emergent
Life Sciences Research

Research Article

Effect of fertigation and foliar spray of nutrients on soil fertility and yield of bottle gourd (*Lagenaria siceraria* L)

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Received: 19 March 2022
Accepted: 21 May 2022
Online: 26 May 2022

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Emer Life Sci Res (2022) 8(1): 146-151

E-ISSN: 2395-6658
P-ISSN: 2395-664X

DOI: https://doi.org/10.31783/elsr.2022.81146151

Abstract

The field experiment was conducted during *Kharif*, 2020-21 at Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola (Maharashtra) to study the effect of fertigation and foliar spray of nutrients on soil fertility and yield of bottle gourd *(Lagenaria siceraria L*). The experiment was conducted in a factorial randomized block design with three replications. The two factors i.e., fertigation levels and foliar spray levels were evaluated against soil fertility and yield of bottle gourd. The results indicate, that the foliar spray of nutrients did not influence significantly the soil pH, EC, while with fertigation levels, significantly lowest pH was observed with S_1 (200:100:100 kg ha^{-1} N, P_2O_5, K_2O) while EC was not significant. The organic carbon content and major nutrient i.e., available nitrogen, phosphorus and potassium were increased by 11, 25, 22 and 5% with fertigation level of S_1 (200:100:100 kg ha^{-1} N, P_2O_5, K_2O) over S_3 (100:50:50 kg ha^{-1} N, P_2O_5, K_2O), and by 21, 7, 15 and 5% with foliar spray level of F_3 (Two foliar spray of $ZnSO_4$ @ 0.25% + $FeSO_4$ @ 0.25%) over F_0 (water spray). The micronutrient contents particularly Fe, Mn, and Zn were significantly increased by 32, 11, and 14% with foliar spray levels of S_1 (200:100:100 kg ha^{-1} N, P_2O_5, K_2O) over S_3 (100:50:50 kg ha^{-1} N, P_2O_5, K_2O) and by 52, 18, and 62% with foliar spray level of F_3 (Two foliar sprays of $ZnSO_4$ @ 0.25% + $FeSO_4$ @ 0.25%) over F_0 (water spray). The yield of bottle gourd was significantly higher with F_3 (Two foliar sprays of $ZnSO_4$ @ 0.25% + $FeSO_4$ @ 0.25%) in combination with S_1 (200:100:100 kg ha^{-1} N, P_2O_5, K_2O) and S_2 (150:75:75 kg ha^{-1} N, P_2O_5, K_2O).

Keywords bottle gourd, fertigation, foliar spray, soil fertility, yield

Introduction

Vegetables are crucial in human nutrition. In India, bottle gourd is grown widely in the state of Bihar, Uttar Pradesh, Haryana, and Madhya Pradesh. The research reports indicated the declining yield of this vegetable crop due to the indiscriminate use of chemical fertilizers.

Excessive constant usage of inorganic fertilizers for vegetable crops disrupts the soil and surrounding environment and inorganic fertilizers alone cannot endure high levels of vegetable crop productivity. Moreover, it leads to widespread nutrient deficiency in soils, reduced organic matter, disturbed soil reaction, nutrient imbalance in plants, susceptibility to plant diseases, and increased environmental pollution as well as human health hazards [1]. The bottle gourd yield varies significantly with the method of fertilizer application.

Fertigation and foliar spray are one of the most effective and convenient method of supplying nutrients and water as per the specific requirements of the crop to uphold optimum soil fertility and better-quality produce. Drip fertigation plays the main role in the summer season for irrigation and nutrient application as there is a shortage of irrigation water and high competition for accessible water resources and it also boosts the movement of less mobile nutrients like P in soil.

The vegetable crop suffers from micronutrient deficiencies due to their inherently low concentration in soils. Therefore, their correction at right time is important for achieving a higher yield of bottle gourd. The foliar spray has been reported to be one of the best approaches for correcting micronutrient deficiencies, however, the dose and concentration in foliar spray need to be identified for a particular region taking into account the soil fertility and yield potential of crop variety. The adoption of fertigation and foliar spray of nutrients is essential to make optimum use of each type of fertilizer and achieve balanced nutrient management for proper crop growth and nutrient uptake as well as enhancing soil fertility. Keeping in mind the above views, the present study is undertaken to study how different levels of nutrients through drip irrigation and foliar application of micronutrient sources affects the soil fertility and yield of bottle gourd.

