



P-ISSN: 2349-8528

E-ISSN: 2321-4902

www.chemijournal.com

IJCS 2020; 8(2): 1756-1761

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Received: 13-01-2020

Accepted: 15-02-2020

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International Journal of Chemical Studies

Influence of different zinc management options on productivity, profitability and protein yield of basmati rice (*Oryza sativa* L.) in inceptisol of Western Uttar Pradesh

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DOI: <https://doi.org/10.22271/chemi.2020.v8.i2aa.9014>

Abstract

A field experiment was conducted at Crop Research Centre of Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut (UP) India to study the effect of sources and methods of zinc application on growth, yield and zinc use efficiency in Basmati rice (*Oryza sativa* L.). The experiment was carried out during *kharif* season of 2017 with ten treatments *viz.* Control (T₁), Seedling treatment with 1% ZnO solution (5 min.) (T₂), 5 kg Zn/ha through ZnSO₄ (21% Zn) as soil application (T₃), 0.5 kg Zn/ha through Chelated zinc (Zn EDTA) as soil application (T₄), 7.5 kg Zn/ha through ZnSO₄ (21% Zn) as soil application (T₅), 1 kg Zn/ha through Chelated zinc (Zn EDTA) as soil application (T₆), Foliar spray of ZnSO₄ with lime (0.1% Zn solution (T₇), Foliar spray of ZnSO₄ with urea (0.1% Zn solution (T₈), Foliar spray of ZnSO₄ with lime (0.15% Zn solution (T₉) and Foliar spray of ZnSO₄ with urea (0.15% Zn solution (T₁₀). Experiment was laid out in Randomized Block Design with three replications. Grain, straw and biological yield of rice crop was influenced by different sources and methods of zinc application and were recorded significantly highest with the application of 7.5 kg Zn/ha through ZnSO₄ (21% Zn) as soil application (T₅). The significantly lowest yield was recorded in control treatment. Highest protein content and protein yield was also associated with the same treatment, the next in the order best treatments were T₃ (5 kg Zn/ha through ZnSO₄ (21% Zn) as soil application) and T₆ (1 kg Zn/ha through Chelated zinc (Zn EDTA) as soil application). The maximum net return and benefit: cost ratio was recorded in T₅. The lowest profitability from rice was associated with control (no zinc) treatment.

Keywords: Basmati rice, zinc, protein yield

Introduction

Cultivation of rice is important to food security of Asia, where more than 90% of the global rice is produced and consumed. India is the second largest producer and consumer of rice in the world after china. In India, the area, production and productivity of rice is 43.79 mha, 112.91 mt and 2.57 t/ha, respectively, (Anonymous, 2018) [1]. In India, it accounts more than 40% of food grain production, providing direct employment to 70% people in rural areas. Being the staple food for more than 65% of the people, our national food security hinges on the growth and stability of rice production. Rice provides protein, minerals, vitamins and fiber, although all constituents except carbohydrates are reduced during milling is realized as staple food by majority of world's population.

Zinc deficiency under semi-arid climate has emerged as a serious limitation to crop production. Deficiency of zinc is being widely expressed in the light textured soil. The soils of Meerut region vary in texture from sandy to clay loam, alkaline in nature, low in organic carbon content and generally quite low in fertility status. All these factors lead to the deficiency of zinc in soils as such it is also possible that the application of zinc may be helpful in increasing the rice yield under agro-climatic condition of Meerut (U.P.). The different approaches for correction of zinc deficiency include dietary intervention, supplementation and biofortification through agronomic and genetic approaches for improving grain zinc concentration. Although, a large number of studies are available on the role of soil and foliar applied Zn fertilizers in correction of Zn deficiency and increasing plant growth and yield (Mortvedt and Gilkes 1993; Rengel *et al.* 1999) [9, 5].

Zinc can be directly applied to soil as both organic and inorganic compounds. Zinc sulfate (ZnSO_4) is the most widely applied inorganic source of Zn due to its high solubility and low cost. Zinc can also be applied to soils in form of ZnO , Zn-EDTA and Zn-oxy-sulfate.

