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Effect of micronutrients on total dry matter yield and benefit cost ratio (BCR) in onion (*Allium cepa* L.)

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Abstract
A field experiment was conducted to evaluate the efficacy of micronutrients on the performances of onion (*Allium cepa* L. var. Arka Kalyan) with respect to its total dry matter yield during 2014-15 at College of Horticulture (OUAT), Sambalpur, Odisha under All India Network Research Project on Onion and Garlic, India. The experiment was laid out in RBD having four replication with following treatments: T_1 (soil application of Zinc Sulphate @ 10.0 kg ha^{-1}), T_2 (foliar application of Zinc Sulphate @ 0.5 % at 30 & 45 days after planting), T_3 (soil application of Borax @ 10.0 kg ha^{-1}), T_4 (foliar application of Borax @ 0.25% at 30 & 45 DAP), T_5 (Foliar application of Micronutrient Mixture i.e. iron-2.5 %,boron-0.5%,zinc -3%,copper -1%and manganese-1% @ 0.5% at 30 & 45 DAP) and T_6 (control i.e. without micronutrients). The recommended dose of fertilizer (RDF) used for onion crop was 150:50:80:30 NPK kg ha^{-1} along with FYM @ 20 t ha^{-1}, applied uniformly in all the treatments. The results revealed that foliar application of micronutrient mixture significantly increase the number of leaves plant^{-1} (12.62), total bulb yield (268.28 qha^{-1}), dry matter yield of leaves (1.18 tha^{-1}), bulb (4.74 tha^{-1}), total dry matter yield (5.91 tha^{-1}), highest gross income (2.68 lakhs/ha) as well as net income (1.95 lakhs/ha) than rest of the treatments. The second-best treatment was found to be foliar application of borax @ 0.25 % at 30 and 45 DAP (T_4) in all parameters. Similar trend was also observed for Benefit Cost Ratio (BCR), significantly highest being calculated in T_5 (2.65) closely followed by T_4 (2.26) which was statistically at par with each other.

Keywords: micronutrient, foliar application, DAP, RBD, RDF, BCR

Introduction
Onion (*Allium cepa* L.) is one of the most important popular commercial crop not only in India but also in the world. India ranks second in position both in area (12.04 lakhs ha) and production (194.02 lakh tones) in the world (NHB, 2014). In India, it is treated as most important export-oriented vegetable, exporting to the tune of 13, 58,193.00 MT of Rupees 2, 87,713.00 lakhs during 2013 – 2014 (NHB, 2014). Although India enjoys better position in the world scenario but the productivity of Indian onion is very less, only 161.2 qha^{-1} as compared to many other countries in the world (NHB, 2014).

Modern crop fertility programs are complex in nature, resulting from the interactions of many factors. Out of the major factors, fertilizer cost, contributing a large portion of the crop production expenses. Application of unneeded nutrients contributes to farming inefficiency and ground water pollution. Further, the deficiencies of micronutrients have emerged in the farmer's field and are recognized symptoms on foliage and reduction in the quality and yield of many crops, including vegetable crops. Deficiency of micronutrients in Indian soil during the last three decades has grown in both, magnitude and extent. This has become a major constraint to production and productivity of vegetables in general and onion in particular. The benefit of micronutrients is not limited solely to the replenishment of the micronutrients itself but in addition micronutrient acts as catalyst in the uptake and use of certain macronutrients. The requirement of micronutrients (boron, iron, copper, zinc, manganese, chloride and molybdenum) is only in traces, which is partly met from the soil or through chemical fertilizer or through other sources. Even though, micronutrients are needed by the plants in a minor quantity but it is involved in a wide variety of metabolic processes as well as cellular functions within the plants. In general, micronutrients play an active role in the plant metabolic process starting from cell wall development to respiration, photosynthesis, chlorophyll formation, enzyme activity, nitrogen fixation etc. (Ballabh *et al*., 2013) [6]. Besides these, micronutrients also work as co-enzyme for a large number of enzymes. In addition, they play an essential role in improving growth and yield of the crops (Tohamy *et al*., 2009 and Alam *et al*., 2010) [33, 1]. Foliar application of micronutrients during active crop growth stage was successfully used for correcting their deficits and improving the mineral status of the plants as well as increasing the crop yield and quality (Kolota and Osinska, 2001) [14]. Boron and zinc are the most important micro-nutrients which are essential for cell division, nitrogen and carbohydrate metabolism and water relation in plant growth (Brady, 1990) [9]. Application of boron can increase bulb size and yield of onion (Smriti *et al*., 2002) [31]. Increased in number of leaves plant^{-1} may be attributed to the role of micronutrients (zinc, boron) in cell

