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Lakkam Yashwanth Reddy
PG Scholar, Department of Vegetable Science, College of Horticulture, Rajendranagar, Sri Konda Laxman Telangana State Horticultural University, Mulugu, Telangana, India

J Cheena
Associate Dean, College of Horticulture, SKLTSHU, Rajendranagar, Hyderabad, Telangana, India

A Nirmala
Assistant Professor, Department of Horticulture, College of Agriculture, PJTSAU, Rajendranagar, Hyderabad, Telangana, India

A Mamatha
Assistant Professor, Department of Vegetable Science, College of Horticulture, SKLTSHU, Rajendranagar, Hyderabad, Telangana, India

S Praneeth Kumar
Scientist (Crop Physiology), Floricultural Research Station, Rajendranagar, Hyderabad, Telangana, India

Corresponding Author:
Lakkam Yashwanth Reddy
PG Scholar, Department of Vegetable Science, College of Horticulture, Rajendranagar, Sri Konda Laxman Telangana State Horticultural University, Mulugu, Telangana, India

Effect of plant growth regulators on growth, yield and quality parameters in tomato (*Solanum lycopersicum* L.) hybrids under Southern Telangana zone

Lakkam Yashwanth Reddy, J Cheena, A Nirmala, A Mamatha and S Praneeth Kumar

Abstract
A field experiment was carried out at PG Research Block, College of Horticulture, Sri Konda Laxman Telangana State Horticultural University, Rajendranagar, Hyderabad, to assess the "Effect of Plant Growth Regulators on Growth, Yield and Quality parameters in Tomato (*Solanum lycopersicum* L.) Hybrids under Southern Telangana Zone'' during *Rabi* season 2022-23. The experiment was laid out in Factorial Randomized Block Design (FRBD) with fourteen treatments and three replications with two factors *viz*., factor one consists of two treatments A_1 – Arka Rakshak, A_2 – Arka Samrat and factor two includes seven treatments B_1 – GA_3 @ 20 ppm, B_2 – GA_3 @ 30 ppm, B_3 – NAA @ 20 ppm, B_4 – NAA @ 30 ppm, B_5 – 2,4-D @ 5 ppm, B_6 – 2,4-D 10 ppm, B_7 – Control. Significant difference was observed for all the parameters under study. Results revealed that highest Ascorbic acid (19.34 mg/100 g), T.S.S. (4.38 ^{0}brix) and Lycopene (5.27 mg/100 g) was recorded in the treatment combination of T_2 - A_1B_2 - Arka Rakshak + GA_3 @ 30 ppm. While the lowest Ascorbic acid (14.82 mg/100 g), T.S.S. (3.03 ^{0}brix) and Lycopene (3.66 mg/100 g) was recorded in the treatment combination of T_{14} - A_2B_7 – Arka Samrat @ control (3.66 mg/100 gm) compared with all other treatments.

Keywords: Ascorbic acid, growth regulator, lycopene, tomato, gibberellins

Introduction
India is the world's second-largest producer of vegetables after China. This is due to the country's varied agro climatic conditions, which make certain regions of the country ideal for the cultivation of a wide range of vegetable crops, from extreme tropical to temperate vegetables. These vegetables are essential for a balanced diet because they are the richest sources of carbohydrates, proteins, and vitamins.

Among the vegetables tomato is the important fruit vegetable grown throughout the world and it occupies 4th position in area and 2nd position in production in India. Tomato (*Solanum lycopersicum* L.) is one of the most popular and important vegetable crop of *Solanaceae* family having a chromosome number 2n=24. The crop is native to Central and South America (Vavilov, 1951) [9]. Tomato was introduced to India by the Portuguese. Because of its many benefits and high economic importance, tomatoes are also known as "Poor man's Orange" and "Love of Apple" and are universally regarded as protected foods. It is consumed in many different ways, including raw in salads and sandwiches, cooked or processed in ketchup, pickles, puree, sauces, or dried powder, etc. Lycopene, a strong antioxidant found in tomato, it plays a significant role in the prevention of cancer. (Agarwal and Rao, 2000) [1].

