International Journal of Economic Plants

https://ojs.pphouse.org/index.php/IJEP

Crossref

IJEP March 2025, 12(2): 01-05

Article IJEP5976a

Full Research

Natural Resource Management

Doi: HTTPS://DOI.ORG/10.23910/2/2025.5976a

Impact of Zinc Nutrition on Growth and Yield of Sweet Basil (*Ocimum basilicum*)

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Article History

Received on 11th December, 2024
Received in revised form on 03rd March, 2025
Accepted in final form on 16th March, 2025
Published on 27th March, 2025

Abstract

The present experiment was done during May, 2022 to February, 2023 at the Departmental plot of Plantation Crops and Processing, Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar, West Bengal, India. Seeds of *Ocimum basilicum* variety CIM-Saumya were collected from the Central Institute of Medicinal and Aromatic Plants, Lucknow. The experiment was done to study the performance of sweet basil (*Ocimum basilicum*) under varying levels of zinc. Zinc is an important micronutrient associated with several enzymatic activities in all photosynthetic plants. The design of the experiment followed was randomized block design with seven treatments and three replications. The treatment details are as follows: T_1=Control (FYM @ 10 t ha^{-1}), T_2=Recommended dose of fertilizer (FYM @ 10 t ha^{-1} with N:P:K 120:100:100 kg ha^{-1}), T_3= RDF+Zn @ 0.25%, T_4=RDF+Zn @ 0.50%, T_5=RDF+Zn @ 0.75%, T_6=RDF+Zn @ 1.0%, T_7=RDF+Zn @ 1.25%. The maximum plant height (114.66 cm), number of primary branches (16.43) and secondary branches (85.07), and plant spread (1911 cm^2) was recorded when treated with RDF+Zn @ 0.75% whereas the highest plant girth (1.29 cm) obtained in RDF+Zn @0.50%. Yield parameters like number of leaves found maximum with RDF+Zn @ 0.75% at 30, 60 and 90 days interval respectively. Fresh and dry herbage yield was also found highest in RDF+Zn @ 0.75% (32.5 t ha^{-1}). The results of the experiment showed that application of recommended dose of fertilizers with zinc increased both vegetative growth as well as herbage yield of *Ocimum basilicum* under *Terai* zone of West Bengal.

Keywords: Sweet basil, fertilizer, FYM, zinc, yield

1. Introduction

Sweet Basil *(Ocimum basilicum)* has vast importance in the pharmaceutical and aromatic industry belonging to the family of Lamiaceae. It is known by several names like French basil, and Indian basil all over the world. The crop was originated from tropical, warm regions of South America (Brazil), Africa, and Asia (Farooqi and Sreeramu, 2004). Sweet basil is an autogamous, aromatic and herbaceous plant that is annual and perennial in nature (Naz et al., 2015). This plant requires low maintenance, and it is easy to grow in indoor and outdoor settings. Although it can be damaged by frost and temperatures below freezing, this species flourishes under conditions of long daylight with full sun and well-drained soil (Azizah et al., 2023). Sweet basil is a tetraploid (2n=48) in nature. It is a broad, herbaceous, erect, annual herb. Flowers are 0.72–1.25 cm long, born in racemose inflorescences. Seeds are blackened ellipsoids that become mucilaginous when wet (Anonymous, 2014).

Sweet basil contains biologically active constituents that are insecticidal, nematocidal, fungistatic and anti-microbial properties (Pragya et al., 2016). Pharmacological advantages include analgesics and anti-inflammatory, hypoglycaemics and hepato-protective, cardioprotective and anti-ulcer, memory retention, stroke prevention activity, and anti-cancerous properties (Sharif et al., 2015). Basil is a very good source of beta-carotene. Beta-carotene helps to prevent damage to the cells by free radicals. Magnesium is essential mineral present in basil which helps the heart and blood vessels to relax, improving blood flow. Other nutrients found in basil include iron, calcium, potassium, and vitamin C. (Gebrehiwot et al., 2015). It can be concluded that foliar application of the Zn and NPs is necessary for obtaining better quantity and quality in basil (Abbasifar et al., 2020).

