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MORPHOLOGICAL CHARACTERIZATION OF *EUCALYPTUS* CLONES FOR GALL TOLERANCE OF SOUTH GUJARAT, INDIA

Sachin Kumar Singh, Vikas Kumar[1]*, Dilip Sinh Bhupat Sinh Jadeja and Sushil Kumar Saxena

College of Forestry, Navsari Agricultural University, Navsari - 396 450 (Gujarat), India.
[1]College of Forestry, Kerala Agricultural University, Thrissur - 680 656 (Kerala), India.

Abstract

The investigation was comprised of 14 *Eucalyptus* clones and two *Eucalyptus* species of fifteen months age planted in complete randomized block design with 3 replications each in 2m × 2m spacing. Among all the *Eucalyptus* entries *E. torellina* was found resistant (free of gall). *Eucalyptus* entries P-411, P-413, P-2136, ERK-04, P-526 and *E. pellita* were found highly tolerant (GDI: >0-1); P-286, JK-04, B-2153 and SRO-16 were found moderately tolerant (GDI: >1-25); JK-08 and JK-02 were found moderately susceptible (GDI: >25-200) and P-2049, P-2155 and P-405 were found highly susceptible (GDI: >200). Gall wasp damage had significant and negative correlation with growth parameters (height, DBH and volume growth). With respect to growth performance, highest average height (11.42 m) was obtained in P-411 (highly tolerant) and followed by P-413 (10.77 m), P-2136 (10.33m), P-526 (11.19 m), B-2153 (10.58 m) and SRO-16 (10.27 m). The highest average DBH (85.64 mm), average volume (22599.96 cm^3) and average wet biomass (1129.99 kg) were obtained in P-526 (highly tolerant), which was at par and followed by P-411 (84.23 m, 22168.57 cm^3 and 1108.43 kg, respectively); P-413 (82.89 m, 20426.23 cm^3 and 1021.31 kg, respectively); SRO-16 (81.06 m, 18534.21 cm^3 and 926.71 kg, respectively); JK-08 (80.58 m, 18963.40 cm^3 and 948.17 kg, respectively) and B-2153 (76.89 m, 17926.87 cm^3 and 896.34 kg, respectively). Among all the *Eucalyptus* entries highly tolerant P-411, P-413 and P-526, moderately tolerant B-2153 and SRO-16 and moderately susceptible JK-08 were found to be comparatively higher in biomass production under South Gujarat conditions.

Key words : *Eucalyptus,* morphological characterization, gall tolerance, clones and biomass.

Introduction

Eucalyptus belongs to family Myrtaceae is extensively cultivated in India including Gujarat by wood based industries, Forest Development Corporations and tree growing farmers. Recently, a severe attack by a new invasive gall insect has been reported by Andhra Pradesh Forest Development Corporation. This pest was identified as Blue Gum Chalcid, *Leptocybe invasa* Fisher and La Salle (Hymenoptera : Eulophidae). The outbreak of this wasp in India was first reported in 2007 (Anonymous, 2007). Its distribution has been reported in Andhra Pradesh, Karnataka, Kerala, Tamil Nadu (Anonymous, 2007a). It has also been reported from Gujarat (Kumar *et al*., 2007) and Madhya Pradesh (Roychoudhury *et al*., 2007). The wasp displays thelytokous reproduction and has relatively a narrow host range (Mendel *et al*., 2004). The damage has gradually increased over the year and there was an outbreak during 2008. The attack was severe on seedlings and young trees. Currently, the insect attack assumes greater significance since it has spread to other states of the country. The survey further revealed that the pest is spreading to newer areas (Jhala *et al*., 2009). Presently, most of the *Eucalyptus* clones or seedlings in Gujarat are infested by the pest under consideration.

As the tree species is vigorous in growth, the pest management measures followed in other crops or tree species have not yield successful results in *Eucalyptus*. Lack of availability of indigenous natural enemies has also been responsible for multiplication and outbreak of the pest. Thus, availability of pest free or tolerant planting material using host plant resistance technique can fit best in the management of this pest.

