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Advances in Agriculture, Food Science and Forestry

Vol.9(3),pp.05-18,July,2021

Alleviating fertilize use farmers perception constraints to increase fertilizer use and increase crop yield

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ABSTRACT

To feed the human population adding fertilizers to crops is needed to producing enough food. Provide fertilizers for crops with nutrients like potassium, phosphorus, and nitrogen, which allow crops to grow bigger, faster, and to produce more food. To grow, plants require nitrogen compounds from the soil, which can be produced naturally or be provided by fertilizers. Agriculture is the backbone of the Ethiopian economy, and the agricultural sector is dominated by smallholder farming systems. The farming systems are facing constraints such as small land size, lack of resources, and increasing degradation of soil quality that hamper sustainable crop production and food security. This review overview the constraints of Farmer's access to fertilizer, fertilizer marketing systems, and suggest modification of existing fertilizer policies to mitigate the constraints. Adoption of integrated soil fertility management, practices by smallholder farmers is often limited, mainly due to shortage of cropland, lack of adequate knowledge about appropriate fertilizer use, land tenure issues, slow return on investments, and insufficient policy and implementation schemes. The events should include the utilization of degraded and marginal lands, improvement of the soil organic matter management, provision of capacity-building opportunities and financial support, as well as the development of specific policies for smallholder farming to increase fertilizer use and to increase crop yields.

Keywords: Farmer knowledge, Adoption, Fertilizer, Soil management.

INTRODUCTION

In Ethiopia enhancing agricultural productivity is one of the central challenges to achieving food security and poverty reduction. As the fact that soil fertility is one of the biggest challenges, an obvious strategy is to increase fertilizer application and promote good agronomic practices to enhance productivity. As a result, national annual fertilizer use grew from 3,500 t to about 140,000 t by the early 1990s, and reached about 200,000, 400,000, 550,000 t in 1994, 2005, and 2010, respectively. According to (Tefera et al., 2012) investigation the total amount of fertilizer available for application will exceed one million tons in the 2012/13 cropping year.

All around the world fertilizers are applied to keep lawns green and to produce more crops in agricultural fields. Any substance or substantial added to soil that promotes plant growth is called fertilizer. Here are many fertilizer varieties, and most contain phosphorus (P), nitrogen (N), and potassium (K). Now the fact, fertilizers sold in stores have an N-P-K ratio on their packaging. Three groups of fertilizers are: Organic fertilizers (manure and compost) are made from animal feces, and plant or animal decomposed matter, Mineral fertilizers (phosphorus and

potash) are mined from the environment and crushed or chemically treated before being applied, And Produced industrially by humans through chemical reactions which is Industrial fertilizers (ammonium phosphate, urea, ammonium nitrate). Despite the fact organic and mineral fertilizers have been used to increase crop yields in agriculture for a long time, industrial fertilizers are a relatively new development. Even if industrial fertilizers are the most widely used fertilizers today (Aczel, 2019, Andrew et al., 2020)

In all region of the world, the intensification of crop-based agriculture has been associated with a sharp increase in the use of chemical fertilizer. In general fertilizer use in Africa is low levels, there can be little doubt that fertilizer use must increase in Africa if the region is to meet its agricultural growth targets, poverty reduction goals, and environmental sustainability objectives. For this reason, policies and programs are needed to encourage fertilizer use in ways that are technically efficient, economically rational, and market-friendly. At the same time, it is important to recognize that fertilizer is not a panacea for all of the problems that afflict African agriculture and that promoting fertilizer in isolation from other needed actions will have little lasting impact. Several fertilizer promotion schemes implemented in Africa have succeeded in for the moment cumulative use of fertilizer, but then only in ways that have fortified use of fertilizer at non optimal levels, compulsory heavy administrative and economic burdens on governments
and damaged the development of viable profitable fertilizer markets.

Extension workers, policy makers, and Scientists concerned with land management strategies in agricultural areas can benefit from understanding the local knowledge and perceptions of agricultural resource managers. The aforementioned of particular interest to know whether Farmer's perceptions of resource conditions and the returns to proposed responses to resource deficiencies diverge from those suggested by scientific measurements and, if so, by how much and why. This is an important issue given the degradation of farmlands and very low levels of fertilizer use in Sub-Saharan Africa (SSA). For example, at application rates of 9 kg per hectare of fertilizer-derived nutrients, compared to 73 in Latin America and 100-135 in Asia, fertilizer use in SSA lags far behind the rest of the world (IFDC, 2006). Though, recent studies repeatedly show that fertilizer can be remunerative crossways a broad range of agro-ecological and socioeconomic conditions, especially when fertilizer use is go together with organic inputs.

In SSA why then many farmers are not using soil nutrient improvements at all or at least not anywhere near recommended levels (IFDC, 2006)? A number of forthcoming clarifications exist. First, Farmer's liquidness constraints and perhaps low expected returns to fertilizer use on some plots may discourage farmers from buying and applying fertilizer when it is available. Second traders' liquidity constraints and thin fertilizer markets and poor infrastructure often make fertilizer trade unprofitable, leading to limited supplies available on rural African markets. Third, farmers might not perceive soil fertility status nor the returns to fertilizer use the way agricultural scientists do, leading to what outsiders interpret as under application that may be appropriate to Farmer's perceptions. For a variety of reasons-e.g., low levels of education, poor access to and quality of agricultural extension services, etc.-farmers may misperceive soil conditions and yield responses from fertilizer inputs. Especially, if farmers underestimate one or both, they may fail to In SSA why then many farmers are not using soil nutrient improvements at all or at least not anywhere near recommended levels (IFDC, 2006)? A number of forthcoming clarifications exist. First, Farmer's liquidness constraints and perhaps low expected returns to fertilizer use on some plots may discourage farmers from buying and applying fertilizer when it is available. Second traders' liquidity constraints and thin fertilizer markets and poor infrastructure often make fertilizer trade unprofitable, leading to limited supplies available on rural African markets. Third, farmers might not perceive soil fertility status nor the returns to fertilizer use the way agricultural scientists do, leading to what outsiders interpret as under application that may be appropriate to Farmer's perceptions. For a variety of reasons-e.g., low levels of education, poor access to and quality of agricultural extension services replenish. The percentage of smallholder households using fertilizer in Africa is often below 10% (FAO 2004; Tegemeo Institute 2006), corresponding to the wealthier families in the community, and fertilizers applications do follow specific recommendations (Ibid. also see Manyong et al. 2001).

ALLEVIATING FERTILIZER USE FARMER'S PERCEPTION CONSTRAINTS TO INCREASE FERTILIZER USE AND INCREASE CROP YIELD

Farmer's perceptions of soil fertility and fertilizer yield response: Farmer's perceptions of soil fertility on their plots are strongly associated with observed yields. Crop yields are widely accepted as important indicator of soil fertility. Therefore Farmer's reliance on yields as the main indicator of soil fertility is consistent with current soil science paradigms which use yield as one the best proxies for soil fertility (Holden, 2007). Farmer's behavior necessarily follows from their perceptions of the state of their resource base and the likely response of crops to different interventions, including soil nutrient supplementation through fertilizer application. If scientists and policymakers are concerned about insufficient fertilizer application by smallholder farmers in sub Saharan Africa, it becomes important to ascertain whether farmer misperception of soil conditions, yield response to fertilizer, or both, might play a role addressable through targeted extension and other interventions (Paswel et al., 2020).

