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Optimizing Fungicide Sprays to Tackle Powdery Mildew (*Uncinula necator*) At The Right Time For healthy grapes production

Mueen Uddin[1], Taimoor Khan[1], Faheem Ahmed[2], Juma Khan Babar[2], Muhammad Ejaz[2], Faisal Adnan[2], Rehan Fareed[2]*, Hidayatullah Kakar[2]

[1]*Department of Plant Pathology, Lasbela University of Agriculture, Water and Marine Sciences Uthal Lasbela, Balochistan, Pakistan*
[2]*Agriculture Research Institute (ARI), Sariab Quetta, Balochistan, Pakistan*

Abstract: Introduction: Powdery mildew, caused by the fungus Uncinula necator, is a prevalent and harmful disease affecting grapevines, resulting in decreased fruit set and yield. This study aimed to evaluate the effectiveness of various fungicides and spray timings in managing U. necator in grape vineyards. **Methods:** A field trial was conducted in Pishin, Balochistan in 2020, employing a randomized complete block design with two factors: four fungicides (control, protective fungicide-Bordeaux mixture, curative fungicide-Elite 45 wp, systemic fungicide-Quintec) and four spray timings (dormant spray, bud break, one week before bloom, and berry formation). **Results:** The findings revealed significant variations in disease severity (PDI) among leaves, inflorescence, and bunches across different fungicides, spray timings, and their interactions. Application of the protective fungicide one week before bloom proved highly effective in preventing U. necator infection, resulting in the lowest PDI values for leaves (0.44%), inflorescence (0.67%), and bunches (0.0%). Curative fungicides sprayed at bloom stage also reduced PDI for inflorescence (2.17%) and bunches (3.56%). Systemic fungicides applied during berry formation exhibited lower PDI for inflorescence (6.44%) and bunches (4.0%) compared to other fungicides. The highest grape production (27.10 t ha-1) was achieved with the protective fungicide sprayed at bloom stage, followed by the curative fungicide at bloom stage (25.87 t ha-1). The negative and highly significant relationship (R2=0.809) between PDI of leaves and grape yield indicated that higher disease severity led to decreased yield. **Conclusion:** In conclusion, a protective fungicide spray before bloom, followed by a systemic fungicide spray at berry formation, effectively controls U. necator and ensures healthier and higher grape yields.

Keywords: Disease severity, Fungicides, Grape yield, Powdery mildew, Spray timings.

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***Correspondence:** Rehan Fareed, Agriculture Research Institute (ARI), Sariab Quetta, Balochistan, Pakistan. Mobile: +923337840534, Email: syedrehan.hashmi@yahoo.com

Introduction

Grapes can grow successfully in diverse range of climates and soils, making them different from other deciduous fruits which are primarily confined to areas with a Mediterranean climate or transitional climates. However, grapevines can also be grown in colder, warmer, or more humid regions; as long as the meso- and micro-climatic conditions; and the characteristics of the grapevine variety; are taken into account [1-3]. Sandy loam soil with a low water-holding capacity is particularly favorable for the growth of grapes. In Pakistan, Balochistan is the primary region, contributing 98% to the country's grape production, followed by Khyber Pakhtunkhwa, which produces 1.22 million tons of grapes annually. The potential yield of grapes is 25 tons per hectare, but the growers in Pakistan are only able to obtain an average yield of 19 tons per hectare

[4]. Various local and exotic grape varieties are cultivated in the Balochistan uplands, specifically in districts such as Quetta, Pishin, Killa Abdullah, Mastung, Kalat, Loralai, and Zhob. The most commercially popular grape types in these areas include Haita, Kishmishi, Shundokhani, Sahibi, Shekhali, and Red Goble [5]. Grapevine's yearly cycle is similar to other deciduous fruits, which include seven stages: bud break, vegetative growth, blooming, fruiting, ripening, shedding of leaves, and a dormant period from December to the end of March in winter [6]. This growth cycle means that only 100 days are available from berry setting to grapevine harvesting.