In present investigation, clones and species were screened for the reaction against this insect and finally resistant or tolerant clones and species have been identified on the basis of field screening. Once, resistant

***Author for correspondence :** E-mail: vkskumar49@gmail.com

or tolerant planting material is identified, it can be further multiplied using either *in-vitro* technique or clonal multiplication. Keeping in view the requirement of tolerant or resistant planting material, the investigation was proposed with the following objectives:

(i) To study the incidence of gall damage on some clones and species of *Eucalyptus*.

(ii) To correlate susceptibility and tolerance of *Eucalyptus* clones and species to gall incidence and damage with morphological parameters.

Materials and Methods

The present investigation was carried out at Instructional farm of ASPEE College of Horticulture and Forestry, Navsari Agricultural University (NAU), Navsari, Gujarat, India. Total fourteen *Eucalyptus* clones (P-411, P-413**,** P- 286, P- 2136, P- 2049, P- 405, P- 526, P- 2155, B- 2153, B- 2153, ERK- 04, JKSC- 08, JKSC- 04, JKSC- 02, SRO- 16) and two species (*E. pellita* and *E. torellina*) were selected randomly from the *Eucalyptus* plantation established during September, 2009 at Instructional farm, ASPEE College of Horticulture and Forestry, Navsari Agricultural University, Navsari, Gujarat, India, which is located at $20.55^{0}33.4'$ N, $072.54^{0}45.6'$ E and 13.72 m above msl. The clones were planted in complete randomized block design with 3 replications each in 2m × 2m spacing.

Morphological observations

Pest incidences *i.e.* leaf damage per cent (LD%) and number of galls per leaf (galls/leaf) were recorded at monthly interval and growth parameters i.e. tree height, diameter at breast height (DBH), volume and leaf area were recorded at two month interval during December, 2010 to November, 2011. Gall incidence was recorded from five ramets (trees) of a *Eucalyptus* entry from each replication (total three replications). Two branches of 50 cm in length from each selected tree were selected randomly to record the gall incidence.

(i) Leaf Damage per cent (LD%)

$$LD\% = \left(\frac{\text{Gall infested leaves}}{\text{Total leaves}}\right) \times 100$$

Average values per replication were worked out.

(ii) Number of galls per leaf (Galls/Leaf)

$$\text{Galls/Leaf} = \left(\frac{\text{Total number of galls}}{\text{Total number of leaves on a sample branch}}\right)$$

Average values per replication were worked out.

(iii) Gall development : Process of gall development from tissue disruption to exit hole appearance were categorized as per Mendel *et al*. (2004). The total number of leaves having a particular stage of galls was counted and per cent occurrence of a gall stage on total number of leaves of a sampled branch was worked out as under:

Per cent gall occurrences (GS)

$$= \left(\frac{\text{Total number of leaves having a particular gall stage}}{\text{Total number of leaves of a sample branch}}\right) \times 100$$

Average values per replication were worked out.

iv. Gall location : The total number of leaves having galls on leaf mid-rib or leaf petiole was recorded and percentage occurrence was worked out as under. The infestation of galls on the twig of a branch was recorded as absence or presence on a sampled branch.

Per cent occurrence of galls on leaf mid-rib/leaf petiole

$$= \left(\frac{\text{No. of leaves having galls on leaf midrib / petiole}}{\text{Total number of leaves on a sample branch}}\right)$$

Average values per replication were worked out.

Observation of growth : The trees were of fifteen month age. The tree height and diameter at breast height (1.37 m above ground level) were measured from four plants per replicate and its average was worked out. The height of trees was measured using Ravi altimeter and diameter at breast height of trees was measured with the help of vernier caliper. The average total volume was calculated using formula $\left(\frac{\pi r^2 h}{3}\right)$ (Abed and Stephens, 2003) or which can be converted into $\left(\frac{\pi D^2 h}{12}\right)$. Leaf area of twenty leaves in each replication of Eucalyptus entry was recorded to calculate mean leaf area.

