International Journal of Statistics and Applied Mathematics

ISSN: 2456-1452
Maths 2023; SP-8(6): 1278-1282

https://www.mathsjournal.com
Received: 30-10-2023
Accepted: 02-12-2023

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Screening of different genotypes/cultivars of black gram against stem fly, *Melanagromyza sojae* (Zehntner) in summer season

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Abstract
Total thirteen black gram genotypes/cultivars (SKNU-13-02, SKNU-13-03, SKNU-13-05, SKNU-11-11, SKNU-12-04, SKNU-12-07, SKNU-12-08, SKNU-15-01, SKNU-15-02, SKNU-15-03, T9, GU 1 and Rajasthan local) were screened for their relative susceptibility against stem fly, *Melanagromyza sojae* during summer (2017) at Entomological farm, BA College of Agriculture, Anand Agricultural University, Anand. SKNU-15-02 (23.88%), SKNU-15-01 (27.50%) and SKNU-12-07 (27.58%) exhibited less infestation of stem fly which reflected on yield and found resistant to stem fly. The genotypes/cultivars SKNU-12-08 (45.43%), SKNU-13-05 (45.47%) and Rajasthan local (50.21%) found moderately resistant. GU 1 (60.21%), SKNU-13-02 (65.90%), SKNU-12-04 (66.26%), T_9 (67.05%) and SKNU-15-03 (68.86%) categorised as moderately susceptible, whereas SKNU-11-11 (71.02%) and SKNU-13-03 (71.04%) categorized as susceptible against stem fly. Maximum seed yield was obtained from the cultivar Rajasthan local (775 kg/ha) followed by SKNU 15-02 (767 kg/ha) and SKNU-12-07 (741 kg/ha).

Keywords: Black gram, Stem fly, Rajasthan local, SKNU 15-02 & SKNU-12-07

Introduction
Pulse crops are hugely important in India since they help with crop diversity, revenue production, food security, sustainable agriculture, resilience to climate change, and export potential. One of the main pulse crops farmed in India is black gram, which is important to Indian cuisine. It is believed that black gram (*Vigna mungo* L.) originated in India. In India, the total production of black gram is 30,59,990 tons with 546 kg/ha productivity from an area of 56,02,470 ha in 2018-19 (Anonymous, 2019a) [1]. It is mainly cultivated in Andhra Pradesh, Bihar, Madhya Pradesh, Maharashtra, Uttar Pradesh, West Bengal, Punjab, Haryana, Tamil Nadu and Karnataka. In Gujarat, the production of black gram is 73560 tons with 669 kg/ha productivity from an area of 1,09,960 hectares in 2018-19. The major black gram growing districts in Gujarat are Sabarkantha, Panchmahal, Dahod, Vadodara, Mehsana and Bharuch. It is also cultivated to some extent in Rajkot, Surendranagar and Junagadh districts (Anonymous, 2019b) [2]. In India, quantitative avoidable losses (7-35%) caused by insect-pest complex, both in black gram and green gram vary with different agro-climatic conditions (Hamad and Dubey, 1983) [4]. On an average, 2.5 to 3.0 million tonnes of pulses are lost annually due to pest problems (Rabindra *et al*., 2004) [15]. The annual yield loss due to the insect-pests has been estimated as 30 per cent in urd bean and mung bean (Justin *et al*., 2015) [5]. In India, 60 insect species are known to attack black gram at different stages of crop growth (Lal and Sachan, 1987) [6]. Yield loss due to stem fly varies between locations and according to the plant growth stage. Gaur *et al*. (2015) [3] reported 100% infestation and 33.84% stem tunnelling caused by *M. sojae* in soybean at Pantnagar in Uttarakhand. Pathan *et al*. (2023) [14] from Anand, Gujarat reported that *Melanagromyza sojae* (Zehntner) severely damages black gram at the seedling stage. The first set of seedling leaves are favoured locations for oviposition and result in widespread tunneling in young plants. Infested plants grow yellowish, stunted, and in severe situations, the pest completely destroys the crop as a result of the maggot feeding inside the stem after the egg hatches.