Judging from the significance of some household and plot specific variables in explaining the relationship between estimated returns and Farmer's perceptions of these returns, the results imply that while the two measures generally track each other, there remain some systematic patterns of deviations between statistical estimates and Farmer's perceptions of returns to fertilizer. We therefore conclude that farmer' perceptions of the current state of their soils and the expected returns to increased fertilizer use track laboratory and statistical estimates albeit with some systematic deviations. However, the role of errors of perceptions in discouraging fertilizer use appears small at best (Paswel et al., 2020).

The most significant implication is that the use of yields as a key indicator of soil fertility may introduce delays in perceiving these changes. Because farmers use yields as the key soil fertility indicator, they may be unable to perceive small but important soil fertility changes over time. This is especially true if yield changes lag behind that of soil fertility (especially considering factors such as soil organic matter), in which case they may delay in initiating soil fertility remedies. Such delays can lead to significant deterioration in soil quality, making it more costly to regenerate. By the time they perceive a permanent yield decline, with underlying soil fertility deterioration; they correctly begin to perceive the use of fertilizer as unprofitable. By relying on a slow indicator of soil fertility (yields), farmers may miss the best time for intervention (e.g. increased organic matter incorporation and fertilizer application) assuming of course that household liquidity and market supply constraints are not binding (Paswel et al. 2020).

Low fertilizer use is a problem in Africa: Low fertilizer use is one of the factors explaining lagging agricultural productivity growth in Africa. In 2002, the most recent year for which data are available, the average intensity of fertilizer use in Sub-Saharan Africa was only 8 kilograms per hectare of cultivated land, much lower than in other developing regions.
Africa's land degradation problems can be attributed to many causes, but analysts generally agree that a fundamental contributing factor has been the failure by most farmers to intensify agricultural production in a manner that maintains soil fertility. The inherent lack of fertility, along with widespread soil nutrient mining, has led to expansion of the agricultural frontier in Africa and the opening up of less favorable soils for cultivation. This is a scenario for disaster over the long run, given the difficulty of restoring tropical soils to productive capacity. In many tropical soils, the restoration of organic matter-a key component in soil fertility-is a very long-term proposal, and in lateritic soils such as those found throughout large parts of Africa, restoration may even be impossible. So without nutrient replenishment, many African farmers risk taking their soil resource base beyond a point of no return (Srijna, et al.,2020)

Past efforts to promote fertilizer in Africa: In considering future strategies for increasing fertilizer use in Africa, policy makers and the development agencies with whom they partner would be well advised to heed the lessons of the past. Efforts to promote fertilizer use in Africa have a long and varied history, and there is much to be learned from what has already been done. During the 1970s and early 1980s, fertilizer programs in Africa were often characterized by large, direct government expenditures using various entry points to stimulate fertilizer demand and ensure supply. Interventions frequently included, direct subsidies that reduced fertilizer prices paid by farmers, government-financed and managed input credit programs, centralized control of fertilizer procurement and distribution activities, and centralized control of key output markets (with the goal of stabilizing prices and linking input and output markets to ensure smoother credit management).

Factors of low fertilizer use in Africa: Many initiatives have been launched in Africa to

remove fertilizer market distortions and harness the power of the private sector to procure fertilizer and deliver it to farmers, yet use of fertilizer continues to grow very slowly in most African countries. Because evidence reviewed in this report suggests that the low use of fertilizer in Africa can be explained by demand-side as well as supply-side factors. Demand for fertilizer is often weak in Africa because incentives to use fertilizer are undermined by the low level and high variability of crop yields on the one hand and the high level of fertilizer prices relative to crop prices on the other.

Essential for an Integrated Approach to Promoting Fertilizer Despite the many initiatives that have been launched to liberalize and privatize fertilizer markets in Africa, little progress has been made toward developing the type of enabling environment that is needed for a smooth and rapid transition from state-run to private sector-led marketing systems. So a key lesson that emerges from past efforts to promote increased fertilizer use in Africa is that there is a need for much clearer thinking about how fertilizer policy fits into a country's overall development strategy. In recent years, expectations have increased regarding the role that fertilizer can play in the economic development process. Once viewed mainly as a productivity-enhancing input for agriculture, today fertilizer is seen by many policy makers and even some development partners as a tool that can be used to achieve a range of broad development goals, including stimulating rapid economic growth, alleviating poverty, and protecting the rural poor in times of crisis. Some of these expectations are frankly unrealistic. Increased use of fertilizer can contribute to a range of objectives, including (in some cases) welfare objectives, but the size and the sustainability of the contribution that fertilizer can make will be limited, especially if underlying structural problems in the economy remain unaddressed. Additional fundamentally, public interventions can involve not only direct budgetary payments designed to influence fertilizer prices in the short run, but also a wide range of other measures that improve the profitability of fertilizer over the medium to long run by directly or indirectly influencing market prices, costs incurred, or benefits received by consumers and producers of fertilizer. If lasting solutions are to be found to redress Africa's fertilizer crisis, policy makers and development partners must work to identify and implement interventions aimed at addressing the underlying structural problems that undermine incentives for farmers to use fertilizer and for firms to supply fertilizer. Public interventions that can be used to strengthen demand for fertilizer include, strengthening agricultural research and extension (for example, by increasing support to organizations that conduct crop management research and by sponsoring on-farm fertilizer trials and demonstrations), improving Farmer's ability to purchase fertilizer (for example, by improving their access to credit or by introducing cost-sharing mechanisms such as matching grants), providing farmers with financial tools to better manage risk (for example, by introducing innovative insurance instruments tailored to the needs of farmers-such as weather-indexed crop insurance), improving market information (for example, by increasing investment in market information systems and building capacity in the private sector to manage such systems on a commercial basis), protecting farmers against low and volatile output prices (for example, by investing in measures to reduce production variability-such as irrigation, research on drought-tolerant crops, and grain storage systems), empowering farmers by supporting producer organizations (for example, by increasing investment in rural education and by offering farmers training in organizational management skills),and improving the agricultural resource base so that use of fertilizer can be more profitable (for example, by investing in soil and water conservation measures and irrigation infrastructure).

USE OF FERTILIZER IN ETHIOPIA

The Policy Evolution: As of the early days of field level demonstration to the collapse of central planning in 1991, fertilizer markets in Ethiopia have been controlled by the government through its input marketing agency, called Agricultural Input Supplies Corporation, later renamed as Agricultural Input Supplies Enterprise in 1992. This agency had its own marketing network throughout the country, which included marketing centers and service cooperatives for distributing fertilizers to the farmers. As in many other African countries, Agricultural Input Supplies Corporation's controlled marketing was inefficient, involved large direct subsidies, and incurred large administrative costs. In the new marketing system introduced in 1992, the transitional government articulated its desire to end government monopoly as part of its overall market liberalization policies.

