RESEARCH REPORT No. 13

REVISITING UGANDA'S INORGANIC FERTILIZER SUPPLY CHAIN: NEED FOR A STRONGER REGULATORY SYSTEM

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May 2015

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ACKNOWLEDGEMENTS

Many institutions and individuals contributed in putting together information that led to successful production of this paper. We appreciate the financial support from the Alliance for a Green Revolution in Africa (AGRA); and the collaborative partnership and guidance from the staff in the Department of Crop Protection, Ministry of Agriculture, Animal Industry and Fisheries (MAAIF).

Great appreciation is extended to the technical team of consultants from the College of Agricultural and Environmental Sciences (CAES), Makerere University that was involved in collecting and laboratory analysis of fertilizer samples.

The compilation of this paper was enabled by the relentless services of Messers: Joseph Mawejje and Musa Mayanja Lwanga from the EPRC; Fred Muzira from Department of Crop Protection (MAAIF); and Bonny Balikudembe and Kenneth Senkosi from the College of Agriculture and Environmental Studies (CAES), Makerere University.

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ABSTRACT

This paper highlights the quality concerns of inorganic fertilizers on the Ugandan market. The findings reported are based on 170 samples (in 50 kg bags and small 1-2 kg packs) of the commonly used fertilizers on the Ugandan market i.e. Urea, NPK, DAP, MOP and CAN purchased and subjected to a laboratory analysis. Procedures followed in the purchasing of fertilizer samples mimicked a farmer purchasing fertilizers randomly from any input dealer country wide. Analytical results from the fertilizer samples revealed low quality fertilizers with moisture content above acceptable limits of 0.5-1.5 percent; and untruthfulness in both weight and nutrient content. In some instances, the nutrient content quoted on the labels did not match with the analytical content. This has serious consequences because fertilizer recommendations are based on the nutrient content. If the nutrients are not of the right quality, then the end-user (a farmer) will not attain the intended crop response to fertilizer application. The study reveals that re-packaging fertiliser into small quantities is justifiable to meet the requirements of smallholder farmers, but leads to loss of nutrients (especially nitrogen); and also aggravates the high moisture content problem. Results reveal gaps in the current regulatory system; therefore there is an urgent need for government to approve and operationalize the fertilizer policy, regulations and strategy.

1. INTRODUCTION

The agricultural sector remains a key sector in Uganda's growth, poverty reduction and food security. Consequently, among the government to priorities as articulated in its National Development Plan (NDP) is to enhance agricultural production and productivity. Currently the sector is characterized with low productivity partly attributed to declining soil fertility. This is increasingly constraining farmers' efforts to meet food security and improve household incomes in Uganda on a sustainable basis (Pender *et al*. 2004; MAAIF 2010). There is growing consensus that nutrient mining and low fertilizer use are some of the leading causes of declining soil productivity. The Government of Uganda (GoU) through its Ministry of Agriculture Animal Industry and Fisheries (MAAIF) in the recent past has acknowledged the need for increased fertilizer use as a cornerstone for addressing the problem of declining soil productivity to increase crop production, and food security as well as household incomes. This is greatly demonstrated by its on-going efforts to streamline and strengthen the regulatory framework as well as to create an enabling environment for increased quality fertilizer supply and demand by smallholder farmers.

With high population growth (of 3.2 percent) as well as growing urbanization rate, addressing the declining soil fertility is a matter of priority. Use of inorganic fertilizers in Uganda remains low - at about 1 kg of nutrient per hectare per year (Okoboi & Barungi 2012; World Bank 2015), a level well below the Abuja declaration target of 50 kg per hectare by 2015. Uganda like more landlocked African countries depends largely on inorganic fertilizer imports with limited fertilizer control regimes. The market remains small, fragmented and is yet to create the dynamism required to boost the productivity of the agricultural sector. Notwithstanding the underdeveloped fertilizer market structure, there are growing concerns on quality of fertilizers on the market. The quality could impact on the ability to restore and maintain soil fertility and in turn either promote or hinder agricultural production.

There is a growing vice on the Ugandan fertilizer market of tampering with fertilizers as well as fertilizer labels along the supply chain. Yet it remains unclear at which stage of the chain this practice is done. To epitomize the extent of the problem, the East African News Paper (September 13, 2014) reported that *"thousands of farmers in Uganda are making losses as a result of using counterfeit farm inputs"*[1]. Ashour et *al.* (2015) noted that the low levels of agricultural technology adoption in Uganda have been compounded by a lack of farmer trust in the current inputs supply system, which has been plagued by counterfeiting. Until the fertilizer quality on the Ugandan market is guaranteed, all efforts to inform farmers about the benefits from use of fertilizer, and thereby attracting farmers into investing the meagre resources on fertilizers will be hard to attain.

Despite its small size, the fertilizer market in Uganda remains undeveloped. This makes monitoring of the quality along the market supply chain very challenging. This is so especially when fertilizers are imported in weights which the small-holder farmers cannot afford warranting the need for the agro-dealers to open, and re-pack the fertilizer in smaller quantities. While the practice of re-packaging is thus justifiable given the market structure, it is likely to be abused along the supply chain without strong regulatory framework in place. There are other practices such as storage that might comprise on the quality of fertilizer along the chain.

It is against this background that this study assessed the quality of inorganic fertilizers along the supply chain, with the intention of pushing for a stronger and effective regulatory framework. Specifically, first, the study identifies the most critical stages at which the fertilizer quality is compromised - focusing on the level of fertilizer tampering and adulteration as well as establishing the level of illegality through untruthfulness in labeling on fertilizer packages. Second, the study explores how institutional factors (such as licensing mechanisms and membership) have promoted or hindered the presence of quality fertilizers on the Ugandan market.

This study is undertaken at a time when MAAIF is training

inspectors and analysts on how to monitor, and regulate the quality of fertilizers on the Ugandan market. The study findings will inform these trainings as well as provide a benchmark for assessing future interventions towards the development of the fertilizer market. More important, it generates evidence for MAAIF to strengthen the controls and regulatory framework along the fertilizer industry's supply chain all the way from importers through the stockists who interface directly with the end-users, the farmers. In addition, the findings will inform the development of a laboratory chemical fertilizer analytical protocol for use by MAAIF agro-chemical inspectors and analysts as well as the process of developing standard operating procedures (SOPs) for testing inorganic fertilizers, in addition to the bio-fertilizers on the Ugandan market.

The rest of the paper is structured as follows: The next section presents a detailed description of the sampling design and methods of analysis. Section three presents and discusses the market survey findings prior to the conclusions and emerging policy options.

2. STUDY APPROACH

2.1 Sampling design

The sampling design was done at the importer/wholesale and retail levels along the fertiliser supply chain as detailed below. It excluded overseas suppliers and manufacturers, large farms and smallholder farmers on assumption that there is no incentive for adulteration and tempering with fertilizers at these levels of the supply chain.

Importer/wholesale level: Initially, the study had planned to randomly select three importers and five wholesalers. Instead, the practice on the ground was different as the importers were also doubling as wholesalers. Firms importing, and wholesaling fertilizer were selected from a list obtained from MAAIF (department of crop protection). The firms were all located in Kampala, and randomly selected using random numbers.

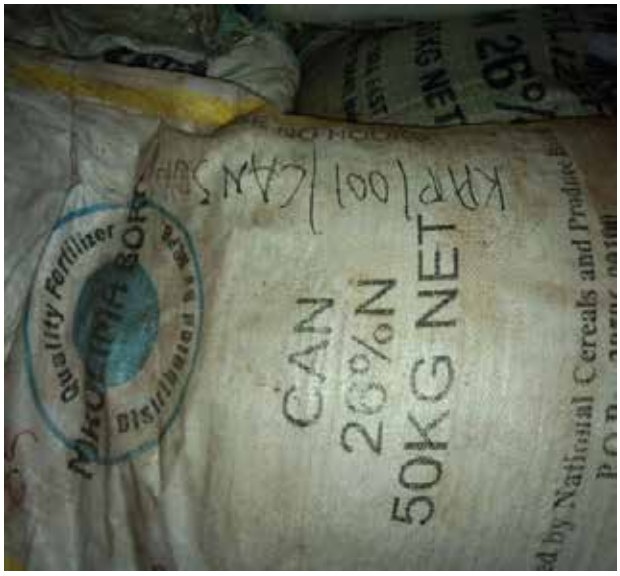
Retail level: Two districts were purposively selected from each of the four regions. The districts of Kampala and Masaka were selected from the central region, Gulu and Lira from the northern region, Mbale and Kapchorwa from the eastern region, and Kisoro and Masindi from the western region. The fertilizer supply chain broadens into a wider distribution network formed by retail outlets that deliver the fertilizer close to the farmers (end users). It is at this level that the challenges of monitoring and enforcement of fertilizer quality are experienced most. One way of ensuring some form of regulatory control is through trade licensing by MAAIF. The network of input dealers are encouraged to be registered as members of UNADA. It is envisaged that the organization stipulates the code of conduct and good practices to its members, which is periodically monitored by the Department of Crop Protection in MAAIF. Membership to UNADA, however, is encouraged but remains optional. Given the laxity in enforcement there are traders that sell fertilizer without officially being registered by MAAIF (illicit – unregistered trading), and or UNADA subscription. Consequently, to provide insights into the strength of the current regulatory controls, the input dealers/stockists were categorized into three mutually exclusive groups within each district: (a) the MAAIF[1] registered, and officially certified input traders; (b) membership to UNADA an umbrella organization for input dealers (hereinafter the UNADA registered); and (c) *unregistered (illicit)* input dealers that are neither licensed by MAAIF nor registered by UNADA. For category (a) and (b), the lists of traders in the selected districts were obtained from the respective organizations. In each category, *one* shop was randomly selected giving a total of three shops per district. Although there were instances when all these categories were non-existent in some districts as reflected in the final sample.

