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# Studies on Effect of Plant Growth Regulators and Micronutrients on Growth, Flowering, Fruit Set and Yield of Drumstick cv Bhagya

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**ABSTRACT: Drumstick (*Moringa oleifera*) is belongs to the family Moringaceae, The leaves, pods, flowers and immature pods of this tree has enormous nutrients and because of these high nutritive values it is used as vegetable in many countries. The present investigation was carried out to find out the response of foliar application of plant growth regulators and micronutrients on growth, flowering, fruit set and yield parameters of drumstick cv. Bhagya in a randomized block design, twenty treatments with two replication *during rabi - summer* 2021-22 at Department of Vegetable Science, Kittur Rani Channamma College of Horticulture, Aabhavi, Karnataka, India. The experimental results revealed that all treatments performed significantly better when compared to control with respect to all morphological and yield attributes. The maximum number of primary branches (6.90), length of primary leaf rachis (50.99 cm & 67.19 cm at 30 & 60 DAS), number of flowers per panicle (40.00), number of panicles per plant (72.50), number of pods per panicle (2.50), fruit set (6.25%), number of pods per plant (171.25), individual pod weight (54.30 g), individual pod girth (4.93 cm), yield per plant (9.30 kg) and highest benefit cost ratio (3.43) were recorded in NAA @ 40 ppm + Zinc Sulphate @ 0.5 per cent + Boric Acid @ 0.2 per cent. However, maximum plant height (2.80 m & 4.09 m at 30 & 60 DAS) and individual pod length (66.24 cm) was recorded in $GA_3$ at 20 ppm.**

**Keywords:** Drumstick, plant growth regulators, micronutrients, yield, fruit set, pod.

## INTRODUCTION

Drumstick is the most well-known crop with a wide range of uses, which belongs to the Moringaceae family (Nadkarni, 1976; Ramachandran *et al.*, 1980). There are more than 13 species in the genus *Moringa* two of which *M. oleifera* and *M. concanensis* are grown as vegetables in India (Morton, 1991). The moringa tree has been grown throughout the plains, especially in backyards. The tree can reach heights of 5 to 10 meters. It grows best in tropical climates with little drought. It also thrives well near sandy river banks and stream beds (Qaiser, 1973; Morton, 1991) with pH levels ranging from 5.0 to 9.0. It needs an annual rainfall minimum of about 250 mm and maximum at over 3000 mm (Palada and Chang 2003).

Moringa plant is native of the western and sub-Himalayan tracts, India, Pakistan, Asia Minor, Arabia and Africa. (Somali *et al.*, 1984). *Moringa oleifera* popularly known as, Miracle tree, West Indian ben, Mother's best friend, Spinach Tree, Drumstick tree, Horse radish tree, Murungai (In Tamil) *etc.*, (Ramachandran *et al*., 1980). *Moringa oleifera* also possess number of remedial traits and all the plant parts - leaf, Roots, pods, bark, gum, seeds, flowers and seed oil have been utilized for several diseases in the traditional medicine of South Asia for the curing of inflammation and infectious diseases like cardiovascular, gastrointestinal, haematological and hepatorenal disorders (Siddhuraju and Becker 2003).

Though moringa produce lush flowering in seasons, percentage of fruit set is just around one per cent (Sadashakthi, 1995). Hence, to reach the growing demand for moringa there is a necessary to improve the pod set per cent. Plant growth regulators are compound when added in small amount, alters the plant growth usually stimulating or modifying the natural growth system, thereby increasing the yield (Surendra *et al.*, 2006).

Sandeep *et al*. (2019) conducted the research to find out the response of foliar application of micronutrients on growth and quality parameters of annual moringa var. PKM-1. Results revealed that, plant height (3.06 m), trunk girth (17.40 cm), the number of panicles per tree (68.30), number of flowers per panicle (33.66), number of pods per panicle (2.29), number of pods per tree (120.00), pod length (80.25 cm) and pod girth (7.93 cm) were highest recorded in mixture of all micronutrients (Fe, Mn, Zn and B).

Monisha *et al*. (2019) carried out the experiment on the effect of foliar spray of growth regulators, micronutrients and chemicals in different methods of propagation on growth and yield attributes of ratoon crop of Moringa. The results declared that, growth parameters such as tree height, leaf area were found to be higher in NAA at 20 ppm.