Methodology

Experimental site

A field experiment was conducted at Chili and Vegetable Research Unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during the Kharif, 2020-21. The experimental field is situated in the subtropical region at an altitude of 307.42 m above mean sea level (Agromet observatory). The average annual precipitation was 944.4 mm. The texture of the soil was clay loam with pH 8.3, EC 0.3 dSm^{-1}, organic carbon 6.5 g kg^{-1}, available nitrogen 184.5 kg ha^{-1}, phosphorus 22.4 kg ha^{-1}, potassium 288.5 kg ha^{-1} and sulfur 16.2 mg kg^{-1}. The experiment was laid out in Factorial Randomized Block Design (FRBD) with two factors (fertigation of major nutrients (S) and foliar application of $ZnSO_4$ and $FeSO_4$ (F)) replicated three times. The treatments details in factor (A) S_1: - 200:100:100 kg ha^{-1} N, P_2O_5, K_2O, S_2: 150:75:75 kg ha^{-1} N, P_2O_5, K_2O, S_3: - 100:50:50 kg ha^{-1} N, P_2O_5, K_2O and factor (B) F_0: - water spray, F_1: - Two foliar spray of $ZnSO_4$ @ 0.5%, F_2: - Two foliar spray of $FeSO_4$ @ 0.5%, F_3: - Two foliar spray of $ZnSO_4$ @ 0.25% + $FeSO_4$ @ 0.25%. The two foliar sprays were given at the time of flower initiation and the fruit set of bottle gourd. In fertigation major nutrients i.e., N, P, and K were supplied through drip irrigation. Bottle gourd variety F1 (Co-1) was sown at spacing 1.0 m X 0.75 m by the dibbling method. The seed was sown at the seed rate of 1.5 kg ha^{-1} in the first week of July 2020. The picking (total of twelve) of tender and marketable healthy fruits was done at an interval of 3 to 4 days. The post-harvest soil samples were collected and analyzed for pH, EC, OC, $CaCO_3$, available nitrogen, phosphorus, sulfur, potassium, and micronutrients i.e., iron, manganese, zinc, copper by standard methods.

Statistical analysis

The mean data on various parameters obtained from the analysis were statistically analyzed as per the procedure given by Gomez and Gomez [2]. The least significant difference (LSD) values at P = 0.05 were used to determine the significance of the difference between treatment means.

Results and Discussion

In the present investigation, it is reported that the individual effect of fertigation (factor A) and foliar spray (factor B) was significant on the majority of the soil properties, while the interaction effect was not significant, hence, with regards to soil fertility, the only individual effect of fertigation and foliar sprays are presented and discussed.

Soil fertility

The fertigation and foliar spray of nutrients have significantly affected the soil pH, while the effect on EC was not significant (Table 1). In fertigation levels, soil pH was increased by decreasing the fertilizer dose from S_1 to S_3. Soil pH was lowest in S_1 and increased by 2.7% in S_3. Among the fertigation levels, the lowest soil pH was observed in S_1, followed by S_2, and the highest in S_3. However, treatments S_1 and S_2 were statistically at par with each other. The lowest pH in S_1 as compared to S_3 may be due to acidity produced by the application of higher levels of nitrogen fertilizers through drip irrigation. The lowest pH in S_1 compared to S_3 may be because of the application of higher nutrient rates particularly nitrogen in S_1. Higher nitrogen application might have produced residual acidity associated with N-fertilizers during the nitrification process. The soil pH and EC were not significantly affected by the foliar sprays of nutrients. Similar results were also reported by Chaudhary et al., [3] and Ibrahim et al., [4]. The organic carbon content of the soil was significantly affected by fertigation and foliar spray of nutrients (Table 1). In fertigation levels, the OC decreased with decreasing the fertigation level from S_1 to S_3. It was significantly highest in S_1 being statistically at par with S_2. The OC was 11% higher in S_1 as compared to S_3. In foliar spray levels, the OC increased significantly from F_0 to F_3. Highest OC was found in F_3 which was at par with F_2. As compared to F_0, the OC in F_3 increased by 21%. The observed highest OC in S_1 and F_3 levels is might be because of improved plant and root growth. Under optimum nutrient supply through fertigation and foliar spray levels, there was marked enhancement in the above-ground and root biomass of bottle gourd which ultimately contributed to soil organic matter and thus improved the soil organic carbon. The available nitrogen, phosphorus, and potassium content of soil significantly affected the fertigation and foliar spray levels (Table 1). In fertigation, available nitrogen, phosphorus, and potassium were significantly decreased from S_1 to S_3. The available nitrogen, phosphorus, and potassium in S_1 were 25, 22%, and 5% higher than compared in S_3. In foliar spray levels, available nitrogen, phosphorus, and potassium were significantly higher in F_3 as compared to F_0. Foliar spray levels of F_1, F_2, and F_3 were statistically at par with each other, but significantly higher than F_0. The content of these nutrients in F_3 was 7, 15, and 5% higher as compared to F_0. Similar results were also reported by Meena et al., [5] and Prasad et al., [6]. The highest available nitrogen, phosphorus, and potassium contents were observed in the S_1 fertigation level and F_3 foliar spray level. This is because, in S_1, higher doses of N, P, and K were supplied through drip irrigation. In fertigation levels, especially in S_1, 50% more nitrogen, phosphorus, and potassium were given through drip irrigation as compared to S_3. This help in enriching the soil fertility after satisfying the nutrient needs of the bottle gourd. The available sulfur content of the soil was significantly affected by foliar spray levels only. The available sulfur was significantly increased from F_0 to F_3 and it was higher in F_3 and F_2, where $FeSO_4$ was applied. The highest available sulfur was observed in F_3 over F_0 to the tune of 34%. The available micronutrients in soil i.e., Fe, Mn, and Zn were significantly affected by the fertigation and foliar spray levels, while the effect on available Cu was non-significant (Table 2). The available Fe, Mn, and Zn contents in soil were 32, 11, and 14% higher in S_1 as compared to S_3. In fertigation, the levels where $FeSO_4$ and $ZnSO_4$ were applied through foliar spray (F_1, F_2, and F_3) had the highest content of available Fe, Zn, and Mn. Fe content was statistically at par in F_2 and F_3 and Zn content was statistically at par in F_1 and F_3, because $FeSO_4$ and $ZnSO_4$ were foliar applied in the respective treatments. In general, the content of Fe, Mn, and Zn were 52, 18, and 62% higher in F_3 over F_0. The highest available micronutrients in S_1 fertigation levels and F_3 foliar spray levels is may be attributed to the indirect effect of enhanced crop growth and root activity as a result of increased fertigation levels. The higher root activity helped in producing the organic acids and thus chelated the micronutrients in available form. These results are in conformity with the studies of Karthick et al., [7] and Lone et al., [8].

