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Towards Appraising the Impact of Legume Research

Standing Panel on Impact Assessment (SPIA)
August 2014

CGIAR | Independent Science and Partnership Council

Brief Number 44

Key messages

- Research into the adoption of improved legume varieties provides evidence that farmers are now growing these in many developing countries and regions.
- There has been large-scale adoption of improved chickpea varieties in southern India and small-scale adoption in the Horn of Africa. Specifically, there has been a shift in cultivated area from north to south/central India that is attributed to the availability of improved short-duration chickpea varieties. The share of cultivated chickpea area in two major chickpea-growing states in relation to the total chickpea area in India has increased from 0.99% and 4.70% in 1966–68 to 7.27% and 15.33% in 2008–10 for Andhra Pradesh and Madhya Pradesh, respectively.
- In Africa, more improved bean varieties have been released than any other legume. This is mostly due to the Pan-Africa Bean Research Alliance (PABRA), a highly effective regional research network, of which CGIAR is a key member. To date, more than 3 million farmers are using improved bean varieties in Sub-Saharan Africa (SSA).
- Three-quarters of African cowpea is produced in just two countries in West Africa, Niger and Nigeria, and recent expert opinion surveys indicate that approximately 39% of the 3.8 million hectares (Mha) of cowpea area in Nigeria and 17% of the 5.2 Mha of cowpea are planted with improved varieties.
- Recent surveys have found pockets of adoption of improved pigeonpea varieties in East and Southern Africa, and expert opinion shows that large-scale adoption (more than 65% of total cultivated pigeonpea area) has occurred in four major pigeonpea-growing states of south and central India (Andhra Pradesh, Maharashtra, Tamil Nadu and Madhya Pradesh).
- Despite this evidence, there remain many constraints to farmers adopting new legume varieties, including weak seed systems. Relatively little is known about the poverty, natural resource, nutritional or gender impacts of the adoption of improved legume varieties.

This brief is based on the paper: Pachico, D. 2014. *Towards Appraising the Impact of Legume Research: A Synthesis of Evidence*. ISPC Secretariat, Rome.

Background

CGIAR has invested significantly in research into improved legume varieties over the last four decades. Four of its international agricultural research centers work on the six legumes covered in the report 'Towards appraising the impact of legume research: a synthesis of evidence', which this Brief summarizes. The International Center for Tropical Agriculture (CIAT) works on bean; the International Center for Agricultural Research in the Dry Areas (ICARDA) on lentil; the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) on chickpea, groundnut and pigeonpea; and the International Institute of Tropical Agriculture (IITA) on cowpea. In 2010, this expertise was brought together in the CGIAR Research Program on Grain Legumes.

Despite these investments, the impact of legume research is not as well documented as it is for cereals (Tripp, 2011). Assessing the outcomes of legume research is important to ensure accountability for investors, inform future research activity (Kelley *et al.*, 2008), and measure success towards reaching the CGIAR system-level goals of reducing rural poverty, increasing food security, improving nutrition and health, and managing natural resources more sustainably.

The Legumes Synthesis Report documents the most important cases of farmers adopting new varieties, and the economic, social and environmental impacts of legume technologies developed by CGIAR in collaboration with national agricultural research system (NARS) partners. This was one in a series of *ex post* impact assessments of CGIAR research that examined thematic areas which, up to 2010, had not been properly evaluated but for which anecdotal evidence suggested considerable impact.

Methodology for measuring adoption

The team used several sources of information. These included research based on household-level data, collected to assess factors such as adoption rates, productivity and income information. Gathering data directly from farmers provides accurate estimates of adoption, but these data are comparatively expensive to collect as they tend to cover regions that are broad and difficult to access (Walker *et al.*, 2014).

Due to the high costs of collecting farm survey data, impact assessment practitioners often rely on 'expert panels' – individuals within a country considered knowledgeable about the extent of the adoption of new practices or varietal changes. This method was used for the 'Diffusion and Impact of Improved Varieties in Africa' (DIIVA) study, which provided much of the recent adoption data used in the Legumes Synthesis Report.[1]

The following sections summarize the findings of this analysis of CGIAR legume research outputs, adoption data on legumes in SSA and South Asia, and impacts on CGIAR system-level outcomes (SLOs) as well as gender impacts.

Intensity of research output

The intensity of research output is measured either by the number of releases per research program per year, or by varietal releases per Mha. Table 1 analyzes the release of crops in SSA. Both methods show that the intensity of research output is high for bean and chickpea, but modest for cowpea and groundnut. The results for lentil and pigeonpea vary between the two measurements.

