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Response of Micronutrients and Biofertilizers on Yield Attributes and Protein Content under Rice – Chickpea Cropping System in Central Uttar Pradesh

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Authors' contributions

This work was carried out in collaboration among all authors. Author NK designed the whole study, conducted the field work and data collection and performed the statistical analysis. Authors RP, AKS and SD helped in data collection, managed the analysis of the study and literature searches. All authors read and approved the final manuscript.

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ABSTRACT

The present study was conducted to investigate the changes in yield attributes and protein content with the application of zinc and biofertilizers in hybrid rice and chickpea. The experiment was conducted in as a Randomized Block Design (RBD) in Students Instructional Farm, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, Uttar Pradesh, India, during 2018-2019 and 2019-2020. The experiment included twelve treatment groups replicated three times in Randomized Block Design. The results revealed that the treatment which received T_7 (100 per cent RDN + 25 per cent N FYM + S_{40} + ZnO + *Azotobacter or **Rhizobium) recorded highest value of all yield attributes and protein content. The mean values of both years of plant height, number of tillers/hill, panicle length, no. of filled grains/panicle, no. of unfilled grains/panicle and total no. of grains/panicle increased up to 96.08 cm, 8.38, 24.29, 181.03, 18.71 and 199.74, respectively in treatment T_7 in hybrid rice. Similarly, in case of chickpea the mean values of plant height, no. of branches/hill, no. of pods/plant, no. of seeds/plant, no. of nodules/plant and dry weight of nodules/plant also increased up to 62.60 cm, 5.22, 62.62, 1.88, 17.63 and 2.08, respectively. The protein content was also found to be maximum in Treatment T_7 in rice (7.94 and 8.04%) and in

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chickpea (23.25 and 23.27%) during the years, respectively. Therefore, combination of micronutrients and biofertilizers, as remunerative and beneficial for growth, improved the yield and ultimately productivity of both hybrid rice and chickpea in areas with deficient available micronutrients in soil.

Keywords: Hybrid rice; chickpea; micronutrients; nutrient uptake and soil fertility status.

1. INTRODUCTION

India occupies largest area among rice and ranks second in production after China. About 90 per cent of rice grown in world is produced and consumed in Asian region. India produces 116.42 million tonnes of rice from an area of 43.38 million hectares with a productivity of 2550 kg ha $^{-1}$ (2018-19). Chickpea (*Cicer arietinum* L.) is also the most important pulse crop of India, because it is grown under varying soil and climatic conditions and also in soils of low fertility condition. In India, chickpea occupies an area of about 8.32 million ha with an annual production of 10.13 million tonnes and productivity of 851 kg ha^{-1} (2018-19). With the continuous use of high yielding and fertilizer responsive varieties, the practice of using large amount of high analysis macronutrient fertilizers together with much decreased use of organics and biofertilizers, little recycling of crop residues lead to micronutrient hunger in many crops and the need of micronutrient has been essentially and entirely met through its native reserve of soil. However imbalanced chemical fertilization and improper use of pesticides have resulted in fast soil degradation and deficiency of micronutrients, deterioration of soil physical properties, properties of land and water and health hazards to animal and human.

Biofertilizers are cost effective, eco friendly and renewable sources of plant nutrients to supplement or complement chemical fertilizers and helps in maintaining long term fertility and sustainability. Nitrogen fixing and P – solubilizing inoculants are important bio-fertilizers used in rice [1]. Thus, to achieve higher yields and also to overcome micronutrient deficiencies, proper dose and method of application of these micronutrients becomes most relevant. Since these micronutrients are essential for proper metabolic and physiological activities of plant they enhance crop yields. Application of beneficial micro – organisms is known to help in mineralization and mobilization of macro and micronutrients needed by the crop. The yield levels of chickpea have been generally low which might be attributed to its major cultivation under rained conditions with less/imbalance use of fertilizers, limited seed inoculation (10% approximately) with *Rhizobium* and phosphorus solubilizing bacterial cultures [2] and also due to its susceptibility to wilt, insect, pest and diseases.

