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Effect of water quality parameters from different districts of Vidarbha on efficacy of insecticides under laboratory conditions

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Abstract

Spray water quality is an often overlooked factor that can substantially influence the stability and efficacy of insecticides, particularly when spray solutions are stored before application. However, limited information is available on the combined influence of water pH, dissolved salts, electrical conductivity on the efficacy of insecticides. The present study was therefore undertaken to evaluate the influence of different water qualities on the efficacy of selected insecticides against *S. litura*. Three water sources differing in physicochemical and microbiological characteristics, viz., 3 natural water sources Yavatmal, Sindewahi and Akola water, were evaluated. The water samples were tested for pH, total dissolved solids (TDS), electrical conductivity (EC). Four insecticides, namely Emamectin benzoate 5% SG, Profenofos 50% EC, Spinetoram 11.70% SC and Chlorantraniliprole 9.30% + Lambda-cyhalothrin 4.60% ZC, were treatment. The study further assessed the effect of a three-hour holding period between preparation and application of the spray solutions, to assess the influence of short-term storage on insecticide performance. Among the water samples, Sindewahi sample with near neutral pH (7.4) produce high mortality and Akola water with High pH, EC and TDS produce lowest Mortality. Among the insecticides, Spinetoram 11.70 SC exhibited the highest overall efficacy, followed by Chlorantraniliprole + Lambda-cyhalothrin, Emamectin benzoate and Profenofos. The three-hour holding period accentuated the reduction in efficacy under alkaline conditions, particularly for Profenofos, indicating greater susceptibility to degradation. The findings demonstrate that spray water pH is a critical determinant of insecticide performance, while low TDS and EC further favour insecticide stability. The study highlights the importance of selecting suitable spray water and minimizing the interval between spray preparation and application for achieving consistent insecticidal efficacy and improving pest management.

Keywords: Water quality, pH, EC, TDS, *Spodoptera litura*, insecticide efficacy

Introduction

Water, being the primary diluent in spray solutions making 95% of the spray mixture plays a crucial role in determining the physical-chemical stability and efficacy of insecticides through hydrolysis, changes in solubility and dispersion, interaction with dissolved salts. Certain water chemistry can potentially react with, and change the efficacy of pesticides (Park and Chong, 2015) [3]. One of the most defining factors of water quality is the pH of water. Pesticides are generally formulated to be in the range of slightly acidic to slightly alkaline. Therefore, most pesticides will perform best when mixed with water with pH ranging from 4.0 to 6.5 (Whitford *et al.*, 2009) [7], and up to pH 7.0 (Tharp and Sigler, 2013). According to Mekonnen and Zerihun (1999) [2], insecticide effectiveness decreases when water hardness and organic content increase because they cause chemical binding and reduced bioavailability. Pawar *et al.* (2022) [4], who emphasized that when the pH of the spray solutions is alkaline it is advisable to lower the pH to reduce the risk of degradation and consequently lower the efficacy of insecticides. Farmers commonly use locally available water sources without assessing their suitability for pesticide preparation, while differences in water quality may contribute to inconsistent pest control even when the recommended insecticide and dose are used. The present investigation focuses on understanding how different water quality parameters affect the performance of selected insecticides under controlled conditions.

By studying their effect on *Spodoptera litura* using the leaf dip method.

Materials and Methods

The study was conducted to evaluate the “Effect of water quality parameters on efficacy of insecticides”. The water samples were collected from three different districts viz. Akola, Yavatmal. Water samples were analyzed for pH, EC & TDS. The study was conducted in the Toxicology Laboratory of Department of Entomology, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola (M.S.) during the year 2025-2026.

The test insect *Spodoptera litura* was reared in laboratory on Castor leaves. Procedure described by Tabashnik and Cushing (1987) [5] was adopted for leaf dip bioassay. Third instar larvae of test insect was exposed to test insecticide solution prepared with given concentrations of insecticides. The prepared insecticide solutions from given concentration of insecticides were kept as such for 1 hour and after 1 hour castor leaves were dipped in the insecticide solutions and were feed to insects. Mortality of the insects was recorded after 1,3,5,7 days of feeding. Similarly, the prepared insecticide solutions from given concentration of insecticides were kept as such for 3 hour and after 3 hour leaves were dipped in the insecticide solutions and were feed to insects. Mortality of the insects was recorded after 1,3,5,7 days of feeding.

