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Research Paper

Battling with the white threat: managing powdery mildew in bottle gourd for optimal crop performance

Humira Gulzar[1], Baby Summuna[2], P.A.Sheikh[3], Asha Nabi[1], Subaya Manzoor[1], Zohra Shabir[1], Suhail Quyoom Wani[2], Mohammad Aasif Sheikh[4], Hemu Majeed[1] and Zahoor Ahmad Mir[5]

[1]Division of Plant Pathology, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Wadura, 193201, India; [2]Directorate of Research, SKUAST-K, Shalimar, 190 025, India; [3]Division of Plant Pathology, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Shalimar, [4]Division of Plant Entomology, SKUAST-K, Wadura, 193201India; [5]Department of Plant Science and Agriculture, University of Manitoba, Canada, R2M0TB.
*e-mail: *summunabhat@gmail.com*

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ABSTRACT

Bottle gourd (*Lagenaria siceraria* L.) is one of the most important cucurbitaceous vegetable widely grown in India. The crop is affected by the most destructive disease known as powdery mildew caused by the pathogen *Podosphaera xanthii* (syn. *Sphaerotheca fuliginea*). Powdery mildews (Ascomycotina, Erysiphales) are some of the world's most frequently encountered plant pathogenic fungi. Therefore, detailed investigations were undertaken with the objectives to record disease incidence and intensity in different districts of Kashmir and also devise suitable management strategies with chemicals. Survey revealed that the disease was prevalent in Kashmir. The highest disease incidence was recorded in district Budgam (37.11%) and minimum in district Kulgam (28.73%). The maximum disease intensity was observed in district Budgam (28.02%) and minimum at district Kulgam (19.58%). The pathogen was identified based on the anamorphic and teleomorphic features as *Podosphaera xanthii*. Field experiment was carried out to know the effect of different fungicides against powdery mildew of bottle gourd during Kharif season (2021). Among the twelve treatments, Hexaconazole (5% EC) proved to be most effective for the management of powdery mildew with highest disease control of 77.52 per cent followed by Flusilazole (40% EC) with disease control of 72.10 per cent and the least effective treatment was Mancozeb (75% WP) that showed only 38.97 per cent disease control. These findings underscore the potential of hexaconazole as a promising solution for the management of powdery mildew in bottle gourd cultivation.

Key words: Bottle gourd, fungicides, *Podosphaera xanthii*, powdery mildew, status

Bottle gourd (*Lagenaria siceraria* L.) belonging to the family Cucurbitaceae, is a cosmopolitan vegetable grown extensively in tropical and sub-tropical regions (Saurabh *et al*., 2023). The crop is enriched with minerals such as calcium, iron, potassium, phosphorus and carbohydrates (2.9%), proteins (0.25%), fats (0.5%) and vitamins A and B (Bose *et al*., 1993). It also contains various biologically active constituents including flavonoids, saponins, and triterpenes. The crop is being affected by different groups of microorganisms such as fungi, bacteria, virus and nematodes causing significant yield reduction (Gaie *et al*., 1998). Powdery mildew is a serious fungal disease occurring on the wild as well as cultivated plants due to fungi belonging to the order erysiphales and family erysiphaceae. It is one of the easier plant diseases to recognize, as its symptoms are entirely distinctive (Dhananjaya *et al*., 2023). This potentially devastating disease has been shown to reduce yield by decreasing the size and number of fruits, and length of time these fruits can be harvested (McGrath and Thomas 1996). Enormous expenditures are made annually on fungicides and resistant varieties for the

management of powdery mildew diseases (Camele *et al*., 2009). So, it is important to be aware of powdery mildew and its management as the resulting disease can remarkably decrease important crop yields. Hence, the present study was aimed to assess the status of disease and to devise a suitable chemical management strategy for the disease.

MATERIALS AND METHODS

Status of powdery mildew disease: The extensive field survey of major bottle gourd growing areas in three Districts *viz*., Kulgam, Budgam and Baramulla of the Kashmir was conducted to determine the disease incidence and intensity of Powdery mildew of bottle gourd during the months of July and August (peak periods of disease), 2021. In each district, three blocks were selected and in each block three sites were selected and from each site three fields were randomly surveyed as depicted in **(Fig 1**). In each field, five random plants were selected and from each plant forty leaves were assessed for powdery mildew symptoms to record the disease incidence and intensity.



