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Physical Compatibility of Fungicides and Insecticides used in Blackgram Pest and Disease Management

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ABSTRACT

In order to verify the physical compatibility of three most commonly used fungicides (azoxystrobin, propiconazole and mancozeb) against diseases with three most commonly used insecticides (triazophos, acetamiprid and chlorantraniliprole) against pests of blackgram, individual chemicals and their combinations were assessed for physical compatibility. Sedimentation test revealed no creamy layer or sedimentation in any of the combinations. Further, specific gravity values did not deviate too much from their individual specific gravity values. This indicated physical compatibility among the test combinations.

Key words: *Acetamiprid, Azoxystrobin, Chlorantraniliprole, Mancozeb, Physical Compatibility, Propiconazole, Triazophos*

India is the largest producer and consumer of pulses in the world contributing around 25–28 % of the total global production (Avinash and Patil, 2018). Blackgram (*Vigna mungo* (L) Hepper) occupies an area of 44.78 lakh ha producing 28.32 lakh tons with a productivity of 632 kg/ha (Indiastat.com, 2016-17). Blackgram crop is most opted crop in A.P as it fits well in rice – pulse cropping system as a relay crop particularly in North Coastal and Krishna – Godavari zones.

The crop suffers from many biotic stresses leading to decreased productivity levels. . Important diseases that infect blackgram are powdery mildew (*Erysiphe polygoni)*, rust (*Uromyces appendiculatus)*, leaf spots (*Corynespora cassicola, Cercospora canescens, Alternaria altrenata),* anthracnose (*Colletotrichum lindemuthianum)*, Macrophomina blight (*Macrophomina phaseolina)*, root rot and leaf blight (*Rhizoctonia solani)*, bacterial leaf blight (*Xanthomonas phaseoli)* and viral diseases caused by *Mungbean yellow mosaic virus* and *Leaf crinkle virus.*

The insect pests which attack blackgram are whitefly (*Bemisia tabaci*), jassid (*Empoasca* spp.), bean aphid (*Aphis craccivora*), leaf webber (*Grapholita critica*), tobacco caterpillar (*Spodoptera litura*), spotted pod borer (*Maruca vitrata*), flea beetle (*Madurasia obscurella)*, hairy caterpillar (*Spilosoma obliqua*), gram caterpillar (*Helicoverpa armigera*), Epilachna beetle (*Epilachna* spp.), flower thrips (*Caliothris* ssp.), leaf miner (*Chromatomyia horticola*) and stem fly (*Ophiomyia phaseoli*).

The yield losses due to pests and diseases was about 20-55% and 30-50% respectively (Singh, 2009). There have been a few reports of fungicide expressing insecticidal action on certain insect pest species and insecticides having fungicidal properties. A chemical possessing both insecticidal and fungicidal properties, if identified, would help in reducing the pesticide consumption and pesticide load in the environment. Hence, there is every need to generate information on effective and economical combinations; so as to advise the farmers about detrimental effect of combinations which would result in wasteful expenditure as well as crop loss. Though tank mixes are not recommended growers often mix insecticides and fungicides to control both insect pests and fungal diseases simultaneously to save time, labour and money. As the prices of blackgram are on a high in recent times, farmers are rushing to spraying pesticides, either alone or in combination, indiscriminately.

Besides other problems such as resurgence, resistance, pollution *etc*, incompatibility also poses many problems like impairment of effectiveness of either of the component, development of undesirable physical properties, reduction of toxicity and increased phytotoxic effects. There was resurgence of whitefly in cotton and tomato crops when dinotefuran and clothianidian were applied (Ghosal and Chatterjee, 2018). *Uncinula necator* variants showed resistance to triazole fungicides used against grape powdery mildew (Halleen *et al*., 2000). The symptoms of phytotoxicity include chlorotic spots (Peshney, 1990) and foliage injury, darkened shallow pits on fruits (Poe and Jones, 1972), scorching and bleaching of foliage and reduced growth.

Keeping these problems in view and also the scanty information on the compatibility of new

pesticides, the present investigation is aimed at assessing the physical compatibility of popularly used insecticides and fungicides in blackgram.

MATERIALS AND METHODS

Six popularly used pesticides, (three fungicides and three insecticides) in blackgram were selected for the present study and their recommended dosages and relevant information are furnished in Table 1.

Physical Compatibility

Physical compatibility of spray solutions of selected fungicide - insecticide combinations was tested by conducting emulsion stability test and specific gravity test. Details of combinations and dosages are mentioned in Table 2.

