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Efficacy of Foliar Application of Micronutrients on Production of Onion Seed [*Allium cepa* L.] cv. Red Creol in Rukum West, Nepal

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ABSTRACT

Field research was commenced in Rukum West on a standing crop of onion during the flowering stage to assess the effectiveness of foliar sprays of micronutrients on the yield of onion seeds (*Allium cepa* L.) cv. Red Creol. The experiment was carried out using two levels of Zinc (300 ppm and 375 ppm) and two levels of Boron (240 ppm and 360 ppm) in an RCBD design with treatments applied either separately or in combinations, comprising nine treatments and three replications. The treatments were administered before flowering, during flowering, and after flowering at the seed production stage at 15 days intervals. The application of Zinc and Boron increased total seed yield, seed yield per umbel, seed yield per plant, and germination percentage. The highest seed yield per plant, seed yield per umbel, and seed yield per plot were recorded from Treatment 8 (Zn 375ppm + B 360ppm) i.e. 52.8 gm per plant, 6.12 gm per umbel, and 966.67 kg ha^{-1} respectively. Similarly, Treatment 1 (Zn300ppm) and Treatment 8 (Zn 375ppm + B 360ppm) showed the highest germination percentage (70%), and Treatment 9 (control) showed the lowest (45%). The treatments did not affect the thousand seed weight.

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Introduction

One of the most valued monocot crops is the onion (Allium cepa L.), which belongs to the Alliaceae or Amaryllidaceae family. For seed production, it is biennial, involving one season in bulb production and then another season in seed production from the bulb. Onions are strong in polyphenols, which possess high antioxidant activity as well as therapeutic qualities against a variety of chronic illnesses (Liguori et al., 2017).

Foliar application of micronutrients aid to enhance fertilizer use efficiency while also minimizing pollutants in the environment (Singh Shivay, 2022). Micronutrients have a role in all areas of metabolic activities, including cell wall formation, respiratory and photosynthetic activities, chlorophyll synthesis, enzyme activity, nutrient availability, and so on. Zinc and boron treatments, whether soil-applied, foliar-applied or combined, have a good effect on onion growth and development at any stage (Acharya et al., 2015).

Boron deficiency frequently leads to unfilled pollen grains, low pollen vitality, and reduced flowering (Bloodnick, 2021a). The foliar treatment of 1% zinc sulfate to onion resulted in the maximum seed yield per plant and unit area, and even a high germination rate, indicating Zinc's efficacy in seed health promotion (Ganeshamurthy et al., 2016). Zinc is required for enzyme activation, synthesis of chlorophyll, and the formation of auxins, which promote growth and stem elongation (Bloodnick, 2021b).

In Rukum, the average maximum temperature is 24°C, the lowest temperature is 13°C, the relative humidity is 79 percent, and the annual rainfall ranges from 1400-3200 mm, making it ideal for vegetable seed production. Out of the total country's vegetable seed production, the Rapti zone contributes 25 to 30 percent with Rukum contributing 60% of seed production (Bhandari, 2019). According to the annual report of the vegetable seed production center Rukum 2076/2077 the production of the seed of onion is about 30-40 kg ropani^{-1} and bulb production is of var. Red Creol has been recorded at 800- 1200 kg ropani^{-1}. Despite such potential areas, onion productivity in Nepal is 13.91 Mt/ha, which is much lower than the global productivity of 19.89 Mt ha^{-1} (Paudel, 2014). Nepal has a per capita onion consumption of 7.7 kg, which is much lower than the global average of 10.8 kg (Tha et al., 2021).

The import status of onion from a neighboring country is high in Nepal. On the one hand, domestic production is not able to meet the 10 percent demand of the people. On the other hand, the imported commodity is more inexpensive than locally available goods (Kaini, 2020). The reasons behind such failure are poor farm mechanization, low involvement of the young generation in farming activities, high cost of cultivation, lack of suitable cultivars and seeds, a poor storage facility for bulb onion, lack of research and extension activities, labor shortage, etc. (Kaini, 2020).

Table 1 and 2 shows the area, production and productivity of onion in Nepal and in Rukum west respectively. As per the (MOALD, 2020), the national productivity of onion is more in Nepal than in Rukum West.

