

# Assessment of Mineral Fertilizer Use in Rwanda

**Niyitanga Fidèle**Lecturer, Department of Rural  
development and Agricultural Economics,  
University of Rwanda  
email: fniyitanga@yahoo.fr**Bizimana Jean Pierre**Lecturer, Department of Geography and  
Centre for Geographic Information  
Systems and Remote Sensing, University  
of Rwanda**Mugiraneza Théodomir**Lecturer, Department of Geography and  
Centre for Geographic Information  
Systems and Remote Sensing, University  
of Rwanda

**Abstract:** This study assessed the status of NPK17-17-17, Urea and DAP application on staple crops (maize, irish potato, beans, rice, cassava and wheat) of the Crop Intensification Program in Rwanda. The fertilizer application rate of NPK, Urea and DAP and the deficit in fertilizer use with reference to these crops were assessed. The findings of the study show that the use NPK17-17-17, Urea and DAP in maize, irish potato, bean, rice, cassava and wheat crops is inferior to the scientifically recommended fertilizer application rate for maximizing the yield. The deficit ranges from 60% to 90% for urea, 30% to 70% for DAP and 24% to 84% for NPK17-17-17 for all crops except maize for which there is an overdose of 76% for NPK17-17-17. The assessment of fertilizer use shows also that the lower the size of farm land the higher is the fertilizer application rate to the extent of overdosing the fertilizer use, and vice versa. This situation can explain the extent to which the intensive agriculture development is important for farmers facing the land scarcity and extensive agriculture development for farmers with sufficient land. The Government of Rwanda (GoR) should continue to adopt measures and setup strategies for the encouragement, improvement and increase of fertilizer use in order to maximize the crop yield.

**Keywords:** Fertilizer Use, Staple Crops, Crop Intensification Program

## I. INTRODUCTION

Evidence from soil science shows that inorganic fertilizer is a necessary component for sustainable growth in agricultural productivity, even in fragile soils and low rainfall zones. Despite this growing evidence that mineral fertilizer can substantially increase crops yield and slow down environmental degradation in sub-Saharan Africa, the region still lags far behind other developing areas in fertilizer use (Heisey and Mwangi, 1996; Wallace and Knausenberger, 1997; Liverpool-Tasie and Takeshima, 2013). The low rates of fertilizer use persist despite numerous efforts to ease farmers' access to quality and affordable fertilizer (Liverpool-Tasie and Takeshima, 2013) in Sub-Saharan Africa mainly because of poor inherent soil fertility, poor extension services, constraints to fertilizer availability and limited availability of complementary inputs. The low fertilizer use also reflects the low crops response to fertilizer and poorly developed marketing systems and unstable prices of outputs (Dittoh *et al.*, 2012).

Historically, farmers in rural areas of Rwanda settled along the upper ridges of hillsides where soils were more fertile and cultivation was simple task than it was on steeper slopes and in marshy valleys (Clay, 1992).

However, the rapid population growth has brought several changes in traditional agricultural systems: farm holding have become smaller due to constraints on land availability; holdings are more fragmented; cultivation has pushed onto bottomlands and fragile margins on steep slopes previously held in pasture and woodlot (Clay *et al.*, 1998). Further, many households now rent land, particularly households owning little land or those with large families; and fallow periods have become shorter and cultivation periods have grown longer (Clay *et al.*, 1998). Crop productivity in Rwanda started therefore declining as a result of population pressure and intensive farming on steep slopes, which led to soil loss and declining soil fertility (Clay, 1995; Clay and Lewis, 1996). Productivity decline resulting from excessive soil loss occurs everywhere in Rwanda (Roose and Ndayizigiye, 1997) but it is particularly acute in highlands (Lewis and Nyamulinda, 1996; Steiner, 1998).

