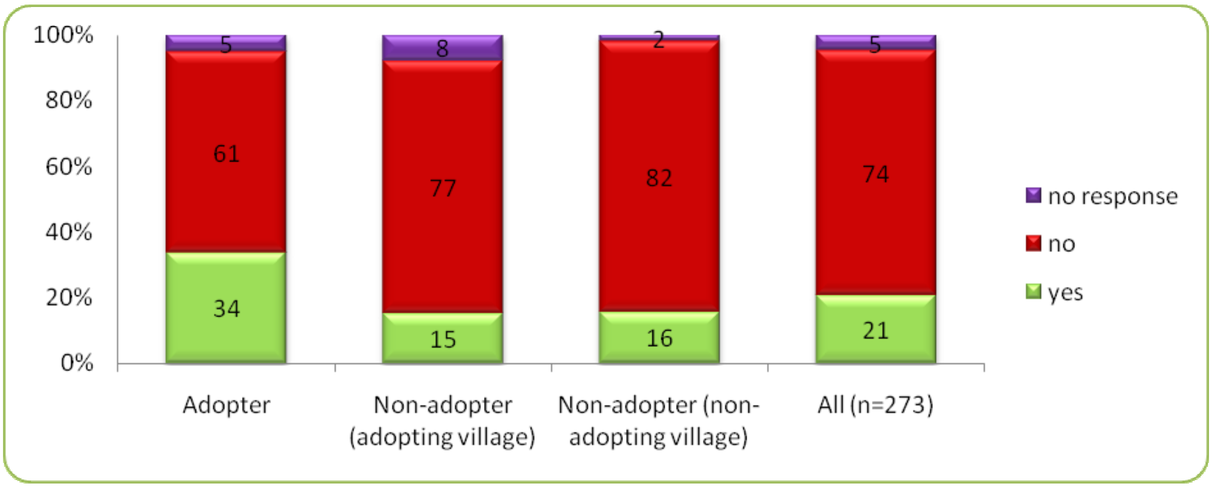
Figure 3: Distribution of households [%] reporting links to AF




In regard to the overall institutional influence on groundnut variety decisions (

), the difference between adoption categories was not as great as in the links to AF, although the percentage was still twice as high for adopters compared to non-adopters. Nevertheless, the results show that amongst adopters not all farmers felt that their links to AF had determined their variety decision and amongst non-adopters other institutions than AF have also been promoting groundnut development.

Figure 4: Distribution of households [%] reporting a role of institutional support in their decision on groundnut variety




### 4.3. Role of groundnuts in livestock systems

Livestock play a considerable role in farming systems in Anantapur. According to the results of the household survey about a fifth of total agricultural revenue originates from livestock. The share amongst adopters appears to be lower, but this is mainly due to their considerably higher returns from crop production (Table 15).

Table 15: Average annual revenue [Rs] per household from farming activities by adoption category

| | adopters | non-adopters (adopting hamlet) | non-adopters (non-adopting hamlet) |
|---|---|---|---|
| animal sales | 5669 | 5671 | 5489 |
| product sales (milk, etc.) | 17142 | 13860 | 6646 |
| livestock services (draft etc.) | 1043 | 0 | 1027 |
| trading in animals and products (net income) | 1192 | 220 | 144 |
| livestock total | 25045 | 19751 | 13307 |
| crops total | 125886 | 63987 | 62626 |
| other total | 431 | 866 | 667 |
| farming total | 151363 | 84604 | 76599 |

One of the major constraints livestock keepers face in the study sites, and in semi-arid locations in general, is access to feed especially in the dry season. One of the expected advantages of ICGV91114 is that it produces more haulms and haulms of better nutritional quality, than other groundnut varieties. According to the data, adopters have more animals than the general population (Table 3). However, within the "matched" household sample the picture is not so clear. More adopters produce and sell milk than non-adopters, but amounts do not differ greatly between adopters and non-adopters in adopting villages. However, both the number of practicing households and milk amounts produced and sold are lower in non-adopting villages (Table 16). Because there is a market for fodder (including groundnut haulms), it is not necessarily the case that only livestock keeping households care about haulm quality and quantity, especially as the relative value of fodder to grain increases, if haulms are sold by variety – in Anantapur groundnut haulms are generally not differentiated by variety when marketed. However, to the extent that fodder markets are incomplete or imperfect, households depending relatively more on livestock may place more importance on haulm-related traits.

