*Original Research Article*

# The Use of Biological and Chemical Compounds in the Integrated Control Program of Powdery Mildew of Apricot in Egypt

**Abstract**

This study aims to evaluate an integrated control program for powdery mildew caused by*Sphaerothecapannosa* in apricot trees *Prunus armeniaca*, where four fungicides Copper,Carbendazim, Pleas and Topas ) and three biocides ( Bio Z , Bio Arc and Activator Yeasts ) were evaluated in the first season 2020 in Ismailia and Beheira governorates in the regions of South Tahrir and Nubariya. All compounds significantly reduced the percentage of disease severity on leaves and flowers compared to the control, and the activator yeasts was among the best treatments, as it recorded in the last spraying a percentage of disease severity on leaves and flower 28.5% and 27.6% respectively compared with control 52.7 %and 56.2%, followed by the biocides Bio Z and Bio Arc.In the second season 2021, the compounds were evaluated during the flowering period, which led to their precipitation and the occurrence of plant toxicity for flowers at their highest rates with copper. As for the biocides compounds, they were completely safe.From here, an integrated control program was designed for two seasons 2022 and 2023 that combines fungicides and biocides. It is applied early before flowering. It gave excellent results, reduced the rate of fungicide use, and was safer and cost-saving.

**Keywords: Apricot; Powdery mildew; Biological and Chemical Control.**

## INTRODUCTION

Apricot*Prunus armeniaca* L. is the tree of yellow pearls, has the greatest control in the governorates of the Republic, and the owner of the first taste, which everyone from all governorates of Egypt accepts to buy, as it is eaten fresh or dried, or in the manufacture of juices and jams, it's a kind of stone fruits grown in sub-temperate and temperate regions of the world, however, in Egyptranks second in the Arab world and ninth in the world, with an annual production of 102 thousand tons Encyclopaedia Britannica2023The area under these fruits is increasing every year but the production is not increasing corresponding to the increase in area because these fruits are subjected to a number of a biotic and biotic stresses of which fungal and bacterial diseases.Powdery mildew Different species of *Sphaerothecapannosa*Wallr. and Lev. cause powdery mildew apricot. The disease is very serious in nurseries where seedling stocks infected early in the growing season remain stunted. Khan *et al.* (1975), Sharma (1985), Kaul (1967) and Pandotra*et al.* (1968) they reported that symptoms of the fungus infectleaves young shoots and fruits. On the young leaves the disease appears at first as blister like areas that soon become covered with grayish white patches of fungus growth. Infection causes leaf distortion, curling and premature leaf fall. White patches of fungus appear on green shoots, which may

become curved at the tips. Buds and flowers may also be directly attacked. In that case buds either fail to open or open improperly while flowers are discolored, stunted, and eventually dry up. Infected fruits first show circular spots which may spread over the whole fruits. The color is at first pinkish and later becomes dark brown. Control The disease can be effectively controlled by three sprays of wettable sulphur or carbendazim/thiophanate methyl before opening of blooms, at petal fall and two weeks later (Anonymous, 1995). New fungicides viz myclobutanil, fenarimol, flusilazole, pyrifenox, triademefon, captafol and tebuconazole provide good control of powdery mildew in stone fruits (Torre Almaraz and Ceballos Silva, 1990, Dong *et al*., 1991, Jones *et al*., 1993 and Huang *et al*., 1995). Biological fungicides (Bio Arc and Bio Z) are commercially available beneficial microorganisms formulated into a product that, when sprayed on the plant, inhibit or destroy fungal pathogens. The active ingredient in Bio Arc is a bacterium, *Bacillus megaterium*, that helps prevent the powdery mildew from infecting the plant and the active ingredient in Bio Z is a fungus, *Trichoderma album*, while these product functions to kill the powdery mildew organism and is nontoxic to people, pets, and beneficial insects. Radwan, M. A. and D. R. Darwesh,2018.

The main objective of this study is to implement an integrated control program of powdery mildew in apricot that combines chemical and biological control and taking into account the climatic area from one region to another in Egypt, in order to reduce the number of chemical sprays per week, cost, and most importantly, preserving the environment and health and increasing exports.