Ten larvae were carefully transferred into each petri dish using a fine camel hairbrush. Larval mortality at the respective insecticide concentrations was recorded at 1, 3, 5 and 7 days after exposure to the insecticides. percent mortality was calculated using the formula

$$\text{Percent mortality} = \frac{\text{Number of insects dead}}{\text{Total number of insects' release}} \times 100$$

Results and Discussion

The performance of the selected insecticides against *Spodoptera litura* varied with the source of natural water used for spray preparation as well as the period for which the spray solutions were kept before application. The three natural water sources showed differences in their physicochemical and microbiological properties. Yavatmal water had a pH of 7.6, TDS of 357 ppm and EC of 0.71 dS m⁻¹, while Sindewahi water had a slightly lower pH of 7.3, TDS of 359 ppm and EC of 0.72 dS m⁻¹. Akola water was comparatively more mineralized, with a pH of 7.8, TDS ranging from 820 ppm and EC of 1.58 dS m⁻¹.

Effect of water quality on insecticide efficacy after one-hour holding period

Factor A (water samples)

After holding the insecticide solutions for one hour before application, significant differences were observed among the natural water sources throughout the observation period. Sindewahi water performed best, with cumulative larval mortality increasing from 44.10% at 1 DAT to 72.85, 82.35 and 96.31% at 3, 5 and 7 DAT, respectively. Yavatmal water recorded 35.48, 52.51, 70.24 and 83.25%, whereas Akola water recorded 31.37, 47.49, 66.92 and 75.24% at the corresponding observations.

At 1 DAT, mortality in Sindewahi water was significantly higher than that recorded in both Yavatmal and Akola water,

while Yavatmal was also significantly superior to Akola. At 3 DAT, Sindewahi continued to record significantly higher mortality than the other two water sources, whereas Yavatmal and Akola were statistically comparable, both recording 50.84% mortality. A similar trend was observed at 5 DAT, when Sindewahi recorded 77.99% mortality compared with 68.47% in Yavatmal and 69.65% in Akola; the latter two were statistically at par. At 7 DAT, mortality increased to 94.16% in Sindewahi, followed by 83.35% in Yavatmal and 74.41% in Akola, with the three water sources showing significant differences.

The comparatively better performance of Sindewahi water may be associated with its slightly lower pH and relatively favourable mineral characteristics. Although the TDS and EC of Sindewahi and Yavatmal water were almost similar, Sindewahi had a lower pH. Akola water, on the other hand, had both a higher pH and considerably greater TDS and EC. The lower mortality observed with Akola water may therefore be related to its higher concentration of dissolved salts and ions, which could influence the behaviour and stability of insecticide molecules in the spray solution.

Factor-B Insecticide

The four insecticides differed significantly in their efficacy at all observation periods. Spinetoram 11.70 SC was the most effective, with mean mortality increasing from 41.56% at 1 DAT to 68.71, 89.42 and 95.10% at 3, 5 and 7 DAT, respectively. The next best treatment was Chlorantraniliprole 9.30% + lambda-cyhalothrin 4.60% ZC, which recorded 34.68, 59.93, 82.47 and 90.37% mortality at the respective observations. Emamectin benzoate 5% SG resulted in 31.89, 52.27, 76.02 and 88.53%, while Profenofos 50% EC recorded the lowest mortality, with 24.94, 46.04, 66.10 and 77.20% at 1, 3, 5 and 7 DAT, respectively. The CD at 1% was 1.54, 1.67, 2.55 and 3.47%, respectively.

Thus, the efficacy of the insecticides followed the order Spinetoram 11.70 SC > Chlorantraniliprole 9.30% + lambda-cyhalothrin 4.60% ZC > Emamectin benzoate 5% SG > Profenofos 50% EC. The consistently higher mortality recorded with Spinetoram suggests that it retained a greater proportion of its insecticidal activity after dilution and one-hour holding. In comparison, the lower mortality recorded with Profenofos indicates comparatively poorer performance under the tested water conditions.

The present findings are in close agreement with observations of Hanan and Hafez (2015) [1] reported that insecticides particularly organophosphates & carbamates undergo chemical breakdown in alkaline water (pH>7), salinity and pH of spray water can diminishes the effectiveness of insecticides.

