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Studies on the varietal resistance against apical twig gall maker (*Betousa stylophora* Swinhoe) on aonla (*Phyllanthus emblica*) in Gwalior region (M.P.)

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Abstract
A survey was carried out at different locations in Gwalior at during the year 2021-2022 to investigate the varietal resistance against apical twig gall maker on aonla crop. During the varietal screening the observations were taken from the 46th Standard Meteorological Week to the 19th Standard Meteorological Week during which the gall population was significantly different in all the weeks. The highest average gall population was recorded in Local (desi) variety (6.97 galls/plant) which was significantly higher than all other varieties whereas the lowest average population of gall was found to be in Laxmi-52 variety (5.16 galls/plant) which was significantly lowest among all the varieties. According to the present findings of percent branch infestation, the highest average infestation was recorded in Local (desi) variety (52.30%) which was significantly higher than all the other varieties whereas the lowest average branch infestation was recorded in NA-10 variety (47.69%) which was significantly lowest among all varieties. Summing up varietal screening experiment results of aonla against *Betousa stylophora*NA-10 variety, Laxmi-52 variety, Chakaiya variety and NA-6 variety were found to be less susceptible against *Betousa stylophora* whereas Local (desi) variety, Kanchan variety and NA-7 were found to be most susceptible against *Betousa stylophora*.

Keywords: Aonla, gall maker, Gwalior, resistance

Introduction
Phyllanthus emblica, also known as Indian gooseberry or aonla, is a deciduous tree of the family Phyllanthaceae. The tree is small to medium in size, reaching about 1-8 m in height. It possesses a high productivity unit area and is of a good deal of interest among research scientists. Aonla fruit is one of the richest sources of ascorbic acid, Vitamin "C" (500-700mg per 100g pulp) and antioxidants. Incorporating the superfruit in your diet may improve your overall health. The bitter taste may derive from the high density of ellagitannins.

Aonla has recorded various diseases like fruit rot, wilt, rust, sooty mould and anthracnose. A variety of insect pests are recorded in Aonla. The major pests are *Betousa stylophora* Swinhoe, *Gracillaria acidula* (Meyrick), *Selepa celtis* Moore and *Indarbela tetraonis* Moore belonging to the order Lepidoptera, Cerciaphis emblica, Nipaecoccus vastator (Maskell) and Oxyrhachis tarandus Fabricius of Homoptera, Myllocerus discolor Boheman of Coleoptera and termite, Odontotermes spp. of Isoptera. Among the natural enemies, two species of coccinellid beetles *viz., Cheilomenes* (Menochilus) *sexmaculata* Fabr. And *Coccinella septempunctata* Linn. Four species of spiders (*Neoscona sp., Peucetia sp., Argiope sp. and Oxyopes sp*.) are generally found on the aonla crop.

Infestation of major pests like apical twig gall maker is a major problem in aonla cultivation in many parts of the country. Eggs are laid on the leaves of aonla by the moth in the month of June. During the infestation of a major pest twig gall maker, terminals swell, which increases in size with the passage of time. Fresh galls are seen in July-August and a peak of infestation can be seen in the month of October-November Chandha (2001) [2], Meshram *et al*. (2003) [9], Singh and Mishra (2007) [12], Bharpoda *et al*. (2009) [1], Kulkarni *et al*. (2014) [6], Singh and Kaur (2015) [13], Haldhar (2019) [5].

In Madhya Pradesh, the area under aonla cultivation has increased over the years owing to its high productivity. As cultivation is increasing, the farmers in the M.P. region are facing problems with insect pests in the berry crop.

Keeping all the points in mind, the present research work was carried out at different locations in Gwalior to find out the varietal resistance of apical twig gall maker on aonla in Gwalior region.

Methods and Materials

The details of the experiment are as follows:

Design: Randomized Block Design (RBD)

Treatments (Varieties): 07

1. Kanchan
2. Chakaiya
3. NA-7
4. NA-10
5. Local (Desi)
6. NA-6
7. Laxmi-52

Replications: 03

Weekly observations were recorded on the population dynamics and infestation level of twig gall maker on different varieties of aonla. The observations on the twig gall maker were recorded as in the above experiments.

