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Efficiency of Black Urea Fertilizer over White Urea

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Abstract

To reduce the loss of nitrogen and to improve cost effectiveness as well as plant nitrogen content, a humic acid coated urea fertilizer, called Black Urea is used in the present experiment. Four sets of pot experiment was conducted here to compare the efficiency of black urea fertilizer over conventional white urea. Kalmi, a fast growing, leafy vegetable, was allowed to grow for 60 days to carry out this experiment. After harvesting, both the root and shoot growth of the plants for all four sets of experiment and the available N and P content was calculated. In addition to that plant protein content was analyzed to draw the conclusion undoubtedly. Black urea was evidenced to posses better efficiency over white urea fertilizer as far as the nutritional quality and cost of the experiment was concerned.

Keywords: Black urea, efficiency, White urea.

1. Introduction

Nitrogen, the most essential plant nutrient, is an integral component of many essential compounds like amino acids, enzymes, nucleic acids and chlorophyll. This element is vitally important for carbohydrate use within plants and for stimulating root growth and development as well as the uptake of other nutrients. To ensure desired production of crops, N is applied to soils in different plant available forms at different rates. Most commercial fertilizers supply N in soluble forms, such as nitrate (NO^{-3}) or ammonium (NH^{+4}) or as urea [$CO(NH_2)_2$], which rapidly hydrolyzes to form ammonium (Brady and Weil 2004).

Most crops on all soils are found to respond on N-applications as urea fertilizers. In fact, an increase of two to threefold is common for most crops including rice with N-fertilizers over no fertilizer. N-fertilizers, especially urea, have received special attention as fertilizer material within the last 40 years or so (Tisdale *et al*. 1985) and have occupied the major portion of fertilizer use in the world. The N-fertilizer consumption in Bangladesh during 2010-2011 was more than 3 million metric tons (Imamul Huq and Shoaib 2013).

Though used universally, many agriculturists have reservations about using urea and its cost effectiveness because of potential problems related to (i)harmful effects of biuret on germination and early growth of seedlings, (ii)phytotoxicity of urea due to release of ammonia and/or accumulation of nitrite, and (iii)a great loss of nitrogen as ammonia. But, practical experience with urea during the past 15 to 20 years or so has shown that it can be proved with better results and with higher cost effectiveness if a bit manipulated and used properly (Tisdale *et al*. 1985).

Pure urea contains 45-46% N by composition which is a great source of available nitrogen supply to the plants. Upon application to soil, urea is acted on by the enzyme urease, which hydrolyzes it to ultimately ammonia and carbon dioxide through an unstable intermediate product of ammonium carbamate.

$$CO(NH_2)_2 + H_2O \rightarrow H_2NCOONH_4 \rightarrow 2NH_3 + CO_2$$

These hydrolysis and nitrification take place before urea becomes abundantly available to most crops, which proceed rapidly in warm, moist soils. Although urea is considered a slow-release fertilizer, most of the available nitrogen lost from the soil within a few days by different processes like volatilization, denitrification, fixation by soil minerals and humus or immobilization, leaching, run-off and erosion. These processes result a loss of 10-15% of the total applied urea.

To enhance the effectiveness, increase the release time and lowering the manufacturing costs of urea, different scientific measures have been adopted gradually. Urea solution with 1.5% biuret, formaldehyde treated urea and most importantly, productions of granular urea are the evidences of the measures. Granular urea's crushing strength and resistance to mechanical breakdown is more than twice that of urea prills. Another advanced step to improve the effectiveness of urea fertilizer is coating of urea granules by other nutrient elements like sulfur coated urea, phosphate coated urea and coating of calcium or magnesium chloride or nitrate on urea. The latest invention in the N fertilizer world is the carbon coated urea, termed as Black Urea, which is claimed to be more efficient and cost effective N fertilizer as other nutrient elements like phosphorus and potassium are also incorporated.

Black Urea is a granulated urea, coated in an organic complex of carbon and other biological stimulants that increase the microbial activity around the granule optimizing nitrogen use efficiency.

Black Urea works by making small improvements to each leg of the nitrogen cycle. By using biological processes to stabilize nutrients in the soil, nitrogen losses via volatilization and leaching, can be significantly reduced (Web-1). It is specifically targeted to improve profits on low fertility soils. Application in concert with sustainable farming practices such as incorporation, split application and irrigation management will produce best results (Web-2).

The use of Black Urea is claimed to be beneficial over white urea as the nitrogen availability is better controlled which maximizes nitrogen use efficiency, burning potential is lowered, potential losses of nitrogen via volatilization and leaching and their impacts on environment are reduced and soil microbial activity as well as nutrient availability is increased due to having 21% carbon in it (Web-1). The main objective of this research was to justify these claims.

2. Methodology

For conducting a comparative study of the efficiency of black and white urea fertilizer, a pot experiment was carried out with a green leafy-vegetable: Kalmi (*Ipomoea aquatica*).