Productivity can be enhanced by growing improved varieties and by following proper agronomic management practices. As far as nutrient requirement of chickpea is concern a dose of 20 kg N, 50 kg P_2O_5, 20 kg K_2O and 20 kg S is recommended in chickpea [3]. Hence, supplementation of micronutrients (Zn and Mo) and organic/inorganic sources of nutrients along with *Rhizobium* inoculation in chickpea cultivation may increase biological nitrogen fixation, P availability to this crop and thereby its productivity.

Therefore, suitable combination of chemical fertilizers, organic manures and biofertilizers need to be developed for particularly rice – chickpea is predominant under irrigated production system. Hence, the present study was undertaken to investigate the response of paddy and chickpea to micronutrients and biofertilizers on yield attributes and quality.

2. MATERIALS AND METHODS

A field experiment was done in Students Instructional Farm, Kanpur Nagar, at Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, India, during the crop growing period 2018-19 and 2019-20 which is of 25°26'and 26°58'north latitude and 79°31' and 80°34' East longitude with an elevation of 125.9 m from sea level in the alluvial belt of Indo-gangetic plains of central Uttar Pradesh. The soils of experimental site was sandy clay loam in texture and saline in reaction having pH value of 8.40 and organic carbon of 0.45 per cent. The amount of available N, P_2O_5 and K_2O were 190.00, 11.80 and 170.00 kg ha^{-1}, respectively. The soil is deficient in available sulphur 12.54 kg ha^{-1} and DTPA extractable zinc 0.40 mg g^{-1}. Hybrid rice variety PHB-71 and chickpea variety

Uday were taken for the study. The experiment was laid out in Randomized Block Design with twelve treatments and three replications. The treatments consist of T_1 = Control, T_2 = 125 per cent RDN, T_3 = 100 per cent RDN , T_4 = 100 per cent RDN + 25 per cent N FYM, T_5 = 100 per cent RDN + 25 per cent N FYM + S_{40}, T_6 = 100 per cent RDN + 25 per cent N FYM + S_{40} + ZnO, T_7 = 100 per cent RDN + 25 per cent N FYM + S_{40} + ZnO + *Azotobacter or **Rhizobium, T_8 = 75 per cent RDN, T_9 = 75 per cent RDN + 25 per cent N FYM, T_{10} = 75 per cent RDN + 25 per cent N FYM + S_{40}, T_{11} = 75 per cent RDN + 25 per cent N FYM + S_{40} + ZnO, and T_{12} = 75 per cent RDN + 25 per cent N FYM + S_{40} + ZnO + *Azotobacter or **Rhizobium. The seedlings are uprooted from the nursery at the optimum age. Transplanting may be done at the 4 to 5 leaf stage. Before transplanting seedlings of respective treatments were inoculated with biofertilizer slurry. In Hybrid rice Half dose of N and full dose of P, K, S and Zn were applied just before transplanting. Rest quantity of N was applied in two split doses in standing crop at tillering and panicle initiation stage respectively and in case of Chickpea Nitrogen, phosphorus and potash were applied as basal dressing in all plots. Diammonium phosphate applied as source of nitrogen and phosphorus, potassium was applied through muriate of potash as basal dose. Sulphur and zinc were also applied as basal dressing as per treatment through elemental sulphur and zinc respectively. All the management practices as suggested in the package of practice of CSAUA&T, Kanpur were adopted. The data were subjected to analysis of variance (ANOVA) using CoStat software package.

3. RESULTS AND DISCUSSION

3.1 Yield Attributes of Rice

The data Table 1 on yield attributing characters of rice as affected by different treatments clearly showed the significant difference for plant population per m^{-2} plant height (cm), No. of tillers per hill, panicle length, no. of filled grains per panicle, no. of unfilled grains per panicle, total no. of grains per panicle and test weight of grain (gm) in both the years.

