

# **Effect of cumulative amendment of soil with fly ash in combination with other nutrients on change in grain yield, crude protein, NPN and true protein contents of rice**

## **Abstract**

An experiment was planned and conducted at Instructional Farm (IF), Odisha University of Agriculture & Technology (OUAT), Bhubaneswar in the years 2022 and 2023 to study the effect of the cumulative addition of nine varieties of nutrients on the yield and protein contents of two varieties of rice namely Gayatri and Vandana. It was observed that the grain yield, crude protein, non-protein nitrogen (NPN) and true protein content decreased by the application of only fly ash (FA) over control (only NPK fertilizer). The crude protein content decreased in all the treatments in 2023 over its 2022 counterpart whereas NPN increased by the cumulative addition of nutrients. This resulted in higher values of true protein content in the grains. Grain yield increased in all the treatments over the previous year (2022) resulting in a higher yield of true protein content.

**Key Words:** Fly Ash, Yield, Crude protein, non-protein nitrogen, True protein

## **Introduction**

Fly ash is an obnoxious solid waste material produced from thermal power plants. India is producing a large amount of FA, i.e., around 226.13 million tons in the year 2019-20 and it is predicted to be around 300-400 million tons by the year 2025 [1]. It creates environmental hazards and is a challenge for environmental scientists for its safe disposal. It is mostly used for the production of bricks, the filling of mines and the construction of roads. The use of ash in agriculture is not new. From primitive time, ash from burnt dry leaves, straw and wood were applied in crop fields. The use of these ashes in coconut plantations is well known as a source of potassium. However, in recent years FA has been used in agriculture at large scale as it contains many essential nutrients for plant growth. FA has some characteristic properties which is helpful for the improvement of soil quality and consequently plant growth and grain quality. It has nitrogen (N) in low range but medium range of phosphorous (P) and potassium (K).

Generally, farmers apply fertilizers to each crop, season after season, in a cropping system. The yield of individual crops in multiple cropping systems is not only influenced by freshly applied fertilizers and organic manures but also by their carry-over effect from the preceding crops. The residual effect of organic matter is more common because of the fixation and accumulation of

organic nitrogen. The organic matter benefits the present crop directly by providing available P and indirectly by improving P availability in the soil through solubilisation or reduced fixation.

Growing of crops with chemical fertilizers (CF) alone cannot mitigate the loss of C, N and P while combined application of organic manure and CF was effective in this respect [2]. The use of industrial waste like FA in conjunction with CF and FYM under a rice-rice cropping system is yet to be explored for mitigating the nutritional imbalances and overcoming the problems of acid soils. This calls for the development of an integrated soil management practice utilizing organic manure and industrial waste (FA) to supplement chemical fertilizers.

## **Materials and Methods**

Studies on the integrated effect of fly ash, organics and inorganic on yield, crude protein content, non-protein nitrogen and true protein content of grains for the rice- rice cropping system were planned. The experiment was carried out at the IF,O.U.A.T, Bhubaneswar- 751003 during the Kharif seasons of 2022 and 2023. After the harvest of Kharif crop in 2022, the same treatments were applied in the plots during the Kharif season of 2023. The rice varieties grown were Gayatri and Vandana respectively. Bhubaneswar is the capital city of Odisha. The IF is located at the latitude of 20 15'N to 20 17'N and longitude 85 49'E to 85 52'E with 45 m above mean sea level. The average rainfall is about 1470 mm. The experiment was carried out on a medium land with nine numbers of treatments replicated thrice in a randomized block design (RBD). Both of those were given nine treatments consisting of various doses of FA, nitrogen, phosphorous, potassium (NPK) fertilizer and farm yard manure (FYM) with only NPK serving as the control as per Pradhan, 2002. The treatments were: (1) Recommended Dose of fertilizer (RDF) of N, P ( $P_2O_5$ ), K ( $K_2O$ ) @ 80, 40, 40 kg $ha^{-1}$  (2) FA @ 20  $tha^{-1}$  (3) FA @ 40  $tha^{-1}$  (4) RD + FA @ 20  $tha^{-1}$  (5) RD +FA @ 40  $tha^{-1}$  (6) 50 % RD + FA @ 20  $tha^{-1}$  (7) 50 % RD+ FA @ 40  $tha^{-1}$  (8) 50 % RD + FA @ 20  $tha^{-1}$  + FYM @ 10  $tha^{-1}$  (9) 50 % RD + FA @ 40  $tha^{-1}$  + FYM @ 10  $tha^{-1}$ . The averages of the data are taken as the results. 20 days old seedlings of both varieties were transplanted.