A composite soil sample was collected from the surface (0-15 cm) of the field of Bangladesh Jute Research Institute (BJRI) of Manikgonj district (23º52'60" N and 90º02'12" E) as suggested by the Soil Survey Staff of the USDA (1951) to conduct the research work. After removing visible roots and debris, the collected soil samples were air-dried, ground and divided into two portions. A small portion of the soil was passed through a 0.5mm sieve for determining some chemical and physico-chemical parameters for the background information of the soil. The bulk sample was screened through a 5mm sieve and used for pot experiment. The design of the pot arrangement with symbols and elaborations are given in Table 1.

Table 1. The design of the pot arrangement with symbols and elaborations

Set	Symbol	Elaboration	Replications
1	C	Control: No fertilizer	3 (C-1, C-2, C-3)
2	WU	Recommended dose of white urea + equivalent amount of P,K,S fertilizer present in black urea sample	3(WU-1, WU-2, WU-3)
3	BU	Black urea (equivalent to the amount of white urea recommended)	3 (BU-1, BU-2, BU-3)
4	OPT	Recommended optimum doses of all fertilizers (N, P, K, S) for high yield goal	3 (OPT-1, OPT-2, OPT-3)

According to Table 1, there were four sets of pots with three replications and 1 kg of soil in each. Recommended doses of BU and WU fertilizers were applied to three sets and the other was kept as control one. Additional amount of TSP was also added to the pots of WU fertilizer and the pot of optimum (OPT) level fertilizer experiments as recommended in the Fertilizer Recommendation Guide (BARC 2005).

It is to be mentioned here that, all the fertilizers that are added to the soil were also analyzed before the application to ensure the content of nutrient elements. Analytical results for nitrogen (N) and phosphorus (P) content for the used fertilizer materials are given below in table 2.

Table 2. Analytical result of used fertilizers

Name of fertilizer	N(%)	P(%)
Black urea (BU)	38.2	7.2
White urea (WU)	29.9	1.9
Triple superphosphate (TSP)	-	16.32

Table 2 ensures that the content of available N and P is much higher in BU than WU. Probably, a certain percentage of phosphetic fertilizer is mixed with the BU fertilizer to enhance its efficiency over WU fertilizers in case of increasing both the productivity of crops and the cost-effectiveness of using commercial fertilizers.

As, BU ensures a certain percentage of P content, no TSP was added to the pot of BU treatment. Factorial experiment was followed to conduct the research.

Kalmi seeds were sown in each pot, watered regularly and allowed to grow for forty days. Then the plants were harvested by uprooting, washed, wiped thoroughly and cut to measure the length and weight of both root and shoot of plants. The plant samples were then oven dried, ground and sieved through a 0.2mm sieve for further analysis. The processed plant samples were digested with H_2SO_4 to determine total N and with ternary acid mixture (HNO_3:H_2SO_4:$HClO_4$ = 5:2:1) to quantify the nutritional elements so that the effects of black and white urea fertilizers can be evaluated.

3. Results and Discussions

The root:shoot ratio of Kalmi, fertilized with black urea, was found to be lower in comparison to others (Table 3) which indicates that black urea promotes better growth of roots compared to the white urea. The root-shoot ratio for the plants grown with other treatments was more or less similar. White urea failed to impose better effect on root growth like the black one. The growth of the above ground parts and the underground parts of Kalmi as affected by the two different types of urea and different doses along with a control one are shown in Table 3. The root and shoot growth was calculated as the fresh and dry weight basis (g/100 plants).

Table 3. Root-shoot ratio and plant growth on fresh and dry weight basis (g/100 plants) for different treatments

Treatment	**Root:Shoot**	**Fresh weight (g/100 plants)**			**Dry weight (g/100 plants)**		
		Root	**Shoot**	**Total**	**Root**	**Shoot**	**Total**
C	1:5.8	5.83	116.29	122.12	0.39	6.50	6.89
BU	1:4.8	11.8	145.02	156.82	0.72	9.16	9.88
WU	1:5.6	10.74	129.13	139.87	0.48	8.09	8.57
OPT	1:5.9	9.12	123.09	132.21	0.41	8.04	8.45

Nitrogen content in plant root and shoot parts differed markedly with different fertilizers. It is observed from Table 4 that, N content in both the root and shoot were found to be greater in case of black urea treatment in comparison to others. It is also noticed that the growth of plant roots is more pronounced with the application of both black and white urea fertilizers. A common trend of a bit lower content of N in shoot than root N content for the fertilizers is also clearly observed from Table 4.