division, meristimatic activity of plant tissue and metabolism in plants (Lal and Maurya, 1981) [15]. Lal and Maurya (1981) [15] as well as Abedin *et al*. (2012) [1] showed that both zinc and boron significantly increased the dry weight of leaves in onion. Meena and Singh (1998) [19] reported that zinc significantly increased dry matter content in onion bulb. However, significantly better effect of both zinc and boron on dry matter content in onion was recorded by Acharya *et al.* (2015) [2]. The treatment combination of 40 kg sulphur + 1 kg boron per hectare gave the highest net return and benefit: cost ratio (Smriti *et al.*, 2002) [31]. Marginal analysis showed that the maximum marginal rate of return (MMR) was obtained when the crop was fertilized with zinc only (Nasreen *et al*.).

It has been a challenge to Indian farmers for production of quality onion bulbs for both local and foreign markets with the prevailing condition like deficiency of micronutrients and limiting factors. Keeping this in view, the field experiment entitled "Effect of micronutrients on total dry matter yield and benefit cost ratio (BCR) on onion (*Allium cepa* L.)" was conducted.

Materials and Methods

A field experiment was conducted during *Rabi* 2014-15 under AINRP on Onion and Garlic at College of Horticulture, Chiplima, Sambalpur, Orissa University of Agriculture and Technology (OUAT), Odisha, India. Soil of the experiment area was sandy loam having pH of 5.89; available NPK151.25:15.78:178.75 kg ha^{-1}. The field trial was laid out by adopting RBD replicated four with six treatments. The details of treatment are presented in Table no.1. Onion seeds variety Arka Kalyan obtained from the IIHR, Bangalore were sown in the nursery beds (1 m width, 3 m length and 15 cm height) on 22.10.2014at a distance of 5 cm and at a depth of 2 cm. Nursery beds were prepared by mixing FYM @ 20 kg and NPK mixture @ 20 g bed-1.About 55 days old seedling of 10-15 cm, height were transplanted in the field on 01.12.2014 and 02.12.2014 at a spacing of 15 x 10cm. All the recommended package of practices was adapted uniformly to all the treatments except the application of micronutrients. The recommended dose of fertilizer (RDF) used for onion crop was150:50:80:30 NPK kg ha-1 along with FYM @ 20 t ha-1, applied uniformly in all the treatments. The sources of NPKS for the present study were Urea, Di Ammonium phosphate (DAP), Muriate of Potash (MOP) and Gypsum, respectively. The nutrient content of FYM used in the study was estimated at 1.04:0.59:0.97:0.25% NPKS, respectively. The whole FYM was applied 15 days prior to planting. The full dose of P, K, S and half dose of N was applied as basal at the time of planting. The remaining 50% of N was applied in two equal splits during 30 and 45 days after transplanting of onion seedlings. As per the treatment schedule (Table no. 2), micronutrients were applied to the experiment. The data recorded on various parameters were subjected to statistical analysis as per the procedure suggested by Sukhatme and Amble (1995). Economics of production was made by keeping a record on operations carried out, number of labours engaged, power and inputs utilized. The standard cost of cultivation was calculated as per govt. and OUAT specifications. The gross and net returns (rupees per hectare) were calculated considering the prevailing market price of input and produce. Benefit cost ratio, represents the returns per rupee invested, was worked out for different package of practices under each treatments by dividing Gross returns with corresponding cost of cultivation.