## MATERIAL AND METHODS

### Field experiments

Field experiments were conducted on apricot trees Canino cultivarat Ismailia and South of Tahrir and Nubariya at Behera governorates during 2020,2021, 2022 and 2023 growing seasons to evaluate the effect of biocides and fungicides against the natural infection of apricot powdery mildew. In 2020 we evaluate the effect of program i.e. four fungicides (Copper,Carbendazim, Pleas and Topas ) sprayed four times each alone alternative 15 days as well as the biocides and yeast among them, three biocides ( Bio Z ,Bio Arc and Activator Yeasts )are commercial products where are produced in Agricultural Research Center, they sprayed four times each alone as well as the alternation among them,Table 1.showd the all treatments. The trees were left to the natural infection bypowdery mildew andit were received the same cultural practices that are recommended.Distributed according to a completerandomized design, with three replicates, using five trees asexperimental unit. Four foliar sprays were applied at 15-day intervals during spring seasons in first February. In the second season 2021we starting spray in the flowering period to estimate all treatments on flowers, in the third season 2021/2022 we applied the integrated control program we sprayed in November in the dormancy period and sprayed fungicides twice to reduce the number of sprays alternative with biocides and in the fourth season 2022/2023 we repeat the program. Infected leaves and flowers wereexamined at the end of the experiment to estimate diseaseseverity. Twenty leaves were selected randomly from eachtree five days after the last application and assessed for thepresence or absence of mildew. Disease severity % wasrecorded using disease scale

Disease severity % was assessed according to the modified scale (0-5) by Reuveni and Reuveni, (1995) where:

0 = No powdery mildew colonies observed.

1 = 1–10% of the leaf area infected.
2 = More than 10–25% of the leaf area infected.
3 = More than 25–50% of the leaf area infected.
4 = More than 50 –75% of the leaf area infected.
5 = More than 75–100% of the leaf area infected.

The following formula was used to estimate the disease

Disease severity % =∑nxv/5N X100

Where:

n = Number of the infected leaves in each category.
v = Numerical values of each category.
N = Total number of the examined leaves.

Table 1. Application programs and test treatments.

| treatments | rate/100liter water | active ingredient |
|---|---|---|
| Cobox 50% WP | 250g | Copper oxchloride contact fungicide |
| Praiz 54%SC | 250 g | Chlorothalonil contact fungicide |
| Carbendazim 80%WP | 30-50g | carbendazim systemic fungicide |
| Topas 10%EC | 25 ml | Penconazol systemic fungicide |
| Bio Z | 250g | *Trichoderma album* biocides |
| Bio Arc | 250g | *Bacillus megaterium* biocides |
| Activator Yeasts | 10L/ acre | *Saccharomycescerevisiae*and *Candidatropicalis*biocides |

Statistical analysis

All experiments were analyzed by Wasp computer program. Least significant difference (LSD0.05) was calculatedaccording to Gomez and Gomez (1984).

RESULTS:

Table: 2 evaluate fungicides and biocideson % disease severity of powdery mildew in apricot at Ismailia governorate in 2020:

| Treatments | First Spray | | Second Spray | | Third Spay | | Fourth Spray | |
|---|---|---|---|---|---|---|---|---|
| | leaves | bloom | leaves | bloom | leaves | bloom | leaves | bloom |
| Copper | $40.4^{ab}$ | $39.6^{bc}$ | $35^{bcd}$ | $36^{bc}$ | $31.5^{c}$ | $36.2^{b}$ | $35.8^{b}$ | $34.7^{b}$ |
| Topas | $39^{bc}$ | $38^{bcd}$ | $34^{cd}$ | $32^{bcd}$ | $31.7^{c}$ | $33.3^{bc}$ | $35.2^{b}$ | $35.6^{b}$ |
| Praiz | $38^{bc}$ | $35.6^{cd}$ | $35.3^{bcd}$ | $32^{cd}$ | $33.8^{bc}$ | $33.6^{bc}$ | $35.5^{b}$ | $35^{b}$ |
| Carbendazem | $37^{bc}$ | $35.8^{bcd}$ | $33^{cd}$ | $34^{bcd}$ | $33.8^{bc}$ | $33.6^{bc}$ | $33.3^{bc}$ | $34^{b}$ |
| Bio Arc | $40^{ab}$ | $39.7^{b}$ | $36^{bc}$ | $38^{b}$ | $32.4^{bc}$ | $33.6^{bc}$ | $30.8^{cd}$ | $30.6^{c}$ |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Bio Z | 41$^{ab}$ | 37.1$^{bcd}$ | 38$^{b}$ | 33$^{bcd}$ | 36.2$^{b}$ | 34.3$^{bc}$ | 29.8$^{d}$ | 29$^{cd}$ |
| Activator Yeasts | 35$^{c}$ | 34.8$^{d}$ | 33$^{d}$ | 32$^{d}$ | 30.4$^{c}$ | 30.3$^{c}$ | 28.5$^{d}$ | 27.6$^{d}$ |
| Control | 43$^{a}$ | 46.3$^{a}$ | 50 $^{a}$ | 49.6$^{a}$ | 44.7$^{a}$ | 50.2$^{\mathbf{a}}$ | 52.7$^{a}$ | 56.2$^{a}$ |
| LSD.05 | 3.947 | 4.14 | 3.76 | 3.844 | 4.165 | 4.182 | 2.794 | 2.966 |