Table 4. Nitrogen and phosphorus content in plant root and shoot

Treatment	Plant N (%)		Plant P (%)	
	Root	Shoot	Root	Shoot
C	0.41	0.39	0.22	0.19
BU	1.48	1.11	0.27	0.25
WU	1.18	0.97	0.31	0.28
OPT	1.03	0.86	0.38	0.29
LSD at 5%	0.04	0.09	0.11	0.07

It is apparent from the same table that, BU caused higher accumulation of N in both root and shoot. This concentration was significantly higher than the controlled plants and the plants grown with optimum fertilizer application. This is may be due to the reason that BU works by ensuring small improvements to each leg of the nitrogen cycle, which is by the fact of using biological processes to stabilize nutrients in the soil and reducing the chances of losses of nitrogen via volatilization or leaching, significantly (Web-1).This results in a significantly improved level of nitrogen available for plant uptake, which ensures maximum plant performance, reduced environmental impact and improved cost effectiveness. Many research trials over the past decade were evidenced to show the similar result that BU is at least 25% more efficient than WU (Web-3).

In case of P, plant roots were found to posses better content of P (Table 4) than the shoot parts. The reasons for higher P content in plant roots may be, a variety of strategies, including alteration of root structure and function as well as modification of the rhizosphere, which plants evolve to increase the uptake of P from the soil. Phosphorus in the rhizosphere moves to the root by diffusion, where it is transported into the roots by an active high-affinity process (Grennan, 2008).

The root and shoots of the plants from control treatment (C) showed lower P content than all other treatments. Though no TSP was added to the C treatment pots, plant root and shoots exhibited a minimum content of P which may be taken up from the soil P content reserves. BU possessed better accumulation of P in comparison to other treatments though no additional phosphate fertilizer was incorporated. On the other hand, both the WU and OPT treatments failed to show any satisfactory level of P content even after being incorporated with recommended amount of TSP. The reasons for a little more content of P in both root and shoot of plants from WU and OPT treatments may be the incorporation of TSP fertilizer in soils of these pots. So, it can be said that, BU may impose better effect on P content than WU if incorporated with TSP; which may result in better growth and nutritional quality of plants as well as economic feasibility of farmers.

But, as BU promotes better growth (on both fresh and dry weight basis) for the total plant, especially for the roots, the uptake of both the nutrients (N and P) is found to be greater than WU fertilizer.

Additionally, protein content of plants for all the treatments was also assessed. To calculate the amount of protein present, N content is customarily multiplied by a factor of 5.7 or 6.25 (Tkachuk 1969). Though Magomya *et al.* (2014) suggested that 6.25 is the more appropriate factor for protein calculation, this factor is used for most food materials from animal origin which were found to content approximately 16% N (100÷16=6.25) (Tkachuk 1969). On the other hand, the value of 5.7 is usually applied for cereals and oilseeds and its use is apparently derived from the careful work done by Osborne (1907). In this experiment, protein content of a leafy vegetable, Kalmi, was also calculated by multiplying %N by 5.7.

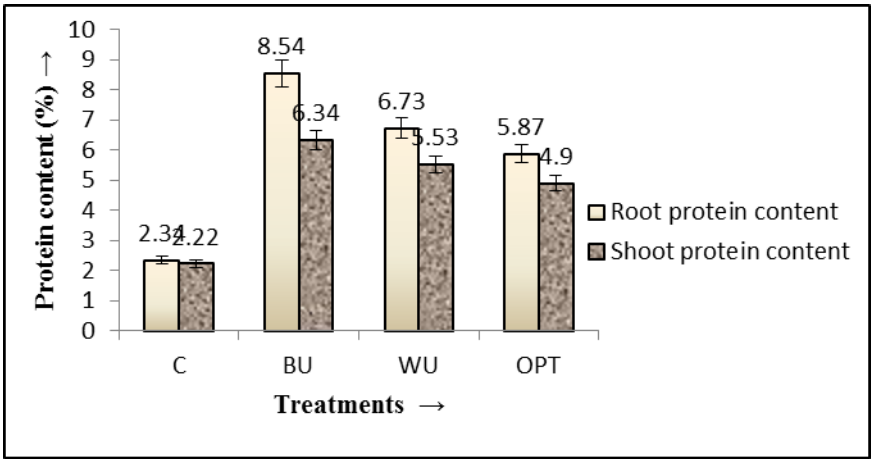

Figure 1. Root and Shoot protein content in kalmi for different fertilizer treatments

It is apparent from the above figure (Figure 1) that protein content of plant root is much higher than shoot protein content for all the treatments. BU showed higher protein content than all other fertilizer treatments as the N percentage was also higher. Field trials for BU in Zimbabwe showed a similar pattern of increase in case content of N as well as protein and also per hectare yield of maize (Web-4) and barley (Web-5).

4. Conclusion

Black urea is proved as a better N fertilizer than WU as far as the growth of yield, content of nutrient and cost effectiveness in fertilizer application are concerned. As BU is evidenced to show best result if applied by following proper management practices and to fulfill the target of improved benefits and reduced costs. Reduction cost or farm inputs may be ensured by cutting off the usual application rate by 15-35% (Web-2) of WU for BU. The findings of experiment will help to grow confidence among the growers that more of the N they do apply in their fields, will actually get to the plant when using BU. So, it can be said that BU is simply a more effective source of N for crops at the same time more economical too.

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