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MANAGEMENT OF BOTTLE GOURD DOWNY MILDEW THROUGH PLANT GEOMETRY AND HOST RANGE

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ABSTRACT

Downy mildew caused by *Pseudoperonospora cubensis* is one of the most destructive disease of cucurbits worldwide. The present investigation was conducted to study the host range and effect of plant spacing on disease development in bottle gourd. Cucurbit hosts, including watermelon, muskmelon, pumpkin, sponge gourd, ridge gourd, cucumber, bitter gourd and round gourd were evaluated for per cent disease intensity (PDI). The pathogen infected all tested hosts, with cucumber showing highest disease intensity, while ridge gourd recorded lowest PDI. A separate experiment assessed six plant spacings in bottle gourd to determine their influence on disease severity and yield. Narrow spacing (1.0m × 1.0m) recorded highest PDI and produced maximum yield, whereas wider spacing (2.0m × 1.0m) significantly reduced disease intensity with comparatively lower yield. Study revealed negative correlation between plant spacing and disease development and highlighted importance of host susceptibility and optimum plant spacing in managing disease.

Key words: Bottle gourd; host range; *Pseudoperonospora cubensis*; spacing.

Introduction

Among cucurbit diseases, downy mildew caused by *Pseudoperonospora cubensis* stands out as one of the most economically devastating and widespread pathogens globally (Palti and Cohen, 1980). It infects various cucurbit hosts, with bottle gourd (*Lagenaria siceraria*), cucumber (*Cucumis sativus*), squash, pumpkin, and zucchini (*Cucurbita pepo*), watermelon (*Citrullus lanatus*), and muskmelon (*Cucumis melo*) suffering the greatest impacts due to their economic importance (Lebeda and Widrlechner, 2003). The bottle gourd (*Lagenaria siceraria*), a member of the Cucurbitaceae family is believed to have originated in India, as wild varieties are still found in humid regions such as Dehradun and along the Malabar coast. Ancient Indian texts indicate that this plant was cultivated as early as 2000 B.C. *Lagenaria siceraria* is one of the few cucurbit species known to have existed in both the old and new Worlds during prehistoric times. Archaeological evidence also shows

that humans in Peru were using bottle gourds between 1100 and 13,000 B.C. *Lagenaria siceraria* commonly referred to as bottle gourd and known in Hindi as doodhi or lauki is recognized in the Ayurvedic Pharmacopoeia. Downy mildew (DM), one of the most damaging foliar diseases affecting cucumbers globally, is a major production restriction caused by the oomycete *Pseudoperonospora cubensis*. High humidity and moderate temperatures are optimal for the pathogen's proliferation, which significantly influences photosynthesis and can cause susceptible cultivars to lose up to 70-90% of the yield (Thomas, 1996).

The disease symptoms of bottle gourd downy mildew typically begin with pale green areas on the upper leaf surface, which turn into yellow angular spots. A fine, white to grayish downy growth appears on the lower leaf surface. As the disease progresses, infected leaves often die, curl inward and may remain erect. The infection usually starts at the center of a plant row. The infected

area spreads outward, causing defoliation, stunted growth, and poor fruit development, ultimately reducing yield. In severe cases, the entire plant may be killed (Kuepper, 2003). During moist weather, the underside of the leaves develops a downy, pale gray to purple mildew. Early-stage lesions appear light green, turning chlorotic and eventually necrotic as the host cells die, resulting in completely dead. This symptom has been called as “wildfire” as leaves appear to be burned (Colucci and Holmes, 2010).

The incidence of disease and its severity ranged from 50-100 per cent during 1998 crop season (Sharma *et al.*, 2003). Yield losses because of Downy mildew-disease are around 30-40% (Colucci *et al.*, 2006) which may increment up to 100% under great conditions (Hausbeck, 2007; Holmes *et al.*, 2006; Lebeda and Urban, 2007). Yield-losses (10 to 40%) and (16-34%) were watched much of the time in cucumber producing-territories of United States (Colucci *et al.*, 2006) and Korea (Yeon, 2007). Fungicide-based management is unsustainable from an economic and environmental standpoint, particularly for smallholder farmers. Therefore, this research was conducted to check the impact of different spacing followed during sowing on the downy mildew disease incidence and the yield of the bottle gourd and also the impact of downy mildew on different hosts of the Cucurbitaceae.

