International Journal of Agricultural and Applied Sciences, June 2021, 2(1):163-169
https://www.agetds.com/ijaas
ISSN: 2582-8053
https://doi.org/10.52804/ijaas2021.2122

Research Article

OPEN ACCESS

Evaluation of brinjal genotypes for morphological characters, yield performance and resistance to bacterial wilt and shoot and fruit borer

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(**Received:** 28/12/2020; **Revised:** 19/04/2021; **Accepted:** 05/06/2021)

ABSTRACT
Bacterial wilt (*Ralstonia solanacearum*) and fruit borer (*Leucinodes orbonalis)* are major concerns in cultivation of eggplant in Jharkhand and even in the other parts of the country. Keeping their adverse impact on quality production, nine brinjal genotypes were evaluated for three consecutive crop seasons against bacterial wilt and shoot and fruit borer. Results revealed wide range of variations among genotypes for important morphological characters *viz*., colour of stem, leaf, petiole, mid-rib, prickleness (spinyness), fruit shape, colour and fruit yield. The genotypes, CB-27, CB-41 and CB-1 showed resistance showing the lowest bacterial wilt incidence ranging from 2.7 to 4.5 per cent and minimum mean infestation of shoot borer ranging from 2.92 to 3.97 per cent with significantly higher fruit yield. Resistance against wilt and shoot and fruit borer depicted a significant importance for the breeders as well as for the commercial growers of this crop. On the basis of these findings, the superior genotypes *viz*., CB-1 (egg shaped & purple fruit), CB-27 (oblong & purple fruit) and CB-41 (oblong & light green fruit) could be recommended for commercial cultivation in the state of Jharkhand and adjoining areas of the similar agro-climatic conditions.
Keywords: Brinjal, *Solanum melongena*, morphological characters, bacterial wilt, shoot and fruit borer.

INTRODUCTION

Eggplant (*Solanum melongena* L.), popularly known as brinjal in Indian sub-continent, is an important solanaceous vegetable crop of India. The name 'brinjal' is derived from Arabic and Sanskrit literature whereas, the name 'eggplant' has been derived from the shape of fruit of some varieties, which are white in colour and resemble in shape to chicken eggs (Khan and Singh, 2014). It is also called *aubergine* in France, England and other European countries, whereas, it is popular as eggplant in USA and Canada. This crop is extremely variable in India substantiated by the presence of wild relatives of *Solanum melongena* which are perennial herb or shrub with bitter fruits (Bhaduri, 1951).

Eggplant is susceptible to various diseases *viz*., bacterial wilt; fusarium wilt; verticillium wilt, early blight, leaf spot, *potato virus-Y* (PVY), *tobacco ring spot virus*, *tomato spotted wilt virus* (TSWV), phytoplasma, and root-knot nematode. Due to these diseases, quality of eggplant production is adversely affected (Singh *et al*., 2019). Bacterial wilt (*Ralstonia solanacearum*) in brinjal is a major concern in Jharkhand and even in the most part of the country. This pathogen is race specific and has five different races. In India, bacterial wilt is mainly caused by *Race-1 Biovar-3* (Gopalakrishnan *et al.,* 2005). The inoculum of *R. solanacearum* can survive in soil for ten years even in absence of host plant and has the ability to colonize in non-host plants including a wide range of symptomless weeds (Gopalakrishnan *et. al.*, 2014). The mode of infection of pathogen into the plants through various ways i.e. wounds or secondary root initiation points leading to pathogen colonization in the vascular parenchyma and breakage on cell wall (Ramesh, 2008). The initial wilt symptoms start with the leaf drooping, leading towards full-plant wilting as well as vascular discoloration. In ooze test, milky white streaming can be observed if cut ends of wilted plant placed in water. The brinjal fruit and shoot borer (BFSB) *Leucinodes orbonalis* (Lepidoptera: Pyrallidae) is one of the most important destructive insect pests of this vegetable crop. It could cause yield losses as high as 70% (Islam and Karim, 1991; Dhandapani *et al*., 2003). The losses caused by pests vary from season to season because moderate temperature and high humidity favour the population build-up of brinjal shoot and fruit borer