Statistical analysis:

In varietal experiment, data on the percent infestation of twig gall maker is subjected to transformation into arc sin (angular) as given by Fisher and Yates (1963) [3] as the case may be for analysis of variance.

Results and Discussions

Aonla crop is infected by many insect pests which damage the crop and decrease the yield of the crop. Pest infestation factors include many factors like abiotic factors and biotic factors. Variety screening studies will help Gwalior farmers to know the best variety to grow in Gwalior region to get a better yield.

According to the present experimental findings, all the 26 observations showed significant results in gall population. The observations were taken from the 46th Standard Meteorological Week (12 Nov-18 Nov) to the 19th Standard Meteorological Week (7 May-13 May) during which the gall population was significantly different in all the weeks. The significantly highest average gall population was recorded in Local (desi) variety (6.97 galls/plant) whereas the lowest average population of gall was found to be in Laxmi-52 variety (5.16 galls/plant) which was significantly lower than other varieties. However the pooled analysis of all the 26 observations during the experimental period showed significant results.

According to the present findings of percent branch infestation, the significantly highest average infestation was recorded in Local (desi) variety (52.30%) whereas the significantly lowest average branch infestation was recorded in NA-10 variety (47.69%). The experiment was carried out for 26 weeks starting from the 46th Standard Meteorological Week (12 Nov-18 Nov) to the 19th Standard Meteorological Week (7 May-13 May). During the experiment out of 26 weeks, 3 weeks (48th, 9th and 12th Standard Meteorological Week) recorded uniform infestation of gall in all the varieties whereas the rest 23 weeks (46th, 47th, 49th, 50th, 51st, 52nd, 1st, 2nd, 3rd, 4th, 5th, 6th, 7th, 8th, 10th, 11th, 13th, 14th, 15th, 16th, 17th, 18th and 19th Standard Meteorological Week) showed significantly different infestation level among different varieties. On the basis of pooled analysis, the results showed significant difference of branch infestation level in all the different varieties with highest infestation in Local (desi) variety (52.30%) which is significantly higher than the rest of the varieties i.e. NA-6 variety (47.82%), Kanchan variety (50.63%), NA-7 variety (48.59%), Laxmi-52 variety (47.95%), Chakaiya variety (48.07%) and NA-10 variety (47.69%) which is significantly found with the lowest infestation.

According to present findings, Local (desi) variety is the most susceptible variety against *Betousa stylophora* as compared to the rest of the varieties whereas NA-10 variety is the least susceptible against *Betousa stylophora*. Summing up the varietal screening experiment results of aonla against *Betousa stylophora* NA-10 variety, Laxmi-52 variety, Chakaiya variety and NA-6 variety were found to be less susceptible against *Betousa stylophora* whereas Local (desi) variety, Kanchan variety and NA-7 were found to be most susceptible against *Betousa stylophora*. The difference in the susceptible maybe due to the non-preference for oviposition. For a better understanding of susceptibility of varieties to *Betousa stylophora* plant morphology characters maybe taken into study. In accordance with the previous literature Patel *et al.* (1996) [11] revealed Kanchan to be less susceptible against gall insect whereas in the present findings Kanchan was found to be more susceptible to gall insect. From the literature Meshram and Garg (2000) [8] revealed Kanchan and Chakaiya less susceptible against *Betousa stylophora* whereas in the present findings Kanchan was found to be more susceptible and Chakaiya was found to be in close conformity with Meshram and Garg (2000) [8] to being less susceptible against *Betousa stylophora.* The present findings were found to be in conformity with the findings of Meshram and Soni (2011) [7] revealing that NA-10 to be least susceptible against *Betousa stylophora.* Gaur (2014) [4] revealed that the highest mean population of gall was found to be in NA-10 variety whereas in the present findings the highest mean gall population was found to be in Local (desi) variety. According to Gaur (2014) [4] maximum infestation was found to be in NA-10 variety whereas in the present findings the maximum infestation was found to be in Local (desi) variety. From the present findings after analysis revealed that incidence of gall maker, *Betousa stylophora* on aonla was maximum in middle canopy followed by upper and lower canopy region which was found to be in close conformity with Mishra *et al*. (2014) [10].