Powdery mildew (*Uncinula necator* (Schw. Burr) is one of the widely spread diseases of grapevines. A dry climate is quite conducive to the development of powdery mildew but it can also be spread over a wide range of humidity levels [7-10]. *U. necator* is a specialized fungal pathogen that causes powdery mildew that primarily affects plants in the Vitaceae family [11, 12]. The pathogen produces haustoria, which are extensions that grow into living epidermal cells, while adjacent palisade cells become necrotic. Powdery mildew can attack all green parts of the host plant, such as leaves, berries, and canes. The pathogen overwinters as mycelium in dormant buds and causes primary infections that lead to the formation of conidia. These conidia can spread through wind or contact with infected plant parts and cause secondary infections [13]. The powdery mildew has caused significant damage to vineyards in recent years.

Most of the grape types that are grown from the *Vitis vinifera* species lack genetic defenses against *Erysiphe necator*, which makes them quite vulnerable to grapevine powdery mildew, ranging from moderately to highly susceptible. As a result, the widespread use of fungicides is implemented globally to prevent the disease from spreading [14-16]. The use of fungicide programs is common in order to keep grapes free from diseases. However, even in an arid climate, powdery mildew outbreaks may still occur in some seasons due to favorable weather conditions or the absence of appropriate spray programs [17]. The majority of fungicides are created to be applied preventatively rather than curatively. In grape-growing regions, foliar fungicide programs are put in place with fixed intervals, mainly during the early season, to prevent the start of an epidemic by controlling inoculum loads while they are small. This is done in order to manage the situation and avoid larger issues later on [18-20]. A typical program recommended for grapevine management suggests applying fungicides at specific intervals after bud burst, which are typically at two, four, and six weeks, concluding about two weeks before flowering. Further applications can be made if monitoring detects the presence of powdery mildew or if weather conditions are favorable for disease development. It is considered a mistake in management to delay fungicide application until the disease is already present in the vineyard [21]. Standardizing grapevine powdery mildew management programs and improving disease control can be achieved by timing fungicide applications to specific phenological stages. According to Kast and Bleyer [22], three consecutive sprays - before flowering, during flowering, and when berries reached a diameter of 2mm - were shown to have a 90% effect in reducing powdery mildew on clusters, compared to a program containing seven sprays. Additionally, timing fungicide applications to phenological stages may offer the benefits of the unique chemical attributes of fungicides that redistribute [21].

Grapevine cultivation in high pathogen stress areas poses a significant challenge, especially for disease-susceptible varieties that suffer severe damage, leading to substantial economic losses. In such circumstances, utilizing fungicides becomes the primary approach for disease management [23]. Typically, fungicides are applied at specific timings to proactively shield the plant surface. However, it is crucial to avoid spraying fungicides too early or too late during the crop's production cycle, as this can compromise their effectiveness when the disease is already widespread [24].

Although optimal methods for controlling powdery mildew have been created and different active ingredients have been evaluated, there is limited information available in Balochistan regarding which products are used and how grape growers implement them. This includes information on when fungicide programs are initiated, whether the spray program emphasizes early or mid-season controls, and how the spray programs respond to varying levels of disease pressure between growing seasons. Given the significance of powdery mildew in grape vineyards, this field study was conducted to determine the most effective fungicide and optimal timing for its application to control powdery mildew in grapevines.

Materials and Methods

A field trial was carried out on grapevine at Pishin, Balochistan in 2020 to evaluate different fungicides against powdery mildew of grape. The trial was designed in a randomized complete block design (RCBD) in two factorial arrangements with three replications. The treatments comprised of two factors such as factor (A)-fungicides (F_1 = Control, F_2 = protective fungicide, F_3= curative fungicide, and F_4 = systemic fungicide) and factor (B)- spray time (S_1 **=** dormant spray (one month before bud break, S_2 **=** at bud break, S_3 **=** at bloom and S_4 = at berry formation) while their treatment combination are as under:

$T_1 = F_1S_1$	$T_5 = F_2S_1$	$T_9 = F_3S_1$	$T_{13} = F_4S_1$
$T_2 = F_1S_2$	$T_6 = F_2S_2$	$T_{10} = F_3S2$	$T_{14} = F_4S_2$
$T_3 = F_1S_3$	$T_7 = F_2S_3$	$T_{11} = F_3S_3$	$T_{15} = F_4S_3$
$T_4 = F_1S_4$	$T_8 = F_2S_4$	$T_{12} = F_3S_4$	$T_{16} = F_4S_4$