(Shukla and Khatri, 2010; Bhushan *et al.*, 2011). At vegetative phase, the newly hatched larvae bore into petioles, midrib of large leaves and young tender shoots. They feed on the internal tissue causing the shoot droop down and withering, at the reproductive phase, the larvae prefer to bore into flower buds and also enter into the infested fruits through the calyx. While observing the boring holes, the infested fruits can easily be identified. Besides, the dark colour excreta can also be easily seen near holes of infested fruits Larvae of this insect bore inside plant shoots and fruits, adversely affecting plant growth, yield and fruit quality, and thus making it unfit for human consumption (Netam *et al.*, 2018).

Hence, to produce damage-free marketable fruits and to avoid production loss, the farmers in the region rely exclusively on the application of chemical insecticides to combat FSB which has resulted in a tremendous misuse of pesticides. Indiscriminate use of insecticides to control FSB in eggplant and other vegetables resulted in soil, water and environmental pollution as well as bioaccumulation and bio-magnification of toxic residues and causes disturbance in ecological balance. So, there is a need for an expedient to seek for safe and eco-friendly pest control measures. The most important and effective way to manage an insect pests and diseases is the development and use of resistant cultivars and it can be easily adopted with reduced cost of production. The use of resistant varieties is regarded as the farmer's first line of defense against pests and diseases and one of the safest and the most compatible approach with other control strategies (Lit, 2009). Therefore, the application of integrated pest management (IPM) is desirable and sustainable in managing these pests because it combines biological, cultural, physical, and chemical tools in a way that minimizes economic, health and environmental risks (Rechcigl and Rechcigl, 2000). At present several varieties/hybrids has been released by public and private institutions but still many of the commercial varieties/hybrids are highly susceptible to bacterial wilt. Farmers are usually using large quantity of chemicals to control the wilt problem which ultimately leads to the presence of chemical residues in the fruits, thus, raises the concern of food safety and detrimental for the human health and environment. The most economical way of bacterial wilt control is to develop bacterial wilt resistant varieties. The principal method used for improvement of this crop is selection from indigenous genotypes. Comprehensive characterization of this crop is yet lacking. The evaluation of genotypes gives considerable information to characterize the available materials and collection, characterization, evaluation and maintenance of germplasm are pre-requisite for starting any breeding programme for the genetic improvement of the crop. In the present investigation, an attempt has been made to evaluate brinjal genotypes for various morphological characters and yield attributes including resistance against bacterial wilt as well as shoot and fruit borer.

MATERIALS AND METHODS

The present investigation was consisted of nine genotypes of brinjal collected from different sources *viz.*, four genotypes from Zonal Research Station, Chianki (CB-1, CB-2, CB-27 and CB-41), one each from ICAR, RCER, Ranchi Centre, Plandu (Swarna Pratibha), IARI, New Delhi (Pusa Upkar), GBPUAT, Pantnagar (Pant Samrat), local collection (LC-3) and private firm (Lal Gulab). The field trials were conducted at Zonal Research Station (Birsa Agricultural University, Ranchi), Chianki, Palamau, Jharkhand (Latitude 24.013º N, Longitude 84.107º E) for yield performance and entomological studies, and at KVK, Chianki, Palamau for pathological studies during *rabi* (winter) seasons of 2017-18, 2018-19 and 2019-20. Chianki falls under dry sub-tropical zone and is situated in the western plateau region of Jharkhand (sub zone-V) which comes under rain shadow area. The seeds of nine genotypes were sown in the beginning of *rabi* season in raised beds. One month old seedlings were transplanted in well prepared field. Recommended package of practices was followed to grow normal crops. Experiment was laid out in randomized block design with three replications of nine entries including three checks *viz.*, Swarna Pratibha (State Check), LC-3 (Local Check) and Lal Gulab (Private Check). Seedlings were transplanted at the spacing of 60 cm between rows and 50 cm within rows. Moreover, each genotype was represented as fifty plants in each replication. Measurements on marketable tender fruit yield was taken on five plants per treatment which were systematically sampled. This involves tagging of five plants on internal rows of each genotype in each replication whereas, for the screening against bacterial wilt and for shoot and fruit borer contained hundred plants in each replication for all genotypes which were considered for data recording and scaling of disease and insect-pest. Genotypes were characterized for twelve morphological characters and yield attributes. Mean data were subjected to suitable statistical analysis (Panse and Sukhatme, 1985) and scaling for bacterial wilt was as suggested by Hussain *et al.* (2005) and for scaling of shoot and fruit borer was as suggested by Khan and Singh (2014).

