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Enhancing Sunflower Productivity Through Foliar Application of Thiourea

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Abstract **–** Pakistan is sternly deficit in edible oil production. Sunflower is an oilseed crop, which contains 36-50 % oil content. By using nutrients with different combinations, its growth, yield and oil percentage can be increased. Sulphur is more important to boost oil production in oilseed crops. Thiourea contains four elements including Sulphur (42.11%), Nitrogen (36.81%), Hydrogen (5.31%) and carbon (15.77%). To determine the impact of thiourea application on sunflower cultivated under rain fed conditions, the current study was executed at University Research Farm of PMAS Arid Agriculture University, Rawalpindi, Pakistan. The experiment was designed in Randomized Complete Block Design (RCBD) with 3 replications. There was one control and three treatments of thiourea including 5 m mol, 15 m mol and 25 m mol. The study parameters included were plant height (cm), head diameter (cm), stem girth (cm), achenes per head and oil yield. After 4 weeks of thiourea application, plant height was observed the highest of 80.14 cm in plants treated with thiourea when applied @ 25mmol that was statistically higher to other application rates of 5 and 15 mmol and also the control. After 8 weeks of thiourea application, plant height was observed the highest of 150.42 cm in plants treated with thiourea when applied @ 25mmol that was statistically similar to its application rates of 5 and 15 mmol but significantly different from that of the control. After 4 weeks of thiourea application, head diameter with the maximum of 22.75 cm in plants treated with thiourea with its application of 25 mmol that was statistically different to all other application rates and the control. After 8 weeks of thiourea application, head diameter was recorded the highest of 47.10 cm in plants treated with thiourea with its application of 25 mmol that was statistically similar to its application of 15 mmol but significantly higher to other application rate of 5 mmol and also the control. Stem girth observed the highest of 9.45 cm in plants treated with thiourea when applied @ 25mmol that was statistically higher to other application rates of 5 and 15 mmol and also the control. The maximum achenes of 1089.28 per head were recorded in plants treated with thiourea with its application rate of 25 mmol that was statistically similar to those plants treated with application rate of 15 mmol but significantly different from those treated with application rate of 5 mmol. The oil content of sunflower was recorded the highest of 40.79 % in plants treated with thiourea with its application of 25 mmol that was statistically different and higher to its application of 15 mmol and 5 mmol and also the control..

Keywords – Sunflower, thiourea, application rates, plant height, head diameter, oil content

I. INTRODUCTION

Agriculture, a cornerstone of human survival, is currently facing mounting pressures due to population growth. This sector has relied heavily on artificial fertilizers and pesticides to increase crop yields. Unfortunately, this reliance has led to environmental challenges, including water pollution, soil deterioration, and air pollution. These challenges necessitate a shift towards sustainable agricultural practices to address the global food security and nutrition crisis [1].

Sunflower (*Helianthus annuus*), a significant oilseed crop, faces unique challenges as it expands into less productive regions with lower-fertility soils and unfavorable conditions. Its properties, including high oleic acid content and protein-rich seeds, offer diverse applications, from food to bio-fuels and biomaterials. Future cultivation of sunflower holds promise, with potential opportunities for a bio-refinery approach to maximize the plant's overall value [2]. In the context of sunflower cultivation, exogenous potassium (K) application has shown potential in improving the tolerance of sunflower hybrids to salt stress, addressing the challenges of salinity. Foliar K treatment significantly enhances the growth of sunflower hybrids, resulting in increased shoot and root lengths, as well as higher plant and achenes weight. Overall, foliar K application can mitigate the adverse effects of salt stress on sunflower [3]. Boron application to sunflower leaves has demonstrated a significant impact on sunflower development and yield. Foliar treatment with boron increases sunflower yield, contributing to improved agricultural productivity [4].

Foliar-applied trehalose under drought stress conditions has been shown to enhance sunflower plant growth, strengthen the oxidative defense system, and improve yield and oil composition. This demonstrates a potential solution to mitigate the adverse effects of drought on sunflower crops [5]. The application of zinc oxide (ZnO) in both standard and nanoparticles forms via foliar sprays to sunflower cultivars have been examined for its impact on growth, proline levels, and antioxidant enzyme activity. ZnO foliar spray, particularly in nanoparticles form, enhances sunflower shoot dry weight and superoxide dismutase (SOD) activity, highlighting its potential to increase biomass production in sunflower plants [6].