Currently, poor agricultural productivity remains a crucial problem in Rwanda despite numerous technological interventions in term of soil management (Rushemuka *et al.*, 2014). Rwandan agriculture is still characterized by a very low level of fertilizer use, especially mineral fertilizer. Prior to 2000 year, the national rate of mineral fertilizer use per cultivated hectare (4kg/ha) remained far below the average of 9 to 11kg/ha for sub-Saharan Africa, and the lowest fertilizer utilization rate in the world (Crawford *et al.*, 2005; MINAGRI, 2009). This rate is still the weakest fertilizer utilization level worldwide (Kelly *et al.*, 2001). This fertilizer use was a small fraction of profitable potential of fertilizer use (Desai, 2002); and relatively low until the GoR introduced a subsidy program in 2008. This low level of mineral fertilizer use also leads to a critically low productivity of agricultural sector in Rwanda due to decreasing soil fertility. According to Henao and Banaante (2006), depletion rates in NPK17-17-17 were estimated to be 77 kilograms of nutrients per hectare. Even if soil erosion is the main cause of fall in agricultural productivity, the primary cause is over cultivation, fall in fertility due to short or lack of fallowing and inadequate application of fertilizer inputs (Waller, 1996; Kelly and Murekezi, 2000). The evidence leaves no doubt that the nutrient recycling mechanisms that sustain soil fertility are insufficient to support the needed growth in food production without mineral fertilizer use in Rwanda.

Recognition of the declining soil fertility and the low level of fertilizer use led the Government of Rwanda (GoR) to setup the Crop Intensification Program (CIP) in 2007 for boosting the agriculture sector through the use of

mineral fertilizer and hence improve the food security and respond to increasing needs of the population increasing rapidly. More specifically the CIP program aims at significantly increasing the food production through a multi-pronged approach that includes facilitation in fertilizer provision; land use consolidation; agricultural extension services and improvement of post-harvest and storage mechanisms (MINAGRI, 2011). The CIP program focuses on six priority crops namely maize, wheat, rice, irish potato, bean and cassava. These crops have been proposed because of their high nutritional value, importance in cropping patterns of the country (Rwanda), adaptability to agro-climatic zones and for their potential responsiveness to fertilizer use (MINAGRI, 2010). Amongst these criteria, fertilizer is a critical element given that all other elements are mostly based on natural factors while the fertilizer is most based on the available financial capacities of farmers and of the country to invest in fertilizer market.

Hence, given its importance in increasing agricultural productivity and the expected outcomes of CIP, fertilizer sector gained the particular consideration of the government. Within this framework, in 2006, the Government of Rwanda took over the importation of fertilizer which was liberalized since 1999. However, the distribution and retailing activities remained in the hands of private sector. The GoR's objective when re-entering the procurement activity was that its intervention would be for a period of five years (2006-2011), by which time the private sector including producer cooperatives and farmer associations should be in a position to take over fertilizer procurement, importation, distribution and marketing (MINAGRI, 2010). It also introduced the voucher system for boosting agricultural production by reducing the cost and increasing the quantity of fertilizer use (Ellis, 1992). In 2008, due to the spike in international fertilizer prices, the GoR also introduced subsidized fertilizer auctions and "smart subsidies" in form of voucher. These measures had to lead to increase mineral fertilizer such as NPK17-17-17, Urea and DAP which are mostly the types of inorganic fertilizer used in Rwanda. Therefore, this study assessed the status of NPK17-17-17, Urea and DAP application to main staple crops under CIP program. In other words, this study assessed the application rate of NPK17-17-17, Urea and DAP to maize, irish potato, bean, rice, cassava and wheat and determined the gaps with reference to recommended application rates.

## II. METHODOLOGY

In addition to the review of existing documents on trends in fertilizer (NPK17-17-17, DAP and Urea) use; especially in maize, wheat, irish potato, rice, cassava and bean production in order to collect secondary data on fertilizer use rate per crop, a quantitative survey of 2,022 small-scale farmers involved in maize, wheat, irish potato, rice, cassava and beans production was organized and conducted in order to collect primary data on fertilizer use. The survey covered thirty districts composing the four