One trench containing 12 Grape vines represents one treatment. In this way, 48 trenches were selected in the Pishin district in the first week of March 2020, and treatments as per design were marked before starting the fungicide spray program. In the central plant of each trench, periodically, in four branches as marked in advance, the severity of powdery mildew was recorded in ten leaves per branch, and severity was determined by the percentage of affected leaf area (ALA) by the disease. The most prominent symptoms of powdery mildew appear on the leaves and fruits of grapes appear as a coating of whitish-gray powder which is the fruiting bodies of fungi termed mycelium and conidia. The chlorotic spots appear on the upper leaf surface as the first symptoms that transform into whitish lesions later on. While brown or black diffuse patches manifested on shoots whereas, such patches appear reddish brown on dormant canes of grapes.

Fungicides Sprays

Three types of fungicides as mentioned in Table-1 were purchased from the market at Quetta. These fungicides were sprayed at dormant, bud break, one week before flowering, and at berry formation. Elite 45 WP and Quintec fungicides were used at the rate of 4 fluid ounce per acre where 1 fluid ounce (fl. oz) is equal to 28.431 ml under British Imperial Units. While, Bordeaux mixture solution was prepared by mixing copper sulfate and hydrated lime at the ratio of 10:10 in 100 parts of water particularly for dormant sprays. For spraying young, actively growing plants, the amounts of copper sulfate and hydrated lime are reduced, and the formulas used may be 2:2:100, 2:6:100, and so on. For plants known to be sensitive to Bordeaux, a much greater concentration of hydrated lime may be used, as in the formula 8:24:100.

Table 1. Types of fungicides used against powdery mildew (*Uncinula necator*) of grapes under field conditions

S.#	Type of fungicide	Name of fungicides	Active ingredient	Mode of action
1	Protective	Bordeaux mixture	Copper sulfate and calcium hydroxide	The copper ions in the mixture affect enzymes in the fungal spores in such a way as to prevent germination

			(hydrated lime)	
2	Curative	Elite 45 WP	Tebuconazole	Sterol inhibitor
3	Systemic	Quintec	Quinoxyfen	Disruption of early cell signaling events that control morphological changes leading to infection.

Observations Recorded

Observations were recorded 10 days after last spray by randomly selecting 30 leaves and bunches per replication adopting 0-4 scale [25,26]. The detail of PDI is given in the table as under:

0	no diseases present
1	15-25% leaf area and berries infected
2	26-50% leaf area and berries infested
3	51-75% leaf area and berries infected
4	more than 75% leaf area and berries infected

PDI: Percent Disease Index (PDI) was calculated by following formulae [27].

$$\text{PDI}= \frac{\text{Sum of all individual ratings}}{\text{Total number of leaves observed}} \times \frac{100}{\text{Maximum disease grade}}$$

Marketable Yield: Marketable yield was recorded separately after the removal of infected berries at the time of harvest.

1. Disease severity before spray
2. Powdery mildew PDI and marketable yield for fungicide spray at dormant stage
3. Powdery mildew PDI and marketable yield for fungicide spray at bud break stage
4. Powdery mildew PDI and marketable yield for fungicide spray before bloom
5. Powdery mildew PDI and marketable yield for fungicide spray at fruit setting stage
6. Number of berries with split skin
7. Marketable yield (kg plant^{-1})

Statistical Analysis

The data obtained was analyzed statistically using two-way analysis of variance and least significant difference (LSD) test at 5% probability level was used to test the difference among treatment means.

Results

Powdery mildew (*Uncinula necator*) of grapes can effectively be controlled by fungicide spray but it depends on the type of fungicides used and the proper time of spray. Three types of fungicides i.e. protective, curative, and systemic were sprayed including control at dormant, bud break, and at berry formation, and plant disease index (PDI) was recorded by observing the leaves, inflorescence, and bunches as shown in Table 3. The percent disease index of leaves, inflorescence, and bunches, as well as the incidence of split skin berries and grape yield, showed a high level of significant variation across different fungicides, time of application, and their interaction, as revealed by the analysis of variance (Table 3). But the time of fungicide application showed significant variation in PDI of inflorescence. Whereas, the Monthly maximum, minimum and average temperature (^{o}C) and average monthly precipitation (mm) of district Pishin during 2020 are shown in Table 2.