Bacterial Wilt Disease Screening

R. solanacearum inoculum was prepared as suggested by Urquhart *et al.* (1998) from bacterial wilted brinjal plants. The bacterium colonies were collected from wilted plant using ooze out test, and streaked on Triphenyl Tetrozolium Chloride (TZC or TTC) plate. The plates were incubated at 28 ºC – 30 ºC for 48 hours, and the TZC plates were checked for development of avirulent and virulent colonies. The separated virulent colonies were selected and suspended in sterile distilled water. The concentration of inoculum was recorded using a spectrophotometer and stored at 4 ºC for further use. Soil drenching method was used for inoculating the

25 days seedlings with *R. solanacearum* suspension, with concentration of 1.0 x108 CFU / ml (OD 600 nm = 0.3) (Rashmi *et al.*, 2012).

According to Hussain *et al.* (2005), bacterial wilt symptoms and total number of wilted plants per germplasm/variety were recorded on a 0-5 modified scale. Based on the percentage of wilted plants, accessions were categorized as highly resistant to highly susceptible. Where, Highly Resistant (HR) with **0 score** No wilt

Resistant (R) **(1)**	: 1-10 % wilt
Moderately Resistant (MR) **(2)**	: 11-20 % wilt
Moderately Susceptible (MS) **(3)**	: 21-30% wilt
Susceptible (S) **(4)**	: 31-40 % wilt
Highly Susceptible (HS) **(5)**	: >40 % wilt

Shoot and Fruit Borer Screening

According to Khan and Singh (2014) shoot and fruit borer symptoms on shoots counted in each genotypes before flowering and fruiting stage and later on number of fruits counted as damaged by fruit borer at marketable fruit stage. Based on the percentage damage on shoot as well as on number of fruits, accession were categorized as resistant to highly susceptible.

Scale for shoot damage

0.1-5.0	Resistant (R)
5.1-10.0	Moderately Resistant (MR)
10.1-15.0	Tolerant (T)
15.1-20.0	Susceptible (S)
> 20	Highly Susceptible (HS)

Scale for fruit damage

0.1-10.0	Resistant (R)
10.1-20.0	Moderately Resistant (MR)
20.1-30.0	Tolerant (T)
30.1-40.0	Susceptible (S)
> 40	Highly Susceptible (HS)

RESULTS AND DISCUSSION

In this study, different genotypes showed different morphological characters which were depicted in the Table 1. It revealed distinguished variations among the genotypes of brinjal. Stem colour was dominating by purple green (six genotypes) and green (three genotypes). Leaf colour was purple green (six genotypes), green (three genotypes), dark green (one genotype), dark purple (one genotype) and light green (one genotype). Mid-rib colour was observed as dominated with purple (six genotypes) followed by light purple (two genotypes) and light green (one genotypes). Fruit colour is an important character in brinjal. Out of nine genotypes, six genotypes were found purple followed by light green (two genotypes) and light purple (one genotype). All genotypes were with non-spiny (non-prickle) on mid-rib, leaves and petiole whereas, in the epicalyx it was absent in six genotypes and present in three genotypes. As far as prickles on stem is concerned, it was present in the seven genotypes whereas, absent in only two genotypes. Besides shape, size and colour of brinjal fruits, the colour of epicalyx is also an important character which resembles to show the brinjal fruits fresh for longer period due to green or light green epicalyx as compared to purple colour epicalyx which leads to become dull fruits just after a few hours of picking or harvesting. Out of nine genotypes, 8 were found purple green epicalyx and only one genotype of green colour (preferred) in the genotype CB-41. Types of epicalyx are also other characters in brinjal which decides its market value as fleshy epicalyx has been preferred by the consumers with respect to papery or leathery epicalyx. As far as types of epicalyx is concerned, six genotypes were fleshy and three genotypes with papery epicalyx. Fruit shape is also an important character, not only for brinjal but also for other vegetable crops. The fruit shape was observed that dominating shape with oblong fruits (four genotypes) followed by egg shaped (two genotypes), long (two genotypes) and round fruits (one genotypes). The colour variations in brinjal fruits were also reported by Shinde *et al*. (2012), Singh *et al*. (1999) and Tumbe *et al*. (1992).