Table 16: Average household milk production and sale by adoption category

| | adopters n=80 | | non-adopters (adopting hamlet) n=91 | | non-adopters (non-adopting hamlet) n=102 | |
|---|---|---|---|---|---|---|
| | milk [l/d] | hh practicing [no.] | milk [l/d] | hh [no.] | milk [l/d] | hh [no.] |
| Milk production | 4.5 | 63 | 4.8 | 49 | 3.2 | 48 |
| Milk sale | 4.0 | 55 | 4.9 | 38 | 2.9 | 37 |

Overall, more farmers were purchasing fodder (roughly half in each category, Table 17) than were selling (one adopter and about 10% of non-adopters). Also, more households were buying paddy straw than groundnut haulms in all three categories. However, while adopters were purchasing less groundnut haulms than paddy straw, non-adopters were buying more. Both paddy straw and groundnut haulm prices were higher in adopting hamlets, an issue worth further study. Similarly, the indication that the single adopter selling groundnut haulms received a price considerable lower than non-adopters should be investigated further. This is not consistent with an expected price premium for fodder from ICGV91114 due to its higher nutritional quality.

Table 17: Quantity, value and no. of hh purchasing and selling fodder/concentrate by adoption category

| | | adopters | | non-adopters (adopting hamlet) | | non-adopters (non-adopting hamlet) | |
|---|---|---|---|---|---|---|---|
| | | purchased | sold | purchased | sold | purchased | sold |
| Total fodder | quantity [t] | 2.7 | 4.2 | 4.6 | 3.2 | 3.5 | 2.3 |
| | price[INR/t] | 1,678 | 1,905 | 1,670 | 1,671 | 1,422 | 1,698 |
| | hh [no.] | 35 | 1 | 52 | 9 | 58 | 11 |
| Gn haulm | quantity [t] | 2.1 | 0.7 | 3.4 | 2.8 | 2.7 | 1.7 |
| | price[INR/t] | 1,990 | 1,429 | 1,728 | 1,596 | 1,569 | 1,688 |
| | hh [no.] | 15 | 1 | 29 | 8 | 38 | 11 |
| Paddy straw | quantity [t] | 2.4 | 3.5 | 3.0 | 3.2 | 2.4 | 3.3 |
| | price[INR/t] | 1,523 | 2,000 | 1,628 | 1,938 | 1,271 | 1,727 |
| | hh [no.] | 26 | 1 | 46 | 2 | 42 | 2 |

## 5. The impact of ICGV on farm productivity

### 5.1. Impact of ICGV on groundnut productivity

Compared to the traditional variety TMV2, ICGV91114 yielded considerably more profit per hectare in both seasons (Table 18). The input costs for ICGV91114 were 42% higher than for TMV2 in kharif, with the biggest cost increases coming from fertilizer/manure (32% of cost difference) and seed costs (31% of cost difference). However, this is far outweighed by the increase in output value to which both pods and haulms contributed. In kharif the output value of ICGV91114 was nearly three times the value produced by TMV2. While most of this increase is due to the yield difference, prices also contributed. Pod prices of ICGV91114 were about 18% higher (26.86 INR/kg) than of TMV2 (22.69 INR/kg); there was little difference to the price of K6 (25.18 INR/kg). However, it is not known how far seed sales have contributed to this price difference. Within the household survey, farmers could not recall the variety of the groundnut haulms they had sold or purchased over the past year. Thus, it was not possible to determine a haulm price effect. In rabi, production costs of ICGV91114 were only 13% higher than TMV2, mainly due to greater expenditure on seed. Many of the other costs were actually lower. However, when comparing ICGV91114 to K6, the most popular new variety, the differences are not so large. The value of outputs in kharif is 28% higher for ICGV91114 than for K6 and 22% in rabi. However, as the costs of K6 are slightly higher, ICGV91114 shows considerably higher net revenues (227% in kharif, 42% in rabi). For all varieties, revenues in kharif are far lower than in rabi, mainly due to pod yields which are only a fraction of rabi yields. In addition, kharif yields are highly unreliable and complete crop failure is a regular phenomenon. Thus, crop insurance, which is being promoted by government agencies in connection with seed supply and input credit, is an attractive support measure.

