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Effect of Water pH on Bioefficacy of Insecticides Against Leafhopper *Amrasca biguttula biguttula* (Ishida) on *Bt* cotton

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ABSTRACT: The field experiment was conducted during *kharif* in year 2023-24 to study the effect of water pH on bioefficacy of insecticides against sucking pests of *Bt* cotton." at Seed Technology Research Unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola. The experiment was carried out in Factorial Randomized Block Design (FRBD) of two factors *i.e.* Factor A *i.e.* insecticides and Factor B *i.e.* water pH levels with nine treatments replicated three times. The treatment details of experiment, spraying three insecticides (*i.e.* Afidopyropen 50g/L DC, Fenpyroximate 5% EC, Spiromesifen 22.90% SC) with Acidic, Alkaline, and neutral water pH levels. The study revealed that, Among insecticides, The leaf hopper population identified significantly lowest in treatment of Afidopyropen 50g/L DC was shown most effective insecticide treatment against leafhopper, it was at par with Fenpyroximate 5%EC followed by Spiromesifen 22.90% SC. Among water pH levels. The leaf hopper population found to be lowest under treatment with acidic water (5-6 pH) it was at par with neutral water (7 pH) and highest population was observed in alkaline water (8-9 pH). In terms of the interaction impact, leafhopper control on *Bt* cotton was more effective by insecticides in acidic and neutral water than by those applied to alkaline water. The yield was recorded significantly highest in Afidopyropen 50g/L DC (13.63 q ha^{-1}). It was at par with Spiromesifen 22.90% SC and yield was observed lowest in Fenpyroximate 5%EC. Among water pH levels, the maximum yield was obtained in treatment of acidic pH (12.78 q ha^{-1}) followed by neutral pH which is at par with acidic pH. The yield was recorded lowest in alkaline pH. Based on ICBR, the result among different treatments indicated that treatment with of Afidopyropen 50g/L with neutral pH gave the highest incremental cost benefit ratio of 1:9.60 than other treatments. To control the number of cotton leafhoppers, cotton growers can apply an alternate spray of concluded insecticides at a suitable pH level of water.

Keywords : *Bt* Cotton, Cost Benefit Ratio, Efficacy, Insecticides, leafhopper, Water pH levels, Yield.

INTRODUCTION

India's main cash crop, cotton, is termed to as the "White Gold" and is referred to as the "king of fibers." It belongs to the genus *Gossypium* and family Malvaceae. Cotton has played a significant role in agriculture and industrial activities of the nations (Mayee and Rao 2002). In Maharashtra cotton production area was 42.29 lakh ha with a production of 81.85 lakh bales and yield 329 kg per hectare for the year 2022-23 .In the last five years, Maharashtra produced on an average 79.54 lakh bales from 43.78 lakh hectare (Anonymous, 2023).

In India, *Bt* cotton since its release in 2002 by Genetic Engineering Approval Committee (GEAC) replaced more and more conventional cotton area and which has Developed through the incorporation of a gene from the soil bacterium (*Bacillus thuringiensis*) (*Bt*), this crop is engineered to express a protein that is toxic to certain pests, particularly the cotton bollworm. The area cultivated with *Bt* cotton is growing continuously because hybrids with guaranteed bollworm protection, presently sucking pests have become a serious challenge to cotton growers, resulting in significant yield losses. Aphids, *Aphis gossypii* (Glovar), leafhoppers, *Amrasca biguttula biguttula* (Ishida), thrips, *Thrips tabaci* (Linn), and whiteflies, *Bemisia tabaci* (Genn.), are among the sucking pests that are major from the seedling stage and result in significant losses of between 21.20 and 22.86 percent (Kulkarni *et al*., 2003). Among the previously listed sucking pests, damage estimated yield loss from *Amrasca biguttula biguttula* damage was observed to be around 18.78 percent due to the Leafhopper, whereas damage estimated yield loss from the sucking pests decreased by approximately 8.45 q/ha (Sarma *et al*., 2021). Leafhoppers are undoubtedly more severe among the many destructive sucking pests of cotton. Hence, suitable techniques to manage the sucking pest population on transgenic cotton are needed (Bheemanna *et al.,* 2015). This pest pose significant threats to crop yield and quality, necessitating the use of insecticides for effective control. However, the efficacy of these insecticides can be influenced by various environmental factors, one of the most critical being the pH of water used for their application.