Yield of any crop is the ultimate objective, thus fruit yield per plant and per hectare are also the most desirable characters in brinjal. Genotypes differed significantly for yield attributing characters which were depicted in table 2. Significantly higher fruit yield was obtained by CB-27 with 1.701 kg/plant and 378.00 q/ha followed by CB-1 with 1.602 kg/plant and 355.92 q/ha during *rabi* 2017-18 whereas, significantly higher fruit yield was obtained by CB-1 with 1.534 kg/plant and 340.94 q/ha followed by CB-41 with 1.520 kg/plant and 337.85 q/ha and CB-27 with 1.471 kg/plant and 326.79 q/ha during *rabi* 2018-19. During *rabi* 2019-20 significantly highest yield was recorded in the genotype CB-41 with 2.170 kg/plant and 482.25 q/ha followed by CB-1 with 2.085 kg/plant and 463.43 q/ha, CB-27 with 1.826 kg/plant and 405.78 q/ha as well as Lal Gulab with 1.773 kg/plant and 393.99 q/ha. The lowest yield was recorded in Pusa Upkar over the years of experimentations. The yield variation in brinjal genotypes was also observed by Tumbe *et al*. (1992). Rest other characters these results are in consonance to the reports of various workers at different locations (Chaudhary and Pathania, 1998; Dhankar *et al*., 1978; Kumar *et al*., 2000; Mehta *et al.*, 2004; Patel *et al.*, 2004; Singh and Gopalakishnan, 1999; Srinivasan, 2008).

The reactions of the brinjal accessions to *R. solanacearum* were shown in the Table 3. The genotypes CB-27 (2.7%), CB-41 (3.6%), CB-1 (4.5%), Swarna Pratibha (5.05%) and La Gulab (9.91 %) showed resistance against the bacterium with lowest wilt incidence (table 3). The genotypes LC-3 (10.8 %), Pant Samrat (11.7%) and CB-2 (13.47%) showed moderately resistance reaction with the range of 10-20 % wilt incidence; while the genotype Pusa Upkar was susceptible with 33.21 % of wilt incidence. Results of the present study were in agreement with those obtained by Hanson *et al.* (1996) and Wang *et al.* (1997) where the field reaction of tomato lines to different strains of *R. solanacearum* differed at different locations in South East Asia and to eggplants respectively. Hanson *et al.* (1996) found that in Malaysia and Taiwan most of the tomato lines were resistant, but in the Philippines and Indonesia they were susceptible. This indicates that it is necessary to evaluate different accessions in local conditions against the *R. solanacearum.* Atabug and Juan (1981) had taken 10% of wilted tomato plants to assess the incubation period of *R. solanacearum* and observed that the resistant accessions had longer incubation period compared to susceptible accessions. Rahman (1997) observed similar result in chilli. The present study produced similar results, i.e. the resistant accessions had longer incubation periods and took a longer time to produce disease symptoms than the susceptible accessions.