The research activities on the use of micronutrients are very low in the case of onions. Nepalese farmers seldom use micronutrients. Although a high portion of farm costs is invested in macronutrients like Nitrogen, Phosphorus, and Potassium, the attention to micronutrients is always less. Farmers apply micronutrients these days through soil application but scarcity/less availability/due to dry soil presence, the nutrients become unavailable for the crop plants. Under such crucial conditions, the foliar application of Boron and Zinc is reliable and sustainable (Wasaya et al., 2017). The prime objective of the research is to assess the efficacy of foliar applications of micronutrients (Zinc and Boron) at varying concentrations and combinations on the production of onion seeds in Rukum West.

Materials and Methods

Time and Location of the Research

The research was carried out from February 2021 to June at Musikot Municipality, at Vegetable Seed Development Center Rukum West. It is located at 28° 63' North latitude and 82° 49' East latitude, at a height of approximately 1440 meters above sea level (masl) (Wikipedia, 2022).

Agro Meteorological Features

The monthly average data on different weather parameters were recorded from Meteorological Station, Musikot, Rukum.

The table 3 shows the various weather parameters at the research site including minimum temperature, average temperature, maximum temperature and total annual precipitation. It is recorded that the minimum temperature was on March, maximum temperature on April and total annual precipitation is highest in June (829.2 mm). Likewise, there was low annual precipitation on March (Metrological Station Rukum West, 2020).

Experimental Details

The research was carried out on the onion variety Red Creol in Rukum farm in the standing crop of 150 days planted on 11th October 2020 to see the effect of Boron and Zinc and also their combined effect on the yield and quality of seed. The research consists of 9 treatments in a randomized complete block design (RCBD) in 3 replications. The treatments were used before flowering on 13th March 2021, at the time of flowering on 27th March 2021, and after flowering at the grain-filling stage on 13th April 2021.

Treatment Details

The sources of Zinc and Boron were Chelated Zinc and B-Boron respectively. Micronutrient containing Boron and Zinc in percentage was converted into ppm (parts per million).

Boron content in B-Boron was 12% whereas Zinc content in chelated Zinc was 15%.

1% = 1ml = 1000ppm

Boron content in 1 liter= 12/100×1000 =120ml

Concentration of Boron=1000×120=120000 ppm

Similarly, Zinc content in 1 liter= 15/100×1000= 150 ml

Concentration of Zinc = 150×1000=150000 ppm

Formula for calculating ppm:

$C_1V_1 = C_2V_2$

Using the above formula, the level of Zinc and Boron is calculated. Other disease and pest control measures were carried out as per the crop demand.

Table 1. Area, production, and productivity of onion in Nepal

Years	Area (ha)	Production (Mt)	Productivity (Mt ha^{-1})
2018/19	20908	291538	13.94
2019/20	20,424	284926	13.95

(Source: MoALD, 2020)

Table 2. Area, production, and productivity of onion in Rukum west

Years	Area (ha)	Production (Mt)	Productivity (Mt ha^{-1})
2016/17	172	2105	12
2018/19	88	1097	12.41
2019/20	89	1121	12.52

(Source: MoALD, 2020)

Table 3. Various weather parameters (minimum, average, and maximum temperature and total annual precipitation) at the research site

Parameters	Minimum temperature (°C)	Maximum temperature (°C)	Average day temperature (°C)	Total annual precipitation (mm)
Months				
March	13.7	25.7	19.7	2.5
April	16.1	28.8	22.4	52
May	17.6	26.3	22	124.1
June	21.2	27.5	24	829.2

(Source: Metrological Station Rukum West, 2020)

Table 4. Details on various combinations of treatments

Treatments	Zinc	Boron	Zinc + Boron (combination)
T1	300 ppm	-	-
T2	375 ppm	-	-
T3	-	240 ppm	-
T4	-	360 ppm	-
T5	-	-	300ppm + 240ppm
T6	-	-	300ppm + 360ppm
T7	-	-	375ppm + 240ppm
T8	-	-	375ppm + 360ppm
T9 Control	-	-	-