Changes in crop production technology often present opportunities to develop fertilization strategies that may reduce production costs associated with product application or materials, improve nutrient delivery to plants, or provide flexibility in the timing of crop inputs. Due to high cost of zinc and its unavailability at proper time not only reduces the yield of rice but also there is a lot of contradiction in recommendation of the method and time of zinc application in rice. Present investigation was planned to determine the effect of different zinc management options on the productivity and profitability of transplanted basmati rice.

Materials and Methods

A field experiment was conducted at Crop Research Centre of Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut (UP) India to study the effect of sources and methods of zinc application on growth, yield and zinc use efficiency in Basmati rice (*Oryza sativa* L.). The experiment was carried out during *kharif* season of 2017 with ten treatments viz control (T_1), Seedling treatment with 1% ZnO solution (5 min.) (T_2), 5 kg Zn/ha through ZnSO_4 (21%

Zn) as soil application (T_3), 0.5 kg Zn/ha through Chelated zinc (Zn EDTA) as soil application (T_4), 7.5 kg Zn/ha through ZnSO_4 (21% Zn) as soil application (T_5), 1 kg Zn/ha through Chelated zinc (Zn EDTA) as soil application (T_6), Foliar spray of ZnSO_4 with lime (0.1% Zn solution (T_7), Foliar spray of ZnSO_4 with urea (0.1% Zn solution (T_8), Foliar spray of ZnSO_4 with lime (0.15% Zn solution (T_9) and Foliar spray of ZnSO_4 with urea (0.15% Zn solution (T_{10}). The experiment was laid out in Randomized Block Design with three replications.

The climate of this region is semi-tropical characterized with hot summers and extremely cold winters. The mean maximum temperature was noticed in June, which is the hottest month of the year, ranges from 40° to 45°C while very low temperature (4°C) accompanied by frost may be experienced in Dec.-Jan. The winters are cool, frost generally occurs towards the end of December and may continue till the end of January. The mean annual rainfall of the Meerut is about 840 mm, of which nearly 90 per cent is received in the monsoon period from June to September and the remaining in the period between October to May. The mean daily pan evaporation value reaches as high as 16.0 mm in the month of June and as low as 2.2 mm in the month of January. The mean annual pan evaporation reaches about 850 mm. The mean wind velocity varies from 3.5 km ha^{-1} during season.

