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Effect of Foliar Application of Iron and Zinc on Performance of Transplanted Rice in middle Gangetic Plains of Bihar

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ABSTRACT

A field experiment was conducted during kharif season of 2015 and 2016 at research farm of the ICAR- Indian Agricultural Research Institute Regional Station Pusa, Samastipur, Bihar to determine the foliar feeding of micronutrients (iron and zinc at different growth stages) on growth, yield and economics of rice in middle Gangetic plains of Bihar. The experiment was laid out in randomized block design consisting of 9 treatments with 3 replications. The treatments consist of 0.5% spray of Zinc Sulphate and 1% spray of Ferrous Sulphate at four different growth stages i.e. 40, 50, 60 and 70 days after transplanting (DAT) and one control. The results shown significant increasing trends of growth, yield attributes and yield of rice with four sprays of 1.0% solution of $FeSO_4$ at 40, 50, 60 and 70 days and three sprays of $ZnSO_4$ at 50, 60 and 70 days recorded significantly higher plant height, effective tillers/m^2, panicle length, grains/panicle, 1,000-grain weight, biological yield, grain yield and straw yield at maturity. These treatments also gave significantly higher net returns and benefit: cost ratio over the control.

KEYWORDS

Foliar application, Iron, Transplanted rice, Zinc, Gangetic plains

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INTRODUCTION

Rice-wheat cropping system is one of the most important cropping systems in South Asia as well as in middle Gangetic plains of Bihar (Singh *et al*, 2017). Rice is a staple food crop of more than half of the population of South Asia (Mahajan and Chauhan, 2015). It is also a staple food crop representing the major carbohydrate and even protein source in North-Eastern Plain Zone of India (Singh *et al* (2012)). The sustainability and productivity of this cropping system is under threat due to deteriorating soil health and micronutrient deficiency and resulting in less grain yield and poor quality (Kumar *et al* 2016 and Singh *et al* 2015). Injudicious use of major nutrients, less use of organic fertilizers and manures, poor on-farm residue management and intensive cropping create negative nutrients balance and deficiency of micronutrients (Nadeem and Farooq, 2019). Micronutrient deficiency is considered as one of the major causes of the declining productivity trends observed in rice growing countries (Singh *et al*, 2012). Micronutrient deficiencies occurs in both crops and humans (Seilsepour, 2007) and deficiencies of iron (Fe) and zinc (Zn) result in impaired mental development, anemia, reduced immunity, poor appetite and stunting. Iron deficiency is one of the most prevalent micronutrient deficiencies in the world. Micronutrient malnutrition, particularly Zn and Fe deficiency, affects over three billion people worldwide (Bouis, 2007).

Increasing the Fe and Zn concentration of staple foods, such as rice could solve Fe and Zn deficiencies. Enrichment of cereals grains with micronutrients is a high priority area of research and will contribute to minimizing micronutrients deficiency-related health problems in humans (Prasad *et al* 2013 and Sudha and Stalin 2015)Foliar application of micronutrient is a simple way for making quick correction of plant nutrient status. Foliar sprays of these micronutrients have proved to be a sustainable, effective and low cost strategy to improve Fe and Zn levels in edible portions of staple food crops (Ling *et al*, 2013). Foliar spraying is a new method for crop feeding in which micronutrients in form of liquid are sprayed on leaves (Nasiri *et al*, 2010). Foliar fertilization with micronutrients is proved to be an effective strategy to remove the deficiency when soil application is not beneficial (Cakmak, 2008). Foliar spraying of microelements is very helpful when the roots cannot provide necessary nutrients (Babaeian *et al*, 2011). Foliar application of nutrients seems helpful compared to soil amendments for efficient use of nutrients and curing the visual deficiency problems in a short time (Fageria *et al*, 2002). Foliage applied Zn enhances the grain yield of field crops including wheat, barley and rice (Ullah *et al*, 2018). Foliar feeding results in rapid absorption and is less costly (El-Fouly and El-Sayed, 1997). Timing of foliar micronutrient application is an important factor determining the effectiveness of the foliar applied fertilizers

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in increasing grain micronutrient concentration (Ozturk *et al*, 2006). Hence, in view of the above, the present study was planned with the objective to find out the foliar application of iron and zinc on performance of transplanted rice (Oryza sativa) in middle Gangetic plains of Bihar.