Interaction between natural water sources and insecticides after one-hour holding

The response of *S. litura* was also influenced by the interaction between water source and insecticide. Among the combinations involving natural water sources, Sindewahi water in combination with Spinetoram produced the highest mortality throughout the observation period, recording 43.31, 79.99, 86.99 and 99.97% at 1, 3, 5 and 7 DAT, respectively. Sindewahi + chlorantraniliprole + lambda-cyhalothrin recorded 40.00, 73.48, 73.48 and 95.23%, while Sindewahi + Emamectin benzoate resulted in 36.59, 63.41, 80.00 and 90.00% mortality.

With Yavatmal water, Spinetoram recorded 40.00, 69.97, 73.47 and 90.00% mortality at 1, 3, 5 and 7 DAT, respectively. Yavatmal + Emamectin benzoate recorded 30.00, 50.00, 70.00 and 86.99%, whereas Yavatmal + Profenofos resulted in 20.00, 40.00, 63.40 and 70.00% mortality.

In Akola water, Spinetoram again performed better than the other insecticides, recording 36.59, 60.00, 80.00 and 80.00% mortality at 1, 3, 5 and 7 DAT. Akola + Emamectin benzoate recorded 23.18, 53.35, 73.47 and 76.82%, while Akola + chlorantraniliprole + lambda-cyhalothrin recorded 30.00, 50.00, 63.41 and 73.47%. The lowest mortality was

consistently associated with Akola + Profenofos, which recorded only 13.01, 40.00, 56.69 and 66.74% mortality at the respective observation periods.

These results indicate that the effect of water quality was not uniform across insecticides. The combination of Sindewahi water with Spinetoram was particularly effective, ultimately producing almost complete mortality at 7 DAT. In contrast, the Akola water + Profenofos combination showed considerably lower activity throughout the observation period. This suggests that the chemical characteristics of the spray water can modify insecticide performance depending on the active ingredient and formulation.

Table 1: Effect of water quality on insecticide efficacy after 1hr of spray solution preparation. preparation.

Treatment	Percentage Larval Moratlity (%)			
	1 DAT	3 DAT	5 DAT	7 DAT
Factor-A Water Parameters				
YAVATMAL	35.48 (36.56)	52.51 (46.44)	70.24 (56.94)	83.25 (65.84)
SINDEWAHI	44.10 (41.61)	72.85 (58.60)	82.35 (65.16)	96.31 (78.93)
AKOLA	31.37 (34.06)	47.49 (43.56)	66.92 (54.89)	75.24 (60.16)
F test	Sig	Sig	Sig	Sig
SE(m±)	0.65	0.39	0.51	0.86
CD @ 1%	2.58	1.55	2.00	3.42
Factor-B Insecticides				
Emamectin benzoate 5% SG	33.26 (35.22)	53.51 (47.01)	70.34 (57.00)	83.86 (66.31)
Profenofos 50% EC	26.31 (30.86)	47.77 (43.72)	63.41 (52.78)	73.84 (59.24)
Spinetoram 11.70% SC	45.54 (42.44)	67.08 (54.99)	82.68 (65.41)	93.01 (74.67)
Chlorantraniliprole 9.30% + Lambda-cyhalothrin 4.60% ZC	43.27 (41.13)	62.82 (52.43)	76.21 (60.81)	91.48 (73.03)
F test	Sig	Sig	Sig	Sig
SE(m±)	0.75	0.45	0.58	1.00
CD @ 1%	2.97	1.79	2.31	3.95
AxB Interaction				
A1B1	30.00 (33.21)	50.00 (45.00)	70.00 (56.79)	83.64 (66.14)
A1B2	23.18 (28.78)	43.31 (41.15)	60.00 (50.77)	70.00 (56.79)
A1B3	46.65 (43.08)	60.00 (50.77)	79.99 (63.43)	90.00 (71.57)
A1B4	43.31 (41.15)	56.69 (48.85)	70.00 (56.79)	86.99 (68.86)
A2B1	40.00 (39.23)	70.00 (56.79)	80.00 (63.43)	90.00 (71.57)
A2B2	36.59 (37.22)	60.00 (50.77)	70.00 (56.79)	83.64 (66.14)
A2B3	50.00 (45.00)	79.99 (63.43)	90.00 (71.57)	99.97 (89.01)
A2B4	50.00 (45.00)	79.99 (63.43)	86.99 (68.86)	99.97 (89.01)
A3B1	30.00 (33.21)	40.00 (39.23)	60.00 (50.77)	73.47 (59.00)
A3B2	20.01 (26.57)	40.00 (39.23)	60.00 (50.77)	66.74 (54.78)
A3B3	40.00 (39.23)	60.00 (50.77)	76.82 (61.22)	80.00 (63.43)
A3B4	36.59 (37.22)	50.00 (45.00)	70.00 (56.79)	76.82 (61.22)
F test	Non Sig	Sig	Sig	Sig
SE(m±)	1.30	0.79	1.01	1.73
CD @ 1%	5.15	3.11	4.00	6.84
CV%	6	2.7	2.9	4.3

