

Effect of foliar application of liquid nutrient solution on morpho-physiology, quality and yield performance of chilli (*Capsicum frutescens*) germplasm

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ABSTRACT

Aims: An experiment was conducted to study the influence of commercially available liquid fertilizers on local chilli germplasm.

Study design: The experiment was laid out in Randomized Complete Block Design with four replications.

Place and Duration of Study: The experiment was conducted in the crop field of the Department of Agricultural Botany, Sher-e-Bangla Agricultural University, Dhaka-1207, during the period from October 2015 to July 2016.

Methodology: The experiment consist of three levels of locally available common liquid fertilizers (F_0 = Control, F_1 = Calsol, F_2 = Wuxal) which is a blend of more than one macro and micronutrients. F_1 (Calsol) and F_2 (Wuxal) were applied @ 21 ml per 7 litre water for 168 m² of land at every 15 days interval. Foliar application was started from 30 days after setting up the experiment and continued up to 120 days.

Results: Maximum plant height (59.5 cm) and branches (33.0) plant⁻¹, leaf number (78.4) plant⁻¹ Chlorophyll content (57.1%), flowers plant⁻¹ (68.7), vitamin C content in green chilli fruits (75.28 mg/100g fruit) and dry chilli (39.47 mg/100g fruit), protein content (3.9%) were obtained from (Calsol) F_1 and minimum from (control) F_0 (57.0 cm), (23.8) and (67.2) plant⁻¹, (49.5%), (47.8), (58.80 mg/100 g), (29.77 mg/100 g) and (2.9%). Application of waxul gave the maximum leaf area plant⁻¹ (95.9 cm²) at 85 days after transplanting (DAT) which was identical with calsol (92.2 cm²) and the control gave the minimum (78.0 cm²). Liquid fertilizers application in leaves highest fresh weight of 50 fruit and dry weight of fruit (81.3 g and 15.7 g), single fruit weight (2.6 g), length (76.2 mm) and diameter (9.9 mm), fruit pant⁻¹ (214.8), 1000 seed weight (3.5 g), yield pant⁻¹ (466.7 g) and fresh yield (17.6 t ha⁻¹) were achieved from treatment F_1 (calsol) as minimum amount of 50 fresh fruit and dry fruit weight (64.9 g and 11.2 g), single fruit weight (1.9 g), length (60.8 mm), diameter (7.6 mm), number of fruit pant⁻¹ (139.1), 1000 seed weight (2.9 g), yield pant⁻¹ (229.4 g) and fresh yield (12.8 t ha⁻¹) were found from F_0 .

Conclusion: In view of overall performances, this study suggests that Calsol (F_1) as a potential source of plant liquid fertilizer for improving morphophysiology, yield and quality of local varietie of chilli.

Keywords: *Capsicum frutescens*, Foliar fertilizer, fruit quality, growth and yield.

1. INTRODUCTION

Chilli (*Capsicum frutescens*) is an important spice crop grown all over Bangladesh. It belongs to the genus *Capsicum* and family Solanaceae. It is an unavoidable spice, which is liked for its pungency, spicy taste and its appealing color adds to the curry. Green chillies are rich in vitamin A and C and the seed contain traces of starch [1, 2]. It is an indispensable spice, which is liked for pungency and spicy taste and the appealing color adds to the curry. Currently, chilli production in Bangladesh is very low compare to cultivable land and other chilli growing countries of the world. Low yield may be attributed to a number of reasons such as lack of screening of local cultivars and their improvement through fertilizer management. Foliar feeding means to apply liquid fertilizer directly to the leaves of the plant

[3]. Foliar fertilizers contain various macro and micro nutrients that are being used in vegetables. Which respond constructively to the application of small quantities of micro as well as macro-nutrients [4, 5]. The key functions of micronutrients are to favor the photosynthesis and the synthesis of chlorophyll in green plants. Foliar application of nutrients has become an important practice in the production of vegetables while application of fertilizer to the soil remains the basic method of feeding the majority of the vegetable and fruit plants. It has been found that a substantial percentage of the total requirements of certain plant nutrients can be fed by the foliar method. But very often it is found that a variety of unfavourable conditions in the soil make the nutrients unavailable to the plants. Sometimes these nutrients are lost from the soil through leaching and evaporation. Many studies have highlighted the advantages of foliar fertilization in improving plant growth, crop yield, nutrient uptake, product quality and environmentally safe. This technique can assure quick translocation of nutrients to various plant parts through leaf tissues under various nutrient deficiencies [6, 7, 8, 9]. It is well-established verity that macro or micro nutrients applied as foliar application become swiftly available to crop plants [5]. At present there are many liquid fertilizers available in Bangladesh. To mitigate overall plant nutrition problem in which Calsol and Wuxal are two commercially available common liquid fertilizers those provide complimentary mingle of both macro and micronutrients. Application of these fertilizers may foster proper formation of vegetative and originative organs of plants, processes of formation and accumulation of assimilates in the plants, resulting in high and stable yields of good quality.