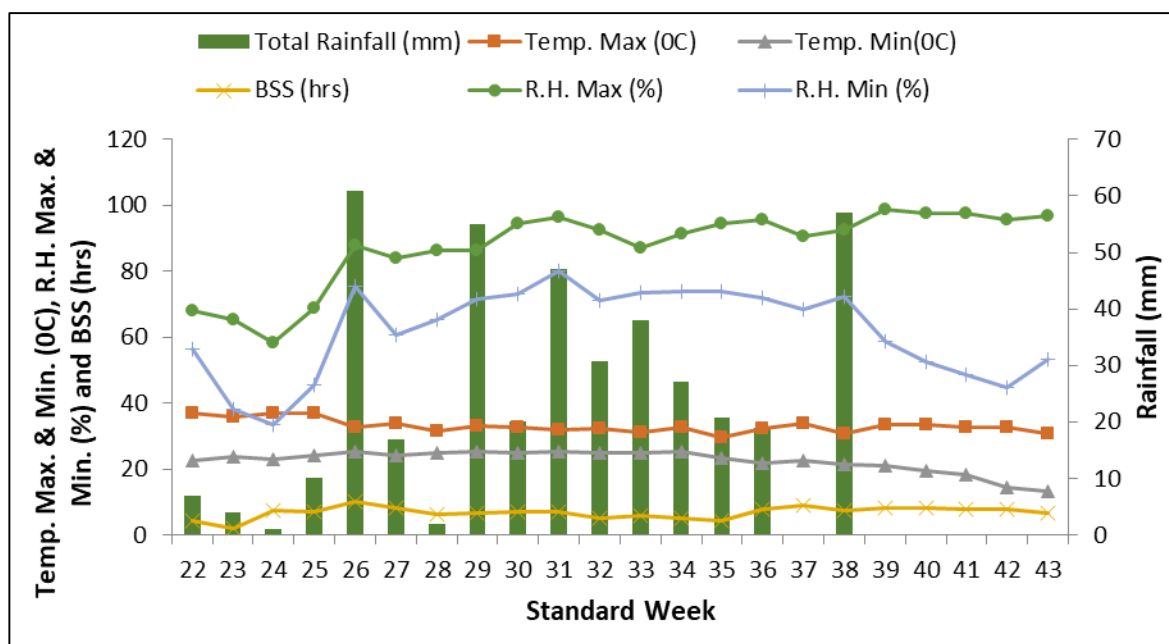


Fig 1: Mean weekly agro-meteorological data during the crop growing season (kharif-2017)

The soil of the experimental field was sandy loam in texture and slightly alkaline in nature and low in organic carbon, available nitrogen, available potassium and medium in available phosphorus. The basmati rice (PB-1) was transplanted on 20th July 2017. The experimental field was ploughed immediately after the harvest of previous wheat crop by a tractor drawn harrow in summer to expose weeds and the eggs of harmful insects. The field was prepared by practicing two cross disc harrowing and two cross ploughing operations and finally the field was leveled and planked.

The required quantities of N, P, K and Zn were applied in the different treatments by Urea, Diammonium Phosphate, Muriate of potash, Zinc sulphate Zinc oxide and chelated Zinc respectively. Half dose of nitrogen and full dose of other nutrients (as per treatments) was applied as basal and rest

nitrogen was applied in two equal splits at tillering and panicle initiation stages into the soil uniformly. A thin layer of water (approximately 3.0 cm) was maintained during the initial stage of crop growth for better establishment of seedlings and maximum 5.0 cm at tillering stage and later an intermittent irrigation at the time of panicle initiation, flowering and grain formation stage were applied. Water was drained out from the field one week before the harvesting of crop. Two days after transplanting Butachlor @ $2.6 \text{ liter ha}^{-1}$ was applied to control the weeds. In order to control stem borer, leaf hopper, gundhi bug and other insects, the recommended insecticide as Cartap hydro chloride 4G was applied @ 20 kg ha^{-1} .

Harvesting was done manually when the crop reached at full physiological maturity stage. First of all, the border rows were

harvested and separated. Later, the crop from net plot area was harvested and sun dried. The harvested material from each plot was carefully bundled, tagged and brought to threshing floor. Threshing was done plot wise and grains were cleaned, dried and weighed separately for each net plot and computed to q ha^{-1} at 14% moisture level. The straw yield was obtained by subtraction grain yield from biological yield, also recorded plot wise after sun drying and computed to q ha^{-1} .

Result and Discussion

Zinc Management and Productivity of Basmati Rice

Biological Yield (q/ha): The maximum biological yield of 122.65 q ha^{-1} was recorded with the application of 7.5 kg Zn/ha through ZnSO_4 (21% Zn) as soil application (T_5) which was statistically at par with T_3 (5 kg Zn/ha through ZnSO_4 (21% Zn) as soil application) and T_6 (1 kg Zn/ha through Chelated zinc (Zn EDTA) as soil application) with the straw yield of 120.80 and 119.90 q ha^{-1} respectively. The increment

in biological yield under treatment T_5 (7.5 kg Zn/ha through ZnSO_4 (21% Zn) as soil application) was to the tune of 20.48% over control (T_1). However, the lowest biological yield (97.52 q ha^{-1}) was recorded under control plots.

