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Identification of Sources of Multiple Disease Resistance in Advanced Breeding Lines of Bottle Gourd (*Lagenaria siceraria* (Molina) Standle)

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ABSTRACT

Bottle gourd [*Lagenaria siceraria* (Molina) Standle] is one of the most widely grown cucurbit in India valued for its various medicinal and nutritional properties. The crop is plagued by a multitude of diseases which drastically affect the yield and quality of produce. Under South Indian conditions, Gummy Stem Blight (GSB) caused by *Didymella bryoniae* is creating havoc wiping out entire populations during recent times. Till now there are no reported sources of resistance to GSB. The present study is aimed at screening advanced breeding lines of bottle gourd for GSB along with powdery mildew, CGMMV and phyllody. We found that three lines BG 95-3, 95-4 and 95-6 were showing moderate to high resistance to GSB. Among these 95-3 and 95-4 were also showing high resistance to powdery mildew with the absence of CGMMV and phyllody infection. Twelve lines were found to have low to medium resistance to GSB however with excellent yield attributes. The lines identified can be successfully utilized to breed high yielding multi-disease resistant bottle gourd varieties.

Introduction

Bottle gourd [*Lagenaria siceraria* (Molina) Standle; 2n = 22] commonly known as 'white-flowered gourd' or 'calabash gourd' belongs to the family Cucurbitaceae. One of the most ancient crops cultivated by man in the tropics, bottle gourd is grown as a rainy season and as well as summer season vegetable in India. Although known as the poor man's vegetable, it is attaining fast popularity among the health-conscious urban elite due to its numerous medicinal properties reported (Barot *et al.,* 2005). Its juice is reported to have cooling, calming, diuretic and anti-bilious properties. It is low in saturated fat and cholesterol but high in water, dietary fibre, Vitamin C, Zinc, Riboflavin, thiamine, iron, magnesium and manganese. 100g of tender fruit contains 96g water, 0.2g protein, 0.1g fat, 2.5 g carbohydrate, 0.6 g fibre, 0.5 g minerals, 12 kilocalories of energy, 20 mg calcium, 10 mg phosphorus, 0.7 mg iron, 0.3 mg thiamine, 0.01 mg riboflavin and 0.2 mg niacin. In addition glycosides such as Cucurbitacins B, D, G and H are present (Roopan *et al.*, 2016).

Bottle gourd is plagued by several diseases which drastically affect yield. Gummy stem blight (GSB) is one of the newly emerging and deadly disease which was reported from most of the cucurbits grown all over the world (Rennberger and Keinath, 2018); among which watermelon and cucumber (dos Santos *et al.,* 2009; Keinath 2014) are reported to be the most susceptible. The disease is caused by three genetically distinct species of *Stagonosporopsis* (Stewart *et al.,* 2015). Among the three, two *S. citrulli* and *S. cucurbitacearum* (syn. *Didymella bryoniae*), are host specific to cucurbits.

The symptoms include leaf spot, stem canker, vine wilt and black fruit rot. During the rainy season, lesions can become water-soaked and spread leading to severe defoliation. Gummy exudates may ooze from cracks and severe infection leads to plant death (Brewer *et al.,* 2015). Since inoculum is present in the soil, chemical control is proven difficult under open field conditions although cultural practices like crop rotation have been found effective in reducing the inoculum load. The presence of GSB in bottle gourd has been reported from different parts of India (Katoch *et al.,* 2017; Bhardwaj *et al.,* 2018). Here, we report GSB occurrence in bottle gourd for the first time from Bengaluru, India; resulting in wiping out of entire populations.