SKNU-11-11 (60.36%) proved to be susceptible against *M. sojae* (Pathan and Sisodiya, 2023) [14] in *kharif*. Stem fly infestation exhibited a highly significant positive association (r = 0.519** and 0.655*) with bright sunshine hours (BSS) and maximum temperature (MaxT), respectively in *kharif* (Pathan *et al*. 2023) [14] while minimum temperature ((r = 0.769**) and evening during summer respectively in summer (Pathan *et al*. 2022) [11]. The black gram crop sown during the fourth week of August demonstrated the highest level of infestation (53.68%) and tunneling (15.44%) followed by the crop sown during the third week of August during the *kharif* season (Pathan *et al*. 2023) [14] on the other hand crop sown late i.e. 1st week of April showed significantly higher infestation (64.28%) of stem fly in summer (Pathan *et al*. 2022) [11].

In Gujarat, the stem fly, *M. sojae* (Diptera: Agromyzidae), is a new pest of black gram. Effective management strategies other than applying insecticides to the pest are not available in the current situation. Under these conditions, it becomes crucial to identify some environmentally friendly alternative techniques for managing insect pests, including cultural norms like the usage of resistant varieties. Utilizing pest-resistant varieties identified through varietal screening can reduce the reliance on synthetic insecticides and other pest control measures. Keeping these points in view, detail investigations were undertaken to screen the different genotypes/cultivars against *M. sojae* during summer.

Materials and Methods

With a view to determine the comparative resistance as well as to locate the source of resistance against stem fly, 13 genotypes/ cultivars (SKNU-13-02, SKNU-13-03, SKNU-13-05, SKNU-11-11, SKNU-12-04, SKNU-12-07, SKNU-12-08, SKNU-15-01, SKNU-15-02, SKNU-15-03, T9, GU 1 and Rajasthan local) of black gram were screened under field conditions during summer 2017 at Entomological farm, B. A. College of Agriculture, Anand Agricultural University, Anand. The genotypes/cultivars were grown in a plot of 1.35 x 5.00 m at 45× 10 cm spacing in a Randomized Block Design with three replications. All the recommended agronomical practices were adopted to raise the crop except plant protection measures. Genotypes used under the present investigation were procured from Pulse Research Station, S. D. Agricultural University, Dantiwada.

In order to record the stem fly infestation, ten randomly selected seedlings were uprooted from each plot and brought in the departmental laboratory. The roots were gently washed in tap water to remove adhering soil. Stem of each plant was dissected with a scalpel and observations on length of stem, length of tunnel and the number of larva (e) and pupa (e) present in the stem were recorded. The number of stem fly infested plants in each sample were also recorded. The observations were recorded at weekly interval starting from one week after germination. Tunnelling and infestation per cent were calculated based on given formula (Laxmigudi *et al*., 2014). The seed and haulm yield (kg/plot) were also recorded from the net plot area and were converted to kg/ha. The data thus obtained were analysed by following standard statistical technique (Steel and Torrie, 1980) [16].

Different black gram genotypes/ cultivars were categorized into Highly Resistant (HR), Resistant (R), Moderately Resistant (MR), Moderately Susceptible (MS), Susceptible (S) and Highly Susceptible (HS) categories. The scale used for categorizing different genotypes/ cultivars is as per statistical tools as followed by Patel *et al*. (2002) [8].

Results and Discussion

Infestation and tunnelling caused by the pest to the black gram were commenced from one week after germination and continued up to end of season. Larval population of *M. sojae* initiated from first week after germination and continued up to sixth week in summer. Similarly, pupal population of *M. sojae* initiated from second week after germination and continued up to eighth week in summer. The data (Table 1) on stem fly infestation, tunnelling, number of larvae, and pupae in different black gram genotypes and cultivars are shown as pooled over period data of throughout season which was taken at weekly interval.