Zinc is one of the essential micronutrient elements and is required by crop plants in small amount that is engaged in different enzymatic and physiological activities (Singh, 2009). The efficiency of Zn absorption from a diet range from 15–35%, depending upon the amounts consumed (decreases with an increase in amounts consumed) and the presence of dietary phytate (Hambidge et al., 2010). Zinc when applied with nitrogen, it helps to promote plant growth (Hafeez et al., 2013). Zinc exerts a great influence on basic plant life processes, such as (i) nitrogen metabolism-uptake of nitrogen and protein quality; (ii) photosynthesis-chlorophyll synthesis (Palai et al., 2017). The two main approaches for seed (grain) biofortification are breeding (Phattarakul et al., 2012; Beebout et al., 2016) and micronutrient application. The later is a cost-effective approach for enhancing Zn concentration in grains (Nadeem et al., 2018), also termed as agronomic biofortification resulted in higher Zn concentration in seed (grains) and yield (Prasad, 2009). Zinc is an important micronutrient associated with several enzymatic activities in all photosynthetic plants. Zn is necessary in vital enzymes and growth regulators. Application of Zn significantly increased the plant height (Yadegari, 2014). Zinc spraying gave the best results in plant height, number of branches, herb fresh weight, essential oil percentage, and total flavonoid percent during the vegetative stage. Fallahi et al. (2016) found out that zinc treatment enhanced fresh and dried herb yield. By using three levels of $CuSO_4$ (0, 5, 25 mg kg^{-1}) and $ZnSO_4$ (0, 10, 50 mg kg^{-1}) and their combinations, an experiment was carried out by Ghorbanpour et al. (2016) and found that the treatments with Cu_0Zn_{10}, Cu_5Zn_0 and Cu_5Zn_{10} were more effective than controls at increasing the dry weight of roots, shoots, and essential oil output. Mahmoudi et al. (2021) studied the effects of elevated zinc on growth traits and oxidative stress of sweet basil.

2. Materials and Methods

The present experiment was carried out from *kharif* (May, 2022) to *rabi* (February, 2023) at the Departmental plot of Plantation Crops and Processing, Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar, West Bengal, India. The experimental site was 48 m above mean sea level and located at 26°22'N latitude and 89°29'E longitude. The soil pH of the experimental site was 5.49 with available zinc content was 5.54 kg ha^{-1}. Seeds of *Ocimum basilicum* variety CIM-Saumya were collected from the Central Institute of Medicinal and Aromatic Plants, Lucknow. The nursery bed was prepared in May for raising the seedlings and seeds were sown up to 2 cm depth of soil. Germination was started 7–8 days after sowing. Seedlings were transplanted at a spacing of 30×30 cm^2 when they were six weeks old and having 4–5 leaves. The experiment consisted of seven treatments and each treatment was replicated thrice. The size of each plot includes 1.5×1.5 m^2. Treatment details include T_1=control (FYM @ 10 t ha^{-1}), T_2=Recommended dose of fertilizer (FYM @ 10 t ha^{-1} with N:P:K::120:100:100 kg ha^{-1}) (Anonymous, 2014). T_3=RDF+Zn @ 0.25%, T_4=RDF+Zn @0.5%, T_5=RDF+Zn @ 0.75%, T_6=RDF +Zn @1.0%, T_7=RDF+Zn @ 1.25%. Before a week of transplanting, a basal dose of 10 ton ha^{-1} of well-rotted farmyard manure (FYM) was broadcasted onto the soil. N was applied as Urea (46% N_2), P was applied as SSP (16% P_2O_5), and K was applied in the form of MOP (60% K_2O). Full dose of phosphorous, potassium and 1/3rd of nitrogen were applied as basal doses and rest of 2/3rd nitrogen was applied at vegetative stage. NPK were applied through broadcasting method only. Zinc was sprayed as a foliar spray at vegetative (45 days) and flowering stage (75 DAP) by mixing of required amount of chelating zinc according to treatment wise with one litre of water. To prepare 0.25% Zn, 2.5 g chelated Zn was dissolved in 1 lit of water and sprayed, thus for 0.5% Zn solution, 5 g Zn dissolved in 1 l of water and sprayed in the field, for preparing 0.75% Zn solution, 7.5 g of Zn was dissolved in 1 l of water. To get Zn @ 1% solution, 10 g of Zn was dissolved in 1 l of water and sprayed and to make Zn @ 1.25%, 12.5 g of zinc was dissolved in 1 l of water. The data on growth parameters were taken at 30, 60 and 90 days after planting. Growth parameters include plant height (cm), plant spread (cm^2), number of primary branches plant^{-1}, number of secondary branches plant^{-1}, number of inflorescence plant^{-1}, stem diameter (cm), commencement of flowering (days), completion of flowering (days) etc. Yield parameters include number of leaves plant^{-1}, fresh herbage yield plant^{-1} (g), plot^{-1} (kg) and ha^{1} (t), dry herbage yield plant^{-1} (g), plot^{-1} (kg) and ha^{1} (t). The experimental data were analysed by using one-way ANOVA given by Panse and Sukhatme (1951). Statistical significance was tested by the F value at 5 percent level of significance. The critical difference value at 0.05 level of significance was calculated by using the SPSS software system and DMRT was done to indicate superior results.