Fig 1: symptomatology of Powdery mildew on bottle gourd leaves

The disease incidence was recorded by counting the total number of leaves and the number of infected leaves

$$\text{Percent disease incidence} = \frac{\text{Number of infected leaves}}{\text{Total no.of leaves ex amined}} \times 100$$

The percent disease intensity for each disease was recorded by visual observation using 0-6 scale adopted by (Yan *et al*., 2006) as shown below:

The disease intensity on leaves was calculated by using the following formula:

Grade	Percent leaf area covered by mycelial growth
0	No visible mycelial growth
1	less than 1%
2	1 to 5%
3	6 to 20%
4	21 to 40%
5	41 to 60%
6	>60%

$$\text{Disease intensity (\%)} = \frac{\Sigma(n \times v)}{N \times G} \times 100$$

Where, n =number of leaves in a category, v =numerical value of category, N =total number of leaves examined and G= maximum category value

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Unveiling the power of fungicides against bottle gourd powdery mildew: To evaluate the efficacy of fungicides on powdery mildew of bottle gourd, the field experiment was conducted during kharif 2020-2021 in randomized complete block design (RBD) at experimental field of Division of Plant Pathology, SKUAST-K, Wadura. Bottle gourd seeds were raised in polybags and then transplanted on raised beds with individual plot size as 2.5m x 3m. Proper intercultural operations and irrigation were maintained duly. Per hill two plants were established and necessary trailer were made. To find out the efficacy of fungicides, eleven fungicides *viz*., Hexaconazole 5 EC @ 0.05%, Mancozeb 75 WP @ 0.3%, Captan 70% + Hexaconazole 5% @0.05%, Chlorothalonil 75 WP@0.2%, Trifloxystrobin 25% + Tebuconazole 50% (75 WG) @0.04%, Flusilazole 40 EC @0.02%, Thiophanate methyl 70 WP @0.05%, Triadimefon 25 WP @0.05%, Zineb 68% + Hexaconazole 4% (72 WP) @ 0.1%, Myclobutanil 10 WP@0.03%, Mancozeb 63% + Carbendazim 12% @0.25% were sprayed and one untreated control was maintained. Fungicides were sprayed immediately at their recommended concentration after the onset of the first symptom and second spray was applied after 15th day of first spray. All the sprays were conducted in late afternoon hours and care was taken to prevent drift of chemicals from one treatment to another.

Statistical analysis: The data collected from experiments was analysed by using software SPSS.

RESULTS AND DISCUSSION

Symptomatology and morphological characterization of pathogen: The symptoms of powdery mildew were observed as tiny, white, round, superficial spots on stems and leaves. The white lesions increased in number and coalesced and eventually covered the stems and both surfaces of the leaves. Fungal hyphae and conidia were produced in profusion and formed white powdery mycelia that showed resemblance to talcum powder or dust on the leaf surface as presented in (**Fig 1**). Also, conidia were freely carried to adjacent leaves and plants within a field by air movement which favoured secondary spread of disease. Leaves were reported to be most susceptible for damage due to powdery mildew. At the end of season, dark brown or black pinpoint bodies, the chasmothecia (cleistothecia) occurred on leaf surface which were conspicuous and visible to the naked eye. This chasmothecia served as overwintering stage and source of primary inoculum.