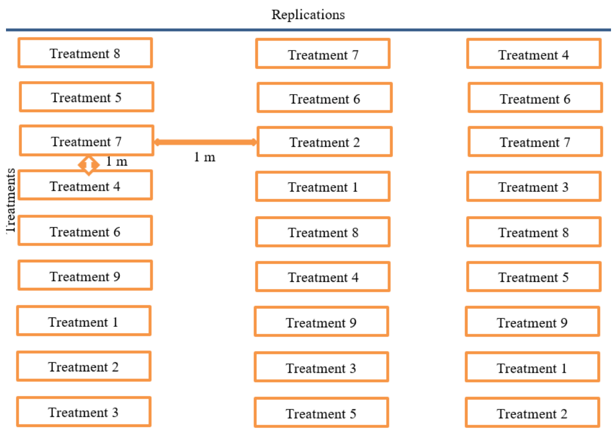

Figure 1. Layout of an experimental field


Figure 2. Foliar application of micronutrients


Figure 3. Seed germination test carried out in Petri dishes at laboratory condition

The table 4 represents the details on various combination of treatments as set by the researchers to achieve the objectives. There were altogether 9 treatments. Two treatment T1 (300 ppm) and T2 (375 ppm) consists of only Zinc doses, other two treatments T3 (240 ppm) and T4 (360 ppm) consists of only Boron doses, treatments T5, T6, T7, and T8 consists the combination of both Zinc and Boron while the remaining treatment T9 is control without the use of Zinc and Boron.

Layout of an Experiment

Spacing between replication = 1m; Spacing between treatments= 1m; Individual plot size= 2m×2m= 4 sq. m; Spacing: RR= 60 cm; PP= 50 cm (Figure 1)

Cultural Operations (Weeding, Irrigation, Pest Control Operations, Harvesting, and Threshing)

The manual method of weeding was practiced. Altogether, two hand weeding were done at an interval of 1 month. If there is no rainfall within this period, irrigation was provided at an interval of 15 days by the flooding method (Figure 2)

Systemic insecticide imidacloprid was applied 2 times at an interval of 15 days to control onion thrips. Multiple harvesting is practiced since all the umbels do not mature at the same time. The harvested seeds were sun-dried and the cleaning of the seed was done and the data were taken.

Observations to be recorded

Seed yield per plant

From a plot, five random plants were selected and harvesting of umbels was carried out, later dried in the sunlight, and threshing was done by hand. The seeds were then separated and cleaned. Finally, the weight was taken and recorded.

Thousand seed weight

Seed samples from each plot were taken, and 1000 seeds were counted and recorded from each plot. Their average seed weight per treatment was calculated.

Seed weight per umbel

Random 10 umbels were taken from each plot, separately harvested, and threshed. After cleaning the seeds, the seed was weighed and recorded. The average seed weight per umbel was calculated and recorded.

Seed weight per plot

All the umbels were harvested, sundried, threshed, and cleaned manually and the weight of each plot was taken independently and the average seed weight per treatment was calculated and recorded.

Germination percentage

Seed samples from each treatment were taken and 4 replications were made for the germination test. A Petri dish was used to carry out the germination test. 100 seed were placed for germination in one petri dish. Altogether, 400 seeds were taken for germination test from each treatment. The first germination count was taken on the 7^{th} day, 2^{nd} on the 9^{th} day, and the final count was taken on the 11^{th} day (Figure 3).

Data Analysis

The collected data were entered in Ms-Excel. The data was analyzed using the R-studio program. Duncan's multiple range tests (DMRT) were used to figure out the significant difference in average value at a 5% level of significance.

Result

Seed Yield Attributing Characters of Onion

Seed yield per plant

The analysis of variance showed that the effect of different doses of Zinc and Boron and their combination was significant ($P<0.05$) on seed yield per plant.

The analyzed data in table 5 shows that the seed yield per plant was significantly higher in treatment 8 (Zn375ppm+360ppm) which is 52.82 g per plant followed by treatment 6 (Zn300ppm+B360ppm) yielding 38.37 g per plant which is statically similar to treatment 8 (Zn375ppm+360ppm) and others.

Thousand-grain weight

The analyzed data in table 5 shows that the thousand-grain weight of onion seed was not significantly influenced by the different concentrations of micronutrients (Zinc, Boron, and their combination). The thousand-grain weight of all treatments was found to be statistically similar to one another.

Seed Weight per Umbel

The analysis of variance showed that the effect of different concentrations of Zinc and Boron and their combinations was significant at a 5% level of significance i.e. ($P<0.05$) on seed weight per umbel.