MATERIALS AND METHODS

A field experiment was conducted during the two consecutive kharif seasons of 2015 and 2016 at research farm of ICAR-Indian Agricultural Research Institute, Regional Station Pusa Samastipur (Bihar). The experimental field is situated at a latitude of 25°58'49" N, longitude of 85°40'48" E and altitude of 52.12 meters experienced even topography and good drainage. The soil of the experimental site was sandy loam in texture having low organic carbon (0.35 to 0.38%), medium range of available P_2O_5 and available K_2O and high pH (8.4) whereas, EC was in the range of 0.25 to 0.3 dS/m during both years. The climate of the site is sub-humid tropical with hot summer and cold winter.

The experiment was laid out in randomized block design with 9 treatments viz. Control (no spray of micronutrients), NPK + 1 spray of $ZnSO_4$ 0.5% at 70 days after transplanting, NPK + 2 sprays of $ZnSO_4$ 0.5% at 60 and 70 days after transplanting, NPK + 3 sprays of $ZnSO_4$ 0.5% at 50, 60 and 70 days after transplanting, NPK + 4 sprays of $ZnSO_4$ 0.5% at 40, 50, 60 and 70 days after transplanting and NPK + 1 spray of $FeSO_4$ 1.0% at 70 days after transplanting, NPK + 2 sprays of $FeSO_4$ 1.0% at 60 and 70 days after transplanting, NPK + 3 sprays of $FeSO_4$ 1.0% at 50, 60 and 70 days after transplanting and NPK + 4 sprays of $FeSO_4$ 1.0% at 40, 50, 60 and 70 days after transplanting and replicated thrice. The source for zinc was $ZnSO_4.H_2O$ ($ZnSO_4$) and Iron was $FeSO_4.7H_2O$ ($FeSO_4$) with nutrient content of 33% Zn and 19% Fe. Recommended dose of fertilizer (RDF) were applied uniformly to all the experimental plots @ 150: 60:40 kg/hathrough chemical fertilizers i.e. urea, diammonium phosphate and muriate of potash. Half of nitrogen, full dose of phosphorous and potash were applied as basal and remaining half of nitrogen were top dressed in two equal split doses first at active tillering and second at panicle initiation stage equally in all treatments. Other management practices were adopted as per recommendation of the crop grown under Middle Gangetic plains of India. Pusa Sugandha 5 was used as test variety. The transplanting of rice was done manually during the second fortnight of July. Weeds were controlled by applying Oxadiargyl @ 90.00 g a.i./ha within 3 days after transplanting of rice and a herbicide mixture of Nominee Gold 10 SL (bispyribac) @ 25 g a.i./ha and Pyrazosulfuron @ 15 g a.i./ha was applied at 30 days after transplanting of rice as post emergence. Irrigation was applied as per requirement to rice crop. Observations of growth and yield-attributing characters were recorded at 30, 60, 90 days after transplanting and harvest of rice under different treatments. Plant height was recorded from each plot at 5 different selected plants and averaged. Five panicles were selected at random from each plot to compute panicle length and recorded in cm. Effective tillers (Panicle-bearing tillers) were counted with the help of quadrate (1 m^2) placed randomly at three different points of each plot. When rice crop matured, plants from net plot area were harvested manually with the help of sickle separately and crop produce was left in the field for 4-5 days to be dried up to desired moisture. Bundle weight was recorded separately for each plot and threshing was done manually. The weight of rice straw was calculated by substracting grain weight from bundle weight and was expressed in t/ha. For test weight, a representative sample of grains was taken from the grain yield of each plot after drying and cleaning and weight of 1000-grains recorded and was expressed in grams. The prices in rupees of the inputs and outputs (grain and straw yields) that were prevailing at the time of their use and harvest of the crop respectively were taken into account to work out the cost of cultivation and gross return in both the years. Net monetary returns per hectare were calculated by deducting the cost of cultivation per hectare from gross returns. The data collected were assessed following standard statistical procedures of Gomez and Gomez (1984) with 5% probability.