Grain Yield (q/ha): Sources and methods of zinc application caused significant variation in grain yield (q ha^{-1}) of rice. The maximum grain yield of 53.30 q ha^{-1} was recorded with the application of 7.5 kg Zn/ha through ZnSO_4 (21% Zn) as soil application (T_5) which was significantly at par with T_3 (5 kg Zn/ha through ZnSO_4 (21% Zn) as soil application) and T_6 (1 kg Zn/ha through Chelated zinc (Zn EDTA) as soil application) with the yield of 52.50 and 51.90 q ha^{-1} , respectively. The increment in grain yield under treatment T_5 (7.5 kg Zn/ha through ZnSO_4 (21% Zn) as soil application) was to the tune of 23.32% over T_1 (control). However, the lowest grain yield (40.87 q ha^{-1}) was recorded under control plot.

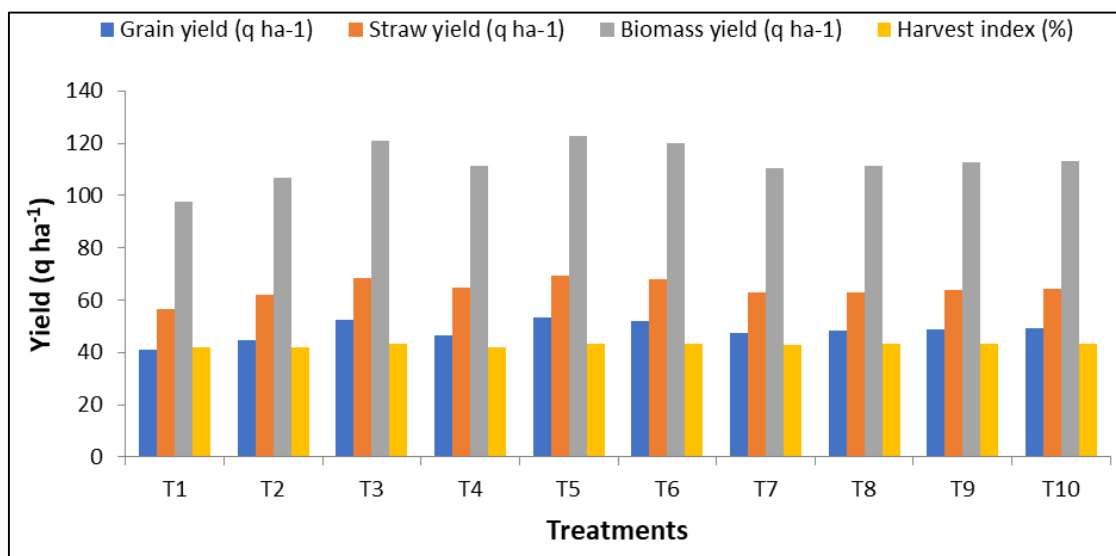


Fig 2: Productivity of Basmati rice as influenced by different zinc management options

Straw Yield (q/ha): The straw yield differs from 56.65 to 69.35 q ha^{-1} . The maximum straw yield (69.35 q ha^{-1}) was recorded with the application of 7.5 kg Zn/ha through ZnSO_4 (21% Zn) as soil application (T_5) which was statistically at par with all the treatments except T_1 (control) and T_2 (Seedling treatment with 1% ZnO solution (5 min.)). The increment in straw yield under treatment T_5 (7.5 kg Zn/ha through ZnSO_4 (21% Zn) as soil application) was to the tune of 18.38% over T_1 (control). However, significantly lowest straw yield (56.65 q ha^{-1}) was recorded in control treatment (T_1). The straw yield is function of crop biomass developed during the crop growth period and also makes important contribution to the overall crop residues as it is used as feed for the cattle. The straw yield is depicted in all the treatments were significantly higher than control. Among the various zinc sources and methods of zinc application T_5 (7.5 kg Zn/ha through ZnSO_4 (21% Zn) as soil application) gave significantly higher straw yield during the year of study. Higher straw yield with higher levels of zinc could be due to a greater number of tillers sq. m^{-1} , dry matter accumulation and plant height as compared to other treatments

Harvest Index (%): Harvest index which is a ratio of grain yield to biological yield was highest (43.50%) with the application of 7.5 kg Zn/ha through ZnSO_4 (21% Zn) as soil

application (T_5) followed by T_3 (5 kg Zn/ha through ZnSO_4 (21% Zn) as soil application) and T_6 (1 kg Zn/ha through Chelated zinc (Zn EDTA) as soil application) which gave 43.46 and 43.29 percent harvest index, respectively. The lowest harvest index (41.91%) was observed in control treatment (T_1).