Emulsion stability test

For testing the emulsion stability of the combinations, each fungicide (30 ml) and insecticide (30 ml) solutions were poured into a beaker. The contents of the beaker were stirred with a glass rod at the rate of four revolutions per second during the addition of pesticides. Such diluted emulsion was made to 100 ml with a standard hard water and transferred immediately to clean and graduated cylinder and kept at room temperature ($\cong 30 \pm 1\ ^0C$) for one hour. After the specified time, the volume of the creamy matter at the top and/or the sediment, if any, at the bottom was observed. The same test was performed with normal tap water and distilled water. The emulsion was considered "stable" when the creamy matter or the sediment, if any, did not exceed 2.0 ml (ISI). The experiment was repeated thrice.

Specific gravity test

Cleaned and dried specific gravity bottle of 25 ml capacity was weighed without water (W_1) or with distilled water (W_2) or with pesticide combination or individual fungicide/ insecticide (W_3). Specific gravity of pesticide combination was calculated using the following formula

$$\text{Specific gravity} = \frac{\text{Weight of known volume of the pesticide}}{\text{Weight of known volume of the water}}$$

$$= \frac{(W_3 - W_1)}{(W_2 - W_1)}$$

RESULTS AND DISCUSSION

Physical compatibility of fungicide and insecticide combinations was tested by emulsion stability test and specific gravity test as prescribed by Indian standard specifications. All the chemicals were assessed singly and in combinations at three different concentrations, *i.e*., recommended concentration, half of recommended concentration and double the recommended concentration with three different waters (tap water, distilled water and standard hard water) in order to see the effect of decrease or increase in the concentration on compatibility in different types of water.

Emulsion stability test

The results obtained from emulsion stability test revealed that when the test fungicides and test insecticides were mixed with tap water, distilled water and standard hard water (324 ppm) at three doses *i.e*., recommended dose, higher dose and lower dose, there was no sedimentation at the bottom and creamy layer at the top of the measuring cylinder. More over there was no formation of clumps, clods, emulsions and separation of mixtures when they were mixed. As there was no formation of sedimentation or creamy layer (>2ml) in all the three types of water with the three doses tested it is proved that all the fungicide and insecticide combinations tested are physically stable and compatible.

All the nine combinations of the fungicides and insecticides are found to be physically compatible as the sedimentation and foaming are below the prescribed limit (2 ml/l) at the top or bottom of the 100 ml measure cylinder. Similar results were obtained by different workers with different fungicide and insecticide combinations in various crops. Devi and Prakasam (2013) reported that azoxystrobin at three concentrations 0.08, 0.1, 0.12 ml with triazophos was physically compatible as they did not show any creamy appearance at the top and sedimentation at the bottom of the cylinder. The findings of Aravind *et al*. (2015) also revealed that difenthiuron is physically compatible with mancozeb. The experimental results of Raju *et al*. (2018) also concluded that chlorantraniliprole with propiconazole showed neither foaming nor sedimentation indicating that all the 15 pesticide combinations were physically compatible. Goud *et al*. (2010) had reported that propiconazole in combination with each of the insecticides viz., novaluron and indoxacarb was physically compatible since no foaming was observed with 0.0 and 1.8 ml of sedimentation, respectively which was less than the limits of 2 ml / 100 ml as specified by ISI (Indian Standards Institute).

Table 1. Particulars of pesticides used to study the physical and chemical compatibility of fungicide and insecticide combinations.

S. No	Common name	Trade name	Formulation	Dosage	Source
1	Azoxystrobin	Amistar	23%SC	1ml/l	Syngenta India Ltd., Mumbai
2	Propiconazole	Tilt	25%EC	1ml/l	Syngenta India Ltd., Mumbai
3	Mancozeb	Indofil M -45	75% WP	2.5g/l	Indofil industries Ltd., Mumbai
4	Triazophos	Sutathion	40%EC	1.5ml/l	Sudarshan Chemical Industries Ltd. Mumbai
5	Acetamiprid	Dhan Preet	20%SP	0.2g/l	Dhanuka Agritech Ltd., Haryana
6	Chlorantraniliprole	Coragen	18.5%SC	0.3ml/l	DuPont India Pvt. Ltd., Haryana

Table 2. Particulars of dosage of fungicides, insecticides alone and their combinations used in physical compatibility test.