The data obtained were subjected to statistical analysis using Randomized Block Design. The statistical analysis for each parameter was carried out using mean values.

Screening of different *Eucalyptus* germplasm

Based on the leaf damage per cent as well as severity of gall damage (number of galls per leaf), a Gall Damage Index was worked out by multiplying these two factors. Based on this Gall Damage Index all the *Eucalyptus* entries were categorized as under.

Categorization of *Eucalyptus* clones

Gall Damage Index (GDI)	Categorization
No damage	Resistant
>0 – 1	Highly tolerant
>1 - 25	Moderately tolerant
>25 - 200	Moderately susceptible
>200	Highly susceptible

Statistical analysis

Morphological parameters observed in three replications and were analyzed with the period by split plot randomized block design (SPRBD). Relationship between pest incidence and growth characters of all the clones and species were studied by correlation.

Results and Discussion

Leaf damage (%) (LD%) and number of galls per leaf (Galls/Leaf)

Among sixteen entries of *Eucalyptus* under investigation, *E. torellina* was not infested throughout the study period. *E. pellita* (LD%: 1.75, Galls/Leaf: 0.02) and P-526 (LD%: 1.83, Galls/Leaf: 0.02) had the lowest leaf damage per cent and number of galls per leaf while P-2049 (LD%: 84.90, Galls/Leaf: 10.66) showed highest leaf damage per cent and number of galls per leaf followed by P-2155 (LD%: 75.81, Galls/Leaf: 9.94) and P-405 (LD%: 76.48, Galls/Leaf: 7.18) which in turn were at par with it (table 1). *E. pellita* indicated lower damage severity with higher survival in the field (Thu *et al*., 2009). *E. pelita* was the tolerant species to the pest *Leptocybe invasa* (Goud *et al*., 2010).

Screening of *Eucalyptus* germplasm against gall infestation

Eucalyptus germplasm was screened on the basis of damage index worked out from galls per leaf and per cent leaf damage and ranked under five gall susceptibility categories (table 1) :

I. Highly susceptible- *Eucalyptus* clones *viz*. P-2049, P-2155 and P-405 (GDI greater than 200).

II. Moderately susceptible- JK-08 and JK-02 (GDI ranging from >25 to 200).

III. Moderately tolerant- JK-04, P-286, B-2153 and SRO-16 (GDI ranging from >1 to 25).

IV. Highly tolerant- Six *Eucalyptus* entries (ERK-04, P-411, P-413, P-526, P-2136 and *E. pellita*) (GDI ranging from >0 to 1).

V. Resistant- *E. torellina* remained free from gall infestation and designated as resistant (GDI is 0).

E. torelliana was found resistant. They are morphologically different species compared to *E. tereticornis* as they have pubescent hairs on leaf, petiole and the growing shoot (Tiwari, 1992; Mendel *et al.*, 2004 and Goud *et al*., 2010), which prohibits *L. invasa* in laying eggs in the plant system. On *E. pellita* only first stage galls marked by ooze due to ovipositional damage and subsequent tissue disruption was noticed by Basavanagoud *et al*. (2010). Whereas, in our result first stage (tissue disruption) and second stage galls (green typical bump shaped) were marked on *E. pellita*.

Stages of galls

First (tissue disruption) and second stage galls (green typical bump shaped) were found in all the gall infested *Eucalyptus* entries whereas, third (green to pinkish with glossiness), fourth (pinkish without glossiness) and fifth stage galls (exit hole appearance) were absent in P-526 and *E. pellita.* Fourth and fifth stage gall were absent in ERK-04, JK-04, P-413 and P-2136. Occurrence of gall was found absent in *E. torellina*.