Tomato is regarded as nutritional vegetable crop and good source of Vitamin A (1000 IU), Vitamin C (22 mg), minerals like Potassium, Iron, Calcium, Organic acids (Maleic and Citric acid) and it is also serves as cheapest source to meet daily nutritional requirements (Saleem *et al*, 2013 [7]; Gupta *et al*, 2019) [2]. Ripe tomato fruit contains 94.1% of water, 1.0 g of calcium, 7.0 mg of magnesium, 0.09 mg of thiamine, 0.03mg of riboflavin and 0.8 mg of niacin. It is also considered as a very good source of income for marginal and small-scale farmers as it contributes to the nutrition of the consumer (Singh *et al*., 2010) [8].

The growth regulators available are often inadequate in the plants. The specific quantities in the plants are directly responsible for the promotion, inhibition or otherwise modification in the physiological processes. It is obvious that the growth is directly related to the yield, the growth regulator NAA (Naphthalene acetic acid) & 2, 4-D (2, 4-dichlorophenoxy acetic acid) belongs to the Auxin group and GA_3 (Gibberellic acid) belong to the gibberellins may be used

to enhance the Growth, yield and quality of tomato. Hence, the present investigation was aimed to study the suitable plant growth regulator and its optimum concentration for improving the yield and quality of the tomato under Southern Telangana Zone.

Materials and Methods

The present investigation was conducted at PG Research Block, College of Horticulture, Sri Konda Laxman Telangana State Horticultural University, Rajendranagar, Hyderabad, during *Rabi* season for the year 2022-23. The experiment was laid out in Factorial Randomized Block Design (FRBD) with fourteen treatments and three replications with two factors *viz*., factor one consists of two treatments A_1 – Arka Rakshak, A_2 – Arka Samrat and factor two includes seven treatments B_1 – GA_3 @ 20 ppm, B_2 – GA_3 @ 30 ppm, B_3 – NAA @ 20 ppm, B_4 – NAA @ 30 ppm, B_5 – 2,4-D @ 5 ppm, B_6 – 2,4-D 10 ppm, B_7 – Control (Table 1.). The standard recommended package of practices of SKLTSHU was followed to raise the successful crop. Periodical observation was recorded for TSS, Ascorbic Acid content and Lycopene content. The data for these parameters were significantly analyzed in ANOVA are presented in Table 2. The standard procedures for estimation of the quality parameters are as followed.

Table 1: Different Treatment combinations

Sl. No.	Number of Treatments	Treatment combinations	
1	T_1	A_1B_1	Arka Rakshak @ GA_3 20 ppm
2	T_2	A_1B_2	Arka Rakshak @ GA_3 30 ppm
3	T_3	A_1B_3	Arka Rakshak @ NAA 20 ppm
4	T_4	A_1B_4	Arka Rakshak @ NAA 30 ppm
5	T_5	A_1B_5	Arka Rakshak @ 2,4-D 5ppm
6	T_6	A_1B_6	Arka Rakshak @ 2,4-D 10 ppm
7	T_7	A_1B_7	Arka Rakshak @ Control
8	T_8	A_2B_1	Arka Samrat @ GA_3 20 ppm
9	T_9	A_2B_2	Arka Samrat @ GA_3 30 ppm
10	T_{10}	A_2B_3	Arka Samrat @ NAA 20 ppm
11	T_{11}	A_2B_4	Arka Samrat @ NAA 30 ppm
12	T_{12}	A_2B_5	Arka Samrat @ 2,4-D 5ppm
13	T_{13}	A_2B_6	Arka Samrat @ 2,4-D 10 ppm
14	T_{14}	A_2B_7	Arka Samrat @ Control

I. Total soluble solids

A hand refractometer was used for direct determination of total soluble solids TSS (˚Brix) from fresh juice of fully ripened fruits. Mean of at least 5 samples, read directly from a Brix scale superimposed over the refractive index scale.

II. Ascorbic acid content (mg /100 g fresh weight)

Reagents

1. **Metaphosphoric acid (HPO_3) 3%:** Prepared by dissolving the sticks or pellets of HPO_3 in glass distilled water.
2. **Ascorbic acid standard:** 100 mg of L-ascorbic acid was dissolved in 3% HPO_3 and volume made up to 100 ml. Dilute 10 ml with 3% HPO_3 (1 ml = 0.1 mg of ascorbic acid).
3. **Dye solution:** 50 mg of the sodium salt of 2, 6-dichlorophenol-indophenol was dissolved in approximately 150 ml hot glass distilled water containing 42 mg of sodium bicarbonate. Cooled and diluted with distilled water to 200 ml stored in a refrigerator and every day standardization was done.

