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Comparative Study of Urea in Prilled and Briquette Forms on Rice Production in Marshlands of Rwanda

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Abstract

Broadcasting of urea in prilled form is a common method of field application of fertilizer that is used in Rwanda as well as all over the world. This method results in loss of 35% nitrogen through, either being profited by weeds, leaching, runoff, de-nitrification and high cost incurred by farmers, to buy excess fertilizers and ultimately poor yield of rice. This study was conducted in Ntende marshland, Rugarama sector of Gatsibo District with the main objective of comparing the effect of prilled and briquette urea on soil quality and rice production, variety Yun yin used. The experiment was laid out in RCBD with three treatments and three replications.

The results from research have shown that: Nitrogen content increased from 0.17 to 0. 23% in Plot without urea (PWUB) and from 0.17 to 0.19% in plot without urea prilled (PWUP) and decreased in control from 0.17 to 0.11%, the best plant height of 117.77 cms was observed in PWUB and compared to PWUP (111.4 cms) and treatments were significantly different ($P \leq 0.001$) and PWUB recorded highest means of 2.7 tillers followed by PWUP with 25.7 tillers. The grain yield and weight of 1000 grains weight were significantly different ($P \leq 0.001$) and highest yield was recorded in PWUB (7.43 t/ha) compared to prilled form of urea (5.81 t/ha) and the lowest yield was recorded in control plot with a yield of 3.16 t/ha. The highest grain yield was observed in plots treated with urea in briquette form with 7.34 per hectare compared to those where urea was applied in prilled form with 5.81 and the least results were observed in control with 3.16 t/ha. Hence, applying urea briquette in paddy plantation should be sensitized and adopted by rice farmers, since the application of 65 Kg N/ha of briquette urea improved soil properties and rice productivity over 80 Kg N/ha of prilled urea.

Keywords: Urea fertilizer; Briquette forms; Marshland; Prilled forms; Rice production

Introduction

Rice is a staple food for almost half of the world's population and cultivated in wide range of environment [1]. In Rwanda, rice has been recognized as one of the most promising crop and this is due to increasing importance of rice as food both in urban communities and rural areas [2]. To meet the global rice demand, the production has to increase at the compound rate of 1.7% per year [3].

However, the agricultural input sector has critical impact on the rice productivity of a nation as it influences farmers' success to and use of productivity enhancing input like agrochemicals, fertilizer, and seed [3]. Low agricultural input use is often associated with declining soil fertility, declining yields, and low farmer income. Increased use of fertilizer and improved seeds as well as controlling pests and diseases using pesticides are partially credited with the large increases in agricultural productivity growth. It is evident that agrochemicals, fertilizer, and seed use must increase in Africa, if the continent is to see significant productivity growth [2].

Despite various national programs that were established to promote rice commodity chain and the importance of rice in combating hunger, raising farmer's income, farmers are experiencing low production [3].

Broadcasting of urea in prilled form is a common method of field application of fertilizer that is used in Rwanda as well as all over the world (www.ifdc.org). This method results in loss of 35% nitrogen through, either being profited by weeds, leaching, runoff, de-nitrification and high cost incurred by farmers, to buy excess fertilizers and ultimately poor yield of rice (www.ifdc.org). To mitigate these challenges, a method that relies on compacting prilled urea into briquette form, and placed 7-10 cms cm deep, where it reduces the chances of being lost 96%, thus allowing the achievement of the above stated objectives was developed through International Fertilizer Development center (IFDC).

Hence there is a need to adopt and devise new strategies that can while minimizing above stated losses, and achieve national goals as stated in national agricultural policy for rice commodity [3]. In the light of the above facts, a comparative study of prilled and briquette form on rice production was undertaken in Ntende marshland, Rugarama Sector of Gatsibo district.

Materials and Methodology

Experimental sites

Rwagitima-Ntende site is located in Eastern Province, in Gitoki; Rugarama and Rwimbogo Sectors of Gatsibo District and in Murundi Sector of Kayonza District. For the first time the Marshland has been rehabilitated with irrigation structure about 75 ha in 2003-2004 under Adventist Development and Relief Agency Project (ADRA). During years 2009-2010; the marshland was rehabilitated under Rural Sector Support Project (RSSP): the support was aimed at the construction of two water storage dams and irrigation infrastructures. Finally, an area of 900 Ha of the marshland was rehabilitated for rice growing.