## MATERIALS AND METHODS

The experiment was conducted from October, 2021 to June, 2022 at Kittur Rani Channamma College of Horticulture, Arabhavi, Belagavi, Karnataka. The site is located in the agro climatic Zone-3 of Karnataka state. Arabhavi is geographically located at 16°15′ North latitude, 74°45′ East longitude and at an altitude of 612 m above mean sea level. The experiment was laid out in a randomized complete block design (RCBD), twenty treatments with two replications. The drumstick seedlings are transplanted in main field by the spacing of 5 × 5 m.

**Treatment details.** There were twenty treatments *viz.*, $T_1$- NAA @ 20 ppm; $T_2$ - NAA @ 40 ppm; $T_3$- $GA_3$ @ 20 ppm; $T_4$ - Mepiquat Chloride @ 50 ppm; $T_5$ - Zinc Sulphate @ 0.5%; $T_6$ - Boric Acid @ 0.2%; $T_7$ - Zinc Sulphate @ 0.5% + Boric Acid @ 0.2%; $T_8$ - NAA @ 20 ppm + Zinc Sulphate @ 0.5%; $T_9$ - NAA @ 20 ppm + Boric Acid @ 0.2%; $T_{10}$ - NAA @ 20 ppm + Zinc Sulphate @ 0.5% + Boric Acid @ 0.2%; $T_{11}$ - NAA @ 40 ppm + Zinc Sulphate @ 0.5%; $T_{12}$ - NAA @ 40 ppm + Boric Acid @ 0.2%; $T_{13}$ - NAA @ 40 ppm + Zinc Sulphate @ 0.5% + Boric Acid @ 0.2%; $T_{14}$ - $GA_3$ @ 20 ppm + Zinc Sulphate @ 0.5%; $T_{15}$ - $GA_3$ @ 20 ppm + Boric Acid @ 0.2% $T_{16}$ - $GA_3$ @ 20 ppm + Zinc Sulphate @ 0.5% + Boric Acid @ 0.2%; $T_{17}$ - Mepiquat Chloride @ 50 ppm + Zinc Sulphate @ 0.5%; $T_{18}$ - Mepiquat Chloride @ 50 ppm + Boric Acid @ 0.2%; $T_{19}$ - Mepiquat Chloride @ 50 ppm + Zinc Sulphate @ 0.5% + Boric Acid @ 0.2%; $T_{20}$ - Control (water spray). All the treatments were applied as foliar spray at two stages *viz.*, vegetative stage and flowering stage.

**Observations recorded.** Observations on various growth, flowering and yield parameters like plant height, number of primary branches, length of primary leaf rachis, number of flowers per panicle, number of panicles per plant, number of pods per panicle, fruit set, number of pods per plant, individual pod weight, individual pod length, individual pod girth, yield per plant and benefit cost ratio were recorded on three randomly selected plants for each treatment in each replication. Average values were computed and the data were subjected to statistical analysis.

**Table 1: Effect of plant growth regulators and micronutrients on growth and flowering attributes of drumstick cv. Bhagya.**