Materials and Methods

In order to determine the range of *Pseudoperonospora cubensis* on various hosts and effect of plant to plant spacing on the downy mildew disease development an experiment was conducted at Vegetable Research Station, C. P. College of Agriculture, S.D. Agricultural University, Sardarkrushinagar (Dantiwada) Gujarat during Summer 2024. Watermelon, muskmelon, pumpkin, sponge gourd, ridge gourd, cucumber, bitter gourd and round gourd were among the eight Cucurbitaceae crops that were planted and different plant to plant distance maintained and total numbers of spacing differences adopted were six as shown in Table 2. With the exception of the use of fungicides, all advised horticultural techniques for the production of cucumber were implemented. Ten randomly chosen plants per plot were used to measure the prevalence of downy mildew in order to assess the effectiveness of treatments. Fruits were picked and block by block observations were made to assess each treatments yield and were noted and calculated in q/ha. The computer program “OPSTAT” created by O. P. Sheoran, CCS HAU, Hisar, was also used to investigate the data collected throughout the research.

Table1: Criteria for calculating of Per cent disease intensity.

Scale	Leaf area infected
0	Leaf area free from infection
1	Leaf area infected up to 1%.
3	Leaf area infected up to 10%.
5	Leaf area infected up to 25%.
7	Leaf area infected up to 50%.
9	Leaf areas infected with more than 50%.

Disease rating scales used from 0-9 scale for recording disease intensity of downy mildew (Datar and Mayee, 1986) as shown in Table 1.

The PDI was calculated by using formula given by Wheeler (1969)

$$PDI = \frac{\text{Sum of all the diseases rating}}{\text{Total no. of samples observed} \times \text{Maximum disease rating}} \times 100$$

To calculate the AUDPC the per cent disease index was determined at ten-day intervals using the formula developed by Shaner and Finney (1977).

$$AUDPC = \sum_{t=1}^n \{(Xi + Xi + 1) \times ti\} / 2$$

Where,

X_i and X_{i+1} are severities on date i and date $i+1$, respectively

t_i is the number of days in between date i and date

$i+1$ n is the number of observations recorded

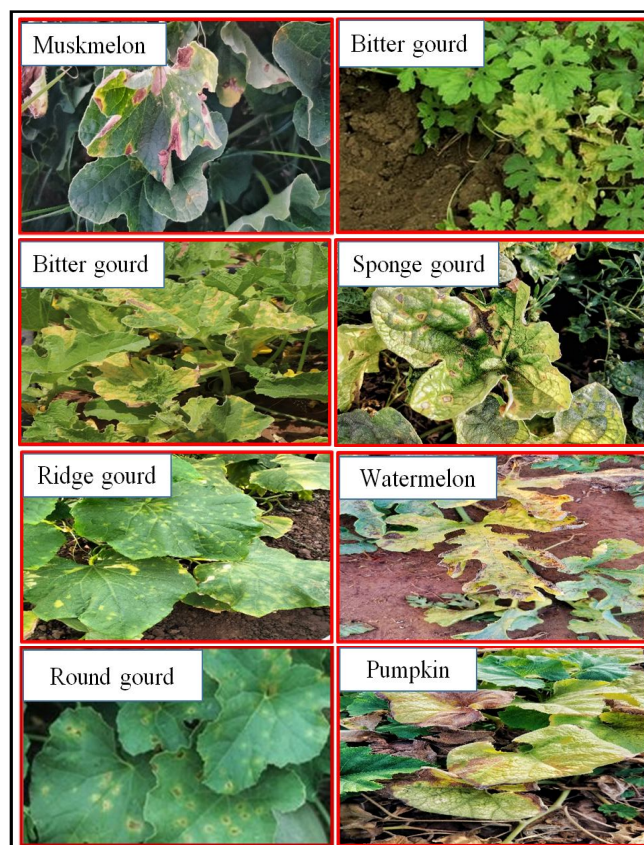


Plate I: Host range of bottle gourd downy mildew.

Table 2: Spacing details.

Treatments	Spacing
S ₁	1.0 m × 1.0 m
S ₂	1.2 m × 1.0 m
S ₃	1.4 m × 1.0 m
S ₄	1.6 m × 1.0 m
S ₅	1.8 m × 1.0 m
S ₆	2.0 m × 1.0 m

Results and Discussion

Host Range of Downy Mildew Pathogen (*Pseudoperonospora cubensis*) on Cucurbitaceae