2. MATERIAL AND METHODS

The experiment was conducted on chilli (*Capsicum frutescens*) germplasm at Sher-e-Bangla Agricultural University, Dhaka (23°74' N and 90°35' E), Bangladesh during October 2015 to July 2016. The soil of experimental area is situated to the Modhupur Tract under the Agro- Ecological Zone of (AEZ 28) and Tejgoan soil series. The soil was sandy loam in texture with pH 5.47- 5.63. The experiment was designed in randomized block design (RBD), with four replications. Chilli germplasm is more suitable for cultivation during the robi season in rainfed uplands. Also need well drained soils with adequate soil moisture for the growth of the crop. Commercially available common liquid solutions were collected from local market in Sher-e-Bangla Nagar, Dhaka-1207, Bangladesh. It is a blend of more than one macro and micro nutrients. Chemical composition of the commercially available common liquid fertilizers were, Calsol: N₂- 1.4%, K₂O-0.1%, Mg-0.71%, S-1.5%, Zn-0.12%, B-0.34%, Mo- 50 ppm, Mn-200 ppm with Ca and Fe. Wuxal: N₂-8.0%, P₂O₅-8.0%, K₂O-6.0%, S-0.9%, Zn-0.005%, B-0.01%, Cu-0.007%, Mn-0.013%, Mo-0.001%, Fe-0.015%, Cl-0.9%. F₁ (Calsol) and F₂ (Wuxal) were applied @ 21 ml per 7 litre water for 168 m² of land at every 15 days interval. Foliar application was started from 30 days after setting up the experiment and continued up to 120 days. A hand garden sprayer was used to spray foliar fertilizer solution. Foliar fertilizers were applied on leaves at evening; because of less sun light, low transpiration and evaporation rate, absorbing more nutrients over night by the plant and beneficial pollinating agents are absent or return to their hive and also save to them from their nutrients. Thirty days-old healthy seedlings were transplanted at the spacing of 40 cm × 40 cm in the experimental plots. Thus the 16 plants were accommodated in each unit plot. Planting was done in the afternoon. Intercultural activities and watering was done, if it was necessary. During mature green chilli turned yellow, it was harvested at weekly intervals. Harvesting was started at 65 days after transplanting (DAT) and continued till 175 DAT. Data randomly selected on different parameter, for example, plant height (cm), branches plant⁻¹, leaf plant⁻¹, days to flower bud initiation after transplanting, flowers plant⁻¹ (counting up to 60 days after first flowering), fruits plant⁻¹, single fruit fresh weight (g), fruit diameter (mm), fruit length (mm), 1000 seed weight (g), vitamin-C content in green chilli fruits (mg per 100 g fruit), vitamin-C content in dry chilli fruits (mg per 100 g fruit), protein contain in chilli fruits (% per 100 g fruit), yield plant⁻¹ (g) and fresh fruit yield (t ha⁻¹). Growth parameters, viz., Plant height (cm), number of branch Plant⁻¹, number of leaf plant⁻¹, were recorded at 45 to 85 DAT at 10 days interval. Mature leaf from middle portion of the plant (above 20cm from ground level) was used for leaf area by destructing method using CL-202 Leaf Area Meter (USA). Leaf chlorophyll content was measured by using chlorophyll meter SPAD-502. Fruit length and diameter were measured using Digital Caliper-515 (DC-515) in millimeter (mm). Fresh weight and dry weight of 50-fruits were measured by Electric Precision Balance in gram (g). Fifty randomly selected fresh fruits from each treatment were weighed and dry in room temperature. Then fifty dry fruits were weighed. 2, 6 - dichlorophenol indophenols (visual titration method) determined vitamin C content of green and dry fruits of chilli [10]. Micro Kjeldahl method was determined protein content of five local chilli germplasms. All parameters were statistically analyzed by using MSTAT-C program. Mean for all

85 cultivars was calculated and difference between cultivars was evaluated by Least Significant
 86 Difference (LSD) at 5% level of significance [11].