*Values in parentheses are arcsine transformed values

Effect of water quality on insecticide efficacy after three-hour holding period

Factor A (water samples)

Extending the holding period from one to three hours resulted in a reduction in the overall performance of the natural-water treatments, although the relative ranking of the water sources remained similar. Sindewahi water again recorded the highest mortality, followed by Yavatmal and Akola water. Sindewahi recorded 38.26% mortality at 1 DAT, increasing to 60.22, 79.04 and 95.36% at 3, 5 and 7 DAT, respectively. Yavatmal recorded 28.87, 47.49, 63.56 and 79.81%, whereas Akola recorded 21.82, 41.54, 59.28 and 70.26% at the corresponding observations. The consistent superiority of Sindewahi water after both holding periods indicates that this water source provided comparatively favourable conditions for maintaining insecticide activity.

Notably, increasing the holding period to three hours reduced mortality in all three natural waters. The reduction was particularly evident in Akola water, where mortality declined from 31.37 to 21.82% at 1 DAT, 47.49 to 41.54% at 3 DAT, 66.92 to 59.28% at 5 DAT, and 75.24 to 70.26% at 7 DAT. This indicates that prolonged holding of the spray solution may have contributed to a gradual reduction in insecticide effectiveness.

Factor-B Insecticide

The insecticide response after three-hour holding followed the same general order observed after one hour. Spinetoram recorded 40.41, 61.54, 86.33 and 94.16% mortality at 1, 3, 5 and 7 DAT, respectively. This was followed by chlorantraniliprole + lambda-cyhalothrin (33.08, 55.26, 78.82 and 90.17%), Emamectin benzoate (32.47, 47.21, 70.66 and 85.47%) and Profenofos (22.74, 43.21, 61.54 and 74.36%). The persistence of Spinetoram as the most effective insecticide under both holding periods indicates relatively better retention of its insecticidal activity. Profenofos, in contrast, remained the least effective treatment, particularly after prolonged holding.

Interaction between natural water sources and insecticides after three-hour holding

The interaction between water source and insecticide further demonstrated the influence of water quality on insecticide performance. Sindewahi + Spinetoram remained the most effective combination, producing 43.31, 66.74, 76.82 and 99.97% mortality at 1, 3, 5 and 7 DAT, respectively. Sindewahi + chlorantraniliprole + lambda-cyhalothrin recorded 40.00, 63.40, 70.00 and 95.23%, whereas Akola + Profenofos was the least effective combination, with mortality of only 10.00, 36.59, 50.00 and 63.41%, respectively.

Table 2: Effect of water quality on insecticides efficacy after 3hr of spray solution preparation