Powdery mildew caused by *Podosphaera fuliginea* (also known as *Podosphaera xanthii)* is another important disease of bottle gourd (Nayak and Babu, 2017) where yield losses up to 50-60% have been reported. The symptoms include the presence of tiny, white spots on the above-ground parts of plant especially the leaves, which became powdery as they enlarge. The infection results in chlorosis and death of younger leaves while the older leaves become brown and shrivelled. Disease development accelerates with cool temperatures and low light intensity, a condition observed in the field as the vines mature. Although chemical control is commonly practised (Keinath, 2015) the enhanced costs, as well as pesticide residues, leave a huge question mark against the practical utility. Moreover, resistance to fungicides is quite common for *P. xanthii* populations (Lebeda *et al.,* 2010; McGrath, 2017; Keinath *et al.,* 2018). For effective disease management, the cultivation of resistant cultivars provides a safe and healthy option for both humans and the environment. Hence, breeding for resistance to these deadly diseases is the need of the hour and must be taken in an urgent manner along with yield improvement.

Materials and Methods

Plant materials

Germplasm comprising of 115 lines of bottle gourd were planted in the open field during Rabi (2016-17) along with a susceptible check for GSB; 'Desi local' in an Augmented Block Design with ten plants per genotype. The three completely susceptible lines identified in the field during previous season screening viz; BG118-3, BG118-4 and BG 119-2 were also included as checks. The experimental field comprised an area of 50m^2 in the vegetable research filed of ICAR-IIHR farm at Hessaraghattta.

The presence of *Didymella* in the field was established by culture studies by the pathologist and for effective spread of inoculum 'Desi local'; the susceptible line was planted all around the field also. Standard agronomic practices recommended for the crop was followed without any chemical spraying.

Scoring of disease incidence in the field

Based on the symptoms on the leaf, stem cracking, gum oozing and wilting of plants; a visual score of 1-5 was given for GSB incidence. All the plants were scored and data was taken on a weekly basis. Based on the severity of symptoms, powdery mildew incidence in the field was given a score of 1-10, with ten given for complete drying. A genotype was scored as completely susceptible when more than half of the population showed wilting for either or both of the diseases.

Phenotyping for other traits

The genotypes were scored for germination percentage and vigour before field planting. In the field observations taken include date of emergence of the female flower, the number of fruits, yield/genotype and fruit shape. In addition the presence or absence of phyllody and CGMMV (Cucumber Green Mottle Mosaic Virus) was visually scored.

Calculation of AUDPC scores

The area under the disease progress curve (AUDPC) is used to assess disease intensity over time, or across years, locations, or management tactics. The trapezoidal method is most commonly used method for estimating the AUDPC based on different time variable (hours, days, weeks, months, or years) help to calculate the average disease intensity between each pair of adjacent time points (Madden *et al.,* 2007).

The AUDPC scores for GSB as well as powdery mildew were calculated by taking the average score for biweekly interval based on the formula

$$AUDPC = \sum_{i=1}^{n} \frac{yi + yi + 1}{2}(ti + 1) - ti)$$

using R software. In the formula, n= the total number of observations, y_i=crop health data at the i^{th} time period, and t= time at i^{th} observation. The first term in the equation gives the height of the rectangle (the midpoint between y_i and y_{i+1}) whereas the second term is the width of the rectangle. The combined resistance for both the diseases for individual lines showing resistance was also worked upon by modification of the formula.

Analysis of phenotypic data

For individual genotypes including the check varieties, the average yield and the average number of fruits per plant were calculated in Excel based on field data. This data along with combined disease score was used to predict the yield performance. A regression analysis was conducted using the software SYSTAT ver.13 by keeping average yield as the dependent variable and the disease scores (intensities) of GSB and powdery mildew as the independent variables.

Results and Discussion

Screening for Gummy Stem Blight (GSB)

The disease progress was quite rapid under hot humid conditions with recurrent rainfall. 30 days after transplanting we observed small brown lesions (score of 1-2) on most of the lines. However, some plants remained asymptomatic at this stage (score 0). By 60 DAT, the brown lesions coalesced into big brown patches and leaf and vine drying was observed. At this stage, most of the susceptible plants and checks (12% of the total population) were given a score of 3-4. By 85 DAT; stem cracking, oozing of gummy exudates and complete wilting was noticed in 23% of the total population corresponding to a score of 5. A score 5 was given when complete wilting was noticed in more than 50% plants in a particular line. Almost 90%

disease incidence (score of 4-5) with a few plants showing complete wilting was noticed in about 57 lines (49% of the total population). All the plants in all the replicates of check lines BG118-3, BG118-4 and BG 119-2 showed complete wilting at this stage. After 120 days, the disease wiped out 80% of the germplasm with a disease incidence of 90-100%. Complete drying of plants was noticed 46% population corresponding to 53 lines.