A field study explores the effects of foliar urea application on sunflower growth and yield. The results indicate that the absence of urea application to leaves and relying solely on soil application leads to lower growth, yield, and oil yield in sunflower cultivation. To maximize sunflower seed and oil yields, it is recommended to combine soil-applied urea with foliar applications after 35 days of seeding. Different timings of foliar urea applications reveal substantial differences in yield [7]. Foliar application of boron at a concentration of 0.7% has a significant impact on sunflower yield attributes and achene yield. This approach offers a promising method to boost sunflower production [8].

Seeding sunflower plants along ridges and utilizing foliar sprays containing 200 ppm nanometric zinc oxide can lead to the best oil output per unit of land. This innovative approach demonstrates the potential to optimize sunflower cultivation [9]. Under field conditions, the combined foliar application of nitrogen (N), zinc (Zn), and boron (B) has been assessed for its impact on sunflower growth and production. The findings suggest that this combination of foliar nutrients can significantly enhance various sunflower growth parameters and seed yield [10].

High salt concentrations in water and soil cause abiotic stress, significantly reducing plant productivity. In this context, foliar alpha-tocopherol application has been examined to reduce salt stress on various sunflower cultivars. Optimal application rates of alpha-tocopherol enhance development, chlorophyll levels, and gas exchange characteristics, offering a solution to mitigate the negative effects of salt stress [11]. Chitosan, calcium carbonate, and salicylic acid have been explored as foliar sprays on sunflower plants, particularly under different water levels, normal (100%) and deficit (50%). These foliar applications have shown significant improvements in growth factors, yield components, photosynthetic pigments, and more. This research provides insights into optimizing water usage while maintaining yield in sunflower cultivation [12].

II. MATERIALS AND METHOD

To explore the potential role of thiourea on sunflower, the field experiment was conducted during the spring season 2023 at University Research Farm of Pir Mehr Ali Shah Arid Agriculture University Rawalpindi under rain-fed conditions. At the time of sowing, two to three ploughings were done with the help of cultivator. The soil was tamed to a depth of 7 inches. The crop was sown in an individual plot size of 8m × 3.75m and sowing was done on ridges manually. 25 cm plant-to-plant and 75 cm row-to-row distance was maintained. The total numbers of treatments were four with three replications. Thinning was done after two leaf stage. The experiment was arranged in a randomized complete block design (RCBD) and there were 5 lines in each plot. The variety Hysen-33 was used and seeds were taken from the National Agriculture Research Center (NARC) Islamabad. As the recommended NP dose is 60:45 per hectare so one bag of Urea and one bag of DAP was applied by band placement method before sowing. Thiourea was used with three different concentrations which are as follows:

Treatments

T1= 0 m mol (Control)
T2 = 5 m mol
T3= 15 m mol
T4 = 25 m mol

Foliar application of thiourea was done at two stages:

1. Two-leaf stage.
2. At the stage of flower initiation.

Following parameters were studied and recorded during the experiment.

i. Plant Height (cm)

Plant height of randomly selected five plants from each plot at maturity was recorded.

ii. Head Diameter (cm)

Head diameter of the same randomly selected five plants for height was also measured.

iii. Stem Girth (cm)

A clean, sharp knife was used to cut a 3- to 4-inch shoot below a leaf node (the spot where a leaf emerges from a stem as shown). The bottom leaves of the shoot was cut off and snipped off.

iv. Achens per Head

Ten heads from each plot was taken and the seeds per head will be counted.

v. Oil content (%)

Seed oil content was determined with the help of the Near Infrared Reflectance Spectroscopy System.

Statistical Analysis:

The data recorded was statistically analyzed using the statistical package, SPSS 20 for Windows program.

III. RESULTS

The results in Table 1 showed that plant height was observed the highest of 80.14 cm in plants treated with thiourea when applied @ 25mmol that was statistically higher to other application rates of 5 and 15 mmol and also the control. The applications of 5mmol and 15 mmol were significantly alike to each other but different to the control that showed the minimum plant height of 55.08 cm.