The maximum plant population (in the year 2018-19 it was 49.30 per m^2 and 50.72 per m^2 in the year 2019-20) were recorded with the treatment T_{12} (75 per cent RDN + 25 per cent N FYM + S_{40} + ZnO + *Azotobacter or **Rhizobium.) which was statistically at par with the treatment T_{10} (75 per cent RDN + 25 per cent N FYM + S_{40}) and significantly superior over rest of the treatments.

The maximum plant height (cm) was recorded in treatment T_7 (100 per cent RDN + 25 per cent N FYM + S_{40} + ZnO + *Azotobacter or **Rhizobium) which was also statistically at par with the rest of the treatments in both the years. This suggested that application of organic, inorganic and biofertilizer with 100% RDN was more advantageous than 100% RDN. It has improved the release patterns of nutrients by making its slowly available, synchronizing with crop requirements at different phinopses. Similar results have been reported by Dipankar et al. [4].

Maximum no. of tillers per hill was 8.33 and 8.43 in the years of 2018-19 and 2019-20, respectively and test weight (in the year 2018-19 it was 23.48 gm and 23.98 gm in the year 2019-20) were recorded in treatment T_7 (100 per cent RDN + 25 per cent N FYM + S_{40} + ZnO + *Azotobacter or **Rhizobium) and the lowest were observed under control. Application of S, Zn and biofertilizer with 100% RDN also showed accelerating effect on no. of tillers $hill^{-1}$ during both the years. Increase in no. of tillers $hill^{-1}$ might be due to increased availability and uptake of nutrients. It is in close proximity with findings of Mustafa et al. [5].

Maximum length of panicle, 24.16 (cm) and 24.53 (cm) was recorded with T_7 (100 per cent RDN + 25 per cent N FYM + S_{40} + ZnO + *Azotobacter or **Rhizobium) Table 1 followed by 23.43 (cm) and 23.80 (cm)in the treatment T_6 (100 per cent RDN + 25 per cent N FYM + S_{40} + ZnO) Table 1 and minimum 17.19 (cm) and 17.45 (cm) was recorded all control (T_1) during first and second year respectively. It was observed that influence of length of panicle within 100% RDN (T_3) and 125% RDN (T_2) was found statistically at par during both the years.

Similar trend was also recorded with respect to number of tillers per hill, no. of filled grains per panicle, no. of unfilled grains per panicle, total no. of grains per panicle in both the years i.e. 2018-19 and 2019-20. The results also revealed that test weight in grain and it showed significant increase in all the treatments over control during both the years. Maximum increase in test weight was recorded 23.48 (gm) and 23.98 (gm) was

recorded with T_7 (100 per cent RDN + 25 per cent N FYM + S_{40} + ZnO + *Azotobacter or **Rhizobium) followed by 22.67 (gm) and 23.15 (gm) in the treatment T_6 (100 per cent RDN + 25 per cent N FYM + S_{40} + ZnO) and minimum 17.99 (gm) and 18.37 (gm) was recorded all control (T_1) during first and second year respectively. It was observed that application of 125% RDN (T_2) showed over increase in test weight in comparison to 100% RDN (T_3) during both the years.

Super imposition of 25% N through FYM with 100% RDN along with micronutrients and biofertilizers showed higher increase over super imposition of 100% RDN alone. Increase in yield attributes might lead to increase the cell expansion and various metabolic processes in the presence of adequate available nutrients. These findings are in close conformity with the findings of Khan et al. [6]. The increase in yield attributes might be also be due to increase in photosynthesis activity of leaves, translocation of photosynthates from source to sink and nutrient's uptake. These results collaborate with the findings of Shivay et al. [7].