Fertiliser samples: The study focused on the commonly used fertilizer types in Uganda - Urea, Di-ammonium phosphate (DAP), Nitrogen, phosphorus, potassium (NPK), Muriate of Potash (MOP), and Calcium ammonium nitrate (CAN). Because of the complexity and sensitivity of the study, samples at both levels (wholesale and retail) were purchased from the suppliers in a manner that resulted into minimal divulging of details. Two types of samples were purchased – bulky samples of 50 kgs and small packs of 1-2 kgs. From each of the above fertilizer type, 20 bags of bulky sample and 40 samples of small packs were purchased. This resulted into 80 bags of the bulky sample and 160 of the small packs. The number of samples purchased was dictated by the budget. For ease of identification, the samples were coded based on dealer shop name, location, type of fertilizer, and the date when sample was collected (see Plate 1 – as KAP/001/CAN50K). The samples were delivered to one of the nationally recognized laboratories in the country located in the Department of Agricultural Production, College of Agricultural and Environmental Sciences, Makerere

1 All Agricultural chemical handlers/users must be registered to ensure judicious use of the chemicals in a way that safe guards humans, animals and the environment. As a prerequisite for registration, one must have attended and attained a minimum of Ordinary Secondary Level certificate as well a safe pesticide use and application course. This is followed by filling of applications forms D (dealership) and F (premises) and these are purchased from MAAIF. The forms are filled and returned to MAAIF and an inspection of the premises is organized by the Secretariat from which a report is compiled and submitted to the Agricultural Chemicals Control Technical Committee (ACCTC) for consideration. The committee reviews the report and makes its recommendations to the Registrar i.e. the Agricultural Chemicals Board (ACB) for the final decision. Once the ACB grants permission to be registered, certificates for recognition of one's Dealership and Premises are issued upon payment of the prescribed fees. Both registrations are valid for a specific period and are renewable upon payment of a specified fee and satisfaction of certain set conditions.

University and stored in a well-ventilated store on top of dry non-metallic (asbestos) sheets to prevent moistening. In each region, the sampling was done starting with the farthest district to minimize period of handling during transportation. The samples were clearly labelled and transported on pickups covered with a tarpaulin but allowing air circulation.

Plate 1: Illustration of the fertiliser sample



In addition to the physical fertiliser samples, a follow-up survey was conducted through a structured questionnaire in the sampled shops. In the follow-up survey additional information was collected that included: enlisted self-reported categorizations of fertilizer types; ranking of fertilizer by type and demand; involvement in repackaging into small packs; and general information on frequent complaints raised by farmers to dealers on fertilizers; and how the dealers address such complaints, among others. The study had two field teams that implemented the survey. The first team purchased the fertilizer samples from the selected shops as well as taking note of the way fertilisers were handled and stored at various levels and the labelling (see Plates 1 - as CAN 26% 50KG NET). The second team, visited the same shops to administer the structured questionnaire in the follow-up survey.

2.2 Laboratory analysis of samples

Fertilizers are globally traded as standard commodities, and their quality parameters are known and specified by the manufacturers through labelling (Plate 1). In other words, the formulations of nutrient contents appear on labels of fertilizer bags. Making it possible to subject the samples to quality assessment test based on known parameters set by the manufacturer. The samples were thereby assessed for the afore-mentioned parameters[2]. Standard protocols (Appendix A1) for fertilizer testing (FAMIC, 2013) were used to analyse the samples. Urea was tested for percentage nitrogen (N) content; DAP for percentage nitrogen and phosphate (P_2O_5) content; NPK for percentage of nitrogen, P_2O_5 and potash (K_2O) content; MOP was tested for percentage of potash content; and CAN was tested for percentage nitrogen and calcium (Ca) content. Hereinafter, the scientific and non-scientific names are used interchangeable through the paper.

Prior to laboratory tests, the fertilizers were assessed for moisture content, weight and labelling. The fertilisers were weighed using a pre-calibrated Salter weighing scales. The method of moisture determination varied with the type of fertilizer. The gravimetric method was used for MOP while sulphuric desiccation was used for NPK, CAN, DAP and Urea. As earlier mentioned, the bulky samples had external labels indicating the nutrient contents (concentration of the nutrients) which were matched with the laboratory analytical data. This was aimed at establishing compliance (truthfulness) in external labelling, and the actual fertilizer nutrient contents in the sampled bags.

2 Fertilizer quality standards are benchmarked mainly in terms of the physical and chemical characteristics. The physical parameters include moisture content and particle size. While the chemical parameters refer to the amount, form of nutrients, and the levels of impurities that may be toxic to plants above a critical limit.

3. RESULTS AND DISCUSSION

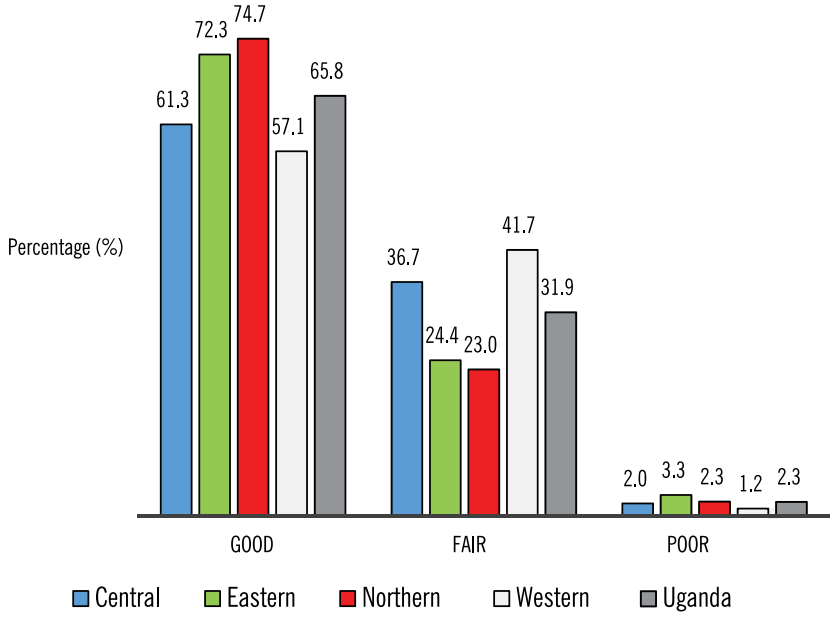
3.1 Findings from the qualitative survey

The survey results revealed that the function of fertilizer wholesale trading is performed by importers in the country with a higher concentration in and around Kampala. Therefore, Kampala is generally the *"hub"* in the fertilizer supply chain in Uganda. In addition, most of the shops in the fertilizer retail business were involved in merchandizes other than agro-inputs, including items remotely related to agriculture like motor spares as observed in Kisoro district. By implication, fertilizer is not yet a commodity of primary focus at the retail level. It was not easy to get bulky samples of all the different types of fertilisers in the districts of Gulu, Lira and Masindi. These observations indicate that fertilizer demand in Uganda is not only low but has a regional dimension. The low use of fertilizers in the sampled districts in the northern region partly reflects the impact of the two decade Lord Resistance Army (LRA) conflict that led to the distraction of agricultural systems. On one hand, while the population is slowly returning to agriculture, there are perceptions that soils are still fertile. This is supported by the 2013/14 Uganda National Panel Survey (UNPS) data; where the majority (75 percent) of farming households in Northern Uganda reported the soils were of good quality (Figure 1) – hence no need to apply fertilisers. On the other hand, people seem not to be aware of/are sceptical of the benefits of using fertilizers and lastly, that fertilizers are expensive (Bumb 2011; Benson *et al*. 2012; MAAIF 2012).