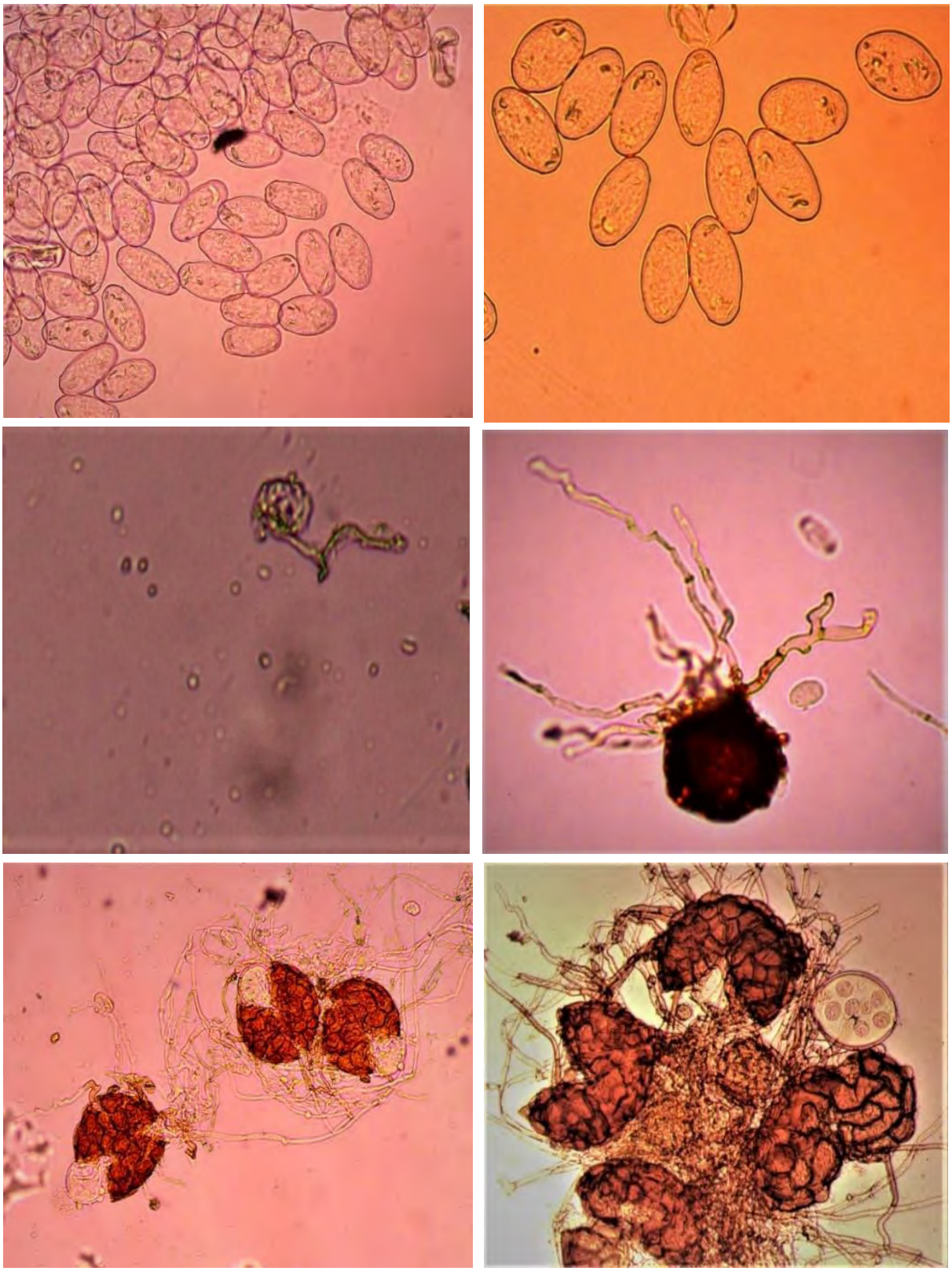




The sexual spores within these structures are protected from adverse environmental conditions. Fruits were free of visible infection, even when the foliage was heavily infested. Microscopic examination of the fungus *Podosphaera xanthii* revealed that the conidia were hyaline and ellipsoid to ovoid with values of length and breadth ranged between 30-34 ×15-18 µm as illustrated in (**Fig 2c**). Chasmothecia was dichotomously branched as shown in (**Fig 2f**) and its diameter was about 80-84 × 75-80 µm. It contained single globular ascus with dimensions of 66-70 × 54-60 µm (**Fig 2g**) and in each ascus eight ascospores of 12-16 × 10-14 µm in size were present (**Fig 2h**).