3.2 Yield Attributes of Chickpea

The maximum of pods per plant (in the year 2018-19 it was 61.10 per plant and 64.15 per plant in the year 2019-20) and no. of branches per plant (in the year 2018-19 it was 5.14 per plant and 5.31 per plant in the year 2019-20) were recorded with the treatment T_7 (100 per cent RDN + 25 per cent N FYM + S_{40} + ZnO + *Azotobacter or **Rhizobium) which was statistically at par with the treatment T_6 (100 per cent RDN + 25 per cent N FYM + S_{40} + ZnO) having (in the year 2018-19 it was 5.05 per plant and 5.23 per plant in the year 2019-20) and significantly superior over rest of the treatments Table 2. Plant height, no. of seeds per plant, no. of nodules per plant also showed similar trend. Photosynthetic food material synthesized and gets deposited in leaves and other growing plant parts leading to enlargement and development of meristematic tissues. This causes faster growth of the growing points, ultimately plant height. These present findings are supported by the results of Mohesen and Sabaghnia [8]. It might also be due to the increase in plant growth which attributed to the increase in the availability of nutrients with application of inorganic fertilizer, continuous supply of macro and micro nutrients which helped in acceleration of various metabolic processes viz., photosynthesis, might have energy transfer reaction and symbiotic biological N– fixation process, which resulted in better yield attributes.

Test weight was found to be maximum (in the year 2018-19 it was 17.53 gm and 17.56 gm in the year 2019-20) in plot T_7 (100 per cent RDN + 25 per cent N FYM + S_{40} + ZnO + *Azotobacter or **Rhizobium) and lowest under control. Similarly, the maximum number of root nodules plant^{-1} 17.29 and 17.98 was recorded with T_7 (100 per cent RDN + 25 per cent N FYM + S_{40} + ZnO + *Azotobacter or **Rhizobium) followed by 16.20 and 16.85 in the treatment T_6 (100 per cent RDN + 25 per cent N FYM + S_{40} + ZnO) and minimum 11.35 and 11.82 was recorded all control (T_1) during first and second year respectively. The increase in nodules and their dry weight is the response of application of Rhizobium. Rhizobial activity might have accelerated in the rhizosphere due to supplementation with, sulphur and zinc which resulted in better response. The results are also in support of findings and [9] and [10].

3.3 Protein Content of Rice

The protein content (N concentration% x 6.25) of hybrid rice grain effected by different treatments is depicted in Table 3 and illustrated in Fig. 1 revealed that it varied from from 7.25 (%) and 7.94 (%) during first year and 7.34 (%) and 8.04 (%) during second years. Maximum protein content rice grain of 7.94 (%) and 8.04 (%) which was recorded with T_7 (100 per cent RDN + 25 per cent N FYM + S_{40} + ZnO + *Azotobacter or **Rhizobium) and minimum 7.25 (%) and 7.34 (%) was recorded all control (T_1) during first and second year respectively. Application of S Zn, biofertilizer and FYM with 100% RDN also showed its acceleration effect of protein content in grain and increase in protein content was recorded significant within all the treatments during both the years. Protein content in rice grain was recorded higher in all the treatments except control during second year than the first year. . Application of S Zn, biofertilizer and FYM with 100% RDN also showed its acceleration effect of protein content in grain and increase in protein content was recorded significant within all the treatments during both the years. Result of the present study are in conformity with the results of other investigators [11].

Table 1. Effect of micronutrients and biofertilizers on yield components of Hybrid rice (cv.- PHB-71)