Yield of bottle gourd

Unlike soil fertility parameters, the yield of bottle gourd was significantly affected by fertigation levels, foliar spray levels as well as interaction effect of fertigation and foliar spray

(Figure 1). Averaged across foliar spray levels, significantly higher bottle gourd yield was found in S_1 followed by S_2, and least in S_3. The bottle gourd yield in S_1 was 34% higher as compared to S_3. Similarly, averaged across fertigation levels, significantly higher bottle gourd yield was recorded in F_3 and least in F_0. In F_3, the bottle gourd yield was higher over F_0 to the tune of 25%. The interaction effect of fertigation and foliar spray revealed that the yield of bottle gourd was significantly higher in F_3 along with S_1 and S_2. Moreover, F_1, F_2, and F_3 in combination with S_1 also produced higher yields as compared to other combinations. This yield improvement was mainly because of improvement in the fertility status of soil and the indirect effect of fertigation. The drip irrigation helped in maintaining the nutrients is soluble form and facilitated the steady and continuous supply of nutrients and enhanced the nutrient uptake during the critical crop growth period. Similar results were also reported by Karthick et al., [7] and Leghari et al., [9].

Table 1. Effect of fertigation and foliar spray of nutrients on soil properties and fertility status

Treatments	pH (1:2.5)	EC (dSm^{-1})	OC ($g\ kg^{-1}$)	Available Nutrients ($kg\ ha^{-1}$)			
				N	P	K	S
Fertigation levels (Factor A)							
S_1	8.0	0.32	5.86	225.90	23.10	380.28	19.10
S_2	8.11	0.27	5.71	211.68	20.71	360.11	18.43
S_3	8.24	0.32	5.25	180.70	18.92	361.63	18.10
CD (p=0.05)	0.1	NS	0.42	18.8	2.29	17.78	NS
Foliar spray levels (Factor B)							
F_0	8.3	0.33	5.05	201.40	17.49	342.54	16.28
F_1	8.2	0.27	5.23	212.77	20.37	353.74	16.10
F_2	8.2	0.32	6.02	213.53	20.86	351.72	19.61
F_3	8.3	0.28	6.13	215.34	20.14	359.36	21.97
CD (p=0.05)	NS	NS	0.72	11.2	2.64	5.53	2.71

S_1:- 200:100:100 N, P_2O_5, K_2O, S_2: 150:75:75 N, P_2O_5, K_2O, S_3:- 100:50:50 N, P_2O_5, F_0:- water spray,
F_1:- Two foliar spray of $ZnSO_4$ @ 0.5%, F_2:- Two foliar spray of FeSO4 @ 0.5%,
F_3:- Two foliar spray of $ZnSO_4$ @ 0.25% + $FeSO_4$ @ 0.25%

Table 2. Effect of fertigation and foliar spray of nutrients on micronutrient contents