The input dealers were requested to rank the fertilisers according to demand. Overall, the most commonly demanded fertiliser in order of importance were Urea, DAP and NPK. However, the demand varied across retail outlets in the districts, partly reflecting differences in soil nutrients.

The practise of re-packaging fertiliser into small packs is commonly done at retail level. The practise is largely driven by the structure of the Uganda's agricultural sector which is dominated by smallholders. These smallholder farmers normally demand for fertilizers in smaller quantities;

Figure 1: Households' perceptions about the quality of soils by region, %



Source: Author's calculations based on UBoS 2013/14 UNPS data.

and the pack are not clearly labelled and at times some different fertilizers tend to look similar.

Nearly seven in every ten input dealers acknowledged receipt of complaints from farmers. The leading complaint was the high cost of fertilizers, which the traders relate to high government taxes on inputs. Just like other businessmen, agro-dealers pass on this tax levies to farmers. Thus smallholder farmers bear the tax burden (since they are not VAT registered and cannot claim this tax); which leads to an unnecessary increase in fertilizer prices (Benson *et al*. 2012). This finding demonstrates limited internalisation of government policy on withholding tax on fertilisers. Otherwise, dealers are eligible for tax refund. Lack of knowledge about fertilizer application was rated as the second most important complaint raised by farmers. However, all traders indicated that they educate farmers on the proper use of the fertilizers. Other complaints included: quality of fertiliser to the extent that farmers preferred fertilisers from Rwanda due to perceived thinking that there are of better quality compared to those of the local market; and underweight fertiliser bags.

3.2 Findings based on fertiliser samples

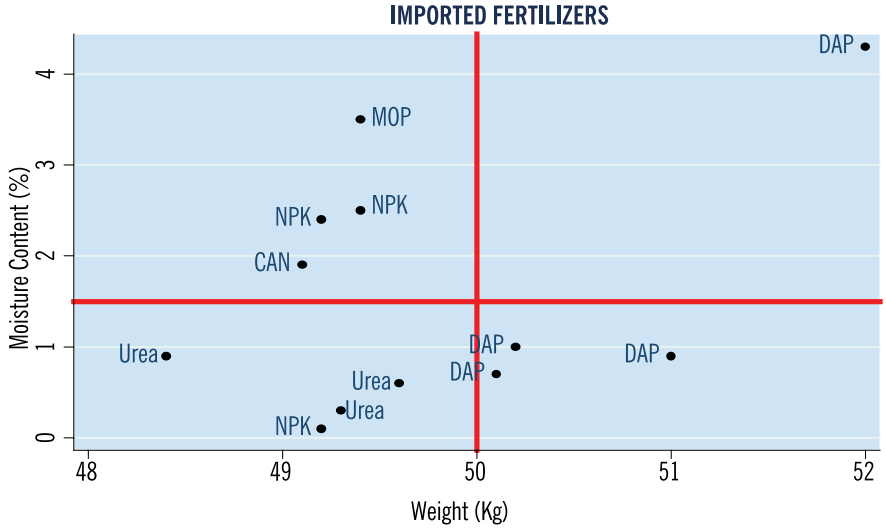
Physical attributes (i.e. labelling of nutrient content; moisture content; and weight of the bags) are indicative of the quality of fertilizer. Therefore the task of ascertaining the quality of fertilizers on the Ugandan market along the supply chain started by analysing such attributes.

3.2.1 Moisture content and weight

An attempt was made to classify bulky samples procured from the market on the basis of compliance to weight and acceptable moisture content limits of at least 49.5 kg, and 0.5-1.5 percent, respectively. Notably, five out of 12 bulky samples procured from import/wholesale level did not meet requisite moisture content standards as illustrated in Figure 2.

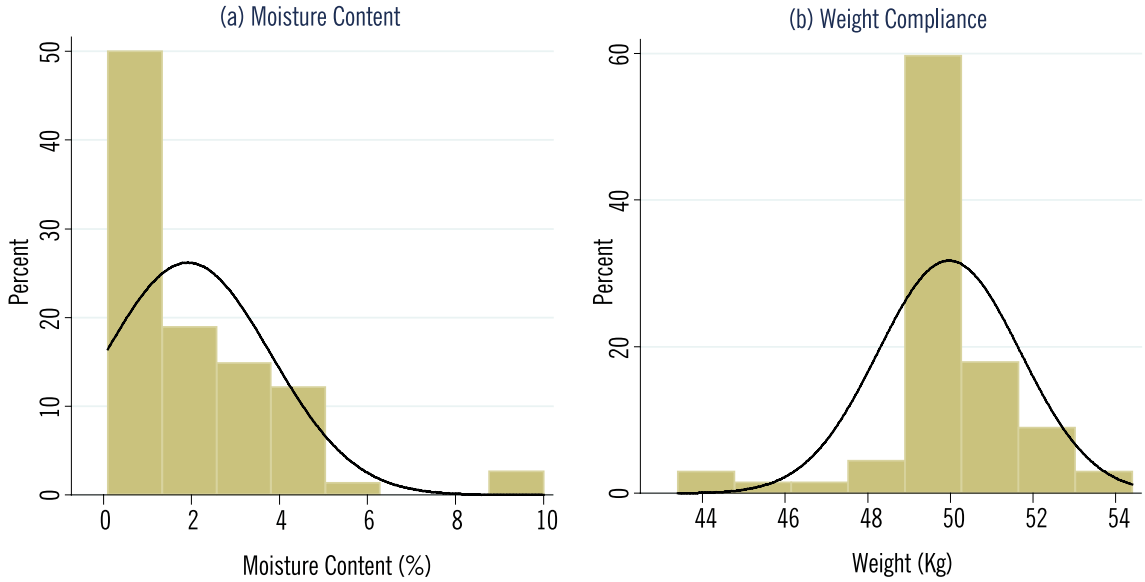
Figure 2 by implication, some fertiliser imports do not meet the required specifications. The moisture content varies at different stages of the fertiliser supply chain – from 1.59 percent at import level against 1.92 percent at retail level. At the retail level, extreme cases of the moisture was as high as 10 percent (Figure 3(a) to 4.3 percent at import level (Table 1). This is partly explained by the quality of storage facilities. By extension, on average, the moisture content seem to increase with re-packing of fertiliser into smaller packs. To illustrate this finding, the average for bulky fertiliser was 1.92 percent compared to 2.18 percent for small packs (see Table 1).

Figure 2: Quality of bulky fertilisers in terms of weight and moisture content at import level



Source: Fertiliser Market Survey, November 2014.

Figure 3: Quality of bulky fertilisers in terms of weight and moisture content at the retail level



Source: Fertiliser Market Survey, November 2014.