These results were somewhat similar to those described by Chen *et al*., 2008. The conidia contained well defined fibrosin bodies that were easily visualized using standard light microscopy when conidia were mounted in 3% aqueous KOH (potassium hydroxide) solution as illustrated in (**Fig 2d**). These findings resembled those detailed by (Braun, 1987). Also, germ tubes formed by the pathogen were usually short and forked as shown in (**Fig 2e**).

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Fig 2: Microscopic studies of pathogen (*Podosphaera xanthii*)

a Mycelium (400x**), b)** Conidiophore (400x), **c)** Conidia (400x), **d)** Fibrosin bodies inside conidia (400x), **e)** Lateral and forked germ tube (100x), **f)** Chasmothecia with dichotomous appendages (100x), **g)** Chasmothecia with single ascus (100x), **h)** Single ascus with 8 ascospores (100x)

Status of powdery mildew disease in Kashmir: With a view to assess the status of the powdery mildew disease of bottle gourd in Kashmir, the survey was conducted in three districts *viz* Kulgam, Budgam, Baramulla during 2020-2021 which indicated that the powdery mildew of bottle gourd was more or less prevalent in all the surveyed areas as shown in (**Fig 3**). The data on disease incidence reveals the varying levels of incidence ranging from 21.78 per cent to 41.11 per cent and mean disease incidence of 32.14 per cent. Highest disease incidence (41.11%) was recorded at Narkara (district Budgam) and the lowest (21.78%) at Duslipora (district Baramulla). The data on disease intensity reveals varying levels of intensity ranging from 16.42 to 34.60 per cent (**Table 1**). Highest disease intensity (34.60%) was recorded at Narkara (district Budgam) and the lowest (16.42%) was recorded at Redwani (district Kulgam).

Table 1: Survey for incidence and intensity of bottle gourd powdery mildew in Kashmir during 2020-2021

District	Block	Site	Disease incidence (%)	C.I (95%)	Disease intensity (%)	C.I (95%)
Kulgam	Qaimoh	Wazirpora	34.15		24.23	
		Redwani	28.52		16.42	
		Wanigund	29.33		17.9	
	Kulgam	Paniwah	32.56		22.23	
		Bugam	29.63		18.47	
		Bolsoo	24.81		17.14	
	Yaripora	Humshalibug	23.22		22.15	
		Budru	26.37		19.04	
		Matibugh	29.96		18.68	
		Mean	28.73	**26.36 - 31.09**	**19.58**	**17.79– 21.37**
		Range	10.93		**7.81**	
Budgam	Budgam	Narkara	41.11		34.60	
		Ompora	39.26		32.72	
		Batahar	36.11		26.97	
	Chadoora	Bugam	39.04		26.56	
		Dawlatpora	35.74		28.49	
		Wathura	34.22		26.05	
	Beerwah	Beerwah	34.11		21.78	
		Drang	36.21		25.33	
		Aripathan	38.19		29.73	
		Mean	37.11	**35.48-38.74**	28.02	**25.39- 30.65**
		Range	7.00		12.82	
Baramulla	Baramulla	Stadium colony	37.22		24.63	
		Janbazpora	36.67		29.89	
		Chakloo	32.33		23.52	
	Sopore	Arampora	33.70		29.89	
		Wadura bala	24.22		22.70	
		Tarzoo	31.11		22.28	
	Pattan	Duslipora	21.78		20.80	
		Palhallan	26.81		17.59	
		Hanjivara	31.48		17.72	
		Mean	30.59	**26.99 – 34.18**	23.23	**20.20-26.24**
		Range	15.44		12.30	
		Overall mean	**32.14**		**23.61**	

