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Wheat Crop and Environmental Safety: The Impact of Sulphur-Coated Urea

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Abstract

Using biotechnology, substantial amounts of mechanization, and significant energy inputs in the form of enhanced irrigation, fertilizers, and pesticides, modern agriculture is a sophisticated scientific endeavor. The application of pesticides and fertilizers has resulted in a notable boost in our agricultural output. The development of these synthetic materials involves a significant amountof chemistry and the chemical industry. In the last several decades, many inorganic and organic substances have been created and evaluated for use as agrochemicals. Regarded as an inorganic nutrient source, chemical fertilizers are essential for both sustaining soil productivity and raising crop yields. For the last 35 years, 50–55% of the increase in yield in developing countries can be attributed to the nutrients provided by synthetic fertilizers. Even though inorganic fertilizers havegrown in popularity in India in recent years, the country's fertilizer nutrient use efficiency remainslow (30–50% for N and 15-20% for P), which is the cause of nutrient losses or their conversion into slowly cycling in the soil. The fertilizer business is always trying to find ways to make its products better so that they may be used more effectively—especially when it comes to nitrogenous fertilizers—and have minimal negative influence on the environment as possible. Thisis accomplished either by creating new, targeted fertilizer kinds or by improving the fertilizers thatare currently in use. Over time, the use of high-analysis fertilizers, such as urea instead of ammonium sulfate and diammonium phosphate in place of regular superphosphate, has resulted ina significant decline in the application of sulfur to crop fields, which has caused a widespread sulfur deficit in Indian soils. sulfur (S) and increased fertilizer nitrogen efficiency. Applying 100%NCU, 100% NCU, and 100% N urea combined with 100% P K increased grain yield by 59%, 57.8%, and 41.5%, respectively. This is known as coated urea. Significantly more wheat grain wasproduced than with the control treatment, even with 75% N via SCU and full dosages of P and K.

The recommendation is to use sulfur and improve the efficiency of nitrogen fertilizer for wheat in India, as it meets the needs of the wheat crop and increases nitrogen recovery efficiency by 60%..

Keywords: - Sulfur coated urea, Nitrogen use efficiency, Environmental safety.

INTRODUCTION:

The use of fertilizers has been increasing significantly in India over the past few decades, but their indiscriminate mismatch use negatively affects soil health, leading to a deterioration in soil chemical, physical, and biological properties (1). It is important to note that Indian agriculture is operating at a net negative nutrient balance of a staggering 8-10 million tons per year (2), which is expected to reach around 15 million tons (mt) by 2025.

When a farmer applies fertilizer without understanding the crop's nutritional requirements or the state of the soil's fertility, it negatively impacts both the crop and the soil (3). The "fertilizer elements"—primary nutrients, nitrogen (N), phosphorous (P), and potassium (K)—are also known as necessary in high amounts and are provided by fertilizers (4). While in most soils, others are needed in smaller quantities. Combining these nutrients in fertilizer is a typical practice for a variety of crops grown under different conditions both in India and beyond for the last 35 years, 50–55% of the increase in yield in developing countries can be attributed to the nutrients provided by synthetic fertilizers. Even though inorganic fertilizers have been used more frequently in India in recent years, the country's fertilizer nutrient use efficiency is still low (30–50% for N and 15-20% for P), which may be the cause of nutrient losses or their conversion into slowly cycling or recalcitrant pools in the soil (5). The slow/controlled-release fertilizers offer a promising alternative. Different longevity ratings of slow-release fertilizers could synchronize the demand for nutrients at different growth stages with the release pattern of nutrients. In this context, slow-release technology such as fertilizer coating especially urea with different materials such as sulfur, phosphogypsum, Dicyclopentadiene (DCPD), resin polymers, and neem to improve the efficiency of fertilizer urea. [(6)].

A. NEED FOR CONTROLLED FERTILIZERS

Nowadays, a lot of research is being done on controlled-release fertilizers (CRFs), which are safe to use and very cost-effective when compared to conventional fertilizers. In this approach, the nutrients are sustained in the soil for a longer period [(7).] They effectively administer the nutrient to

the target at the required rate and concentration. By utilizing the nutrients in the soil to their fullest potential, plants avoid both superfluous buildup and nutrient waste in the soil.