Table 18: Value of output, yield and cost of cultivation of ICGV91114, TMV2 and K6 by season

| | | Rabi (2009-10) | | | Kharif (2010) | | |
|---|---|---|---|---|---|---|---|
| | | ICGV 91114 | TMV2 | K6 | ICGV 91114 | TMV2 | K6 |
| Hh growing | [no.] | 15 | 34 | 16 | 56 | 208 | 55 |
| Outputs | | | | | | | |
| value of production | [INR/ha] | 64,398 | 26,835 | 52,480 | 21,810 | 7,440 | 17,014 |
| pod yield | [t/ha] | 2.12 | 0.97 | 1.72 | 0.68 | 0.25 | 0.53 |
| haulm yield | [t/ha] | 2.84 | 2.44 | 3.41 | 1.58 | 0.98 | 1.50 |
| Input costs | [INR/ha] | | | | | | |
| seeding/planting | | 677 | 615 | 868 | 626 | 393 | 589 |
| seed | | 7,310 | 5,221 | 7,741 | 5,032 | 3,850 | 5,268 |
| irrigation | | 102 | 101 | 130 | 19 | 2 | 24 |
| fertiliser | | 1,079 | 2,066 | 2,874 | 1,251 | 793 | 1,263 |
| manure | | 1,354 | 1,529 | 1,813 | 2,057 | 1,282 | 1,917 |
| weeding | | 1,746 | 1,977 | 1,632 | 1,522 | 1,229 | 1,757 |
| pesticides | | 1,098 | 1,106 | 1,096 | 818 | 427 | 652 |
| harvesting/threshing | | 3,081 | 2,002 | 2,577 | 1,379 | 908 | 1,485 |
| other | | - | - | - | - | 55 | 44 |
| Total | [INR/ha] | 16,447 | 14,617 | 18,731 | 12,704 | 8,938 | 13,001 |
| Net revenue | [INR/ha] | **47,951** | **12,217** | **33,749** | **9,107** | **-1,499** | **4,013** |

Source: Household Survey. Note: The calculations are based on the aggregated groups of growers: areas and costs were summed and then total output value (using average prices) and total costs were calculated.

The results of estimating the contribution of input factors and household characteristics to total product value per ha through a Cobb-Douglas production function are presented in Table 19. They have been calculated on the basis of household-season-variety records for all groundnut growing households – excluding those which had started growing ICGV91114 in rabi 2011. On the input side irrigation cost and fertiliser costs are the only significant variables. Fertiliser costs had also featured strongly in the profitability comparison, while irrigation costs had differed, but only on a low level (electricity for driving groundwater pumps not charged in Anantapur). However, seed cost which featured strongly in the cost comparison is not significant in the production function. Out of the household characteristics the household head gender is significant with a negative coefficient, which is not surprising. Also in line with previous results is the negative significant coefficient of land cultivated (smaller farmers were moving faster to new varieties) and the positive significant coefficient of the share of irrigated land. Similarly, the significant season dummy indicates how yields in rabi are higher than in kharif. The variety dummies are significant in regard to TMV2 and JL24, with TMV2 showing the largest standardised beta of all coefficients. However, there appears to be no significant decrease in production value when switching to K6, which is line with results recorded earlier. Finally, the adoption status of the household as distinct from the variety is non-significant for both hamlet types. This would indicate that in regard to productivity potential the three household categories do not differ, which would validate the sample selection process.