One of the earlier studies (Demeke et al., 1998) provides some specific examples of how holding companies received support from the government. The study reported that in

Amhara, the regional holding company Ambassel enjoyed larger market shares due to policy privileges of being the sole agent of AISE, because farmers who received fertilizer credits from the government were not allowed to purchase from private companies. However, several arguments counter this position. For instance, it was widely known that the fertilizer market in Ethiopia is thin and opportunity costs of private-sector capital in this market can be high; so the private sector might find it more profitable to invest elsewhere in the rapidly expanding economy than in the perilous fertilizer market (Rashid and Ayele, 2009).

Fertilizer Use Patterns: Cooperatives have been involved in input marketing in Ethiopia since the 1970s, but they were never involved in imports until recently. In the new millennium the government adopted a strategy to develop an input marketing system with strong participation of Farmer's organizations. The initiative was welcomed because it was also one of the policy prescriptions emerging from the development partners for addressing the problems of thin markets and product aggregation problems.6 This was an aggressive strategy, and the cooperatives' market share grew rapidly, reaching almost 75 percent of the total fertilizer use in 2007/2008 (Figure 1). This rapid growth was promoted by providing subsidized credits to the cooperative unions to import and distribute fertilizer. However, the policy faced problems due to the rising cost of fertilizer and a balance of payment problems during 2007/2008. The government requested financial support from its development partners for and managed to receive $250 million from the World Bank and another fund worth 100,000 tons of fertilizer from the African Development Bank. Through some negotiations, the government and the two banks agreed to coordinate all fertilizer imports through AISE. This policy decision resulted in withdrawal of all holding companies except Wondo from fertilizer markets in Ethiopia (World Bank, 2009).

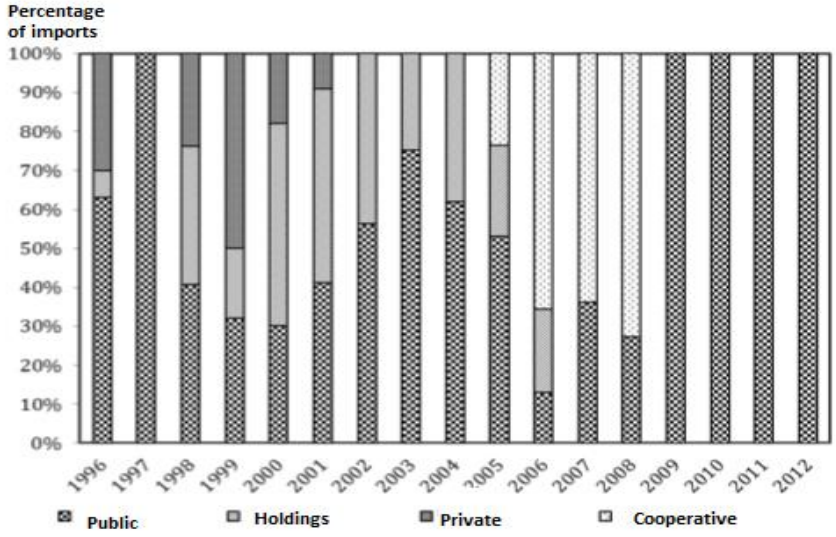

Figure 1. Distribution of fertilizer imports by importer types, 1995-2012.

In Ethiopia Chemical fertilizer is primarily used in cereal production. Rendering to Ministry of Agriculture and Rural Development (MoARD) statistics, cereals account for 90 percent of the country's total chemical fertilizer application; and during 2005/2006-2010/2011, only two regions, Oromia and Amhara, accounted for 70 percent of total use, with Oromia alone accounting for about 40 percent. The shares of the other two major cereal-growing regions the Southern Nations, Nationalities, and Peoples' Region (SNNPR) and Tigray-were 10% and 3%, respectively.

IN ETHIOPIA CURRENT STATUS OF SMALLHOLDER FARMING

Agricultural Productivity: About 60% of farmers in Ethiopia cultivate less than 0.90 ha in very fragmented land escapes. However, smallholder farming is responsible for a large proportion of Ethiopian food production. It cultivates more than 90% of the total cropland and provides more than 90%ofagricultural output. Smallholder farmers commonly cultivate cereals such as teff (Eragrostis teff [Zucc.] Trotter), maize (Zea mays), wheat (Triticum aestivum), barley (Hordeum vulgare), and sorghum (Sorghum bicolor).

Crop yields in the smallholder farms are very low compared to their potential capacity and are also substantially lower (less than 50%) than the yields obtained in experimental farms and research stations. The gap is especially remarkable for maize, with an average yield of 2.6 t ha−1 compared with the potential yield of 7.8 t ha-1 obtained in on-farm trials. The low crop yield affects food security, with a large amount of grain needing to be imported. For instance, 30% to 50% of domestically consumed wheat was imported in the past, due to a lack of production inside the country (Gebeyanesh et al. 2021).

The backbone of the Ethiopian economy and it contributes about 50% of the country's gross domestic product (GDP) and more than 80% of its exports are Agricultural products. Furthermore, it is one of the main employment sectors with about 80% of the country's population depending on the agricultural sector for their livelihoods. Smallholder farming dominates the agricultural sector of Ethiopia. Smallholder farms are defined as being smaller than 2 ha and are mainly managed with family labor. About 95% of main crops (e.g., cereals, pulses, oilseeds, vegetables, root crops, fruits, and cash crops) are produced by smallholder farms in Ethiopia. Yet, these farms are facing various constraints that hamper crop productivity. Main constraints include poor soil fertility, severe land degradation, high dependence on rainfall, low availability and poor quality of seeds and fertilizers, economic constraints like low income and lack of financial support, as well as insufficient policies and guidelines. Climate change like severe drought and heavy rainfall also affect the agricultural sector. Smallholder farmers with limited resources have particular difficulties overcoming these obstacles. These problems are exacerbated by the rapid population growth and environmental degradation. Subsequently, appropriate management practices are urgently needed to resolve the constraints and to increase crop production without altering its potential for future generations (Gebeyanesh et al. 2021). The perception of farmers about the fertility of their farmland, status of education, and proportion of steep slope land affected organic fertilizer use negatively whereas access of extension services, availability of composting materials, health status of household head and sex of household head had influenced use of organic fertilizers positively in the Ethiopia. The main instrument in the promotion of organic fertilizer use was the extension services. Therefore, appropriate and adequate extension services have to be provided in line with current agricultural development policies of the country. This could be done by designing appropriate capacity-building program to train additional development agents to reduce the existing higher ratio of farmers to development agents as well as to provide refreshment training for development agents. Forthcoming intervention strategy promotion has to be developed by increasing technologies such as organic fertilizers use. Consequently, expansion of composting materials allows more farmers to use high amount of organic fertilizer to increase production of crop and to raise crop and livestock product (Gedefaw Abebe and Sisay Debebe, 2019).