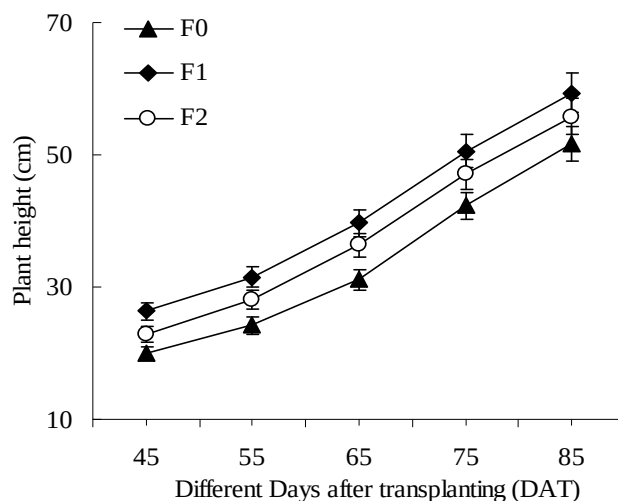
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88 3. RESULTS AND DISCUSSION

89

90 3.1 Plant height

91 Maximum plant height was counted in calsol (F_1 ; 59.5 cm) treated plants where as minimum in control
 92 (F_0 ; 57.0 cm) that is statistically similar with F_2 at mature stage (Figure 1). Plants which were fertilized
 93 with macro and micro-nutrient solutions increased their height as compared to control treatment [12].
 94 Increase in plant height with boost up in nutritional level of macro nutrients i.e. NPK up to certain level
 95 and lowering the levels of macro nutrients taking more time and give less production [13]. The effect of
 96 foliar application of micronutrients along with the recommended dose of fertilizer [14]. They reported
 97 that the combined spraying of Zinc, Boron and Iron each @ 0.1 per cent along with recommended
 98 dose of NPK @ 150:50:50 resulted in maximum height of the plant (70.36 cm).



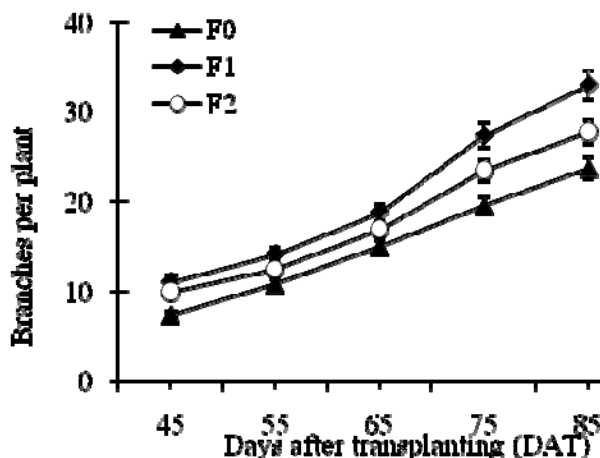
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100 **Fig. 1:** Effect of foliar nutrient on plant height at different days after transplanting (F_0 , Control ; F_1 ,
 101 Calsol ; F_2 , Wuxal).

102

103 3.2 Branches plant¹

104 Number of branches of chilli germplasms exposed statistically significant inequality among control,
 105 calsol and waxul at 45, 55, 65, 75 and 85 DAT. Maximum number of branches was counted in Calsol
 106 (F_1 ; 33.0) treated plants where as minimum in Control (F_0 ; 23.8) at mature stage (Fig. 2). This is an
 107 agreement with the report of gladiolus [15]. Combined spraying of zinc, boron and iron each @ 0.1
 108 per cent along with recommended dose of NPK @150:50:50 caused maximum number of branches
 109 per plant [14].



110

Fig. 2: Effect of foliar nutrient on branch per plant at different days after transplanting (F₀ , Control ; F₁ , Calsol ; F₂ , Wuxal).

3.3 Leaf plant⁻¹

Improvement in growth characters such leaf number as by the application of nutrients may exist due to enhanced photosynthetic and other metabolic activity which leads to an increase in various plant metabolites responsible for cell division and elongation [14]. Leaves number of chilli germplasm exposed statistically significant inequality among control, calsol and wuxal at 45, 55, 65, 75 and 85 DAT. Maximum leaf number was counted in F₂ (Calsol ; 78.4) treated plants where as minimum in F₀ (control ; 67.2) at mature stage (Fig. 3). Similar observation [16] and also reported that application of macro and micro nutrients solution increased the number of leaves per branch compared to control [12]. Increased number of leaves due to the foliar application of zinc (zn) and boron (B) [17].