The type of fungicide had a significant impact on the occurrence of powdery mildew in grapes. The highest percent disease index (PDI) was observed on leaves, inflorescence, and bunches in the control treatment, where no fungicide was applied. The use of protective fungicides resulted in the lowest PDI for leaves (6.84%), inflorescence (5.28%), and bunches (3.83%), followed by curative fungicides. On the other hand, systemic fungicides showed higher PDI for leaves, inflorescence, and bunches compared to protective and curative fungicides, but still lower PDI compared to the control (Table 3). In the case of bunches with split-skin berries, there were no significant differences among the types of fungicides, but all fungicides showed a significant reduction in PDI compared to the control. This implies that regardless of the fungicide type, spraying helped control powdery mildew and resulted in healthier bunches. The treatment with the protective fungicide achieved the highest grape yield (23.39 t ha-1), followed by 22.90 t ha-1 when the curative fungicide was used. Without fungicide spray, the grape yield decreased by 39.46%.

Table 2. Monthly maximum, minimum and average temperature (^{o}C) and average monthly precipitation (mm) of district Pishin during 2020

Months	Temperature (^{o}C)			Average precipitation (mm)
	Maximum	Minimum	Average	
January	24.46	11.74	19.04	0.43
February	23.49	9.79	17.4	3.19
March	31.32	16.64	23.33	3.24
April	35.23	21.53	30.7	1.06
May	38.17	29.36	34.28	0.76
June	44.04	34.25	39.34	0.00
July	43.06	40.12	41.83	0.00
August	44.04	37.19	39.65	0.04
September	40.12	36.21	38	0.00
October	37.19	27.4	30.59	0.40
November	27.4	12.72	19.83	2.37
December	21.53	13.7	17.42	0.15

The timing of fungicide application plays a crucial role in the effective control of powdery mildew in grapes. The results of the study showed that the application of fungicide during the bloom stage resulted in the minimum percent disease index (PDI) for leaves (11.83%), inflorescence (12.65%), and bunches (13.12%), which were significantly lower than those recorded at other three time periods. Furthermore, fungicide spray during the bloom stage resulted in a lower number of bunches with split skin berries (4.08%), while no significant variation was observed in the other spray timings for berry skin splitting. The timing of fungicide spray also had a significant impact on grape yield, with the highest yield of 19.80 t ha^{-1} achieved when the spray was carried out during the bloom stage, followed by 18.61 t ha-1 and 18.58 t ha^{-1} under spray during dormant and bud break, respectively (Table 3). These findings indicate that, in addition to the type of fungicide used, the proper timing of the spray is also crucial for producing healthy grapes and achieving higher yields.

Table 3. Effect of fungicides and time of application on PDI of leaves, inflorescence, and bunches; percent bunches with split skin and grapes yield (t ha^{-1})

	Leaves	Inflorescence	bunches	Bunches with split skin berries (%)	Yield (t ha^{-1})
	PDI (%)				
Fungicides					
Control	27.78 a	33.33 a	31.78 a	14.42 a	9.23 d
Protective	6.84 d	5.28 d	3.83 d	2.50 b	23.39 a
Curative	10.69 c	9.02 c	7.98 c	2.00 b	22.90 b
Systemic	16.61 b	16.50 b	16.83 b	2.83 b	19.03 c
S.E.	0.991	1.32	1.02	0.85	0.19
LSD ($p<0.05$)	2.024	2.68	2.08	1.74	0.40
Time of Fungicide application					
Dormant spray	15.86 b	17.53 a	17.02 a	5.67 ab	18.58 b
At bud break	15.50 b	17.61 a	16.52 a	5.41 ab	18.61 b
At bloom	11.83 c	12.65 b	13.12 b	4.08 b	19.80 a
At berry formation	18.72 a	16.33 a	13.78 b	6.58 a	17.57 c
S.E.	0.991	1.312	1.02	0.85	0.19
LSD ($p<0.05$)	2.024	2.68	2.08	1.74	0.40
F value					
Fungicides (F)	169.87**	179.88**	294.35**	99.02**	2203.04**
Time of application (TA)	16.26**	6.30**	7.31**	2.94*	42.62**
Interaction (F x A)	30.97**	9.47**	15.67**	4.48**	168.92**
Mean bearing the same letters are statistically at par; * mean significant difference; ** mean highly significant difference					

