Comparative Analysis and Characterization of Varying Molar Ratios of Urea Formaldehyde (UF) Modified Rice-Straw as Slow – Release Fertilizer

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ABSTRACT

A comparative analysis and characterization of varying molar ratios of urea formaldehyde (1:2, 1:2.5 and 1:3) modified Rice-straw was done. The swell index, cold water insoluble nitrogen (% CWIN) at 25^0C and hot water insoluble nitrogen (% HWIN) at 98^0C were determined. Also, the slowly available nitrogen and the activity index (AI) were evaluated. The result from these characterizations shows that rice-straw has a good water retention capacity due to its high swell index of 1535% facilitating the slow release of nutrients. All the various formulations of urea formaldehyde in this work have their % CWIN values above the 60 % minimum, 78 % for UF 1:2, 80 % for UF 1:2.5 and 84 % for UF 1:3 while the activity indices stood at 17.9 %, 41.3% and 25% for UF 1:2, UF1:2.5 and UF 1:3 respectively. UF modified Rice-straw with molar ratio 1:2.5 whose AI is 41.3% which is within the good quality level and has the highest amount of slowly release nitrogen is therefore adduced to be a better slow- release fertilizer than the rest.

Key Words: Comparative, Characterization, Slow release and Fertilizer.

INTRODUCTION

The increase in the use of conventional nitrogenous fertilizer has given rise to economic and environmental problems. The economic loss of about 50% of nitrogenous fertilizer on application to farms through volatilization, leaching and water run-off has become a major concern. Water run-off with dissolved fertilizer causes unwanted growth of weeds, undesirable growth of algae in water bodies and water pollution. (Babar et al., 2014; Fayaz et al., 2019). The application of slow or controlled release fertilizer which regulates the amount of nitrogen release to plants because of its high nitrogen use efficiency helps to a large extent in curbing environmental threats, economic waste of fertilizers in addition to promoting high crop yield. (Shaviv, 1993).

The preparation and characterization of varying molar ratios (UF 1:2, UF1:2.5 and UF1:3) of urea formaldehyde (UF) modified rice straw as slow- release fertilizer has been reported. It shows -NH, and $-NH_2$ functional groups; the nitrogenous nutrients present in the fertilizer, obtained from the Fourier transform infra-red spectroscopy. The porous nature of the fertilizer which absorbs water, indicated by the scanning electron microscopy and the amorphous nature of the fertilizer enhance the process of nutrient release as shown by the x-ray diffraction (Stephen et al,.2023).

In the present work, using the same varying molar ratios of urea formaldehyde, the swell index, cold and hot water insoluble nitrogen (CWIN and HWIN at 25^0C and 98^0C) as well as their activity index (A1) and the

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slowly available nitrogen were respectively determined. These were comparatively subjected to the standard of the association of Official Analytical Chemist to bring out the most suitable slow-release fertilizer among the three different molar ratios.

MATERIALS AND METHODS.

Determination of Swell index

2_g of the samples were wrapped and tied in a piece of cloth in such a way to allow room for swelling

These were dipped in distilled water in a beaker and kept in an oven maintained at 25^0C for eight days.

Results are in Table 1.

Qw (%)= (*W2-W1*)/W1 x 100 (Samear, 2016)

Where, Qw= Swell index

W_1 = the weight of dried sample

W_2 = the weight of swollen sample

Determination of Percentage Nitrogen Content (TN)

The Micro-Khedjahl method for the determination of the percentage (%) or total nitrogen in the samples was used, this includes digestion, distillation and titration of the samples. (Byjus, 2023).

The result is presented in Table 2.

Weight of Nitrogen in the sample (WNS)

WNS=(*TN* ×*WS*)/100 (William, 1980)

Where: TN = percentage Nitrogen

WS = Weight of sample (result in Table 3).

Determination of Cold Water and Hot Water Insoluble Nitrogen (CWIN) and (HWIN)

About 0.1 g of each of the sample were put in two (2) set of replicate flasks containing 50 ml each of nitrogen free water, one set of flasks was kept at 25^0 C with intermittent and vigorous stirring, the other set at 98^0 C. They were both kept in this state for 1 hour, then filtered. The mass of dry residue obtained were taken and presented as weight of samples after urea dissolved in both cold and hot water (WSAUD). The weight of nitrogen in sample after urea dissolved (WNSAUD) is calculated as:

WNSAUD=TN/100 ×WSAUD (Williams, 1980)

For the calculation of the % CWIN and % HWIN the formula used is (Samuel and Werner, (1975)

% CWIN= WNSAUD /WNS ×100

The results are presented in table 4 and 5

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Determination of slowly available nitrogen.

The slowly available nitrogen for each of the sample was calculated by subtracting the % HWIN from the % CWIN (Abou-Zied, 2018). The values are shown in Table 6.

Determination of Activity Index (AI)

The activity index for all the samples were determined using the formula (Fayaz, 2019)

AI=(CWIN-HWIN)/CWIN X 100

As shown on table 6.