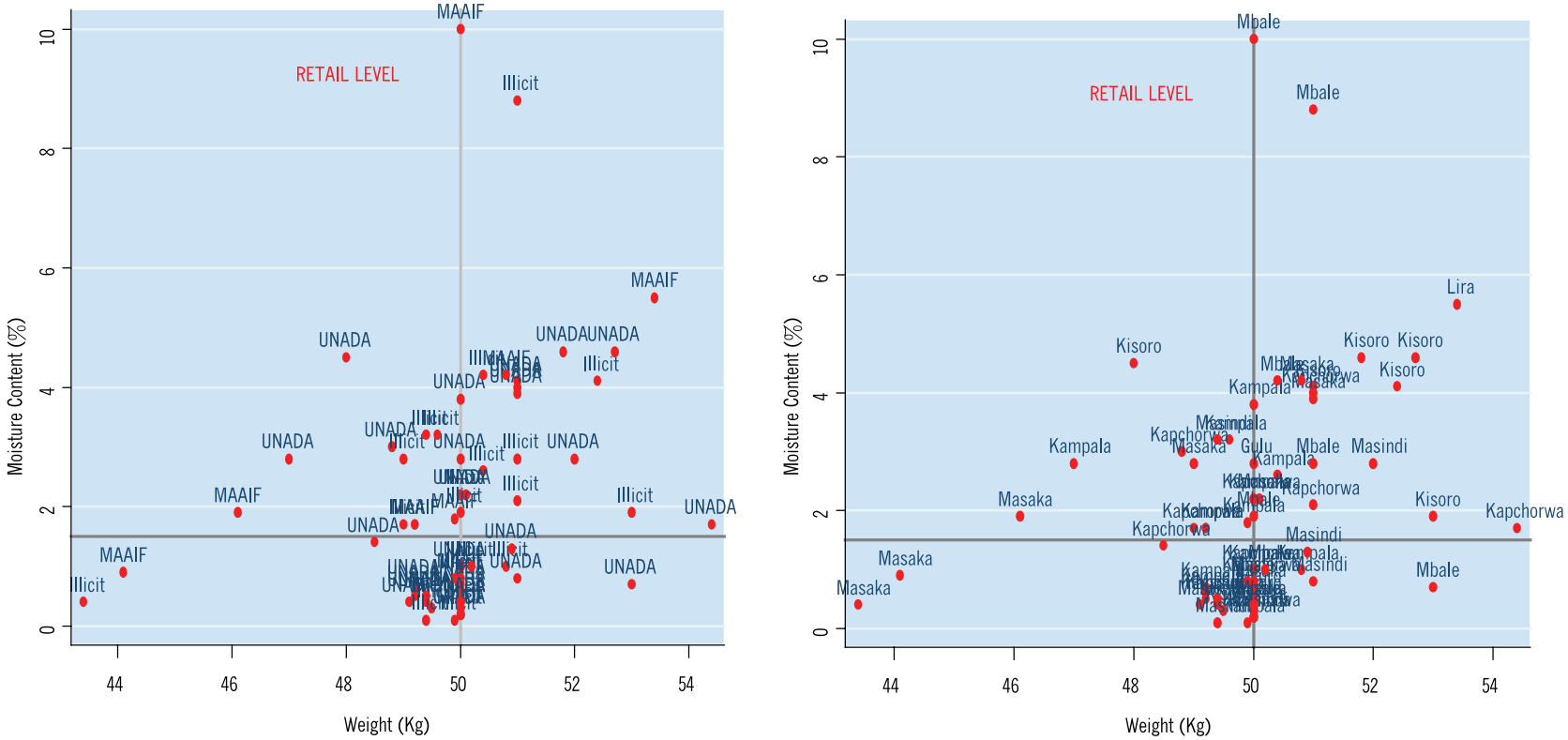
Table 1: Moisture content and weight by level

	Mean	STD	Minimum	Maximum	Sample
Moisture content, %					
Bulky samples					
Wholesale/import level	1.59	1.33	0.10	4.30	12
Retail level	1.92	1.88	0.10	10.00	74
Small packs	2.18	2.01	0.30	9.60	60
Weight, Kg					
Bulky samples					
Wholesale/import level	49.77	0.93	48.40	52.00	13
Retail level	49.97	1.72	43.40	54.40	67

Source: Fertiliser Market Survey, November 2014.

Most remarkably, under-weight was not a major problem both at import and retail level of the supply chain. **Error! Reference source not found.**(b) shows that nearly 60 percent of the samples at the retail level had weight within the permissible maximum deviation of ±0.5 kgs as stipulated in the Draft Fertilizer Control Regulations, (2012). Probably because most fertilizer dealers are aware that underweight is the parameter the farmers and any other suspicious client can detect easily.

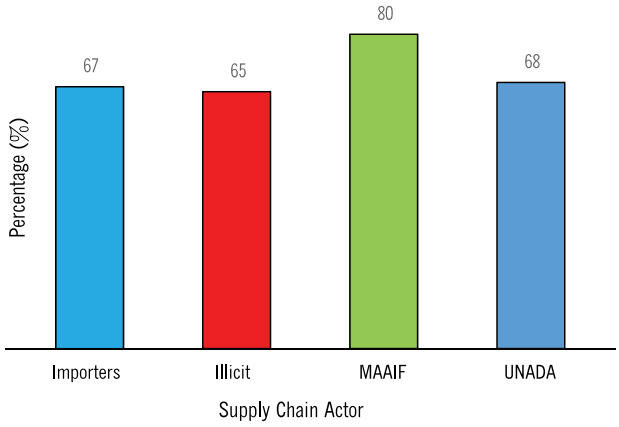
Figure 4: Quality of fertilisers in terms of weight and moisture content by regulation status (district)



Source: Fertiliser Market Survey, November 2014.

An extended analysis of the effect of the regulation and licensing on ensuring that fertilizers on the market are of the quality in terms of moisture content and weight was undertaken. Figure 4, shows no distinctive and exemplary quality pattern between samples procured from MAAIF licensed input retailers and samples from illicit (unregistered) traders and UNADA members. Bringing these attributes together, some observations emerge on the degree of non-compliance (see Figure 5). The non-compliance is within range for all other actors, with the exception of MAAIF registered actors. This finding would imply that MAAIF inspectors pay less attention, if any in enforcing fertilizer quality control measures among its registered input traders.

Figure 5: Share of non-compliant the 50kg bag sample fertiliser, %



By extension, the spread of the problem across the different districts does not exhibit a systematic trace of the problem along the supply chain (Figure 4). It is expected that fertilizer quality to decrease in more distant districts away from Kampala (where most wholesale trade by importers takes place) like; Lira, Kisoro and Masindi and Mbale. However, this is not the case – implying that probably the supply chain does not only originate in Kampala. Possibly cross-border trade in fertilizer contribute to the supply chain.

3.2.2 Chemical characterization of the fertilizers

The chemical composition of the fertilizers was analysed guided by the outlined nutrient content on the label of each fertilizer sample. The following section provides details of results from the laboratory analysis for each respective nutrient in the different fertilizers. The analysis considers the quality of fertilizers at both wholesale/import, and retail level. This provides for an opportunity to assess fertilizer quality at the different levels of the entire supply chain. In addition, the results provides insights into how re-packaging impacts on fertilizer quality in the Ugandan market across the different parts of the country. The results are presented in Table 2 and the discussion is by level and nutrient content.

a) Quality of fertilisers at import/wholesale level

In terms of nitrogen (N) content, the labels on the bulky samples of the Urea fertiliser indicated that it constituted 46 percent of nitrogen. The study results reveal that the nitrogen content was within the acceptable minimum range of 45-46 percent except for Mth importer. For the DAP fertiliser, N content almost matched that indicated on the labels of 18 percent. Put differently, the quality of both Urea and DAP imports was of satisfactory quality in terms of N content.

Table 2 further reveals that the nitrogen content of NPK and CAN fertiliser was below the specified content on the labels. Nitrogen content in the NPK fertiliser was in the range of 6-9.4 percent well below 17 percent of amount indicated on the labels; whereas for the CAN fertiliser ranged between 2.4 – 11.5 percent against the labelled nitrogen content (of 26 percent).

Considering phosphate and potash contents, the results in Table 2 show that imported fertilizers are of reasonable quality in respect of the two nutrients. The amount of K_2O in the imported NPK and MOP fertilisers are within acceptable limits with the exception of a sample from Oth importer – with potash content of 4.7 percent. Worth noting is the low amounts of calcium in the CAN fertilizers that ranged between 2.3 – 6.9 percent, which are below the critical level of 8 percent [Here the minimum requirement is based on literature since the fertiliser containers never indicated the content on the labels]. The study also encountered misleading labelling of fertilizer bags on the market (Plate

Table 2: Chemical characterisation by importer/wholesaler agent, %

Import/wholesale	Urea	DAP		NPK			MOP	CAN	
Agent	Nitrogen	Nitrogen	P_2O_5	Nitrogen	P_2O_5	K_2O	K_2O	Nitrogen	Ca
M	44.2	18.2	43.5	9.4	16.6	16.7	60.7	2.4	2.3
N	na	17.2	46.2	7.3	17.2	16.3	na	na	6.9
O	46.0	18.0	46.1	6.0	15.9	4.7	na	11.5	na
Q	46.7	18.7	46.4	8.9	16.4	21.0	67.9	na	Na
Labelled content[a]	46.0	18.0	46.0	17.0	17.0	17.0	60.0	26.0	8.0

Sources: [a] Fertiliser Control Regulation, 2012; the rest of the results based on the Fertiliser Markey Survey, November 2014.

Plate 2: Case of misleading labelling in Mbale district

- The label indicates NPK fertilizer with a nutrient content of 25:5:5+5S.
- In brackets the same label, indicated the fertilizer was MOP.
- It should be noted that MOP is not a compound fertilizer and it only contains potassium.
- The same label breaks down the nutrients showing water soluble phosphate (P_2O_5) as 60% contrary to what is in the main formulation of 25:5:5 (Plate 4).