Table 1: Gall population on different varieties of Aonla during 2021-2022

SMW	Varieties								
	NA-6	NA-7	Chakaiya	Kanchan	Laxmi-52	Local (desi)	NA-10	S.Em(±)	CD (5%)
46	5.33 (2.41)	7.33 (2.80)	4.22 (2.17)	3.53 (2.01)	3.33 (1.93)	6.88 (2.72)	4.22 (2.17)	0.09	0.28
47	11 (3.39)	7.66 (2.86)	6.33 (2.61)	7.10 (2.75)	3.33 (1.93)	8.11 (2.93)	3.55 (2.01)	0.09	0.29
48	3.10 (1.90)	9.11 (3.10)	4.63 (2.26)	10.00 (3.24)	3.55 (2.01)	6.66 (2.68)	7.66 (2.86)	0.07	0.21
49	4.90 (2.57)	4.55 (2.92)	4.43 (2.35)	5.20 (2.67)	4.22 (1.96)	5.88 (2.78)	5.11 (2.35)	0.05	0.16
50	3.99 (2.12)	3.33 (1.96)	5.66 (2.48)	5.20 (2.38)	5.11 (2.37)	4.22 (2.17)	6.3 (2.61)	0.05	0.16
51	7.44 (2.82)	6.44 (2.63)	6.99 (2.73)	4.43 (2.22)	5.11 (2.37)	5.11 (2.37)	5.88 (2.53)	0.05	0.17

52	4.55 (2.25)	5.99 (2.55)	5.66 (2.46)	4.43 (2.22)	5.88 (2.53)	3.44 (1.98)	3.55 (2.01)	0.10	0.31
1	7.77(2.88)	4.11(2.15)	3.44(1.98)	3.53(2.01)	3.55(2.01)	4.66(2.27)	3.77(2.07)	0.05	0.15
2	3.44 (1.98)	5.99 (2.55)	5.43 (2.43)	5.20 (2.38)	4.22 (2.17)	9.11 (3.10)	6.33 (2.61)	0.05	0.16
3	3.33 (1.96)	5.33 (2.41)	5.43 (2.43)	5.40 (2.43)	3.77 (2.07)	3.88 (2.09)	6.33 (2.61)	0.04	0.13
4	3.55 (2.01)	7.44 (2.82)	5.53 (2.46)	6.20 (2.59)	6.33 (2.61)	9.66 (3.19)	7.44 (2.82)	0.04	0.13
5	5.99 (2.55)	9.55 (3.17)	4.43 (2.22)	8.10 (2.93)	6.33 (2.61)	8.22 (2.95)	10.11 (3.26)	0.04	0.12
6	6.66 (2.68)	9.00 (3.08)	5.43 (2.43)	7.33 (2.80)	7.44 (2.82)	9.11 (3.10)	6.33 (2.61)	0.04	0.12
7	5.77 (2.50)	5.88 (2.53)	5.43 (2.43)	4.43 (2.22)	6.33 (2.61)	3.22 (1.93)	6.11 (2.57)	0.04	0.12
8	4.33 (2.20)	3.33 (1.96)	3.44 (1.98)	3.53 (2.01)	6.11 (2.57)	3.11 (1.90)	3.66 (2.04)	0.05	0.15
9	6.11 (2.57)	7.55 (2.84)	4.22 (2.17)	9.53 (3.17)	7.44 (2.82)	10.55 (3.32)	10.55 (3.32)	0.04	0.13
10	4.33 (2.20)	4.99 (2.34)	11.0 (2.97)	1.96 (1.56)	7.77 (2.88)	6.10 (2.57)	4.44 (2.22)	0.18	0.56
11	5.33 (2.41)	6.00 (2.55)	6.33 (2.61)	6.33 (2.61)	6.66 (2.68)	9.55 (3.17)	6.33 (2.61)	0.04	0.12
12	7.66 (2.86)	6.99 (2.74)	3.44 (1.98)	8.00 (2.91)	6.66 (2.68)	4.44 (2.22)	7.55 (2.84)	0.07	0.20
13	8.33 (2.97)	9.44 (3.15)	6.33 (2.61)	5.40 (2.43)	7.66 (2.86)	6.55 (2.65)	6.77 (2.70)	0.06	0.18
14	2.66 (1.78)	3.44 (1.98)	4.63 (2.26)	6.55 (2.65)	2.00 (1.58)	8.22 (2.95)	4.11 (2.15)	0.04	0.12
15	2.00 (1.58)	9.55 (3.17)	10.33 (3.29)	7.33 (2.80)	2.66 (1.78)	9.66 (3.19)	9.55 (3.17)	0.04	0.13
16	2.55 (1.75)	3.22 (1.93)	5.77 (2.50)	4.66 (2.20)	3.00 (1.58)	9.55 (3.17)	3.44 (1.98)	0.05	0.14
17	5.00 (2.35)	6.33 (2.61)	5.77 (2.50)	5.76 (2.50)	4.33 (2.20)	9.33 (3.13)	7.33 (2.80)	0.03	0.10
18	6.44 (2.63)	5.33 (2.41)	5.86 (2.52)	10.33 (3.29)	5.00 (2.35)	6.66 (2.68)	5.33 (2.41)	0.05	0.15
19	4.33 (2.20)	11.55 (3.47)	10.66 (3.34)	10.66 (3.34)	6.44 (2.63)	9.22 (3.12)	9.22 (3.12)	0.06	0.20
Mean	5.23 (2.37)	6.52 (2.64)	5.80 (2.47)	6.16 (2.55)	5.16 (2.33)	6.97 (2.71)	6.19 (2.56)	0.01	0.03

