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 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 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 the environmental scientists for its safe disposal. It is mostly used for the production of bricks, filling of mines and construction of roads. Use of ash in agriculture is not new. From primitive time, ash from burnt dry leaves, straw and wood were applied in crop fields. Use of these ashes in coconut plantation 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 system is not only influenced by freshly applied

fertilizers and organic manures, but also by their carry-over effect from the preceding crops. Residual effect of organic matter is more common because of 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]. Use of industrial waste like FA in conjunction with CF and FYM under rice-rice cropping system is yet to be explored for mitigating the nutritional imbalances and overcoming the problems of acid soils. This calls for 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, 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 $kgha^{-1}$ (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 the 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

0.8*N* (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 $dSm^{-1}$and organic carbon was 0.08 %. It was low in nitrogen having value of 5.0 ($mgkg^{-1}$). The soil of the experimental site at the Instructional Farm,Odisha University of Agriculture and Technology, Bhubaneswar was lateritic sandy loam having acidic pH of 5.32, electrical conductivity 0.31 dSm^{-1}, medium organic carbon content 5.3 gkg^{-1}, available nitrogen, phosphorous and potassium content were 370.0, 19.6 and 166.8 $kgha^{-1}$ 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

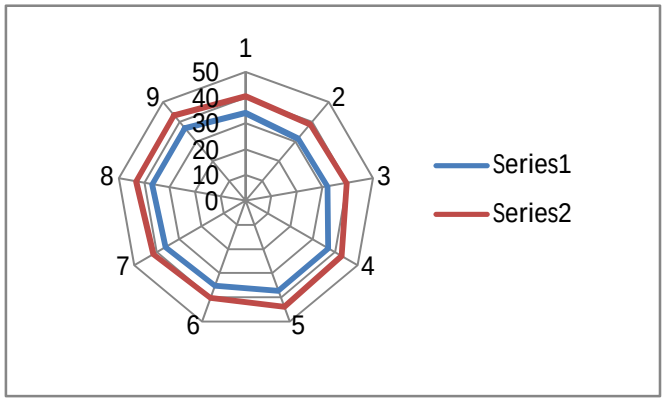
Properties	Experimental Soil	Applied fly ash
pH (1:2)	5.32	7.30
Electrical Conductivity (E.C) (dSm^{-1})	0.31	0.73
Organic Carbon (O.C)	5.30 (gkg^{-1})	0.08 (%)
Available Nitrogen (N)	370.0 ($kgha^{-1}$)	5.0 ($mgkg^{-1}$)
Available Phosporous (P)	19.6 ($kgha^{-1}$)	30.0 ($mgkg^{-1}$)
Available Potassium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

Grain Yield

The grain yield of the Kharif crop in 2022 varied from the lowest of 31.56 qha^{-1} in T_2 to a highest of 37.21 qha^{-1} in T_5. With FA @ 20 tha^{-1} and 40 tha^{-1}, a fall by 7.74% and 5.72% respectively, over control was registered. In a study, treatments receiving FA @ 5 and 15 tha^{-1} 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 increase in the dose of FA from T_2 to T_3 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 increase of FA from 0 to 15 tha^{-1} [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 tha^{-1} in conjunction with FYM @ 10 tha^{-1} [9]. The grain and straw yield of rice var. Tella Hamsa 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_4 andT_5. It might be because T_4 and T_5 had 50% more of N, P, and K. Even though treatments 8 and 9 received FYM it could not counter balance 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 (40tha^{-1}) recorded highest yield in both the 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 the nutrients which might have paved their way to have more productivity.

Fig-1: Grain Yield

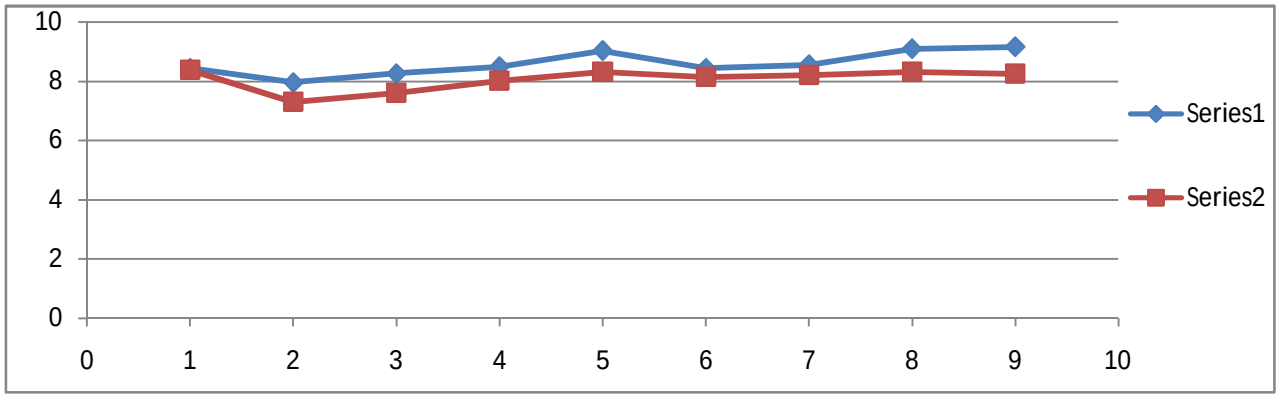


Crude Protein

` It is revealed (Fig-2) that the crude protein content of rice cv. Gayatri (2022) varied from a minimum of 7.97% in T2 receivingFA 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 @ 20tha^{-1} and 40tha^{-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 control receiving full dose of NPK fertilizer only. This proved that the reduction in the dose of fertilizer by 50% had been counter balanced 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. 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]. 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 40tha^{-1} fly ash recorded an increase in crude protein content by 2.96% over 20tha^{-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 difference.