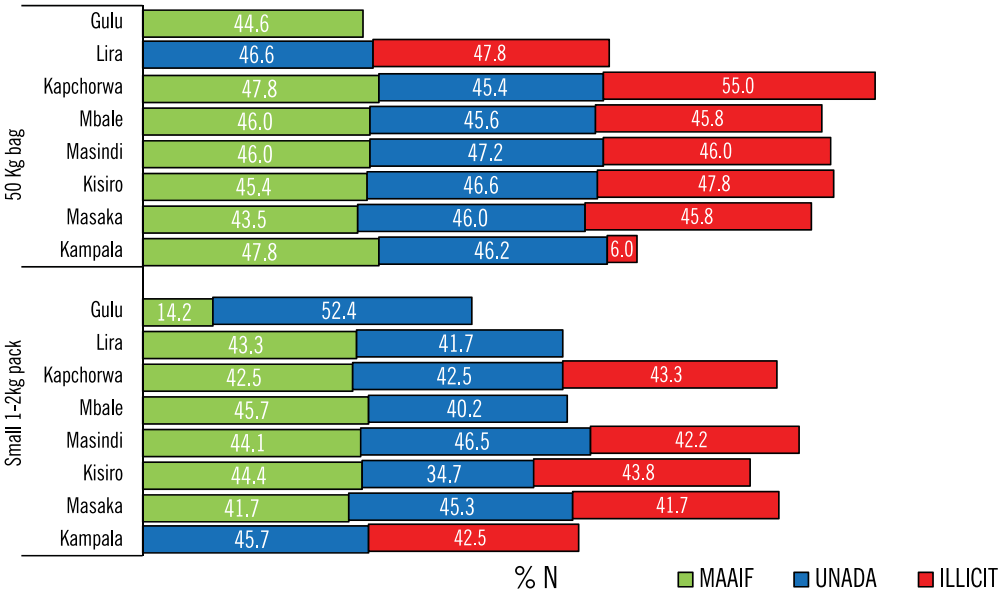
b) Quality of fertilizers at retail level

The size of the bar in Figures 6 to 14, represents the quantity of respective nutrient content in the fertilizer sample procured from a particular supply chain actors' store (i.e. importer; MAAIF or UNADA registered; and or unregistered dealers), located in the different part of the country.

Nitrogen Content

Figure reveals that the nitrogen content in the bulky samples of Urea was of satisfactory quality. The exceptions were for samples purchased from the MAAIF registered traders in the districts of Masaka (43.5 percent) and Gulu (44.6 percent), and an *illicit* traders in Kampala (6 percent) and Kapchorwa (55 percent). Yet, regardless of the licensing authority, the Nitrogen content decreases in smaller packs. This gives an indication that perhaps re-packaging encourages adulteration of urea. There are also district level variations noted for the small packs. For instance, the 1-2kg Urea packs from the UNADA traders in the districts of Kampala, Masaka, Gulu and Masindi; and the MAAIF trader in Mbale had satisfactory nitrogen content. However, there was no clear pattern on the impact of registration by MAAIF, and or membership to UNADA on the quality of urea sold.

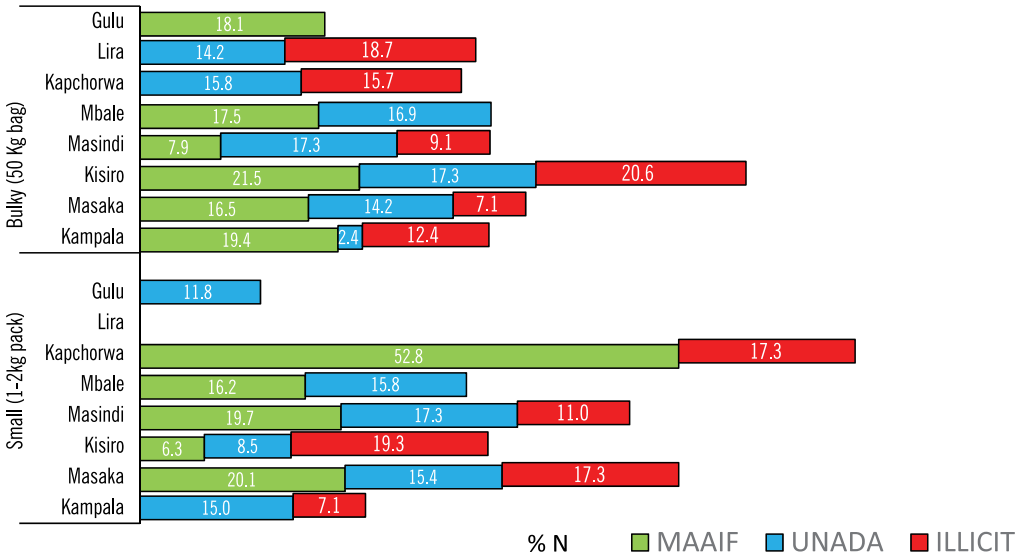
Figure 6: Nitrogen content in Urea for bulky and small packs



Source: Author's calculations based on the Fertiliser Market Survey, November 2014.

Turning to DAP fertiliser (Figure 7), there are wider variations in the nitrogen content across the sampled districts. The draft Fertilizer Control Regulations (2012) provides for minimum acceptable range of nitrogen (N) content by weight (dry basis) of 16-18 percent. Considering this regulatory provision, only traders in Kisoro district sold bulky DAP bags of the right nitrogen content. Just like urea, it is worth noting that no clear pattern is evident to trace the impact of re-packaging; and, licensing by MAAIF, and or membership to UNADA on the quality of DAP fertiliser.

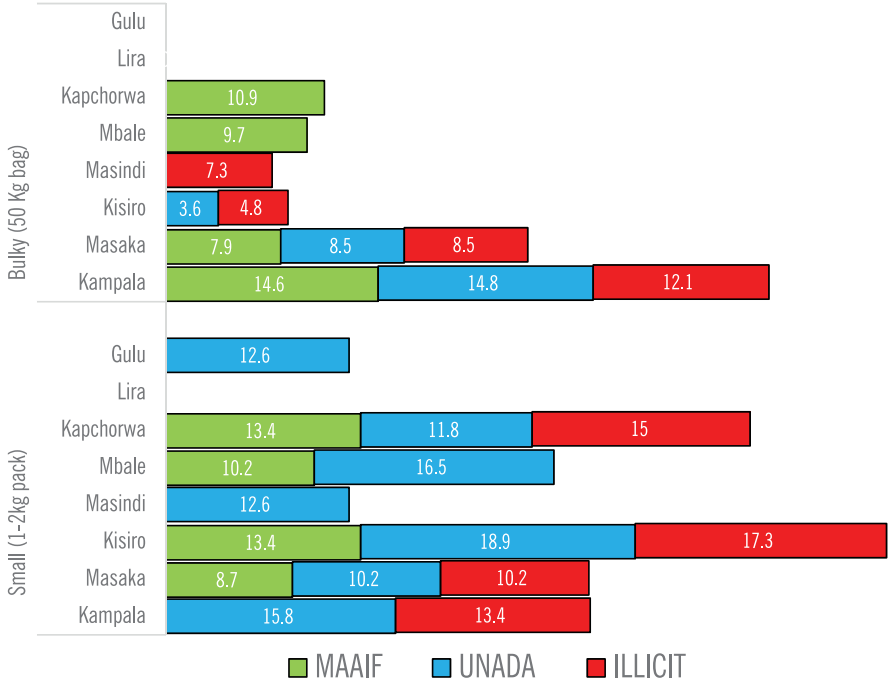
Figure 7: Nitrogen content in DAP fertiliser



Source: Author's calculations based on the Fertiliser Market Survey, November 2014.

Fertilizer samples of NPK (Figure 8) and CAN (Figure 9); had the poorest quality in terms of nitrogen content. None of the bulky samples tested had that content as specified on the labels. The worst case scenario was experienced in NPK fertilizer picked from the UNADA registered trader in Lira without a trace of N. This could be linked to mislabelling, a factor that needs more investigation. Interestingly, results (Figure 8) reveal that small packs of NPK had higher and better Nitrogen content than bulky samples across all study districts irrespective of the registration authority. This creates a complicated scenario whose cause is not very clear. Figure 6 reveals scarcity of NPK fertilizer in Gulu and Lira districts by the time of the survey.