Water pH plays a pivotal role in determining the chemical stability and bioavailability of insecticides. Water pH affects the efficacy of insecticides used for management of insect pests of cotton. When a pesticide is combined with water, its efficacy may decrease. The ionization state of the active ingredient can be impacted by water pH variations. Pesticide molecules break due to a chemical process called hydrolysis, releasing individual ions that recombine with other ions. As a result new combinations lack of miticidal or insecticidal qualities, target pests may take them up, which could reduce the efficacy of the pesticide application as a whole. For instance, certain insecticides may degrade more rapidly in alkaline conditions or may become less toxic at extreme pH levels (Raymond, 2016). Water pH affects the efficacy of insecticides used for management of insect pests of cotton (Pawar *et al.,* 2022). Both potato and shallot, pest and disease control results are slightly better with spray solutions with a pH 5 compared to pH 8 (Putter *et al.*, 2017b). In the context of *Bt* cotton, where integrated pest management strategies are employed, understanding the interaction between water pH and insecticide efficiency is essential for optimizing sucking pests control measures. Therefore, Keeping in view the above situation and need, an experiment was made to study "Effect of water pH on bioefficacy of insecticides against leafhopper on *Bt* cotton" at Seed Technology Research Unit, Dr. PDKV, Akola during *Kharif* 2023-24.

MATERIAL AND METHODS

The field experiment was conducted at Seed Technology Research Unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra during *Kharif* season of the year 2023-24 on gross plot size 5.4 × 5.4 m^2 with spacing 90 × 60 cm and variety Ajeet-5 BG II of *Bt* cotton. The experiment was carried out in Factorial Randomized Block Design (FRBD) of two factors i.e. Factor A i.e. insecticides and Factor B *i.e.* water pH levels with nine treatments replicated three times **.**Treatments details are given in the table below (Table 1).

The chemicals ammonia and citric acid were used to change the pH of the water to the proper requirement level. The pH of the field water was 7.4, and it changed to a different level for every 500 lit of water. Field water was treated with 0.26 ml of citric acid, 0.05 ml of citric acid and 0.66 ml of ammonia for pH ranges of 5–6pH, 7 pH, and 8–9pH, respectively.

To determine the bio-efficacy of insecticides at three water pH levels, three sprays on *Bt-cotton* were applied against leafhopper population. Insecticides at their prescribed doses were applied after crossing ETL of leafhopper. The subsequent sprays had given at an interval of 15 days. Spraying was done by using knapsack sprayer. The pre-treatment observations for leafhopper (*i.e.* No. of leafhoppers/3 leaves) was recorded one day before spraying. After treatment completion observations on leafhopper population were taken on 1st, 3rd, 7th, and 14 days after spraying on randomly selected five plants per plot. This field collected data on population of leafhopper was subjected to square root transformation before analysis. The square root transformed data was analyzed statistically for its significance by following ANOVA technique for Factorial Randomized Block Design (FRBD) statistical design and analyzed using OPSTAT software.

RESULTS AND DISCUSSION

Observations of leafhopper nymphs and adults were recorded, that includes the population of leafhoppers during the first, second, and third sprayings.

A. Cumulative effect of water pH levels on efficacy of insecticides after three spraying (1^{st}, 2^{nd} and 3^{rd}) against leafhopper population on cotton during 2023-24

Cumulative effect on leafhopper population one day before and 1, 3, 7 and 14 days after three spraying are presented in Table 2.

Factor (A) (Insecticides). In precount, significant differences were observed among treatments. The lowest number of leafhoppers population observed in the treatment of Afidopyropen 50g/L DC(7.65/3 leaves) and it was followed by Fenpyroximate 5%EC (7.99 / 3 leaves) which was at par with Afidopyropen 50g/L DC. The plots treated with Spiromesifen 22.90% SC recorded highest population of leafhopper (8.94 / 3 leaves).