Net returns = Gross returns –Cost of cultivation

B: C ratio =	**Gross returns**
	Cost of cultivation

Results and Discussion

1. Number of leaves plant^{-1}

A perusal of table no. 3 revealed significantly increase in production of number of leaves plant^{-1} by foliar application of micronutrient mixture (iron - 2.5 %, boron - 0.5 %, zinc - 3 %, copper -1 % and manganese – 1 %) @ 0.5% (12.36) and foliar application of borax @ 0.25% (12.20). Invariably, use of micronutrients increased the production of more leaves plant^{-1} than control. This might be due to their role in cell division, meristematic activity of plant tissue and expansion of cell (Patil *et al.*, 2009) [10]. The favourable effect of micronutrients on plant growth might be due to its role in physiological processes and cellular function within the plant. Bhattal *et al.* (2004) [8] and Hansch and Mendel (2009) [13] mentioned that in general the micronutrients play an essential role in biosynthesis of endogenous hormones which are responsible for promoting plant growth. Similar trend were also recorded by many scientists in onion (Sliman *et al.*, 1999; Gamelli *et al.*, 2000; Shafie *et al*., 2002; Tohamy *et al*., 2009 and Alam *et al*., 2010) [30, 11, 28, 33, 3]. Reports of increased number of leaves plant^{-1} with application of zinc and boron was also reported by Baghel and Sarnaik (1988), Dake *et al.* (2011) [10], Manna *et al*. (2013) and Acharya *et al*. (2015) [2]. According to Tisdel *et al*. (1985), the better efficacy of zinc towards vegetative growth parameter might be due to its involvement in auxin metabolism and other enzymatic reaction in onion.

2. Total bulb yield (qha^{-1})

The present study indicated, application of micronutrients either soil or foliar spray increased the total yield of onion bulb (211.47 qha^{-1} to 268.28 qha^{-1}) as compared to the control, without any micronutrients (210.45 qha^{-1}). The better efficacy of micronutrients might be due the pivotal role of micronutrients in strengthening the plant cell wall and translocation of carbohydrates from leaves to other plant parts. Further the improvement of bulb yield was due to better vegetative growth as observed in the present study. This result corroborates the findings of Singh and Tiwari (1996) [29] who reported that a high yield was a reflect of vigorous vegetative growth and healthy plants. The higher photosynthesis accumulation in the bulbs would ensure higher individual bulb weight and large bulb diameter which collectively increases the bulb yield in onion. Similar report of increased bulb yield was observed by several workers (Maurya and Lal, 1975; Phor *et al*., 1995; Paul *et al*., 2007 as well as Abedin *et al.*, 2012) [18, 1, 25]. Similarly, the better efficacies of zinc towards increased bulb yield of onion were obtained by Sliman *et al.* (1999) [30], Gamelli (2000) [11], Shafie and Gamaily (2002) [28], Alam *et al*. (2010) [1] and Trivedi and Dhamal (2013). The better efficacy of boron towards enhanced bulb yield was also observed by several research workers in onion (Smirti *et al*., 2002; Paul *et al*., 2007 as well as Manna, 2013) [25]. Increased bulb yield due to added zinc or boron with

recommended fertilizer was reported by Anwar *et al.* (1996) [4] and Nasreen *et al*. (2009) in garlic. Mishra *et al.* (1990) [20] stated that yield of onion was enhanced most by boron followed by zinc which was contradicted by Abedin *et al*. (2012) [1]. They concluded that the response of different micronutrients for onion production can be expressed the following orders: (Zinc + Boron) > Zinc > Boron > Molybdenum. The result of present investigations well corroborates the findings of Abedin *et al*. (2012) [1] in onion.