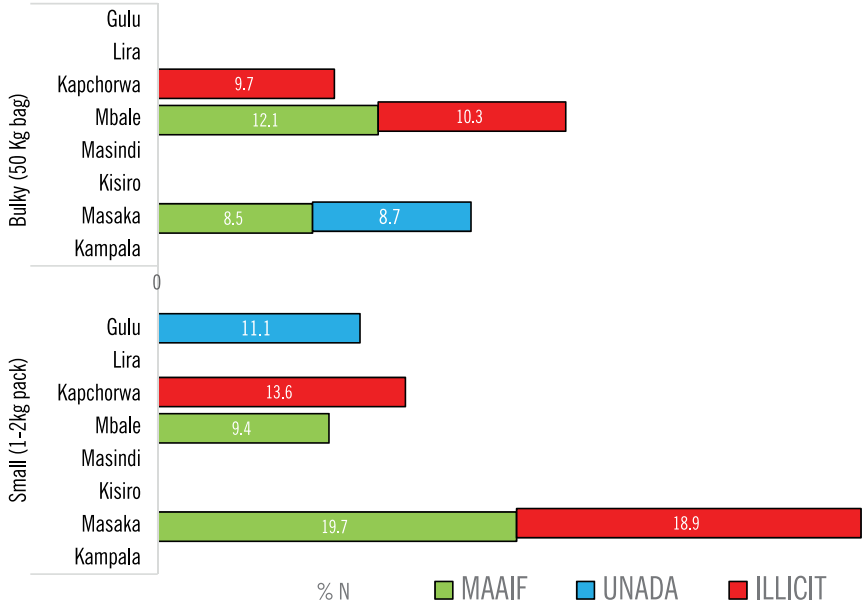
Figure 8: Nitrogen content in NPK



Source: Author's calculations based on the Fertiliser Market Survey, November 2014.

Among the target fertilizers, CAN is one of the least available type of chemical fertilizer on the Ugandan market. Notably in Figure 9, there were few dealers who had CAN fertilizer – for dealers in the districts of Masindi, Lira and Gulu. Either its demand is low or knowledge of its role in soil fertility management in Uganda is still low. It is also probably so because CAN only becomes a fertilizer of choice to urea in acid soils to avoid further lowering of pH that results from the urea mineralization process. The results show that the N content was less than half the declared or permissible amount. Similar to NPK, small packs of CAN were found to have better quality than the bulky samples across all study districts irrespective of the registration authority. It is yet to be established that the fertilizers for small packaging are not usually tempered with may be for fear of visibility of foreign material since repackaging is in clear bags. While the bulky bags had labels of 26 percent of Nitrogen, there was no declaration of Calcium content. This practise was also true at the import/wholesale level.

Figure 9: Nitrogen content in CAN

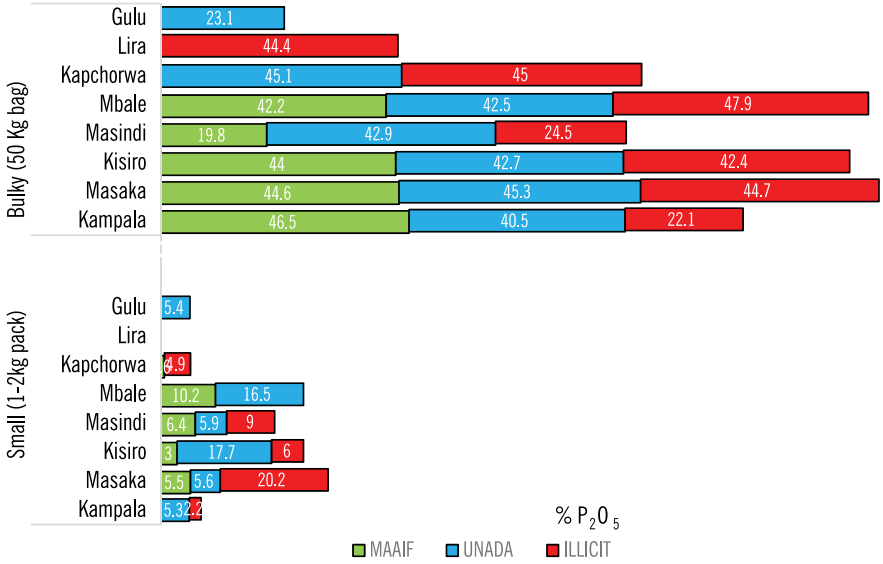


Source: Author's calculations based on the Fertiliser Market Survey, November 2014.

Phosphate content

The bulky sample of DAP fertilizer with very low phosphate were observed in the districts of Masindi, Gulu and Kampala (with an *illicit* dealer); while Masaka stood out with better quality DAP fertilizer (Figure 10). Across all districts irrespective of the registration authority and dealer membership, smaller packs had extremely lower content of phosphate compared to the bulky samples - again showing that re-packaging encourages adulteration of DAP.

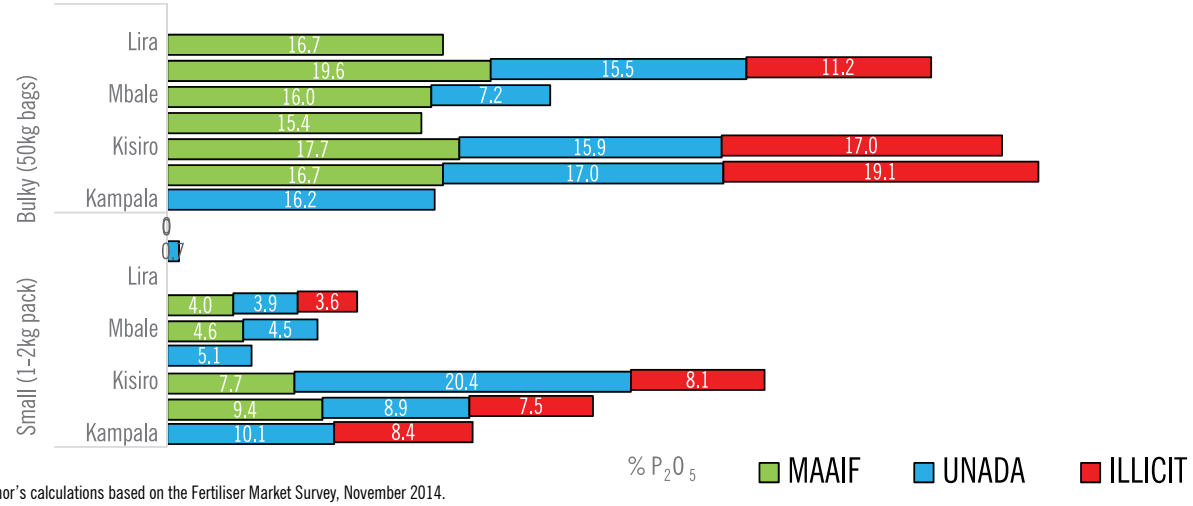
Figure 10: Phosphate content in DAP



Source: Author's calculations based on the Fertiliser Market Survey, November 2014.

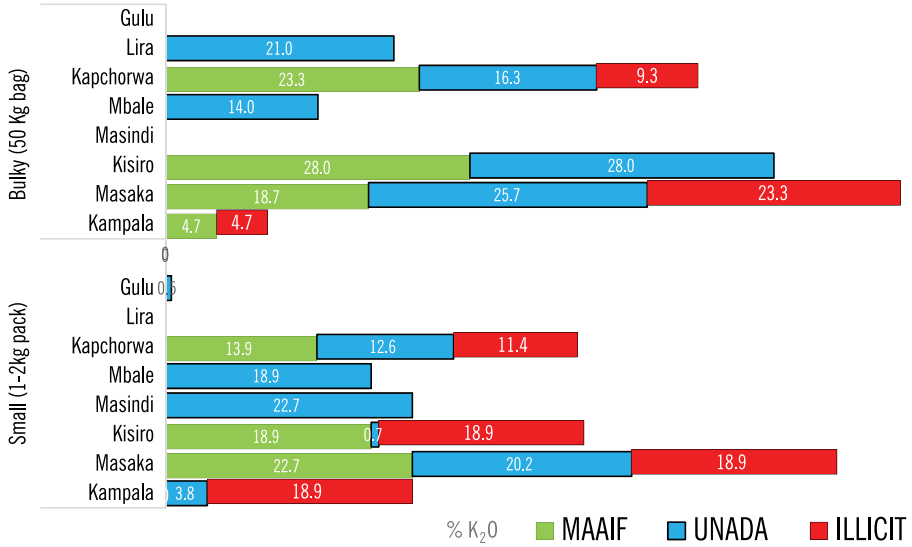
Phosphate content in bulky NPK (17:17:17) fertilizer bags across the sampled districts also varied though not very widely (Figure 11). The worst cases were in Mbale and Kapchorwa where the concentration was 7.2 percent and 11.2 percent respectively. Again, across all districts irrespective of the registration authority and dealer membership, smaller packs had lower content of phosphate, alluding to the fact that re-packaging offers opportunity to compromise the quality of NPK fertilizers. It is surprising (Figure 12), that most of the NPK fertilizers tested contained more percentage of potash than the amount indicated on the label of 17 percent for both bulky and small pack samples. This also further reveals the lack of a clear pattern to trace the impact of re-packaging; and, licensing by MAAIF, and or membership to UNADA on the quality of NPK on the market.