Table 1. Effect of thiourea on plant height (cm) after 4-weeks of its foliar application

Treatments (Thiourea application rates)	**Mean ± SEM**
5 mmol	65.02 ± 1.64 b
15 mmol	70.95 ± 1.33 b
25 mmol	80.14 ± 5.21 c
Control	55.08 ± 0.89 a

Means followed by the same letters within columns and rows are non significant (P ≤ 0.05); DMRT, Duncan, 1951.

Table 2. Effect of thiourea on plant height (cm) after 8-weeks of its foliar application

Treatments (Thiourea application rates)	**Mean ± SEM**
5 mmol	137.67 ± 3.34 ab
15 mmol	142.25 ± 4.46 ab
25 mmol	150.42 ± 6.41 b
Control	135.25 ± 2.53 a

Means followed by the same letters within columns and rows are non significant (P ≤ 0.05); DMRT, Duncan, 1951.

Table 2 showed that plant height was observed the highest of 150.42 cm in plants treated with thiourea when applied @ 25mmol that was statistically similar to its application rates of 5 and 15 mmol but significantly different from that of the control. The applications of 5mmol and 15 mmol also showed the similar results but also similar to the control that showed the minimum plant height of 135.25 cm. Figure 1 also showing the plant heights after 4 and 8 weeks of foliar application of thiourea.

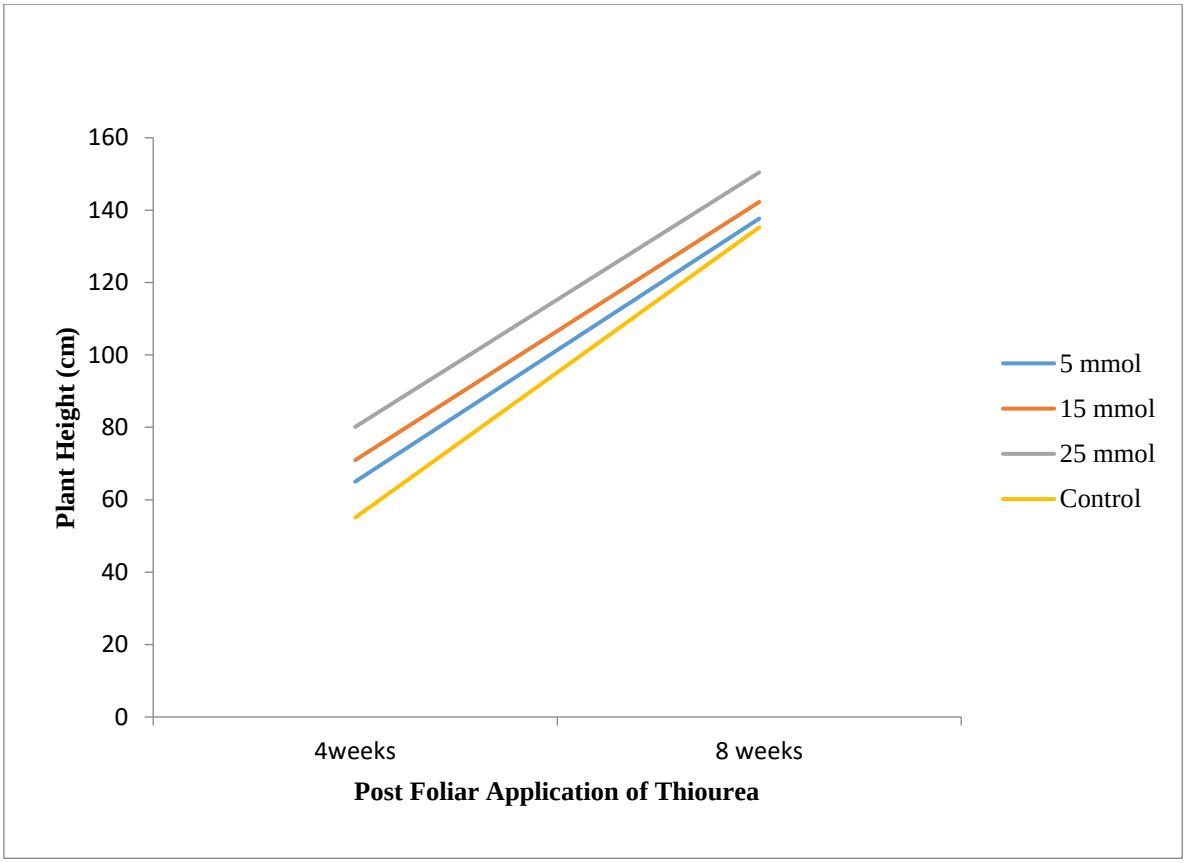

Figure 1. Effect of thiourea on plant height (cm) after 4 and 8 weeks of its foliar application