Plant pathogens can shift their host time to time depending on their suitability they take their nutrition and complete life cycle. In the present investigation eight different hosts belonging to family Cucurbitaceae were tested against the pathogenic potential of *Pseudoperonospora cubensis* which cause downy mildew in bottle gourd. Host plant used includes watermelon (*Citrullis velgaris*), muskmelon (*Cucumis melo*), pumpkin (*Cucurbita moschata*), sponge gourd (*Luffa aegyptiaca*), ridge gourd (*Luffa actangula*), cucumber (*Cucumis sativus*), bitter gourd (*Momordica charantia*) and round gourd (*Praecitrullus fistulosus*). The host range study indicates that *Pseudoperonospora cubensis* was able to infect all the cucurbits included in the study i.e., ridge gourd, sponge gourd, bitter gourd, round gourd, cucumber, pumpkin, watermelon and muskmelon in field conditions [Plate I] with first symptoms occurring uniformly forty days after planting across treatment. Similar results were obtained by Bains and Jhooty (1978), Bains and Vidyaprakash (1985) and Choudhary (2024) and emphasized its epidemiological relevance in polyculture cucurbit systems often used in Indian agriculture.

Table 3: Disease intensity of *Pseudoperonospora cubensis* on different hosts under field condition.

Sr. No.	Crop Name	Per cent disease intensity				AUDPC
		10 DAI	20 DAI	30 DAI	40 DAI	
1.	Watermelon	20.00 ^{cd} (11.85)	28.04 ^{bcd} (22.22)	35.65 ^b (34.07)	45.19 ^{abc} (50.37)	874.06 ^{bcd}
2.	Muskmelon	21.93 ^{bcd} (14.07)	31.50 ^{ab} (27.41)	37.9 ^{ab} (37.78)	44.34 ^{abc} (48.89)	966.65 ^{bc}
3.	Pumpkin	23.18 ^{bc} (15.56)	28.61 ^{bcd} (22.96)	39.63 ^{ab} (40.74)	46.47 ^{ab} (52.59)	977.76 ^b
4.	Sponge gourd	24.9 ^b (17.78)	29.55 ^{bc} (24.44)	39.21 ^{ab} (40.00)	43.49 ^{abc} (47.41)	970.36 ^b
5.	Ridge gourd	17.96 ^d (9.63)	24.29 ^d (17.04)	35.22 ^b (33.33)	39.16 ^c (40.00)	751.83 ^d
6.	Cucumber	30.04 ^a (25.18)	35.24 ^a (33.33)	42.63 ^a (45.93)	49.04 ^a (57.04)	1203.69 ^a
7.	Bitter gourd	23.18 ^{bc} (15.56)	27.52 ^{bcd} (21.48)	34.64 ^b (32.59)	41.33 ^{bc} (43.70)	837.02 ^{bcd}
8.	Round gourd	19.40 ^{cd} (11.11)	27.03 ^{cd} (20.74)	34.29 ^b (31.85)	43.06 ^{abc} (46.67)	814.80 ^{cd}
S. Em. ±		1.22	1.28	1.57	1.81	46.51
C. D. at 5 %		3.69	3.89	4.76	5.50	141.09
C.V.%		9.32	7.66	7.27	7.14	8.71
Figures in parenthesis are original values and outside are arcsine transformed values, DAI- Days after infection Treatment mean with the common letter/letters are not-significantly different by DNMRT at 5% level of significance						

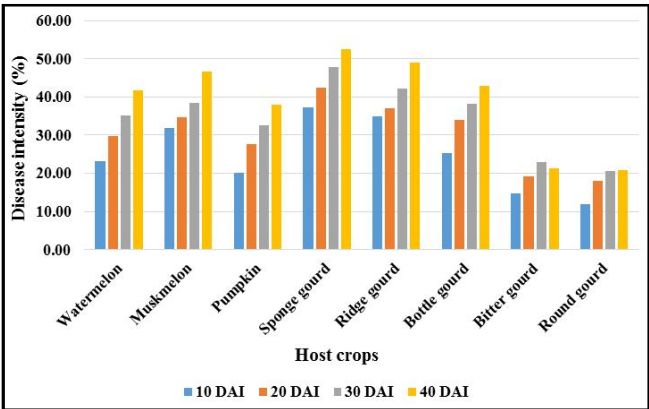


Fig. 1a: Disease intensity of *Pseudoperonospora cubensis* on different hosts.

Quantitative Disease Progression

The disease starts after forty days of sowing. The Table 3 and Fig. 1a depicts that after the ten days of the first appearance of disease in the field maximum per cent disease intensity was observed in the cucumber (25.18%). The next hosts in relation to per cent disease intensity were sponge gourd (17.78%), pumpkin (15.56%), bitter gourd (15.56%), muskmelon (14.07%) and these hosts were found at par with each other. Lowest PDI was found watermelon (11.85%), round gourd (11.11%) and ridge gourd (9.63%) had shown statistically at par results with each other.