Characteristics Affecting Farmer's Adoption and Intensity of Fertilizer Use : Economics of fertilizer use, Price policies and credit, Privatization of supply and Infrastructural development, Demand factors, Availability, Supply factors, pricing environment and distribution costs are the major factor affecting fertilizer use. Demand and supply factors are hard to separate when evaluating Farmer's decisions to adopt fertilizer and their subsequent decisions about application rates. For example, many of the key influences discussed in the adoption literature (farm size, access to credit, membership of cooperatives, contact with extension, access to outside information, availability of inputs, distance to markets) may be related at least as much to supply side constraints as to farmer demand (Mwangi, 1995).

Farmers in Ethiopia use low levels of fertilizer. Given that fact and the up-to-date state of knowledge, low-input systems are unlikely to increase food production rapidly, reverse the decline in rural incomes, and slow environmental degradation. Rises in food production must now come primarily from higher yields per unit of land rather than from land expansion. Factually, inorganic fertilizer has been a major component in achieving such increases. Success of applying inorganic fertilizers often varies due to the variations in crop response and the high and variable cost of fertilizer in relation to product prices. Use of fertilizer is strongly affected by various policies, especially those that affect input supply and prices. In numerous areas of SSA, fertilizer adoption has been slowed by the absence of appropriate institutional structures to supply inputs, credit, and information (W. Mwangi, 1996).

The donor community (spearheaded by the World Bank and IMF) is encouraging governments to promote private enterprise and competition with respect to fertilizer

imports and distribution. Therefore, the experience has been mixed. Upcoming strategies should include a greater mix of public and private-sector initiatives involving organizations throughout SSA's fertilizer sector. The title role of each partner especially that of the government will have to be clearly spelled out. National fertilizer policies and plans a part of the overall agricultural development strategy must make by the Governments. Such efforts should produce more predictable policies and more stable institutions so that the private sector can develop the confidence necessary to invest in the fertilizer trade. Sufficient price incentives exist to make fertilizer use profitable for farmers and suppliers should be ensuring by that of policies. Praise, for instance, must be extended not only to farmers but to private traders as well (W. Mwangi, 1996).
Fertilizer subsidies can help to compensate for these cost increasing factors in the short and medium terms. In the long-term, however, SSA must find other ways to make the right type of fertilizer available at the right time, place, and price. Study can help to clarify what fertilizers work best in particular situations. Furthermore, regional cooperation in international fertilizer procurement (Vlek, 1990; Pinstrup-Andersen, 1993) would help offset problems associated with the small volume of fertilizer purchased by countries in SSA, volumes that do not take advantage of scale economies for purchasing and shipment. In SSA Governments consider fertilizer a strategic and politically sensitive commodity, however, and given their experience with regional cooperation, this kind of cooperation may not be feasible (W. Mwangi, 1996).

A major cause of high fertilizer prices is poor rural infrastructure-especially rural/feeder road. Administrations must increase their investments in infrastructure if they are to increase agricultural productivity. Development of infrastructure should be treated as a social cost and charged to a social overhead account in the national budget (Bumb and Baanate, 1995). For fertilizer use to increase over the long term, political commitment to agriculture must be translated into investments that develop institutions and infrastructure. Such support will enable agriculture to play remits crucial role in SSA's overall economic development (W. Mwangi, 1996).

Major challenges we highlight in the current fertilizer value chain is the costs and margins allowance for the primary cooperatives. At this time, about 2.6 million ha, 35 percent of total cultivated land, are allocated to cereals (barley, rice, millet, and so forth), but only about 4 percent of this area is fertilized. In the high-potential regions of Amhara and Oromia, where 1.9 million ha of cultivated land is allocated to these crops is used less fertilizer. Thus crops have received little attention until recently. In Ethiopia the government has been able to attract two large brewing companies from Europe, Heineken and Diageo, to set up brewing plants. This public–private partnership is likely to boost fertilizer use in barley. Initiatives to promote rice, for which irrigated land is expected to triple from 26,000 ha to 78,000 ha by 2014, and increase even more to 775,000 ha by 2019. The establishment of blending facilities is the other initiative that is likely to increase fertilizer use. If successful, this will not only lower costs and increase the returns to fertilizer use but also directly contribute toward soil fertility management (Shahidur et al., 2013).
In Ethiopia use of chemical fertilizer has grown remarkably since the official elimination of subsidies in the 1990s. Such growth has occurred under various policy regimes, but it accelerated under a new set of policies adopted in 2008. This policy reform has two key components of (1) granting monopoly control over fertilizer imports to the Agricultural Input Supplies Corporation, the government's input marketing agency, and (2) carrying out marketing and distribution of fertilizer exclusively through Farmer's fertilizer value chain in Ethiopia is competitive relative to its neighbors.

Due to heavy investments in infrastructure can explain part discounts in transactions costs differences, but it is also possible that some costs elements are not captured by our survey. While the adjustments of all implicit support cannot explain the price differences with its neighbors, these supports add up to significant fiscal costs-estimated to have averaged $40 million per year since 2008. The estimates become much higher if the costs of carry-over stocks are added, which is estimated to be $14 million per year during 2002–2011. It is important to note that the clearly increasing trend since the country embarked on a new policy in 2008; and if only the 2008-2011 periods is considered, the annual average costs of carry-over stocks goes up to $30 million. If the implicit supports and the costs of carry-over stocks are added, the cost of fertilizer promotion policies averaged about $105 million, equivalent to about 15 percent of the retail price. Thus, we can conclude that although Ethiopia does not have a direct subsidy program, fertilizer promotion policies have not been inexpensive organization (Shahidur et al.,2013).

Strengthening understanding and perceptions of mineral fertilizer use among smallholder farmers

To improve their understanding of fertilizers and their use, Farmer's knowledge must be strengthened. Mineral fertilizers must play an important part in improving agricultural productivity in farming systems. Farmers participating were able to differentiate types of fertilizer, and understood rates of application and the roles of respective fertilizers in nutrient supply.

Fertilizer is considered the most important input for the achievement of increased agricultural productivity and food security status of farm households in Ethiopia. Though, fertilizer adoption remains very low, especially among small-scale farmers in the country. Recently in Ethiopia increased fertilizer prices and the concomitant decrease in output prices have been the most important factors associated with use of new agricultural technologies. Share of the increase in fertilizer prices to farmers is the increased transportation cost for the movement of fertilizer from the central market. Due to poor road conditions, running costs for transport operators is very high. The development of rural roads reduces the transaction cost associated with acquisition of farm inputs and sale of farm products. This enables farmers to buy farm inputs at lower prices and sell their produce at competitive prices. More effort in expanding roads in rural areas is therefore needed (B Fufa & RM Hassan, 2006).

