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Evaluation of Fertigation and Foliar Spray of Nutrients for the Performance of Bottle Gourd [*Lagenaria siceraria* (Molina) Standl.] on Yield, Quality and Economics

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The field experiment entitled "Evaluation of fertigation and foliar spray of nutrients for the performance of bottle gourd [*Lagenaria siceraria* (Molina) Standl.] on yield, quality and economics" was conducted during *Kharif* season from 2020-21 to 2022-2023 at Chilli and Vegetable Research

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Unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola (Maharashtra). The site is Situated in the subtropical region at $22^0$42' North latitude and $77^0$02' East longitude and at an altitude of 307.42 m above mean sea level with average annual precipitation was 944.4 mm. Experimental field is situated at the latitude of 20^0 40' 35'' North and longitude of 76^0 59' 10'' East. The experiment was laid out in factorial randomized block design with twelve treatments combinations and three replications. The two factors *i.e*., fertigation levels and foliar spray levels *i.e*. soil application with S_1 (200:100:100 kg ha^{-1}) NPK through fertigation in ten equal doses along with two foliar spray of F_3 ($ZnSO_4$ @ 0.25% + $FeSO_4$ @ 0.25%) at flower initiation and fruit setting (S_1F_3) was found better for maximum highest yield and B:C ratio (2.17) of bottle gourd followed by statistically at par with the treatment with (S_2F_3) soil application of S_2 (150:75:75 kg ha^{-1}) NPK through fertigation in ten equal doses along with foliar application of F_3 ($ZnSO_4$ @ 0.25% + $FeSO_4$ @ 0.25%) at flower initiation and fruit setting. Similarly, the quality parameters like reducing, non -reducing sugars (g/100g) and ascorbic acid content (%) were significantly improved with fertigation level of S_1 (200:100:100) kg NPK along with foliar spray of F_3 (foliar spray of ZnSO4 @ 0.25% + FeSO4 @ 0.25%).

Keywords: Yield; quality; economics; fertigation; bottle gourd; vegetable crop; ascorbic acid.

1. INTRODUCTION

"Bottle gourd (*Lagenaria siceraria L*.) is an important vegetable crop cultivated in several tropical and subtropical countries for its edible fruit. It is one of the most important cucurbitaceous vegetable crop with chromosome number 2n=22. Among gourds, bottle-gourd (*Lagenaria siceraria L.)* commonly known as "lauki", "kaddu" or "dudhi" is grown extensively in India. Immature, tender bottle gourd fruit is used as a fresh vegetable and in preparation of pickles and other products [1,2].'' "This vegetable can provide multiple medicinal benefits. They contain the pharmaceutically active compounds used to treat acne, hyper-seborrhea, BHP, hirsutism and alopecia" [3-5].

"It is cultivated in several tropical and sub-tropical countries for its edible fruit. It needs a well distributed rainfall of 600-1500 mm and is adopted to semi-arid conditions. The optimum temperature for germination is 20-25 °C however, germination rates decline below 15 °C and above 35°C. It tolerates low temperature but if the temperature falls below 10 °C flowering often reduced due to its intolerance to frost. It grows in a wide range of soils, but prefer well aerated, fertile soils with pH 6-7" [6,7].

In India, it is grown extensively in the state of Bihar, Uttar Pradesh, Haryana, Madhya Pradesh, Chhattisgarh, Odisha and Punjab. Bihar is the leading state in both area (40.3 thousand hectare) and production (631.60 thousand tones) with the productivity of 25.4 tones ha^{-1}. It is gaining importance due to high yielding potential, steady market price throughout the season and export potential.

"The composition of immature fruits of bottle gourd per 100 gm of fresh edible portion consists of water 93.99 gm, energy 21 kcal, protein 0.5 gm, fat 0.1 gm, carbohydrate 5.2 gm, fiber 0.6 gm, P 34 mg, Fe 2.4 mg, β carotene 25 µg, thiamin 0.03 mg, niacin 1.2 mg and ascorbic acid 10 mg. The leaves per 100 mg of fresh edible portion comprise 4.4 gm, fat 0.3 gm, carbohydrate 8.3 gm, fiber 1.8 gm, Ca 560 mg, P 88 mg and Fe 7.4 mg" [8]. "The N, P, K concentrations in leaves of bottle gourd ranged from 3.45 to 3.86%, 0.32 to 0.34%, and 3.50 to 3.94% respectively", [9]. "Zinc content in bottle gourd seed range from 32.71 to 38.11 ppm" [10].