Crop productivity is the rate at which a crop accumulate biomass which depends primarily on the photosynthesis and conversion of light energy into chemical energy by green plants. The yield of rice is composed of yield components like as number of panicles, panicle length and 1000 grain weight. Though, 1000 grain weight an influence on grain yield but its effect is lower than panicle length and number of grains panicle⁻¹. All sources and methods of zinc application differ significantly from each other except T_5 and T_3 and T_6 . Positive effects of micronutrients application by soil and foliar sprays on grain yield of rice might be due to increase chlorophyll content of leaves of rice which might have increased photosynthesis and resulted in more dry matter accumulation and leaf area and hence lead to more capture of solar radiation that resulted in enhanced values of growth parameters and yield contributing characters and ultimately resulted in higher grain yield. These results are in line with Slaton *et al.* (2005) [6], Khattak *et al.* (2015) [3] and Ghoneim (2016) [2].

Table 1: Productivity of Basmati rice as influenced by different zinc management options

Treatments	Biomass yield (q ha ⁻¹)	Grain yield (q ha ⁻¹)	Straw yield (q ha ⁻¹)	Harvest index (%)
(T ₁) Control	97.52	40.87	56.65	41.91
(T ₂) Seedling treatment with 1% ZnO solution (5 min.).	106.79	44.87	61.92	42.04
(T ₃) 5 kg Zn/ha through ZnSO ₄ (21% Zn) as soil application.	120.80	52.50	68.30	43.46
(T ₄) 0.5 kg Zn/ha through Chelated zinc (Zn EDTA) as soil application.	111.22	46.54	64.68	41.84
(T ₅) 7.5 kg Zn/ha through ZnSO ₄ (21% Zn) as soil application.	122.65	53.30	69.35	43.50
(T ₆) 1 kg Zn/ha through Chelated zinc (Zn EDTA) as soil application.	119.90	51.90	68.00	43.29
(T ₇) Foliar spray of ZnSO ₄ with lime (0.1% Zn solution).	110.61	47.60	63.01	43.06
(T ₈) Foliar spray of ZnSO ₄ with urea (0.1% Zn solution).	111.29	48.27	63.02	43.37
(T ₉) Foliar spray of ZnSO ₄ with lime (0.15% Zn solution).	112.75	48.67	64.09	43.18
(T ₁₀) Foliar spray of ZnSO ₄ with urea (0.15% Zn solution).	113.31	49.17	64.14	43.41
SEm±	2.68	0.90	2.31	-
CD (P= 0.05)	8.04	2.69	6.93	-

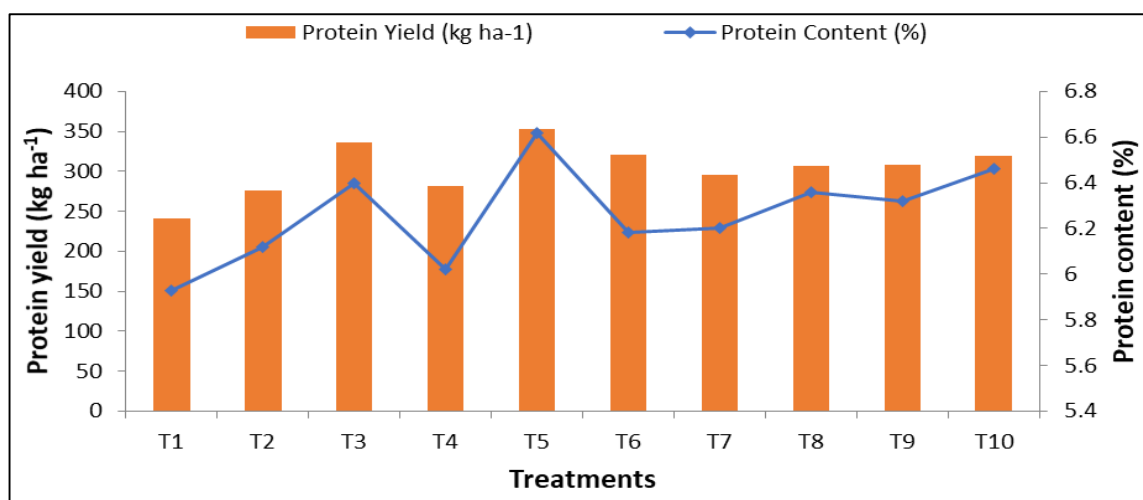
Protein Content in Grains and Protein Yield of Basmati Rice