Standardization of dye

To a standard ascorbic acid solution of 5 ml, 5 ml of HPO_3 was added. Microburrete was filled with the dye. Titrated with dye solution to a pink colour which persisted for 15 sec. dye factor was determined i. e. mg of ascorbic acid per ml of dye, using the formula given by Ranganna (1986) [11].

$$\text{Dye factor} = \frac{0.5}{\text{Titre value}}$$

0.5 = 0.5 mg of ascorbic acid in 5 ml of 100 ppm standard ascorbic acid solution

Titre = Volume of dye used to neutralize 5ml of 100 ppm standard ascorbic acid solution along with 5ml of metaphosphoric acid.

Preparation of sample

Ten grams of grounded fruit sample was blended with 3% metaphosphoric acid (HPO_3) and volume made up to 100 ml with 3% HPO_3. The contents after shaking well were filtered through Whatman No. 1 filter paper

Assay of extract

Ten grams of fruit pulp was grounded and blended with 3 per cent metaphosphoric acid (HPO_3) and volume made up to 100 ml with 3 per cent HPO_3. The contents after shaking well were filtered through Whatman No.1 filter paper. Ten ml of the filtrate was titrated against 2, 6- Dichlorophenol-Indophenol dye until the light pink color persisted for at least 15 seconds.

Calculation

The ascorbic acid content was estimated using the given formula and expressed as mg 100 g-1 (Ranganna, 1986) [11].

$$\text{Ascorbic acid (mg/100 g)} = \frac{\text{Titre value x Dye factor x Volume made up}}{\text{Aliquot of extra taken for estimation x Volume of sample for estimation}} \times 100$$

Titre value = Volume of dye used to titrate the aliquot of extract of a given sample

III. Lycopene content (mg/100 g)

Reagents: Acetone, Petroleum ether and anhydrous sodium sulphate.

Procedure

Five to ten g of sample was taken and crushed repeatedly in acetone in pestle and mortar until the residue is colorless. Transferred the acetone extracts to a separatory funnel containing 10 to 15 ml of petroleum ether. Mixed gently to take up the pigments into the petroleum ether phase. Transferred the lower (acetone) phase to a 100 ml volumetric flask and extract it repeatedly with petroleum ether until colorless. Combined the petroleum ether extracts and dry over a small quantity of anhydrous sodium sulphate. Made up to 100 ml with petroleum ether and measure the O.D. of the solution at 503 nm using petroleum ether as blank.

$$\text{Lycopene (mg/100 gm)} = \frac{3.126 \times \text{OD of sample} \times \text{Vol. of made up} \times \text{dilution}}{1\times \text{weight of sample} \times 1000} \times 100$$

Results and Discussion: The present investigation on "Effect of Plant Growth Regulators on Growth, Yield and Quality parameters in Tomato (*Solanum lycopersicum* L.) Hybrids under Southern Telangana Zone'' during *Rabi* season 2022-23 are discussed and presented below (Table 2.).

Total soluble solids (^{0}brix)

The data presented on total soluble solid (^{0}Brix) of tomato as influenced by different plant growth regulators are presented in Table 2. The findings indicated that total soluble solid (Brix^0) was significantly affected by different treatments. Between the hybrids A_1 - Arka Rakshak (3.94 ^{0}brix) shows highest total soluble solids content followed by A_2 - Arka Samrat (3.73 ^{0}brix). Among the plant growth regulators B_2 - GA_3 @ 30 ppm (4.30 ^{0}brix) concentration was recorded highest total soluble solids followed by B_1 – GA_3 @ 20 ppm (4.16 ^{0}brix), B_3 – NAA @ 30 ppm (4.10 ^{0}brix), whereas lowest TSS was recorded in the treatment B_7 - Control (3.08 ^{0}brix).