S. No.	Treatments	Recommended dose	Higher dose	Lower dose
1	Azoxystrobin 23%SC	1ml/l	2ml/l	0.5ml/l
2	Propiconazole 25%EC	1ml/l	2ml/l	0.5ml/l
3	Mancozeb 75%WP	2.5g/l	5g/l	1.25g/l
4	Triazophos 40%EC	1.5ml/l	3ml/l	0.75ml/l
5	Acetamiprid 20%SP	0.2g/l	0.4g/l	0.1g/l
6	Chlorantraniliprole 18.5%SC	0.3ml/l	0.6ml/l	0.15ml/l
7	Azoxystrobin 23%SC + Triazophos 40%EC	1ml/l + 1.5ml/l	2ml/l + 3ml/l	0.5ml/l+0.75ml/l
8	Azoxystrobin 23%SC + Acetamiprid 20%SP	1ml/l + 0.2g/l	2ml/l + 0.4g/l	0.5ml/l + 0.1g/l
9	Azoxystrobin 23%SC + Chlorantraniliprole 18.5%SC	1ml/l + 0.3ml/l	2ml/l + 0.6ml/l	0.5ml/l + 0.1.5ml/l
10	Propiconazole 25%EC + Triazophos 40%EC	1ml/l + 1.5ml/l	2ml/l + 3ml/l	0.5ml/l + 0.75ml/l
11	Propiconazole 25%EC+ Acetamiprid 20%SP	1ml/l + 0.2g/l	2ml/l + 0.4g/l	0.5ml/l + 0.1g/l
12	Propiconazole 25%EC + Chlorantraniliprole 18.5%SC	1ml/l + 0.3ml/l	2ml/l + 0.6ml/l	0.5ml/l + 0.15ml/l
13	Mancozeb 75%WP + Triazophos 40%EC	2.5g/l + 1.5ml/l	5g/l + 3ml/l	1.25g/l + 0.75ml/l
14	Mancozeb 75%WP + Acetamiprid 20%SP	2.5g/l + 0.2g/l	5g/l + 0.4g/l	1.25g/l + 0.1g/l
15	Mancozeb 75%WP + Chlorantraniliprole 18.5%SC	2.5g/l + 0.3ml/l	5g/l + 0.6 ml/l	1.25 g/l + 0.15ml/l

Table 3. Specific gravity (g) of fungicides and insecticides alone and in combination using tap water at recommended dose

Chemical	Triazophos @1.5 ml/l	Acetamiprid@ 0.2 g/l	Chlorantraniliprole @ 0.3 ml/l	Alone
Azoxystrobin @ 1 ml/l	0.99	0.99	0.98	1.01
Propiconazole @ 1ml/l	1.02	1.01	0.99	1.03
Mancozeb @ 2.5 g/l	1.01	1.01	0.99	1.01
Alone	1.00	1.01	0.99	

Specific gravity test

At recommended dose in tap water, specific gravity of combined chemical did not vary much in comparison with individual fungicide/insecticide (Table 3). The specific gravity values of the fungicides alone ranged from 1.01g (azoxystrobin and mancozeb) to 1.03g (propiconazole) whereas the specific gravity values of insecticides alone ranged from 0.99g (chlorantraniliprole) to 1.01g (acetamiprid). However, the specific gravity values of fungicide and insecticide combinations ranged from 0.99g (azoxystrobin + triazophos, azoxystrobin + acetamiprid and mancozeb + chlorantraniliprole) to 1.02g (propiconazole + triazophos).

At higher dose in tap water, specific gravity of combined chemical did not vary much in comparison with individual fungicide/insecticide (Table 4). The specific gravity values of the fungicides alone ranged from 1.03g (mancozeb) to 1.04g (azoxystrobin and propiconazole) whereas the specific gravity values of insecticides alone ranged from 0.98g (chloran-traniliprole) to 1.04g (triazophos). However, the specific gravity values of fungicide and insecticide combinations ranged from 0.99g (azoxystrobin + triazophos) to 1.04g (mancozeb + triazophos and mancozeb + acetamiprid).

At lower dose in tap water, specific gravity of combined chemical did not vary much in comparison with individual fungicide/insecticide (Table 5).The specific gravity values of the fungicides alone ranged from 1.00g (propiconazole) to 1.02g (azoxystrobin and mancozeb) whereas the specific gravity values of insecticides alone ranged from 0.98g (triazophos and acetamiprid) to 1.00g (chlorantraniliprole). However, the specific gravity values of fungicide and insecticide combinations ranged from 0.98g (propiconazole + chlorantraniliprole) to 1.03g (mancozeb + chloran-traniliprole).