The AUDPC (Madden *et al.*, 20007) scores were worked out based on the monthly average of GSB score calculated in percentage. An AUDPC score of 250 and below were classified as having moderate resistance to GSB while a score of 250-300 was classified as low to moderate resistance. Only 7 lines (<1% of the population) showed moderate to high resistance with a disease incidence of 40-60% (GSB score of 2-3) by the end of the cropping season. These lines are BG 95-3, BG 95-4 and BG 95-6 and the AUDPC scores were 210, 210 and 240 respectively. A total of 12 germplasm lines were found to show low to moderate resistance with AUDPC score ranging 270-300. These lines are BG 124-3, BG-68, BG 114-3, BG 77-6, BG 101, BG 102, BG 116-4, BG 117-3, BG 121-5, BG 124-4, BG 126 and IIHR 22349. The complete devastation of susceptible lines in the field is given in Fig-1. The details are given in Table-1 along with AUDPC score.

The area under the disease progress curve (AUDPC) has been proven as a reliable method for quantitative disease in crop cultivars thereby avoiding the need for repeated measurements between two data points (Jeger and Viljanen-Rollinson, 2001). This method has been widely utilized in resistance studies against fungal pathogens like *Didymella bryoniae* causing GSB in melons (Dalcin *et al.*, 2017; Dalcin *et al.*, 2018; Rennberger and Keinath, 2018). Previously reported study (Bhardwaj *et al.*, 2018) failed to identify any immune or resistant lines which we also found true in the present study. However the moderate to high resistance shown by the advanced breeding lines can be utilized for further development of a resistant cultivar.

Screening for powdery mildew

Powdery mildew is an important foliar disease affecting cucurbit crops grown all over the world (McGrath, 2017). The disease symptoms appeared late when compared to GSB incidence and reached maximum severity after 5-6 harvest completed. The disease progress was also slow compared to GSB. Since a majority of plants succumbed to GSB by this stage, only lines showing some resistance to GSB could be scored effectively for powdery mildew. Among the lines screened, 7 lines were found to be highly resistant to powdery mildew with AUDPC scores <100. However, 4 of these lines were found to be susceptible to GSB. These lines are BG 8-1, BG 05, BG 53 and BG 108-1. We found the lines BG 95-3 and BG 95-4 which showed a moderate to high resistance reaction to GSB to be highly resistant to powdery mildew as well. In addition, high resistance was also shown by BG-68, with low to moderate resistance to GSB. Many lines including BG 5-6, BG 6-3 and the check line BG 119-2 showed a very low powdery mildew incidence (score 1-2), however, were completely wilted due to GSB before the AUDPC scores could be calculated. Similarly, AUDPC scores were used for the identification of powdery mildew resistant rootstock lines in bottle gourd by Kousik *et al.*, 2018. Here also the resistance was expressed as none to few lesions and sparse mycelia on the leaves and exposed plant surfaces. The combined resistance for both the diseases is presented in Fig-2.

Table.1 The AUDPC scores calculated for gummy stem blight (GSB) along with average fruit weight (Av_frt_wt) in kilo grams and total number of fruits harvested (Total_frts) for bottle gourd advanced breeding lines. The three checks are suffixed by symbol ©