Significance interaction effect was observed between hybrids and different levels of plant growth regulators on T.S.S. Among the combinations the highest content of total soluble solids was recorded in T_2 - A_1B_2 - Arka Rakshak + GA_3 @ 30 ppm (4.38 ^{0}brix) followed by T_9 - A_2B_2 - Arka Samrat + GA_3 @ 30 ppm (4.23 ^{0}brix), T_1 - A_1B_1 – Arka Rakshak + GA_3 @ 20 ppm (4.21^{0}brix), T_4 - A_1B_4 – Arka Rakshak + NAA @ 30 ppm (4.17 ^{0}brix) . It was minimum in the treatment combination of T_{14} - A_2B_7 Arka Samrat @ control (3.03 ^{0}brix). The increase in TSS content of fruits may be attributed to growth promoting substances which could have accelerated synthesis of carbohydrates, vitamins and other quality characters. Similar results were reported by Kumar *et al.* (2014) [3] and Ram *et al.* (2014) [6].

Ascorbic acid content (mg/100 g fresh weight)

Ascorbic acid content (Vitamin C) is one of the major quality component in tomato as it improves the nutritional value of fruit. Between the hybrids A_1 - Arka Rakshak (17.79 mg/100 g) recorded higher ascorbic acid content which is followed by A_2 - Arka Samrat (16.83 mg/100 g). Among the application of growth regulators B_2 - GA_3 @ 30 ppm (18.89 mg/100 g) produced maximum ascorbic acid content and this was significantly at par with the B_1 - GA_3 @ 20 ppm (18.65 mg/100 g) and B_4 - NAA @ 30 ppm (18.28 mg/100 g), B_3 – NAA @ 20 ppm (17.97 mg/100 g). The minimum ascorbic acid content was recorded from the treatment B_7 - Control (15.35 mg/100 g).

Interaction was shown significant effect on hybrids and plant growth regulators. The combination of T_2 - A_1B_2 - Arka Rakshak + GA_3 @ 30 ppm (19.34 mg/100 g) was recorded highest ascorbic acid content, which was significantly on par with T_1 - A_1B_1 - Arka Rakshak + GA_3 @ 20 ppm (19.29 mg/100 g) followed by T_3 - A_1V_3 – Arka Rakshak + NAA @ 30 ppm (18.56 mg/100 g), T_9 - A_2V_2 – Arka Samrat + GA_3 @ 30 ppm (18.45 mg/100 g). Minimum ascorbic acid content was recorded in the treatment combination of T_{14} - A_2B_7 - Arka Samrat @ control (14.82 mg/100 g).The increase in ascorbic acid with GA_3 treatment may be brought on by gibberellins promoting the activity of acid invertase, which results in an increase in hexose levels in plant tissue, or it may be the result of protecting synthesized ascorbic acid from oxidation through the enzyme ascorbic acid oxidizes. The results are similar with the findings of Verma *et al.* (2014) [10] and Mistry *et al.* (2020) [5] in tomato.

Lycopene (mg/100 g)

The deep red-colour of tomato is associated with high levels of lycopene, while high β-carotene content accounts for the orange colour. Between the hybrids A_1 - Arka Rakshak (4.81 mg/100 g) recorded highest lycopene content followed by A_2 - Arka Samrat (4.67 mg/100 g). Among the plant growth regulators lycopene concentration of tomato fruits for different treatments varied from 3.99 mg to 5.23 mg/100 g of fresh weight. Among the plant growth regulators highest average lycopene content was observed in B_2 - GA_3 @ 30 ppm (5.23 mg/100 g) which significantly at par with B_1 - GA_3 @ 20 ppm (5.09 mg/100 g) followed by B_4 - NAA @ 30 ppm (4.97 mg/100 g), B_3 - NAA @ 20 ppm (4.83 mg/100 g), while the lowest lycopene content was reported in B_7 - Control (3.99 mg/100 g).

Significance interaction effect was observed between hybrids and different levels of plant growth regulators on lycopene content. Highest lycopene content was recorded in T_2 - A_1B_2 - Arka Rakshak + GA_3 @ 30 ppm (5.27 mg/100 g) followed by T_9 - A_2B_2 – Arka Samrat + GA_3 @ 30 PPM (5.20 mg), T_1 - A_1B_1 – Arka Rakshak + GA_3 @ 20 ppm (5.12 mg/100 g). The lowest lycopene was recorded in the treatment combination of T_{14} - A_2B_7 – Arka Samrat @ control (3.66 mg/100 gm). This might be due to that GA_3 application increased phosphorous accumulation in leaves and stems of tomato plants that was also responsible for required lycopene content in the fruit. Similar findings have also been reported by Masroor *et al.* (2006) [4].