"Among the various factors involved in bottle gourd production, nutrient supply is an important for realizing higher crop yield. Experimental evidences showed that the response of bottle gourd is high due to nitrogen application and moderate to phosphorus application. Soil management practices have recently been changed as farmers utilizing huge amount of NPK fertilizers to increase crop yield. Fertilizer application plays a major role in harnessing optimum and good quality fruits in bottle-gourd. Although chemical fertilizers particularly nitrogenous and phosphatic fertilizers contribute a lot in fulfilling the nutrient requirement but the cultivation of crop requires balance supply of plant nutrients" [10].

"Indiscriminate use of chemical fertilizers will lead to wide spread nutrient deficiency in soils, disturbed soil reaction, development of nutrient imbalance in plants, increase susceptibility to

plant diseases, reduced soil organic matter, lesser occurrence of soil micro-organisms and increased environmental pollution as well as human health hazards" [11]. "Excessive continuous application of inorganic fertilizers to vegetable crops can cause harm to the soil and surrounding environment and continuous use of inorganic fertilizers alone cannot sustain high levels of vegetable crop productivity" [12].

Considering the above facts, the present study was undertaken to investigation the "Evaluation of fertigation and foliar spray of nutrients for the performance of bottle gourd [*Lagenaria siceraria* (Molina) Standl.] on yield, quality and economics".

2. MATERIALS AND METHODS

A field experiment entitled "Evaluation of fertigation and foliar spray of nutrients for the performance of bottle gourd [*Lagenaria siceraria* (Molina) Standl.] on yield, quality and economics" was carried out during *Kharif* season from 2020-21, 2021-2022, and 2022-23 at Chilli and Vegetable Research Unit, Dr.Panjabrao Deshmukh Krishi Vidyapeeth, Akola (Maharashtra). The site is Situated in the subtropical region at $22^0$42' North latitude and $77^0$02' East longitude and at an altitude of 307.42 m above mean sea level with average annual precipitation was 944.4 mm. Experimental field is situated at the latitude of 20^0 40' 35'' North and longitude of 76^0 59' 10'' East. Initial composite soil sample was collected from the experimental site and analyzed for soil properties. The experiment was laid out in Factorial Randomized Block Design (FRBD) with two factors: Factor A for S_1- 200:100:100N,P_2O_5,K_2O through drip irrigation (10 splits at 10 days interval), S_2- 150:75:75 N,P_2O_5,K_2O through drip irrigation (10 splits at 10 days interval) and S_3- 100:50:50 N,P_2O_5,K_2O through drip irrigation (10 splits at 10 days interval) and Factor B for F_0- Water Spray, F_1- Two foliar spray of $ZnSO_4$ @ 0.5 % at the time of flower initiation and fruit set, F_2- Two foliar spray of $FeSO_4$ @ 0.5 % at the time of flower initiation and fruit set and F_3- Two foliar spray of $ZnSO_4$ @ 0.25 % + $FeSO_4$ @ 0.25 % at the time of flower initiation and fruit set as foliar spray .The Initial soil status of the experiment is pH 7.74, EC 0.23 dSm^{-1}, organic carbon 5.25 gm kg^{-1}, $CaCO_3$ (%) 4.95 , available nitrogen 247 kg ha^{-1}, phosphorus 13.6 kg ha^{-1}, potassium 364 kg ha^{-1} and sulphur 9.53 mg kg^{-1}, Zn 0.64 mg kg^{-1} , Cu 0.49 mg kg^{-1} , Fe 4.54 mg kg^{-1}, Mn 4.07 mg kg^{-1}. The soil samples were analysed for soil pH and EC [13] $CaCO_3$ [14], Organic carbon by Walkley and Black method [15], available N using modified kjeldhal method described by Subbiah and Asija [16], available P, [17] Available K Flame photometer [18], Available S turbidmetric method, [14] and micro nutrients DTPA [19]. In fertigation major nutrients *i.e*., N, P, and K were supplied through drip irrigation. Bottle gourd variety (Co-1) was sown at spacing 2.0 m X 0.60 m by the dibbling method. The seed was sown at the seed rate of 1.5 kg ha^{-1} in the 07th July 2020, 28th June 2021 and 30th June 2022. The picking of tender and marketable healthy fruits was done at an interval of 3 to 4 days. The numbers of pickings were twelve in (2020-21), Eighteen (2021-22) and Seventeen (2022-23) respectively.

3. RESULTS AND DISCUSSION

Effect of fertigation and foliar spray of nutrients on yield of bottle gourd are presented in Table 1.