Mendel *et al*. (2004) described the gall stages *viz*; first stage (1-2) weeks after oviposition in the form of corky tissue at egg insertion followed by second stage characterized by typical bump shaped of 2.7 mm size, third stage by green to pinkish with glossiness, fourth stage by pinkish without glossiness and fifth stage by exit hole appearance. Similar results are seen in the present investigation conforming earlier reports.

The variations observed in the gall stages and seasonal changes may be attributed to difference in the genetic constitution of all the *Eucalyptus* entries as well as the gene x environment interaction.

Location of galls

The occurrence of galls on leaf midrib was recorded in all the gall infested *Eucalyptus* entries whereas, galls on leaf petiole were absent in three entries (P-413, P-526 and *E. pellita*) and galls on twig were absent in four entries (P-413, P-526, P-2136 and *E. pellita*) during the period of investigation among the gall infested entries.

Seasonal occurrence of gall infestation

The higher gall incidence (leaf damage per cent) were observed during April (27.72), May (30.61), June (28.90), July (28.14) and August (27.83), which were at par with each other whereas, increasing trend from March to July (1.56, 2.18, 2.23, 2.44 and 2.95, respectively) was observed in gall severity (galls in each leaf) with highest value in July (2.95) (fig. 1). Comparatively less gall incidence was observed during January (22.48) and February 22.00) indicating increasing trend from February to May.

Table 1 : Gall infestation and susceptibility ratings of different *Eucalyptus* entries.

S. no.	*Eucalyptus* germplasm	(A) Leaf damage (%)	(B) Galls/leaf	Gall Damage Index (GDI) (A × B)	Rating
1.	P-2049	68.44[a] (84.90)	3.32 (10.66)	905.03	>200 (GDI) Highly susceptible
2.	P-2155	62.41 (75.81)	3.13 (9.94)	753.55	
3.	P-405	62.82[a] (76.48)	2.73 (7.18)	549.13	
4.	JK-08	51.88 (61.26)	1.90 (3.24)	198.48	>25 – 200 (GDI) Moderately susceptible
5.	JK-02	35.50 (34.26)	1.10 (0.74)	25.35	
6.	P-286	22.55[b] (15.90)	0.90[a] (0.32)	5.09	>1 – 25 (GDI) Moderately tolerant
7.	B-2153	20.47[b] (14.08)	0.83[a] (0.20)	2.82	
8.	SRO-16	21.74[b] (15.50)	0.83[a] (0.20)	3.10	
9.	JK-04	22.33[b] (15.83)	0.82[a] (0.17)	2.69	
10.	ERK-04	14.89[c] (8.37)	0.76[a] (0.08)	0.67	>0 – 1 (GDI) Highly tolerant
11.	P-411	14.65[c] (7.58)	0.76[a] (0.08)	0.61	
12.	P-413	12.73[c] (5.87)	0.74[a] (0.05)	0.29	
13.	P-2136	9.82[c] (3.82)	0.74[a] (0.05)	0.19	
14.	P-526	6.31[d] (1.83)	0.72[b] (0.02)	0.04	
15.	*E. pellita*	6.08[d] (1.75)	0.72[b] (0.02)	0.04	
16.	*E. torellina*	0.405 (0.00)	0.71	(0.00)	0.00 = 0 (GDI) Resistant
S.Em.±		1.988	0.060	**Note :** Figures outside the parentheses are arcsine transformed values in case of leaf damage % and SQR + 0.5 transformed values in case of galls per leaf, those in the parenthesis are original values. Treatment mean with letter(s) in common are non significant at 5% level of significance in respective column.	
C.D. at 5%		5.74	0.17		
C.V. %		44.06	27.94		

The first stage gall showed increasing trend from February (1.17%) to May, 2011 (12.73%) (fig. 2). Second stage gall decreased from December, 2010 (2.18%) to February, 2011 (0.60%) and showed rapid increase from March (2.91%) to June (22.31%). Third stage gall was observed throughout the period of investigation with maximum values in December, 2010 (27.21%), which was at par with August, 2011 (22.74%) and followed by rest of the months. The least observed value was in June (13.90%). The trend of occurrence of fourth stage galls was decreasing from December, 2010 (20.31%) to May, 2011 (9.33%). After May, it showed the increasing trend. The occurrence of fifth stage gall was recorded maximum in February, 2011 (21.23%), which was at par with rest of the months except during July (15.13%) and August (12.15%) showing relatively lower occurrence.