Plant infestation (%): In all total 13 genotypes/ cultivars of black gram were screened against stem fly, *M. sojae* for their susceptibility based on its infestation (%). The data recorded for different treatments during summer, 2017 are presented in Table 1 and depicted in Fig. 1. Data indicated that there was significant difference among the different genotypes/ cultivars screened. Significantly, least infestation due to stem fly was recorded in genotype SKNU-15-02 (23.88%) over rest of the genotypes/cultivars screened. The genotype SKNU-15-01 also found to be promising against stem fly by registering 27.50% infestation and was at par with SKNU-12-07 (27.58%). SKNU-12-08 (45.43%) and SKNU-13-05 (45.47%) performed equally against stem fly. On the other hand significantly highest infestation was registered in SKNU-13-03 (71.04%) followed by SKNU-11-11 (71.02%), SKNU-15-03 (68.86%) and cultivar T-9 (67.05%).

Stem tunnelling (%): Total 13 genotypes/ cultivars of black gram screened against stem fly, *M. sojae* for their susceptibility based on its tunnelling (%). The data recorded for different treatment during summer 2017 are presented in Table 1 and depicted in Fig. 1. So far tunnelling (%) due to *M. sojae* is concerned, it was minimum in SKNU-12-07 (5.71%) followed by SKNU-15-01 (5.75%) and SKNU-15-02 (6.37%). The genotypes/ cultivars *viz.*, GU 1, SKNU-13-02, T9, SKNU-15-03, SKNU-13-03, SKNU-11-11 AND SKNU-12-04 found statistically at par and exhibited 22.14 to 24.05% tunnelling in black gram.

Number of larva/plant: Data on larval population recorded during summer season in different genotypes/cultivars are presented in Table 1 and depicted in Fig. 1. Data on larval counts made during summer 2017 showed that it was significantly less in numbers in SKNU-15-01 (0.11/plant), SKNU-12-07 (0.12/plant) and SKNU-15-02 (0.12/plant). The genotypes SKNU-13-05 (0.40/plant) and SKNU-12-08 (0.42/plant) found at par with cultivar Rajasthan local (0.44/plant). Rest of the genotypes/cultivars found at par in their performance against larval population of stem fly.

Number of pupae/plant: Data on larval population recorded during summer season in different genotypes/cultivars are presented in Table 1 and depicted in Fig. 1. Data on larval counts made during summer 2017 showed that it was significantly less in numbers in SKNU-15-01 (0.11/plant), SKNU-12-07 (0.14/plant) and SKNU-15-02 (0.14/plant). The genotypes SKNU-13-05 (0.42/ plant) and SKNU-12-08 (0.42/plant) found at par with cultivar Rajasthan local (0.46/plant). Rest of the genotypes/ cultivars found at par in their performance against larval population of stem fly.

Categorisation o varieties: Looking to the level of infestation (%) due to stem fly, *M. sojae*, all the genotypes/cultivars screened during summer 2017 were classified in six categories *viz*., Highly resistant, resistant, moderately resistant, moderately susceptible, susceptible and highly susceptible (Table 2). Accordingly, none of the genotype falls in highly resistant and highly susceptible category. SKNU-15-02 (23.88%), SKNU-15-01 (27.50%) and SKNU-12-07 (27.58%) categorized as resistant genotypes, SKNU-12-08 (45.43%), SKNU-13-05 (45.47%) and Rajasthan local (50.21%) as moderately resistant, Gujarat Urad 1 (60.21%), SKNU-13-02 (65.90%), SKNU-12-04 (66.26%), T9 (67.05%) and SKNU-15-03 (68.86%) as moderately susceptible and SKNU-11-11 (71.02%) and SKNU-13-03 (71.04%) as susceptible genotypes/cultivars.

Seed and haulm yield (kg/ha): Data on seed and haulm yield recorded for different genotypes/cultivars screened for their susceptibility against stem fly, *M. sojae* during summer season of 2017 are presented in Table 3 & Fig. 2. It indicated that maximum seed yield was obtained from the cultivar Rajasthan local (775 kg/ha) followed by SKNU 15-02 (767 kg/ha) and SKNU-12-07 (741 kg/ha). Rajasthan local and SKNU-15-02 differed significantly from rest of the genotypes/cultivars, except SKNU-12-07. On the other hand minimum seed yield was registered in SKNU-11-11 (359 kg/ha) followed by SKNU-13-03 (360 kg/ha), SKNU-12-04 and SKNU 12-08 (362 kg/ha). Rest of the genotypes/cultivars found mediocre in producing seed yield. More or less similar trend of treatment effect on haulm yield was observed as noticed in case of seed yield.