| Treatments | Plant height (m) | | Number of primary branches | Length of length of primary leaf rachis | | Number of flowers per panicle | Number of panicles per plant | Number of pods per panicle |
|---|---|---|---|---|---|---|---|---|
| | 30 DAS | 60 DAS | | 30 DAS | 60 DAS | | | |
| $T_1$ | 2.08 | 2.77 | 4.40 | 40.44 | 47.21 | 29.55 | 63.08 | 1.58 |
| $T_2$ | 2.70 | 3.82 | 4.50 | 41.83 | 47.27 | 29.85 | 64.28 | 1.58 |
| $T_3$ | 2.80 | 4.09 | 4.30 | 40.94 | 46.49 | 29.45 | 63.10 | 1.56 |
| $T_4$ | 2.00 | 2.18 | 4.20 | 39.22 | 44.66 | 29.42 | 63.00 | 1.44 |
| $T_5$ | 2.28 | 2.98 | 4.50 | 43.44 | 47.83 | 30.25 | 65.65 | 1.66 |
| $T_6$ | 2.54 | 2.89 | 4.50 | 42.27 | 47.49 | 32.99 | 67.81 | 1.85 |
| $T_7$ | 2.53 | 3.02 | 5.70 | 48.38 | 56.66 | 37.00 | 70.84 | 2.15 |
| $T_8$ | 2.29 | 3.66 | 5.00 | 44.99 | 51.05 | 31.98 | 67.00 | 1.78 |
| $T_9$ | 2.20 | 3.04 | 5.30 | 46.83 | 51.60 | 35.55 | 69.45 | 2.05 |
| $T_{10}$ | 2.35 | 3.11 | 6.50 | 49.16 | 64.88 | 38.50 | 72.20 | 2.35 |
| $T_{11}$ | 2.31 | 2.85 | 5.10 | 45.00 | 51.21 | 32.85 | 67.50 | 1.85 |
| $T_{12}$ | 2.10 | 2.38 | 5.30 | 47.94 | 51.88 | 35.85 | 69.50 | 2.05 |
| $T_{13}$ | 2.05 | 2.48 | 6.90 | 50.99 | 67.19 | 40.00 | 72.50 | 2.50 |
| $T_{14}$ | 2.41 | 2.65 | 4.80 | 44.88 | 50.77 | 31.85 | 66.98 | 1.76 |
| $T_{15}$ | 2.62 | 2.74 | 5.10 | 46.38 | 51.49 | 35.43 | 68.50 | 2.04 |
| $T_{16}$ | 2.57 | 2.79 | 6.10 | 48.27 | 61.49 | 37.80 | 72.09 | 2.30 |
| $T_{17}$ | 2.28 | 2.78 | 4.70 | 44.44 | 48.44 | 30.45 | 65.89 | 1.66 |
| $T_{18}$ | 2.50 | 2.75 | 4.70 | 44.77 | 49.05 | 34.98 | 68.20 | 2.02 |
| $T_{19}$ | 2.17 | 2.55 | 5.70 | 48.33 | 52.44 | 37.50 | 71.55 | 2.19 |
| $T_{20}$ | 1.44 | 1.77 | 3.20 | 34.38 | 42.55 | 27.89 | 60.00 | 1.05 |
| CD at 5% | 0.61 | 0.66 | 0.81 | 5.32 | 7.33 | 3.53 | 5.42 | 0.03 |
| SE.m (±) | 0.20 | 0.22 | 0.27 | 1.78 | 2.45 | 1.18 | 1.818 | 0.01 |
| CV(%) | 12.50 | 11.06 | 7.66 | 5.65 | 6.73 | 5.01 | 3.811 | 0.84 |

**Table 2: Effect of plant growth regulators and micronutrients on yield attributes of drumstick cv. Bhagya.**

| Treatments | Fruit set (%) | Number of pods per plant | Individual pod weight (g) | Pod length (cm) | Pod girth (cm) | Yield/ plant (kg) | B/C |
|---|---|---|---|---|---|---|---|
| $T_1$ | 5.35 | 98.06 | 43.21 | 48.33 | 4.30 | 4.26 | 1.61 |
| $T_2$ | 5.29 | 99.04 | 43.88 | 65.37 | 4.34 | 4.35 | 1.64 |
| $T_3$ | 5.30 | 98.44 | 43.00 | 66.24 | 4.29 | 4.23 | 1.59 |
| $T_4$ | 4.89 | 95.00 | 40.87 | 49.46 | 4.11 | 3.88 | 1.40 |
| $T_5$ | 5.49 | 105.98 | 46.56 | 44.80 | 4.43 | 4.93 | 1.84 |
| $T_6$ | 5.61 | 120.45 | 47.89 | 51.25 | 4.36 | 5.77 | 2.17 |
| $T_7$ | 5.81 | 142.81 | 50.21 | 53.41 | 4.81 | 7.15 | 2.65 |
| $T_8$ | 5.57 | 114.26 | 47.55 | 58.53 | 4.65 | 5.43 | 2.03 |
| $T_9$ | 5.77 | 135.37 | 48.65 | 60.12 | 4.70 | 6.59 | 2.47 |
| $T_{10}$ | 6.10 | 159.67 | 52.80 | 48.91 | 4.93 | 8.43 | 3.12 |
| $T_{11}$ | 5.63 | 119.88 | 47.68 | 46.93 | 4.66 | 5.72 | 2.13 |
| $T_{12}$ | 5.72 | 135.98 | 49.56 | 49.66 | 4.70 | 6.71 | 2.51 |
| $T_{13}$ | 6.25 | 171.25 | 54.30 | 44.24 | 4.93 | 9.30 | 3.44 |
| $T_{14}$ | 5.53 | 112.88 | 47.00 | 51.69 | 4.65 | 5.31 | 1.98 |
| $T_{15}$ | 5.76 | 132.74 | 48.55 | 46.75 | 4.68 | 6.44 | 2.40 |
| $T_{16}$ | 6.08 | 155.81 | 50.89 | 55.04 | 4.90 | 7.93 | 2.92 |
| $T_{17}$ | 5.45 | 106.38 | 46.98 | 49.34 | 4.50 | 5.00 | 1.78 |
| $T_{18}$ | 5.77 | 130.76 | 48.22 | 46.95 | 4.58 | 6.31 | 2.26 |
| $T_{19}$ | 5.84 | 145.69 | 50.55 | 51.12 | 4.74 | 7.42 | 2.62 |
| $T_{20}$ | 3.59 | 66.00 | 38.50 | 38.15 | 3.61 | 2.62 | 1.02 |
| CD at 5% | 0.008 | 10.46 | 0.07 | 4.00 | 0.52 | 1.83 | |
| SE.m (±) | 0.003 | 3.51 | 0.02 | 1.34 | 0.17 | 0.61 | |
| CV(%) | 0.068 | 4.05 | 0.07 | 3.70 | 5.46 | 14.78 | |