line	AUDPC	Av_frt_wt	Total_frts	line	AUDPC	Av_frt_wt	Total_frts
BG 105_1	480	1.62963	27	BG_05	350	1.666667	9
BG 106_2	415	2.192308	26	BG_100	450	1.235484	31
BG 108_1	415	1.3075	40	BG_101	300	0.911538	26
BG 108_2	395	1.359091	22	BG_102	300	1.426667	15
BG 112_1	380	1.18	20	BG_103	340	1.105	20
BG 113_6	415	1.6125	32	BG_104	340	1.230769	13
BG 114_1	415	1.433333	36	BG_105	340	1.16087	23
BG 114_3	280	1.857143	14	BG_108	335	1.282143	28
BG 114_3b	420	1.542308	26	BG_109	340	1.247826	23
BG 114_4	395	1.636111	36	BG_11	415	1.230435	46
BG 114_4b	450	1	23	BG_110	340	1.552941	17
BG 115_1	415	1.556	25	BG_116_1	335	1.458333	12
BG 115_2	430	1.21	40	BG_116_3	335	2.1	10
BG 115_3	385	1.471429	28	BG_116_4	300	1.478571	14
BG 115_4	395	1.25	6	BG_116_5	340	1.48	5
BG 115_4b	395	1.405405	37	BG_117	340	1.32	20
BG 115_5	445	1.366667	21	BG_117_2	340	1.294118	17
BG 115_5b	415	1.3	24	BG_117_3	300	1.263158	19
BG 118_3©	450	1.588	121	BG_117_4	360	1.408	20
BG 118_4©	480	1.6	36	BG_117_5	340	1.418519	27
BG 119_2©	480	1.78	76	BG_12	440	1.845	20
BG 39_112_1	340	1.344444	18	BG_120_3	380	1.2	2
BG 77_6	280	1.994444	18	BG_120_5	380	0.9	1
BG 90_8	380	1.4725	40	BG_121_2	335	1.41875	16
BG 95_3	210	1.683333	18	BG_121_3	335	1.62	10
BG 95_4	210	1.705769	26	BG_121_4	335	1.533333	15
BG 95_6	240	1.583333	18	BG_121_5	300	1.323077	13
BG_03	420	1.35	6	BG_122_5	340	1.273333	15
BG_04	395	1.34	20	BG_123_3	335	1.347368	19
BG_124_2	335	1.68	5	BG_123_5	335	1.414286	7
BG_124_3	270	1.7	15	BG_53	420	1.469444	36
BG_124_4	300	2.014286	7	BG_6_3	470	0.825	12
BG_125_2	305	1.32	20	BG_60	420	1.523077	26
BG_125_4	305	1.185714	21	BG_61	340	1.345	20
BG_125_5	305	1.246667	15	BG_62	470	1.604762	21
BG_126	300	1.066667	6	BG_63	415	1.255	20
BG_13	395	1.443902	41	BG_64	410	1.388462	26
BG_15	440	1.504762	21	BG_65	410	1.281481	27
BG_16	440	2.042308	26	BG_67	420	1.654545	22
BG_17	440	1.092857	14	BG_68	270	0.593939	33
BG_22	470	1.44	15	BG_70	340	1.325	24
BG_23	440	2.005882	17	BG_74	440	0.989474	19

BG_24	485	0.962963	27	BG_75_2	400	1.645	20
BG_25	485	1.245455	22	BG_79	355	1.503226	31
BG_26	385	1.24359	39	BG_8_1	355	0.852941	34
BG_28	420	1.533333	21	BG_8_3	315	1.222222	9
BG_29	450	1.366667	30	BG_92	415	1.212195	41
BG_33	385	1.504762	21	BG_93	385	1.339394	33
BG_34	340	1.75	2	BG_94_1	385	1.613725	51
BG_36	385	1.286957	23	BG_94_3	415	1.510204	49
BG_4_6	330	1	6	BG_96	415	1.242424	33
BG_43	415	1.026087	23	BG_99	340	1.441667	24
BG_44	410	0.962	50	IIHR_19	415	2.031034	29
BG_45	440	1.223333	30	IIHR_22349	300	1.208333	12
BG_47	470	1.781818	11	BG_5_6	440	2.283333	6
BG_49	440	1.195	20	BG_50	420	1.133333	15
BG_5_4	340	1.2	1				

Table.2 Multiple linear regression analysis using yield as the dependent variable with GSB and powdery mildew intensities as independent variables. Statistically significant relationships are highlighted