The integrative effect of fungicides and time of applications statistically expressed highly significant variations for PDI of leaves, inflorescence, and bunches as predicted in Figure 1a, b & c. The use of protective fungicides at bloom recorded the lowest PDI of leaves (0.44%) followed by 1.78 and 2.22% when sprayed at dormancy and at bud break stage (Figure 1a). However, at berry formation, the systemic fungicide spray manifested a minimum PDI of leaves (6.0%) as compared to other fungicides. The PDI pattern of inflorescence under the influence of both fungicides and time of application is reflected in the same way as that in the PDI of leaves (Figure 1b). The application of systemic fungicides at dormancy and at bud break resulted in the incidence of higher PDI of leave and inflorescence as compared to other fungicides but lower as compared to the control treatment. In the case of DPI of bunches, the protective fungicide completely controlled powdery mildew when sprayed during the bloom stage and showed no DPI on bunches followed by 2.0 and 2.67% when sprayed at dormancy and bud break. However, the application of systemic fungicides at berry formation recorded comparatively lower PDI of bunches over protective and curative fungicides (Figure 1c). Both the protective and curative fungicide sprays at the bloom stage ensured healthy berries as predicted in Figure 1d where percent bunches with split skin berries were not found. Likewise, all bunches were healthy when systemic fungicide spray was conducted at berry formation with no split skin berries existed (Figure 1d).