B. WHAT IS COATED UREA

Although urea is a commonly used fertilizer, its easy solubility in water can occasionally work against it. It is encased in a less soluble covering substance to mitigate this drawback. Less urea is needed overall because of the coating's assistance in releasing the urea gradually and under control. Originally, SRFs were prepared using polyethylene and sulfur as coating materials (8). Eventually, this encompassed a wide range of polymer materials, naturally occurring coating agents, multipurpose, super-absorbent materials, and even nano-composite materials. Currently, a large number of CRFs have also been produced on a commercial basis.

C. FEATURED BENEFITS OF COATED UREA

Compared to the traditional urea application method, coated urea is more cost-effective and beneficial in maintaining the soil's nutrient value. Delay the nitrification of urea in the surrounding environment. Up to 50% more yield was recorded with sulfur-coated urea. Protein disulfide bonds, amino acids, vitamins, and cofactors all contain sulfur as a structural element. [(9)].

D. WHY USE SULFUR-COATED UREA

Sulfur-coated urea (SCU) is a type of fertilizer that combines urea, a nitrogen-rich compound essential for plant growth, with a layer of elemental sulfur. This coating serves multiple purposes in agricultural applications.

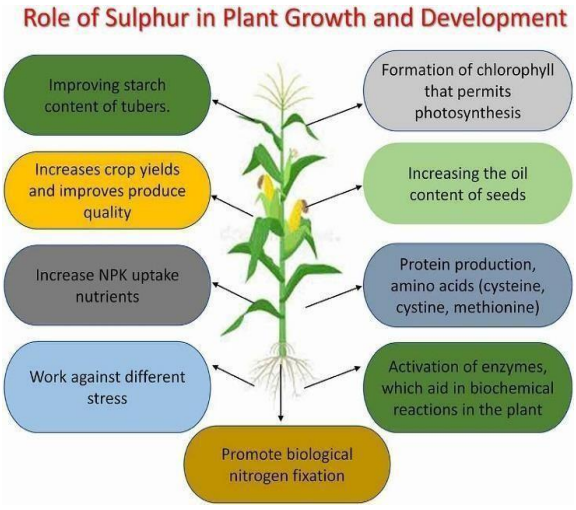


Fig. 1: Schematic representation of the role of sulfur in plant growth and development

Firstly, the sulfur coating regulates the release of nitrogen into the soil, providing a slow and steady

supply of nutrients to plants over an extended period. This controlled-release feature helps prevent nitrogen loss through leaching or volatilization, making the fertilizer more efficient and reducing the risk of environmental pollution.

Additionally, the sulfur component of SCU provides an extra source of sulfur, which is another essential nutrient for plant growth. This dual-nutrient delivery system ensures that plants receive both nitrogen and sulfur in balanced amounts, promoting healthier growth and improved crop yields. Sulphur-coated urea is particularly beneficial in agricultural settings where soil conditions or management practices may lead to nitrogen loss or deficiency. By offering a more precise and sustained nutrient supply, SCU contributes to more efficient fertilizer use, reduced environmental impact, and enhanced agricultural productivity.

E. SULFUR COATED UREA VS. NORMAL UREA

Sulfur coated has several advantages over normal urea applications in the field. The SCU can address the issues related to increased Nitrogen-related environmental issues. The application of normal urea in the fields leads to frequent applications as it is easily soluble in the soil, so to maintain an optimum concentration the concentration as well as the number of applications is increased. Since the plants can absorb a limited amount of urea, the rest of the unused urea gets retained in the soil and this leads to environmental problems.