Regression Coefficients B = (X'X)-1X'Y						
Effect	Coefficient	Standard Error	Std. Coefficient	Tolerance	t	p-Value
CONSTANT	4.23	1.63	0	.	2.59	0.02
GSB	-0.02	0.02	-0.25	0.75	-0.98	0.35
PM	0.05	0.02	0.75	0.75	3.01	0.01
Analysis of Variance						
Source	SS	df	Mean Squares	F-Ratio	p-Value	
Regression	17.4	2	8.69	4.7	**0.03**	
Residual	22.2	12	1.85			

Fig.1 The complete devastation of bottle gourd lines due to gummy stem blight (GSB). The susceptible line BG 118-3 is shown at different time intervals where A) stem cracking and oozing of gummy exudates at flowering stage B) Drying off the entire plant C) Field view of susceptible lines at crop maturity

Fig.2 Combined resistance to GSB and powdery mildew in bottle gourd advanced breeding lines as a function of AUDPC scores. The X-axis represent the time period whereas the Y-axis represent the percentage infection. The graph represents the progress of disease along with time in line BG 94-1 where the late onset of disease was noticed, susceptible check BG 118-3 and the resistant cultivar BG 95-3. The blue line represents the disease severity of GSB whereas the yellow line represents the disease severity of powdery mildew

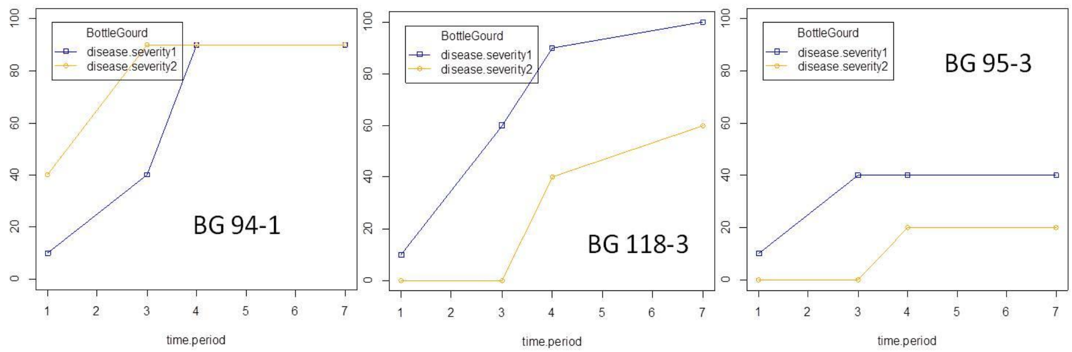
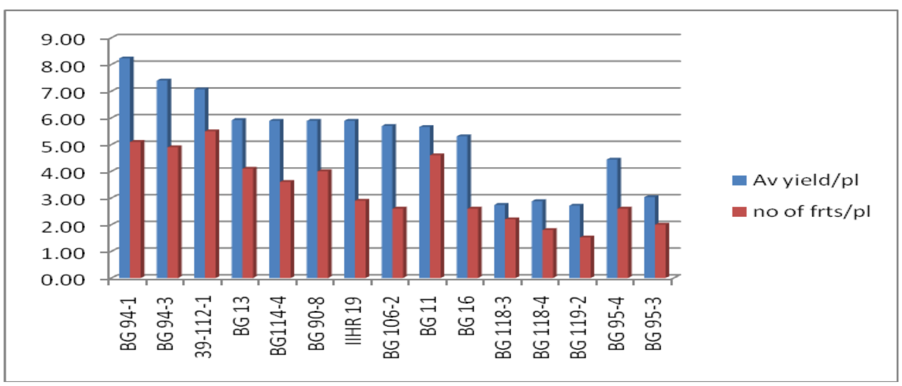


Fig.3 A comparison of yield parameters, average yield/plant and the number of fruits/plant in highly resistant and susceptible lines of bottle gourd. Most of the high yielding lines although showed susceptibility to GSB were characterized by the late onset of disease. The lines showing resistance to GSB viz. BG 95-4 and 95-3 were found to be moderately yielding