VARIABLE FERTILIZER RESPONSES AS AN OBSTACLE AMONG SMALLHOLDERS

Variable responses of crops to mineral fertilizers are often observed on smallholder farms due to their spatial soil variability-a result of the inherent soil land scape variability interacting with past and present soil and crop management (e.g., Buerkert et al., 2001; Tittonell et al., 2005; Vanlauwe et al., 2005). For mineral fertilizers to be used effectively there is need to strengthen Farmer's knowledge about their potential benefits and limitations in the context of smallholder African farms. Unlike crop responses to fertilizers caused by this variability discourage fertilizer use among smallholder farmers. Poor agronomic practices can also be causes variability in the response of crops to fertilizers, e.g. poor seedbed preparation, narrow spacing, limited use of improved genotypes, delay in planting, incorrect fertilizer placement, or weed and pest problems (Tittonell et al., 2007). Countless of these problems result from poor labor availability (e.g., Place et al. 2003). Although different organic sources may be used to manage soil fertility, they are often not available in sufficient amounts to replenish nutrient stocks in already depleted soils. Both negative fertilizer responses with respect to crop produce prices, and lack of cash in hand at planting, contribute to limited adoption of fertilizers (Abdoulaye and Sanders, 2005). However, farmers need to understand that boosting plant nutrient availability does not necessarily require heavy applications of mineral fertilizer (Buresh and Giller, 1998). Indeed, some degree of farmer skepticism concerning recommended rates of application may be well founded (Ibid.). Even if recommended rates were used, if local variability or other circumstances (such as lack of rain, seed quality) are not favorable, commensurate yields for increased application of fertilizer are unlikely (Poulton et al., 2006, p. 15). There is a need to clarify intricacies of fertilizer use among smallholders, such as the causes of variable crop responses, the short and long-term effects of fertilizer use on soil productivity, and the technicalities of fertilizer formulations and application rates.

THE NEED TO STRENGTHEN SMALLHOLDER UNDERSTANDING OF MINERAL FERTILIZERS

Knowledge in selection of farming practices plays an important role in success of smallholder farmers (Bentley, 1989). Knowledge is the most critical element of smallholder farming, more than tools or research inputs such as fertilizer (Netting 1993). Studies on smallholder farming show that "technological inventions and scientific discovery are not the crucial causal factors in the course of agricultural intensification" (Netting 1993, p. 57). It therefore follows that insufficient use of fertilizers must be tackled through strategies that enhance knowledge and counter negative or inaccurate perceptions. Improving Farmer's understanding is an essential element in the development and application of integrated soil fertility management (ISFM) technologies (Deugd et al., 1998). For instance, Bannister and Nair (2003) show the role of knowledge in selection and allocation of trees according to soil fertility levels. For this to be achieved, effective knowledge use strategies must be situated in the respective smallholder context (Fujisaka 1989; Farouque and Tekeya, 2008). Participatory experimentation is an important element in site-specific learning (Defoer et al., 2000).

It is widely recognized that hands-on learning is highly effective for enhancing Farmer's understanding of agricultural technologies (Onduru et al., 2001; De Jager et al., 2004; Ramisch et al., 2006; Hoffmann et al., 2007). It assists smallholders to apply technologies successfully in their specific local conditions (Cf. Jiggins and de Zeeuw, 1992; Ro ¨ling and Van de Fliert 1994; Ro ¨ling and Pretty, 1997). The reality about the critical role of mineral fertilizers described above drove scientists at the Tropical Soil Biology and Fertility Institute of CIAT (TSBF-CIAT) to target improved use of fertilizer among farmers. Central to this goal was collective field experimentation, involving local farmers, to improve their knowledge and fertilizer application practices (Ramisch et al., 2006). These trials were intended to strengthen knowledge by building on Farmer's particular interests, and on their capacity to observe, experiment, and interpret results of fertilizer experiments (cf. Deugd et al., 1998).

Farmer's knowledge was strengthened and perceptions improved, for instance, through the broadened awareness of factors that influenced crop response to mineral fertilizer. The collective fertilizer trials showed why adaptive soil fertility research should not be about reaching a final or universal solution, but rather should serve as a basis. The value of mineral P in legume-cereal rotations is critical for better nitrogen fertilizer response, higher biomass production and sustainable grain yield (Misiko, 2007).

Strengthening understanding and perceptions of mineral fertilizer use informed decision making among smallholders. Lessons from this study show that fertilizer promotion needs to take into account the interactions between biophysical variability and social contexts that influence failures and negative perceptions (Michael et al., 2020) (Figure 2).

Figure 2. Crop responses to fertilizer application.

SOIL FERTILITY MANAGEMENT AND CROP RESPONSE TO FERTILIZER APPLICATION IN ETHIOPIA

More than 80% of the is dependent on agriculture, which contributes about 50% of the country's gross domestic product (GDP) and more than 80% of its export earnings. Although the agricultural sector is the engine of economic growth and the country has designed an "Agricultural led Industrialization", the agricultural sector is still characterized by severe soil erosion, high levels of nutrient mining, low use of external inputs, low productivity and limited capacity to respond to environmental shocks. Thus, the country is grappling with a daunting challenge: produce more food for a fast-growing population on low fertility soils on land owned by poor smallholder farmers who are unlikely to afford adequate input use.

According to (Tamene et al., 2017) review in Ethiopia the last half century research works on fertilizer use and crop yield could be potentially summarized as follows:

1. The productivity of major crops has increased steadily over the last two decades. Maize yield for example has increased from about 1.7 t ha-1 in 1993 to the current 3.4 t ha-1, although most of the increase has occurred within the last decade. The biggest increase in yield for the other crops such as wheat, barley and sorghum has also occurred during this last decade and coincides with Ethiopia's investment in agriculture in 1995–2014 that surpasses CAADP's 10% of total expenditure target.
2. The yield increase is strongly correlated with increased use of mineral fertilizers,

particularly Nitrogen and phosphorus. Traditionally, Diammonium phosphate and urea (supplying nitrogen and phosphorus) were the major fertilizers used by farmers in Ethiopia until few years back, whereby other nutrients, particularly K become limiting to produce high yielding cereals and root crops.

3 A high degree of variability exists in crop response to nutrients and amendments in major cereal growing areas in Ethiopia. This is mainly associated with variability in landscape positions, agro ecologies, soil characteristics and management practices.

4. Wheat grain yield increased by 80 to 300% on vertisols and by 45 to 15% on nitosols in response to the application of higher rates of Nitrogen fertilizers. Similarly a high yield benefit was obtained when wheat was rotated with faba bean as a precursor crop, with yield increment ranging from 0.035 to 1.25 tonnes per ha.

5. In major barley growing region, the recommended fertilizer rate for barley N: P2O5 was recommended as 25:45 kg ha-1 for the nitisols, 20:55 kg ha-1 for the black soils, 20:45 kg ha-1 for the red soils and 30:35 kg ha-1 for the brown soils, respectively. In acidic soils, up to triple yield increase was recorded by application of 3 t ha-1 of lime compared to no lime.

6. Maize response to fertilizer application has been consistently high regardless of locations and season. Higher grain yield and net benefits was obtained with an application of 130 kg N ha-1 with a split application of 50% at sowing and 50% at knee height. The N use efficiency of open-pollinated varieties was significantly lower than hybrid maize genotypes. The application of 4 t FYM ha-1 or more along with half doses of N and P gave reasonably high yield across locations.

7. Incorporating organic residues at a rate of about 5 t ha-1, particularly by integrating predecessor green manures such as Dolichose lablab, Mucuna pruriens, Crotalaria ochralueca and Sesbania sesban, it is possible to enhance soil fertility, increase grain yield by at least 30–40% and offset the cost of 46 kg N ha-1 from urea for smallholder farmers.