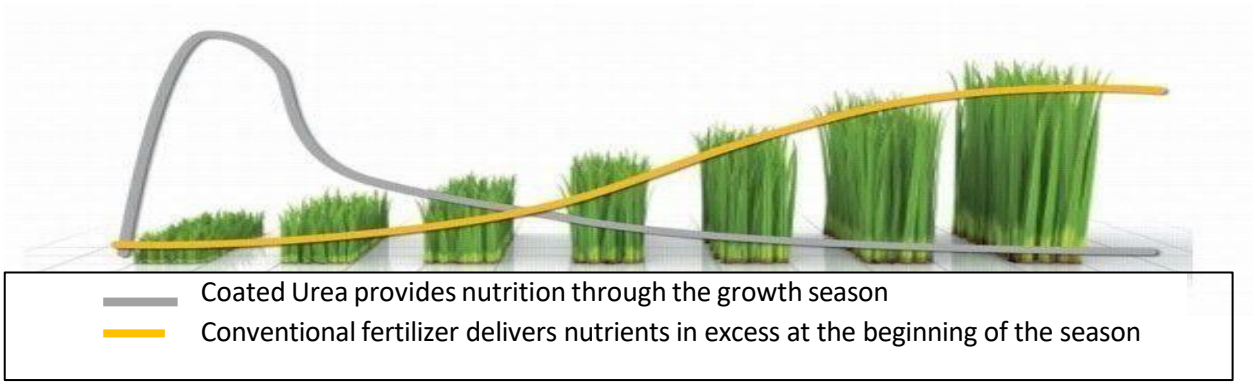


Fig. 2: SULFUR COATED UREA VS. NORMAL UREA

In a study by S.E. Allen *et. al.* (1971) dissolution rates of SCU granules were decreased by heavier coating with Sulfur, by the inclusion of 0.5% coal tar oil microbicide in the coating, and by surface application as compared to the mixing with the soil. [(10)].

I. METHODOLOGY

Sulfur coated has several advantages over normal urea applications in the field. The SCU can address the issues related to increased Nitrogen-related environmental issues. [(11)]. The application of normal urea in the fields leads to frequent applications as it is easily soluble in the soil, so to maintain an optimum concentration the concentration as well as the number of applications is increased. Since the plants can absorb a limited amount of urea, the rest of the unused urea gets retained in the soil and this leads to environmental problems. Hence,considering this account a field study was conducted at the research farm of Aditya biotech lab and Research Pvt Ltd., Raipur, Chhattisgarh to evaluate sulfur-coated urea (SCU) as a source of sulfur (S) and enhanced efficiency of nitrogen fertilizer (Table 1.)

Treatments	Details
T1	Absolute control (No fertilizer)
T2	N (100 %) through normal urea 3 splits(Basal 50% + Max Tillering 25%+ PinacleInititaion 25%)
T3	PK (100%) + N (75%) @ N through normal urea 3 splits (Basal 50% + Max Tillering 25%+ PinacleInititaion 25%)
T4	NPK (100 %)through normal Urea 3 splits (Basal 50% + Max Tillering 25%+ PinacleInititaion 25%)
T5	PK(100%)+ N (75%) @ N through sulfur Coated urea 3 splits (Basal 50% + Max Tillering 25%+ PinacleInititaion 25%)
T6	NPK (100%) @ N through sulfur coated urea 3 splits

Table 1. Treatment doses of the experimental field.

Fig. 3: Wheat growing stages of the experimental field

II. RESULT AND DISSCUSION

A. EFFECT OF SULFUR-COATED UREA ON THE GROWTH CHARACTER OF WHEAT

Wheat (*Triticum aestivum)* is the most important food crop in Asia and the entire world as it daily feeds almost fifty percent of the entire world population. Studies have been conducted on the efficiency of sulfur-coated Urea in the growth of wheat crops. The data about plant heightat different growth stages (60 DAS, 90 DAS, and at harvest stage) are presented in Table 2 which shows that the application of various levels of nitrogen by different fertilizers significantly affects the plant height over no fertilizer control treatments. The highest plant height was recorded in treatment T6 in all the stages i.e 60 DAS, 90 DAS, and at the harvest stage with the average plant height of 72.3, 88.7, and 98.7 cm, treatments had slightly overedged the plant height of T4 (100% N applied through normalurea) (Figure 4)