The genotypes/cultivars screened during the present investigation had not been screened by earlier workers. Hence, it could not be possible to compare and discuss these genotypes/cultivars with earlier findings.

Table 1: Screening of black gram genotypes/cultivars for their susceptibility against stem fly, *M. sojae* (Summer, 2017)

Sr. No.	Genotypes/cultivars	Infestation (%)	Tunneling (%)	Larva/plant	Pupa/plant
T_1	SKNU-13-02	*54.27g(65.90)	*28.29d(22.46)	**1.13c(0.78)	**1.13c(0.78)
T_2	SKNU-13-03	57.44h(71.04)	28.79d(23.19)	1.15c(0.82)	1.16c(0.85)
T_3	SKNU-13-05	42.40d(45.47)	22.96b(15.22)	0.95b(0.40)	0.96b(0.42)
T_4	SKNU-11-11	57.43h(71.02)	29.15d(23.73)	1.15c(0.82)	1.16c(0.85)
T_5	SKNU-12-04	54.49g(66.26)	29.37d(24.05)	1.14c(0.80)	1.15c(0.82)
T_6	SKNU-12-07	31.68c(27.58)	13.83a(5.71)	0.79a(0.12)	0.80a(0.14)
T_7	SKNU-12-08	42.38d(45.43)	23.23bc(15.56)	0.96b(0.42)	0.96b(0.42)
T_8	SKNU-15-01	31.63bc(27.50)	13.87a(5.75)	0.78a(0.11)	0.78a(0.11)
T_9	SKNU-15-02	29.25a(23.88)	14.62a(6.37)	0.79a(0.12)	0.80a(0.14)
T_{10}	SKNU-15-03	56.08gh(68.86)	28.79d(23.19)	1.14c(0.80)	1.15c(0.82)
T_{11}	T9	54.97gh(67.05)	28.54d(22.83)	1.13c(0.78)	1.14c(0.80)
T_{12}	GU 1	50.89f(60.21)	28.07d(22.14)	1.10c(0.71)	1.13c(0.78)
T_{13}	Rajasthan local	45.12e(50.21)	24.29c(16.92)	0.97b(0.44)	0.98b(0.46)
S.E.M.± (Treatment)T		0.855	0.412	0.020	0.018
(Period) P		0.750	0.361	0.013	0.013
T x P		2.704	1.301	0.048	0.048
C. D. at 5%, T		Sig.	Sig.	Sig.	Sig.
C. V. (%)		10.01	9.33	8.21	8.08

Note:
1. *Figures in parentheses are retransformed values and those outside are arc sine transformed values
2. **Figures in parentheses are retransformed values and those outside are $\sqrt{X+0.5}$ transformed values
3. Treatment means with the letter(s) in common are not differing significantly by Duncan's New Multiple Range Test (DNMRT) at 5% level of significance
4. Significant parameters and its interactions: P

Table 2: Categorization of different genotypes/cultivars of black gram based on infestation level for their susceptibility to stem fly, *M. sojae* (Summer, 2017)

Category of resistance	Scale	Genotype/cultivar
	$\bar{X}$ = 53.11	SD = 17.69
Highly Resistant (HR)	$\bar{X}_i$ < (17.70)	-
Resistant (R)	$\bar{X}_i$ > (17.70) < (35.40)	SKNU-12-07
		SKNU-15-01
		SKNU-15-02
Moderately Resistant (MR)	$\bar{X}_i$ > (35.40) < (53.10)	SKNU-13-05
		SKNU-12-08
		Rajasthan local
Moderately Susceptible (MS)	$\bar{X}_i$ > (53.10) < (70.80)	SKNU-13-02
		SKNU-12-04
		SKNU-15-03
		T9
		GU 1
Susceptible (S)	$\bar{X}_i$ > (70.80) < (88.50)	SKNU-13-03
		SKNU-11-11
Highly Susceptible (HS)	$\bar{X}_i$ > (88.50)	-