Table 2: Effect of plant growth regulators on quality parameters in tomato hybrids.

Growth Regulators (B)	Total soluble solids (^{0}brix)			Ascorbic acid (mg/100 g fresh weight)			Lycopene (mg/100 g)		
	Hybrids (A)			Hybrids (A)			Hybrids (A)		
	A_1	A_2	MEAN B	A_1	A_2	MEAN B	A_1	A_2	MEAN B
B_1	4.21	4.12	4.16	19.29	18.02	18.65	5.12	5.06	5.09
B_2	4.38	4.23	4.30	19.34	18.45	18.89	5.27	5.20	5.23
B_3	4.05	3.97	4.01	18.01	17.93	17.97	4.83	4.84	4.83
B_4	4.17	4.04	4.10	18.56	17.99	18.28	4.98	4.97	4.97
B_5	3.80	3.40	3.60	16.95	14.39	15.67	4.56	4.42	4.49
B_6	3.86	3.36	3.61	16.54	16.19	16.36	4.59	4.57	4.58
B_7	3.12	3.03	3.08	15.88	14.82	15.35	4.33	3.66	3.99
MEAN A	3.94	3.73		17.79	16.83		4.81	4.67	
	SEm±	CD @ 5%		SEm±	CD @ 5%		SEm±	CD @ 5%	
FACTOR A	0.02	0.07		0.12	0.36		0.03	0.09	
FACTOR B	0.04	0.14		0.23	0.67		0.06	0.17	
A X B	0.07	0.21		0.32	0.95		0.08	0.24	

Fig 1: Effect of plant growth regulators on Total soluble solids (^{0}brix) of tomato hybrids

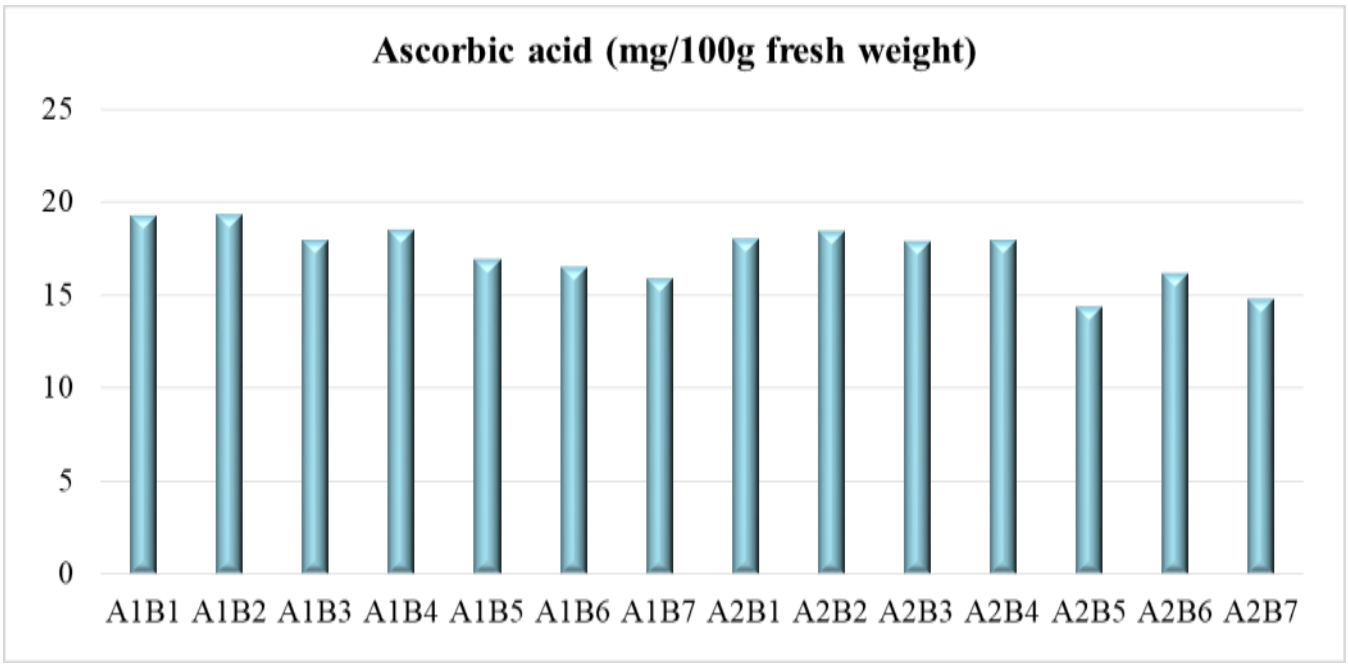

Fig 2: Effect of plant growth regulators on ascorbic acid (mg/100 g fresh weight) of tomato hybrids