On 1 DAS, Afidopyropen 50g/L DC (3.73/3 leaves) was significantly superior treatment against leafhoppers population but at par with Fenpyroximate 5% EC (4.81/3 leaves). The Spiromesifen 22.90% SC recorded maximum leafhoppers population (6.21/3 leaves).

on 3 DAS, The lowest number of leafhoppers was found in the treatment of Afidopyropen 50g/L DC(3.20/3 leaves) and it was followed by Fenpyroximate 5% EC (4.24/3 leaves) which was at par with Afidopyropen 50g/L DC. The plots treated with Spiromesifen 22.90% SC recorded maximum leafhopper population (5.73/3 leaves). Similar trend were recorded on 7 DAS and 14 DAS. The leafhopper population was minimum in Afidopyropen 50g/L DC and Fenpyroximate 5% EC which were at par with each other and maximum in Spiromesifen 22.90% SC.

Similarly, the mean data significantly indicated that, among the insecticides tested Afidopyropen 50g/L DC (3.83/ 3 leaves) was most effective against leafhopper and it was at par with Fenpyroximate 5% EC (4.69/ 3 leaves) was next better insecticides. Spiromesifen 22.90% SC (6.26 / 3 leaves) noticed more population of leafhopper as compared to above insecticides.

Factor (B) (Water pH levels). The data of leafhopper recorded one day before spray was statistically non-significant showing uniform distribution in all experimental treatment plots. On 1 DAS indicated that, the lowest number of leafhopper was found in the treatment of acidic pH (4.39/3 leaves) followed by Neutral pH (4.71/3 leaves) which was at par with acidic pH The highest population of leafhopper was noticed in alkaline pH (5.65/3 leaves) likewise, on 3 DAS, the leafhopper population was less in the treatment of acidic pH followed by Neutral pH The population was more in alkaline pH, Neutral water pH was found at par with acidic pH.

On 7 DAS, the lowest number of leafhopper recorded in the treatment of acidic pH (3.70/3 leaves) followed by Neutral pH (5.02/3 leaves). The maximum incidence of leafhopper was noticed in alkaline pH (5.91/3 leaves). On 14 DAS, indicated that the incidence of leafhopper noticed lowest in the treatment of acidic pH (4.82/3 leaves) and it was followed by Neutral pH (5.26 /3 leaves) which was at par with acidic pH. The leafhopper population was found highest in alkaline pH (6.46 /3 leaves).

The mean data of leafhopper population after treatment application. Significantly showed that, the spray solution having acidic pH (4.09/3 leaves) and neutral pH (4.71/3 leaves) which was at par with acidic pH were effective in reducing leafhopper population than alkaline pH (5.97/3 leaves).

Interaction Effect (Insecticides × Water pH levels). The interaction effect of insecticides and Water pH levels observations of cotton leafhopper showed that the precount, 1, 3 and 14 DAS were non-significant. The interaction showed significant differences on 7 DAS.

On 7 DAS. The treatment of interaction effect of Afidopyropen 50g/L DC in acidic water (3.05 / 3 leaves) was most effective against population of leafhopper and at par with Fenpyroximate 5% EC in acidic water (3.65/3 leaves), Afidopyropen 50g/L DC in neutral water (3.69/ 3 leaves)**,** Fenpyroximate 5% EC in neutral water (4.05/3 leaves) and Afidopyropen 50g/L DC in alkaline water (4.23/3 leaves), Spiromesifen 22.90% SC in acidic water (4.38/3 leaves), Fenpyroximate 5% EC in alkaline water (4.76/ 3 leaves), and it was followed by Spiromesifen 22.90% SC in neutral water (7.03 / 3 leaves) The least effective interaction was Spiromesifen 22.90% SC in alkaline water (8.74/3 leaves)against population of leafhopper.

The mean data indicated that, interaction of Insecticides and Water pH levels showed non-significant differences. However, numerically minimum leafhopper population was observed in Afidopyropen 50g/L DC in acidic water (3.32 / 3 leaves) followed by Afidopyropen 50g/L DC in neutral water (3.65/ 3 leaves), Fenpyroximate 5% EC in acidic water (4.08 /3 leaves), Fenpyroximate 5% EC in neutral water (4.49/3 leaves), Afidopyropen 50g/L DC in alkaline water (4.51/3 leaves), Spiromesifen 22.90% SC in acidic water (4.87/3 leaves), Fenpyroximate 5% EC in alkaline water (5.49/3 leaves), Spiromesifen 22.90% SC in neutral water (5.99/3 leaves) and in alkaline water (7.92/3 leaves).