Figure 11: Phosphate content in NPK



Source: Author's calculations based on the Fertiliser Market Survey, November 2014.

Figure 12: Potash content in NPK

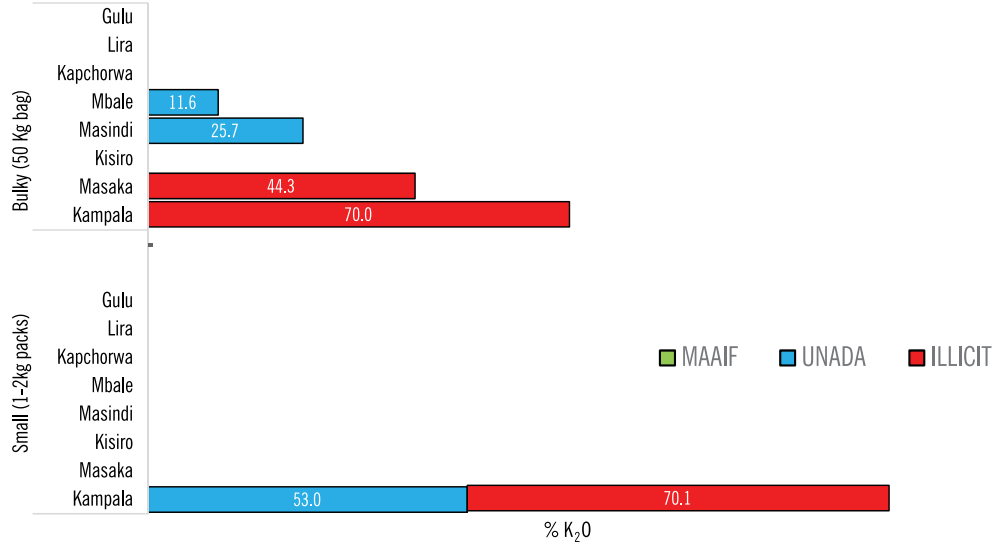


Source: Author's calculations based on the Fertiliser Market Survey, November 2014.

MOP was not well distributed among shops in the sampled districts and rarely sold in small packs – with the exception of Kampala (Figure 13). The few dealers who had MOP, the concentrations of potash was mostly below the quoted content of 60 percent except for the unregistered (illicit) trader in Kampala having about 70 percent potash in both the bulky and small packs samples. Observations from Figure 14 reveal that majority of the dealers had CAN fertilizers severely deficient in Ca content. There were fertilizers with as a low as 3.2 percent Ca.

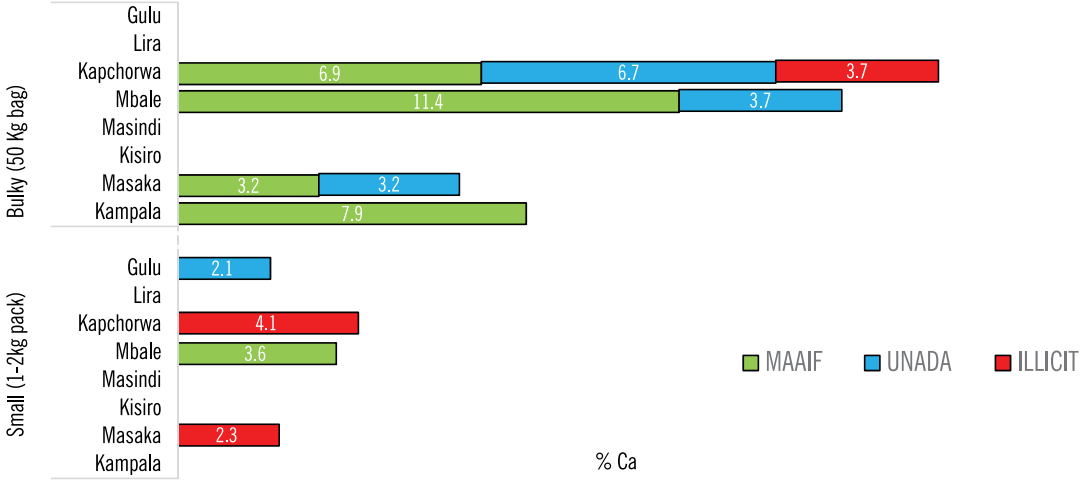
All in all, what is worth noting is the fact that on re-packaging, labelling is not done on smaller packs; information such as fertilizer type and nutrient content is missing. In some shops, neither the fertilizer types nor the content were indicated on the small packages implying that farmers have to rely on what the dealer states. This has wider implications in terms of farmers having the right information on fertilizers they buy and use (Namazi 2011).

Figure 13: Potash content in MOP



Source: Author's calculations based on the Fertiliser Market Survey, November 2014.

Figure 14: Calcium content in CAN



Source: Author's calculations based on the Fertiliser Market Survey, November 2014.

4. CONCLUSIONS

The paper provides insights into the quality of inorganic fertilisers along the supply chain on the Ugandan market. It focused on the commonly available fertilisers on the Ugandan market: including Urea, DAP, NPK, MOP, and CAN. The findings have shown that the quality varies along the supply chain, by bulkiness of the fertiliser, across and within districts. Some of the 50kg bags are underweight, and the moisture levels are above what is recommended. There is no impact of registration of fertilizer traders by MAAIF on the fertilizer quality. Likewise, membership to UNADA does not guarantee that dealers of fertilizer comply with quality standards. These findings point to the extent of weaker fertiliser policy and regulatory systems.

Broadly speaking, urea was the only fertilizers with a generally satisfactory nutrient content. Other fertilizers: DAP, NPK and CAN fall short on nutrient contents below what is prescribed on the labels. CAN and MOP in particular are among the fertilizers of poor entering the Ugandan market. The study findings tend to validate farmers' persistent complaints about the non-responsiveness of crops to fertilizer application. It is therefore true that the supply and thus, subsequent use of fertilizer with low nutrient content means that farmers cannot realise the benefits of fertilizer use especially improved crop and soil production and productivity across all crop value chains. This is a great disincentive to fertilizer use. This could probably be one of the factors contributing to Uganda's being among the World's least users of inorganic fertilizers.

There is also evidence of fertilizer users encountering labelling which is inconsistent with the contents of the fertilizers in the bag. Disturbingly, all fertilizers with deficient nutrient content were well labelled with proper grade analysis implying there is tempering along the supply chain. In some instances including importers, the nutrient content quoted on the labels did not match with the analytical content implying a high rate of quality inconsistences even at import level. This is more evident with DAP, NPK and CAN fertilizers. This has serious consequences because fertilizer recommendations are based on the nutrient content and if the nutrients are low, then the end-user will not attain the intended response by crop to the fertilizer.

It is difficult to underpin the most critical level where fertilizer quality is tampered with because deviations in quality were widespread within the entire supply chain. It was noted that even at the importer/wholesale level, there were cases where the quality was lacking. It, therefore, follows that the quality of imported fertilizer is suspect. Hence, this brings a scenario of either deliberate manufacture of low nutrient fertilizer by overseas manufacturers or the importers do not have the capacity to establish the quality of imports.

While re-packaging of fertiliser is justifiable on grounds that it enables small-holder farmers to access fertilisers, the study findings revealed that this practise encourages misconduct by the some input dealers. This has turned out to be a lucrative business for stockists but a cost to the already resource-constrained small-holder farmers.

Overall, the quality of bulky fertilizer (like CAN and DAP) in Kisoro district seemed to be of better quality compared to the rest of the sampled districts. This finding is greatly supported by the qualitative results that indicated a preference for fertilisers from Rwanda because of the perceived quality. The alternative explanation could be that Rwanda has stronger regulatory framework for imported fertilisers. While the survey did not cover farmers as end-users, the practise in Kisoro could also be explained by the farmers' level of knowledge and awareness. Definitely farmers' knowledge about fertilizer quality would be a strong and functional disincentive to adulteration. Therefore, empowering farmers with basic fertilizer quality analytical skills is imperative in fighting the vice.