SMW- Standard Meteorological Week
Figures in the parenthesis are square root transformed values

Table 2: Percent branch infestation on different varieties of aonla during 2021-2022

SMW	Varieties								
	NA-10	**NA-6**	**Kanchan**	**NA-7**	**Laxmi- 52**	**Local (desi)**	**Chakaiya**	**S.Em(±)**	**CD (5%)**
46	40.00 (33.21)	50.00 (45.00)	43.33 (41.15)	40.00 (39.23)	40.00 (39.23)	56.66 (46.92)	53.33 (46.92)	1.26	3.88
47	53.33 (33.21)	53.33 (46.92)	53.33 (46.92)	40.00 (39.15)	40.00 (39.23)	33.33 (35.22)	33.33 (35.22)	1.97	6.08
48	50.00 (39.23)	43.33 (41.15)	53.33 (46.92)	53.33 (46.92)	46.00 (43.08)	50.00 (45.00)	50.00 (45.00)	1.99	NS
49	60.00 (39.23)	60.00 (50.77)	56.66 (46.92)	46.66 (43.08)	46.66 (43.08)	53.33 (46.92)	40.00 (39.15)	2.03	6.26
50	53.33 (39.23)	30.00 (33.21)	46.66 (43.08)	50.00 (45.00)	40.00 (39.23)	40.00 (39.23)	40.00 (39.23)	0.73	2.24
51	40.00 (33.21)	33.33 (35.22)	43.33 (41.15)	80.00 (63.43)	50.00 (45.00)	53.33(46.92)	16.66 (23.86)	1.72	5.30
52	43.33 (33.21)	50.00 (45.00)	56.66 (48.85)	40.00 (39.23)	46.66 (43.08)	70.00 (56.79)	40.00 (39.15)	1.75	5.40
1	46.66 (39.23)	26.66 (31.00)	40.00 (39.23)	46.66 (43.08)	46.66 (43.08)	43.33 (41.15)	36.66 (37.22)	1.76	5.43
2	53.33 (46.92)	33.33 (35.22)	46.66 (43.08)	40.00 (39.15)	36.66 (37.22)	60.00 (50.77)	50.00 (45.00)	2.12	6.54
3	30.00 (33.21)	36.66 (37.22)	23.33 (28.78)	36.66 (37.22)	36.66 (37.22)	43.33 (41.15)	56.66 (48.85)	1.69	5.20
4	43.33 (41.15)	50.00 (45.00)	50.00 (45.00)	50.00 (45.00)	50.00 (45.00)	46.66 (43.08)	56.66 (48.85)	1.22	3.77
5	56.66 (48.85)	60.00 (50.77)	53.00 (46.92)	53.33 (46.92)	53.33 (46.92)	73.33 (59.00)	50.00 (45.00)	2.21	6.80
6	43.33 (41.15)	56.66 (48.85)	66.66 (54.78)	40.00 (39.23)	50.00 (45.00)	56.66 (48.85)	46.66 (43.08)	1.53	4.71