Soil sampling and analysis

In order to know the soil quality, five locations were selected for each plot and soil from each location was sampled at a depth of 30 cm, using an auger mixed for making a composite sample of 0.5 kg was taken for each plot and used in analysis for each treatment. The soil was dried in oven, crushed, sieved as the procedure of analysis.

One sample was taken before planting from whole farm and one sample from each treatment in every block after experimentation which meant ten samples were taken in total. The analyses were done using appropriate methods, pH H_2O using pH-meter, pH KCl, total nitrogen using Kijeldhal method, available phosphorus using Mehlich III method, calcium and magnesium using Ethylene diaminetetra acetic Acid (EDTA) method and organic carbon as well as organic matter using calcinations method.

Calculation of amounts of nutrients supplied

Applied rates were calculated by taking recommended quantities per hectare and those required per 1.5 m^2 were deducted as following:

If we apply 200 Kg N.P.K 17.17.17/Ha, knowing that 100 Kg of N.P.K 17.17.17 Contains 17 Kg of nitrogen, phosphorus and potassium, it means that 200 Kg of the same fertilizer will supply 34 Kg of nitrogen, phosphorus and potassium and by applying 100 Kg of urea 46-0-0N/Ha that is 46 Kg of nitrogen /Ha for T_1.

Then total supply in nitrogen for T_1 is equal to 80 Kg N/Ha (34+46) equivalent to 12 g/1.5 $m^2$and 34 Kg/ha for P_2O_5 and K_2O equivalent to 5.1 Kg per 1.5 m^2.

For T_2, by applying 74 Kg of DAP 18-46-0/Ha+112.5 Kg/urea briquette(UB)46-0-0/ha+57 Kg KCl 0-0-60/Ha, knowing that 100 Kg of DAP 18-46-0 supply 18 Kg of nitrogen and 46 Kg of phosphorus, KCl supply 60 Kg of potassium/Ha only, Total Supply for T_2 is as follow:

If 100 Kg urea supplies 46 Kg N/Ha, then 112.5 Kg will supply 112.5*46/100=51.75 Kg N/ha. Therefore, total nitrogen supply per hectare is (51.75+13.32)=65.07 Kg N/ha equivalent to 9.76 g per 1.5 m^2 meter.

Equally phosphorus supply was

74 Kg DAP18-46-0

This is equivalent to 5.1 g P_2O_5

Potassium supply for T_2:

100 Kg KCl 60%/Ha supply 60 Kg /Ha of potassium, therefore to apply equal amounts of potassium only 57 Kg of KCl 60% was applied per hectare equivalent to 5.1 g/1.5 m^2.

Therefore, T_1 received 12 g of nitrogen, 5.1 g of phosphorus and potassium/ 1.5 m^2 whereas T_2 received 9.78 g of nitrogen and 5.1 g/1.5 m^2 of both phosphorus and potassium.

The experimental design

The experimental was laid out in a Randomized Complete Block Design (RCBD) with three treatments and three replications. Plot size of 2 × 1 m was considered with clearance between plot (m) and to the field perimeter (m) (Figure 1).

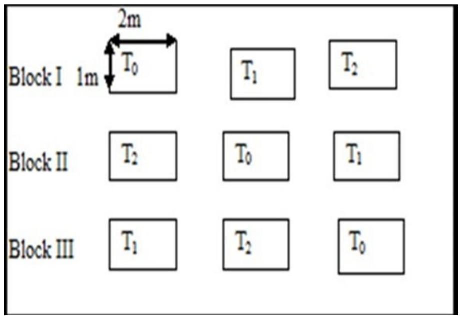

Figure 1: Experimental design.

T_0: plot without urea (PWU): Control (no fertilizer applied); T_1: Plot with urea prilled form (PUPF): Plot treated with urea in prilled form (200 Kg of N.P.K +100 Kg of Urea in prilledform); T_2: Plot with urea briquette form (PUBF): Plot treated with urea in briquette form (74 Kg DAP + 57 Kg KCl +112 Kg of urea in briquette).

Data collection

Soil samples were collected before planting and after the treatments, and used to study the effect of prilled and briquette urea on its pewter, pH KCl, total nitrogen, available phosphorus, calcium, and magnesium content. Further, data were collected on plant height number of tillers, panicle length, and number of panicle per plant, number of grains per panicle, grain yield and weight of 1000 grains.