Treatments	Available micronutrients ($mg\ kg^{-1}$)			
	Fe	Mn	Zn	Cu
Fertigation levels (Factor A)				
S_1	0.95	1.67	0.83	2.56
S_2	0.79	1.67	0.82	2.49
S_3	0.72	1.50	0.73	2.52
CD (p=0.05)	0.23	0.67	0.21	NS
Foliar spray levels (Factor B)				
F_0	0.67	1.12	0.61	2.52
F_1	0.76	1.24	0.91	2.41
F_2	0.94	1.30	0.82	2.49
F_3	1.02	1.32	0.99	2.51
CD (p=0.05)	0.08	0.24	0.09	NS

S_1:- 200:100:100 N, P_2O_5, K_2O, S_2: 150:75:75 N, P_2O_5, K_2O, S_3:- 100:50:50 N, P_2O_5,
F_0:- water spray, F_1:- Two foliar spray of $ZnSO_4$ @ 0.5%,
F_2:- Two foliar spray of $FeSO_4$ @ 0.5%,
F_3:- Two foliar spray of $ZnSO_4$ @ 0.25% + $FeSO_4$ @ 0.25%

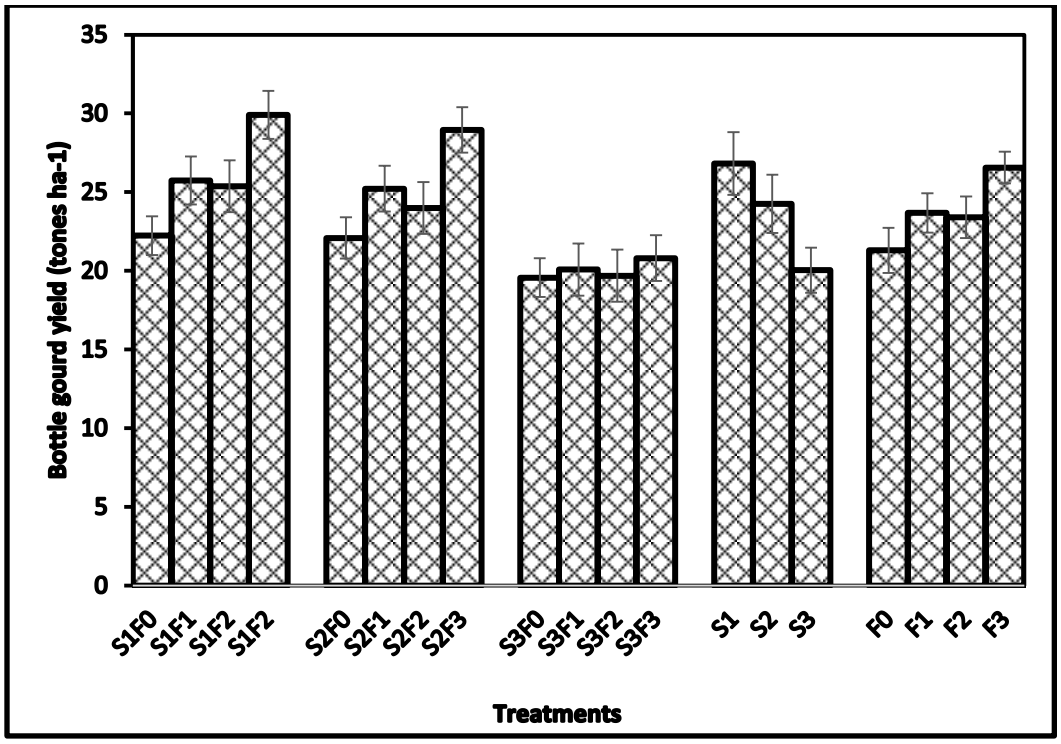

Figure 1. Effect of fertigation and foliar sprays of nutrients on yield of bottle gourd (tones ha^{-1})
S_1:- 200:100:100 N, P_2O_5, K_2O, S_2:- 150:75:75 N, P_2O_5, K_2O, S_3:- 100:50:50 N, P_2O_5, F_0:- water spray,
F_1:- Two foliar spray of $ZnSO_4$ @ 0.5%, F_2:- Two foliar spray of $FeSO_4$ @ 0.5%,
F_3:- Two foliar spray of $ZnSO_4$ @ 0.25% + $FeSO_4$ @ 0.25%

Conclusion

From the present investigation, it may be concluded that bottle gourd responded significantly to fertigation levels of S_1 and foliar spray levels of F_3 and also the combination of S_1 and S_2 along with F_3. These treatments produced the highest yield of bottle gourd and improved the soil fertility status. Moreover, the present study indicated the superiority of the combined use of fertigation and foliar spray of micronutrients for enhancing soil fertility, nutrient use efficiency, and correction of widespread micronutrient deficiencies to improve the productivity of bottle gourd.

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