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The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; 11(4): 706-708

www.thepharmajournal.com
Received: 05-01-2022
Accepted: 09-03-2022

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Combined impact of major and micronutrients on yield, quality and economics of garlic (*Allium sativum* L.)

Shailendra Singh Yadav, KP Asati, Anjali Sharma and Anurag Kamathker

Abstract
A field experiment was carried out at the Research Farm, College of Agriculture, Indore (M.P.) during winter season 2020-21 to study the combined impact of major and micronutrients on yield, quality and economics of garlic. The experiment comprising ten treatments of major-cum-micronutrients was laid out in a randomized block design with three replications. Results revealed that the application of 100:50:50 NPK + 30 kg S ha^{-1} (soil application) + 0.6% S (foliar) resulted in maximum yield attributing parameters (fresh weight of bulb 46.8 g, dry weight of bulb 23.0 g, cloves 23.66/bulb and bulb diameter 6.50 cm) as well as bulb yield (158.44 q ha^{-1} yield), net income (Rs.319611 ha^{-1}) and B:C ratio (2.05). The second best treatment was 100:50:50 NPK + 0.6% S (foliar spray) with 156.44 q ha^{-1}) and net income of Rs.315108 ha^{-1}. Similarly, the maximum value of TSS (39.44 ^{O}Brix) was recorded under 100:50:50 NPK + 30 kg S ha^{-1} (soil application) + 0.6% S (foliar) spray. The overall trend indicated that the soil and foliar application of sulphur treatments were found the best than those of other micronutrient treatments.

Keywords: Major, micronutrients, yield, economics, garlic

Introduction
Garlic (*Allium sativum* L.) belonging to family Alliaceae is commonly used as a spice and also in the medicinal purposes because it contains antibacterial substance allicin which is a effective drug against amoebic dysentery. Its medicinal value is also well recognized to cure hypertension, worm, germ, bacterial and fungal diseases, diabetes, cancer, ulcer and rheumatism. In India, garlic occupies an area of 358 thousand hectares with total annual production of about 2910 thousand million tonnes: (National Horticulture Board, 2020) [4]. The important states growing garlic are Madhya Pradesh, Rajasthan, Uttar Pradesh and Gujarat. The use of major and micronutrient application is also very limited in this crop. Consequently lower yield and quality of garlic. The micronutrients play an important role in photosynthesis, N-fixation, respiration and the metabolic processes of garlic plants. Foliar application of micronutrients during crop growth corrects the deficits and improve the mineral status of plants as well as increasing the crop yield and quality of garlic. Garlic requires different micronutrients which are essential for health, growth and development. These are usually required in smaller amount than nitrogen, phosphorus and potassium. All these are very important for plant growth and general health (Yatsenko *et al.*, 2020) [9].

Boron is one of the most widely applied micronutrient although it is required in very small quantity. It has different role in onion and garlic metabolic activities. Cell division, nitrogen carbohydrates metabolism and water retention in plants are controlled by boron. Sugar translocation within the plant body is controlled by boron (Prusty *et al.*, 2020). Sulphur is the 4th major essential nutrient particularly in garlic. Its role in balanced fertilization and consequently in yield and quality enhancement of garlic is being increasingly appreciated. Sulphur performs many physiological functions like synthesis of methionine (Singh *et al.* 2018) [7]. Zinc is essential component and activator of many enzymes involved in auxin biosynthesis and photosynthesis and their act as an important role in plant growth and yield in garlic. Zinc is the most deficient among all the micronutrients in Indian soils (Prusty *et al.*, 2020). The information on the conjunctive use of major and micronutrients on the productivity of garlic is limited in this region. Therefore, the present research work was taken up.

Materials and Methods

The field experiment was conducted during *rabi* season of 2020-21 at the Research Farm, College of Agriculture, Indore (M.P.). The soil of the experimental field was silty clay-loam having pH 7.2,"organic carbon 7.6 g kg^{-1}, available N, P and K 226, 10 and 448 kg ha^{-1}, respectively. The experiment was laid out in randomized block design keeping three replications. The 10 treatments having different combinations of major and micronutrients fertilizers were: T_0=100:50:50 NPK (control), T_1=100:50:50 NPK + boron 1 kg ha^{-1}(soil application), T_2=100:50:50 NPK + boron 0.5% (foliar), T_3=100:50:50 NPK + 30 kg S ha^{-1} (soil application), T_4=100:50:50 NPK + 0.6 S(foliar), T_5=100:50:50 NPK + zinc 7.5 kg ha^{-1}(soil application), T_6=100:50:50 NPK + zinc 3% (foliar), T_7=100:50:50 NPK + boron 1 kg ha^{-1}(soil application) + S 0.6% (foliar), T_8=100:50:50 NPK + 30 kg S ha^{-1}(soil application) + S 0.6% (foliar), T_9=100:50:50 NPK + zinc 7.5 kg ha^{-1}(soil application) + zinc 3% (foliar). The garlic var. G-282 was sown on 6 October 2020 using 500 kg seed ha^{-1} and keeping 15 x 10 cm spacing. The crop was grown as per recommended package of practices. The crop was harvested during the first week of April, 2021. The TSS ("Brix) of garlic was recorded under each treatment with the help of Pocket Refractometer. The plant growth parameters, yield and yield attributing parameters were recorded in each treatment. The data obtained were statistically analyzed for the various treatments.