Soil quality: Soil quality was determined by determining:

1. pH water and pH KCl values using pH-meter
2. Total nitrogen using kjeldhal method
3. Available phosphorus using mehlich III method
4. Exchangeable calcium and magnesium using EDTA method
5. Organic carbon using calcinations methods
6. Organic matter=% organic matter *1.724

Growth parameters

The number of tillers and height of plants was evaluated by counting tillers on each plant on 18 plants randomly chosen in each treatment on 45^{th}, 75^{th} and 90^{th} days after transplanting. Plant height was taken on the 45^{th}, 75^{th} and 90^{th} days after sowing using a graduated ruler on the 18 plants selected randomly in each plot and then the average plant height was calculated.

Yield parameters

Panicle length (cm): The length of each panicle among sampled ones was measured using a graduated ruler then the average length was calculated. Harvesting was done on the 172 days after transplantation and determining number of panicle per plant was done 10 days after harvesting.

Grain yield (t/ha): The total produce was weighed for determination of total quantity of dry rice in Kg per plot on 1.5 m^2 using electronic balance and thereafter the obtained weights (Kg/1.5 m^2 plot) were converted into t/ha.

Weight of 1000 grains: Here a thousand of seeds were counted and weighed using an electronic balance per plant 10 days after harvesting

Statistical analysis

The collected data have been analyzed by using the Microsoft Excel and the Gen-Stat software and ANOVA in order to determine where there were significant differences between the treatments. These treatment means were compared using least significant difference at $P \leq 0.05$.

Results and Discussion

The objective of our research was to compare the effect of prilled and briquette urea on rice production and on soil chemical properties changes before and after experimental. Results from analysis are presented here below.

Effect of prilled and briquette forms of urea on soil properties

The pH water, pH KCl, total nitrogen (%), available phosphorus, organic matter (%) and exchangeable calcium (meq/100 g) have been analyzed before and after experimentation. The Table 1 below shows the main values of results obtained after experimentation.

Parameter	To	T1	T2	Least significant difference
pH water (Average means of pH water values)	5.77	5.74	7.72	0.03023
pHKCl (Average means of pH KCl)	4.92	4.88	4.9	0.015
Total nitrogen (%)	0.11	0.19	0.23	0.022
Available phosphorus (ppm)	18.1	17.86	16.66	0.2069
Organic matter (%)	5.76	5.55	5.47	0.134
Exchangeable calcium (meq/100 g)	21.93	21.67	21.4	1.661
Exchangeable magnesium (meq/100 g)	5.92	5.41	5.26	0.1244

Table 1: Effects of prilled and briquette urea on soil properties.

Effects of prilled and briquette urea on pH, water and pH KCl: PH water decreased during the experimentation as shown by above table. There was no change in pH_2O and pHKCl in control plots. pH KCl decreased from 4.92 to 4.90 in plots fertilized with urea in briquette form and 4.92 to 4.88 where urea was applied as prills. This decrease in pH_2O and pH KCl values in plots where urea was applied because urea was an acidifying fertilizer making the soil to become acidic. Similar aspects were also investigated by [4] who reported that fertilizer nitrogen, apart from increasing the content of nitrate in soil that leads to its leaching, resulting in changes in soil pH and other soil properties. However, the change observed was significantly different (p=0.006 for pH water and p=0.032 for pH KCL) between treatments and according to [5], if pH_2O ranged between 5.2-6.2, such soils categorised as a moderately acidic class.

Effects of prilled and briquette urea on total nitrogen, available phosphorus and organic matter: As presented in Table 1, it is clear that nitrogen content increased from 0.17 to 0. 23% in plots with urea briquette and from 0.17 to 0.19% with urea prills and decreased in control from 0.17 to 0.11%. The increase was significantly different between treatments each other and can be explained by the fact that the application of nitrogen increased nitrogen content of the soil. IFDC by the year 2012 in Bangladesh, a study on comparative effect of urea briquette and urea prills on paddy production in Bangladesh, reported an increase in soil nitrogen content from 23% (when urea is broadcasted) to 42% (through urea deep placement) thus reducing nitrogen loss to the environment from 35% to 4%. According to classification made by [5], these soils belong to a medium class since nitrogen ranges between 0.075-0.2%.

Available phosphorus decreased from 21.3 ppm to 16.66 ppm in plots with urea briquette and to 17.86 ppm with urea prills and belongs to a low category. Organic matter content decreased in plot with urea briquette from 6.4 to 5.47 and to 5.55 with urea prills and 5.76 for control. Nitrogen and phosphorus content of the soil in treatments were significantly different (P=0.009), between treatments and according to a classification made by [5], the soils belong to a medium class. This is because the availability of nitrogen in the root-zone calls for enhanced absorption of other nutrients such as phosphorus, potassium, calcium, magnesium; etc.