## RESULTS AND DISCUSSION

### Growth attributes

**Plant height.** Among the treatments, $T_3$ noticed maximum plant height (2.80 m & 4.09 m at 30 and 60 DAS, respectively) followed by $T_2$ (2.70 m & 3.82 m, respectively). Minimum plant height was noted in $T_{20}$ (1.44 m & 1.77 m, respectively). Gibberellic acid which enhanced growth activities of plant, stimulated the rate of cell division, cell elongation and thus, contributed stem elongation. Increment in plant height by spraying $GA_3$ was also reported by Fadhil and Almasoody (2019) in broad bean and Tasnim *et al.* (2019) in mung bean.

**Number of primary branches.** More number of primary branches (6.90) were recorded in $T_{13}$ followed by $T_{10}$ (6.50). Minimum number of primary branches (3.20) were recorded in $T_{20}$. The increasing in number of primary branches may be as a result of NAA impact on cell growth, respiration, cell elongation and nucleic acid metabolism (Gupta *et al.*, 2019). Hansch and Mendel (2009) mentioned that, in general the micronutrients play an important role in biosynthesis of endogenous hormones which are responsible for patronizing plant growth. Boron is responsible for the formation of cell wall and cell differentiation and hence, supports in shoot growth and root elongation of plant. Improvement in growth traits as a impact of spraying of micronutrients could be result of the augmented photosynthesis and other metabolic activity which induce to an progress in several plant metabolites cause for cell elongation and division (Hatwar *et al.*, 2003). These results were similar to the result findings of Sandeep *et al*. (2019) in drumstick.

**Length of primary leaf rachis (cm).** Among the treatments, $T_{13}$ showed the maximum length of primary leaf rachis (50.99 cm & 67.19 cm at 30 and 60 DAS respectively) and which was statistically at par with $T_{10}$ (49.16 cm & 64.88 cm, respectively) followed by $T_{16}$ (48.27 cm & 61.49 cm at 30 & 60 DAS respectively). Minimum length of primary leaf rachis (34.38 cm & 42.55 cm, respectively) was noted in $T_{20}$. Increment in the length of primary leaf rachis is caused by foliar application of NAA causes apical dominance by increased the plasticity of cell wall by loosening it and followed by hydrolyzing starch into sugars causing rapid cell elongation and cell division (Arvindkumar *et al*., 2014) and it was in accordance to Monisha *et al.* (2019) in drumstick.