provinces of the country (Northern, Southern, Western and Eastern Provinces) and the rural areas of Kigali City of Rwanda. The districts and rural areas of Kigali city represent the ten agro-ecological zones (AEZs) and agricultural production systems in Rwanda (Delepiere 1974; Gasana 1991). This agro-ecological based approach is recognized by the Government of Rwanda strategy which emphasized the importance of regional specialization in order to profit from the environmental diversity of Rwanda and to maximize the yield of the most suitable crops in each region; and the intensification through the increased use of fertilizer to increase the agricultural productivity (Delepiere, 1974; Gasana, 1991; Olson, 1994; Imerzoukene and Van Ranst, 2002; Verdoodt and Van Ranst, 2003, 2006). The agro-eco-regionalization that categorizes the landscapes for use in crop suitability analysis, and strategic agro economic development (Williams *et al.*, 2008) helped to account for the biophysical properties affecting land use choices, fertilizer use and crop regionalization at national and local scale (Verdoodt and Van Ranst 2006; Verdoodt *et al.*, 2010). Hence, the sectors have been selected in each district based on the predominance of the targeted crops and spatial extent of agro-ecological zones. Within each selected sector, households were randomly determined.

## III. RESULTS AND DISCUSSION

### 1. Fertilizer use and deficit

The rate of fertilizer application mainly depends on factors such as the type of fertilizer and crops, the agro-ecological zone where the crop is grown, and farmers' knowledge in fertilizer use, etc... According to Kelly and Murekezi (2000), the knowledge on recommended fertilizer' application rate for different crops and zones is a critical in implementing the entire program related to fertilizer use and application. Table 1 shows the application rate (in tons) and deficit in fertilizer application rate (in tons) of NPK, DAP and Urea in maize, irish potato, bean, rice, wheat and cassava for A2011 and B2011 crop seasons.

Table 1: Fertilizer application rates and deficit for A2011 and B2011 cropping seasons

Type of fertilizer	Crops	Estimated application Rate (tons/ha)	Recommended rate (tons/ha)	Deficit Use (tons /ha)	Deficit in %
Urea	Irish	0.04*	0.70***	0.66	94
	Beans	0.02*	0.05***	0.03	60
	Rice	0.10*	0.10****	0.00	0
	Wheat	0.04*	0.10****	0.06	60
	Maize	0.04*	0.10****	0.06	60
DAP	Irish	0.05*	0.11**	0.06	54
	Beans	0.03*	0.10****	0.07	70
	Rice	0.07*	0.10****	0.03	30
	Wheat	0.06*	0.10****	0.04	40
	Maize	0.07*	0.10****	0.03	30

NPK	Irish	0.15*	0.30****	0.15	50
17-	Beans	0.18*	0.25****	0.07	28
17-	Rice	0.16*	0.25****	0.09	36
17	Cassa va	0.15*	0.30****	0.15	50
	Wheat	0.04*	0.25****	0.21	84
	Maize	0.44*	0.25****	-0.19	-76

Source: Authors

One star (\*) represents the rate from the survey done in 2011. Two stars (\*\*) show the rate recommended by Murekezi and Kelly, 2000; Three stars (\*\*\*) refer to estimation based on Murekezi and Kelly findings in 2000 and four stars (\*\*\*\*) reflects the rates recommended by MINAGRI in 2009.

Comparing the recommended fertilizer application rates and the current application rates, it is obvious that the use of fertilizer by small scale farmers is still low. Limited knowledge in inorganic fertilizer use and purchasing power can explain the low use of fertilizer by farmers.

#### 2. Use of fertilizer with reference to farm size

The following table presents the use of Urea, DAP and NPK for A2011 and B2011 crop seasons with respect to maize, irish potato, beans, rice, wheat and cassava and farm size.

Table 2: Fertilizer application rates (in Kg/ha) with respect to farm size during A2011 cropping season

Farm size (Ha)	Maize	Irish potato	Beans	Rice	Wheat	Cassava
<b>DAP</b>						
0 - 0.25	165.89	133.98	115	197.35	164.11	121.8
0.26 - 0.50	77.98	79.97	52	66.29	76.2	56.31
0.51-1.00	72.97	73.12	42.93	43.01	56.38	46.05
Above 1	30.04	48	12.44	0.99	47.55	80
<b>NPK17-17-17</b>						
0 - 0.25	108.48	259.99	89.23	176.66	91.04	2.39
0.26 - 0.50	65.89	154.77	36.73	137.73	34.85	51.07
0.51-1.00	43.66	131.15	6.84	148.46	15	100
Above 1	13.2	82.84	8.08	158.15	21.67	231.25
<b>Urea</b>						
0 - 0.25	106.15	82.33	88.1	119.21	106.62	64.55
0.26 - 0.50	53.1	43.61	30.42	91.16	53.15	51.09
0.51-1.00	38.27	51.95	26.55	79.6	28.78	31.86
Above 1	22.79	21.7	9.43	-	20.83	10.91