Treatment	Percentage Larval Moratilty (%)			
	1 DAT	3 DAT	5 DAT	7 DAT
Factor-A Water Parameters				
YAVATMAL	28.87 (32.50)	47.49 (43.56)	63.56 (52.87)	79.81 (63.30)
SINDEWAHI	38.26 (38.21)	60.22 (50.90)	79.04 (62.75)	95.36 (77.56)
AKOLA	21.82 (27.85)	41.54 (40.13)	59.28 (50.35)	70.26 (56.950)
F test	Sig	Sig	Sig	Sig
SE(m±)	0.42	0.48	0.73	0.86
CD @ 1%	1.67	1.90	2.87	3.42
Factor-B Insecticides				
Emamectin benzoate 5% SG	28.49 (32.26)	45.54 (42.44)	64.80 (53.61)	79.43 (63.03)
Profenofos 50% EC	19.31 (26.07)	39.86 (39.15)	56.79 (48.90)	69.23 (56.31)
Spinetoram 11.70% SC	37.68 (37.87)	57.94 (49.57)	78.61 (62.45)	91.48 (73.03)
Chlorantraniliprole 9.30% + Lambda-cyhalothrin 4.60% ZC	33.26 (35.22)	55.73 (48.29)	69.26 (56.33)	89.82 (71.39)
F test	Sig	Sig	Sig	Sig
SE(m±)	0.49	0.56	0.84	1.00
CD @ 1%	1.93	2.20	3.31	3.95
AxB Interaction				
A1B1	26.53 (31.00)	46.65 (43.08)	60.00 (50.77)	79.99 (63.43)
A1B2	20.01 (26.57)	40.00 (39.23)	53.35 (46.92)	66.74 (54.78)
A1B3	50.00 (45.00)	53.35 (46.92)	73.47 (59.00)	86.99 (68.86)
A1B4	30.00 (33.21)	50.00 (45.00)	66.74 (54.78)	83.64 (66.14)
A2B1	40.00 (39.23)	50.00 (45.00)	76.82 (61.22)	86.99 (68.86)
A2B2	30.00 (33.21)	50.00 (45.00)	66.74 (54.78)	79.91 (63.37)
A2B3	43.30 (41.15)	70.00 (56.79)	90.01 (71.57)	99.97 (89.01)

A2B4	40.00 (39.23)	70.00 (56.79)	79.99 (63.43)	99.97 (89.01)
A3B1	20.01 (26.57)	39.23 (40.00)	56.70 (48.85)	70.00 (56.79)
A3B2	10.00 (18.43)	33.21 (30.00)	50.00 (45.00)	60.00 (50.77)
A3B3	30.00 (33.21)	50.00 (45.00)	70.00 (56.79)	76.82 (61.22)
A3B4	30.00 (33.21)	43.08 (46.65)	60.00 (50.77)	73.47 (59.00)
F test	Sig	Sig	Non Sig	Sig
SE(m±)	0.85	0.96	1.45	1.73
CD @ 1%	3.35	3.80	5.74	6.84
CV%	4.4	3.7	4.5	4.5

*Values in parentheses are arcsine transformed values

Comparison of one-hour and three-hour holding periods

A comparison of the two holding periods clearly showed that one-hour holding generally resulted in higher larval mortality than three-hour holding, although the magnitude of reduction differed among water sources and insecticides. For Factor A, Sindewahi water recorded 44.10, 72.85, 82.35 and 96.31% mortality after one-hour holding, compared with 38.26, 60.22, 79.04 and 95.36% after three-hour holding at 1, 3, 5 and 7 DAT, respectively. Yavatmal mortality decreased from 35.48, 52.51, 70.24 and 83.25% to 28.87, 47.49, 63.56 and 79.81%, while Akola declined from 31.37, 47.49, 66.92 and 75.24% to 21.82, 41.54, 59.28 and 70.26%, respectively.

The reduction was also apparent at the insecticide level. Spinetoram decreased from 45.54, 67.08, 82.68 and 93.01% after one-hour holding to 37.68, 57.94, 78.61 and 91.48% after three-hour holding. Profenofos showed a decrease from 26.31, 47.77, 63.41 and 73.84% to 19.31, 39.86, 56.79 and 69.23%, respectively.

Thus, extending the holding period from one to three hours resulted in a noticeable reduction in mortality, particularly at 3 and 5 DAT, although mortality at 7 DAT remained high. The comparatively greater reduction at the earlier observation periods suggests that prolonged holding may have reduced the amount of active insecticide available for effective pest control.

Conclusion

The consistency of the water-source ranking under both holding periods indicates that the characteristics of the natural water played an important role in determining insecticide performance. Sindewahi water, with its relatively lower pH and considerably lower TDS and EC than Akola water, appeared to provide more favorable conditions for maintaining insecticidal activity. In contrast, the higher dissolved-solids content and EC of Akola water may have contributed to reduced efficacy, particularly for insecticides that were comparatively less stable in the spray medium. Overall, the findings emphasize the importance of using suitable-quality water and applying insecticide solutions soon after preparation to achieve better and more consistent control of pest.

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