3. Results and Discussion

The effect of foliar spray of zinc on plant height (Table 1) of sweet basil was recorded at 30, 60 and 90 days after planting and had shown that the treatments was statistically significant during that period. Maximum height (Table 1) was found in the treatment T_5 sprayed with RDF+Zn @ 0.75% which was at par (84.07 cm and 112. 33 cm) with T_4, treated with RDF+Zn @ 0.5% at 60 and 90 days after planting. Zinc affects many growth processes in plants, including photosynthesis, nitrogen metabolism, protein synthesis, hormone production, and regulation of auxin concentration in plants, which might be the cause of the rise in fresh herb yield. These positive effects of zinc led to taller plants, an increase in leaf area and the production of dry matter. Zinc functions as an activator of the enzyme tryptophan, a precursor to IAA, which is involved in protein synthesis, and has a direct impact on the tissues of the plant, which accounts for the increased plant height observed after foliar application of micronutrients like Zn. The results agree with Thakur and Kumar (2020) in Damask rose plants. As from the recorded data (Table 1), the number of primary branches at 60 days after planting was found significantly maximum (15.46) in the treatment (T_5) treated with (RDF+Zn @ 0.75%) Though, at 90 days after planting, no significant result was found among the treatments. Maximum number

Table 1: Effect of zinc nutrition on vegetative growth of sweet basil (*O. basilicum*)

Treat-ment	Plant height (cm)			Primary branches plant^{-1}		Secondary branches plant^{-1}		Plant girth (cm)			Plant spread (cm^2)		
	30 DAP	60 DAP	90 DAP	60 DAP	90 DAP	60 DAP	90 DAP	30 DAP	60 DAP	90 DAP	30 DAP	60 DAP	90 DAP
T_1	27.506^{f}	73.57^{d}	108^{d}	14.46^{ab}	15.4^{ab}	42.56^{c}	77.21^{e}	0.65^{ab}	0.78^{bc}	0.99^{b}	74.36^{a}	648.8^{g}	1489.84^{c}
T_2	30.92^{de}	75.51^{d}	112.2^{bc}	11.4^{c}	15.06^{ab}	42.09^{c}	72.54^{f}	0.65^{a}	0.88^{ab}	1.02^{b}	43.56^{e}	918.51^{e}	1067.76^{e}
T_3	35.43^{b}	82.40^{b}	111.8^{bc}	14.2^{b}	14.62^{b}	45.93^{b}	81.8^{c}	0.65^{ab}	1.00^{a}	1.26^{a}	58.86^{c}	1008.4^{b}	1496.68^{b}
T_4	38.41^{a}	84.07^{b}	112.3^{b}	15.06^{ab}	15.87^{ab}	46.3^{b}	82.38^{bc}	0.65^{a}	0.98^{a}	1.29^{a}	71.2^{ab}	997^{c}	1496.87^{d}
T_5	33.41^{bc}	87.22^{a}	114.66^{a}	15.46^{a}	16.43^{a}	49.4^{a}	84.07^{a}	0.65^{a}	0.92^{a}	1.14^{ab}	67.93^{b}	1434^{a}	1911^{a}
T_6	33.14^{cd}	78.44^{c}	110.7^{c}	10.73^{c}	15.16^{ab}	48.57^{a}	79.83^{d}	0.66^{a}	0.72^{c}	0.80^{c}	53.42^{d}	940.47^{d}	917.8^{f}
T_7	30.44^{e}	68.03^{e}	111.3^{bc}	11.26^{c}	14.73^{b}	44.66^{b}	83.3^{ab}	0.64^{b}	0.66^{c}	0.7c	72.78^{a}	743.88^{f}	720.42^{g}
SEm±	0.74	0.67	0.52	0.41	0.46	0.56	0.46	0.003	0.04	0.05	1.29	2.56	1.94
CD (p=0.05)	2.3	2.11	1.62	1.28	NS	1.75	1.45	NS	0.14	0.15	3.80	7.56	5.74