Mendel *et al*. (2004) reported oviposition and developmental stages of wasp throughout the warm season (April to October). Development during the winter was slow. Vastrad *et al*. (2010) recorded higher trapping of adult of *Leptocybe invasa* from 10.83 to 212.13 in yellow sticky trap during May to September in the nursery and also found their maximum number (98.50 adults/trap) in December. Protasov *et al.* (2008) observed in Israel that adults of the gall wasp emerge from *Eucalyptus* foliage throughout the year in the greenhouse under a temperature regime of 23–31.8^{0}C and humidity ranging from 40 to 70%.

Morphological observations

In concern to growth performance, among all the *Eucalyptus* entries, highest average height (11.42m) was obtained in P-411 (highly tolerant), which was at par with highly tolerant P-413, P-2136 and P-526; moderately tolerant B-2153 and SRO-16 and moderately susceptible JK-08 and JK-02 (table 2). The highest average DBH (85.64mm), average volume (22599.96cm^3) and average wet biomass (1129.99kg) were obtained in P-526 (highly tolerant), which was at par and followed by highly tolerant P-411 and P-413; moderately tolerant B-2153 and SRO-16 and moderately susceptible JK-08. Among all the entries lowest average height (5.61m), DBH (36.48mm),

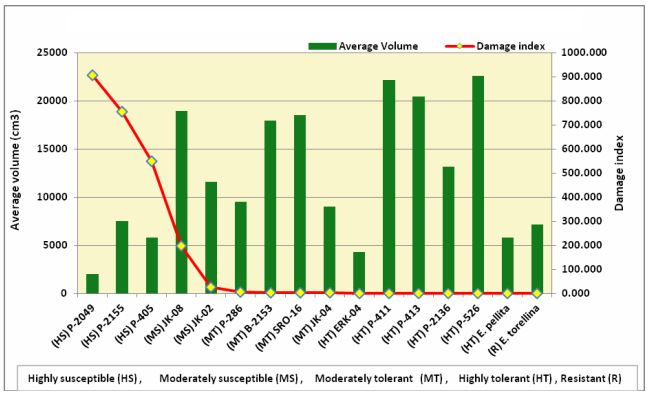

Fig. 1 : Effect of Gall Damage Index on average volume of different *Eucalyptus* entries.

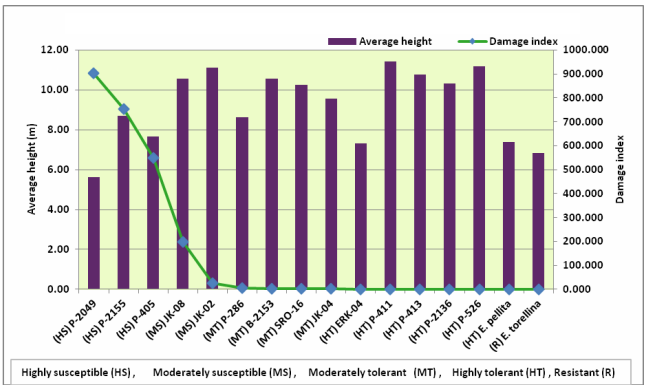

Fig. 2 : Effect of Gall Damage Index on average height of different *Eucalyptus* entries.