8. Despite the ongoing efforts to improve fertilizer recommendation and use through developing soil fertility maps (Ethiosis), including for micronutrients, the fertilizer recommendations have not been adequately updated or cover mainly N and P. Further research is thus needed to further establish crop response patterns and underlying characteristics, and to define the extent of K, S and micronutrient elements limitations to crop production in various farming systems, landscape positions and soil types.

9. Although inputs organic and mineral fertilizers are the major factors affecting crop productivity in the country, integrated soil fertility management (ISFM) is becoming an important strategy to adapt (Figure 3).

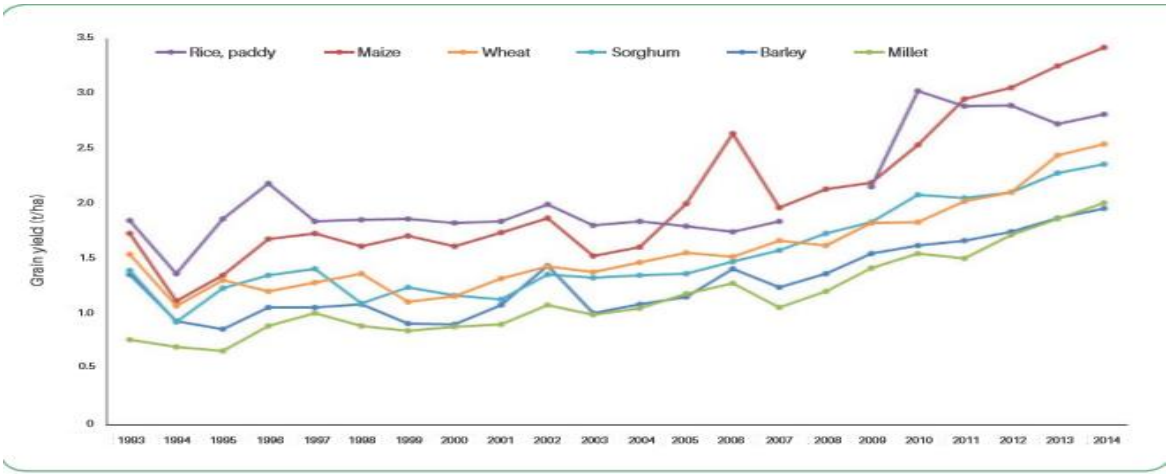

Figure 3. Productivity trends of major cereal crops in Ethiopia. Source: FAOSTAT database 2014.

MAJOR CROPS RESPONSE TO FERTILIZERS

The productivity of major crops has increased steadily over the last two decades (Figure 4a). Maize yield for example has increased from about 1.7 t ha-1 in 1993 to the current 3.4 t ha-1, although most of the increase has occurred within the last decade. The biggest increase in yield for the other crops such as wheat, barley and sorghum has also occurred during this last decade and coincides with Ethiopia's investment in an input must make economic sense to a farmer. Agriculture in 1995–2014 that surpasses CAADP's 10% of total expenditure target (AGRA, 2016). However, the increased productivity is still insufficient to meet the food demand in Ethiopia with a sharp rise in net imports (especially of wheat from 35 hg in 1993 to 161

hg) in 2014 (Tamene et al. 2017).

The results show that there is a limited response to N and P in the absence of the other while combining N and P results in large increases in yield (Figure 4a). Not including P in crop nutrition has a greater effect on attainable yield in areas with low than with high (>4 t ha-1) unfertilized/control yield. Recommendations for fertilizer would thus likely include N and P. With fertilizer application, many observations indicate elevated yields beyond the national averages (Figure 4b). There was a positive response to N, P and S with the test crops (wheat, maize, teff and rice) although some of the observations show no response/negative responses to the applied nutrient. Some crops, especially wheat, rice and teff, showed a positive response to S. There was a positive response to P although some negative observations were also made for wheat and rice.

Based on (Figure 4b), N and P responses were observed in a majority of the cases for all the crops (except wheat) in almost all environments. The response of these nutrients related to wheat demonstrates a clear need to contextualize responses (e.g. by application levels, regions, etc.). No data shows a clear response to other important nutrients e.g. secondary and micronutrien