After twenty days of the first appearance of disease in the field maximum per cent disease intensity was observed in cucumber (33.33%) which was found at par with muskmelon (27.41%). The next hosts in relation to per cent disease intensity were sponge gourd (24.44%), pumpkin (22.96%), watermelon (22.22%) and bitter gourd (21.48%) these hosts were found at par with each other. Lowest PDI was found round gourd (20.74%) and ridge gourd (17.04%) had shown statistically at par results with

Table 4: Effect of spacing on downy mildew intensity and yield of bottle gourd.

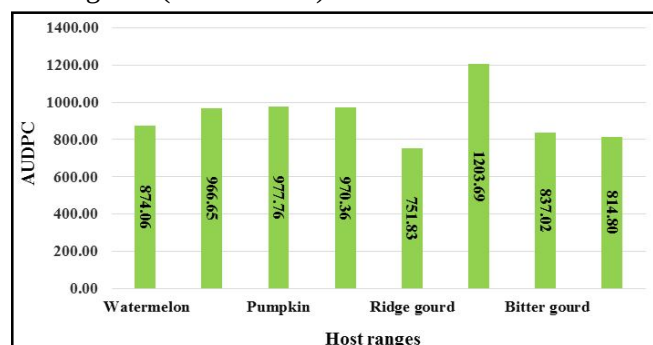
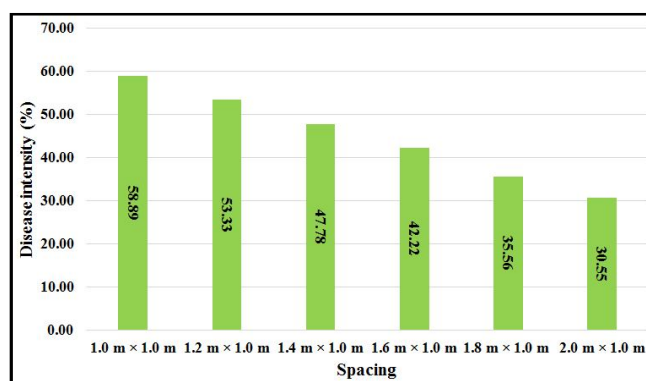
Tr. No.	Treatments	PDI	Yield (q/ha)
1	1.0 m × 1.0 m	50.1 ^a (58.89)	95.63 ^a
2	1.2 m × 1.0 m	46.9 ^{ab} (53.33)	92.57 ^{ab}
3	1.4 m × 1.0 m	43.7 ^{bc} (47.78)	89.41 ^{ab}
4	1.6 m × 1.0 m	40.46 ^{cd} (42.22)	85.11 ^{abc}
5	1.8 m × 1.0 m	36.55 ^{de} (35.56)	82.58 ^{bc}
6	2.0 m × 1.0 m	33.49 ^e (30.55)	77.17 ^c
S.Em. ±		1.70	3.49
C.D. at 5%		5.12	10.51
C.V. %		8.12	8.01
Figures in parenthesis are original values and outside are arc sine transformed values; Treatment mean with the common letter/letters are not-significantly different by DNMR at 5% level of significance			

each other.

After thirty days of the infection the highly infected host found was cucumber (45.93%) which was at par with pumpkin (40.74%), sponge gourd (40.00%) and muskmelon (37.78%). The next hosts in relation to per cent disease intensity were watermelon (34.07%), ridge gourd (33.33%) and bitter gourd (32.59%) and round gourd (31.85%) had shown statistically at par results with each other.

After forty days of the infection the host found with maximum per cent disease intensity was cucumber (57.04 %) which was at par with pumpkin (52.59%) and watermelon (50.37%). The next hosts in relation to per cent disease intensity were muskmelon (48.89%), sponge gourd (47.41%), round gourd (46.67%) and bitter gourd (43.70%). These hosts were found at par with each other. Lowest PDI was found ridge gourd (40.00%).

Perusal of data presented in Table 1 and Fig. 1b revealed that all the host crops in field condition shows downy mildew disease in relation to area under disease progress curve. The lowest AUDPC was recorded in crop ridge gourd (751.83 units) which was at par with round gourd (814.80 units). The next host in merit were

**Fig. 1b:** Effect of host range on AUDPC of downy mildew of bottle gourd.**Fig. 2:** Effect of spacing on per cent disease intensity.