Total nitrogen in grain was determined by the auto-analyzer (KEL Plus). Percentage of crude protein was calculated using a conversion factor of 5.95 [3]. The % of moisture in each sample was determined separately and the results were expressed on oven dry basis. Non-protein nitrogen (NPN) was estimated according to the procedure given by Becker *et al.* [4]. Into a 150 mL. of beaker, 0.5 gram of powdered grain sample was weighed and stirred with 20 mL. of 0.8N (13.6%) trichloro acetic acid for one hour on a magnetic stirrer. The suspension was centrifuged for 10 minutes at 2000 r. p. m. The clear supernatant was taken for nitrogen

determination. Percentage of true protein was calculated by subtracting non-protein nitrogen (NPN) from total nitrogen and multiplying the results with 5.95.

Wherever statistical significance was observed, critical difference (CD) @P=0.05% level of probability was worked out for comparison of mean data.

## Results and Discussion

The fly ash used for the experiment was collected from ICCL, Chowdwar had alkaline nature (pH 7.30), electrical conductivity (EC) 0.73 dSm<sup>-1</sup> and organic carbon was 0.08 %. It was low in nitrogen having value of 5.0 (mgkg<sup>-1</sup>). The soil of the experimental site at the Instructional Farm, Odisha University of Agriculture and Technology, Bhubaneswar was lateritic sandy loam having an acidic pH of 5.32, electrical conductivity 0.31 dSm<sup>-1</sup>, medium organic carbon content 5.3 gkg<sup>-1</sup>, available nitrogen, phosphorous and potassium content were 370.0, 19.6 and 166.8 kgha<sup>-1</sup> respectively. The properties of the experimental soil and the FA used are given in table-1.

**Table-1: Properties of experimental soil and fly ash**

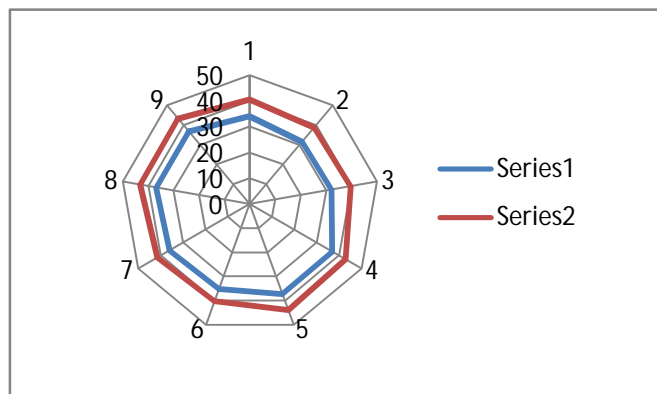
Properties	Experimental Soil	Applied fly ash
pH (1:2)	5.32	7.30
Electrical Conductivity (E.C) (dSm <sup>-1</sup> )	0.31	0.73
Organic Carbon (O.C)	5.30 (gkg <sup>-1</sup> )	0.08 (%)
Available Nitrogen (N)	370.0 (kgha <sup>-1</sup> )	5.0 (mgkg <sup>-1</sup> )
Available Phosphorous (P)	19.6 (kgha <sup>-1</sup> )	30.0 (mgkg <sup>-1</sup> )
Available Potassium (K)	166.8 (kgha <sup>-1</sup> )	180.0 (mgkg <sup>-1</sup> )

### Grain Yield

The grain yield of the Kharif crop in 2022 varied from the lowest of 31.56 qha<sup>-1</sup> in T<sub>2</sub> to the highest of 37.21 qha<sup>-1</sup> in T<sub>5</sub>. With FA @ 20 tha<sup>-1</sup> and 40 tha<sup>-1</sup>, a fall by 7.74% and 5.72% respectively, over control was registered. In a study, treatments receiving FA @ 5 and 15 tha<sup>-1</sup> recorded higher yield of rice by 23.3% and 32.4% respectively [5]. It happened because FA is deficient in the major N, P and K nutrients. Although FA generally has a high concentration of phosphorous, the form of P is not readily available to plants, presumably due to interactions with Al, Fe and Ca in alkaline FA [6]. However, there is some increase in grain yield by 2.18% with an increase in the dose of FA from T<sub>2</sub> to T<sub>3</sub> which might be attributed to the better physical properties of the soil and induced more native nutrient availability in soil. Yield of rice increased with the increase of FA from 0 to 15 tha<sup>-1</sup> [7, 8]. With the integration of full dose of fertilizer with FA, a significant increase by 16.17% over FA and 8.34% over control was registered. But, when