Fig-2: Crude Protein

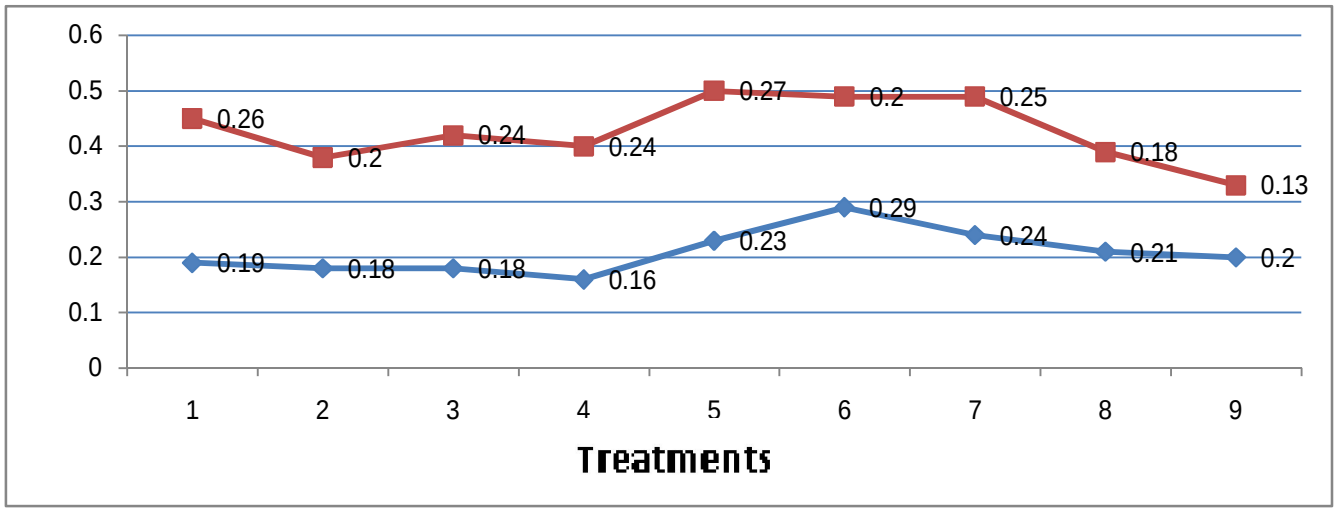


Non-Protein Nitrogen

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 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 dose recorded an increase in NPN by 16.43% over its lower dose.

Fig-3: NPN



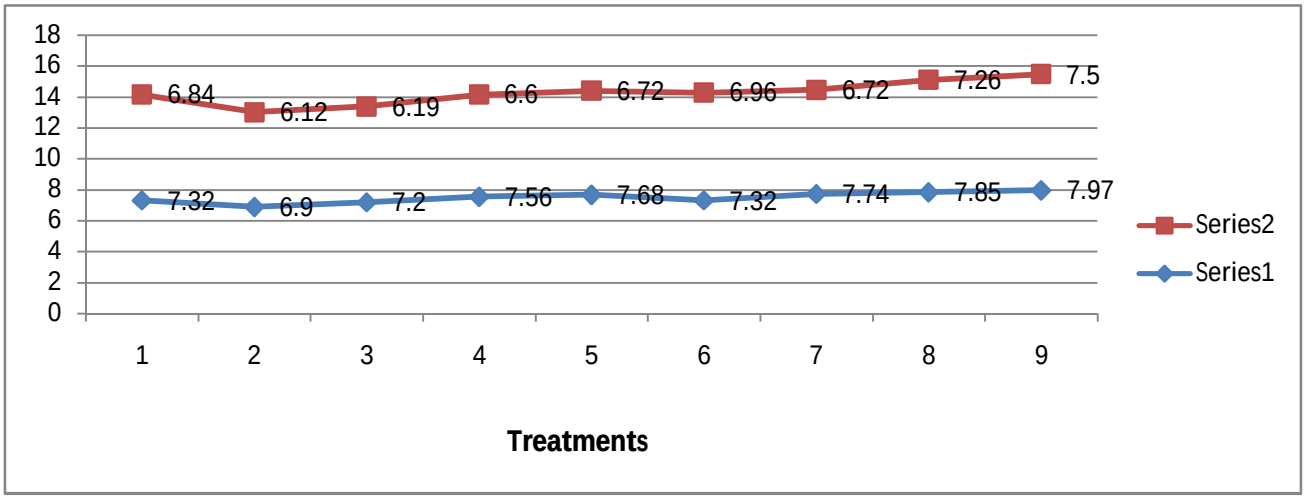
In all the treatments the NPN content recorded a higher value in 2023 over its 2022 counterpart (Fig-3). It might be due to varietal difference which would have resulted in spite of adding nutrients in a cumulative manner.

True Protein content

True protein content in 2022 varied from the lowest of 6.90% in T_2 to the highest of 7.97% in T_9. With the application of FA in both lower and higher doses, there was a fall by 5.73% and 1.64% respectively, over T_1 (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 counter balanced 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. 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^{-1} 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 due to varietal difference and 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 difference 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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