The present findings correlate with the research conducted by Santhoshi *et al*. (2022), which determined that the pesticide Flonicamid 50WP @ 150gha^{-1} was the most successful in controlling the leafhopper population. Next best treatment, Afidopyropen 50 OD @ 1000 mlha^{-1} was the most effective treatment. These chemical pesticides are the most effective at controlling the number of cotton leafhoppers in both normal and HDPS planting situations. Similar findings were also reported by Chandaragi *et al.* (2023) results revealed that, among the tested chemicals afidopyropen 5.0% + abamectin 2.5% DC @ 56.26 g a.i./ha was found to be effective in reducing the population of cotton leafhoppers .Whereas, Desai *et al.* (2014) reported that, After three rounds of spraying initiating at ETL of leaf hopper (> 6/3 leaves) at 15 days interval, fenpyroximate 5 EC at both the doses @ 25 g a.i. /ha and 37.5 g a.i. / ha were found as effective as standard check imidacloprid 17.8 SL in cotton leafhopper control.

Hock (2012) suggested that, alkaline water supplying for spraying pesticide, especially if the pH is 8 or greater, is sensitive to hydrolysis, lower the pH of the water in the spray tank. A pH in the range 4-6 is recommended for most pesticide sprays. The pH can be adjusted to the 4-6 pH range using adjuvant that are marketed as buffering agents. Similarly, according to Raymond (2016), insecticides are typically more susceptible to alkaline hydrolysis than fungicides or regulators of plant development. The chemical groups of organophosphate (like acephate and chlorpyrifos), carbamate (like methiocarb), and pyrethroid (like bifenthrin, cyfluthrin, and fluvalinate) contain insecticide active components that are especially susceptible to alkaline hydrolysis or "high" pH solutions. These findings line up with research by Pawar *et al.* (2022), which found that the population of leafhoppers was largest under alkaline water conditions (9 pH) and lowest under acidic water treatment (5 pH). In terms of the interaction impact, insecticides in neutral or acidic water worked better than those in alkaline water to control leafhoppers on *Bt* cotton.

B. Yield and Economics

Among insecticides, seed cotton yield was recorded significantly highest in Afidopyropen 50g/L DC (13.63 q/ha),it was followed by Spiromesifen 22.90% SC (12.62 q/ha) which was at par with Afidopyropen 50g/L DC and The lowest yield was recorded in Fenpyroximate 5%EC (10.12 q/ha).Among Water pH levels, the yield was recorded significantly highest in spray solution in acidic water (12.78 q/ha), followed by neutral pH (12.33 q/ha) was found at par with acidic water and The lowest yield was recorded in alkaline pH (11.26 q/ha). The interaction effect showed non-significant differences. However, the seed cotton yield was numerically highest in Afidopyropen 50g/L DC in acidic pH(14.35 q/ha), followed by in Afidopyropen 50g/L DC in neutral pH(13.92 q/ha) and The lowest yield was recorded in Fenpyroximate 5% EC in alkaline pH(9.49 q/ha).

The present findings on seed cotton yield finds support in the work carried out by Pawar *et al.* (2022) result revealed that, the yield was recorded significantly highest in spray solution in acidic water (11.51 q/ha), followed by neutral pH (11.31 q/ha) and alkaline pH (10.77 q/ha). The interaction effect showed non-significant differences. However, the seed cotton was highest in insecticides in acidic and neutral pH. The lowest yield was recorded in insecticides in alkaline pH. Whereas, Kaneria *et al.* (2022) reported that, Considering the efficacy and yield, afidopyropen 50 g/l DC 0.010 % found the most effective treatment over rest of the treatments as it occupied the first rank with yield (2538 kg/ha).

The ICBR data presented in Table 3 revealed that, treatment with Afidopyropen 50g/L DC in neutral pH emerged as the most economically viable treatment giving the highest ICBR of 1:9.60. It was followed by the treatment Fenpyroximate 5% EC in neutral pH (1:9.57). The treatment with Spiromesifen 22.90% SC in alkaline pH found to be comparatively less economical exhibiting ICBR of 1:6.05.