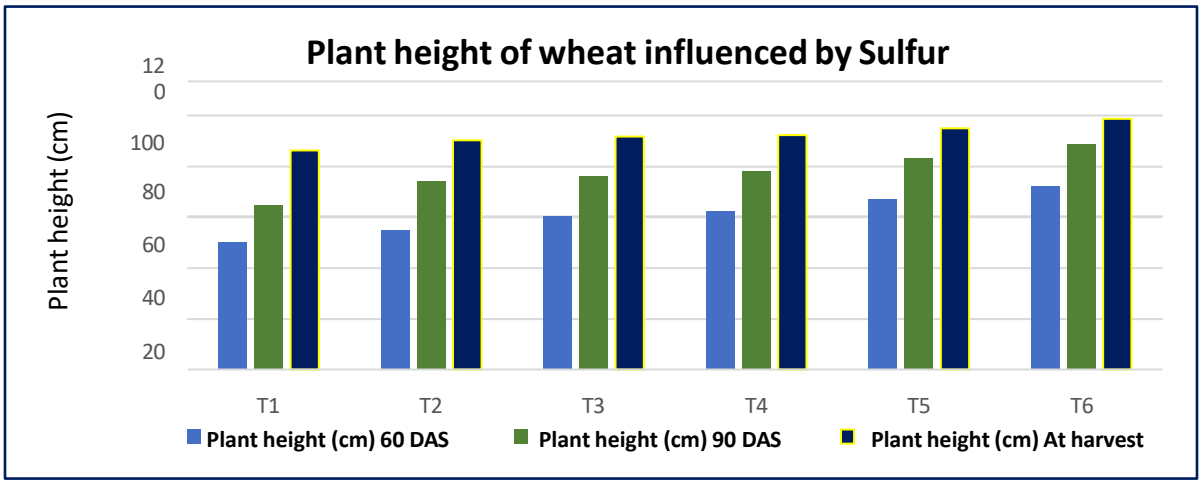


Fig. 4: **Plant height of wheat crop influenced by sulfur-coated urea**

B. EFFECT OF SULFUR-COATED UREA ON THE GRAIN AND STRAW YIELD OF WHEAT

The grain yield of wheat was recorded from each treatment and the data after statistical analysisare depicted in Table 3 and exhibited in Figure 5 The data revealed that the response to the application of nitrogen to wheat, invariable to source, had significantly increased wheat grainyield. The grain yield of wheat in the present investigation varied from 2655 to 4323 kg ha^{-1} under different treatments. The highest grain yield was obtained in T6 followed by treatment as compared to

unfertilized (control) and normal urea-applied treatments. Further the application of normal urea also significantly increased grain yield over no fertilizer treatment (T1).

The data presented in Table 3 and Figure 5 indicated that the straw yield of wheat was significantly affected by different treatments. The lowest straw yield was obtained at control (no fertilizer treatment). The highest straw yield 5733 kg ha^{-1} was observed in T6 (100% NPK- N applied through SCU) followed by T4 also significantly affected and obtained more yield as compared to T1 (absolute control). The grain yield as influenced by the different treatments followed as T6 (5733 kg ha-1) >T5 (4891 kg ha-1) >T4 (5001 kg ha-1) >T3 (4690kg ha-1) >T2 (4512 kg ha-1) >T1 (4123 kg ha-1) respectively. In the study of (Y.S. Shivay, 2019) three field trials are conducted on aromatic rice to test boron-coated urea (BCU), sulfur-coated urea (SCU), and zinc-coated urea (ZnCU) in 2013 and 2014.