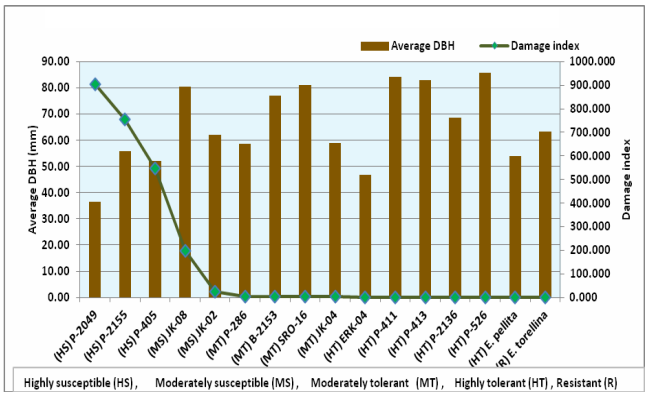

Fig. 3 : Effect of Gall Damage Index on average DBH of different *Eucalyptus* entries.

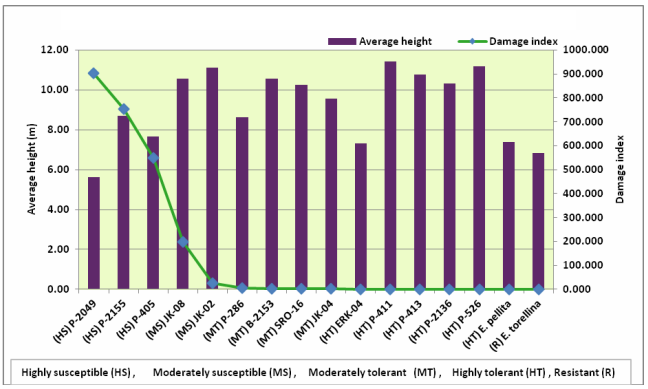

Fig. 4 : Effect of Gall Damage Index on average height of different *Eucalyptus* entries.

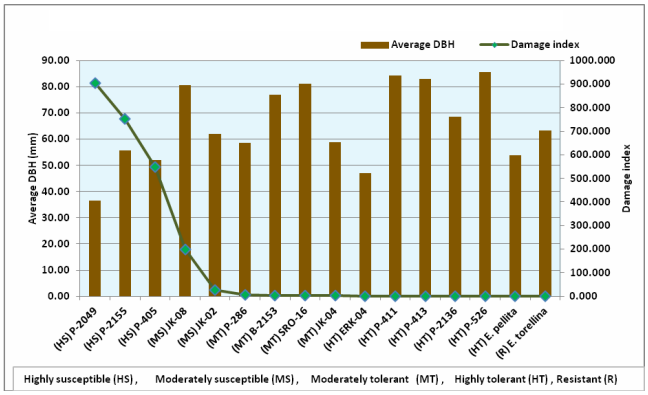

Fig. 5 : Effect of Gall Damage Index on average DBH of different *Eucalyptus* entries.

volume (2025.31cm^3) and wet biomass (101.27kg) was found in highly susceptible P-2049, which was at par and followed by highly susceptible P-405 and highly tolerant ERK-04 and *E. pellita* in volume and wet biomass. Maximum average leaf area was attained by resistant *E. torellina* (85.20cm^2) followed by moderately tolerant JK-04 (56.09cm^2) which was at par with highly tolerant *E. pellita* (53.94cm^2) and moderately tolerant P-286 (51.61cm^2). The lowest leaf area was attained by highly tolerant ERK-04 (24.79cm^2) which was at par with highly gall susceptible P-2049 (27.59cm^2).

Gall susceptibility and growth performance might vary as per the edaphic, climatic and geo-physical condition of the site. Therefore, it can be concluded that P-526, P-411 and P-413 performed best in South Gujarat climatic condition.

Correlation and regression of gall incidence (per cent leaf damage), gall severity (Galls/leaf) and damage index with abiotic factors and morphological characters

Gall severity, leaf damage and damage index in *Eucalyptus* entries had significant and positive correlation with minimum temperature as well as with morning, evening and average relative humidity (table 4). Gall Damage Index was also correlated significantly and positively with average temperature and rainfall days whereas, gall severity with rainfall days. Leaf damage was also significantly and positively correlated with average and maximum temperature and evaporation. Gall severity and damage index in *Eucalyptus* entries had significant and negative correlation with average height, average DBH and average volume (table 3, figs. 3, 4,

Table 2 : Effect of pest infestation on growth characteristics.