Table 1: Swell index Qw (%) for the samples

SN	Sample	Sample + Cloth weight	Weight of Cloth	W_1 (g) Weight of dried sample	W_2 (g) Weight of sample – weight of cloth	W_2-W_1 (g)	QW%
1	Rice straw	41.55	8.86	2.00	32.69	30.69	1535.00
2	UF 1:2	13.79	4.37	2.00	9.42	7.42	371.00
3	UF1:2.5	7.17	3.94	2.00	3.23	1.23	62.00
4	UF 1:3	7.58	2.98	2.00	4.60	2.60	130.00

Table 2: Percentage Nitrogen Content of Rice-straw and Various Molar Ratios of Urea Formaldehyde.

S/N	Sample	Titre volume of H_2 SO_4 Used (ml)	Weight (mg)	% Nitrogen (TN)
1	Rice-straw	0.43	1.0×10^2	0.182
2	UF 1:20	4.50	1.0×10^2	5.880
3	UF 1:2.5	8.00	1.0×10^2	10.780
4	UF 1:3	3.33	1.0×10^2	4.240

Table 3: Weight of Nitrogen in Varying Molar Ratios of Urea-Formaldehyde and the Standard (Rice-straw).

S/N	Sample	Weight of sample (mg)	TN	WNS (mg)
1	Rice-straw	100.00	0.182	0.182
2	UF 1:1.5	100.00	5.880	5.880
3	UF 1:2	100.00	10.780	10.780
4	UF 1:3	100.00	4.240	4.240

Table 4 Percentage Cold Water Insoluble Nitrogen (% CWIN) for the Varying Molar Ratios of Urea Formaldehyde Modified Rice-straw

S/N	SAMPLE	TN	WSAUD (mg)	WNSAUD (mg)	WNS (mg)	%CWIN
1	Rice-straw	0.182	15.00	0.0273	0.182	15.00
2	UF 1:2	5.880	78.00	5.0568	5.880	78.00
3	UF 1:2.5	10.780	80.00	8.624	10.780	80.00
4	UF 1:3	4.240	84.00	3.562	4.240	84.00

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Table 5: Percentage Hot Water Insoluble Nitrogen (%HWIN) for the Varying Molar Ratios of Urea Formaldehyde Modified Rice-straw

S/N	SAMPLE	TN	WSAUD (mg)	WNSAUD (mg)	WNS (mg)	%HWIN
1	Rice-straw	0.182	13.00	0.0237	0.182	13.00
2	UF 1:2	5.880	64.00	3.7632	5.880	64.00
3	UF 1:2.5	10.780	47.00	5.0666	10.780	47.00
4	UF 1:3	4.240	63.00	2.6712	4.240	63.00

Table 6: Slowly available nitrogen and the Activity Index (AI) for the Samples

S/N	SAMPLE	%CWIN	%HWIN	%CWIN-%HWIN	%AI
1	Rice-straw	15.00	13.00	2.00	13.33
2	UF 1:20	78.00	64.00	14.00	17.30
3	UF 1:2.50	80.00	47.00	33.00	41.30
4	UF 1:30	84.00	63.00	21.00	25.00

Slowly available nitrogen=%CWIN-%HWIN

DISCUSSION AND CONCLUSION

Rice straw has high water retention capacity Weishuai et al, (2021). This is because of its very high swell index (1525 %) which decreased after it is modified with various molar ratios of urea formaldehyde as found in fertilizer formulations; UF 1:2 (371 %), UF 1:2.5 (62 %), UF 1:3 (130 %). UF 1:2.5 with the least swell index has the highest slowly available nitrogen (33 %) enhancing the slow release of fertilizer to the plants. It is a good source of humus and attracts more microbial activity leading to improved soil quality. The percentage nitrogen content or the total nitrogen (TN) and the weight of nitrogen in the fertilizer samples indicate the amount of nitrogenous plant nutrient present in each sample. UF 1:2.5 has the highest with 10.78 % and 10.78mg respectively.

Urea formaldehyde products of lower molecular mass are used as slow-release fertilizers where controlled release of nutrient is required. Based on the specifications by the Association of Official Analytical Chemist, (AOAC, 2010). The % CWIN minimum value should be 60 % and show an activity index greater than 40 %. From the result all the samples have their CWIN above 60 %; UF 1:2 has 78 %, UF 1:2.5,80 % and UF 1:3, 84 %. Only UF 1:2.5 has its % AI value above 40 %. In addition, has the highest slowly available nitrogen at 33 %, making it the best fertilizer out of the three, which have theirs below.

The duration of release of nutrients from the CWIN is UF 1:2 which has the least duration, followed by UF 1:2.5 which has longer duration. The longest being UF 1:3. This is affected by the molecular mass of the polymer formed. (Nwufo and Onov 1989). Dimethylol urea (UF 1:2) is more soluble than trimethylol urea (UF 1:3) as can be seen from their CWIN values. It implies that for longer duration of the release of nutrients in aqueous environment, UF 1:3 should be used. However, for some plants the need for nutrient uptake is faster, urea formaldehyde modified rice straw UF 1:2.5 becomes more adequate since it has the CWIN value at 80 and the % AI at 41.30 as determined.

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