3. Total Dry Matter Yield (tha^{-1})

Application of micronutrients had significant impact on dry matter yield of onion crops including the dry matter yield of leaves (0.61 to 1.18 t ha^{-1}), bulbs (3.33 to 4.74 t ha^{-1}) and total (3.97 to 5.91 t ha^{-1}) as compared to without micronutrients (0.51, 3.12 and 3.62 t ha^{-1}), respectively indicating better efficacy of micronutrients alone or in combinations on crop growth and development, in turn dry matter yield in onion. Similarly, significantly maximum dry weight of leaves (1.18 t ha^{-1}), bulb (4.74 t ha^{-1}) and total (5.91 t ha^{-1}) was recorded by foliar application of micronutrient mixture (iron - 2.5 %, boron - 0.5 %, zinc - 3 %, copper -1 % and Manganese – 1 %) @ 0.5% which might be due to better efficacy of micronutrient mixture in onion, increasing vegetative growth and bulb yield attributing parameters, observed in the present study. This effect might be due to that micronutrients plays a pivotal role in strengthening plant cell walls and translocation of carbohydrates from leaves to other plant parts, this means that a possibility of increasing dry matter percentage as well as yield (Barker and Polbeam, 2007 and Hanch and Mendel, 2009) [13]. Similar results on better efficacy of zinc on increased dry matter yield was reported by Meena and Singh (1998) [19] while boron by Manna (2013) in onion. Acharya *et al*. (2015) [2] observed significantly better effect of application of zinc and boron on dry matter in onion var. multiplier onion under Coimbatore while Manna *et al.* (2013) under West Bengal condition. The study also revealed better efficacy of foliar application of micronutrients than soil application, which corroborates the findings of Acharya *et al*. (2015) [2] in onion.

4. Gross income, Net income and BCR

The results on production economics of onion as influenced by micronutrients revealed significant variations among different treatments (Table no.2 and Figure no. 1 and 2). The treatment T5 *i.e.*; foliar application of micronutrient mixture (iron - 2.5 %, boron - 0.5 %, zinc - 3 %, copper -1 % and manganese – 1 %) @ 0.5 % at 30 and 45 DAP recorded significantly highest gross income (2.68 lakhs) as well as net income (1.95 lakhs) than rest of the treatments. However, the treatment T4 *i.e.*; foliar application of borax @ 0.25 % at 30 and 45 DAP (2.39 and 1.66 lakhs) was *statistically at par* with T5 for gross income and net income, respectively. On the other hand, significantly lowest gross and net income was recorded in control plot, T6 (2.10 and 1.37 lakhs, respectively). This higher gross return was obviously due to the higher total bulb yield of application of micronutrients, as observed in the present study. Similar trend was also observed for Benefit Cost Ratio (BCR), significantly highest being calculated in T5 (2.65) closely followed by T4 (2.26) which was *statistically at par* with each other. This was obviously due to significantly higher total bulb yield. Significantly lowest benefit cost ratio of 1.87 was recorded in control plot, without micronutrients. Thus, in general, it may be concluded that application of micronutrients, preferably as foliar spray either boron as borax @0.25 % or micronutrient mixture @0.5% at 30 and 45 DAP significantly increased all the economic parameters of gross and net returns as well as benefit cost ratio indicating the feasibility of use of micronutrients for optimum profit in commercial cultivation of onion. The present results corroborates the findings of Smiriti *et al*. (2002) for boron while Nasreen *et al*. (2007) and Nasreen *et al*. (2009) for zinc as a source of micronutrients towards increased benefit cost ratio in onion production.

Table 1: Experimental techniques details

Crop	Onion (*Allium Cepa L.*)
Variety	ArkaKalyan
Season	*Rabi* season (2014-15)
No. of Treatments	6 (Six)
Design and Experiments	Randomized Block Design (RBD)
No. of Replication	4 (Four)
Net plot area	6m X 2m
No. of plots	24
Spacing	15cm X 10cm

Table 2: Time of application of different micronutrients on different treatments

Treatments	Treatment details	Source
T_1	Soil application of Zinc Sulphate @ 10.0 kg ha^{-1}	Zinc Sulphate
T_2	Foliar application of Zinc Sulphate @ 0.5 % at 30 & 45 days after planting (DAP)	
T_3	Soil application of Borax @ 10.0 kg ha^{-1}	Borax
T_4	Foliar application of Borax @ 0.25% at 30 & 45 DAP	
T_5	Foliar application of micronutrient mixture @ 0.5% at 30 & 45 DAP	2.5% Fe, 0.5% B, 3% Zn, 1% Cu and 1 % Mn
T_6	Control (Without application of any micronutrients)	