Treatments	Plant Population / m^2			Plant height (cm)			No. of tillers per hill			Panicle length			No. of filled grains per panicle			No. of unfilled grains per panicle			Total no. of grains per panicle			Test weight (gm)		
	2018-19	2019-20	Mean	2018-19	2019-20	Mean	2018-19	2019-20	Mean	2018-19	2019-20	Mean	2018-19	2019-20	Mean	2018-19	2019-20	Mean	2018-19	2019-20	Mean	2018-19	2019-20	Mean
T_1 = Control	47.46	48.43	47.94	67.33	68.45	67.89	5.91	5.98	5.94	17.19	17.45	17.32	127.85	129.75	128.80	24.15	25.66	24.90	152.30	155.41	153.85	17.99	18.37	18.18
T_2 = 125 per cent RDN	47.50	48.40	47.95	84.90	86.32	85.61	7.45	7.53	7.49	21.67	22.01	21.84	161.11	163.53	162.32	23.27	24.44	23.58	184.39	187.98	186.18	21.69	22.15	31.92
T_3 = 100 per cent RDN	47.75	48.71	48.23	85.46	86.89	86.17	7.50	7.59	7.54	21.80	22.16	21.98	162.13	164.57	163.35	23.10	24.26	23.68	185.23	188.83	187.03	22.17	22.64	22.40
T_4 = 100 per cent RDN + 25 per cent N FYM	47.32	49.03	48.17	83.23	88.02	85.62	7.60	7.69	7.64	22.10	22.46	22.28	164.37	166.85	165.61	21.53	22.62	22.07	185.89	189.47	187.68	21.99	22.45	22.22
T_5 = 100 per cent RDN + 25 per cent 47.92N FYM + S_{40}	47.67	49.41	48.54	89.44	90.95	90.19	7.84	7.93	7.88	22.80	23.18	22.99	169.60	172.14	170.87	22.52	23.66	23.09	192.12	195.80	193.96	22.50	22.98	22.74
T_6 = 100 per cent RDN + 25 per cent N FYM + S_{40} + ZnO	47.92	49.28	48.60	92.45	94.00	93.22	8.09	8.20	8.1	23.43	23.80	23.61	174.28	176.88	175.58	21.38	22.47	21.92	195.66	199.35	197.50	22.67	23.15	22.91
T_7 = 100 per cent RDN + 25 per cent N FYM + S_{40} + ZnO + *Azotobacter or **Rhizobium	47.95	48.95	48.26	95.32	96.84	96.08	8.33	8.43	8.38	24.16	24.43	24.29	179.68	182.39	181.03	18.25	19.17	18.71	197.93	201.55	199.74	23.48	23.98	23.73
T_8 = 75 per cent RDN	47.95	49.21	48.58	72.18	73.43	72.80	6.35	6.45	6.40	18.50	18.81	18.65	137.57	140.37	138.97	20.20	21.22	20.71	157.77	161.59	159.68	19.25	19.69	19.47
T_9 = 75 per cent RDN + 25 per cent N FYM	47.90	49.26	48.58	82.02	83.15	82.58	7.23	7.33	7.28	21.04	21.38	21.21	156.50	159.02	157.76	23.50	24.66	24.08	180.00	183.68	181.84	21.03	21.48	21.25
T_{10} = 75 per cent RDN + 25 per cent N FYM + S_{40}	48.67	49.17	48.92	83.97	85.42	84.69	7.38	7.47	7.42	21.47	21.80	21.63	159.65	162.07	160.86	23.15	24.31	23.73	182.80	186.39	184.59	21.53	21.99	21.76
T_{11} = 75 per cent RDN + 25 per cent N FYM + S_{40} + ZnO	48.59	50.05	49.32	87.04	88.55	87.79	7.65	7.75	7.70	22.24	22.61	22.42	165.45	168.03	166.74	21.79	22.90	22.34	187.24	190.93	189.08	22.03	22.50	22.26
T_{12} = 75 per cent RDN + 25 per cent N FYM + S_{40} + ZnO + *Azotobacter or **Rhizobium	49.30	50.72	50.01	90.69	92.25	91.47	7.97	8.07	802	23.13	23.52	23.32	172.05	174.65	173.35	21.52	22.60	22.06	193.58	197.26	195.42	22.60	23.08	22.84
C.D.	N.S	N.S.		4.01	4.97		1.15	1.15		12.06	2.35		10.34	11.48		2.69	2.94		11.92	14.67		1.46	1.54	
SE (m)	0.75	1.01		1.36	1.69		0.39	0.39		0.70	0.80		3.50	3.91		0.91	1.00		4.06	5.00		0.50	0.52	
SE (d)	1.06	1.43		1.93	2.39		0.55	0.55		0.99	1.13		4.90	5.53		1.29	1.41		5.74	7.07		0.70	0.74	