### Flowering attributes

**Number of flowers per panicle.** Among the treatments, $T_{13}$ was noted the highest number of flowers per panicle (40.00) and which was statistically at par with $T_{10}$ (38.50) followed by $T_{16}$ (37.80). Whereas, lowest number of flowers per panicle (27.89) was noted in $T_{20}$. The increase in number of flowers per panicle by these growth regulators might be the impact of translocation of assimilates which mobilized towards floral region as it has been reported in case of NAA application (Matwa *et al*., 2017). Maximum flower production could be due to presence of boron. The number of flowers, flower clusters were influenced by the application of boron that attributed to flower retention, assimilation of nitrates that might have induced better mineral utilization of plants accompanied with the enrichment of photosynthesis, further metabolic activity and greater diversion of food materials (Bajpai and Chauhan 2001). Similarly, it could be due to increment in the RNA and DNA content in reproductive tissue in the present of zinc which may enhance the flower bud initiation. These findings were supports by Monisha *et al*. (2019) and Sandeep *et al*. (2019) in drumstick.

**Number of panicles per plant.** The result revealed that, among the 20 treatments, $T_{13}$ recorded the highest number of panicles per plant (72.50) and which was statistically at par with $T_{10}$ (72.20) followed by $T_{16}$ (72.09). The minimum number of panicles per plant (60.00) was noted in $T_{20}$. Spraying of NAA increased the synthesis of auxin in the root system and their transport to the axillary buds helps in incrementing the number of panicles per plant (Kannan *et al.,* 2009). Presence of boron and zinc in the micronutrient mixture might have increased the nitrate assimilation and other metabolic process by diverting food materials to the reproductive parts like panicles and flowers (Moniruzzaman *et al.,* 2014; Bajpai and Chauhan 2001). Research findings of the current study was similar with results of Sandeep *et al*. (2019) in drumstick.

**Yield attributes**

**Number of pods per panicle.** The result revealed that, among the 20 treatments, $T_{13}$ recorded maximum number of pods per panicle (2.50) followed by $T_{10}$ (2.35). Whereas, minimum number of pods per panicle (1.05) was recorded in $T_{20}$. The increasing in number of pods per panicle might be due to NAA effect on process of fertilization and hormonal metabolism, helpful in maintaining better nutritional status of tree which ultimately proved beneficial in improving fruit set (Saraswat *et al.,* 2010). Presence of micronutrients increased the number of pods might be due to favorable environment under these treatments which gives congenial affect for better growth and development of the pods. The possible reason may be due to micro-element ascribed to better photosynthesis, lesser fruit drop, improve fruit size and quality characters. The beneficial role of boron is important in the sugar translocation from leave is important to enhance photosynthesis, zinc in growth promoting substance (Shivanandam *et al*., 2007; Sandeep *et al*., 2019).

**Fruit set (%).** Among the treatments $T_{13}$ noted maximum fruit set percentage (6.25%) followed by $T_{10}$ (6.10%). Whereas, minimum fruit set percentage (3.59%) was noted in $T_{20}$. The exogenous spraying of NAA could have incremented the concentration of auxin in plants which possibly induced to prevents the flower abscission and improved the pod set (Matwa *et al*., 2017). Presence of boron and zinc in the micronutrient mixture might have increased the nitrate assimilation, retention of flowers, pollination efficiency and other metabolic process by diverting food materials to the reproductive parts like panicles and flowers (Hazra *et al.,* 1987; Bajpai and Chauhan 2001). Same findings observed by Sandeep *et al*. (2019).

**Number of pods per plant.** Among the treatments, $T_{13}$ revealed the maximum pods per plant (171.25) followed by $T_{10}$ (159.67). Whereas, the minimum number of pods per plant (66.00) was noted $T_{20}$. The increasing in number of pods per plant might be due to application of NAA resulted into well photosynthesis, more starch accumulation in fruits. The action of zinc in auxin synthesis and boron in transfer of starch to pods. The biosynthesis of auxin in plant balance the fruit drop or retention in plants, which alternate the fruit drop reduction and raised the total pods number per tree (Tsomu and Patel 2019). Research findings of the current study was similar with results of Sandeep *et al*. (2019).