Table 3 depicted results of head diameter with the maximum of 22.75 cm in plants treated with thiourea with its application of 25 mmol that was statistically different to all other application rates and the control. The minimum head diameter of 15.75 cm was recorded in the control plants, which was statistically alike to treatments of thiourea application of 5 mmol but significantly different to that of 15 mmol where it was recorded 20.00 cm. However, both application rates of 5 mmol and 15 mmol were statistically alike.

Table 3. Effect of thiourea on head diameter (cm) after 4-weeks of its foliar application

Treatments (Thiourea application rates)	**Mean ± SEM**
5 mmol	17.75 ± 0.25 ab
15 mmol	20.00± 1.08 b
25 mmol	22.75 ± 0.75 c
Control	15.75 ± 0.95 a

Means followed by the same letters within columns and rows are non significant (P ≤ 0.05); DMRT, Duncan, 1951.

The results in Table 4 showed that head diameter was recorded the highest of 47.10 cm in plants treated with thiourea with its application of 25 mmol that was statistically similar to its application of 15 mmol but significantly higher to other application rate of 5 mmol and also the control. The applications of 5mmol and the control were significantly alike to each other. The minimum head diameter of 29.22 cm

was recorded in the control plants. Figure 2 also showing the head diameter after 4 and 8 weeks of foliar application of thiourea.

Table 4. Effect of thiourea on head diameter (cm) after 8-weeks of its foliar application

Treatments (Thiourea application rates)	**Mean ± SEM**
5 mmol	32.91 ± 2.53 ab
15 mmol	41.19 ± 2.16 bc
25 mmol	47.10 ± 4.09 c
Control	29.22 ± 3.12 a

Means followed by the same letters within columns and rows are non significant (P ≤ 0.05); DMRT, Duncan, 1951.