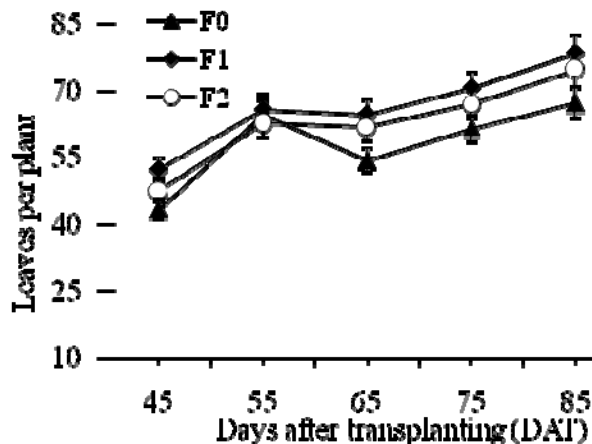


Fig. 3: Effect of foliar nutrient on leaves per plant at different days after transplanting (F₀ , Control; F₁ , Calsol; F₂ , Wuxal).

3.4 Chlorophyll content (SPAD values) at mature stage

Chlorophyll content was showed the significant variation by different foliar fertilizer viz. F₀ , control; F₁ , calsol; F₂ , wuxal at 85 days transplanting. Highest chlorophyll percentage (57.1%) was obtained from F₂ and lowest (49.5%) was reported from F₀ (Table 1). Citrus treated with zinc, iron and boron provide significant improvement in chlorophyll content [18]. Combined application of micronutrient increase chlorophyll content in tomato leaf [19].

3.5 Leaf area (cm²)

Leaf area represents the foliage of plants that give excellent results after foliar spraying of macro and micro nutrients .The food prepares by leaves and maximum leaf area provides more food to body of the plant to keep it healthy. Leaf area was significantly affected by foliar fertilizer treatment directly to the leaf. Leaf area of chilli germplasms exposed statistically significant inequality among control, calsol and wuxal at 85 DAT (Table 1). Maximum leaf area (95.9 cm²) was marked in F₂ (Wuxal) treatment which was statistical similar with treatment F₁ (Calsol) (92.2 cm²). Minimum leaf area (77.99 cm²) was marked in F₀ (Control) treatment (Table 4).Maximum leaf area from macro and micro nutrients treatment and minimum from control treatment [13]. Leaf area was increased due to foliar application of nutrient solution (Wuxal) [20]. It composed of the essential macro and micro nutrients for the plants and thus may be responsible for improvement of these characteristics. Positive effect of foliar application of zinc and boron on leaf area to tomato plant [21].

3.6 Days to first flower bud initiation after transplanting

Days to flower bud initiation was significantly affected by foliar fertilizer application. Flower bud initiation was the earliest in control (F₀) (46.45 days) treated variety and delayed in calsol (F₁) (52.95 days) (Table 1). Appropriate time for flower bud initiation is important to plant because in this time maximum photosynthetic translocation occurs in vegetative part development. The fertilization level of micro nutrients improves the growth and productivity of plants. Carnation has greater response to foliar application of nutrients [22].

3.7 Flowers plant⁻¹ (Counting up to 60 days after first flowering)

Calsol treated plants produced maximum number of flowers (F₁) (68.7 plant⁻¹) while minimum in control (F₀) (47.80 plant⁻¹) (Table 1). Maximum flowering plant⁻¹ was found by providing micro-nutrients. Nutrient application compared with the control plants provided 14% greater numbers of flowers [23, 24]. Foliar application of balance nutrition (Zn 6%), (B 5%), (N 2%) enhanced number of flower in tomato plant [25]. Number of flowers in tomato plant was increased by combined application of micronutrient [19].

Table 1. Effect of liquid fertilizers on the growth related attributes of chilli ^Y

Treatments ^x	Chlorophyll percentage (%) at mature stage	leaf area (cm ²) At 85 dat	Days to flower bud initiation after transplanting	Number of flower plant ⁻¹
F ₀	49.5 c	78.0 b	49.5 c	47.8 c
F ₁	57.1 a	92.2 a	57.1 a	68.7 a
F ₂	53.9 b	95.9 a	53.9 b	57.2 b
CV (%)	5.3	11.8	6.7	7.5
LSD (0.05)	1.8	6.7	2.1	2.8

^x F₀, Control ; F₁, Calsol ; F₂, Waxul.

^y In a column means having similar letter (s) are statistically identical and those having dissimilar letter (s) differ significantly as per 0.05 level of probability.