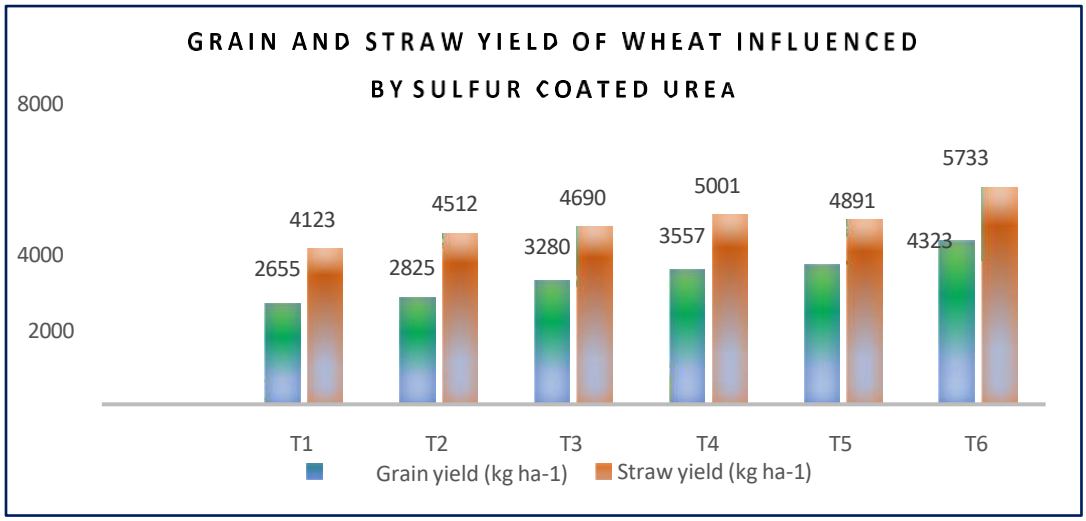


Fig. 5: Grain and straw yield of wheat influenced by sulfur-coated urea

C. EFFECT OF SULFUR-COATED UREA ON THE NITROGEN USE EFFICIENCY

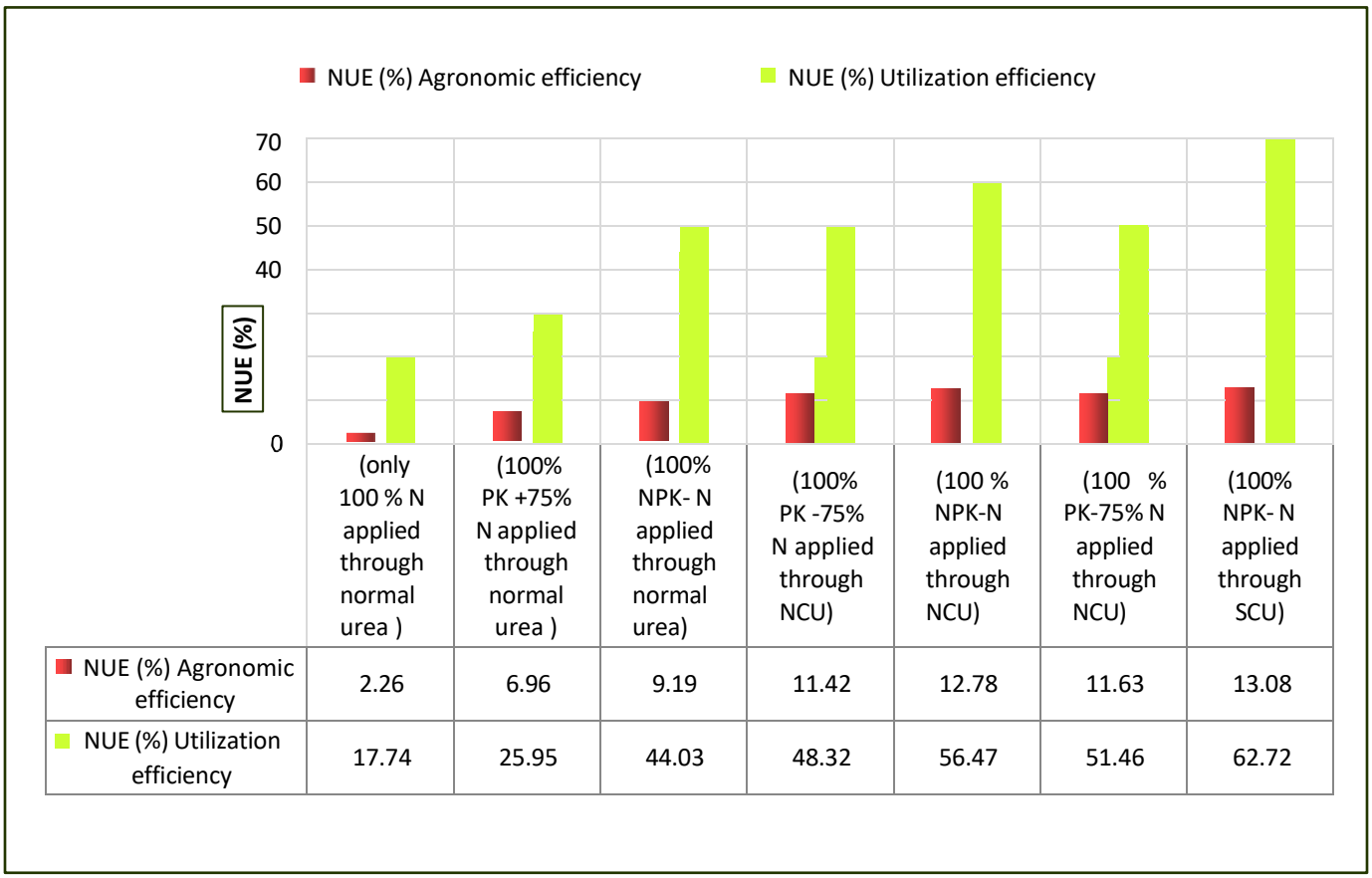
a) Nitrogen use efficiency- Nitrogen use efficiency by wheat in terms of agronomic efficiency (AE) and utilization efficiency (UE) or apparent N recovery (ANR) under various fertilizer treatments, varied from 2.22-13.45 and 17.74 - 62.72 respectively (Table 4). Among the treatments, AE and UE were observed significantly lower in T2 (100% nitrogen applied alone) while the highest recorded in T6 (100% NPK- N applied through SCU) over the other treatments.