Eucalyptus Entries (Fifteen months age)	Damage index	Average height (m)	Average DBH (mm)	Average volume (cm^3)	Average wet biomass (kg)	Leaf area (cm^2)
Highly susceptible						
P-2049	905.03	5.61	36.48	2025.31^{c}	101.27^{c}	27.59^{e}
P-2155	753.55	8.72^{b}	55.72^{c}	7534.05^{b}	376.70^{b}	43.34^{b}
P-405	549.13	7.66^{c}	51.96^{c}	5780.47^{c}	289.02^{c}	45.06^{b}
Moderately susceptible						
JK-08	198.48	10.58^{a}	80.58^{a}	18963.40^{a}	948.17^{a}	41.77^{c}
JK-02	25.35	11.11^{a}	62.00^{b}	11607.10^{b}	580.35^{b}	45.68^{b}
Moderately tolerant						
P-286	5.09	8.63^{b}	58.51^{b}	9518.91^{b}	475.95^{b}	51.61^{a}
B-2153	2.82	10.58^{a}	76.89^{a}	17926.87^{a}	896.34^{a}	29.24^{d}
SRO-16	3.10	10.27^{a}	81.06^{a}	18534.21^{a}	926.71^{a}	48.33^{b}
JK-04	2.69	9.58^{b}	58.84^{b}	9019.76^{b}	450.99^{b}	56.09^{a}
Highly tolerant						
ERK-04	0.67	7.31^{c}	46.89^{c}	4316.14^{c}	215.81^{c}	24.79^{e}
P-411	0.61	**11.42**^{a}	84.23^{a}	22168.57^{a}	1108.43^{a}	42.01^{c}
P-413	0.29	10.77^{a}	82.89^{a}	20426.23^{a}	1021.31^{a}	33.76^{d}
P-2136	0.19	10.33^{a}	68.52^{b}	13179.64^{b}	658.98^{b}	43.30^{b}
P-526	0.04	11.19^{a}	**85.64**^{a}	**22599.96**^{a}	**1129.99**^{a}	45.96^{b}
E. pellita	0.04	7.39^{c}	53.86^{c}	5817.033^{c}	290.85^{c}	53.94^{a}
Resistant						
E. torellina	0.00	6.82^{c}	63.25^{b}	7419.82^{b}	370.99^{b}	**85.20**
S.Em.±		0.46	4.29	2105.27	105.26	2.078
C.D. at 5%		1.32	12.38	6080.45	304.02	6.00
C.V. %		20.99	27.78	72.60	72.60	8.02

Note: Values with letter(s) i.e. a, b, c... in common are non significant at 5% level of significance in respective column.

and 5). The correlation of per cent leaf damage was found non-significant with all the morphological characters studied.

The findings of Patel (2010) based on correlation of weather factors with damage of *Eucalyptus* gall insect *Leptocybe invasa* in *Eucalyptus* seedlings revealed that gall incidence increased with increase in temperature, relative humidity and wind velocity indicating highest incidence (100%) in June when minimum temperature (28.29°C), average temperature (31.05°C), evening relative humidity (67.93 %) and wind velocity (14.06 kms/ hour) were also highest. On the other hand, there was no incidence (0%) when minimum temperature (15.14°C), average temperature (22.58°C), evening relative humidity (29.56%) and wind velocity (3.97kms/hour) were comparatively lower. Likewise, Dhiman and Shalu (2010) indicated maximum infestation from August – October at 19-32°C with 55-93 per cent relative humidity.

Though, there is no authentic information available on seasonal incidence of gall insect, *Leptocybe invasa* on either *Eucalyptus* or any other tree species, the data in the present investigation have indicated peak status in May which is similar to the reports of Patel (2010). Thus, results of the present investigation are in agreement with the earlier report.