RESULTS AND DISCUSSION

Growth parameters

The pooled data over two years revealed no significant changes in plant height observed at 30 days after transplanting (DAT). However, at 60 DAT a significant variation was observed when foliar application of $ZnSO_4$ and $FeSO_4$ was done at all four stages. At maturity significantly, higher plant height (113.8 cm) was recorded with 4 sprays of $FeSO_4$ 1.0% over control (104.8 cm) and 1 spray of $FeSO_4$ 1.0% at 70 DAT but statistically at par with rest of the $FeSO_4$ treatments. However, it was also significantly higher than all the $ZnSO_4$ 0.5% treatments. Among $ZnSO_4$ 0.5% treatments significantly higher plant height (107.1 cm) was recorded with 3 spray of $ZnSO_4$ 0.5% followed by 4 sprays (106.9 cm**)** over control and was at par with rest of the $ZnSO_4$ 0.5% treatments (Table 1). However, significantly higher dry matter accumulation (12.96 t/ha) was recorded with 4 sprays of $FeSO_4$ 1.0% at 40, 50, 60 and 70 DAT over control (11.33 t/ha) and 1 spray of $FeSO_4$ 1.0% at 70 DAT and statistically at par with rest of the $FeSO_4$ treatments. It was also significantly higher over all the $ZnSO_4$ 0.5% treatments (Table 2). Among $ZnSO_4$ 0.5% treatments highest dry matter accumulation (12.18 t/ha) was recorded with 3 sprays followed by 4 sprays (12.02 t/ha) and both were significantly superior over control. Similar findings were also reported by Naguib *et al* (2007) and Js and Walia (2013)). More dry matter accumulation with foliar sprays of micronutrients to rice crop might be owing to more plant height and more tillers than the control. These findings are conformity with the findings of Rpr and P (2009) and Habib (2012). Js and Walia (2013) also reported that four sprays of 1.0% solution of $FeSO_4$ at 40, 50, 60 and 70 DAT were at par and recorded significantly higher plant height (101.6 and 101.3 cm), dry matter (15.0 and 15.1 t/ha), leaf-area index (3.3 and 3.6) over the control.

Table 1: Effect of foliar application of iron and zinc ongrowth and yield attributes of rice (pooled data over 2 years)

Treatments	Plant height (cm) at 30 DAT	Plant height (cm) at 60 DAT	Plant height (cm) at maturity	Effective tillers/m^2	Panicle length (cm)	Total grains/ panicle (no.)	Filled grains/ panicle (no.)	Unfilled grains/ panicle (no.)	Grain filling (%)	Sterility (%)
NPK + $ZnSO_4$ 0.5% spray at 70 DAT	60.5	80.9	104.8	164.0	27.6	136.7	121.6	15.1	88.9	11.1
NPK + $ZnSO_4$ 0.5% spray at 60 & 70 DAT	62.1	81.8	105.3	167.3	27.8	137.8	123.3	14.6	89.4	10.6
NPK + $ZnSO_4$ 0.5% spray at 50, 60 & 70 DAT	61.8	81.9	107.1	173.7	28.4	140.0	126.0	13.9	90.0	10.0
NPK + $ZnSO_4$ 0.5% spray at 40, 50, 60 & 70 DAT	62.0	81.5	106.9	169.3	28.3	139.3	124.9	14.5	89.6	10.4
NPK + $FeSO_4$ 1% spray at 70 DAT	63.1	82.0	108.4	174.5	28.7	140.5	126.5	13.9	90.1	9.9
NPK + $FeSO_4$ 1% spray at 60 & 70 DAT	63.3	85.7	109.9	177.8	29.1	141.1	128.3	12.8	90.9	9.1
NPK + $FeSO_4$ 1% spray at 50, 60 & 70 DAT	60.0	86.5	110.5	183.2	29.3	141.9	129.4	12.5	91.2	8.8
NPK + $FeSO_4$ 1% spray at 40, 50, 60 & 70 DAT	60.2	90.6	113.8	198.0	29.6	143.4	132.3	11.1	92.2	7.8
Control (NPK only)	62.5	78.9	101.6	153.3	26.7	135.2	119.5	15.7	88.4	11.6
SEm$\pm$	1.21	1.38	1.36	3.16	0.32	1.12	1.49	0.60	-	-
CD (P=0.05)	NS	4.50	4.44	10.30	1.04	3.64	4.87	1.97	-	-