of primary branches might be attributed to the easily available nutrients from inorganic fertilisers, as well as to the impact of organic fertilisers and readily mobilised zinc, which improve the physical, chemical, and biological properties of soil by increasing soil organic matter, cation exchange capacity, water holding capacity, and availability of mineral nutrients leading to the fact that the taller plant produced more number of primary branches. These findings match with those of Giridhar et al. (2010) in stevia and Dadiga and Jain (2017) in coriander. In respect of secondary branches (Table 1), T_5 was recorded significantly maximum (84.07) when plants were treated with RDF+Zn @ 0.75%. Lowest number of secondary branches (Table 1) found in T_2 (72.54) treated with recommended dose of fertilizer. Zinc plays an important role for plant growth as an activator for production of several enzymes that directly involved in the biosynthesis of growth regulators such as auxin and promotes production of more plant cells (Marschner, 1995). The findings of Ramesh et al. (2011) in Kalmegh, Yeboah et al. (2012) in *Artemisia annua*, Dadiga and Jain (2017) in coriander also supports that hypothesis. From, (Table 1). data showed that at 60 and 90 days after planting, highest plant spread (1434.00 cm^2 and 1911.00 cm^2) was recorded in T_5 treated with RDF+Zn @ 0.75%. Significantly more branches and leaves indicate a more robust nature of plant growth at this level, which might be the cause of the enhanced plant spread. (El-Khateeb et al., 2020). The treatment T_5 (RDF+Zn @ 0.75%) produced maximum number of leaves (289.10, 509.32 and 885.73 at 30, 60 and 90 days after planting) (Table 2) which was found statistically superior over other treatments. The lowest (188.69, 290.45 and 722.28) number of leaves found to be in the treatment T_1 treated with only FYM @ 10 t ha^{-1}. The height of the plant, the number of nodes, and the number of primary and secondary branches that develop from the main shoot of the plant had a positive impact on number of leaves. The findings from Chamroy et al. (2015) in chilli, and Ihenacho et al. (2015) in turmeric, Khan et al. (2015) in *Ocimum* and mint were also in accordance with the present experimental result. Fresh weight (Table 2) was found significantly higher (811.45 g plant^{-1}, 7.40 kg plot^{-1} and 32.50 t ha^{-1} respectively) in treatment T_5 treated with RDF+Zn @ 0.75%. Increase in herbs fresh weight might be the result of increased plant height, spread, branch number and leaf area plant^{-1} along with protein and amino acid accumulation in structural organs. The current findings coincide with the findings made in the Gaillardia by Mishra et al. (1998). Dry weight (Table 2) was recorded significantly higher (101.00 g plant^{-1}, 2.52 kg plot^{-1} and 11.13 t ha^{-1} respectively) in treatment T_5 treated with RDF+Zn @ 0.75%. Increased nutrient availability might help in the production of carbohydrates, which later converted into amino acids and proteins to aid in the structural development of the plant in terms of number of branches, leaves, and leaf area plant^{-1}. Excess nutrients might be accumulated in the plant parts, which were responsible for an increase in the dry weight of the plant. Number of inflorescence (Table 3) recorded maximum (42.86) in treatment T_5 treated with RDF+Zn @ 0.75% and minimum number of inflorescences recorded in treatment T_1 (25.60) treated with FYM @ 10 t ha^{-1}. The results revealed that application of recommended dose of fertilizers with zinc increased the vegetative growth and led to the synthesis of a greater quantity of food materials and photosynthates that were translocated and accumulated in the reproductive parts, leading to profused flowering in plants. Commencement of flowering (Table 3) found early (50.58) in treatment T_3 treated with RDF+Zn @ 0.25% and late flowering observed in treatment T_4 (57.44) treated with RDF+Zn @ 0.5%. Less number of days (102.26) had taken for completion of flowering (Table 3) in treatment T_3 treated with RDF+Zn @ 0.25% and more number of days