3.1 Effect of fertigation

The data regarding yield of bottle gourd (Table 1) indicated that, the significantly highest fruit yield (25.20 t ha^{-1}) was recorded in S_1 (200:100:100 NPK) followed by S_2 (150:75:75 NPK) and lowest fruit yield (19.87 t ha^{-1}) was recorded in S_3 (100:50:50 NPK).

3.2 Effect of Foliar spray

The data regarding yield of bottle gourd indicated that, the significantly highest fruit yield (25.44 t ha^{-1}) was recorded in F_3 (foliar spray of $ZnSO_4$ @ 0.25% + $FeSO_4$ @ 0.25%) followed by F_1, (Two FS of $ZnSO_4$ @ 0.5 %) and F_2 (Two FS of $FeSO_4$ @ 0.5 %), F_1 and F_2 were at par with each other.

Similar results of yield were also observed by Leghari *et al,* [8] in bottle gourd, Sajjan and Prasad, [20], in pumpkin, Das et al., [21], Meenakshi and Vadivel [22] Arvind kumar et al., [23] Karthick et al., [24] in bitter gourd.

3.3 Interaction Effect

Interaction effect pertaining to yield of fruit was found significant (Table 1a). Yield was significantly affect by the interaction effect of fertigation and foliar spray of nutrients. Yield was significantly higher (29.05 t ha^{-1}) in treatment S_1F_3 where 200:100:100 N, P_2O_5 and K_2O was

Table 1. Effect of fertigation and foliar spray of micronutrients on yield of bottle gourd

Treatments	Yield (t ha^{-1})			
	2020-21	**2021-22**	**2022-23**	**Pooled Means**
Factor A				
S_1-200:100:100 N,P_2O_5,K_2O	25.82	21.94	28.31	25.20
S_2-150:75:75 N,P_2O_5,K_2O	23.17	19.71	25.63	22.84
S_3-100:50:50 N,P_2O_5,K_2O	20.04	17.13	22.56	19.87
SE(m)±	0.96	0.81	0.93	0.85
CDat5%	2.82	2.38	2.73	2.50
Factor B				
F_0 :Water Spray	20.66	17.53	23.08	20.37
F_1 :Two FS of $ZnSO_4$ @ 0.5 % at the time of flower initiation and fruit set	23.06	19.63	25.45	22.62
F_2 :Two FS of $FeSO_4$ @ 0.5 % at the time of flower initiation and fruit set	22.40	19.17	24.86	22.12
F_3 :Two FS of $ZnSO_4$ @ 0.25 % + $FeSO_4$ @ 0.25 % at the time of flower initiation and fruit set	25.92	22.05	28.62	25.44
SE(m)±	1.11	0.94	1.08	0.98
CDat5%	3.25	2.75	3.16	2.88
INTERACTION (S×F)	Sig.	Sig.	Sig.	Sig.

Table 1a. Interaction effect of fertigation and foliar spray of micronutrients on yield of bottle gourd

	Foliar Application				
Soil Application	**F_0 : FS Water Spray**	**F_1 :Two FS spray of $ZnSO_4$ @ 0.5 % at the time of flower initiation and fruit set**	**F_2 :Two FS spray of $FeSO_4$ @ 0.5 % at the time of flower initiation and fruit set**	**F_3 :Two FS of $ZnSO_4$ @ 0.25 % + $FeSO_4$ @ 0.25 % at the time of flower initiation and fruit set**	**Average**
Treatment	**Yield (t ha^{-1}) of bottle gourd (2020-21 to 2022-23)**				
$S_1$200:100:100 N,P_2O_5,K_2O	21.83	25.12	24.82	29.05	25.21
$S_2$150:75:75 N,P_2O_5,K_2O	19.91	22.94	21.80	26.69	22.84
$S_3$100:50:50 N,P_2O_5,K_2O	19.38	19.78	19.75	20.57	19.87
	20.37	22.61	22.12	25.44	22.64
'F' Test	SA	FA	Interaction (SxF)		
SE(m)±	0.85	0.98	1.70		
CD at 5%	2.50	2.88	4.99		
CV	13.0	13.0	13.0		

Table 2. Effect of fertigation and foliar spray of micronutrients on reducing sugar content in fruit of gourd