*DAT= Days after transplanting

The pooled analysis of data revealed significant variations in all the yield attributes over control. Increasing trends of number of effective tillers/m^2 was recorded only up to three spray of $ZnSO_4$ 0.5% at 50, 60 and 70 DAT but effective tillers/m^{2}declined with $ZnSO_4$ 0.5% 4 spray at 40, 50, 60 and 70 DAT. Among $ZnSO_4$ treatments, all the treated plots recorded significantly effective more tillers per hills over control. Maximum effective tillers/m^2 (173.7/m^2) was recorded due to 3 sprays at 50, 60 and 70 DAT followed by 4 sprays at 40, 50, 60 and 70 DAT. All the $ZnSO_4$ treatments were statistically at par among them but significantly higher over control. Effective tillers/m^2 was increased with increased in number of spray of $FeSO_4$ 1.0%. Application of 4 sprays of $FeSO_4$ 1.0% at 40, 50, 60 and 70 DAT recorded significantly highest effective tillers/m^2 (198.0) over rest of the treatments ($FeSO_4$ as well as $ZnSO_4$ treatments). Unlike effective tillers increasing trend of panicle length, grains/panicle and 1000 grain weight was recorded only up to three spray of $ZnSO_4$ 0.5% at 50, 60 and 70 DAT and these parameters were slightly declined with $ZnSO_4$ 0.5% 4 sprays at 40, 50, 60 and 70 DAT. Highest panicle length (28.4 cm), total grains/panicle (140.0), filled grains/panicle (126.0) and 1000 grain weight (24.7 gm) were recorded with three spray treatment of $ZnSO_4$ 0.5% being statistically at par with 4, 3 and 1 spray treatments of $ZnSO_4$ 0.5% and significantly higher over the control. Foliar application of Zn increased the total number of grains per panicle as reported by Karim *et al* (2012) and Khan *et al* (2008). However, grains/panicle, panicle length and 1000 grain weight was increased significantly with increase in number of sprays of $FeSO_4$ 1.0% up to 4 sprays at 40, 50, 60 and 70 DAT of rice crop. Highest panicle length (29.6 cm), total number of grains/panicle (143.4), filled grains/panicle (132.3.0) and 1000 grain weight (26.0 gm) was observed when crop was treated with 4 sprays of $FeSO_4$ 1.0% at 40, 50, 60 and 70 DAT which was significantly higher over control and at par with rest of the treatments of $FeSO_4$ 1.0% and $ZnSO_4$ 0.5% (Table 1 &

2). In contrary to these results higher number of unfilled grains per panicle (15.7) and sterility percentage (11.6%) was recorded in control in which no any micronutrient spray was done. Among $ZnSO_4$ treatments highest grain filling percentage (90.0%) and lowest sterility percentage (10.0%) were recorded with three spray of $ZnSO_4$ 0.5% at 50, 60 and 70 DAT. Karim et al., 2012 also reported that foliar application of Zn increase the viability of pollen grains ultimately reducing the sterility percentage. Lowest number of unfilled grains per panicle (11.1) was observed with 4 sprays of $FeSO_4$ 1.0% at 40, 50, 60 and 70 DAT. Highest grain filling percentage (92.2%) and lowest sterility percentage (7.8%) were recorded with 4 sprays of $FeSO_4$ 1.0% at 40, 50, 60 and 70 DAT.

Grain yield increased with the increase in number of sprays of $ZnSO_4$ 0.5% only up to 3 sprays at 50, 60 and 70 DAT and significantly higher grain yield (4.35 t/ha) was obtained with 3 sprays of $ZnSO_4$ 0.5% at 50, 60 and 70 DAT over control and was at par with 1, 2 and 4 sprays of ZnSO4 0.5% (Table 2). In contrary to $ZnSO_4$ treatments, increasing trend of grain yield was recorded with increase in number of sprays of $FeSO_4$ 1.0% up to 4 sprays at 40, 50, 60 and 70 DAT. Significantly, highest grain yield (4.86 t/ha) was recorded with 4 sprays of FeSO4 1.0% at 40, 50, 60 and 70 DAT over all other treatments of FeSO4 1.0%, $ZnSO_4$ 0.5% and control, but it was statistically at par with 3 sprays of $FeSO_4$ 1.0% at 50, 60 and 70 DAT. Foliar application with 4 sprays of $FeSO_4$ 1.0% at 40, 50, 60 and 70 DAT produced 19.0% more yield than the control. Similar findings were also reported by Js and Walia (2013) and Roosta and Hamidpour (2011). Positive effects of foliar application of micronutrients spray on grain yield of rice might be due to increase in chlorophyll content of leaves of rice which might have increased photosynthesis and resulted in more dry matter, tillers/m^2 and LAI and hence led to more capture of solar radiation that resulted in enhanced values of growth parameters and yield-attributing characters and finally resulted in higher grain yield (Js and Walia, 2013). Straw yield and harvest index of rice was found non-significant and statistically similar straw yield was obtained with application of $ZnSO_4$ 0.5% and $FeSO_4$ 1.0% at different growth stages of rice crop (Table 2). However, relatively higher straw yield (8.11 and 7.83 t/ha) was obtained with 4 sprays of $FeSO_4$ 1.0% and three sprays of $ZnSO_4$ 0.5%, respectively to the tune of 5.75% and 9.00 % higher straw yield, respectively over the control. Significantly, higher biological yield (12.96 and 12.18 t/ha) was obtained with 4 sprays of $FeSO_4$ 1.0% and three sprays of $ZnSO_4$ 0.5%, respectively. Similar findings were also reported by Js and Walia (2013).