Table 2: Effect of Zinc nutrition on leaf and whole herbage yield of Sweet basil (*O. basilicum*)

Treatments details	Number of leaves			Fresh herbage yield			Dry herbage yield		
	30 DAP	60 DAP	90 DAP	Plant^{-1} (g)	Plot^{-1} (kg)	ha^{-1} (t)	Plant^{-1} (g)	Plot^{-1} (kg)	ha^{-1} (t)
T_1	188.69^{f}	290.45^{g}	722.28^{f}	230.90^{g}	2.61^{b}	11^{b}	35.16^{d}	0.87^{d}	3.86^{d}
T_2	236.48^{c}	450.45^{d}	797.35^{c}	291.76^{f}	3.70^{b}	16^{b}	45.73^{cd}	1.14^{cd}	5.04^{cd}
T_3	203.56^{e}	410.35^{f}	864.45^{b}	509.25^{c}	6.20^{a}	27^{a}	80.00^{ab}	2.00^{ab}	8.86^{ab}
T_4	283.23^{a}	492.96^{b}	884.58^{a}	690.88^{b}	6.5^{a}	28^{a}	89.3^{a}	2.23^{a}	9.90^{a}
T_5	289.10^{a}	509.32^{a}	885.73^{a}	811.45^{a}	7.4^{a}	32.5^{a}	101^{a}	2.52^{a}	11.13^{a}
T_6	221.61^{d}	432.37^{e}	794.2^{d}	482.62^{d}	5.94^{a}	26^{a}	74.16^{abc}	1.85^{abc}	8.06^{abc}
T_7	250.48^{b}	477.91^{c}	764.51^{e}	373.69^{e}	5.77^{a}	26^{a}	49.66^{bcd}	1.24^{bcd}	5.43^{bcd}
SEm±	3.93	0.29	0.55	3.55	0.63	2.94	9.69	0.24	1.07
CD (p=0.05)	12.10	0.90	1.70	10.96	1.96	9.17	30.19	0.75	3.33

Table 3: Effect of zinc nutrition on flowering behaviour of sweet basil (*O. basilicum*)

Treat-ments	No. of inflorescence plant^{-1}	Commencement of flowering (DAP)	Completion of flowering (DAP)
T_1	25.60^{b}	52.81^{c}	112.70^{b}
T_2	32.60^{ab}	53.24^{bc}	114.36^{ab}
T_3	42.26^{a}	50.58^{c}	102.26^{c}
T_4	34.06^{ab}	57.44^{a}	117.25^{a}
T_5	42.86^{a}	56.51^{ab}	116.32^{ab}
T_6	33.70^{ab}	51.99^{c}	113.33^{b}
T_7	39.60^{a}	50.98^{c}	112.65^{b}
SEm±	3.13	1.11	1.13
CD (p=0.05)	9.78	3.42	3.48

(117) has taken for completion of flowering in treatment T_4 treated with RDF+Zn @ 0.5%. Early flowering in those treatments may be due to improved vegetative development in the presence of bioactive growth-promoting chemicals like auxin which are activated by Zinc by acting as metal component and enzyme cofactor. The role of zinc in the biosynthesis of indole acetic acid (IAA) and particularly its role in the initiation of primordia for reproductive parts and the partitioning of photosynthates towards them contributed to the improvement in yield attributes, which cause better flowering and fruiting. (Choudhary et al., 2015)

4. Conclusion

Zinc spraying had a significant positive impact on the growth and yield of sweet basil. The treatment with RDF+Zn @ 0.75% proved best among the treatments in influencing vegetative growth of sweet basil viz. leaf and total herbage yield.

5. Acknowledgement

Authors acknowledge the supports from Uttar Banga Krishi Viswavidyalaya for providing land and other necessary inputs. Also giving Thanks to CSIR-CIMAP, Lucknow for the planting material provided for research work.

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