Table 19: Production function estimation for groundnut production value

| Dep. variable: Log (Production value) | coefficient | std. error | p>t | beta |
|---|---|---|---|---|
| Seeding/planting cost | 0.00 | 0.03 | 0.92 | 0.00 |
| Seed cost | 0.02 | 0.02 | 0.36 | 0.04 |
| Irrigation cost | 0.09 | 0.03 | 0.01 | 0.13 |
| Fertilizer cost | 0.00 | 0.00 | 0.00 | 0.15 |
| Manure cost | -0.01 | 0.01 | 0.36 | -0.04 |
| Weeding cost | -0.04 | 0.04 | 0.24 | -0.05 |
| Pesticide cost | 0.02 | 0.02 | 0.44 | 0.03 |
| Other cost | -0.03 | 0.04 | 0.44 | -0.03 |
| Sex of head=1, otherwise=0 | 0.86 | 0.34 | 0.01 | 0.10 |
| Age of head [y] | 0.03 | 0.21 | 0.90 | 0.01 |
| Education of head [y] | 0.02 | 0.06 | 0.75 | 0.02 |
| Food Expenditure Cost [%] | -0.09 | 0.17 | 0.61 | -0.02 |
| Land Cultivated | -0.18 | 0.08 | 0.03 | -0.11 |
| % of Irrigated of cultivated land | 0.11 | 0.04 | 0.01 | 0.13 |
| Season: Rabi=1, otherwise=0 | 0.81 | 0.18 | 0.00 | 0.23 |
| Variety: TMV2=1, otherwise=0 | -0.78 | 0.18 | 0.00 | -0.29 |
| K6=1, otherwise=0 | -0.18 | 0.20 | 0.37 | -0.05 |
| JL24=1, otherwise=0 | -0.95 | 0.39 | 0.02 | -0.11 |
| Non-adopter in adopting hamlet=1, otherwise=0 | -0.19 | 0.16 | 0.23 | -0.07 |
| Non-adopter in non-adopting hamlet=1, otherwise=0 | 0.00 | 0.17 | 0.99 | 0.00 |
| Constant | 8.73 | 1.25 | 0.00 | . |

n=421; Prob > F = 0.000; Adj R-squared= 0.3361;

Note: Fertiliser is not taken as log

### 5.2. Impact on livestock productivity

Evidence from feeding trials on station and on farm show that ICGV91114 haulms contribute to increased milk production when weather conditions do not lead to reduced haulm quality (Ravichandran, 2011). As most households adopting ICGV91114 also grow other groundnut varieties and farmers generally mix their groundnut haulms during storage, livestock productivity effects of groundnut varieties are difficult to estimate based on household survey data alone. Nevertheless, we estimated the effect of having adopted ICGV91114 on the average household milk yield, being the variable which would most clearly show any effect of improved fodder quality. The results are contained in Table 20. They confirm that some input factors associated with intensification of milk production show highly significant and strong effects. In particular, the milk marketing percentage as an indication of production objective and the share of improved animals contributed strongly. While purchases of fodder showed a significant contribution, concentrate purchases did not, which is surprising. Similarly, having more buffaloes also did not show a significant effect, which might be due to the fact, that improvements offered by cross-bred cattle outweighed the species advantage. None of the household characteristics showed a significant contribution. This also holds for the adoption dummies. Adopting households did not show higher milk yields just because they had adopted ICGV91114.

Table 20: Production function estimation for average milk yield

| Dep. variable: ln_MilkYield | coefficient | std. error | p>t | beta |
|---|---|---|---|---|
| ln_FodderPurchasedTlu | 0.12 | 0.06 | 0.04 | 0.15 |
| ln_ConcentratePurchasedTlu | -0.06 | 0.06 | 0.29 | -0.07 |
| ln_MilkMarketingPct | 0.15 | 0.03 | 0.00 | 0.41 |
| ln_BuffPct | 0.00 | 0.02 | 0.95 | 0.00 |
| ln_ImprBreedPct | 0.09 | 0.03 | 0.00 | 0.26 |
| SexHead | -0.66 | 0.43 | 0.13 | -0.10 |
| ln_AgeHead | 0.04 | 0.18 | 0.84 | 0.01 |
| ln_EducationYrsHead | -0.01 | 0.05 | 0.91 | -0.01 |
| ln_FoodExpCost | 0.13 | 0.14 | 0.34 | 0.07 |
| ln_LandCultivated | -0.09 | 0.07 | 0.18 | -0.10 |
| ln_LandCultivatedIrrigPct | -0.02 | 0.03 | 0.46 | -0.05 |
| adopdummy2 (non-adop, adop hmlt) | 0.04 | 0.12 | 0.72 | 0.03 |
| adopdummy3 (non-adop, non-adop hmlt) | -0.08 | 0.13 | 0.52 | -0.06 |
| Constant | 0.09 | 0.97 | 0.93 | . |

n=175; Prob > F = 0.000; Adj R-squared= 0.2834

## 6. Discussion

As indicated earlier, the number of adopters found in the hamlets selected by stratified random sampling was far lower than expected. Although there had been reports that drought had limited the expansion of ICGV91114 in recent years it was nevertheless assumed that the area planted with the new variety was growing considerably. On the other hand, preliminary discussions with state seed suppliers had indicated that not all institutions shared the enthusiastic view of those involved in ICGV91114's development. In order to assess future prospects of ICGV91114 it is therefore important to assess who these few adopters are.