The analyzed data in Table 5 shows that seed weight per umbel was significantly influenced by the different treatments. The highest weight per umbel was recorded in treatment 8 (Zinc 375ppm+Boron 360ppm) which was 6.12g, followed by treatment 7 (Zinc 375ppm +Boron 240ppm) which was 4.03g which is statically similar to other treatments.

Seed yield per plot (kg ha^{-1})

The analysis of variance showed that the effect of different doses of Zinc and Boron and their combinations were significant at a 5% level of significance i.e. ($P<0.05$) on seed yield per plot.

The analyzed data in table 5 shows that seed yield per plot was significantly influenced by the different treatments. The highest yield recorded was on treatment 8 (Zinc 300ppm+Boron 360ppm) which was 966.67 kg ha^{-1} followed by treatments (Zinc 300ppm+Boron 360ppm), (zinc 375 ppm+ Boron 240ppm), Boron 360, and (Zinc 300ppm+Boron 240ppm) which yields 836.67 kg ha^{-1}, 748.33 kg ha^{-1}, 736.67 kg ha^{-1}, and 723.33 kg ha^{-1} respectively. The lowest yield was recorded on treatment 1 (Zinc 300ppm) which was 471.67 kg ha^{-1}.

Correlation between Yield and Yield Components

Correlation between umbel per set and yield per plot (kg ha^{-1})

There is a moderate correlation(r=0.45**) between the number of umbels per set and seed yield per plot. It shows that the seed yield per plot increases with an increase in the number of umbels per set.

Correlation between seed yield per plant and seed yield per plot

A moderate correlation(r=0.55**) was found between the seed yield per plant and seed yield per plot. It shows that the seed yield per plot increases with an increase in seed yield per plant (Figure 5).

Correlation between the number of umbels per plant and seed yield per plant

A moderate correlation (r=0.50**) was found between the seed yield per plant and the number of umbels per set. It shows that seed yield plant^{-1} increases with an increase in the number of umbels per set (Figure 6).

Seed Germination

The analysis of variance showed that the effect of different doses of Zinc and Boron and their combination was significant at a 1% level of significance i.e. ($P<0.01$) on seed germination percentage.

The analyzed data in table 6 shows that the germination percentage was significantly affected by different doses of zinc and boron. All the treatments were statistically at par except the control (treatment 9). Though the treatments were at par, treatments of Zinc 300ppm and (Zinc 375ppm + Boron 360ppm) showed the highest germination percentage i.e. 70%, and the lowest germination was obtained from Tr.9 (control). This may be due to the high response of onion to Zinc and the low response to Boron (Vitosh et al., 1998).

Table 5. Seed yield per plant, thousand seed weight, seed weight per umbel, and seed yield per plot of onion as influenced by different concentrations of micronutrients (zinc and boron)

Treatments	Seed yield plant^{-1} (g)	1000grwt (g)	Seed weight umbel^{-1} (g)	Seed yield plot^{-1} (kg ha^{-1})
Zn 300ppm	28.10^{b}	3.42	3.43^{b}	471.67^{b}
Zn 375ppm	31.13^{b}	3.46	3.30^{b}	496.67^{b}
B 240ppm	29.00^{b}	3.42	3.93^{b}	570.00^{b}
B 360ppm	31.50^{b}	3.46	3.67^{b}	736.67^{ab}
Zn300ppm+B240ppm	28.00^{b}	3.49	3.33^{b}	723.33^{ab}
Zn300ppm+B360ppm	38.37^{ab}	3.45	3.83^{b}	836.67^{ab}
Zn375ppm+B240ppm	36.40^{b}	3.46	4.03^{b}	748.33^{ab}
Zn375ppm+360ppm	52.82^{a}	3.93	6.12^{a}	966.67^{a}
Control	29.13^{b}	3.46	3.73^{b}	501.67
SEm (±)	1.96	0.04	0.18	43.02
LSD (=0.05)	1.38*	Ns	1.38*	319.49*
CV (%)	5.78	1.15	4.68	6.40
Grand mean	33.83	3.51	3.93	672.41

Note: -0.001, 0.01, and 0.05 indicate the level of significance at 0.1%, 1%, and 5% respectively, and Treatment means in columns followed by common letters are not significantly different from each other based on DMRT TEST at 5% level of significance.