Table 1: Details of treatments.

Tr. No.	Factor (A) Insecticides	Tr. No.	Factor (B) water pH levels
A_1	Afidopyropen 50g/L DC @ 20 ml per 10 litre of water	B_1	Acidic pH (5 - 6 pH) (Less than 7 pH)
A_2	Fenpyroximate 5%EC @ 15 ml per 10 litre of water	B_2	Neutral pH (7 pH)
A_3	Spiromesifen 22.90% SC @ 12 ml per 10 litre of water	B_3	Alkaline pH (8 - 9 pH) (More than 7 pH)

Table 2: Cumulative effect of water pH levels on efficacy of insecticides after three spraying (1st, 2nd and 3rd) against population of leafhopper on *Bt* cotton during 2023-24

Treatments	No. of leafhoppers/3 leaves					
	Precount	1 DAS	3 DAS	7 DAS	14 DAS	Mean
Factor (A) Insecticides						
Afidopyropen 50g/L DC (A1)	7.65 (2.74)*	3.73 (1.92)	3.20 (1.79)	3.65 (1.89)	4.72 (2.14)	3.83 (1.94)
Fenpyroximate 5%EC (A2)	7.99 (2.80)	4.81 (2.17)	4.24 (2.04)	4.25 (2.05)	5.45 (2.30)	4.69 (2.14)
Spiromesifen 22.90% SC (A3)	8.94 (2.98)	6.21 (2.48)	5.73 (2.36)	6.73 (2.56)	6.37 (2.49)	6.26 (2.47)
F test	Sig	Sig	Sig	Sig	Sig	Sig
SE (m±)	0.10	0.08	0.09	0.09	0.09	0.09
CD at 5%	0.31	0.25	0.26	0.26	0.28	0.26
Factor (B) water pH levels						
Acidic pH (5 - 6 pH) (B1)	7.90 (2.78)	4.39 (2.08)	3.45 (1.85)	3.70 (1.91)	4.82 (2.16)	4.09 (2.00)
Neutral pH (7 pH) (B2)	8.15 (2.83)	4.71 (2.15)	3.86 (1.96)	5.02 (2.21)	5.26 (2.27)	4.71 (2.15)
Alkaline pH (8 - 9 pH) (B3)	8.54 (2.91)	5.65 (2.37)	5.86 (2.38)	5.91 (2.42)	6.46 (2.51)	5.97 (2.42)
F test	NS	Sig	Sig	Sig	Sig	Sig
SE (m±)	0.10	0.08	0.09	0.09	0.09	0.09
CD at 5%	-	0.24	0.26	0.26	0.27	0.26
Interaction (A×B)						
A1B1	7.45 (2.69)	3.50 (1.87)	2.55 (1.59)	3.05 (1.73)	4.18 (2.01)	3.32 (1.80)
A1B2	7.53 (2.72)	3.67 (1.91)	2.72 (1.65)	3.69 (1.90)	4.54 (2.10)	3.65 (1.89)
A1B3	7.98 (2.81)	4.02 (2.00)	4.32 (2.06)	4.23 (2.04)	5.46 (2.31)	4.51 (2.10)
A2B1	7.78 (2.75)	4.50 (2.10)	3.16 (1.76)	3.65 (1.90)	4.99 (2.21)	4.08 (1.99)
A2B2	7.93 (2.79)	4.75 (2.15)	3.59 (1.89)	4.05 (2.06)	5.28 (2.26)	4.49 (2.09)
A2B3	8.28 (2.87)	5.18 (2.25)	5.97 (2.39)	4.76 (2.17)	6.06 (2.43)	5.49 (2.31)
A3B1	8.47 (2.90)	5.16 (2.25)	4.63 (2.14)	4.38 (2.07)	5.29 (2.26)	4.87 (2.18)
A3B2	8.99 (2.99)	5.72 (2.37)	5.25 (2.28)	7.03 (2.57)	5.96 (2.43)	5.99 (2.41)
A3B3	9.34 (3.05)	7.76 (2.77)	7.29 (2.63)	8.74 (2.93)	7.87 (2.77)	7.92 (2.78)
F test	NS	NS	NS	Sig	NS	NS
SE (m±)	0.18	0.14	0.15	0.15	0.16	0.15
CD at 5%	-	-	-	0.45	-	-
C.V.%	10.82	11.24	12.80	12.08	12.18	12.07