Results and Discussion

The data (Table 1) reveal that the best treatment was T_8 having 100:50:50 NPK + 30 kg S ha^{-1} (soil application) + 0.6% (foliar) which recorded significantly higher yield attributes (*viz*. 46.8 g bulb weight, 23.0g dry bulb weight, 23.66 cloves/bulb and 6.50 cm bulb diameter) and bulb yield of 158.44 q ha^{-1}. This was followed by T_3 and T_4 having 100:50:50 NPK + 30 kg S ha^{-1} (soil) applied or 100:50:50 NPK + 0.6% S (foliar). The higher yield and yield attributes may be attributed to the significant role of sulphur in regulating the photosynthesis, enhancing the metabolic activities, promoting chlorophyll formation at one hand and root-development coupled with accelerated nutrient absorption on the other (Vekaria *et al.*, 2018 and Kushwaha *et al.*, 2019) [8, 3].

Being a fourth major nutrient, sulphur played an important physiological role by enhancing cell multiplication, elongation, expansion and chlorophyll biosynthesis, which in turn increased the photosynthate production and its effective partitioning to economic sink. Similar results have been reported by Shukla *et al.* (2018) [6], Singh *et al.* (2018) [7] and Yatsenko *et al.* (2020) [9]. According to Chattoo *et al.* (2019) [2] sulphur plays an important role in growth and development of crops as it is the constituents of amino acids needed for the synthesis of other metabolism processes and chlorophyll. The TSS was found highest (39.44 ^{O}Brix) under 100:50:50 NPK + 30 kg S ha^{-1}(soil application) + 0.6% S (foliar) and the lowest (32.89 ^{O}Brix) under 100:50:50 NPK (control). The results agree with those of Babaleshwar *et al.* (2017).

Table 1: Effect of major and micro-nutrients on yield attributes, yield, quality and economics of garlic

Tr. No.	Fresh weight of bulb (g)	Dry weight of bulb (g)	Number of cloves per bulb	Average weight of 10 cloves (g)	Bulb diameter (cm)	Bulb yield (q ha^{-1})	Net income (Rs ha^{-1})	B:C ratio	TSS (^{O}Brix)
T_0	35.51	15.55	14.66	3.33	4.26	109.67	174948	1.13	32.89
T_1	39.31	18.23	18.77	4.47	5.25	136.78	255528	1.65	36.02
T_2	41.63	19.78	18.88	5.11	5.73	141.33	268053	1.71	36.15
T_3	44.25	21.60	21.11	5.56	5.90	150.89	297110	1.90	37.03
T_4	44.73	21.71	22.44	5.82	5.96	156.44	315108	2.04	37.37
T_5	38.14	17.39	17.11	4.19	4.88	126.66	223419	1.42	36.27
T_6	38.73	17.53	17.55	4.28	4.91	131.11	234270	1.47	36.66
T_7	42.40	20.36	20.33	5.19	5.83	143.44	273663	1.75	38.23
T_8	46.84	23.03	23.66	6.20	6.50	158.44	319611	2.05	39.44
T_9	39.16	18.321	18.44	4.29	5.12	132.22	235101	1.45	37.71
CD at 5%	3.98	0.87	1.62	0.32	0.14	7.19	--	--	1.41

T_0=100:50:50 NPK (control), T_1=100:50:50 NPK + boron 1 kg ha^{-1}(soil application), T_2=100:50:50 NPK + boron 0.5% foliar), T_3=100:50:50 NPK + 30 kg S ha^{-1} (soil application), T_4=100:50:50 NPK + 0.6 S(foliar), T_5=100:50:50 NPK + zinc 7.5 kg ha^{-1}(soil application), T_6=100:50:50 NPK + zinc 3% (foliar), T_7=100:50:50 NPK + boron 1 kg ha^{-1}(soil application) + S 0.6% (foliar), T_8=100:50:50 NPK + 30 kg S ha^{-1}(soil application) + S 0.6% (foliar), T_9=100:50:50 NPK + zinc 7.5 kg ha^{-1}(soil application) + zinc 3% (foliar)

Economics

The application of 100:50:50 NPK + 30 kg S ha^{-1} (soil application) + 0.6% S (foliar) gave the maximum income (Rs.319611 ha^{-1}) with 2.05 B:C ratio. This was followed by 100:50:50 NPK + 0.6% S (foliar) Rs.315108 ha^{-1} with 2.04 B:C ratio. The lowest net income (Rs.174948 ha^{-1} with 1.13 B:C ratio) was obtained from T_0 having only 100:50:50 NPK. The higher net income from these treatments was as a result of similar increases in bulb yield which fetched higher market value in terms of gross income.

It may be concluded from the results that 100:50:50 NPK + 30 kg S ha^{-1} (soil application) + 0.6% S (foliar spray) recorded the maximum yield, net income and TSS from garlic var. G-282 under Malwa region of Madhya Pradesh.

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