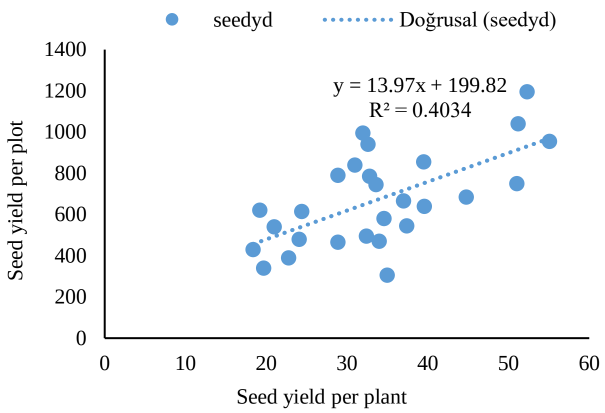

Figure 5. Relationship between seed yield per plant and seed yield per plot

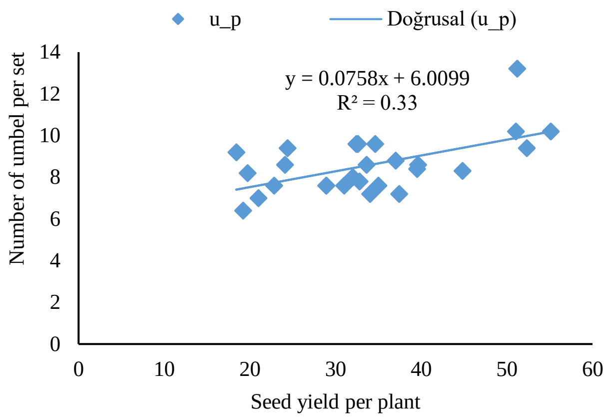

Figure 6. Relationship between the number of umbels per set and seed yield per plant

Table 6. Seed germination is influenced by different concentrations of micronutrients (zinc and boron)

Treatments	Germination percentage
Zn 300ppm	70^{a}
Zn 375ppm	69.25^{a}
B 240ppm	63.5^{a}
B 360ppm	60.5^{a}
Zn300ppm+B240ppm	61.5^{a}
Zn300ppm+B360ppm	65^{a}
Zn375ppm+B240ppm	61^{a}
Zn375ppm+360ppm	70^{a}
Control	45^{b}
SEm (±)	1.55
LSD (=0.05)	10.21**
CV (%)	2.46
Grand mean	62.86

Note: 0.001, 0.01, and 0.05 indicates the level of significance at 0.1%, 1%, and 5% respectively, and Treatment means in columns followed by common letters are not significantly different from each other based on DMRT TEST at 5% level of significance

Discussion

Seed Yield Per Plant

(El-Magd et al., 1989) showed the total seed yield per plot increased as a result of increasing the Boron concentration to 300 ppm. (Khalil et al., 2008) also showed similar results however he did not make use of boron.

Thousand grain weight

(Rashid et al., 2007) reported that the weight of thousand seeds increased when zinc and sulfur were applied, which violates the findings. This might be due to variations in genotype, geography, soil composition, and so forth.

Seed weight per umbel

(Sarker, 2011) reported that applying zinc and boron to the soil improved the number of fruits that is directly related with the seed weight per umbel.

Seed yield per plot

Similar results were suggested by spraying onion plants with a solution containing 300 ppm of micronutrients chelate 14% Zn four times significantly increased total yield (Fouda, 2016). (Khalil et al., 2008) showed that a foliar spray of 1% $ZnSO_4$ to onion produced the highest seed yield per plant and unit area with high germination percentage.

Seed germination

Similar findings were obtained by (Sarker, 2011) demonstrating the highest germination percentage of 91% with the combination of the highest level of zinc and boron i.e. 4kg ha^{-1} each. However, the micronutrients used were applied to the soil before planting the crop. (El-Magd et al., 1989) also showed a similar result, however, he did not make use of Zinc.

Conclusion

There is a positive impact of applying the foliar application of micronutrients viz. Zinc and Boron on seed yield improvement and various physiological attributes of onion seed. The yield parameter was significantly affected by the different levels of Zinc, Boron, and their combination. The optimal level combination of Zinc and Boron to be used for seed production is Zn 375ppm +B 360ppm. Also, Zn 375ppm +B 360ppm has the highest germination percentage i.e. 70%, and the lowest germination at control.

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