Table 3: Effect of micronutrients on Total Dry Matter Yield in onion bulbs var. Arka Kalyan

Treatments	Number of leaves plant^{-1} at 105 DAT	Total bulb yield (qha^{-1})	Dry matter yield (tha^{-1})			Benefit cost ratio
			Leaves	Bulb	Total	
T1	11.15	217.89	0.61	3.36	3.97	1.97
T2	11.96	217.50	0.69	3.79	4.48	1.96
T3	11.91	211.47	0.67	3.33	4.00	1.88
T4	12.20	239.37	0.90	4.19	5.09	2.26
T5	12.62	268.28	1.18	4.74	5.91	2.65

T6	11.31	210.45	0.51	3.12	3.62	1.87
Mean	11.86	227.49	0.76	3.75	4.51	2.10
SE (m) ±	0.36	16.90	0.09	0.33	0.39	0.23
CD (5%)	0.78	36.02	0.19	0.71	0.84	0.49
CV (%)	4.35	10.51	16.96	12.62	12.36	15.52

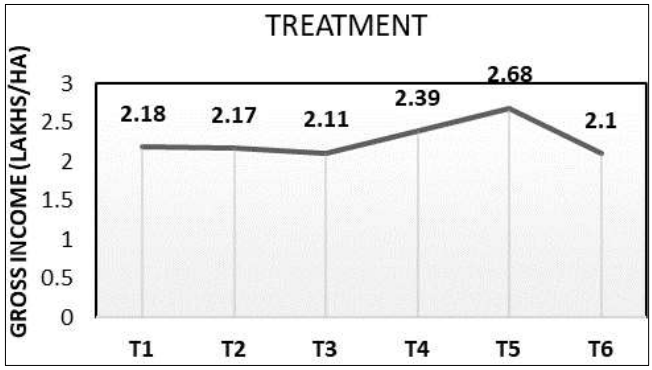

Fig 1: Effect of micronutrients on gross income (Rs. in lakhs) of onion var. Arka Kalyan

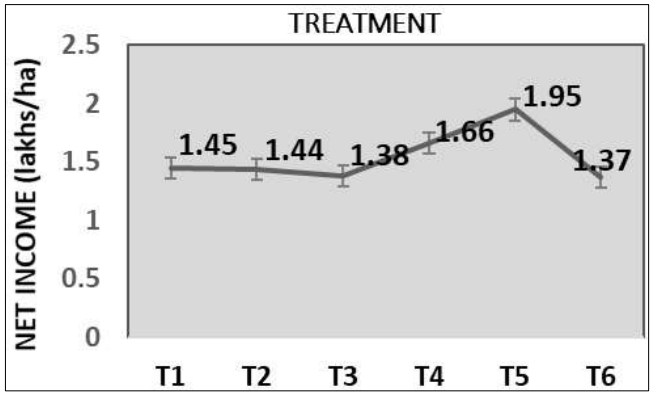

Fig 2: Effect of micronutrients on net income (Rs. in lakhs) of onion var. Arka Kalyan

Conclusion

Among all the micronutrient treatment schedule, it was observed that the treatment schedule, T5 i.e., foliar spray of micronutrients mixture (iron- 2.5 %, boron- 0.5 %, zinc- 3%, copper-1% and manganese- 1%) @ 0.5% at 30 and 45 DAP significantly recorded better number of leaves^{-1} and total bulb yield as a results highest dry matter yield as well highest gross income, net income and BCR were obtained. The second-best treatment identified was foliar application of boron as borax @ 0.25 % at 30 and 45 DAP.

So from this experiment, it can be clearly inferred that foliar application of micronutrients is better than its soil application as plants absorb the elements efficiently and quickly. Similarly, application micronutrients gives better vegetative growth in term of number of leaves and bulb production side by side highest dry matter yield and BCR in onion as compare to control plot.

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