3.8 Vitamin C content in green fruit (mg/100g)

Vitamin C content of the green fruits ranged from 75.3 mg/100 g fruit to 58.8 mg/100 g fruit. The maximum vitamin C was found in F₁ (calsol) treatment. The minimum vitamin C content (58.8 mg/100 g fruit) was obtained from F₀ (control) treatment (Table 2). Vitamin C content was enhanced by combined efficacy of macro-nutrients and micro-nutrients as foliar application in tomato [25]. Application of zinc and boron on tomato increase vitamin C content, it was (32.6 mg / 100 g fruit) [26]. It is reported that application of micronutrients like Zn, Cu, Fe and Mo are essential for increase in ascorbic acid content in tomato fruits [27].

3.9 Vitamin C content in dry fruit (mg/100g)

Vitamin C content of the dry fruits ranged from (39.5 to 29.8 mg/100 g).The Maximum vitamin C content (39.5 mg/100 g fruit) was found in F₁ treatment, while the minimum (29.8 mg/100 g fruit) was found in F₀ treatment (Table 2).

3.10 Percentage of protein in green fruit

The result revealed that treatment F₀ (Calsol) scored the highest protein contents (3.9%) in chilli fruits where as the lowest one (2.9%) was received from control (Table 2). Zinc is essential micronutrients for protein production in plants. Zinc is the main composition of ribosome and is essential for their development. Positive effects of these treatments (NPK, foliar nutrition and their interactions) may be due to the important physiological role of N. N plays an important role in synthesis of the plant constituents through the action of different enzymes activity and protein synthesis [28]. This foliar treatment increased protein content in *Nigella sativa* L.

3.11 Weight of 50 Fresh fruit

Maximum fresh weight of 50 chilli fruit was found in F₁ (Calsol; 81.3 g) treatment whereas lowest in F₀ (Control; 64.6 g) (Table 3).Significant fruit weight of chillies by applying foliar fertilizer "Polyfeed" [29].

3.12 weight of 50 dry fruits

Highest dry weight of chilli was found in foliar treatment by F₀ (Calsol; 15.70 g) whereas, lowest in F₀ (Control; 11.24 g) (Table 3). Among the micro nutrients, only application of boron and mixture of micronutrients enhanced the fruit weight while other micro-nutrients did not show any positive effect. The increase in fruit weight of okra fruits might be due to better mineral utilization of plants accompanied with enhancement of photosynthesis, other metabolic activity and greater diversion of

food material to fruits. Fruit size and weight was increased by application of micronutrients [30]. Similar result was also found in okra [31].

Table 2. Effect of liquid fertilizers on fruits quality related attributes of chilli germplasm

Treatments ^x	Vitamin c content in green fruit (mg/100g)	Vitamin c content in dry fruit (mg/100g)	Percentage % of protein in green fruit (100g)
F ₀	58.8 c	29.8 c	2.9 c
F ₁	75.3 a	39.5 a	3.9 a
F ₂	66.3 b	36.4 b	3.6 b
CV (%)	0.7	0.9	0.1
LSD (0.05)	1.7	4.0	4.1

^x F₀, Control ; F₁, Calsol ; F₂, Waxul.

^y In a column means having similar letter (s) are statistically identical and those having dissimilar letter (s) differ significantly as per 0.05 level of probability.

3.13 Fruit diameter

Fruit diameter of the mature fruits ranged from 9.9 mm to 7.6 mm. The maximum fruit diameter (9.9 mm) was found in calsol (F₁) treatment. The minimum fruit diameter (7.6 mm) was obtained from control (F₀) treatment (Table 3). Fruit diameter was increased by foliar application of (nitrogen 5.5 g/100 mL + Boron 5 g/100 mL + Zinc 5 g/100 mL) combined fertilizer in tomato plant [32]. Effect of foliar application of zinc and molybdenum through foliar spray increased fruit diameter [6]. Foliar application of Zn + Cu + Fe + Mn + B micro nutrient enhance fruit diameter of peach [33].

3.14 Fruit length

Highest fruit length was found in F₁ (Calsol; 76.18 mm) treatment and the shortest in F₀ (Control; 60.81 mm) treatment (Table 3). A foliar fertilizer "Fetrilon-Combi" was applied in chillies and found considerable improvement in fruit development and crop yield as compared to those supplied only with straight chemical fertilizers [4]. Fruit length was increased by foliar spray of micronutrients at flowering stage [34]. Length of fruit was significantly increased by zinc and boron [35]. application by improving cell size or cell number [36].