the dose of NPK fertilizer was reduced to 50%, a significant reduction in grain yield by 4.14% was recorded. However, when FYM was included a significant increase by 3.72% over the treatments receiving the same nutrients excluding FYM was recorded. The highest grain yield of rice was obtained with FA @ 40  $\text{tha}^{-1}$  in conjunction with FYM @ 10  $\text{tha}^{-1}$  [9]. The grain and straw yield of rice var. TellaHamsa was significantly increased with FA, FYM and their interactions [10]. However FYM treated plots registered less grain yield by 0.56% over the treatments T<sub>4</sub> and T<sub>5</sub>. It might be because T<sub>4</sub> and T<sub>5</sub> had 50% more of N, P, and K. Even though treatments 8 and 9 received FYM it could not counterbalance the effect of higher dose of N, P, and K fertilizer. Treatments receiving FA in higher dose registered an increase by 1.23% over the lower dose. The treatment receiving RD of NPK fertilizer along with FA in higher dose (40 $\text{tha}^{-1}$ ) recorded the highest yield in both years. In all the treatments the yield was higher in the year 2023 over 2022 which is shown in Fig-1. The inner circle indicates the yield in the year 2022 and the outer circle in the year 2023. It might be due to the cumulative addition of nutrients which might have paved the way to have more productivity.

**Fig-1: Grain Yield**

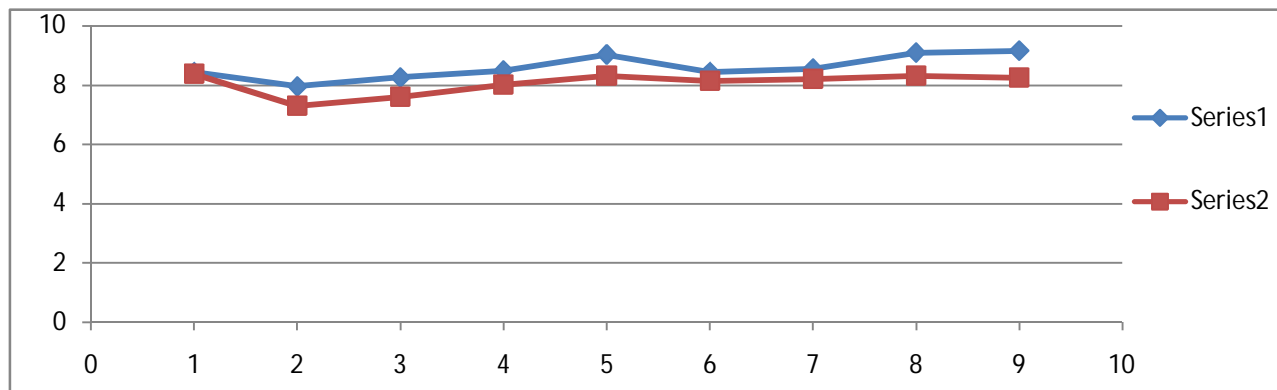


### Crude Protein

It is revealed (Fig-2) that the crude protein content of rice cv. Gayatri (2022) varied from a minimum of 7.97% in T<sub>2</sub> receiving in lower dose to a maximum of 9.16% in treatment 9 receiving 50% recommended dose of fertilizer integrated with fly ash in higher dose and FYM. Application of lone fly ash @ 20 $\text{tha}^{-1}$  and 40 $\text{tha}^{-1}$  registered a fall in crude protein content by 5.68% and 2.13% respectively over control. It might be due to the less availability of nitrogen in the fly ash-treated plots. When 100% recommended dose of NPK fertilizer was integrated with fly ash, there was an increase by 8.13% over lone fly ash and 3.78% over control receiving 100% recommended dose of NPK fertilizer. This might be due to the synergistic effect of NPK fertilizer and fly ash. When the dose of fertilizer was reduced to 50%, a fall by 3.02% was recorded.