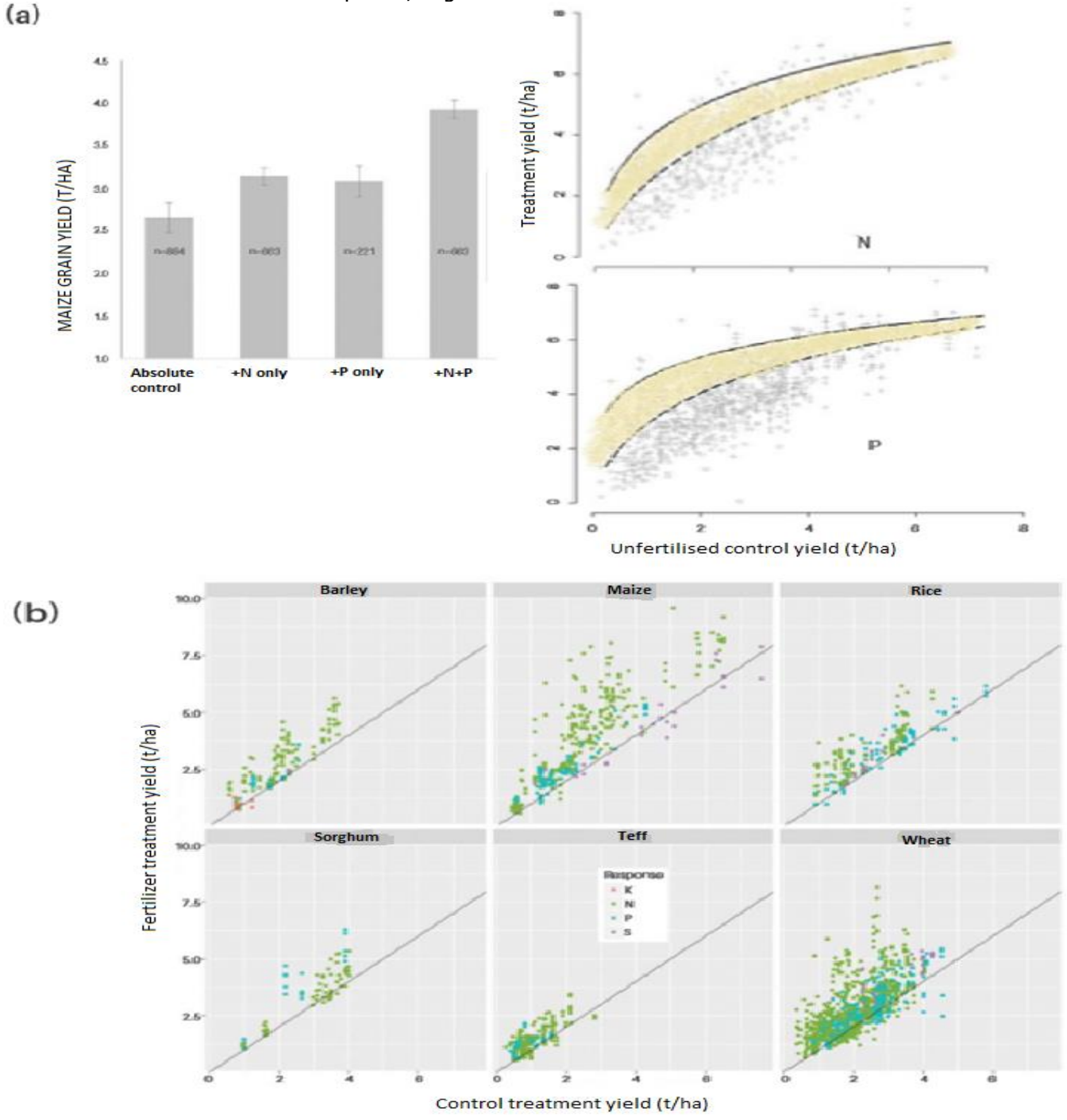

Figure 4. Effects of (a) N, P and NP and (b) N, P, K and S on the yield of different cereal crops

across a range of controls in Ethiopia.

Like cereals, there is also a positive response to fertilizer application for major legumes (Figure 5) but we cannot make a firm conclusion as there are few data points. This shows that either legume is not usually supplied with organic fertilizer or research studies on legumes' response to fertilizer are few.

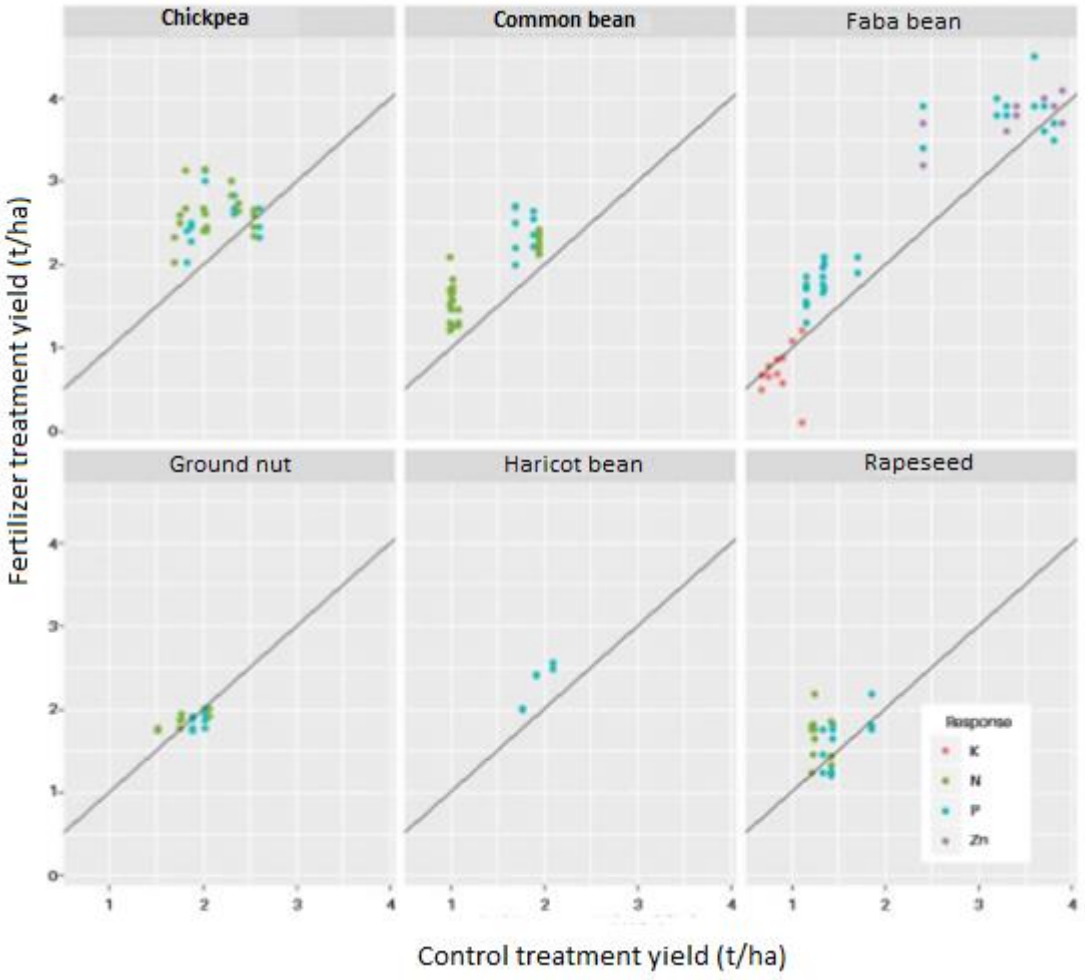

Figure 5. Effect of N, P, K and Zn on yield of different legume crops across a range of control yields in Ethiopia.

Fertilizer is an expensive commodity in SSA, and to achieve agronomic efficiency its application must
be site specific. Investment in an input must make economic sense to a farmer. For example, for the technology to make economic sense and for farmers to adopt them, for every unit of fertilizer applied, the profit obtained from the yield must exceed the expenditure on inputs with good margins (Tamene et al. 2017).

PUBLIC INTERVENTIONS THAT CAN BE USED TO STRENGTHEN SUPPLY OF FERTILIZER INCLUDE

Reducing fertilizer sourcing costs (for example, by lowering trade barriers, adopting common quality standards, and harmonizing approval processes to increase the size of national and regional markets, which would allow fertilizer importers and eventually manufacturers to capture economies of size and scope), reducing fertilizer distribution costs (for example, by improving road and rail infrastructure to reduce high transport costs), strengthening business finance and risk management instruments (for example, by implementing credit guarantee schemes and innovative types of insurance),and, improving supply chain coordination mechanisms (for example, by enacting and enforcing regulations relating to product grades and standards and by introducing market information systems that can help to reduce information costs). All of these measures, regardless of their focus, can potentially contribute to increased use of fertilizer in

Africa. At the same time, none is likely to be effective if implemented in isolation. Policy makers and development partners who are seeking to bring about sustainable increases in fertilizer use must select combinations of these measures to ensure that demand and supply can grow in parallel, thereby providing the basis for the emergence of viable private sector–led commercial fertilizer markets (Michael.et al. 2007).

DISCUSSION AND CONCLUSION

In sub Saharan Africa (SSA) and in Ethiopia the review highlighted that the average fertilizer application rate in general is lower than the recommended rate, despite significant increase in fertilizer use. Because of various reasons including: Farmer's constrained knowledge on how to use fertilizer (improve use efficiency); low fertilizer/nutrient use efficiency; high price of fertilizer; old or incomplete fertilizer recommendation for varieties and some soils, acid soils in the highly-weathered soils; water logging in vertisols; nutrient imbalance in alkaline and saline soils. So, detailed study on the best combinations of inputs that can boost crop yield in different farming systems and soil types is needed. A lot of fertilizer recommendations have not been updated or cover mainly N and P although there are recent initiatives by Ethiosis to include micronutrients in blend formulas. To increasing crop productivity, the integrated use of organic and inorganic nutrient management is critical; crucial information on the nutrient content and quality of organic inputs is lacking. No prescriptive guidelines that are relate to the quality of the organic material to its fertilizer equivalency and its effect on the longer term composition of soil organic matter and crop yields.