Table 1: Morphological characteristics of brinjal genotypes at ZRS, Chianki during 2017-18, 2018-19 and 2019-20

S N	Entry	Stem colour	Leaf colour	Midrib colour	Fruit colour	Prickles on midrib	Prickles on epicalyx	Prickles on leaves	Prickles on stem	Prickles on petiole	Colour of epicalyx	Types of epicalyx	Fruit shape
1	Swarna Pratibha (SC)	PG	DG	P	P	x	x	x	x	x	PG	Fleshy	Oblong
2	Lal Gulab (Pvt. C)	G	G	LG	LP	x	x	x	x	x	PG	Fleshy	Long
3	Pant Samrat	PG	G	P	P	x	x	x	x	x	PG	Papery	Long
4	CB-1	PG	PG	P	P	x	x	x	x	x	PG	Fleshy	Egg shaped
5	CB-27	PG	DP	P	P	x	x	x	x	x	PG	Fleshy	Oblong
6	CB-41	G	G	LP	LG	x	√	x	√	x	G	Papery	Oblong
7	CB-2	PG	PG	P	P	x	x	x	x	x	PG	Fleshy	Egg shaped
8	LC-3 (LC)	G	LG	LP	LG	x	√	x	√	x	PG	Fleshy	Oblong
9	Pusa Upkar	PG	PG	P	P	x	√	x	x	x	PG	Papery	Round

Note: G = Green, PG = Purple Green, LG = Light Green, LP = Light Purple, PGD = Purple Green Dark, DG = Dark Green, LPG = Light Purple Green, LGP = Light Green Purple, x = Absent, √ = Present

Table 2: Evaluation of Brinjal Genotypes at ZRS, Chianki

S N	Genotypes	Yield per plant (kg)			Yield (q/ha)		
		2017-18	2018-19	2019-20	2017-18	2018-19	2019-20
1	Swarna Pratibha (State Check)	1.391	1.278	1.361	309.11	284.09	302.55
2	Lal Gulab (Pvt. Check)	1.053	1.200	1.773	234.07	266.63	393.99
3	Pant Samrat (NC)	0.976	1.274	1.243	216.89	283.15	276.23
4	CB-1	1.602	1.534	2.085	355.92	340.94	463.43
5	CB-27	1.701	1.471	1.826	378.00	326.79	405.78
6	CB-41	1.017	1.520	2.170	226.00	337.85	482.25
7	CB-2	1.218	1.283	1.273	270.74	285.18	282.96
8	LC-3 (Local Check)	1.159	1.182	1.604	257.63	262.66	356.39
9	Pusa Upkar	0.577	0.637	0.608	128.15	141.48	135.18
	CD (5%)	**0.275**	**0.212**	**0.423**	**61.13**	**47.03**	**94.12**
	SE(m)	**0.091**	**0.07**	**0.141**	**20.216**	**15.552**	**31.128**
	CV %	**13.26**	**9.59**	**15.65**	**13.26**	**9.59**	**15.65**

Table 3: **Disease reaction to brinjal genotypes during *Rabi* 2017-18, 2018-19 and 2019-20 at KVK, Palamau, Jharkhand**

		Bacterial wilt (%)				
S N	**Genotypes**	**2017-18**	**2018-19**	**2019-20**	**Mean**	**Reaction**
1	**Swarna Pratibha (C)**	5.33	5.67	4.15	**5.05**	**R**
2	**Lal Gulab Pvt. (C)**	9.60	11.47	8.67	**9.91**	**R**
3	**Pant Samrat**	13.47	11.15	10.48	**11.70**	**MR**
4	**CB-27**	3.17	2.67	2.27	**2.70**	**R**
5	**CB-41**	3.40	4.40	3.00	**3.60**	**R**
6	**CB-1**	5.40	3.67	4.43	**4.50**	**R**
7	**LC-3**	9.40	11.80	11.20	**10.80**	**MR**
8	**CB-2**	13.25	15.67	11.50	**13.47**	**MR**
9	**Pusa Upkar**	33.67	31.40	34.57	**33.21**	**S**
	CD(5%)	**3.21**	**2.96**	**2.75**		
	SEM	**1.060**	**0.978**	**0.908**		
	CV%	**17.09**	**15.57**	**15.68**		

Table 4: **Major Insect-pest reaction to brinjal genotypes during *rabi* 2017-18, 2018-19 and 2019-20 at ZRS, Chianki**