While the household characteristics indicate that adopters generally have more resources and higher capacity than ground-nut growers in general, this doesn't necessarily imply that the variety is more appropriate for better-resourced farmers. It was also reported by AF that larger farmers were specifically targeted initially to increase seed multiplication.

Another characteristic of adopting households was the higher share of links to AF amongst them (45%), indicating the continued importance of this NGO in regard to promoting ICGV91114. Nevertheless, for the majority of current adopters AF was neither directly instrumental in their variety decision nor was the NGO the main source of their groundnut seed. Rather, they relied on other farmers and their own seed. It is interesting to note that while nearly three quarters of farmers in the household survey received their TMV2 seed from government institutions, this applied to only just over half of the farmers growing K6, the new government variety. Nevertheless, this variety showed similar number of adopters in the household survey, without having been considered in the selection process. It appears that farmer-to-farmer seed distribution is not only important for varieties developed outside the government system.

In regard to the effects of cultivating ICGV91114, the results of the surveys conducted within this study confirm previous results that ICGV91114 will deliver benefits to those households who adopt it. The groundnut production function indicates a considerable yield benefit of ICGV91114 compared to TMV2 and JL24, while the difference to K6 is not significant. The regression takes into account the differences in household characteristics which were not considered during the matching procedure. These show that smaller farms amongst the sample are more successful in regard to productivity which corresponds to the greater share of ICGV91114 amongst smaller farmers. Unsurprisingly, the access to irrigation has a strong influence. Nevertheless, the adoption-group dummy variables are non-significant, confirming the efficiency of the matching process. Although market-related effects were not a focus of this study price differences will also determine the variety's success. It should be further investigated what the recorded price differences signify.

In regard to effects on milk yield, direct farmer experiments showed significant yield effects of feeding ICGV91114 haulms compared to TMV2 while feeding the rabi crop (Ravichandran, 2011). However, in the survey-based production function "variety" could not be included as a determinant because haulms are generally not separated by variety during storage or feeding. As adopters were growing ICGV91114 on only less than half of their groundnut area, the improvements in overall haulm quality were not sufficient to show a significant effect in adopting households. This result should also be viewed in the context of current intensification of milk production in Anantapur. Regular formal milk marketing, a considerable driver of intensification, has only recently become widely accessible to farmers in the area. The initial responses to these changes are generally an increase in cross-bred or improved animals and investment in feeds. Similarly, increasing mechanisation is reducing the demand for draft animals and therefore also an important reason for keeping local cattle breeds. Accordingly, the share of milk being sold, the share of improved breeds and feed purchases (though not concentrates) contribute the most to the wide variation in milk yield amongst the milk producing households within the sample. In order to investigate feed quality effects in greater detail through statistical methods, a sample would have to specifically consider these factors. Nevertheless, the benefits indicated by the farmer trials are still valid. They highlight the opportunity offered by improving feed quality through crop breeding approaches. It has to be pointed out though that only about half of non-adopting were producing milk compared to over three quarters amongst the adopters. It should be studied in more detail if the higher importance of milk production and sale within adopting households has contributed to their adoption of ICGV91114.

The extent to which the increases in asset indices can be attributed to ICGV91114 should be investigated further. On the one hand three years is not a very long time to measure such changes. In fact, most adopters have only started growing ICGV91114 within the past year. On the other hand, greater capacity for change amongst adopting households (education, irrigation, institutional linkages etc.) may have also contributed to increases in asset levels.