**Individual pod weight (g).** Among the treatments, $T_{13}$ recorded the highest individual pod weight (54.30 g) followed by $T_{10}$ (52.80 g). The lowest individual pod weight (38.50 g) was noted in $T_{20}$. NAA could be contributed to the cell multiplication, cell elongation and increment volume of intercellular spaces in mesocarpic cells. It may further due to greater food mobilization and minerals from other plant parts to the developing pods that are extremely active metabolic sink (Tsomu and Patel 2019). Boron contributed in the intake of water and carbohydrate metabolism there might be increment in pods weight along with the presence of zinc with better mineral utilization of plants accompanied with enhancement of photosynthesis, other metabolic activity and greater diversion of food material to pods (Haque *et al.,* 2000; Bajpai and Chauhan 2001). Alike results were perceived in the results of Sandeep *et al*. (2019).

**Individual pod length (cm).** Among the treatments, $T_3$ recorded the maximum pod length (66.24 cm) followed by $T_2$ (65.37 cm). Whereas, the minimum pod length (38.15 cm) was noted in $T_{20}$. The increment in length of pod due to spraying of gibberlic acid could be outcome of improved internal physiology during fruit development which induced efficient utilization of resources like nutrients, water and other vital compounds (Akand *et al.,* 2015).

**Individual pod girth (cm).** Maximum pod girth (4.93 cm) was noted in the treatments of $T_{13}$ and $T_{10}$ and which was statistically at par with $T_{16}$ (4.90 cm) followed by $T_7$ (4.81cm). Whereas, lowest pod girth (3.61 cm) was noted in $T_{20}$. The increasing in girth of pod with application of NAA might be result of greater mobilization of photosynthates towards the sink along with enhanced cellular activity. It could be also ascribed to NAA increment the permeability of the pod cell wall for water and dissolved materials to enter the cells of fruits, resulting in increased fruit size. The boron helps in the uptake of water and carbohydrate metabolism. Whereas, the presence of zinc increases the mineral utilization of plants accompanied with enhancement of photosynthesis, other metabolic activity and greater diversion of food material to pods (Bajpai and Chauhan 2001; Haque *et al.,* 2000). Identical results were got in the research trials of Sandeep *et al*. (2019).

**Yield per plant.** Among the treatments $T_{13}$ noted highest yield per plant (9.30 kg) and which was statistically at par with $T_{10}$ (8.43 kg) followed by $T_{16}$ (7.93 kg). Whereas, lowest yield per plant (2.62 kg) was noticed by $T_{20}$. This increment in the pod yield was supported by the parameters like number of flowers per panicle, number of panicles per tree, number pods per panicle and pod weight. These parameters are influenced by the foliar application of NAA, $ZnSO_4$ and $H_3BO_3$. The increment in yield with the spraying of NAA might be due to incremented the plant metabolic activities, resulting in enhancement of reproductive phase and higher fertility rate of reproductive organ due to creation of favorable balance of hormones and more fruit setting. Application of boron was revealed effective in increment in the fruit set and fruit development. Zinc and boron in the present study might be due to their role in the cell division and other physiological processes. Increment in the plant height may be attributed to the role of zinc in auxin synthesis and association of boron with development of cell wall and cell differentiation which helps in root and shoot growth of plants. Similar results of yield per plant where observed in Sandeep *et al*. (2019); Monisha *et al*. (2019) in drumstick,

**Benefit cost ratio.** Among different plant growth regulators and micronutrients, the maximum benefit cost ratio (3.44) was noted in $T_{13}$ followed by $T_{10}$ (3.12). Whereas, the minimum benefit cost ratio (1.02), was noticed in $T_{20}$. This might be due to the maximum pod yield per plant recorded in the foliar spraying of plant growth regulators and micronutrients in $T_{13}$ (NAA @ 40 ppm + Zinc Sulphate @ 0.5% + Boric Acid @ 0.2%). Similar results found with Sandeep *et al*. (2019); Patil *et al.,* 2010; Mohsin *et al.,* 2011).

## CONCLUSION

In the nutrient management of drumstick cv. Bhagya was found that, the foliar application of NAA at 40 ppm + Zinc Sulphate at 0.50 per cent + Boric Acid at 0.20 per cent effectively increased the growth, flowering, fruit set and yield with maximum benefit cost ratio than control (water spray).

## FUTURE SCOPE

Mechanisms involved in increase in growth, yield, nutrient uptake and other micronutrients need to be studied. Mechanisms involved in increasing quality parameters and quality controlling attributes need to be studied with plant growth regulators and micronutrients.

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**Conflict of Interest**. None.

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