Treatments	Reducing sugar content (g /100 g)			
	2020-21	2021-22	2022-23	Pooled Means
Factor A				
S_1-200:100:100 N,P_2O_5,K_2O	4.83	5.06	4.65	4.85
S_2-150:75:75 N,P_2O_5,K_2O	4.59	4.82	4.41	4.61
S_3-100:50:50 N,P_2O_5,K_2O	4.37	4.60	4.19	4.39
SE(m)±	0.08	0.07	0.08	0.08
CD at 5%	0.24	0.20	0.24	0.24
Factor B				
F_0 :Water Spray	4.31	4.54	4.13	4.33
F_1 :Two FS of $ZnSO_4$ @ 0.5 % at the time of flower initiation and fruit set	4.57	4.80	4.39	4.59
F_2 :Two FS of $FeSO_4$ @ 0.5 % at the time of flower initiation and fruit set	4.48	4.71	4.30	4.50
F_3 :Two FS of $ZnSO_4$ @ 0.25 % + $FeSO_4$ @ 0.25 % at the time of flower initiation and fruit set **Table**	5.02	5.25	4.84	5.04
SE(m)±	0.09	0.08	0.09	0.09
CD at 5%	0.27	0.23	0.27	0.27
Interaction (S×F)	Sig.	Sig.	Sig.	Sig.

Table 3. Effect of fertigation and foliar spray of micronutrients on non- reducing sugar content in fruit of bottle gourd

Treatments	Nonreducing sugar content (g ha^{-1})			
	2020-21	2021-22	2022-23	Pooled Means
Factor A				
S_1-200:100:100 N,P_2O_5,K_2O	2.93	3.16	2.75	2.94
S_2-150:75:75 N,P_2O_5,K_2O	2.71	2.94	2.53	2.72
S_3-100:50:50 N,P_2O_5,K_2O	2.49	2.72	2.31	2.50
SE(m)±	0.08	0.09	0.08	0.08
CD at 5%	0.23	0.26	0.23	0.23
Factor B				
F_0 :Water Spray	2.44	2.67	2.26	2.46
F_1 :Two FS of $ZnSO_4$ @ 0.5 % at the time of flower initiation and fruit set	2.67	2.90	2.49	2.69
F_2 :Two FS of $FeSO_4$ @ 0.5 % at the time of flower initiation and fruit set	2.58	2.81	2.40	2.60
F_3 :Two FS of $ZnSO_4$ @ 0.25 % + $FeSO_4$ @ 0.25 % at the time of flower initiation and fruit set	3.13	3.36	2.95	3.15
SE(m)±	0.09	0.10	0.09	0.09
CD at 5%	0.26	0.29	0.26	0.26
Interaction (S×F)	Sig.	Sig.	Sig.	Sig.

Table 4. Effect of fertigation and foliar spray of micronutrients on ascorbic acid content in fruit of bottle gourd

Treatments	Ascorbic acid content (%)			
	2020-21	2021-22	2022-23	Pooled Means
Factor A				
S_1-200:100:100 N,P_2O_5,K_2O	9.29	9.64	9.20	9.38
S_2-150:75:75 N,P_2O_5,K_2O	8.63	8.98	8.54	8.71
S_3-100:50:50 N,P_2O_5,K_2O	8.44	8.79	8.35	8.53
SE(m)±	0.14	0.14	0.15	0.14
CD at 5%	0.41	0.41	0.43	0.41
Factor B				
F_0 :Water Spray	8.34	8.70	8.25	8.43
F_1 :Two FS of $ZnSO_4$ @ 0.5 % at the time of flower initiation and fruit set	8.69	9.04	8.60	8.78
F_2 :Two FS of $FeSO_4$ @ 0.5 % at the time of flower initiation and fruit set	8.66	8.99	8.57	8.74
F_3 :Two FS of $ZnSO_4$ @ 0.25 % + $FeSO_4$ @ 0.25 % at the time of flower initiation and fruit set	9.46	9.81	9.37	9.54
SE(m)±	0.16	0.16	0.17	0.18
CD at 5%	0.48	0.48	0.49	0.48
Interaction (S×F)	Sig.	Sig.	Sig.	Sig.

Table 5. Ecomonics of bottle gourd as influenced by effect of fertigation and foliar spray of micronutrients (pooled mean)

Treatments	Economics			
	COC (Rs ha^{-1})	GMR (Rs ha^{-1})	NMR (Rs ha^{-1})	B:C
Factor A				
S_1-200:100:100 N,P_2O_5,K_2O	193978	614588	420610	2.17
S_2-150:75:75 N,P_2O_5,K_2O	179490	553525	374035	2.08
S_3-100:50:50 N,P_2O_5,K_2O	165002	482603	317601	1.92
SE(m)±	-	21725	21725	-
CDat5%	-	63707	63707	-
Factor B				
F_0 :Water Spray	179406	494959	315553	1.76
F_1 :Two FS of $ZnSO_4$ @ 0.5 % at the time of flower initiation and fruit set	179580	550475	370895	2.06
F_2 :Two FS of $FeSO_4$ @ 0.5 %	179456	536765	357309	1.99
F_3 :Two FS of $ZnSO_4$ @ 0.25 % + $FeSO_4$ @ 0.25 %	179518	618754	439236	2.43
SE(m)±	-	25086	25086	-
CDat5%	-	73562	73562	-