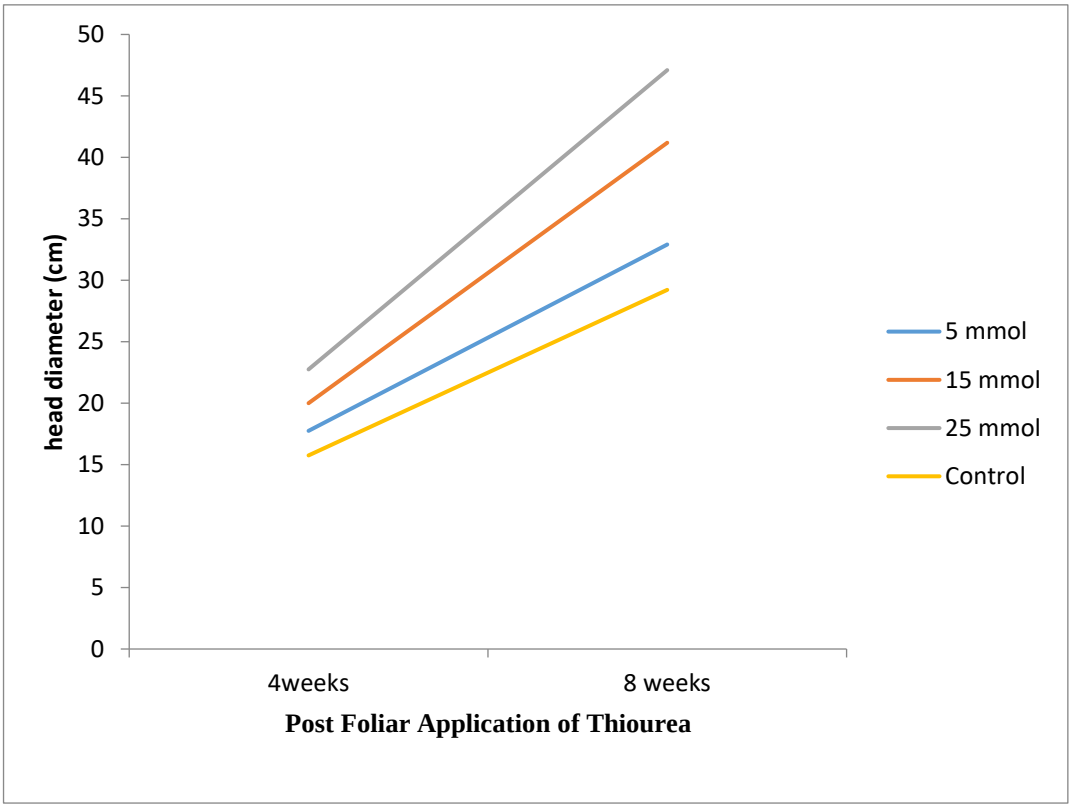

Figure 2. Effect of thiourea on head diameter (cm) after 4 and 8 weeks of its foliar application

The results in Table 5 showed that stem girth observed the highest of 9.45 cm in plants treated with thiourea when applied @ 25mmol that was statistically higher to other application rates of 5 and 15 mmol and also the control. The applications of 5mmol and 15 mmol were significantly alike to each other. Plants in control plots showed the minimum stem girth of 6.33 cm that was significantly similar to the application rate of 5mmol.

Table 5. Effect of thiourea on stem girth (cm) after 8-weeks of its foliar application

Treatments (Thiourea application rates)	**Mean ± SEM**
5 mmol	7.40 ± 0.48 ab
15 mmol	7.97 ± 0.55 b
25 mmol	9.45 ± 0.19 c
Control	6.33 ± 0.46 a

Means followed by the same letters within columns and rows are non significant (P ≤ 0.05); DMRT, Duncan, 1951.

Table 6 revealed that the maximum achenes of 1089.28 per head were recorded in plants treated with thiourea with its application rate of 25 mmol that was statistically similar to those plants treated with application rate of 15 mmol but significantly different from those treated with application rate of 5 mmol. However, application rate of 5 mmol was not significantly different from the control showing the minimum achenes of 765.08 per head.

Table 6. Effect of thiourea on achenes per head after 8-weeks of its foliar application

Treatments (Thiourea application rates)	**Mean ± SEM**
5 mmol	823.73 ± 70.97 a
15 mmol	931.23 ± 68.71 ab
25 mmol	1089.28 ± 100.84 b
Control	765.08 ± 66.06 a

Means followed by the same letters within columns and rows are non significant (P ≤ 0.05); DMRT, Duncan, 1951.

The results in Table 7 showed that the oil content of sunflower was recorded the highest of 40.79 % in plants treated with thiourea with its application of 25 mmol that was statistically different and higher to its application of 15 mmol and 5 mmol and also the control. The applications of 15mmol and 5mmol were significantly alike to each other but statistically different from the control where the minimum oil content of 37.01 % was recorded.

Table 7. Effect of thiourea on oil content after harvesting of sunflower plants

Treatments (Thiourea application rates)	**Mean ± SEM**
5 mmol	38.13 ± 0.25 b
15 mmol	38.58 ± 0.24 b
25 mmol	40.79 ± 0.45 c
Control	37.01 ± 0.27 a

Means followed by the same letters within columns and rows are non significant (P ≤ 0.05); DMRT, Duncan, 1951.