However, returning to the question of low adoption: Do these results mean that ICGV91114 has failed or is the dissemination process only taking longer than expected? Although the limitations of the study do not allow for a conclusive answer, several arguments can be brought forward. The future of ICGV91114 would look questionable if farmers were only growing seed distributed by AF. As a local NGO, AF cannot be expected to have sufficient resources to produce and disseminate seed to the vast number of groundnut growers in Anantapur district. And while nearly half of the adopters in the household survey had links to AF, only a fifth had actually received their seed from the NGO. Farmer to farmer dissemination was the major seed source, which could be seen as a sustainable route. Nevertheless, the strong government support for varieties developed by state institutions does indicate a challenge. Where a government seed supply system is subsidised and well established, the costs of setting up an alternative farmer-based seed system seem difficult to justify; especially if the government system can supply comparable varieties, which appears to be the case with K6. However, seed costs did not contribute to groundnut productivity. Therefore, the impact of the subsidies might be overstated. Also, the cumulative additional benefits from greater drought tolerance as well as feed quantity and quality could be especially attractive to farmers with the intent of intensifying their overall farming operations, rather than relying on government supported crop insurance schemes to maintain a minimum income.

Yet such complex benefits might be difficult to communicate to farmers (Lybbert and Bell), especially with current seed distribution systems which don't emphasise farmer choices. How could this be improved? Government institutions appear to be changing and offering more choices, but they are still slow in taking up and promoting varieties from outside the state system. Meanwhile a strengthening of farmer to farmer seed distribution is perhaps the more efficient approach. Producer groups as well as market actors would offer potential entry points for supporting variety decisions in favour of ICGV91114. In the meantime, a continuing monitoring of variety adoption would considerably improve the efficiency of such activities.

## 7. References

Ashby J. 2003. Introduction: Uniting Science and Participation in the Process of Innovation- Research for Development." In Managing natural Resources for Sustainable Livelihoods, Uniting Science and Participation, Pound B, S. Snapp, C. McDougall and A. Braun (eds). London: Earthscan

Bantilan, M, Deb, U and Nigam, S (2003) 'Impacts of genetic improvement in groundnut', in R. Evenson and D. Gollin (eds.) *Crop Variety Improvement and its Effect on Productivity*, Wallingford, UK: CABI.

Biggs S; Smith S, 2003. Paradox of learning in project cycle management and the role of organizational culture. *World Development* 31 (10): 1743–1757.

Blummel, M., Vellaikumar, S., Devulapalli, R., Nigam, S.N., Upadhyaya, H.D. and Khan, A. 2005b. Preliminary observations on livestock productivity in sheep fed exclusively on haulms from eleven cultivars of groundnut. *International Arachis Newsletter.* Vol. 25:54 –57.

Birthal PS, Nigam SN, Narayanan AV and Kareem KA. 2011. An Economic Assessment of the Potential Benefits of Breeding for Drought Tolerance in Crops: A Case of Groundnut in India. Research Bulletin no. 25. Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics. ISBN 978-92-9066-539-7. pp.

Dalton, T, N Lilja, N Johnson, R Howeler, 2011, Farmer Participatory Research and Soil Conservation in Southeast Asian Cassava Systems, *World Development* Vol. 39, No. 12

Deb, U, Bantilan, M, and Nigam, S (2005) 'Impacts of improved groundnut varieties in India', in P. Joshi, S. Pal, P. Birthal and M. Bantilan (eds) *Impact of Agricultural Research: Post-Green Revolution Evidence from India,* Delhi: NCAP.

De Luca,G., Squicciarini,M., Swinnen,J.F.M., Vandeplas,A., (2010), Trade, Agricultural Policies and Structural Changes in India's Agrifood System; Implications for National and Global Markets; D5.3 Company-level database (based on company survey) and a descriptive report on the results. TAPSIM No. KBBE-212617, LICOS, KU Leuven, Leuven, Belgium.

de Janvry, A., Dunstan, A., and Sadoulet, E. 2011. Recent Advances in Impact Analysis Methods for Ex-post Impact Assessments of Agricultural Technology: Options for the CGIAR. Report prepared for the workshop: Increasing the rigor of ex-post impact assessment of agricultural research: A discussion on estimating treatment effects, organized by the CGIAR Standing Panel on Impact Assessment (SPIA), 2 October, 2010, Berkeley, California, USA. Independent Science and Partnership Council Secretariat:
Rome, Italy.