Screening for CGMMV and phyllody

Bottle gourd is used as a rootstock especially for watermelon grafting is highly susceptible to CGMMV, a highly devastating pathogen (Liu *et al.*, 2017). The visual screening was done for CGMMV and the accessions BG 114-1, BG77-6, BG-114-4b, BG 113-6, BG-118-4, BG-03, BG-11, IIHR-19, BG 118-3, BG 39-112, BG-04, BG-05, BG 8-1, BG-119, BG 119-2, BG-33, BG-68, BG-70 and BG 121-5 were found highly susceptible. Among these BG-68 was found to be highly susceptible and the fruits were highly bitter. Bottle gourd phyllody caused by '*Candidatus Phytoplasma asteris'* (Tripathy *et al.*, 2017) is another emerging disease which has the potential to become a serious threat to bottle gourd due to severe yield losses, floral malformation and sterility (Ashwathappa *et al.*, 2020). The following lines were found highly susceptible to phyllody caused by phytoplasma; BG-04, BG-05, BG 119-2, BG-33, Desi local, BG 115-4, BG 114-3b, BG

108-2, BG 13, BG 79, BG 116-3, BG 117-4, BG 36, BG 118-3 and BG 43. The lines BG 04, BG 05, BG 33 and BG 119-2 were found to be highly susceptible to CGMMV and phyllody.

Yield attributes of germplasm

A wide variation in fruit size and shape was noticed including elongate, cylindrical, oblong, globose and crooked neck type. The highest yield obtained was for the line BG 94-1 (82.3kg) followed by BG 94-3 (74kg). The total number of fruits harvested in these lines was 51 and 49 respectively with average fruit weights of 1.61kg and 1.51kg. These lines also recorded a higher average yield/plant; 8.23kg/plant and 7.4kg/plant. The average fruit weight and the average yield/ plant were comparable with most of the popular varieties and hybrids (Harika *et al.*, 2012; Varalakshmi *et al.*, 2018) cultivated in South India. The highest number of fruits harvested was 55 for the line BG 39-112-1; although the average fruit weight was low 1.26kg. A negative correlation between the number of fruits harvested and fruit weight was reported previously (Shubha *et al.*, 2019). Most of the advanced breeding lines used in the study were found to be better yielding when compared to other evaluation studies (Jain *et al.*, 2017 & 2018; Shubha *et al.*, 2019). Among the checks 118-3 recorded an average yield of 3.49kg/plant. A comparison of yield parameters; average yield/plant and number of fruits/plant of highly resistant and susceptible lines are given in Fig-3 while individual yield parameters are presented in Table-1.

Regression analysis

Multiple regression models have been successfully utilized in the prediction of yield losses caused by multiple diseases and climatic conditions in crops like wheat (Jevtic *et al.*, 2017; Ficke *et al.*, 2018; Jevtic et al.2020), French bean (Kumar and Kudada, 2018), cucumber (Ding *et al.*, 2019), bitter gourd (Prasanth *et al.*, 2019), potato (Yellareddygari *et al.*, 2018) to name a few. Multiple linear regression using yield as dependent variable and GSB and powdery mildew intensities as independent variables was conducted. The analysis was conducted as a yield forecasting means in the events of combined disease incidence. The disease severity of powdery mildew had a significant effect on yield (Table-2) as revealed by P value= 0.011. The overall effect of regression of independent factors on yield was also significant as revealed by the F test (P value=0.031). The effect of GSB on yield was found non-significant; possibly due to the fact that severely affected plants dried off completely without any fruit formation.

In conclusions advanced breeding lines of bottle gourd was screened for devastating diseases gummy stem blight and powdery mildew. Since GSB is soil-borne and chemical control is ineffective breeding efforts must be accelerated to develop resistant varieties. In this context the newly identified sources of resistance to GSB particularly BG 95-3 and BG 95-4 assumes greater significance. Although moderately yielding, they exhibit resistance to powdery mildew. Hence can be successfully incorporated into breeding programs to develop high yielding and multiple disease-resistant bottle gourd varieties.