IV. DISCUSSION

The main focus of this research was to get the maximum results on oil content of sunflower. With a seed yield of 1907.96 kg ha−1 and an oil yield of 841.91 kg ha−1, the sunflower crop that received a foliar application of urea at 60 days or 85 days of seeding in addition to the recommended soil applied urea ranked second and third. The sunflower plantation without foliar urea and grown only on the recommended urea-applied soil (130 kgha−1) ranked fourth. On the other hand, in terms of all growth and yield parameters as well as oil yield, the sunflower plantation that received neither soil applied urea nor foliar applied urea (control) ranked lowest. Therefore, to maximize sunflower seed and oil yields, farmers are advised to apply 1 percent urea foliarly after 35 days of sowing, in addition to 130 kg ha−1 of urea applied soil. The results also revealed that, in most cases, the crop that was treated with urea by foliar application at 60 and 85 days after sowing exhibited similarity ($P > 0.05$); however, the differences were significant ($P < 0.05$) when compared to the other treatments and foliar application at 35 days after sowing. These findings align with the findings of numerous investigators. When urea (3%) was applied foliarly during the seed development stage, it had a greater positive impact on crop performance than when it was applied at other phenological stages [14]. When they applied urea topically during the seed development stage, they observed positive results. The benefits of foliar N application in the form of urea include low cost and quick plant response [15]. [16] recommended applying foliar fertilizer at a rate of roughly 50% of direct fertilizers in order to increase sunflower yields and oil content. According to [17], sunflower crops treated foliarly took 70.50 and 99.34 days to flower and mature, with plant height of 214.25 cm and head diameter of 18.80 cm. The seeds per head weighed 1877.25 g, the seed index was 42.25 g, and the seed yield per hectare was 2710.00 kg. [18] looked into how urea was applied topically to sunflower and found that varying amounts of urea applied topically helped to mitigate the negative effects of salt stress on both cultivars. For these characteristics, 20 mM urea was the most effective level. On the chlorophyll pigmentation of both cultivars, it was found that the effects of salt stress and foliar application of various urea concentrations were negligible. The impact of foliar and soil nutrients on sunflower yield was examined in [19], which found that there was a significant improvement in seed quality parameters. This was demonstrated by higher seedling length (26.67 cm), vitality index (2230), dry weight (375 mg), and germination (90.00%) compared to the control. [20] examined how nutrients applied to the soil and leaves affected the yield of sunflowers. They found that applying urea (N) as a foliar spray resulted in 13.50 m−2 of seed germination, plant height of 170.50 cm, stem girth of 6. 05 cm, head diameter of 28.30 cm, seed weight of 105.62 g per piece, seed index of 80.50 g, seed yield of 2105.75 kg ha−1, harvest index of 35.04%, and oil content of 40.55%. NPK + humic acid or PK applied as a basal rate + N applied foliarly were found to be the most successful integrated nutrient management strategies for sunflower production, based on seed yield and oil content. [21] demonstrated that the number of seeds per head was significantly impacted by the interaction between the foliar N application stage and concentration. When urea was applied foliarly at a concentration of 5% during the 8–10 leaf stage, the number of seeds per head increased by approximately 45% and 28.27%, respectively, in comparison to the control group and other treatments. When nitrogen was applied foliarly with a 5% urea concentration, grain yield was considerably higher than with a 3% urea concentration and control treatment, by roughly 30.27% and 7.50%, respectively. [22] proposed that by reducing the negative effects of salinity on growth and reproductive yield, foliar application of nutrients could be utilized to increase plant tolerance to salinity.

V. CONCLUSION

Foliar application of 25mmol TU should be done at any two stages of growth to improve morphology and oil content of sunflower. 5mmol or 15 mmol is better to applied but 25mmol will show optimum results. After 4 weeks of thiourea application, plant height was observed the highest of 80.14 cm in plants treated with thiourea when applied @ 25mmol that was statistically higher to other application rates of 5 and 15 mmol and also the control. After 8 weeks of thiourea application, plant height was observed the highest of 150.42 cm in plants treated with thiourea when applied @ 25mmol that was statistically similar to its application rates of 5 and 15 mmol but significantly different from that of the control. After 4 weeks

of thiourea application, head diameter with the maximum of 22.75 cm in plants treated with thiourea with its application of 25 mmol that was statistically different to all other application rates and the control. After 8 weeks of thiourea application, head diameter was recorded the highest of 47.10 cm in plants treated with thiourea with its application of 25 mmol that was statistically similar to its application of 15 mmol but significantly higher to other application rate of 5 mmol and also the control. Stem girth observed the highest of 9.45 cm in plants treated with thiourea when applied @ 25mmol that was statistically higher to other application rates of 5 and 15 mmol and also the control. The maximum achenes of 1089.28 per head were recorded in plants treated with thiourea with its application rate of 25 mmol that was statistically similar to those plants treated with application rate of 15 mmol but significantly different from those treated with application rate of 5 mmol. The oil content of sunflower was recorded the highest of 40.79 % in plants treated with thiourea with its application of 25 mmol that was statistically different and higher to its application of 15 mmol and 5 mmol and also the control.

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