At recommended dose in distilled water, specific gravity of combined chemical did not vary much in comparison with individual fungicide/ insecticide (Table 6). The specific gravity values of the fungicides alone ranged from 0.97g (azoxystrobin) to 1.09g (propiconazole) whereas the specific gravity values of insecticides alone ranged from 0.98g (triazophos) to 1.05g (chlorantraniliprole). However, the specific gravity values of fungicide and insecticide combinations ranged from 0.97g (azoxystrobin + chlorantraniliprole and mancozeb + triazophos) to 1.02g (mancozeb + acetamiprid).

At higher dose in distilled water, specific gravity of combined chemical did not vary much in comparison with individual fungicide/insecticide (Table 7). The specific gravity values of the fungicides alone ranged from 0.99g (propiconazole) to 1.02g (mancozeb) whereas the specific gravity values of insecticides alone ranged from 0.99g (triazophos) to 1.02g (acetamiprid and chlorantraniliprole). However, the specific gravity values of fungicide and insecticide combinations ranged from 0.96g (mancozeb + chlorantraniliprole) to 1.05g (propiconazole + acetamiprid).

At lower dose in distilled water, specific gravity of combined chemical did not vary much in comparison with individual fungicide/insecticide (Table 8).The specific gravity values of the fungicides alone ranged from 0.97g (azoxystrobin) to 1.02g (propiconazole and mancozeb) whereas the specific gravity values of insecticides alone ranged from 0.98g (acetamiprid and chlorantraniliprole) to 1.012g (triazophos). However, the specific gravity values of fungicide and insecticide combinations ranged from 0.94g (mancozeb + chlorantraniliprole) to 1.03g (mancozeb + acetamiprid).

At recommended dose in standard hard water, specific gravity of combined chemical did not vary much in comparison with individual fungicide/ insecticide (Table 9). The specific gravity values of the fungicides alone ranged from 0.97g (azoxystrobin and propiconazole) to 0.98g (mancozeb) whereas the specific gravity values of insecticides alone ranged from 0.99g (acetamiprid) to 1.06g (triazophos). However, the specific gravity values of fungicide and insecticide combinations ranged from 0.96g (azoxystrobin + acetamiprid) to 1.05g (mancozeb + triazophos).

At higher dose in distilled water, specific gravity of combined chemical did not vary much in comparison with individual fungicide/insecticide (Table 10). The specific gravity values of the fungicides alone ranged from 0.95g (propiconazole) to 1.02g (mancozeb) whereas the specific gravity values of insecticides alone ranged from 0.97g (acetamiprid) to 1.05g (triazophos). However, the specific gravity values of fungicide and insecticide combinations ranged from 0.98g (mancozeb + acetamiprid) to 1.05g (propiconazole + triazophos and propiconazole + chlorantraniliprole).

At lower dose in standard hard water, specific gravity of combined chemical did not vary much in comparison with individual fungicide/insecticide (Table 11).The specific gravity values of the fungicides alone ranged from 0.97g (propiconazole) to 1.03g (mancozeb) whereas the specific gravity values of insecticides alone ranged from 1.00g (acetamiprid) to 1.03g (triazophos). However, the specific gravity values of fungicide and insecticide combinations ranged from 0.96g (mancozeb + acetamiprid) to 1.05g (azoxystrobin + triazophos).

Table 4. Specific gravity (g) of fungicides and insecticides alone and in combination using tap water at higher dose

Chemical	Triazophos @ 3 ml/l	Acetamiprid @0.4 g/l	Chlorantraniliprole @ 0.6 ml/l	Alone
Azoxystrobin @ 2ml/l	0.99	1.00	1.00	1.04
Propiconazole @ 2 ml/l	1.02	1.01	1.02	1.04
Mancozeb @ 5 g/l	1.04	1.04	1.02	1.03
Alone	1.04	1.00	0.98	

Table 5. Specific gravity (g) of fungicides and insecticides alone and in combination using tap water at lower dose

Chemical	Triazophos @ 0.75 ml/l	Acetamiprid @ 0.1 g/l	Chlorantraniliprole @ 0.15 ml/l	Alone
Azoxystrobin @0.5 ml/l	1.02	1.01	0.99	1.02
Propiconazole @ 0.5 ml/l	1.02	0.99	0.98	1.00
Mancozeb @ 1.25 g/l	1.02	1.01	1.03	1.02
Alone	0.98	0.98	1.00	