7	36.66 (37.22)	66.66 (54.78)	53.33 (46.92)	50.00 (45.00)	56.66 (48.85)	63.33 (52.78)	40.00 (39.23)	1.43	4.41
8	50.00 (45.00)	53.33 (46.92)	60.00 (50.77)	53.33 (46.92)	60.00 (50.77)	60.00 (50.77)	66.66 (54.78)	1.13	3.48
9	60.00 (50.85)	50.00 (45.00)	46.66 (43.08)	53.33 (46.92)	53.33 (46.92)	53.33 (46.92)	56.66 (48.85)	2.09	NS
10	46.66 (43.08)	50.00 (45.00)	70.00 (56.79)	53.33 (46.92)	40.00 (39.23)	30.00 (33.21)	50.00 (45.00)	1.68	5.17
11	43.33 (41.15)	43.33 (41.15)	43.33 (41.15)	46.66 (43.08)	43.33 (41.15)	56.66 (48.85)	40.00 (39.23)	1.76	5.41
12	56.66 (48.85)	50.00 (45.00)	50.00 (45.00)	46.66 (43.08)	50.00 (45.00)	60.00 (50.85)	56.66 (48.85)	1.87	NS
13	40.00 (39.23)	50.00 (45.00)	60.00 (50.77)	50.00 (45.00)	50.00 (45.00)	56.66 (48.85)	46.66 (43.08)	1.57	4.84
14	36.66 (37.22)	36.66 (37.22)	63.33 (52.78)	56.66 (48.85)	60.00 (50.77)	56.66 (48.85)	50.00 (45.00)	1.46	4.51
15	46.66 (43.08)	80.00 (63.43)	80.00 (63.93)	50.00 (45.00)	53.33 (46.92)	43.33 (41.15)	60.00 (50.85)	2.80	8.61
16	60.00 (39.23)	43.33 (41.15)	46.66 (43.08)	46.66 (43.08)	53.33 (46.92)	60.00 (50.77)	60.00 (50.77)	1.29	3.98
17	53.33 (33.21)	50.00 (45.00)	40.00 (39.23)	50.00 (45.00)	50.00 (45.00)	46.66 (43.08)	56.66 (48.85)	0.94	2.89
18	46.66 (43.08)	40.00 (39.23)	40.00 (39.23)	43.33 (41.15)	50.00 (45.00)	40.00 (39.23)	46.66 (43.08)	1.22	3.77
19	50.00 (45.00)	46.66 (43.08)	30.00 (33.21)	46.66 (43.08)	43.33 (41.15)	53.33 (46.92)	50.00 (45.00)	1.48	4.57
Mean	47.69 (40.28)	47.82 (43.74)	50.63 (45.34)	48.59 (44.22)	47.95 (43.81)	52.30 (46.28)	48.07 (43.81)	0.04	0.10

NS- Non Significant
SMW- Standard Meteorological Week
Figures in the parenthesis are angular transformed values