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References

Ashwathappa KV, Reddy L, Venkataravanappa V, Sastry SV, Reddy MG, Rao GP. A new strain of '*Candidatus Phytoplasma asteris'* associated with bottle gourd phyllody disease in South India. Phytopathogenic Mollicutes. 2020; 10(1):43-9.

Barot A, Pinto S, Balakrishnan S, Prajapati JP. Composition, functional properties and application of bottle gourd in food products. RRJoDST.2018; 4(1):15-27.

Bhardwaj DR, Gautam KK, Saha S, Nagendran K, Pandey KK, Singh AK *et al.*, Mining the source of resistance for downy mildew and gummy stem blight in bottle gourd (*Lagenaria siceraria*) accessions. Indian J. Agric. Sci. 2018; 88(5):746-50.

Brewer MT, Rath M, Li HX. Genetic diversity and population structure of cucurbit gummy stem blight fungi based on microsatellite markers. Phytopathology. 2015; 105(6):815-24.

Dalcin MS, Tschoeke PH, Aguiar RW, Fidelis RR, Didonet J, Santos GR. Severity of gummy stem blight on melon in relation to cultivars, use of fungicides and growing season. Hortic. Bras. 2017; 35(4):483-9.

Dalcin MS, Tschoeke PH, Mourão DS, Osorio PR, Aguiar RW. Disease progression and productivity of melon plants with different cultural management techniques. J Plant Physiol Pathol 2018;6 (5): 2.

Ding X, Jiang Y, Hui D, He L, Huang D, Yu J, Zhou Q. Model simulation of cucumber yield and microclimate analysis in a semi-closed greenhouse in China. HortScience. 2019; 54(3):547-54.

dos Santos GR, de Castro Neto MD, Ramos LN, Café-Filho AC, Reis A, Momenté VG *et al.*, Reaction of melon genotypes to the gummy stem blight and the downy mildew. Hortic 2009; 27(2):160-5.

Ficke A, Cowger C, Bergstrom G, Brodal G. Understanding yield loss and pathogen biology to improve disease management: *Septoria nodorum* blotch-a case study in wheat. Plant Dis. 2018; 102(4):696-707.

Harika M, Gasti VD, Shantappa T, Mulge R, Shirol AM, Mastiholi AB, Kulkarni MS. Evaluation of bottle gourd genotypes [*Lagenaria siceraria* (Mol.) Standl.] for various horticultural characters. Karnataka journal of agricultural sciences. 2012;25(2).

Jain A, Singh SP, Pandey VP. Character association among the yield and yield attributes in bottle gourd [*Lagenaria siceraria* (Molina) Standl] genotypes. Plant Arch. 2017; 17(1):711-4.

Jain A, Singh SP,Shukla R, Sriom. Evaluation of mena performance in bottle gourd [*Lagenaria siceraria* (Molina) Standl] genotypes. Int.J.Curr.Microbiol.App.Sci. 2018; 7(4): 2239-2243.

Jeger MJ, Viljanen-Rollinson SL. The use of the area under the disease-progress curve (AUDPC) to assess quantitative disease resistance in crop cultivars. Theor. Appl.Genet. 2001;102(1):32-40.

Jevtić R, Župunski V, Lalošević M, Jocković B, Orbović B, Ilin S. Diversity in susceptibility reactions of winter wheat genotypes to obligate pathogens under fluctuating climatic conditions. Sci. Rep. 2020; 10(1):1-2.

Jevtić R, Župunski V, Lalošević M, Župunski L. Predicting potential winter wheat yield losses caused by multiple disease systems and climatic conditions. Crop Prot. 2017; 99:17-25.

Katoch A, Kapoor P, Singh A. The emergence of gummy stem blight: A threat to cucurbits in India. Agrica. 2017; 6(1):1-6.

Keinath AP, Rennberger G, Kousik CS. First report of resistance to Boscalid in *Podosphaera xanthii*, cucurbit powdery mildew, in South Carolina. Plant Health Prog. 2018; 19(3):220-1.