Table 2. Effect of micronutrients and biofertilizers on yield components of Chickpea (cv. - Uday)

Treatments	Plant Population / m^2			Plant height (cm)			No. of Branches per plant			No. of pods per plant			No. of seeds per plant			No. of nodules per plant			Dry weight of nodules per plant			Test weight (gm)		
	2018-19	2019-20	Mean	2018-19	2019-20	Mean	2018-19	2019-20	Mean	2018-19	2019-20	Mean	2018-19	2019-20	Mean	2018-19	2019-20	Mean	2018-19	2019-20	Mean	2018-19	2019-20	Mean
T_1 = Control	75.15	76.45	75.80	52.28	53.97	53.12	4.42	4.51	4.46	40.10	42.25	41.17	1.23	1.25	1.24	11.35	11.82	11.58	1.36	1.38	1.37	12.25	12.31	12.28
T_2 = 125 per cent RDN	77.80	77.50	77.65	55.90	57.70	56.80	4.65	4.82	4.73	51.23	53.79	52.51	1.57	1.64	1.60	14.50	15.08	14.79	1.74	1.76	1.75	15.64	15.68	15.66
T_3 = 100 per cent RDN	76.45	75.95	76.20	57.85	59.72	58.78	4.82	4.99	4.90	52.22	54.83	53.52	1.60	1.68	1.64	14.78	15.37	15.07	1.77	1.79	1.78	15.97	16.01	15.99
T_4 = 100 per cent RDN + 25 per cent N FYM	77.15	76.30	76.72	58.45	60.34	59.39	4.87	5.04	4.95	53.86	56.55	55.20	1.65	1.73	1.69	15.54	16.16	15.85	1.86	1.89	1.87	16.78	16.82	16.80
T_5 = 100 per cent RDN + 25 per cent 47.92N FYM + S_{40}	76.35	76.05	76.20	59.75	61.68	60.71	4.97	5.15	5.06	55.08	57.83	56.45	1.69	1.77	1.73	15.59	16.21	15.90	1.87	1.90	1.88	16.84	16.88	16.86
T_6 = 100 per cent RDN + 25 per cent N FYM + S_{40} + ZnO	75.90	76.25	76.05	60.65	62.61	61.63	5.05	5.23	5.14	57.23	60.10	58.66	1.75	1.80	1.77	16.20	16.85	16.52	1.93	1.95	1.94	17.09	17.18	17.13
T_7 = 100 per cent RDN + 25 per cent N FYM + S_{40} + ZnO + *Azotobacter or **Rhizobium	76.35	75.95	76.15	61.61	63.60	62.60	5.14	5.31	5.22	61.10	64.15	62.62	1.87	1.90	1.88	17.29	17.98	17.63	2.07	2.10	2.08	17.53	17.56	17.54
T_8 = 75 per cent RDN	77.10	76.45	76.77	55.43	57.22	56.32	4.61	4.78	4.69	43.74	45.93	44.83	1.34	1.41	1.37	12.37	12.86	12.61	1.48	1.50	1.49	13.23	13.27	13.25
T_9 = 75 per cent RDN + 25 per cent N FYM	76.45	75.80	76.12	55.75	57.55	56.65	4.64	4.81	4.72	48.77	51.21	49.99	1.50	1.57	1.53	13.81	14.36	14.08	1.66	1.68	1.67	14.74	14.84	14.79
T_{10} = 75 per cent RDN + 25 per cent N FYM + S_{40}	75.90	76.15	76.02	56.35	58.17	57.26	4.70	4.86	4.78	49.45	51.92	50.68	1.52	1.60	1.56	14.00	14.56	14.28	1.68	1.70	1.69	14.93	15.01	1497
T_{11} = 75 per cent RDN + 25 per cent N FYM + S_{40} + ZnO	76.15	77.10	76.62	57.75	59.62	58.68	4.80	4.98	4.89	53.87	56.56	55.21	1.65	1.73	1.69	15.24	15.85	15.54	1.83	1.85	1.84	15.12	15.18	15.15
T_{12} = 75 per cent RDN + 25 per cent N FYM + S_{40} + ZnO + *Azotobacter or **Rhizobium	77.19	76.35	76.77	59.25	61.16	60.20	4.94	5.11	5.02	54.78	57.52	56.15	1.68	1.76	1.72	15.50	16.12	15.81	1.86	1.88	1.87	15.33	15.41	15.373.
C.D.	N.S.	N.S.		3.13	3.83		0.38	0.34		4.02	4.18		0.19	0.25		1.41	1.76		0.14	0.25		1.02	2.01	
SE (m)	0.85	1.07		1.07	1.30		0.13	0.11		1.37	1.42		0.06	0.08		0.48	0.60		0.04	0.09		0.35	0.68	
SE (d)	1.21	1.52		1.51	1.84		0.18	0.16		1.93	2.01		0.09	0.12		0.68	0.85		0.06	0.12		0.49	0.96	