b) Phosphorus use efficiency

Application of SCU (100%NPK-N applied through SCU) showed higher agronomic efficiency (AE) and utilization efficiency (UE) of phosphorus by wheat which was statistically significantly higher compared to normal urea treatment and control. (figure 6).

c) Potassium use efficiency

Combinations of nutrient sources and levels had a significant impact on K use efficiency in wheat (Table 4.). A perusal of the data indicated that the agronomic efficiency (AE) and utilization efficiency (UE) were affected significantly by different combinations of nutrientsources and levels. The highest AE and UC were recorded with T6 (100% NPK- N applied through SCU) treatment, which was significantly higher than all the treatments. along with P and K also recorded significantly higher AE and UC as compared to the control.

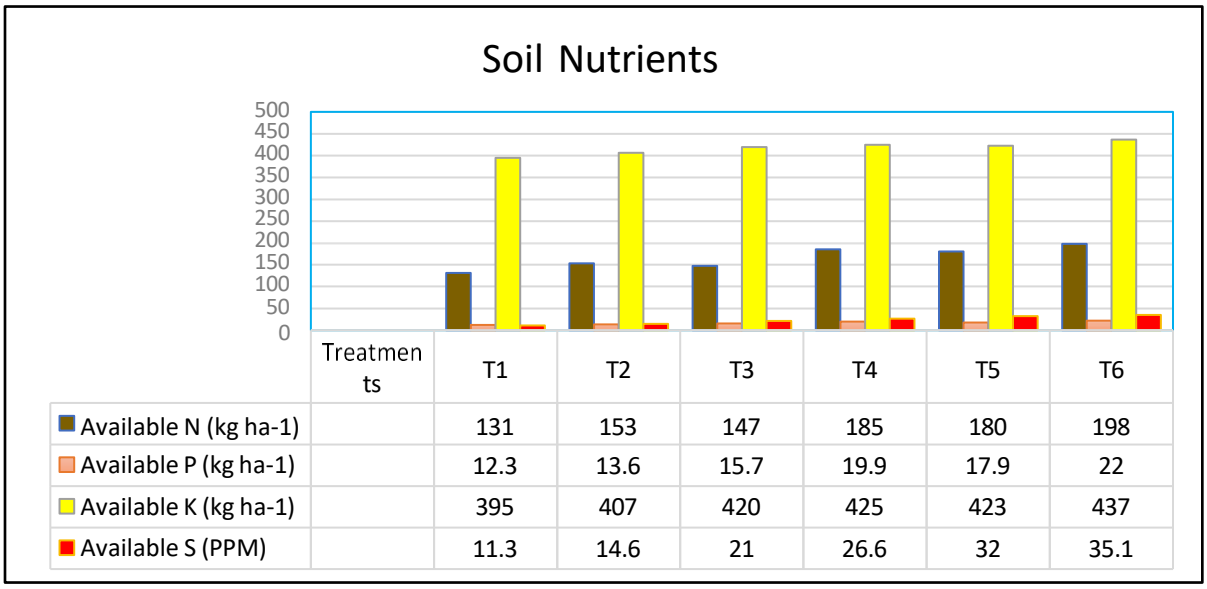


	(only 100 % N applied through normal urea)	(100% PK +75% N applied through normal urea)	(100% NPK- N applied through normal urea)	(100% PK -75% N applied through NCU)	(100 % NPK-N applied through NCU)	(100 % PK-75% N applied through NCU)	(100% NPK- N applied through SCU)
NUE (%) Agronomic efficiency	2.26	6.96	9.19	11.42	12.78	11.63	13.08
NUE (%) Utilization efficiency	17.74	25.95	44.03	48.32	56.47	51.46	62.72

Fig. 6: Nitrogen use efficiency of wheat influenced by sulfur-coated urea

D.EFFECT OF SULFUR-COATED UREA ON SOIL NUTRIENTS

Available nutrient content (NPK and S) in soil as affected by different treatments are presented in Table 5 and Figure 7. A perusal of the data showed that the available nitrogen in the soil was found significantly higher in treatment T6 198kg ha^{-1} and T4 195 kg ha-1 compared to (T1) control treatment where nitrogen was recorded lowest. The soil available P also followed a similar trend as that of nitrogen. Available P content in soil varied from 12.3 to 22.0 kg ha^{-1}. The application of a full dose of nitrogen through SCU accorded significantly higher available phosphorus