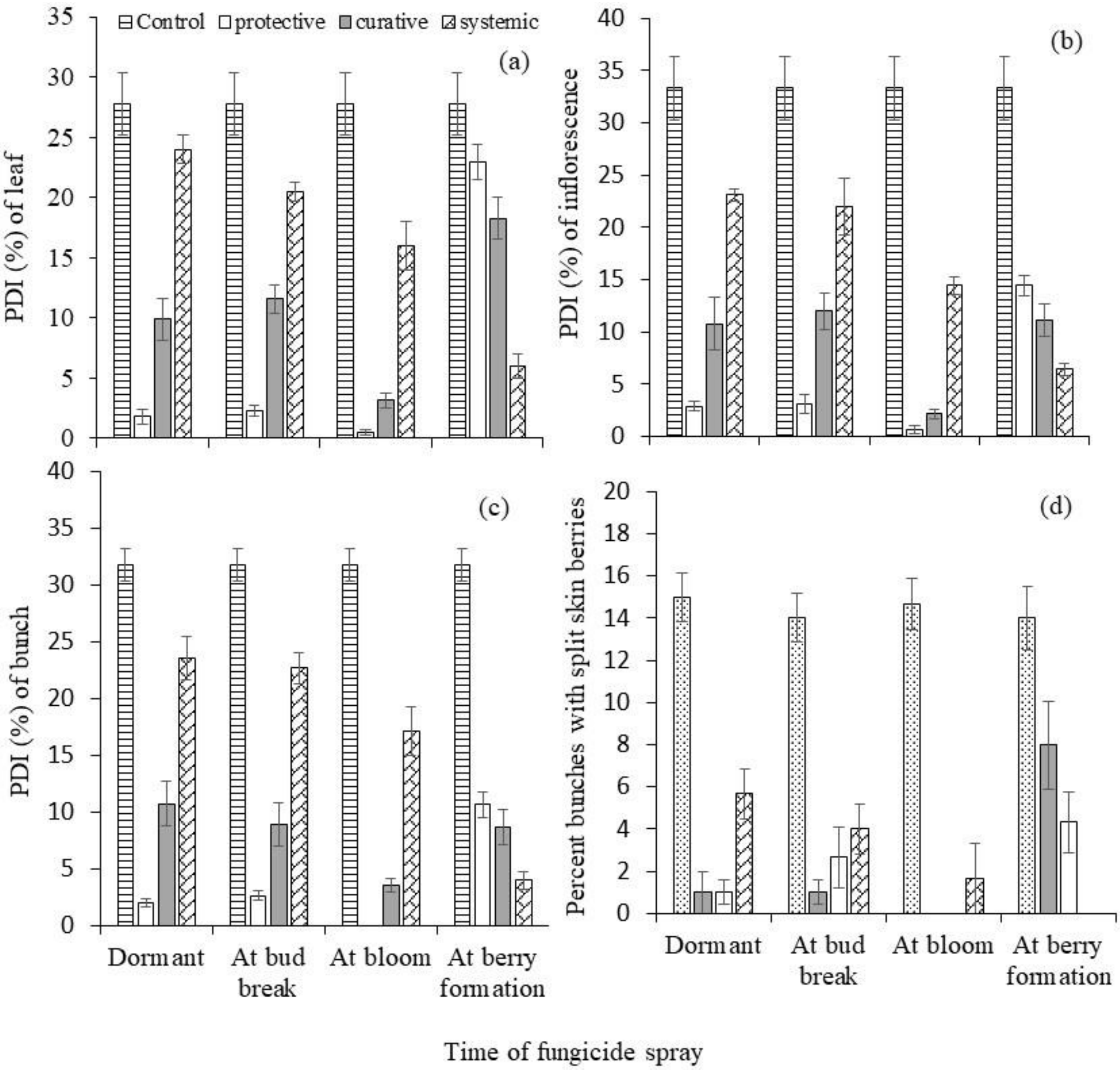

Figure 1. Integrative effect of fungicides and time of application on PDI of the leaf (a), inflorescence (b), fruit (c), and percent of bunches with split skin berries (d) of grapes. The error bar represents the standard error of the mean

The interactive effect of fungicides spray and time of spray showed highly significant differences for grapes yield as shown in Figure 2. The higher grapes yield of 27.10 t ha^{-1} was produced when protective fungicide was sprayed at bloom stage i.e. one week before flowering followed by 25.87 t ha^{-1} in treatment when curative fungicide was sprayed at bloom stage. Likewise, these two fungicides also recorded higher grapes yield at dormant and at bud break over control and systemic fungicide. However, the evaluation of these fungicides sprays at berry formation stage revealed different results where higher grapes yield (25.10 t ha^{-1}) was noted in treatment when systemic fungicide was sprayed and other two fungicides sprays produced comparatively lower yield. This clearly predicts the importance of fungicides for controlling powdery mildew in grapes which directly or indirectly influence grapes yield (Figure 2).

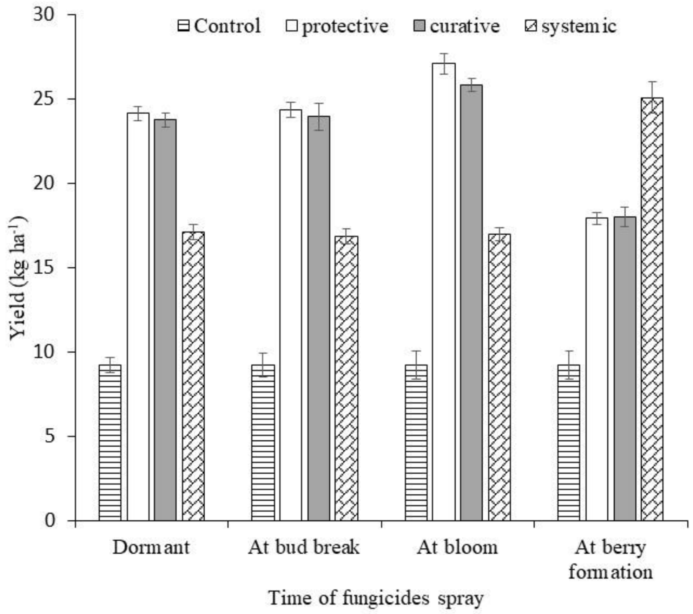

Figure 2. Integrative effect of fungicides and time of application on grapes yield. The error bar represents the standard error of the mean

There is always a kind of relationship among the parameters depending directly or indirectly on each other. When one variable increase consequently the increases other variable which is termed as a linear positive relationship but in some other cases when one variable increase then the other variable started to decrease and this type of relationship is termed as a linear negative relationship. The results of this study showed a positive and highly significant linear correlation among the studied parameters. The extent of the relationship between percent bunches with split skin berries and PDI of bunches was positive and significant with R^2 of 0.6985 (Figure 3). This relationship revealed that a unit increase in PDI of bunches resulted in a corresponding increase in percent bunches with split skin berries. However, the extent of the relationship between grapes yield and PDI of leaves was negative but highly significant with R^2 of 0.809 indicating that a unit increase in PDI of the leaf resulted in a corresponding decrease in yield by 0.55 t ha^{-1} (Figure 3).