However, the decrease in organic matter was not significantly different between treatments since p=0.481). This is also conforming the findings of [6], who reported the decreasing trend in the content of Mg, Ca, P, and K in the studied surface soil, compared to the control while studying performance of promising rice varieties under different rates of nitrogen fertilization.

Effects of prilled and briquette urea on calcium and magnesium content of the soil: As presented in Table 2, plots treated with urea briquette showed high reduction in calcium and magnesium from 25.8 to 21.4 m eq/100 g for calcium and 6.41 to 5.26 c mol/Kg for magnesium compared to those plots with urea prills where calcium decreased from 25.8 to 21.67 m eq/100 g for calcium and from 6.41 to 5.41 m eq/100 g for magnesium. This decrease was not significantly different between treatments since (p=0.696). Since calcium values ranged between 2 and 4 whereas magnesium ranged between 3 and 8 c mol/Kg, according to [5] and such soils belong to the 'high' category.

Effect of prilled and briquette urea on growth parameters

Table 2 presents the mean comparison (p=0.05) of plant height between treatments at 45th, 75th and 90 days after transplanting. As shown in the table below, at all dates best plant height were recorded in plots which urea in briquette form was applied with 77.8, 109.8 and 117.77cm followed by those in which urea was applied in prilled form with 73.43, 105.8 and 111.4 cm respectively, whereas the least results were observed in plots which received no urea (control) with 67.47, 98.07 and 102.23 cms.

Treatments	Days after Transplanting		
	45	75	90
T_0	67.47	98.07	102.23
T_1	73.43	105.8	111.4
T_2	77.8	109.8	117.77
Least significant difference	0.47	0.528	1.269

Table 2: Effect of prilled and briquette urea on plant height.

The results from ANOVA table showed that the difference was highly significant between treatments (P<0.001). This means that the effect of urea in briquette and prilled forms on rice productivity is statistically significant (l.s.d ≤ 0.05). The increased plant height is an effect of fertilizer best management practices. Urea supplies nitrogen, which chemical is responsible for vegetative growth of crops. Thus, top dressing crops with urea at critical stages of plant growth can result in increased plant height compared to those which did not receive. On the other hand, fertilizer application methods have an effect on the way crops benefit from applied fertilizers. Farmers use topdressing their rice plantation with urea in prilled form through broadcasting whereas the application of urea in briquette form is done through deep placement (7 cm deep).

This deep placement of urea keeps nitrogen in the soil in the form of ammonium which is less mobile than nitrates and makes available nitrogen to rice longer period throughout boosting its vegetative growth. Therefore, deep placement reduces chances for applied nitrogen to be leached, volatilized, nitrified, and denitrified, contributing to its availability and absorption by crops which in turn results in increased plant compared to plots where urea was broadcasted and above stated losses occur and being characterized by stunted growth.

These results are in conformity to the findings of [7] who reported that the increase in plant height in response to application of nitrogen fertilizers was probably due to enhanced availability of nitrogen which enhanced more leaf area resulting in higher photo-assimilates and thereby resulted in higher dry matter accumulation. These results are supported by [8] who also reported similar observation.

Effect of prilled and briquette urea on number of tillers

The Table 3 presents the mean comparison at 5% significance level on number of tillers between treatments as at 45th, 75th and 90 days after transplanting. As shows the results, the best number of tillers were recorded in plots which were treated with urea in briquette form with 21.6, 27.0 followed by plots in which urea was applied in prilled form with 19.23, 25.7 and the least results were recorded in control plots with 16.43, 20.97 respectively. Results from ANOVA showed that means were significantly different (P ≤ 0.001) between treatments.

Treatments	Days after transplanting		
	45	75	90
T_0	16.433	20.97	20.97
T_1	19.23	25.7	25.7
T_2	21.6	27	27
Least significant difference	0.34	1.657	1.657

Table 3: Effects of prilled and briquette urea on number of tillers.

This increased number of tillers in plots where urea was applied in briquette form compared to prilled forms is due to the effect of difference in nitrogen availability throughout the growth cycle in these plots. Adequate plant nutrition with nitrogen resulted in increased tillering of plants with tillering ability like rice. This increased number of tillers in plots where urea was applied in briquette form compared to those where urea was broadcasted in prilled form, also, this could be due to the effect of abundance of nitrogen in the root zone. Nitrogen drives the demand for other macronutrients such as Phosphorus and Potassium. Nitrogen supplied through urea is a key element in the synthesis of proteins, nucleic acids, amino-acids, etc in rice.