There is paucity of literature regarding effect of gall infestation on growth of field plantation. Severely attacked trees show leaf fall, loss of growth and vigour, stunted growth, lodging dieback and eventually tree death (Mendel *et al*., 2004). Our result indicated negative and significant effect of gall severity and damage index (explaining variation to the tune of 22.33 and 28.94 per cent) on growth features (average height, DBH, and volume), whereas effect of gall incidence was found non-significant.

Conclusion

Among all the *Eucalyptus* entries *E. torellina* was found resistant against gall which is promising for future tree breeding program. *Eucalyptus* entries P-411, P-413, and P-526 were found highly tolerant, B-2153 and SRO-16 were found moderately tolerant and JK-08 was found

Table 3 : Correlation and regression coefficients of incidence, gall severity and gall damage index of *Eucalyptus* gall insect (*Leptocybe invasa*) in relation to average growth characteristics.

Growth characteristics	Gall severity (Galls/leaf)		Leaf damage (%)		Gall Damage Index	
	Correlation coefficient ('r')	Regression coefficient	Correlation coefficient ('r')	Regression coefficient	Correlation coefficient ('r')	Regression coefficient
Height (X_1)	**-0.582***	-1.001	-0.468	—	**-0.612***	-92.269
DBH (X_2)	**-0.553***	-0.395	-0.482	—	**-0.573***	-36.612
Volume (X_3)	**-0.517***	0.0008	-0.453	—	**-0.531***	0.078
Leaf area (X_5)	-0.236	—	-0.177	—	-0.261	—
R^2		0.3897				0.4416
Variation explained (%)		22.33				28.94
R value		0.624				0.665
Constant (A value)		27.244				2446.063

*Significant at 5 % level of significance = 0.514. **Significant at 1 % level of significance = 0.641.

Table 4 : Correlation and regression coefficients of incidence, gall severity and gall damage index of *Eucalyptus* gall insect (*Leptocybe invasa*) in relation to monthly average weather parameters.

Growth characteristics	Gall severity (Galls/Leaf)		Leaf damage (%)		Gall Damage Index	
	Correlation coefficient ('r')	Regression coefficient	Correlation coefficient ('r')	Regression coefficient	Correlation coefficient ('r')	Regression coefficient
Maximum temperature (X_1)	0.072	—	**0.594***	-0.284	0.257	—
Minimum temperature (X_2)	**0.623***	-0.008	**0.889****	0.398	**0.787****	-1.000
Average temperature (X_3)	0.437	—	**0.859****	-0.100	**0.632***	2.000
Morning relative humidity (X_4)	**0.587***	-0.011	**0.669***	0.103	**0.667***	0.000
Evening relative humidity (X_5)	**0.737****	0.025	**0.672***	-0.024	**0.791****	0.000
Average relative humidity (X_6)	**0.703***	0.000	**0.691***	0.000	**0.769****	0.000
Rainfall (X_7)	0.486	—	0.291	—	0.465	—
Rainfall days (X_8)	**0.632***	-0.015	0.398	—	**0.615***	0.000
Sunshine (X_9)	-0.521	—	-0.157	—	-0.449	—
Evaporation (X_{10})	0.283	—	**0.644***	1.205	0.454	—
R^2		0.579		0.908		1.000
Variation explained (%)		19.5		59.70		83.30
R value		0.761		0.953		1.000
Constant (A value)		1.860		18.768		0.000

*Significant at 5% level of significance = 0.576 ** Significant at 1% level of significance = 0.708

moderately susceptible, which were having comparatively higher wet biomass production under South Gujarat condition. P-2049, P-2155 and P-405 were found to be highly susceptible. The peak period of gall damage was observed during May-July. The gall wasp damage has been observed in young leaves, petiole and twig throughout the year. Gall wasp damage had significant and positive correlation with minimum temperature as well as with morning, evening and average relative humidity whereas significant and negative correlation was observed with growth parameters (height, DBH and volume growth).

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