Protein yield is associated with the nitrogen content in rice grain and this content is depends on nitrogen uptake by rice grain. The protein content of rice grain ranged from 5.93 to 6.62%. The maximum protein content (6.62%) in rice grains was recorded with application of 7.5 kg Zn/ha through ZnSO₄ (21% Zn) as soil application (T₅) followed by T₁₀ (Foliar spray of ZnSO₄ with urea (0.15% Zn solution) and T₃ (5 kg Zn/ha through ZnSO₄ (21% Zn) as soil application). The data revealed that the application of 7.5 kg Zn/ha through ZnSO₄ (21% Zn) as soil application accumulated significantly more protein content in rice grains as compared to other treatments.

However, the minimum accumulation of protein in rice grains (5.93%) was recorded under control treatment (T₁). The data obtained on protein yield in rice grains ranged from 241.57 to 353.50 kg ha⁻¹, being significantly maximum with the application of 7.5 kg Zn/ha through ZnSO₄ (21% Zn) as soil application (T₅) which was statistically at par with T₃ (5 kg Zn/ha through ZnSO₄ (21% Zn) as soil application) and T₆ (1 kg Zn/ha through Chelated zinc (Zn EDTA) as soil application). The addition of 7.5 kg Zn/ha through ZnSO₄ (21% Zn) as soil application (T₅) registered 31.66% more protein yield in rice as compared to control treatment (T₁). The minimum protein yield (241.57 kg ha⁻¹) was recorded under control treatment.

Table 2: Protein content (%) in grains and protein yield (kg ha⁻¹) as influenced by different zinc management options

Treatments	Protein Content (%)	Protein Yield (kg ha ⁻¹)
(T ₁) Control	5.93	241.57
(T ₂) Seedling treatment with 1% ZnO solution (5 min.).	6.12	275.57
(T ₃) 5 kg Zn/ha through ZnSO ₄ (21% Zn) as soil application.	6.40	336.63
(T ₄) 0.5 kg Zn/ha through Chelated zinc (Zn EDTA) as soil application.	6.02	281.05
(T ₅) 7.5 kg Zn/ha through ZnSO ₄ (21% Zn) as soil application.	6.62	353.50
(T ₆) 1 kg Zn/ha through Chelated zinc (Zn EDTA) as soil application.	6.18	320.90
(T ₇) Foliar spray of ZnSO ₄ with lime (0.1% Zn solution).	6.20	295.41
(T ₈) Foliar spray of ZnSO ₄ with urea (0.1% Zn solution).	6.36	307.17
(T ₉) Foliar spray of ZnSO ₄ with lime (0.15% Zn solution).	6.32	308.21
(T ₁₀) Foliar spray of ZnSO ₄ with urea (0.15% Zn solution).	6.46	318.76
SEm±	0.04	7.40
CD (P= 0.05)	0.14	22.16

**Fig 3:** Protein content (%) in grains and protein yield (kg ha⁻¹) as influenced by different zinc management options

Zinc Management and Profitability of Basmati Rice

Cost of cultivation: The cost of cultivation in rice crop varied from Rs 28898 to 33218/ha. The maximum cost of cultivation

(Rs 33218) was observed in T₆ (1 kg Zn/ha through Chelated zinc (Zn EDTA) as soil application) treatment which was

14.95% higher than control. The lowest cost of cultivation (Rs 28898) was associated with control treatment.