5. POLICY ACTIONS

In view of these findings and given the underdeveloped fertiliser market in Uganda, the need to put in place a stronger regulatory framework cannot be overemphasised. Below are some of the policy actions that need to be addressed if Uganda is to enhance the productivity of its agricultural sector through fertiliser application:

(a) There is an urgent need to strengthen the fertilizer inspection unit in MAAIF to be able to routinely monitor the quality of fertilizers at all levels of the market chain. Ugandan fertilizer sector is largely weakly regulated due to weak enforcement of quality assurance mechanisms. Therefore, the government should be very strict on the quality of fertilizers starting with the points of entry into the country as fertilizer quality is suspect even at the import level. In addition, MAAIF should capacitate the private fertilizer sector to self-regulate so as to enforce compliance to truth in labelling within its membership;

(b) With an effective and efficient regulatory framework in place, fertiliser quality enforcement will be assured. The dealers will have no alternative but be compelled to import high quality fertilizers from legitimate overseas suppliers. The role of re-packaging fertilizers in small packs should be the responsibility of either the manufacturer or the importer so that there is no room for pre-opening of the bags before they are sold at retail level. Like the big bags, the small packs must be clearly well labelled;

(c) More importantly, fertilizer analytical services should be increased and strengthened countrywide to speed up tests and to ensure compliance at all levels. Also, much more effort should be directed towards strengthening of the fertilizer analytical skills of all fertilizer chain actors including farmers, importers, stockists, Agricultural Inspectors and analysts through development and dissemination of low cost quick fertilizer quality testing tool kits as well as equipping national fertilizer analytical laboratories. The strengthened fertilizer analytical capacities of fertilizer supply chain actors especially farmers who are largely victims will be a great disincentive to fertilizer adulteration. This will also entail establishment of a robust farmer-centred feedback mechanism; and

(d) The storage facilities and conditions (with a bearing on fertilizer moisture levels) therein should be set at inspection before registration of a fertilizer trader as a precondition for one to qualify. In addition, regular monitoring should be laid and adhered to without any fear or favour.

All the above outlined policy actions could be achieved by operationalization of the Fertilizer Regulations (MAAIF, June 2012), Fertilizer Policy (MAAIF, March, 2013), and National Fertilizer Strategy (MAAIF, March 2014) , which are yet to be tabled before cabinet for approval.

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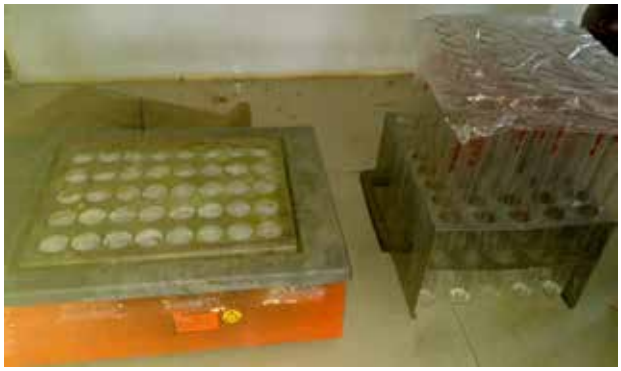
APPENDICES

Appendix 1: Summary of fertilizer analysis protocol

i) Nitrogen Content

Total nitrogen by the Kjeldahl method: The apparatus required included: Kjeldahl distillation unit; some flasks, beakers and pipettes; and a burette. The reagents required are: Standard acid (0.1M HCl); NaOH (40 percent) for distillation; and Boric acid (1 percent) containing a mixed indicator (bromocresol green, methyl red and thymol blue) – see Box A 1.

Box A 1: Block digester and set of digestion tubes containing completely digested samples



Procedure: This involved seven stages as below:

1. Weigh and put 0.2 g $\pm$ 0.02 of the fertilizer sample in a digestion tube.
2. Add slowly 5 ml of digestion mixture through the side of the flask so that the contents do not mix at once.
3. Put the tube on a digestion block and heat at 350 ^{o}C until clear solution is obtained.
4. Cool and dilute the digest to 50 ml with distilled water.
5. Take 5 ml of diluted digest into clean flask containing 10 ml of boric acid containing the mixed indicator and distil for about 5 minutes with 40 percent NaOH.
6. Titrate the distillate with standard 0.1M HCl to determine the amount of ammonia generated during distillation. The HCl used to neutralize ammonia is equivalent to the N content in the sample.
7. A blank sample must be included whose concentration is deducted from that of the fertilizer sample.

The percentage of N content (Np) is expressed as in Eq.

$$Np = (V_s - V_{blk}) * M_{HCl} * \left(\frac{50}{5}\right) * 0.014 * \left(\frac{100}{wt}\right) \quad (1)$$

Where:

- $V_s =$ titre (ml) of standard acid (0.1M HCl) for the sample;
- $V_{blk} =$ titre (ml) of standard acid (0.1M HCl) for the blank;
- $M_{HCl} =$ molarity of HCl;
- wt $=$ weight of the sample taken;
- 50/5 $=$ dilution factor;
- 0.014 $=$ equivalent weight of N (g); and
- 100 $=$ conversion factor to percentage.

Phosphorus content

Ascorbic acid spectrophotometric (Box A 2) method was used. In this method, ammonium molybdate and potassium antimonyl tartrate (as a mixed reagent) were reacted with the orthophosphate in the sample to form phosphomolybdic acid which was reduced to an intensively colored molybdenum blue by ascorbic acid. The color intensity developed was proportional to the amount of phosphate present and was measured at 880 nm with a 1 cm cell on a spectrophotometer. Prior to reading the samples on the spectrophotometer, calibration standards made using KH_2PO_4 ranging from 0 mg kg^{-1} to 10 mg kg^{-1} range and measured to obtain a standard curve that was used to determine sample P content. The derivation of the percentage of phosphorous (Pp) is expressed as in Eq. (2):

$$Pp = (C_s - C_{blk}) * \left(\frac{50}{wt}\right) * F * \left(\frac{1}{10000}\right) \quad (2)$$

Where:

- $C_s =$ concentration of P in sample in mg kg^{-1}
- $C_{blk} =$ concentration of P in blank in mg kg^{-1}

- 50 = total volume of sample digest
- wt = weight of sample digested
- F = dilution factor
- 1/10000 = conversion factor from mg to percentage

The obtained P content value was converted to P_2O_5 for matching with the content on the fertilizer labels as expressed in Eq (3):

$$\text{Percentage } P_2O_5 = Pp * 2.292 \quad (3)$$

Box A 2: Colorimetric reading of P using a Jenway Spectrophotometre

Potassium content

Potassium is measured using the flame emission photometry (see Box A 3) at a wavelength of 766.5 nm. The sample after digestion is diluted with de-ionized water and then measured on a flame photometer. To calibrate the machine, standards are made from KCl and working standards ranging from 0 to 10 mg kg^{-1} are constituted and read on the flame photometer to obtain a standard curve. The derivation of the percentage K (Cp) is as expressed in Eq. (4):

$$Cp = (C_s - C_{blk}) * \left(\frac{50}{wt}\right) * F * \left(\frac{1}{10000}\right) \quad (4)$$

Where:

- C_s = concentration of K in sample in mg kg^{-1}
- C_{blk} = concentration of K in blank in mg kg^{-1}
- 50 = total volume of sample digest
- Wt = weight of sample digested
- F = dilution factor
- 1/10000 = conversion factor from mg to percentage

The obtained K content value was converted to K_2O for matching with the content on the fertilizer labels as expressed in Eq. (5):

$$\% K_2O = Cp * 1.205 \quad (5)$$

Box A 3: Set up for the flame photometric reading of potassium

Calcium content

The extracts from digested samples were measured on an atomic absorption spectrophotometer (see Box A 4) after its calibration with known standards made using oven-dried anhydrous calcium carbonate ($CaCO_3$). The range of Ca standards was between 0 and 50 mg kg^{-1} Ca. In both the sample and standard solutions, an interference suppressor of lanthanum chloride was added. The calibration curve was then used to determine the amount of Ca in the fertilizer samples as expressed in Eq. (6):

$$Cap = (C_s - C_{blk}) * \left(\frac{50}{wt}\right) * F * \left(\frac{1}{10000}\right) \quad (6)$$

Where:

- C_s = concentration of Ca in sample in mg kg^{-1}
- C_{blk} = concentration of Ca in blank in mg kg^{-1}

- 50 = total volume of sample digest
- Wt = weight of sample digested
- F = dilution factor
- 1/10000 = conversion factor from mg to percentage

Box A 4: Automated atomic absorption spectrophotometre (AAS)

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