Treatment 6 receiving half the dose of NPK fertilizer integrated with fly ash in lower dose was at par with the control receiving full dose of NPK fertilizer only. This proved that the reduction in the dose of fertilizer by 50% had been counterbalanced by the combined application of fertilizer and fly ash. However, when FYM was included in the treatments, there was an increase by 7.34% over its exclusion and 8.40% over control. An increase in crude protein content of rice in FYM-treated plots over lone fertilizer was reported by [11]. It is due to the more availability of nitrogen from FYM-treated plots in conjunction with fly ash and NPK fertilizer which is utilized in the synthesis of amino acids and in turn protein [12]. An increase in the protein content of rice by the integrated application of FYM, NPK fertilizer and blue-green algae was reported by [13]. On an average, treatments receiving  $40\text{t ha}^{-1}$  fly ash recorded an increase in crude protein content by 2.96% over  $20\text{t ha}^{-1}$ . The protein content of rice decreased with the increase in the dose of fly ash which might be due to the dilution effect [14]. Although there is cumulative addition of the nutrients in consecutive years, in all the treatments the crude protein content recorded a lower value in 2023 over its 2022 counterpart (Fig-2). The upper line indicates the values in the year 2022 and the lower line in the year 2023. It might be due to varietal differences.

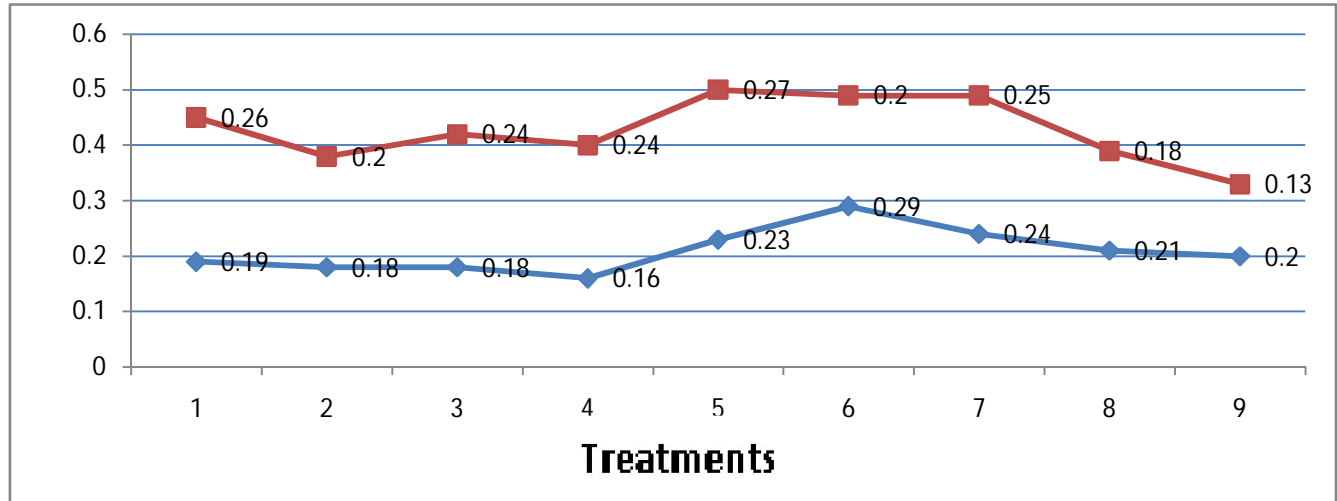
**Fig-2: Crude Protein**



### Non-Protein Nitrogen

Non-protein nitrogen (NPN) content in 2022 varied between the lowest of 0.16% in  $T_4$  and the highest of 0.29% in  $T_6$ . With FA there was a decrease in NPN by 5.26% over control. Treatment receiving FA in a lower dose was at par with its higher dose. When 100% RD of NPK fertilizer was integrated with FA, there was an increase by 8.33% over FA and 2.63% over 100% RD of NPK (control). Reduction in the dose of fertilizer registered an increase by 35.89% over its higher dose. But when FYM was included in the treatments, there was a reduction by 22.64%. This indicated that more of nitrogen is utilized in the synthesis of true protein. The treatments receiving FA in higher doses recorded an increase in NPN by 16.43% over its lower dose.