The effect of three types of commercial biocides and three chemical pesticides on the percentage of powdery mildew disease severity on apricot trees was evaluated, as symptoms appeared on the leaves and the flower cluster. The treatments began to be sprayed 4 times in February after the dormancy period hence the leaves and flowers appeared in each of Ismailia, South Tahrir and Nubariya. The results are shown in Table 2 in Ismailia data indicated that,All compounds significantly reduced the percentage of disease severity on leaves and flowers compared to the control, and the activator yeasts was among the best treatments, as it recorded in the last spraying a percentage of disease severity on leaves and flower 28.5% and 27.6% respectively compared with control 52.7 %and 56.2%, followed by the biocides Bio Z and Bio Arc, which recorded on leaves and flowers 29% and 30%, respectively on leaves and 29% and 30.6% on flowers.

Table 3: evaluate fungicides and biocideson % disease severity of powdery mildew in apricot at South of Tahrir in Behera governorate in 2020:

| Treatments | First Spray | | Second Spray | | Third Spay | | Fourth Spray | |
|---|---|---|---|---|---|---|---|---|
| | leaves | bloom | leaves | bloom | leaves | bloom | leaves | bloom |
| Copper | 40.4$^{b}$ | 40$^{b}$ | 35$^{b}$ | 36.2$^{bc}$ | 36$^{b}$ | 36$^{b}$ | 36$^{b}$ | 34.7$^{bc}$ |
| Topas | 39$^{bc}$ | 37$^{bc}$ | 34$^{b}$ | 32$^{d}$ | 33$^{bc}$ | 36$^{b}$ | 35$^{b}$ | 35.6$^{b}$ |
| Praiz | 38$^{c}$ | 35.6$^{c}$ | 35.3$^{b}$ | 31.7$^{d}$ | 34$^{bc}$ | 33$^{bc}$ | 35.5$^{b}$ | 35$^{bc}$ |
| Carbendazem | 37$^{c}$ | 35.8$^{c}$ | 33.4$^{b}$ | 33.8$^{cd}$ | 33$^{bc}$ | 31$^{c}$ | 33$^{bc}$ | 34$^{bc}$ |
| Bio Arc | 40$^{b}$ | 39.7$^{b}$ | 36.2$^{b}$ | 38$^{b}$ | 34$^{bc}$ | 33$^{bc}$ | 31$^{cd}$ | 32.4$^{c}$ |
| Bio Z | 40.5$^{bc}$ | 37$^{bc}$ | 37.9$^{b}$ | 33$^{cd}$ | 34$^{bc}$ | 31$^{c}$ | 30$^{d}$ | 27$^{d}$ |
| Activator Yeasts | 35.6$^{c}$ | 34.8$^{c}$ | 32.7$^{b}$ | 32$^{d}$ | 30$^{c}$ | 31$^{c}$ | 28.4$^{d}$ | 29$^{d}$ |
| Control | 43$^{a}$ | 47$^{a}$ | 45$^{a}$ | 50$^{a}$ | 50$^{a}$ | 50$^{a}$ | 52.5$^{a}$ | 56$^{a}$ |
| LSD 0.05 | 3.420 | 3.640 | 5.447 | 3.844 | 4.133 | 3.207 | 2.794 | 2.966 |