Source: Authors

The data presented in Table 2 show that the fertilizer application rate is inversely related to the size of the land. The lower the size of land, the higher is the rate of fertilizer application to crops and vice versa. The farm size per household is likely to stimulate the small famers to continuously adopt the use of mineral fertilizer. The high level of application rate would be attributed to the small farmers' need to improve their yield for feeding their family and probably having a surplus. Farmers with smaller landholdings have a greater incentive to improve their land as they depend more on their smallholdings and they must pursue intensification as a substitute for fallow (Clay *et al.*, 1998). The inverse relationship between farm size and productivity was first described as early as 1923. Chayanov (1923) found that as the Kulaks acquired more land, the productivity or yields of their farms declined. Sen (1962) documented the same phenomenon in India; Kimhi (2006) and Barrett, C. B. (1996) in Africa; Akram-Lodhi (2003), Heltberg (1998) and Carter (1984) in Asia;

Alvarez and Arias (2004) in Europe and Berry and Cline (1979) and Bhalla (1979) in Latin America. The empirical evidence is puzzling because this inverse productivity relationship violates a fundamental tenet of the production function—positive or constant returns to scale.

## IV. CONCLUSION AND RECOMMENDATIONS

This study aimed at assessing the fertilizer use in main crops targeted by the CIP program in Rwanda. Specifically the study assessed the NPK17-17-17, Urea and DAP application to maize, irish potato, bean, rice, cassava and wheat and determined the deficit in fertilizer use with reference to these crops. It also assessed the use of fertilizer with reference to both crops and farm land size. For achieving these objectives, this study used the methodological approach consisting of reviewing the existing documents on fertilizer use in Rwanda for collecting secondary data and a quantitative survey to a sample size of 2022 small scale farmers for collecting primary data on fertilizer use in Rwanda. The findings of the study showed that he rate of fertilizer application to seven investigated staples crops (irish potato, bean, rice, cassava, wheat and maize) is still low compared to scientifically recommended rates for maximizing the crop yield. The deficit ranges from 60% to 90% for urea, 30% to 70% for DAP and 24% to 84% for NPK17-17-17 for all crops except maize for which there is overdose of 76% for NPK17-17-17. The assessment of fertilizer use with reference to both crops and farm land size showed that the lower the size of farm land the higher is the fertilizer

application rate to the extent of overdose fertilizer application rate, and vice versa. This situation can explain the extent to which the intensive agriculture development is important for farmers facing the land scarcity and extensive agriculture development for farmers with sufficient land.

The GoR should continue to adopt measures and setup strategies and programs for the encouragement, improvement and increase of fertilizer use in order to maximize the crop yield. For example the government should reinforce the implementation of Crop Intensification Program (CIP), terracing and irrigation and mechanization programs. These programs facilitate the use of fertilizer in farming systems and hence the increase in fertilizer demand and use. The MINAGRI extension services should intensify the training of farmers on the proper use of fertilizers in terms of quantity and appropriate type of fertilizer with respect to crops. The system of agricultural information transfer should be improved and the farmer field schools would be one of the approaches to use for reaching the farmers.

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### **AUTHOR'S PROFILE**

#### **Niyitanga Fidèle**

Lecturer, Department of Rural development and Agricultural Economics,  
University of Rwanda  
email address: fniyitanga@yahoo.fr

#### **Bizimana Jean Pierre**

Lecturer, Department of Geography and Centre for Geographic  
Information Systems and Remote Sensing,  
University of Rwanda

#### **Mugiraneza Théodomir**

Lecturer, Department of Geography and Centre for Geographic  
Information Systems and Remote Sensing,  
University of Rwanda