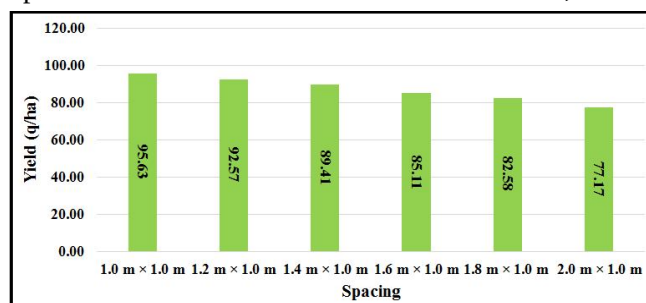
bitter gourd (837.02 units), watermelon (874.06), muskmelon (966.65 units), sponge gourd (970.36 units) and pumpkin (977.76 units). These hosts were at par with each other. The highest AUDPC was recorded in crop cucumber (1203.69 units). Statistical analysis (DNMR at 5%) revealed significant differences ($p < 0.05$) across hosts across all assessment intervals. The coefficients of variation (CV: 7.14-9.32%) indicate experimental accuracy.

These findings support previous research: Bains and Jhooty, (1978) found *P. cubensis* on muskmelon, while Bains and Vidyaprakash, (1985) verified its presence on sponge gourd, ridge gourd, bottle gourd, bitter gourd, cucumber, and pumpkin. Muskmelon's constant sensitivity is most likely due to plentiful stomata density, thinner cuticles, and abundant free moisture retention in its canopy architecture factors that promote oomycete entrance and sporulation under high humidity.

Ridge gourd's greater tolerance, on the other hand, might be due to physical barriers (thicker cuticles, fewer stomata) or biochemical defenses. This differential host response has far-reaching consequences for intercrop design: Ridge gourd might act as a "trap crop" or barrier plant in cucurbit consortia, reducing inoculum load on high-value crops such as muskmelon.

Effect of Plant Spacing on Downy Mildew Development and Bottle Gourd Yield

Plant density has a significant impact on foliar disease epidemics due to microclimate modification, which

**Fig. 3:** Effect of spacing on fruit yield of bottle gourd.

includes aerodynamic resistance, boundary layer conductivity, and canopy wetness duration. This experiment examined the impact of six row-to-row and plant-to-plant spacings (1.0-2.0 m $\times$ 1.0 m) on downy mildew severity and bottle gourd productivity (Table 4, Fig. 2 and 3).

Showed a strong density-dependent trend. The narrowest spacing (1.0 m $\times$ 1.0 m; largest plant population) had the highest PDI (58.89%), which decreased gradually with larger spacings to a low of 30.55% at 2.0 m $\times$ 1.0 m. Intermediate spacings resulted in intermediate PDIs: 53.33%, 47.78%, 42.22% and 35.56% at 1.2, 1.4, 1.6, and 1.8 m $\times$ 1.0 m, respectively. Analysis of variance revealed substantial spacing effects (F-test, $p < 0.01$), with SEM $\pm$ 1.70 and CD (5%) of 5.12. Showed an opposite pattern. Maximum production (95.63 q/ha) was achieved at 1.0 m $\times$ 1.0 m spacing, which is statistically equal to 1.2 m $\times$ 1.0 m spacing (92.57 q/ha). Yield decreased steadily to 77.17 q/ha at the largest spacing, with 1.8 m $\times$ 1.0 m (82.58 q/ha) and 1.6 m $\times$ 1.0 m (85.11 q/ha) in the middle. These findings are consistent with microclimate theory: dense canopies generate damp, still-air pockets that promote *P. cubensis* sporulation and splash spread, whereas broader spacings improve ventilation, UV exposure, and leaf drying, hence decreasing epidemics. Ghebrial and Kenawy (2018) reported analogous density-disease relationships in basil downy mildew, where 10 cm spacing maximized severity versus 25 cm minimum. Similarly, Omer *et al.*, (2021) documented 41-56% incidence reductions when sweet basil density dropped from 24-30 to 14-15 plants/m².

Agronomic optimization necessitates striking a balance between disease and yield. Spacings of 1.2-1.4 m $\times$ 1.0 m are ideal, collecting 97-94% of maximal yield (92.57-89.41 q/ha) and lowering PDI by 10-14% compared to the densest treatment. For resource-constrained farmers, this is a realistic cultural control that should be incorporated into IPM programs alongside resistant cultivars and prudent fungicide usage.

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Declaration

The authors have declared that no competing interests exist.

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