Table 2: Effect of foliar application of iron and zinc on yield, Harvest Index and 1000 grain weight of rice (pooled data over 2 years)

Treatments	Biological yield (t/ha)	Grain yield (t/ha)	Straw yield (t/ha)	HI (%)	1000 grain weight (gm)
NPK + $ZnSO_4$ 0.5% spray at 70 DAT	11.64	4.10	7.54	35.2	24.2
NPK + $ZnSO_4$ 0.5% spray at 60 & 70 DAT	11.75	4.13	7.62	35.2	24.4
NPK + $ZnSO_4$ 0.5% spray at 50, 60 & 70 DAT	12.18	4.35	7.83	35.8	24.7
NPK + $ZnSO_4$ 0.5% spray at 40, 50, 60 & 70 DAT	12.02	4.26	7.76	35.4	24.5
NPK + $FeSO_4$ 1% spray at 70 DAT	12.24	4.40	7.84	36.0	24.8
NPK + $FeSO_4$ 1% spray at 60 & 70 DAT	12.49	4.51	7.99	36.1	25.1
NPK + $FeSO_4$ 1% spray at 50, 60 & 70 DAT	12.63	4.57	8.07	36.2	25.1
NPK + $FeSO_4$ 1% spray at 40, 50, 60 & 70 DAT	12.96	4.86	8.11	37.5	26.0
Control (NPK only)	11.33	3.94	7.38	34.8	23.7
SEm±	0.21	0.10	0.22	1.0	0.27
CD (P=0.05)	0.67	0.33	NS	NS	0.90