Rate of bottle gourd: 2020-21 Rs. 1800/qtl, 2021-22, Rs. 2000/qtl, 2022-23 Rs. 2200/qtl

applied in 10 split doses through fertigation along with two foliar spray of $ZnSO_4$ @ 0.25 % + $FeSO_4$ @ 0.25 % at the time of flower initiation and fruit set which was followed by (26.69 t ha^{-1}) treatment S_2F_3 where 150:75:75 N, P_2O_5 and K_2O was applied in 10 split doses through fertigation along with two foliar spray of $ZnSO_4$ @ 0.25 % + $FeSO_4$ @ 0.25 % at the time of flower initiation and fruit set. Significantly lowest yield (19.38t ha^{-1})) under treatment S_3F_0 where 100:50:50 N, P_2O_5 and K_2O was applied in 10 split doses through fertigation along with two foliar spray of water at the time of flower initiation and fruit set .Similar results were also reported by Meenakshi and Vadivel [22] Arvind kumar et al., [23] and Karthick et al., [24] in bitter gourd.

Effect of fertigation and foliar spray of nutrients on quality characters of bottle gourd. Tables 2,3 and 4.

4. QUALITY OF BOTTLE GOURD – REDUCING SUGAR, NONREDUCING SUGAR AND ASCORBIC ACID

4.1 Effect of Fertigation

The data regarding reducing sugar, non-reducing sugar and ascorbic acid (Tables 2 to 4) indicated that statistically higher values i.e. 4.85 %, 2.94 % and 9.38 %, respectively were recorded in S_1 (200:100:100 NPK) followed at par with the treatment S_2The above results are in conformity with finding of Das et al, [11] in bottle gourd and Sumathi et al., [25] in cucumber.

4.2 Effect of Foliar Spray

The effect of foliar spray of micronutrients ($ZnSO_4$ and $FeSO_4$) on regarding reducing sugar, non -reducing sugar and ascorbic acid indicated that, the Significantly higher values were recorded in F_3 (foliar spray of $ZnSO_4$ @ 0.25% + $FeSO_4$ @ 0.25%) and lowest values are observed under F_0 where water spray was applied. The similar result was obtained in Karthick et al, [24] in bitter gourd.

4.3 Interaction Effect

Interaction effect all the quality parameters were found significant.

Effect of fertigation and foliar spray of nutrients on economics of bottle gourd Table 5.

4.4 Economics of Bottle Gourd

4.4.1 Effect of fertigation

The GMR and NMR of bottle gourd (Table 5) were recorded significantly highest in S_1 (200:100:100 kgha^{-1} NPK) followed by the treatment S_2 (150:75:75 kg ha^{-1} NPK). The highest B:C ratio i.e. (2.17) was recorded in S_1 where 200:100:100 kg ha^{-1} NPK was applied in Factor A.

4.4.2 Effect of foliar spray

Highest values of COC, GMR, NMR and B:C ratio i.e. Rs 1,79,518, Rs. 6,18,754, Rs. 4,39,236 and 2.43, respectively were recorded where two foliar spray of $ZnSO_4$ @ 0.25 % + $FeSO_4$ @ 0.25 % at the time of flower initiation and fruit set were applied in Factor B.Higher yield due to nutrient management was reported earlier earlier in pumpkin by karuthamani et al.[26] and in cucumber by Bindiya et al [27].

5. CONCLUSION

Considering the result of 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. Highest yield, good quality and B:C ratio (2.17) of bottle gourd was recorded under the combination of soil application with 200:100:100 kg NPK along with two foliar spray of $ZnSO_4$ @ 0.25% + $FeSO_4$ @ 0.25% at flower initiation and fruit setting and this treatment is statistically at par with the treatment with soil application of 150:75:75 kg NPK along with foliar application of $ZnSO_4$ @ 0.25% + $FeSO_4$ @ 0.25%.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Authors(s) here by declared that NO GENERATIVE AI TECHNOLOGIES Such as large language models (chatgpt, copilot, etc) and no text-to-image generators have been used during writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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