22.0 kg ha^{-1} over the other treatment. There were no significant differences observedin available K in soil due to various fertilizer treatments. However, the available K content varied from 395 kg ha^{-1}in T1 (control) to 437 kg ha^{-1} in the T8 treatment. The lowest values of available K in T1 were inferior over all other treatments, while the highest value of available K was recorded in T8 (100% NPK- N applied through SCU) 437 kg ha^{-1} followed by T4 195 kg ha^{-1}. The available sulfur content in soil is significantly affected by different treatments (Table 5). Maximum S was recorded in both sulfur-coated urea treatments (T6 and T5) which were statistically significant than normal urea-applied treatment.



Treatments	T1	T2	T3	T4	T5	T6
Available N (kg ha-1)	131	153	147	185	180	198
Available P (kg ha-1)	12.3	13.6	15.7	19.9	17.9	22
Available K (kg ha-1)	395	407	420	425	423	437
Available S (PPM)	11.3	14.6	21	26.6	32	35.1

Fig. 7: Soil Nutrients influenced by sulfur-coated urea

III. STATISTICAL ANALYSIS

The mean date of two years was analyzed using the F-test according to Gomez and Gomez(1984). Least significant difference (LSD) Values at P=0.05 were used to determine the significance of differences between treatment means.

IV. CONCLUSION

Sulfur-coated urea or oil-coated urea always provides slow-release nitrogen to crops. The nitrification and N losses are reduced. The nutrient use efficiency is increased in field crops where the coated urea is used as a comparison to the uncoated urea. In India, in the case of rice and wheat, more than 50% of the area is consumed but it is replaced by the coating of urea and helps to enhance nutrient use efficiency. The data of grain and straw yield of wheat revealed that they respond to the application of nitrogen to wheat, invariable to source, and had significantly enhanced grain and straw yield of wheat. Slow-release coated urea (sulfur-coated urea) fertilization resulted in improved wheat growth, yield, and yield attributes. Further, the coated urea also increased nutrient contents, uptake in grain and straw of wheat, and its use efficiency in terms of agronomic efficiency (AE) and utilization efficiency (UE). This is an important finding considering the environmental safety by increased nitrogen recovery and also productivity in the present scenario.

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