Table 3 showed the effect of spraying three biocides and three chemical fungicides on the percentage of powdery mildew disease severity on leaves and flowers, Where the best treatments were the biocide compounds, as they reduced the disease clearly and significantly in comparison with the control, as well as all the biocides were effective and there were no significant differences between them, as the best of them was the activator yeasts compound, then it was followed by Bio Z and Bioarc on both leaves and flowers the data recorded 28%,30 %and 31% on leaves and 29%,27%and 32% on flowers respectively.The results were the same in Table 4, where the best treatments were also the biocides compounds in reducing the percentage of

disease severity on leaves and flowers, where the percentage were 31%,32%and 34% on leaves and 30%,33%and 34% on flowers on the test in each of the activator yeasts, BioZ and Bio arc respectively.

Table 4: evaluate fungicides and biocides on % disease severity of powdery mildew in apricot at Nubariya in Behera governorate in 2020:

| Treatments | First Spray | | Second Spray | | Third Spay | | Fourth Spray | |
|---|---|---|---|---|---|---|---|---|
| | leaves | bloom | leaves | bloom | leaves | bloom | leaves | bloom |
| Copper | $43.7^{b}$ | $40^{bcd}$ | $41^{a}$ | $38^{bc}$ | $33.6^{bc}$ | $36^{b}$ | $32^{de}$ | $34^{b}$ |
| Topas | $43^{b}$ | $40^{bcd}$ | $35.6^{bc}$ | $34^{c}$ | $35^{bc}$ | $33^{b}$ | $38^{b}$ | $35^{b}$ |
| Praiz | $41^{b}$ | $36.5^{d}$ | $36^{bc}$ | $34^{c}$ | $31.7^{c}$ | $35.8^{b}$ | $36^{cde}$ | $36^{b}$ |
| Carbendazem | $40^{b}$ | $37^{d}$ | $38^{b}$ | $36^{bc}$ | $35^{bc}$ | $34.5^{b}$ | $36^{bc}$ | $36^{b}$ |
| Bio Arc | $40^{b}$ | $41^{bcd}$ | $38^{b}$ | $38.6^{b}$ | $37^{b}$ | $35^{b}$ | $34^{bcd}$ | $34^{b}$ |
| Bio Z | $41^{b}$ | $41^{bc}$ | $34^{c}$ | $37^{bc}$ | $33^{bc}$ | $36^{b}$ | $32^{e}$ | $33^{bc}$ |
| Activator Yeasts | $34^{c}$ | $36^{d}$ | $32^{c}$ | $36^{bc}$ | $32^{c}$ | $33^{b}$ | $31^{e}$ | $30^{c}$ |
| Control | $50^{a}$ | $48.7^{a}$ | $47^{a}$ | $55^{a}$ | $52^{a}$ | $55^{a}$ | $57^{a}$ | $54.4^{a}$ |
| LSD 0.05 | 4.550 | 4.176 | 4.394 | 4.521 | 4.315 | 4.156 | 3.323 | 4 |

Table 5 showed the result of spraying all treatments early before the leaves appear and the time when the flowers are revealed. The results indicated a high percentage of toxicity and flower fall in the case of Copper fungicide the toxicity was 100% and it was 15%-25% in case of Topas ,Praiz and it was 40% with Carbendazim in Nubaria, but the organic compounds did not affect the growth of flowers at all, but the percentage of disease severity was largely controlled. Activator yeasts was the best treatment in reducing percentage of disease severity on flowers also Bio Z and Bio arc gave good results comparing with fungicides .

Table 5: effect of spraying fungicides and biocides at flowering period on % disease severity of powdery mildew in apricot at Ismailia and Behera governorate in 2021:

| Treatments | Ismailia | | South of Al-Tahreer | | Nubariya | |
|---|---|---|---|---|---|---|
| | %Toxicity | bloom | %Toxicity | bloom | %Toxicity | bloom |
| Copper | 100%TOXICITY | | | | | |
| Topas | 15-20% | $34^{bc}$ | 20-25% | $33^{bcd}$ | 25% | $33.627^{cd}$ |
| Praiz | 15-20% | $33^{bc}$ | 20 | $32^{cd}$ | 25 | $32.957^{cd}$ |
| Carbendazem | 20 | $35^{bc}$ | 30 | $33^{bc}$ | 39-40 | $38.326^{b}$ |
| Bio Arc | 0 | $37^{ab}$ | 0 | $36^{b}$ | 0 | $36.672^{bc}$ |
| Bio Z | 0 | $33^{bc}$ | 0 | $34^{bc}$ | | $32.24^{d}$ |
| **Activator Yeast** | 0 | $32^{c}$ | 0 | $30^{d}$ | 0 | $30^{d}$ |
| Control | 0 | $40.819^{a}$ | 0 | $41.98^{a}$ | 0 | $42.693^{a}$ |
| LSD.0.05 | | 4.466 | | 3.326 | | 4.104 |

The integrated control program with biological and chemical fungicides was applied during two consecutive years 2022/2023 in Ismailia and Beheira governorates in the regions of South Tahrir and Nubariya.IN tables 6 and 7, the chemical fungicides of Copper and Topas were sprayed early in the dormancy period before the flower buds were revealed, on the wood as a form of prevention before the infection with powdery mildew, where spraying was done in mid-November three sprays of Copper every 15 days and two sprays of Topas every 15 days as well, then after that it was Interfering with biocides to protect the flowers from toxicity and falling off. Four sprays were sprayed every 10 days and then fungicide Praiz was sprayed twice before biocide Activator Yeasts, at the end of the season, a chemical fungicide Carbendazim was sprayed in May, two sprays between 15 days, in order to preserve the fruits from powdery mildew and post-harvest rot.In table 6,it was clear in the results after each treatment a significant decrease in the percentage of disease severity compared to the control. At the end of the program, the percentage of disease severity on leaves reached 1.2% compared to 55.75% in the control and on flowers 2% in the treatments and 69% in the control in Ismailia and the rest of the regions were in the same way. In second season

Table 6: effect of applying integrated control program on % disease severity of powdery mildew in apricot at Ismailia and Behera governorate in 2022:

| Treatments | Time and sprays | | Ismailia | | South of Tahrir | | Nubariya | |
|---|---|---|---|---|---|---|---|---|
| | | | leaves | bloom | leaves | bloom | leaves | bloom |
| Copper | 15/11<br>30/11<br>15/12 | 1<br>2<br>3 | Dormancy period | | | | | |
| Topas | 15/12<br>30/12 | 1<br>2 | Dormancy period | | | | | |
| Bio Z | 8/1<br>15/1<br>22/1<br>30/1 | 1<br>2<br>3<br>4 | Dormancy period | | | | | 7.25 |
| Control | | | not excite | 7.75 | not excite | 7.5 | not excite | 11.25 |
| Bio Arc | 5/2<br>12/2<br>19/2<br>26/2 | 1<br>2<br>3<br>4 | 8.25 | 8 | 8 | 11.5 | 14.5 | 10.75 |
| Control | | | 22.25 | 25 | 26.25 | 29.75 | 26.75 | 34.75 |
| Praiz | 5/3<br>20/3 | 1<br>2 | 5 | 7.75 | 8.75 | 7.75 | 9.5 | 8.5 |
| Control | | | 28.25 | 32.5 | 34.25 | 34.25 | 39.75 | 41 |
| Activator Yeasts | 20/3<br>6/4<br>13/4<br>20/4 | 1<br>2<br>3<br>4 | 5.25 | 4.25 | 5.75 | 5 | 4.25 | 7.5 |
| Control | | | 38.25 | 39.25 | 36.25 | 47.25 | 52 | 52 |
| Carbendazem | 20/4<br>30/4 | 1<br>2 | 1.25 | 2 | 3.5 | 1.25 | 5 | 5.75 |
| Control | 10/5 | | 55.75 | 69 | 67 | 80.75 | 74 | 87 |

In the second season of applying the program 2023, as shown in Table 7, decrease in % disease severity compared to the control, where it was on leaves was 1.75%, and in the control 66.5%, while the flowers, the percentage of disease severity was 0.5%, and the control was 72%.