* Figures in parentheses are square root transformed values Sig: Significant ;NS: Non-Significant; DAS: Days After Spraying

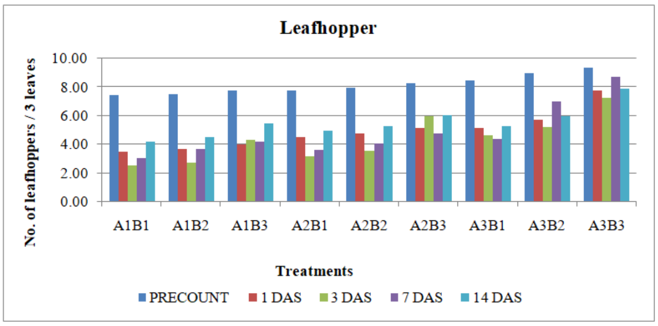

Fig. 1. Cumulative effect of insecticides in different water pH levels on cotton leafhopper population after three spraying (1st, 2nd and 3rd).

Table 3: Impact of insecticides at varying pH levels of water on seed cotton yield in 2023–2024 and Incremental Cost : Benefit Ratio (ICBR) for analysis of insecticidal treatments effectiveness.

Treatments		Quantity of pesticide and Chemical (ml or g/ha)	No. of sprays	Cost of pesticids and Chemical Rs/ha	Labour and sprayer charges (Rs/ha)	Cost of Plant protection (Rs/ha) (A)	Yield of Seed cotton (q/ha)	Gross Profit (Rs/ha) (B)	Net Profit (Rs/ha) (B-A)	ICBR	Rank
T1	A1B1	1000+260	3	8346	1650	9996	14.35	104037.5	94041.5	1:9.40	3
T2	A1B2	1000+42	3	7863	1650	9513	13.92	100920	91407	1:9.60	1
T3	A1B3	1000+660	3	8790	1650	10440	12.62	91495	81055	1:7.76	5
T4	A2B1	750+260	3	5856	1650	7506	10.62	76995	69489	1:9.25	4
T5	A2B2	750+42	3	5373	1650	7023	10.24	74240	67217	1:9.57	2
T6	A2B3	750+660	3	6300	1650	7950	9.49	68802.5	60852.5	1:7.65	6
T7	A3B1	600+260	3	9888	1650	11538	13.38	97005	85467	1:7.40	8
T8	A3B2	600+42	3	9405	1650	11055	12.83	93017.5	81962.5	1:7.41	7
T9	A3B3	600+660	3	10332	1650	11982	11.66	84535	72553	1:6.05	9

1) Labour charges for one spray/ha. @ Rs. 250/ labour / day, 2) price of seed cotton @ Rs. 7250 /qtl.3) Quantity of water: 500 litre/ha/spray

CONCLUSIONS

The results of this study show that, when compared to the chemical insecticides mentioned above, Afidopyropen 50g/L DC was the most effective insecticide against the population of cotton leafhoppers. It was at par with Fenpyroximate 5%, which was the next best insecticide fallowed by Spiromesifen 22.90% SC. The acidic spray solution decreased leafhopper population the most effectively among the water pH levels, followed by neutral, which was at par with acidic pH, and The alkaline spray solution had the largest leafhopper population. In terms of the interaction impact, leafhopper control on *Bt* cotton was better served by insecticides in acidic and neutral water than by those in alkaline water.

Ultimately, it is determined that the pH of the water has an impact on the effectiveness of pesticides employed to control the sucking pest complex in *Bt* cotton. In order to reduce the risk of undesirable effects of water pH, degradation risk, and alkaline hydrolysis risk, the pH of the water or spray solution should be checked and corrected if it is alkaline (pH > 8). This will enhance the efficiency of insecticides.

FUTURE SCOPE

Present study will be helpful to identify optimal water pH conditions for maximizing efficacy of insecticides against specific sucking pests (*i.e.* leafhopper) on *Bt* cotton and will contribute towards developing more efficient pest management practices that can help farmers protect their crops from damage caused by sucking pests in *Bt* cotton .

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Conflict of Interest. None.

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