Gross return: The application of 7.5 kg Zn/ha through ZnSO_4 (21% Zn) as soil application (T_5) gave highest gross return (117003 Rs/ha) followed by application of 5 kg ZnSO_4 (21% Zn) as soil application which gave Rs 115245/ha gross return. The application of 7.5 kg Zn/ha through ZnSO_4 (21% Zn) as soil application resulted into 29.66% more gross return than control treatment. The lowest gross return of Rs. 90237/ha was obtained under control treatment.

Net return: The application of 7.5 kg Zn/ha through ZnSO_4 (21% Zn) as soil application (T_5) gave highest net return (86455 Rs/ha) followed by application of 5 kg ZnSO_4 (21% Zn) as soil application which gave 85347 Rs /ha gross return. The application of 7.5 kg Zn/ha through ZnSO_4 (21% Zn) as soil application resulted into 28.87% more net return than control treatment. The lowest net return of Rs 61489/ha was obtained under control treatment (T_1).

B:C ratio: Benefit: cost ratio of various treatments varied from 3.12 to 3.85. The application of 5 kg Zn/ha through ZnSO_4 (21% Zn) as soil application (T_3) and application of 7.5 kg Zn/ha through ZnSO_4 (21% Zn) as soil application (T_5) resulted into similar benefit:cost ratio (Rs. 3.85/ rupee invested). The lowest value of benefit:cost ratio (Rs 3.12/ rupee invested) was noticed in control treatment.

Moreover, crop fertilized with zinc-based nutrients application (T_5) gave more ruminative in terms of gross return (Rs. 117003 ha^{-1}), net return (Rs. 86605 ha^{-1}) and B:C ratio (3.85) over rest of the treatments (Table 3). It was mainly because of more increase in grain yield and gross income in comparison to increase in cost of cultivation (Kumar *et al.*, 2017) [4]. Higher B:C ratio might have been attributed to dual advantage *i.e.* saving in inputs and additional returns due to higher yields (Ghasal *et al.*, 2015) [8]. Whereas, maximum cost of cultivation (Rs. 29517 ha^{-1}) was recorded in (T_6) during the year of study. It may be due to high cost of fertilizer (Abbas *et al.*, 2010). Zinc based on foliar application had acquired more profit than recommended soil application may be due to saving of zinc (Kumar *et al.*, 2017) [4]. The higher dose of zinc increases insect-pest attack and thus leads to consumption of high doses of insecticides and pesticides, thereby, resulting in increased cost of production. Similar opinion was also mentioned by Jakhar *et al.* (2006) [11]. Moreover, profit and cost were marginally improved with the application of 5 kg Zn/ha through ZnSO_4 (21% Zn) as soil application during the year of experimentation. Variation in cost of cultivation of rice under different nutrient management practices have been reported by Abbas *et al.* (2010). Kumar *et al.* (2017) [4] showed that maximum net return (Rs. 82607/ha) and B:C ratio (2.34) was withered due to 50 kg ZnSO_4 /ha owing to the higher yields of grain and straw. The similar findings have been also reported by Nagrajan *et al.* (1986) [10].