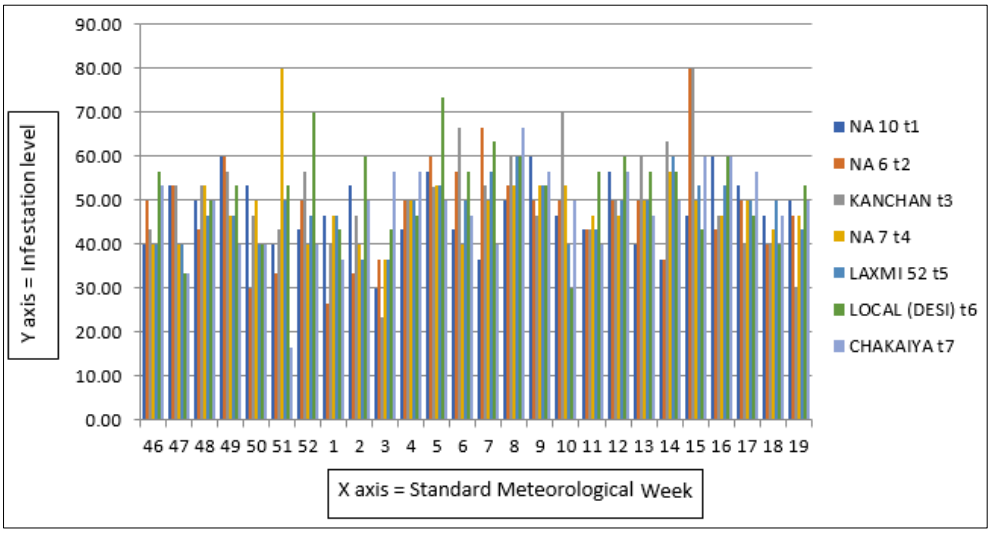

Fig 1: Infestation level on different varieties of aonla during 2021-2022

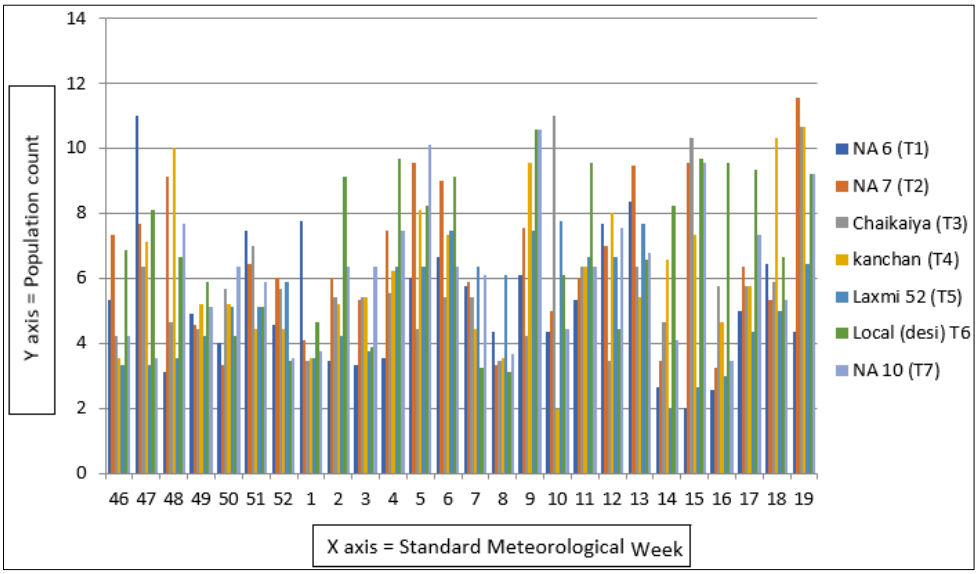

Fig 2: Population of gall on different varieties of aonla during 2021-2022.

Conclusion

Susceptibility against *Betousa stylophora* was found to least in NA-10, Laxmi-52, Chakaiya and NA-6 while Local (desi), Kanchan and NA-7 were found to be most susceptible against *Betousa stylophora*.

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