Table 3. Response of micronutrients and biofertilizers on protein quality of Hybrid rice (cv.- PHB-71)

Treatments combination	Protein content in hybrid rice grain (%)	
	2018-19	2019-20
T_1 = Control	7.25	7.34
T_2 = 125 per cent RDN	7.42	7.51
T_3 = 100 per cent RDN	7.51	7.60
T_4 = 100 per cent RDN + 25 per cent N FYM	7.59	7.68
T_5 = 100 per cent RDN + 25 per cent N FYM + S_{40}	7.81	7.91
T_6 = 100 per cent RDN + 25 per cent N FYM + S_{40} + ZnO	7.89	7.99
T_7 = 100 per cent RDN + 25 per cent N FYM + S_{40} + ZnO + *Azotobacter or **Rhizobium	7.94	8.04
T_8 = 75 per cent RDN	7.34	7.43
T_9 = 75 per cent RDN + 25 per cent N FYM	7.46	7.55
T_{10} = 75 per cent RDN + 25 per cent N FYM + S_{40}	7.68	7.77
T_{11} = 75 per cent RDN + 25 per cent N FYM + S_{40} + ZnO	7.76	7.86
T_{12} = 75 per cent RDN + 25 per cent N FYM + S_{40} + ZnO + *Azotobacter or **Rhizobium	7.85	7.95
C.D. at 5%	**0.20**	**0.22**
SEm +-	**0.07**	**0.07**
SE (d)	**0.09**	**0.10**

Table 4. Effect of micronutrients and biofertilizers on protein content of chickpea

Treatments combination	Protein content in chickpea grain (%)	
	2018-19	2019-20
T_1 = Control	21.29	21.31
T_2 = 125 per cent RDN	21.79	21.81
T_3 = 100 per cent RDN	22.05	22.07
T_4 = 100 per cent RDN + 25 per cent N FYM	22.28	22.30
T_5 = 100 per cent RDN + 25 per cent N FYM + S_{40}	22.93	22.95
T_6 = 100 per cent RDN + 25 per cent N FYM + S_{40} + ZnO	23.10	23.12
T_7 = 100 per cent RDN + 25 per cent N FYM + S_{40} + ZnO + *Azotobacter or **Rhizobium	23.25	23.27
T_8 = 75 per cent RDN	21.55	21.57
T_9 = 75 per cent RDN + 25 per cent N FYM	21.91	21.93
T_{10} = 75 per cent RDN + 25 per cent N FYM + S_{40}	22.55	22.57
T_{11} = 75 per cent RDN + 25 per cent N FYM + S_{40} + ZnO	22.78	22.81
T_{12} = 75 per cent RDN + 25 per cent N FYM + S_{40} + ZnO + *Azotobacter or **Rhizobium	23.01	23.04
C.D. at 5%	**0.17**	**0.20**
SEm +-	**0.05**	**0.06+**
SE (d)	**0.08**	**0.09**