3.15 Single fruit fresh weight

Maximum single fruit weight (2.6 gm) was found from F₁ (calsol); which was statistically similar with F₂ (Wuxal; 2.5 gm). On the other hand minimum (1.9 gm) was found in F₀ (Control) (Table 3). Zinc and boron improves fruit growth by synthesizing tryptophan and auxin [35]. Boron plays key role on accumulation of photosynthates that has correlation with fruit weight [37].

Table 3. Effect of liquid fertilizers on fruits related attributes of chilli^y

Treatments ^x	Weight of 50 fresh fruit (g)	Weight of 50 dry fruit (g)	Fruit diameter (mm)	Fruit length (mm)	Single fruit fresh weight (gm)
F ₀	64.6 c	11.2 c	7.6 c	60.8 c	1.9 b
F ₁	81.3 a	15.7 a	9.9 a	76.2 a	2.6 a
F ₂	73.8 b	13.7 b	8.9 b	72.7 b	2.5 a
LSD (0.05)	1.6	0.7	0.4	2.5	0.1
CV (%)	3.5	8.1	7.26	5.7	9.6

^x F₀, Control ; F₁, Calsol ; F₂, Waxul

^y In a column means having similar letter (s) are statistically identical and those having dissimilar letter (s) differ significantly as per 0.05 level of probability.

3.16 Fruits plant⁻¹

Foliar spray of calsol treatment produced significantly highest number of fruit plant⁻¹ (214.8). Significantly lowest number of fruit plant⁻¹ (139.1) achieved by the control treatment (Table 4). Chilli seedlings with micronutrients fertilizer "Polyfeed" and reported significant effect on fruit number and

fruit weight of chilies [38]. Foliar application of zinc 3.0 ppm, copper 1.0 ppm and boron 0.5 ppm produced the highest number of fruits per plant with increased fruit weight and more total yield per plant [39]. [6, 40] were also similar with the results. Foliar application of balanced nutrition Zn (6%), B (5%), N (2%) increased number of fruit in tomato plant [25].

3.17 1000 seed weight

Calsol gave the highest 1000 seed weight (3.5 g) followed by Waxul. The lowest 1000 seed weight (2.9 g) was found from control treatment (Table 4). The maximum effect was observed in 100 seed weight by application of micronutrients mixture [41].

3.18 Yield plant⁻¹

Yield of the fruits plant⁻¹ ranged from 466.7 to 229.4 g. The highest yield (466.7 g plant⁻¹) was found in F₁ (Calsol) and the lowest (229.4 gm plant⁻¹) was recorded in F₀ (Control) (Table 4). Application of micronutrients like Zn, Cu, Fe and Mo are essential for increasing in yield and quality of tomato fruits [27].

3.19 Fresh fruit yield

Application of foliar fertilizers significantly influenced fresh fruit yield per hectare in foliar macro and micro nutrient spray. The highest fresh fruit yield was obtained from F₁ (Calsol) treatment (17.6 t ha⁻¹) and the lowest yield (12.8 t ha⁻¹) from F₀ (Control) treatment (Table 4). Growth and yield performances of tomato fruit were influenced through macro and micro nutrient supplementation practices [42].

Table 4. Effect of liquid fertilizers related to fruits yield ^Y

Treatments ^x	Fruits plant ⁻¹	1000 seed weight (g)	Yield plant ⁻¹ (g)	Fresh fruit yield (t ha ⁻¹)
F ₀	139.1 c	2.9 c	229.4 c	12.8 c
F ₁	214.8 a	3.5 a	466.7 a	17.6 a
F ₂	179.6 b	3.4 b	400.7 b	16.5 b
CV (%)	4.2	6.8	11.9	6.3
LSD (0.05)	4.8	0.2	27.7	0.6

4. CONCLUSION

Based on the results of the present study, the conclusion may be drawn as the growth parameter viz plant height, number of branches plant⁻¹, number of leaf plant⁻¹, number of flower plant⁻¹ were found maximum from the foliar fertilizer, Calsol. This liquid fertilizer also performed best in respect of fruit characters as well as yield attributes namely, single fruit fresh weight, fruit diameter, fruit length, fruits plant⁻¹, 1000 seed weight and vitamin C content.

CONSENT (WHERE EVER APPLICABLE)

All authors declare that 'written informed consent was obtained from the patient (or other approved parties) for publication of this case report and accompanying images. A copy of the written consent is available for review by the Editorial office/Chief Editor/Editorial Board members of this journal.

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