The high number of releases per area planted in bean is partly because the crop is highly adaptable, growing in diverse environments. Consequently, bean research has concentrated on local adaptation, supported in SSA by PABRA. In contrast, cowpea and groundnut tend to be grown in relatively more homogeneous zones which could, in part, explain the fewer new varieties being released. Lentil is grown in a relatively small area in SSA, which translates into a

1. The DIIVA study attempted to validate estimates from these expert panels with the results of some selected nationally representative household surveys. While expert opinion data appears to yield higher adoption estimates than household survey data, when carefully done it can generate results that are fairly consistent with surveys. (See Walker *et al.*, 2014).

Table 1. Intensity of legume varietal releases in SSA and CGIAR share

	Output intensity (no. of releases/Mha)	Releases per year per country (1999–2011)	% CGIAR share*
Bean	100	1.4	39
Chickpea	108	1.0	96
Cowpea	17	0.5	58
Groundnut	22	0.4	44
Lentil	158	0.3	87
Pigeonpea	46	0.4	82

* This refers to the number of improved varieties released that can be attributed to CGIAR research or released CGIAR-improved varieties.

relatively high output intensity, even though the number of releases is low in absolute terms (on a per-year, per-country basis).

CGIAR's major contributions to new legume varieties in SSA over the period 1999–2011 were in chickpea (96%), lentil (87%) and pigeonpea (82%). These are newer to SSA and still less important crops compared to bean, cowpea or groundnut, so NARS might be less inclined to invest scarce resources into research for the former crops, relying instead on CGIAR research activities. Also, bean, cowpea and groundnut are grown on much larger areas, so there is more national attention on improving them and NARS use a wider range of germplasm providers than just the CGIAR Centers.

Evidence of adoption

The research identified several findings about the adoption of new varieties of the six different legumes.

- Recent surveys show that improved **chickpea** varieties have been adopted across large swathes of India, the world's largest producer (Chand *et al.*, 2013; FAO and ICRISAT, 2013). The introduction of early maturing short-duration chickpea varieties has led to a fivefold increase in the area sown with chickpea in central and south India during the last 15 years, consequently reducing the areas of alternative crops including sorghum, millet, sunflower, groundnut, cotton and tobacco.
- There has been a recent upsurge in the uptake of improved **groundnut** varieties in Africa, but this has been in East Africa rather than the traditionally high-producing countries of West Africa. In countries where adoption has occurred, nearly two-thirds of reported adoption is for varieties released before 1990 (Ndjeunga *et al.*, 2012).
- More improved varieties of **bean** have been released in Africa than for any other legume. This strong research output is mostly due to the highly effective PABRA (Buruchara *et al.*, 2011; Walker *et al.*, 2014). However, generally none of these have been the 'mega-varieties' seen for rice and wheat in Asia or chickpea in India, because beans offer niche roles in many cropping systems. Earlier studies had already documented the widespread adoption of improved bean varieties in Latin America.
- More new varieties of **cowpea** were produced during the 1980s in Africa than for any other grain legume, but recently there has been a downturn in this output. The area planted with improved cowpea varieties is still estimated to exceed 3 Mha – a far greater area than for any other grain legume – and two-thirds are varieties produced in collaboration with CGIAR. Over three-quarters of African cowpea is produced in just two countries, Niger and Nigeria (Walker *et al.*, 2014).

- Improved **pigeonpea** varieties in Kenya, Malawi and Tanzania cover over 180,000 ha – roughly half of the regional area planted to the crop (Walker *et al.*, 2014). In 2005, a random sample of 240 farmers in two districts of Kenya found that 55% were growing improved varieties on 51% of the total area planted with pigeonpea (Shiferaw *et al.*, 2007). Exports to India have partly propelled this rapid growth.
- **Lentil** output in Ethiopia increased by 15% annually in 1994–2008 (IFPRI, 2010), with 28% of production going to market. New varieties include disease-resistant ones, which can be planted earlier using residual moisture from the main season cereal crop, leading to less moisture stress and greater yields (Aw-Hassan *et al.*, 2009).

Other than for improved varieties, there has been little research on the adoption of improved legume technologies. With respect to the former, the current body of literature suggests that there is great diversity in their suitability and uptake in different parts of the world.

As well as analyzing the rates of adoption, the Synthesis Report examines factors influencing high and low adoption rates. One of the most commonly cited reasons for low adoption (or dis-adoption) was the lack of available seed (Tripp, 2011). The widespread availability of improved seed can accelerate adoption in the early stages, while scarce or unavailable seed will choke the process. Consequently, there have been efforts to enhance seed systems. Comparisons of 'adopters' and 'non-adopters' must also consider the differences between these groups, for example, an individual farmer's ability or the soil quality. It is also worth noting that the population of adopters grows throughout the diffusion process (de Janvry *et al.*, 2010).