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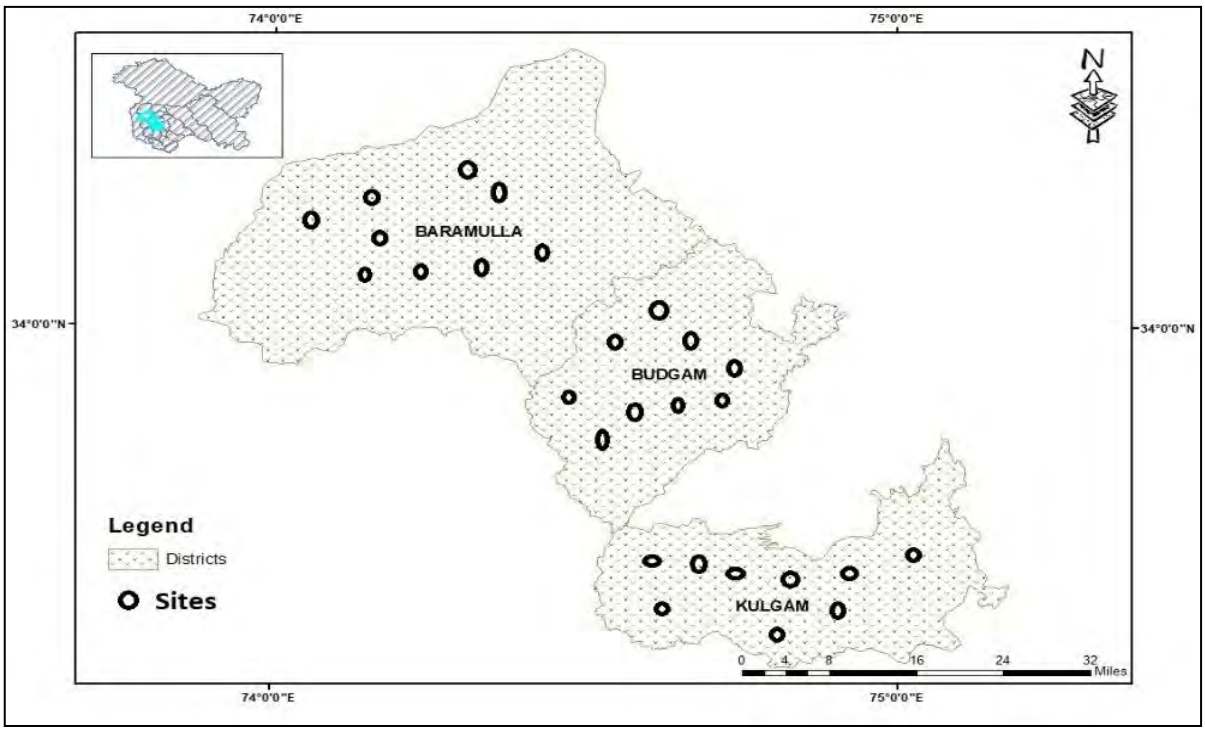


Fig 3: Survey map of different sites in Kashmir

Other locations supporting higher disease intensity were Ompora (32.72%), Aripathan (29.73%), Dawlatpora (28.49%) from district Budgam and Janbazpora (29.89%) from district Baramulla (**Fig 4**). Among the districts surveyed, the maximum disease incidence and intensity was recorded in district Budgam followed by district Baramulla while as the district Kulgam exhibited the least disease incidence as depicted in (**Fig 5**). The variation in disease incidence and intensity recorded in different districts and at different sites may be attributed to different factors like location, stage of the crop, cultural practices adopted, inoculums chain due to continues cultivation of same crop and susceptibility of the cultivars grown (Basavaraj *et al.*, 2019). The results were supported by Parthasarathy *et al.* (2017), Rajalakshmi *et al*. (2016) and Naik *et al*. (2018) while working on powdery mildew of cucumber, bhendi and pea crops respectively, they observed that the incidence and severity of powdery mildew varied in different locations across the state.