Whereas nucleic acids are essential in cell division, their synthesis in greater quantity calls on cell division and tissue differentiation to take place which occur through growth and development of rice. This cell division process calls on cell division enzymes to be released and as this process enhances hormones responsible for new plant tissue and organs are also released. These results are confirming what was found by [9] who reported that nitrogen fertilizer application increased significantly tillers per paddy plant. More number of tillers in experiment might be due to the more availability of nitrogen that played a vital role in cell division.

These results are in accordance to the findings of [10]. According to them, as the amount of nitrogen absorbed by the crop increases, the number of tillers increases as well.

Effects of prilled and briquette urea on panicle length

As it is shown by the Table 4, longest panicle length of with 21.3 cms was recorded in plots with urea briquette followed by those subjected to prilled urea with 19.11 cm and the least results were observed in control plots with 17.9 cm. Results from ANOVA, showed a highly significant difference (P ≤ 0.001) between treatments for their panicle length. The logic behind is that, nitrogen is an essential constituent of amino acids, nucleic acids, nucleotides, and chlorophyll. Nucleic acids are important in cell division, whereas nucleic acids are essential in cell division, their synthesis in greater quantity calls on cell division and tissue differentiation to take place which produced new cells contributes to tissue and plant organ development. These results are [11] who reported that increased panicle length might be due to cell division and tissue differentiation enhanced at flowering stage.

Treatments	Panicle length
T_0	17.9
T_1	19.11
T_2	21.3
Least significant difference	0.3294

Table 4: Effects of prilled and briquette urea on panicle length.

Effect of prilled and briquette urea on rice yield

Table 5 presents the mean comparison at 5% significance level between treatments on grain yield and weight of 1000 grains. Results from ANOVA for grain yield and weight of 1000 grains, results showed a highly significant difference (P ≤ 0.001) between treatments [12-15].

Treatments	Grain yield (t/ha)	Incremental yield	Weight of 1000 grains (gr)
T_0	3.16		24.53
T_1	5.81	1.53	27.67
T_2	7.34		29.16
General mean	5.43		27.12
Least significant difference	0.2759		0.77

Table 5: Effect of prilled and briquette urea on grain yield and weight of 1000 grains.

As shows the results, the highest grain yield was observed in plots treated with urea in briquette form with 7.34 t/ha compared to those where urea was applied in prilled form with 5.81 tons and the least results were observed in control with 3.16 t/ha. Similarly, the best weight of 1000 grains was recorded in plots subjected to urea in briquette form with 29.16 grams followed by those subjected to urea in prilled form with 27.67 grams and the lowest weight of 1000 grains were observed in control plot with 24.53 grams. Grains accumulate product of photosynthesis, proteins, lipids, vitamins, etc., and hence there was an incremental yield of 1.53 tones/ha which was equivalent to 20.84% surplus. These results are in the range of those observations reported by while carrying out a similar study on rice productivity in Bangladesh where an incremental yield of up to 25% were recorded [16-18].

Conclusion and Recommendation

This study was conducted in Ntende marshland Gatsibo district with the objective of comparing the effect of prilled and briquette urea on soil quality and rice production case study in Ntende marsh land, Gatsibo district. As shown by results in above chapter, except results showed the observed significant difference on growth and yield parameter of rice, variety 'Yun yin' was attributed to nitrogen availability throughout rice growth cycle in plots in which received urea in briquette formand slightly available in plots which received urea in prilled form. Enhanced plant height and tillering by increased nitrogen application might be attributed to more nitrogen supply to plant at active tillering stage. Nitrogen is a basic chemical in the manufacturing of these proteins, nucleic acids, amino-acids, a component of chlorophyll whose deficiency or insufficiency result in poor photosynthetic activity, poor synthesis of above stated products and which contribute to grain filling, results in low yield and light weight or even empty grains [19-22].

These results confirm that numbers of tillers per unit are the most important component of yield. More the number of tillers, especially fertile tillers, the more will be the yield and it appears that the application of nitrogen increased the protein percentage, which in turn increased the grain yield and weight of 1000 grains.

Applying urea briquette in paddy plantation should be recommended for sensitizing and adoption by rice farmers and rice farmer cooperatives for improvement of soil properties and rice productivity [23-29].

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