**Fig-3: NPN**

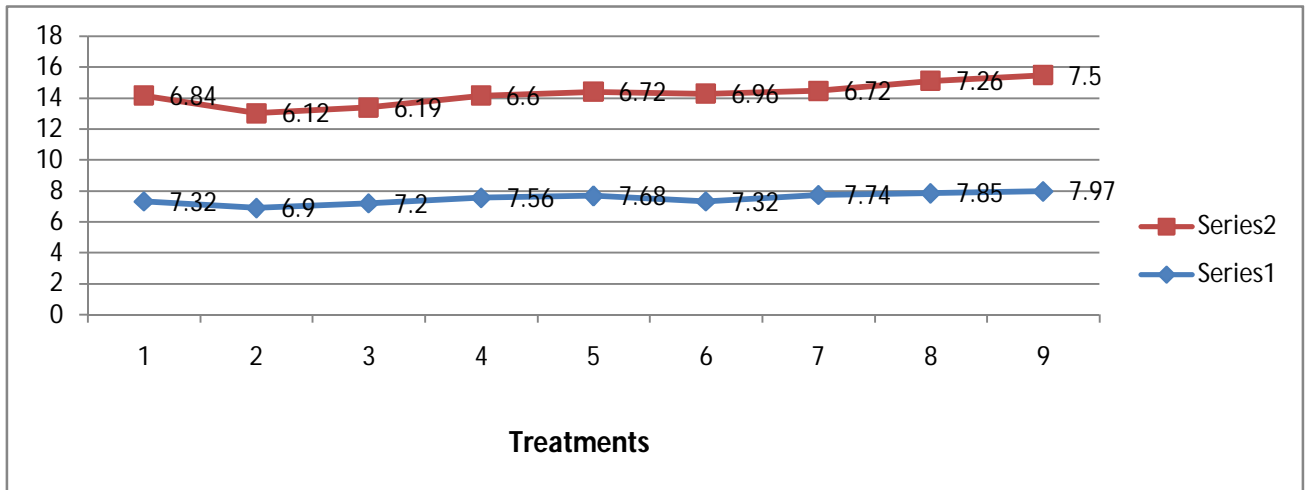


In all the treatments the NPN content recorded a higher value in 2023 over its 2022 counterpart (Fig-3). It might be due to varietal differences which would have resulted in spite of adding nutrients in a cumulative manner.

### **True Protein content**

True protein content in 2022 varied from the lowest of 6.90% in T<sub>2</sub> to the highest of 7.97% in T<sub>9</sub>. With the application of FA in both lower and higher doses, there was a fall by 5.73% and 1.64% respectively, over T<sub>1</sub> (control). When 100% RD of NPK fertilizer was blended with FA, there was an increase in true protein content by 8.08% over FA and 4.09% over control. It might be due to the combined effect of NPK fertilizer and FA. When the dose of fertilizer was reduced to 50%, there was a fall by 0.85% but recorded an increase by 3.21% over control. This proved that the reduction in the dose of fertilizer had been counterbalanced by the combined application of fertilizer and FA. However, when FYM was included, there was a rise by 4.69% over its exclusion and registered a significant increase by 8.06% over control. The highest quantity of true protein in rice in FYM-treated plots than others was reported [15]. Treatments receiving FYM had more amount of crude protein, less NPN and consequently synthesis of more amount of amino acid and hence more amount of true protein. Treatments receiving FA @ 40 tha<sup>-1</sup> recorded an increase by 3.24% over its lower dose. The upper line indicates the values in 2023 and the lower line in 2022. Although there is a fall of crude protein in 2023, there is an increase in NPN in 2023 which resulted in higher values of true protein content in 2023. This may be due to varietal differences and the cumulative addition of nutrients.

**Fig-4: True Protein**



## Conclusion

The cumulative addition of nutrients resulted in higher grain yield. The yield declined by the addition of only FA in both doses in both the years but increased by the combined addition of FA along with other nutrients. Although the crude protein content decreased by the cumulative addition of nutrients but the NPN content increased which resulted in higher values of true protein content in the rice grains. This proves that the cumulative addition of nutrients has a conducive result for true protein content in spite of varietal differences in grains. Since yield increased in the subsequent year along with true protein content, more amount of protein-rich grains can be obtained by the cumulative addition of FA along with other nutrients.

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