Table 6. Specific gravity (g) of fungicides and insecticides alone and in combination using distilled water at recommended dose

Chemical	Triazophos @1.5 ml/l	Acetamiprid@ 0.2 g/l	Chlorantraniliprole @ 0.3 ml/l	Alone
Azoxystrobin@ 1 ml/l	1.00	0.99	0.97	0.97
Propiconazole @ 1ml/l	0.99	1.00	0.99	1.09
Mancozeb @ 2.5 g/l	0.97	1.02	0.98	0.98
Alone	0.98	1.02	1.05	

Table 7. Specific gravity (g) of fungicides and insecticides alone and in combination using distilled water at higher dose

Chemical	Triazophos @ 3 ml/l	Acetamiprid @0.4 g/l	Chlorantraniliprole @ 0.6 ml/l	Alone
Azoxystrobin @ 2ml/l	1.00	1.02	0.99	1.01
Propiconazole @ 2 ml/l	1.02	1.05	1.04	0.99
Mancozeb @ 5 g/l	1.01	1.00	0.96	1.02
Alone	0.99	1.02	1.02	

Table 8. Specific gravity (g) of fungicides and insecticides alone and in combination using distilled water at lower dose

Chemical	Triazophos @ 0.75 ml/l	Acetamiprid @ 0.1 g/l	Chlorantraniliprole @ 0.15 ml/l	Alone
Azoxystrobin @0.5 ml/l	0.97	1.01	0.97	0.97
Propiconazole @ 0.5 ml/l	0.99	0.99	1.02	1.02
Mancozeb @ 1.25 g/l	0.99	1.03	0.94	1.02
Alone	1.01	0.98	0.98	

Table 9. Specific gravity (g) of fungicides and insecticides alone and in combination using standard hard water at recommended dose

Chemical	Triazophos @1.5 ml/l	Acetamiprid@ 0.2 g/l	Chlorantraniliprole @ 0.3 ml/l	Alone
Azoxystrobin @ 1 ml/l	1.02	0.96	0.99	0.97
Propiconazole @ 1ml/l	1.02	0.98	1.02	0.97
Mancozeb @ 2.5 g/l	1.05	0.99	0.99	0.98
Alone	1.06	0.99	1.04	

Table 10. Specific gravity (g) of fungicides and insecticides alone and in combination using standard hard water at higher dose

Chemical	Triazophos @ 3 ml/l	Acetamiprid @0.4 g/l	Chlorantraniliprole @ 0.6 ml/l	Alone
Azoxystrobin @ 2ml/l	1.03	1.00	1.02	1.00
Propiconazole @ 2 ml/l	1.05	1.02	1.05	0.95
Mancozeb @ 5 g/l	1.03	0.98	1.03	1.02
Alone	1.05	0.97	1.01	

Table 11. Specific gravity (g) of fungicides and insecticides alone and in combination using standard hard water at lower dose

Chemical	Triazophos @ 0.75 ml/l	Acetamiprid @ 0.1 g/l	Chlorantraniliprole @ 0.15 ml/l	Alone
Azoxystrobin @0.5 ml/l	1.05	0.98	1.02	1.01
Propiconazole @ 0.5 ml/l	1.03	0.99	1.04	0.97
Mancozeb @ 1.25 g/l	1.03	0.96	1.02	1.03
Alone	1.03	1.00	1.01	

Assessing specific gravity may be a useful measure to find compatibility of chemical combinations. Specific gravity of the combination indicate formation of new compound which reflect on the efficacy of added chemicals, as in the present investigation, on the bioefficacy of insecticides / fungicides. The slight differences in the combinations may be attributed to the higher and lower densities of the respective fungicide and insecticide in their combination.

In the present investigation, no significant changes in the specific gravity of nine combinations at three different doses with three types of water indicate compatibility of the combinations. Kumar (2015) also assessed specific gravity of insecticides chlorpyriphos, cartap hydrochloride, chloran-traniliprole, phosphamidon and fungicides carben-dazim, hexaconazole, tricyclazole, isoprothiolane in possible number of combinations and found that specific gravity did not change.

CONCLUSION

From the present study the results were helpful in understanding the physical reaction between fungicides and insecticides when combined.

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