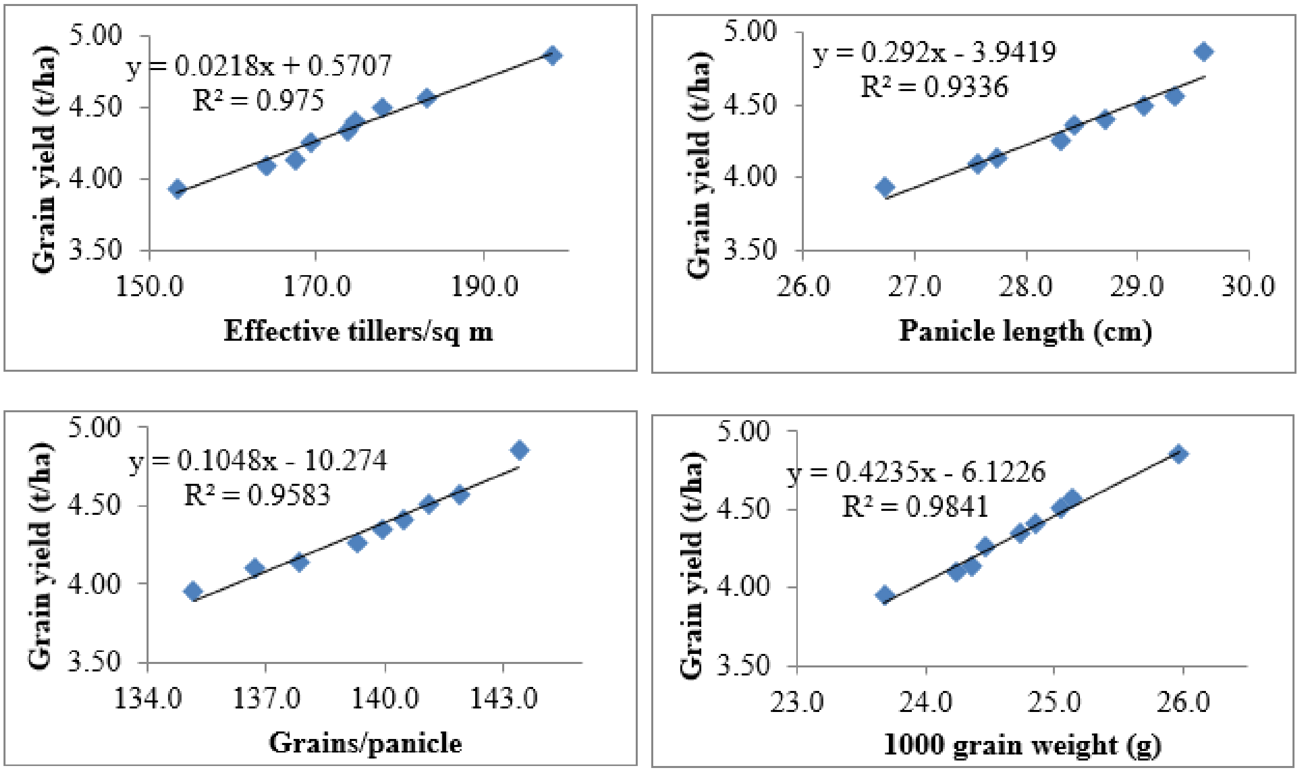

Fig. 1: Regression equation and trend lines of rice grain yield and major yield attributes influenced by foliar spray of micro nutrients at different growth stages

Table 3: Economics of rice crop as influenced by foliar application of micronutrients at different growth stages

Treatments	Cost of cultivation(x 10^3 /ha)	Goss returns(x 10^3 /ha)	Net returns(x 10^3 /ha)	Benefit: cost ratio
NPK + $ZnSO_4$ 0.5% spray at 70 DAT	46.80	110.4	63.6	2.36
NPK + $ZnSO_4$ 0.5% spray at 60 & 70 DAT	47.52	111.4	63.9	2.34
NPK + $ZnSO_4$ 0.5% spray at 50, 60 & 70 DAT	48.24	116.1	67.9	2.41
NPK + $ZnSO_4$ 0.5% spray at 40, 50, 60 & 70 DAT	48.96	114.3	65.3	2.33
NPK + $FeSO_4$ 1% spray at 70 DAT	46.92	117.1	70.2	2.50
NPK + $FeSO_4$ 1% spray at 60 & 70 DAT	47.75	119.6	71.8	2.50
NPK + $FeSO_4$ 1% spray at 50, 60 & 70 DAT	48.59	121.0	72.4	2.49
NPK + $FeSO_4$ 1% spray at 40, 50, 60 & 70 DAT	49.43	126.0	76.6	2.55
Control (NPK only)	46.08	107.0	60.9	2.32
SEm±	-	1.67	1.67	0.03
CD (P=0.05)	-	5.43	5.43	0.11

Correlation and regression analysis was done for assessing the degree of association between the yield components and grain yield. A significant and positive correlation was observed between the yield attributes and the grain yield and all the correlation coefficients were highly significant. There is a very strong relationship pattern between grain yield and yield attributing characters. The higher the value of the positive yield attributes, the higher the yield of grain obtained (Figure 1).

Economics

The net monetary returns and benefit: cost ratio was significantly influenced due to foliar application of different micronutrients at different growth stages. From the data it is revealed that four sprays of $FeSO_4$ 1.0% being at par with three spray of Fe gave higher net return and benefit: cost ratio compared to all other treatments of $ZnSO_4$ 0.5%, $FeSO_4$ 1.0% and the control (Table 3). Foliar spray of $FeSO_4$ 1.0% at 40, 50, 60 and 70 DAT recorded significantly highest net monetary returns (76.6 x 10^3/ha) and B: C ratio (2.55) than foliar spray of $ZnSO_4$ 0.5% at different stages and control. Among the $ZnSO_4$ 0.5% treatment the highest net return (67.9 x 10^3/ha) and benefit: cost ratio (2.41) was recorded in 3 spray of $ZnSO_4$ 0.5% at 50, 60 & 70 DAT which was significantly higher than control and at par with rest of the treatments of $ZnSO_4$ 0.5% spray. The lowest net return and benefit: cost ratio was observed in control. These results are also in conformity with the findings of Js and Walia (2013) .

CONCLUSION

From the present investigation, it can be concluded that foliar feeding with $FeSO_4$ @ 1.0% at 40, 50, 60 and 70 DAT and $ZnSO_4$ @ 0.5% at 50, 60 and 70 DAT to rice crop proved more beneficial than other treatments for improving the growth, yield attributes and yield of rice crop in middle Gangetic plains of Bihar.

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