Erenstein, O, Samaddar, A. Teufel, N and M Blummel, 2011, The paradox of limited maize stover use in India's smallholder crop-livestock systems, *Experimental Agriculture*, 47(4):677-704

Evenson, RE and D. Gollin (eds), 2003, *Crop Variety Improvement and its Effects on Productivity: The Impact of International Agricultural Research*, Wallingford, Oxon., UK: CAB International

Garcia,O.; Saha,A.; Mahmood,K.; Ndambi,A.; Hemme,T. (2006), Dairy Development Programs in Andhra Pradesh, India: Impacts and Risks for Small-scale Dairy Farms. PPLPI Working Papers, No. 38, FAO, Rome, Italy.

Gollin, D. 2006. *Impacts of International Research on Intertemporal Yield Stability in Wheat and Maize: An Economic Assessment.* Mexico, D.F.: CIMMYT.

Joshi KD ; Witcombe JR , 2003. The impact of participatory plant breeding (PPB ) on landrace diversity: A case study for high-altitude rice in Nepal . *Euphytica* 134(1): 117– 125.

KASSIE, M, B. SHIFERAW and G MURICHO, 2011, Agricultural Technology, Crop Income, and Poverty Alleviation in Uganda, *World Development* Vol. 39, No. 10, pp. 1784–1795

Kristjanson, P et al, 2005, Farmer's perceptions of benefits and factors affecting the adoption of improved dual-purpose cowpea in the dry savannas of Nigeria, *Agricultural Economics*, 32:195-120

Lilja and John Dixon**,** 2008, Responding to the challenges of impact assessment of participatory research and gender analysis, *Experimental Agriculture, Volume 44* (special issue on PRGA)

Lybbert TJ and Bell A. 2010. Stochastic benefit streams, learning, and technology diffusion: Why drought tolerance is not new Bt. AgBioForum 13(1):13- 24.

Marra, M., Pannell, D.J., & Abadi, G.A.K. (2003). The economics of risk, uncertainty and learning in the adoption of new agricultural technologies: Where are we on the learning curve? *Agricultural Systems*, *75*(2/3), 215-234.

Neumeister, L, 2011, How Does the Groundnut Get to the Farmer?: An interdependent actor-network study of the adoption of a new dual-purpose groundnut cultivar (ICGV 91114) in Anantapur, India. MS Thesis, Universität Passau

Nigam SN, Aruna R, Yadagiri D, Reddy TY, Subramanyam K, Reddy BRR and Kareem KA**.** 2005. Farmer participatory varietal selection in groundnut – A success story in Anantapur, Andhra Pradesh, India. International Arachis Newsletter 25:13-15.

Prasad, et al, 2006, Participatory varietal selection to multiple actor orientation—case study of groundnut in Anantapur, Andhra Pradesh, *Paper Presented at the International Conference on Social Science Perspectives in Agricultural Research and Development, February 15-18, 2006 at New Delhi, India*

Ravichandran, T., 2011, Impact of Adoption of Superior dual purpose Groundnut cultivars in Mixed Crop-Livestock systems on Household resource allocation and output from animal production. University of Hohenheim (-480-), Stuttgart, Germany.

Scoones, I.; Thompson, J. (eds.) 1994: Beyond farmer first: rural people's knowledge, agricultural research and extension practice. Intermediate technology publications, London. 301 p.

Smale M ; Bellon MR ; Manuel Rosas I ; Mendoza J ; Solano AM ; Martinez R; Ramirez A; Berthaud J, 2003. The economic costs and benefits of a participatory project to conserve maize landraces on farms in Oaxaca, Mexico . *Agricultural Economics* 29: 265–275.

Tripp, R, 2011, The Impacts of Food Legume Research in the CGIAR: A Scoping Study, prepared for the CGIAR Standing Panel on Impact Assessment

Walker T., Maredia M., Kelley T., La Rovere R., Templeton D., Thiele G., and Douthwaite B. 2008. Strategic Guidance for *Ex Post* Impact Assessment of Agricultural Research. Report prepared for the Standing Panel on Impact Assessment, CGIAR Science Council. Science Council Secretariat: Rome, Italy.

Wright, I.A., Tarawali, S., Blümmel, M., Gerard, B., Teufel, N. and Herrero, M. 2011. Integrating crops and livestock in subtropical agricultural systems. Journal of the Science of Food and Agriculture http://onlinelibrary.wiley.com/doi/10.1002/jsfa.4556/abstract;jsessionid=2C344113487E850DD0EBD64C2A8F138A.d02t03