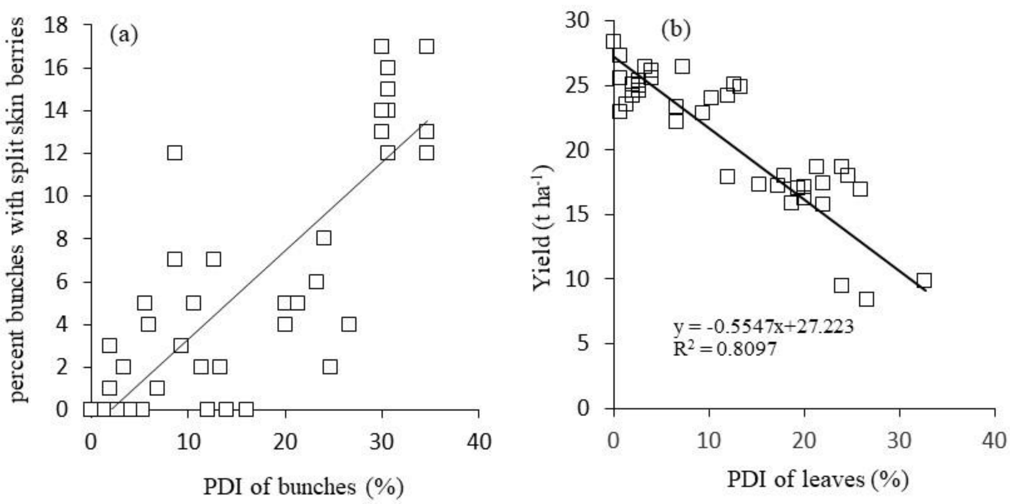

Figure 3. Positive correlation between percent bunches with split skin and PDI of bunches (a), negative correlation between yield and PDI of leaves (b) under the influence of fungicides and time of application on grapes

Discussion

Proper fungicide selection and timing are crucial for effective powdery mildew management in grapes. According to this study, applying protective fungicides at the bloom stage, approximately one week before flowering, proved highly effective in preventing *Uncinula necator* infection, resulting in a zero percent disease index (PDI) of bunches. Curative fungicides at the bloom stage also showed low PDI for bunches. Furthermore, both protective and curative fungicide sprays at the bloom stage resulted in low PDI for leaves and inflorescence. This highlights the common approach of using preventative fungicide sprays to manage grapevine powdery mildew. A more sustainable and cost-effective strategy involves protecting the fruit during its most vulnerable period (from bloom until five to six weeks after bloom) while adopting a less intensive approach to protect the foliage, ensuring functional leaves during fruit ripening. Preventative activity occurs when fungicides are applied before the pathogen arrives or begins to develop, acting as a protective barrier against infection.

Curative or early-infection activity occurs when fungicides are present within plant tissues, stopping the early growth of the pathogen. Fungicides with early-infection prevention often exhibit preventative activity and are most effective when applied before infection. These fungicides target various stages of disease development by inhibiting spore germination, colonization, reproduction, or other biochemical processes or structures of the target fungi. Overall, proper fungicide selection and timing are essential for effective powdery mildew management in grapes. Various unknown and known modes affect cell membranes, cell division, synthesis of proteins, respiration, signaling etc. [28-30]. In this study, the control treatment exhibited higher PDI values of leaves, inflorescence, and bunches. Similar results were reported by Sawant *et al.* [31] who observed that the Highest PDI values (42.31 to 82.13) were observed in control, followed by water spray (27.94 to 64.88) in the first and the subsequent observations. They also observed less PDI (0.00 to 2.25) in flusilazole treatment.