Table 7: effect of applying integrated control program on % disease severity of powdery mildew in apricot at Ismailia and Behera governorate in 2023:

| Treatments | Time and sprays | | Ismailia | | South of Tahrir | | Nubariya | |
|---|---|---|---|---|---|---|---|---|
| | | | leaves | bloom | leaves | bloom | leaves | bloom |
| Copper | 15/11<br>30/11<br>15/12 | 1<br>2<br>3 | Dormancy period | | | | | |
| Topas | 15/12<br>30/12 | 1<br>2 | Dormancy period | | | | | |
| Bio Arc | 5/1<br>12/1<br>19/1<br>26/1 | 1<br>2<br>3<br>4 | Dormancy period | | | | | |
| Control | 3/2 | | not excite | 2 | not excite | 4 | not excite | 5.75 |
| Bio Z | 3/2<br>10/2<br>17/2<br>24/2 | 1<br>2<br>3<br>4 | Dormancy period | | | | | |
| Control | 2/3 | | not excite | 15.75 | not excite | 20.5 | not excite | 23.75 |
| Praiz | 5/3<br>20/3 | 1<br>2 | 4 | 7 | 5 | 10.25 | 5 | 6.25 |
| Control | 25/3 | | 27.5 | 25.5 | 27.75 | 32.75 | 33 | 24 |
| Activator Yeasts | 25/3<br>2/4<br>9/4 | 1<br>2<br>3 | 1.5 | 5.75 | 6 | 1.75 | 8.5 | 2.5 |
| Control | 15/4 | | 44.75 | 49.5 | 43.75 | 44.5 | 46 | 52.5 |
| Carbendazem | 15/4<br>25/4 | 1<br>2 | 1.75 | 0.5 | 1.25 | 4 | 4.5 | 1.5 |
| Control | 5/5 | | 66.5 | 72 | 58.75 | 71 | 84 | 74 |

## DICUSSION

Powdery mildew disease caused by the *Sphaerothecapannosa* fungus is one of the most important and dangerous diseases that affect apricot trees, as the disease appears on the laves, flowers and fruits, and the fungus spores remain dormant for the next season in the wood and begin to attack the flower buds and new leafy shoots, and the disease leads to a heavy loss in the cropMabrouk,*et.al* (2019).In this study, four chemical fungicides were evaluated, including preventive such as Copper andPraiz(Chlorothalonil), and systemic such as Topas(pencoconazole) and Carbidazem, and three biocides, namely BioZ ( *Trichoderma album*) ,Bio arc (*Bacillus megaterium*) and Activator Yeasts (*Saccharomycescerevisiae*and *Candidatropicalis*) .The start of spraying was in February and chemical fungicides were sprayed four times .The results showed in the first season 2020 in Ismailia and Buhaira governorates in the regions of South Tahrir and Nubaria, the high significant effect in reducing the disease severity, whether treated with fungicides or biocides. The results showed that there were no significant effect on controlling the disease after the second spray .Hassan, *et.al* (2019) ,Yousef. (2021)andEl-Morsi *et al*.2012.In the second season 2021, spraying took place in the presence of flowers, and this led to toxicity and falling off as a result of spraying with copper, as well as the rest of the fungicides that showed toxicity when sprayed. On the other hand, the biocides fought the disease, and no toxicity appeared on the flowers.Radwan, and Darwesh (2018). When we applied the program of controlling powdery mildew in season 2022 we started spray early before flowering hence the spray start in half November 2021,the program began with two protective fungicides just with two sprays and then we applied the biocides to protect flowering and also controlling the disease, within heart of flowering process we applied the biocide Activator Yeasts Whereas the yeasts act on the fungi and lead to the decomposition of the hypha tissues, as mentioned with Hartati, *et.al* (2015), some Yeast species were reported to produce chitinolytic enzymes Sugiprihatini,*et.al*.which produce β -1,3-glucanase and chitinase in controlling powdery mildew Urquhart and Punja (2002).In the second season of implementing the program 2022/2023, the results followed the same pattern.

Thus, the program achieved excellent control of the disease, and at the same time, the number of chemical pesticide sprays was reduced, environmentally friendly bio-compounds were introduced, and the residual effect of pesticides on fruits was reduced, whether for local consumption or export, as well as reducing the final cost.

## Conclusion

The main objective of this study is the integrated control of powdery mildew disease in apricot and at the same time limiting the use of fungicides and introducing biological control, but with a system that does not prejudice the control and at the same time reaching the highest levels of efficiency in eradication and increasing the yield, for the sake of public health first, then export and open a door for the global market.

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