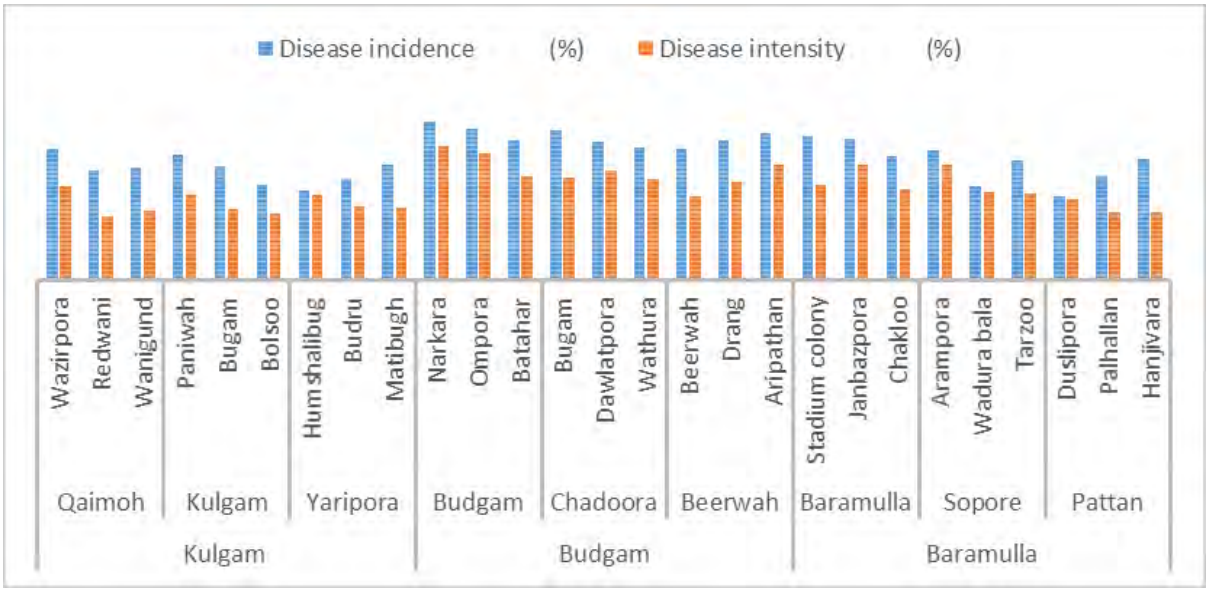


Fig 4: Mean disease incidence and intensity of bottle gourd powdery mildew at various locations of

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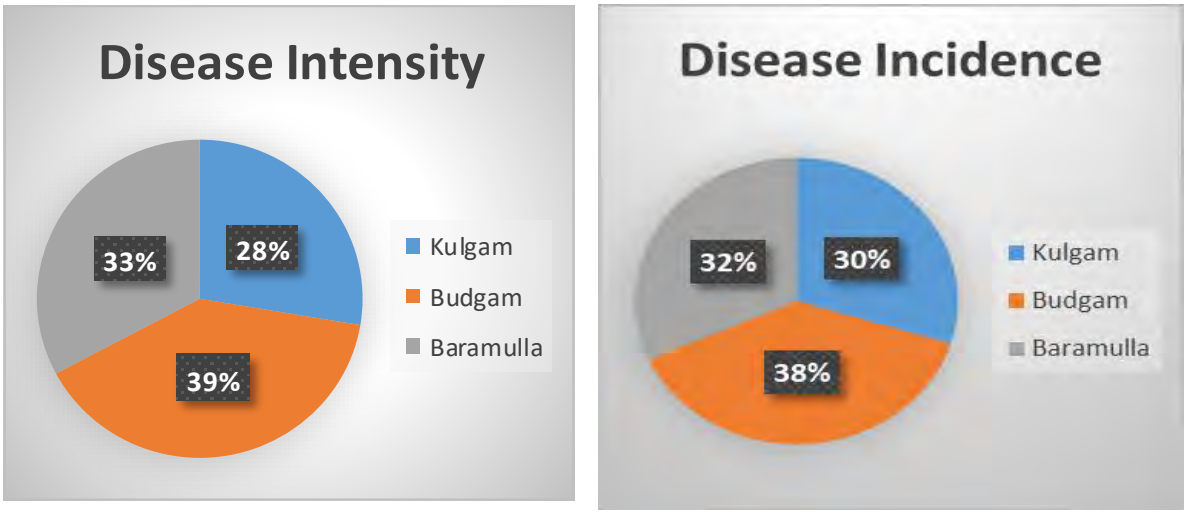