The reviewed research outputs reveal that there is potential for increasing crop productivity through improved and available soil fertility management practices. Application of these options in their respective agro ecologies and soil types can contribute considerably to filling the yield gap.

Soil test-based fertilizer recommendations and fertilizer blending is an interesting initiative in developing site and context-specific fertilizer recommendations which is recent developments under the ATA. But, there is a need to bring all stakeholders together to thoroughly discuss the approaches and reach an agreement on a common protocol. There is also a need to establish demonstration trials to test the applicability of the recommendations and fine-tune the maps, approaches and/or recommendation types and rates. As well, soil conservation based soil fertility management for crop production is needed for a sustainable land-use system in the country. Capacity and capability, development organizations and donors will be willing to provide the necessary financial support.

REFERENCES

Agegnehu G; Nelson PN; Bird MI. (2016). The effects of bio char, compost and their mixture and nitrogen fertilizer on yield and nitrogen use efficiency of barley grown on a Nitisols in the highlands of Ethiopia. Sci Total Environ.569-570:869-879.

Akinnagbe OM, Ajayi AR. (2010). Challenges of farmer-led extension approaches in Nigeria. World J Agricultural Sci. 6(4): 353-359.

Amante AD, Negassa W, Ilfata FG, Negisho K. (2014). Optimum NP Fertilizers Rate For Wheat Production on Alfisols of Arjo and Shambu Highlands, Western Ethiopia**.** J Environ Human.2014(2):87-94.

Amare A, Adane L. (2015). Grain quality and yield response of malt barley varieties to nitrogen fertilizer on brown soils of Amhara Region, Ethiopia. World J Agricultural Sci. 11(3): 135-143.

Argaw A, & Tsigie A. (2015). Indigenous rhizobia population influences the effectiveness of Rhizobium inoculation and need of inorganic N for common bean (Phaseolus vulgaris L.) production in eastern Ethiopia. Chemical and Biological Technologies in Agriculture, 2(1): 1-13.

Asfaw S, Shiferaw B, Simtowe F, Lipper L. (2012). Impact of modern agricultural technologies on smallholder welfare: Evidence from Tanzania and Ethiopia. Food policy. 37(3):283-295.

Assefa A, Tadese T, Liben M. (2013). Influence of time of nitrogen application on productivity and nitrogen use efficiency of rain-fed lowland rice (Oryza sativa L.) in the vertisols of Fogera Plain, northwestern Ethiopia. Ethiopian J Sci Tech. 6(1):25-31.

Ayalew A, Kena K, Dejene T. (2011). Application of NP Fertilizers for better production of Teff (Eragrostis tef (Zucc.) Trotter) on different types of soils in southern Ethiopia. J Natural Sci Research. 1(1): 6-15.

Barrett CB. (2010). Smallholder market participation: Concepts and evidence from eastern and southern Africa. Food Security in Africa.

Bayu W, Getachew A, Mamo T. (2002).

Response of sorghum to nitrogen and phosphorus fertilization in semi-arid environments in Welo, Ethiopia. Acta agronomica hungarica. 50(1):53-65.

Bayu W; Rethman NFG; Hammes PS; Alemu G. (2006). Effects of farmyard manure and inorganic fertilizers on sorghum growth, yield, and nitrogen use in a semi-arid area of Ethiopia. J Plant Nutri.29(2):391–407.

Belay K, Abebaw D. (2004). Challenges facing agricultural extension agents: A Case Study from South-western Ethiopia. African dev rev. 16(1), 139-168.

Bronson KF, Keeling JW, Booker JD, Chua TT, Wheeler TA, Boman RK, Lascano RJ. (2003). Influence of landscape position, soil series, and phosphorus fertilizer on cotton lint yield. Agronomy Journal. 95(4), 949-957.

Chikowo R, Zingore S, Snapp S, Johnston A. (2014). Farm typologies, soil fertility variability and nutrient management in smallholder farming in sub-Saharan Africa. Nutri Cyc Agroecosystems. 100(1):1–18.

Cooper P. J. M, Dimes J, Rao K. P. C, Shapiro B, Shiferaw B, & Twomlow S. (2008). Coping better with current climatic variability in the rain-fed farming systems of sub-Saharan Africa: An essential first step in adapting to future climate change?. Agriculture, ecosystems & environment. 126(1-2), 24-35.

Dawe D, Dobermann A, Ladha J. K, Yadav R. L, Bao L, Gupta R. K, Lal P, Panaullah G, Sariam O, Singh Y, Swarup A (2003). Do organic amendments improve yield trends and profitability in intensive rice systems?. Field Crops Research. 83(2), 191-213.

Desta HA. (2015). Response of maize (Zea mays L.) to different levels of nitrogen and sulfur fertilizers in Chilga District, Amhara National Regional State, Ethiopia. Basic Res. J. 38–49.

Gebrekidan H and Seyoum, M. (2006). Effects of mineral N and P fertilizers on yield and yield components of flooded lowland rice on vertisols of Foger Plain, Ethiopia. J Agriculture Rur Dev Tropics and Subtropics. 107(2):161-176.

Habte D, Tadesse K, Admasu W, Desalegn T and Mekonen A. (2015). Agronomic and economic evaluation of the N and P response of bread wheat grown in the moist and humid midhighland vertisols areas of Arsi zone, Ethiopia. African J Agri Research, 10(3), 89-99.

Jha S, Kaechele H, Lana M, Amjath-Babu T. S and Sieber, S. (2020). Exploring farmers' perceptions of agricultural technologies: a case study from Tanzania. Sustainability. 12(3): 998.

Marenya P, Barrett C. B and Gulick T. (2008). Farmers' perceptions of soil fertility and fertilizer yield response in Kenya. Available at SSRN 1845546.

Michael M., Valerie A., Ron J.K. and Derek B. (2007). Fertilizer Use in African Agriculture Lessons Learned and Good Practice Guidelines. The International Bank for Reconstruction and Development/The World Bank, NW Washington, DC 20433.

Mwangi, W. M. (1996). Low use of fertilizers and low productivity in sub-Saharan Africa. Nutrient cycling in Agroecosystems. 47(2):135-147.

Rashid S, Tefera N, Minot N and Ayele G. (2013). Fertilizer in Ethiopia: An assessment of policies, value chain, and profitability.

Tamene, L, Amede T, Kihara J, Tibebe, D and Schulz S. (2017). A review of soil fertility management and crop response to fertilizer application in Ethiopia: towards development of site-and context-specific fertilizer recommendation. CIAT Publication.

Zerssa G, Feyssa, D, Kim D. G and Eichler-Löbermann, B. (2021). Challenges of Smallholder Farming in Ethiopia and Opportunities by Adopting Climate-Smart Agriculture. Agriculture. 11(3), 192.