The efficacy of fungicides is influenced by the timing of their application, as observed in the case of systemic fungicides. When sprayed at the dormant, bud break, and bloom stages, systemic fungicides exhibited a high percent disease index (PDI) on leaves, inflorescence, and bunches. However, when applied at the berry formation stage, they effectively reduced the incidence of powdery mildew, leading to a decrease in PDI for leaves, inflorescence, and bunches. On the other hand, protective and curative fungicides did not perform well when sprayed at berry formation compared to their application at dormant, bud break, and bloom stages. These fungicides are more effective when used prior to infection and promote plant health. However, their efficacy diminishes in later stages, resulting in less effective control of powdery mildew. Therefore, during the vegetative period, the use of systemic fungicides in spray applications aids in eradicating the fungi. Systemic fungicides are absorbed into the plant. Some systemic fungicides exhibit local systemic activity, moving within the plant but not over long distances from the site of penetration. Certain locally systemic fungicides have a translaminar mode of action, allowing them to move through the leaf from one side to the other. Systemic fungicides require active plant growth to circulate effectively and control disease. They provide a short period of protection for new leaf growth. Unlike contact fungicides, systemic fungicides can sometimes be used to suppress a disease after it has already infected a plant. Researchers have emphasized the importance of spray timing and highlighted that careful application timing is crucial for effective powdery mildew control, optimizing the effectiveness of the control agent and limiting the establishment of *Uncinula necator* [32, 21]. Preventive treatments for powdery mildew should be applied before outbreaks become severe, ensuring the control method remains effective. By timing the application of control agents or chemicals to coincide with peak infection periods, disease levels can be kept below the economic threshold (approximately 3-5% bunch infection) with fewer fungicide applications. A group of researchers reported similar results that might provide additional insights and support in understanding the fungicides application programs for the management of powdery mildew of grapevines [23, 24].

As regard to grapes yield, the protective and curative fungicide sprays increased grape yield by 23.16 and 20.53% over the yield obtained under systemic fungicide spray. Without fungicides sprays resulted in a decrease in yield tremendously and have reduced yield by 76.61, 77.1 and 81.0% when compared to protective, curative and systemic fungicides sprays (4.7). These results are in line with the findings of group of researchers who reported >80% yield losses due to fungal diseases [33, 34]. Plant diseases have a severe detrimental impact on yields in almost any crop, and this situation could be worsen under favorable conditions if no control is applied. This is especially true in developing countries, having limited resources to manage crops. Human intervention is indispensable to get the desired yields by controlling disease and keeping their effect on yield potential at a minimum level [35, 36]. Fungicides may control a disease during the developmental crop stages of crops and increase its productivity. They may also increase its market value by saving the produce from spots and blemishes, in field and storage conditions [37]**.**

The findings of the current study show a positive linear relationship between PDI of bunches and percent bunches with split skin berries, while there is a negative linear relationship between grapes yield and PDI of leaves. These findings are consistent with previous studies that have investigated the relationship between different parameters in grapevines. A similar study was conducted by Karami *et al.* [38] who found a positive relationship between the severity of powdery mildew and the incidence of berry splitting in grapevines. Additionally, a negative correlation between yield and powdery mildew severity has been reported in various grape cultivars [39-41]. Likewise, a study by Gadoury *et al*. [42] investigated the relationship between powdery mildew incidence and grape yield in different grape varieties. Their findings demonstrated a negative correlation between disease severity and yield. Additionally, research by Pearson and Gadoury [43] and Stark-Urnau and Kast [44] focused on the impact of powdery mildew control measures on grape yield. These studies found that effective control of powdery mildew led to increased grape yield, supporting the concept of a negative relationship between disease incidence and yield. Overall, the logical reasoning presented in the passage regarding the relationships among the studied parameters is sound. It aligns with established statistical concepts and is supported by similar research in the field.

Conclusion

For better control of powdery mildew (*Uncinula necator*) in grapes, it is imperative to apply the right fungicides at the right time. From this study, it was inferred that both protective and curative fungicides proved to be highly effective against *U. necator* when sprayed one week before flowering which resulted in greater grape yield with healthy berries. After the bloom stage, the use of systemic fungicide revealed better results when sprayed at the stage of berry formation. So, for effective control of *U. necator*, a protective spray of fungicide before bloom and a subsequent spray of systemic fungicides at the time of berry formation ensure healthy and higher grape yield.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Not applicable.

HUMAN AND ANIMAL RIGHTS

No animals and human samples were used in this study.

CONSENT FOR PUBLICATION

Not applicable.

AVAILABILITY OF DATA AND MATERIALS
None.

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CONFLICT OF INTEREST
The authors declare no conflict of interest, financial or otherwise.

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