Table 3: Profitability of Basmati rice as influenced by different zinc management options

Treatments	Cost of cultivation (Rs/ha)	Gross return (Rs/ha)	Net return (Rs/ha)	Benefit: cost ratio
(T_1) Control	28898	90237	61339	3.12
(T_2) Seedling treatment with 1% ZnO solution (5 min.).	30715	99028	68313	3.22
(T_3) 5 kg Zn/ha through ZnSO_4 (21% Zn) as soil application.	29898	115245	85347	3.85
(T_4) 0.5 kg Zn/ha through Chelated zinc (Zn EDTA) as soil application.	31058	102775	71717	3.31
(T_5) 7.5 kg Zn/ha through ZnSO_4 (21% Zn) as soil application.	30398	117003	86605	3.85
(T_6) 1 kg Zn/ha through Chelated zinc (Zn EDTA) as soil application.	33218	114000	80782	3.43
(T_7) Foliar spray of ZnSO_4 with lime (0.1% Zn solution).	29452	104652	75200	3.55
(T_8) Foliar spray of ZnSO_4 with urea (0.1% Zn solution).	29392	105987	76595	3.61
(T_9) Foliar spray of ZnSO_4 with lime (0.15% Zn solution).	29517	106946	77429	3.62
(T_{10}) Foliar spray of ZnSO_4 with urea (0.15% Zn solution).	29457	107962	78505	3.67

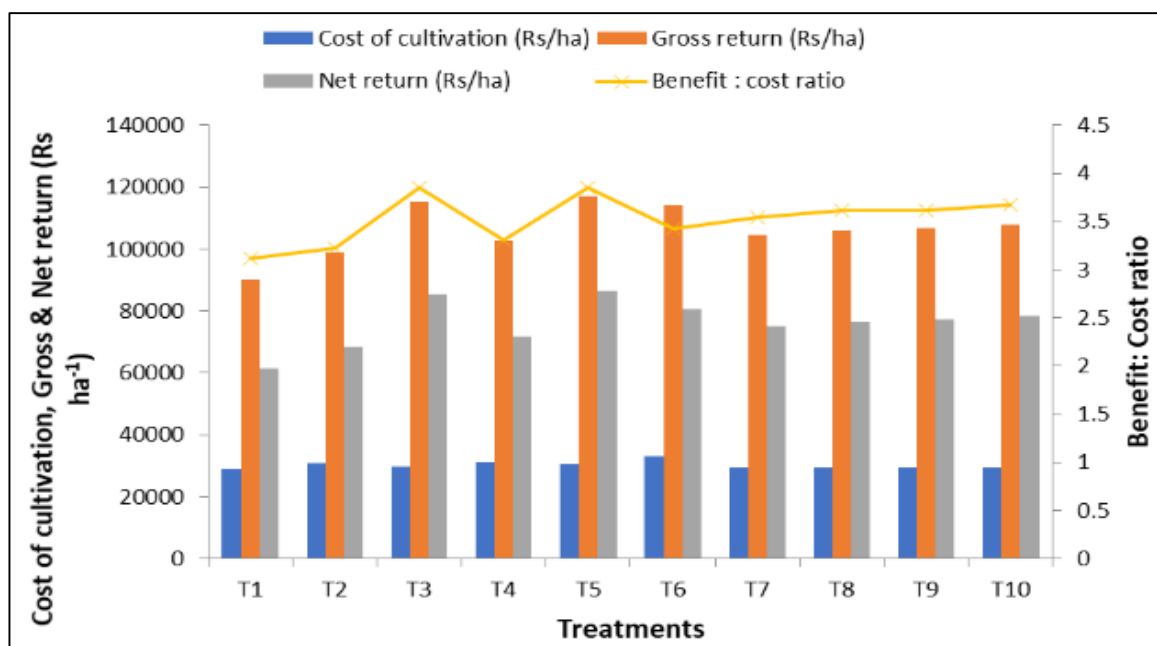


Fig 4: Profitability of Basmati rice as influenced by different zinc management options

Conclusion

From the forgoing discussion it has been cleared that the application of 7.5 kg Zn/ha through ZnSO₄ (21% Zn) as soil application resulted into highest grain, straw and biological yield of Basmati rice. Highest protein content and protein yield was also associated with the same treatment. This treatment also gave the maximum net return and benefit: cost ratio. Thus, it may be concluded that application of 7.5 kg Zn/ha through ZnSO₄ (21% Zn) as soil application is the best option for achieving higher yield and benefit from Basmati rice.

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