Keinath AP. Differential susceptibility of nine cucurbit species to the foliar blight and crown canker phases of gummy stem blight. Plant Dis 2014;98(2):247-54.

Keinath AP. Efficacy of fungicides against powdery mildew on watermelon caused by *Podosphaera xanthii*. Crop Prot. 2015; 75:70-6.

Kousik CS, Ikerd JL, Mandal MK, Adkins S, Webster CG, Turechek WW. Powdery mildew–resistant bottle gourd germplasm lines: USVL351-PMR and USVL482-PMR. HortScience. 2018; 53(8):1224-7.

Kumar M, Kudada N. Effect of sowing dates and

weather conditions on Rhizoctonia root rot disease incidence and green pod yield of French bean. J. Phamacogn. Phytochem. 2018; 7:893-9.
Lebeda A, McGrath MT, Sedláková B. Fungicide resistance in cucurbit powdery mildew fungi. Fungicides. 2010; 11:221-46.
Liu L, Peng B, Zhang Z, Wu Y, Miras M, Aranda MA, Gu Q. Exploring different mutations at a single amino acid position of Cucumber green mottle mosaic virus replicase to attain stable symptom attenuation. Phytopathology. 2017; 107(9):1080-6.
Madden LV, Hughes G, van den Bosch F. The study of plant disease epidemics. 2007,The American Phytopathological Society, APS Press St. Paul, Minnesota.
McGrath MT. First report of resistance to quinoxyfen in Podosphaera xanthii, causal agent of cucurbit powdery mildew, in the United States. Plant Health Prog. 2017; 18(2):94-94.
Nayak A, Babu BK. First report of powdery mildew on Lagenaria siceraria caused by Podosphaera xanthii in India. J.Plant Pathol. 2017; 99(1):289.
Prasanth K, Varalakshmi B, Venugopalan R, Sriram S. Screening of bitter gourd germplasm and advanced breeding lines against powdery mildew. Indian Phytopathol. 2019; 72(1):15-22.
Rennberger G, Keinath AP. Susceptibility of fourteen new cucurbit species to gummy stem blight caused by Stagonosporopsis citrulli under field conditions. Plant Dis 2018; 102(7):1365-75.
Rennberger G, Keinath AP. Susceptibility of fourteen new cucurbit species to gummy stem blight caused by *Stagonosporopsis citrulli* under field conditions. Plant Dis. 2018; 102(7):1365-75.
Roopan SM, Rajeswari VD, Kalpana VN, Elango G. Biotechnology and pharmacological evaluation of Indian vegetable crop Lagenaria siceraria: an overview. Appl. Microbiol. Biotechnol 2016;100(3):1153-62.
Shubha K, Srivastava R, Gangopadhyaya KK, Rana JC. Diversity analysis of bottle gourd (*Lagenaria siceraria* (Molina) Standl.) germplasm by multivariate analysis. Vegetable Science. 2019;46(1and2):50-5.
Stewart JE, Turner AN, Brewer MT. Evolutionary history and variation in host range of three Stagonosporopsis species causing gummy stem blight of cucurbits. Fungal Biol. 2015;119(5):370-82.
Tripathi S, Thorat V, Verma R, Shouche Y, Yadav A. First report of '*Candidatus phytoplasma asteris*'(subgroup 16SrI-X) associated with bottle gourd virescence and phyllody disease in India. Plant Dis. 2017; 101(11):1949.
Varalakshmi B, Manjunath KS, Singh B. Stability analysis for fruit yield and its component traits in Indian bottle gourd (*Lagenaria siceraria* (Mol.) Standl.) varieties. Indian Journal of Plant Genetic Resources. 2018; 31(1):27-31.
Yellareddygari SK, Taylor RJ, Pasche JS, Zhang A, Gudmestad NC. Predicting potato tuber yield loss due to early blight severity in the Midwestern United States. Eur. J. Plant Pathol. 2018; 152(1):71-9.

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