Fig 5: Disease incidence and Intensity in three Districts under survey Kashmir during 2020- 2021

***In vivo* evaluation of different fungicides, unveiling the power of fungicides against powdery mildew:** During the management studies by various chemicals, it was observed that all the treatments, individually or in combination, restrained the disease incidence and intensity to a level significantly lower than that of the control and enhanced the yield appreciably in the experimental field (**Fig 6**). In order to examine the efficacy of different fungicides on management of powdery mildew disease, Twelve treatments were evaluated under field conditions against the pathogen amongst which hexaconazole 5% EC @ 0.05% proved the most effective by showing the highest disease control (77.52%) followed by flusilazole 40% EC with @ 0.02% (72.10 %), captan 70% + hexaconazole 5% @ 0.05% (68.68%), zineb 68% +hexaconazole 4% @ 0.1% (72 WP) (65.81%), trifloxystrobin 25% +tebuconazole 50% @ 0.04% (75 WG) (62.28%), triadimefon 25% wp @ 0.05% (57.65%), thiophanate methyl 70% WP @ 0.05% (52.35%), chlorothalonil 75% wp @ 0.2% (46.94%), myclobutanil 10% WP @ 0.03% (46.25%), mancozeb 63% + carbendazim 12% @ 0.25% (44.18%) and Mancozeb 75% WP @ 0.25% with lowest disease control (38.97 %) (**Table 2**).