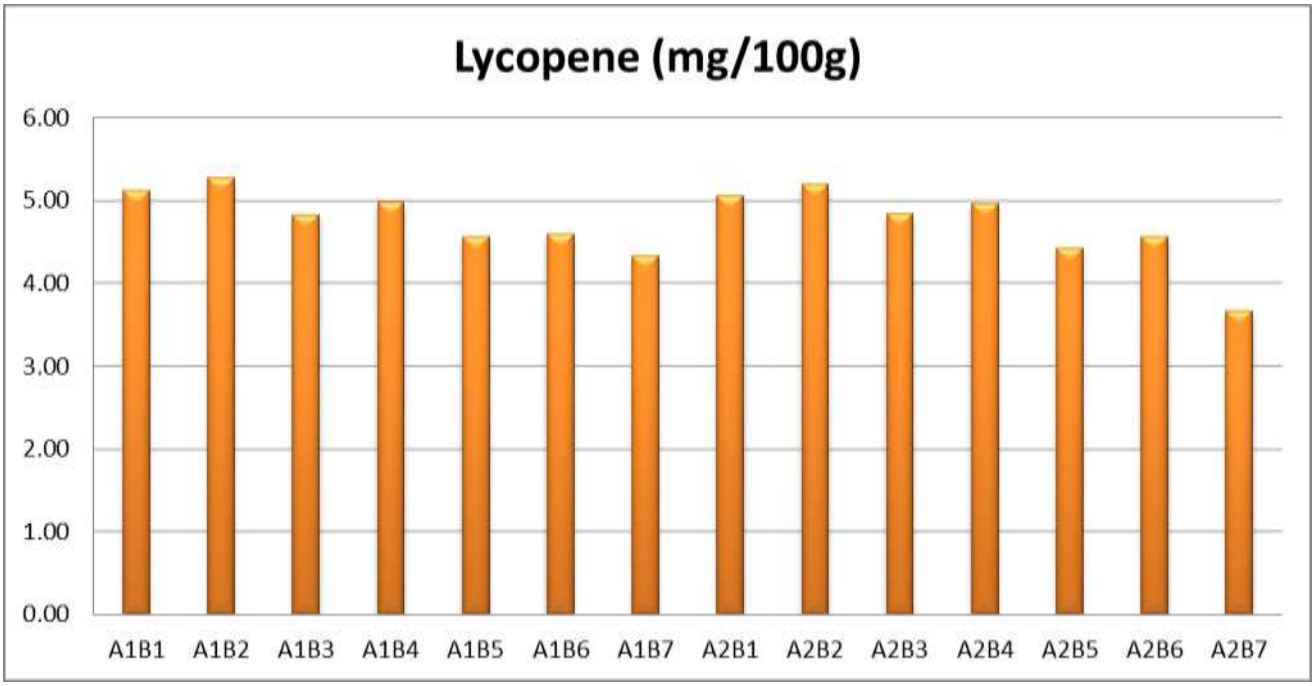

Fig 3: Effect of plant growth regulators on lycopene (mg/100 g) of tomato hybrids

Conclusion

Plant growth regulators had a immense significant influence on growth and quality of the tomato and the treatment combination of T_2 - A_1B_2 - Arka Rakshak + GA_3 @ 30 ppm reported the highest Ascorbic acid (19.34 mg/100 g), T.S.S. (4.38 ^{0}brix) and Lycopene (5.27 mg/100 g) compared with the other treatments. Hence, from this experiment it can be concluded that the treatment combination of T_2 - A_1B_2 - Arka Rakshak + GA_3 @ 30 ppm may be included for cultivation under Southern Telangana Zone.

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