S N	**Genotypes**	Shoot Damage (%)				**Rating**	Fruit Damage (%)				**Rating**
		2017-18	**2018-19**	**2019-20**	**Mean**		**2017-18**	**2018-19**	**2019-20**	**Mean**	
1	**Swarna Pratibha (C)**	4.77	4.19	4.63	**4.53**	**R**	6.98	8.24	7.85	**7.69**	**R**
2	**Lal Gulab Pvt. (C)**	3.78	4.12	4.96	**4.29**	**R**	6.45	6.25	5.85	**6.18**	**R**
3	**Pant Samrat**	4.67	4.24	5.11	**4.67**	**R**	7.87	9.84	8.80	**8.84**	**R**
4	**CB-1**	3.67	3.68	3.60	**3.65**	**R**	5.47	6.30	4.23	**5.33**	**R**
5	**CB-27**	4.37	3.87	3.67	**3.97**	**R**	7.28	5.98	6.91	**6.72**	**R**
6	**CB-41**	3.27	3.05	2.45	**2.92**	**R**	3.88	4.63	4.05	**4.19**	**R**
7	**CB-2**	14.17	13.67	12.27	**13.37**	**T**	28.35	21.74	24.27	**24.79**	**T**
8	**LC-3**	31.70	26.30	25.67	**27.89**	**HS**	43.47	49.37	42.80	**45.21**	**HS**
9	**Pusa Upkar**	33.57	32.52	25.95	**30.68**	**HS**	45.00	47.50	50.05	**47.52**	**HS**
	CD(5%)	**1.19**	**2.59**	**1.89**			**3.56**	**2.39**	**2.47**		
	SEM	**0.395**	**0.857**	**0.625**			**1.178**	**0.791**	**0.817**		
	CV%	**5.93**	**13.97**	**11.04**			**11.87**	**7.14**	**8.22**		

CONCLUSION AND FUTURE THRUST

This study depicted the variability existed in the promising genotypes/varieties of brinjal. Resistance against wilt and shoot and fruit borer depicted a significant importance for the breeders as well as for the commercial growers of this crop. It would be helpful for the ecofriendly management of the crop and sustainability for the agro-ecosystem and health of the common people which ultimately attracts the planners as well as consumers in the greater sense. It was concluded that a wide range of morphological as well as genetic diversity in the brinjal genotypes in public domain as well as research institutes. These variations help to select parental lines for future strategies of breeding in this important vegetable crops in this zone as well as for other parts of the country. Hence, it is necessary to characterize the genotypes of brinjal in other locations comprising with new collections for better acceptance and wider adaptability as well as for the identification of suitable lines for the region and selection of parental lines for breeding programme as well as for the release of superior genotypes as a variety for the specific region or state for their commercial exploitation. The elite varieties, land races, local types, wild relatives, stable breeding lines, indigenous cultivars etc. should be characterized for different quantitative and qualitative characters and utilized for breeding programme and promising ones must be utilized as a variety for the benefit of the farmers. With the help of this investigation, it has been concluded that the crop is extremely variable in this region because of high differential selection pressure according to regional preference of fruits characters. The consumer preference varies from region to region and locality to locality. Further, the identified superior genotypes *viz.*, CB-1 (egg shaped & purple fruit), CB-27 (oblong & purple fruit) and CB-41 (oblong & light green fruit) may be released as a variety for their commercial exploitation for the Jharkhand state and adjoining areas of similar agro-climatic conditions.

ACKNOWLEDGMENT

Authors wish to thank to the Associate Director, ZRS, Chianki, Palamau-822102, Jharkhand and Director Research, Birsa Agricultural University, Ranchi, Jharkhand for providing all necessary facilities and support during the course of investigation

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Citation: Ansari, A.M., Ahmad, E., Kumar, R., Nazrussalam and Singh D.N. 2021. Evaluation of brinjal genotypes for morphological characters, yield performance and reaction against bacterial wilt and shoot and fruit borer. *International Journal of Agricultural and Applied Sciences*, **2**(1): 163-169. https://doi.org/10.52804/ijaas2021.2122