Impacts on productivity and profitability

Adopting improved varieties typically increases yields by 25 to 60%. Many of the examples used in the Legumes Synthesis Report were within this range. For example, a survey of 529 farmers in Uganda showed that the typical yield of local bush bean varieties is about 600 kg/ha, compared to 960 kg/ha for the improved varieties (Kalyebara, 2008). The range is large, but this is partly because differences in yields for new varieties are not always reported. Yield gains below 25% may be of marginal interest to farmers (thus not reported in a survey), while yield increases above 50% are probably unobtainable without other changes to the farming system.

However, estimating changes in productivity and profitability resulting directly from the adoption of an improved variety or new practice is difficult. One complication is the terminology and methodology used. For example, varieties developed decades ago can be considered 'modern' if they are the products of formal research; at the same time, some studies use more recent cutoff dates to qualify improved varieties. These inconsistencies make comparisons challenging. This means that the difference in profitability or yields between improved and 'local' varieties changes over time.

Impacts on poverty

An important issue for CGIAR is whether improved varieties reach poor farm households – this is reflected in the SLO1 (reducing rural poverty). But findings regarding the impacts of improved legume varieties on poverty are inconsistent. Some studies observe that poor farmers have as high (or higher) adoption rates as wealthier farmers, while in other cases adoption is skewed towards wealthier farmers (Ndjeunga *et al.*, 2008; Katungi *et al.*, 2011a; Larochelle *et al.*, 2013; Simtowe *et al.*, 2010). In interpreting these findings, however, it is important to recall that in low-income communities, wealthier farmers (who often cultivate no more than half a hectare per capita) are themselves poor by most standards, and the findings of technology bias in favor of 'the wealthy' may not be very meaningful.

Furthermore, legumes often occupy different proportions of cultivated land on poor farms compared to better-off farms. As a result, they have differential effects on farm productivity and profitability. For example, a study of groundnuts in Nigeria showed that wealthier households received substantially more benefits per ha from improved groundnut varieties, perhaps because they used more fertilizer (Ndjeunga *et al.*, 2008).

Many of the legumes studied are grown as cash crops, for example, groundnut in parts of West Africa although poverty rates remain high there (Ndjeunga *et al.*, 2008). Since many poor people depend more on selling their labor than on the productivity of their tiny landholdings, the adoption of improved varieties may have limited income and hence poverty-reducing effects.

Impacts on food security and nutrition

Although it seems logical that new legume varieties should improve food security and nutrition, evidence of these impacts is scarce. A recent study found that improved bean varieties in Uganda had a much greater impact on food security than they did on poverty (Larochelle *et al.*, 2013). This is a rare result, however, and to date there is almost no evidence of the impact of legume research on health. Addressing this knowledge gap would require an assessment of evidence from studies on SLOs 2 and 3 (food security, nutrition, and health).

Impacts on the sustainable management of natural resources

Legumes play a unique role in the sustainable management of natural resources. For example, they fix nitrogen and there is a lot of evidence that they increase the yields of subsequent crops in rotation systems. However, it is not clear whether new varieties play a more significant role in nitrogen fixation than traditional varieties. Where improved legume varieties displace non-leguminous crops, as in the case of chickpeas in central/south India, it is more likely that there is a significant effect from adoption of the improved varieties on the soil, but this has not yet been studied. While soil fertility is often seen as a benefit of legumes, there may be other potential benefits from new varieties such as 'climate-smart' varieties able to cope with climate change.

Impacts on gender

Evidence on the gender-related impacts of improved legume varieties is fragmented, but shows that the relationship between gender and adoption decisions are highly variable, depending on the role of women in agriculture. For example, women may be more likely to benefit from new legume varieties when they are the household heads and can manage farm decisions and income. The frequency of female-headed households ranges widely: less than 1% of groundnut-growing households are female-headed in Nigeria, but in Mali the figure is 45.5% (Ndjeunga *et al.*, 2008). Of course, even in male-headed households women sometimes manage legume crops.

Almost no previous studies directly assess how improved legume varieties affect women's welfare, but many are now taking steps to address gender-differentiated outcomes. There is a need for new in-depth case studies to address this knowledge gap.

Future research

The Legume Synthesis Report presents a large body of household-based and expert opinion survey data showing the substantial adoption of improved legume varieties in different regions of the world. It can be argued that such considerable evidence of adoption is a strong (indirect) indicator of the benefits of improved varieties to farmers, but further research is necessary to understand theories of change and the extent to which the adoption of improved varieties facilitates the achievement of the CGIAR SLOs.

Further adoption studies are needed where expert opinion indicates there is significant adoption but detailed studies are lacking, such as cowpea in West Africa or pigeonpea in India. Future research into the development impacts of improved varieties is also needed, for example, to better understand the constraints to adoption and to examine whether resource-poor farmers or women or subsistence farmers are adopting with the same degree of success as others.

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