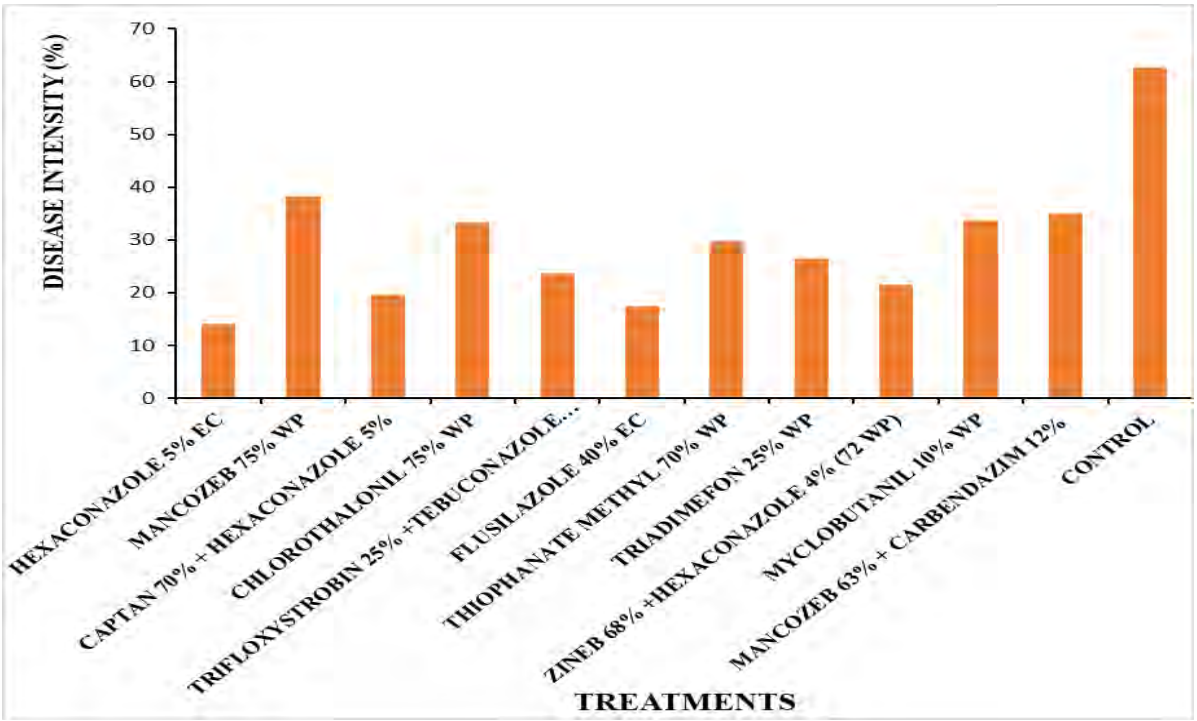


Fig 6: Efficacy of fungicides on per cent disease intensity

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The result is in agreement with several workers, who reported that hexaconazole was found to be effective in reducing powdery mildew incidence in different crops. Sugha *et al*. (2007) worked on management of powdery mildew of cucurbits caused by *Sphaerotheca fuliginea* with fungicides have shown that hexaconazole 5% EC @ 0.05% concentration was found best in controlling the powdery mildew. Wahul *et al*. (2018) proved that hexaconazole 5% EC @0.1% concentration followed by propiconazole 10% EC was found effective against powdery mildew of cucumber. Similar results were supported by Khunti *et al*. (2005) and proved that all the triazoles fungicides performed better as compare to conventional fungicides and observed that the minimum disease intensity and highest yield was recorded with the application of hexaconazole and penconazole in green gram for management of powdery mildew. The effect of hexaconazole was noted curative and gave maximum disease control Khunti *et al*., (2005). Several other scientists reported that hexaconazole, propiconazole, myclobutanil, and triadimefon were found to be effective in reducing powdery mildew incidence in different crops (Sharma, (1991), Sharmila *et al*. (2004), Pramod Prasad and Dwivedi, (2007) and Akhileshwari *et al*. (2012). Also flusilazole 40 % EC proved to be second best fungicide with disease control of 72.10 per cent.

Table 2: *In vivo* efficacy of fungicides againist powdery mildew of bottle gourd (*Lagenaria siceraria*)

S. No.	Treatments	Concentration	Disease intensity (%)	Disease control (%)
1	Hexaconazole 5 EC	0.05%	14.08[a]	77.52
2	Mancozeb 75WP	0.25%	38.22[i]	38.97
3	Captan 70% + Hexaconazole 5%	0.05%	19.61[c]	68.68
4	Chlorothalonil 75 WP	0.2%	33.23[h]	46.94
555 555	Trifloxystrobin 25% + Tebuconazole 50% (75 WG)	0.04%	23.62[e]	62.28
6	Flusilazole 40% EC	0.02%	17.47[b]	72.10
7	Thiophanate methyl 70% WP	0.05%	29.84[g]	52.35
8	Triadimefon 25% WP	0.05%	26.52[f]	57.65
9	Zineb 68% +Hexaconazole 4% (72 WP)	0.1%	21.41[d]	65.81
10	Myclobutanil 10% WP	0.03%	33.66[h]	46.25
11	Mancozeb 63% + Carbendazim 12%	0.25%	34.96[h]	44.18
12	Control	untreated	62.63[j]	0
C.D		**1.77**		
SE(m)		**0.60**		

The result was supported by Sharma *et al*. (2012) and revealed that disease severity was lowest with significantly highest yield in the mango plants treated with flusilazole @ 0.015%. Several other workers have reported efficacy of flusilazole (Lonsdale and Kotze, (1993) and Brooks, (1991). The use of systemic fungicides for the management of powdery mildew was found to be very effective than spraying of non-systemic fungicide wettable sulphur (Daunde *et al*., 2018). In this study, mancozeb 75% WP were observed as least effective fungicide for powdery mildew disease control, such finding was supported by the result of Rahman and Afroz (2016) and observed that mancozeb (Indofil M) has least effectiveness in controlling powdery mildew disease of bottle gourd. To manage this disease an integrated approach using combinations of several approaches will be more effective and timely management of this disease by applying preventive fungicides or development of resistant varieties is very important.

CONCLUSION

The study details the symptomatology and morphology of *Podosphaera xanthii*-induced powdery mildew on bottle gourd. Hexaconazole (5% EC) emerged as the most potential fungicide, achieving a remarkable 77.52 per cent disease control, emphasizing its significance in proactive disease management. These results underscore the need for integrated strategies, with hexaconazole standing out as a promising solution for powdery mildew control in bottle gourd cultivation.

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