3.4 Protein Content of Chickpea

The protein content (N concentration% x 6.25) of chickpea grain effected by different treatments is depicted in Table 4 and illustrated in Fig. 1 revealed that it varied from from 21.29 (%) and 23.25 (%) during first year and 21.31 (%) and 23.27 (%) during second years. Maximum protein content rice grain of 23.25 (%) and 23.27 (%) which was recorded with T_7 (100 per cent RDN + 25 per cent N FYM + S_{40} + ZnO + *Azotobacter or **Rhizobium) and minimum 21.29 (%) and 21.31 (%) was recorded all control (T_1) during first and second year respectively. Application of S Zn, biofertilizer and FYM with 100% RDN also showed its acceleration effect of protein content in grain and increase in protein content was recorded significant within all the treatments during both the years. The resuts are in conformity with those obtained by Tripathi et al. [12].

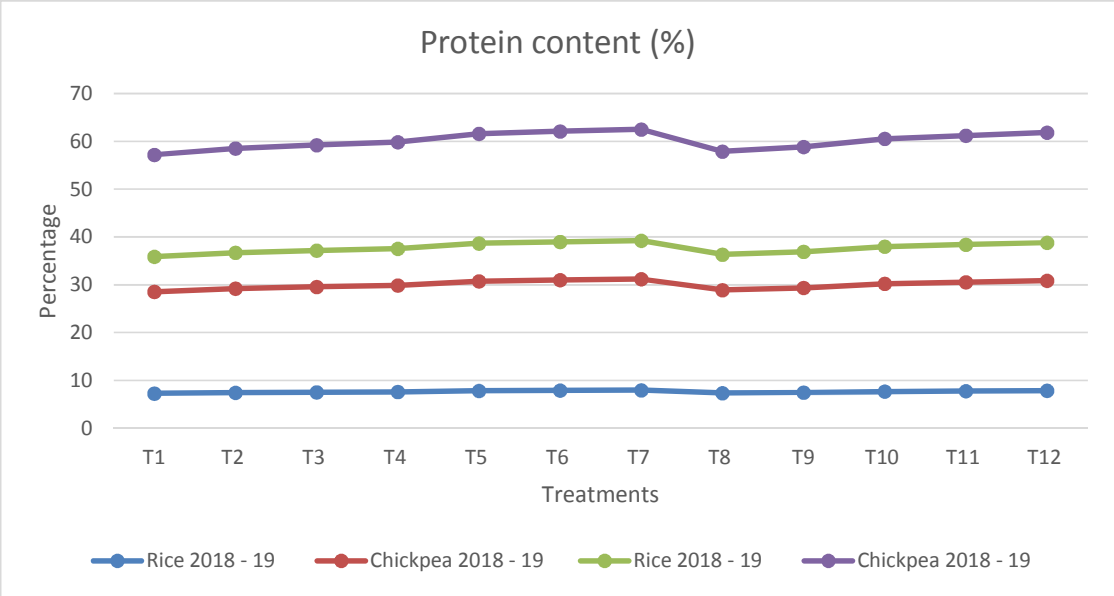

Fig. 1. Response of zinc and biofertilizers to the protein content in rice and chickpea

4. CONCLUSION

As a result of this two growing seasons (2018-19 and 2019-20) field study, it was concluded that yield attributes increased with application of zinc and biofertilizer (Azotobacter in case of rice and Rhizobium in case of chickpea) in both rice and chickpea. Treatment T_7 (100 per cent RDN + 25 per cent N FYM + S_{40} + ZnO + *Azotobacter or **Rhizobium) showed maximum of its yield attributes. The protein content was also found to be maximum in Treatment T_7 in rice (7.94 and 8.04%) and in chickpea (23.25 and 23.27%) during both the years, respectively. Hence, this combination of micronutrients and biofertilizers, proved as remunerative and beneficial for growth, yield and ultimately productivity of both hybrid rice and chickpea in deficient available micronutrients soil areas.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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