Note:
$\bar{X}$ = Mean value of all genotypes/cultivars
$\bar{X}_i$ = Mean value of individual genotype/cultivar
SD = Standard Deviation

Table 3: Yield of different genotypes/cultivars of black gram evaluated for their susceptibility against stem fly, *M. sojae*

Tr. No.	Genotypes/cultivars	Yield (kg/ha) Summer, 2017	
		Seed	Haulm
T_1	SKNU-13-02	364d	492d
T_2	SKNU-13-03	360d	486d
T_3	SKNU-13-05	609c	829c
T_4	SKNU-11-11	359d	485d
T_5	SKNU-12-04	362d	488d
T_6	SKNU-12-07	741ab	1037ab
T_7	SKNU-12-08	362d	489d
T_8	SKNU-15-01	669bc	910bc
T_9	SKNU-15-02	767a	1073a
T_{10}	SKNU-15-03	364d	491d
T_{11}	T9	607c	825c
T_{12}	GU 1	439d	592d
T_{13}	Rajasthan local	775a	1085a
S.E.M. ±		27.51	37.89
C. D. at 5%		Sig.	Sig.
C.V. (%)		9.13	9.19

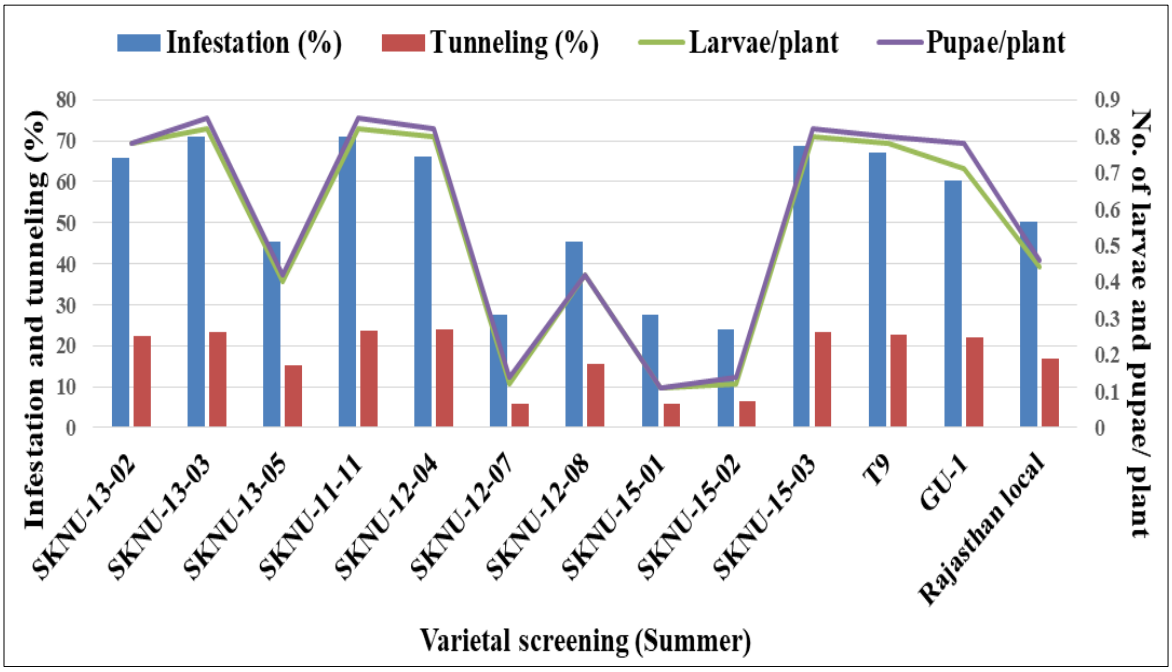

Fig 1: Screening of black gram genotypes / cultivars for their susceptibility against stem fly, *M. sojae* (Summer, 2017)

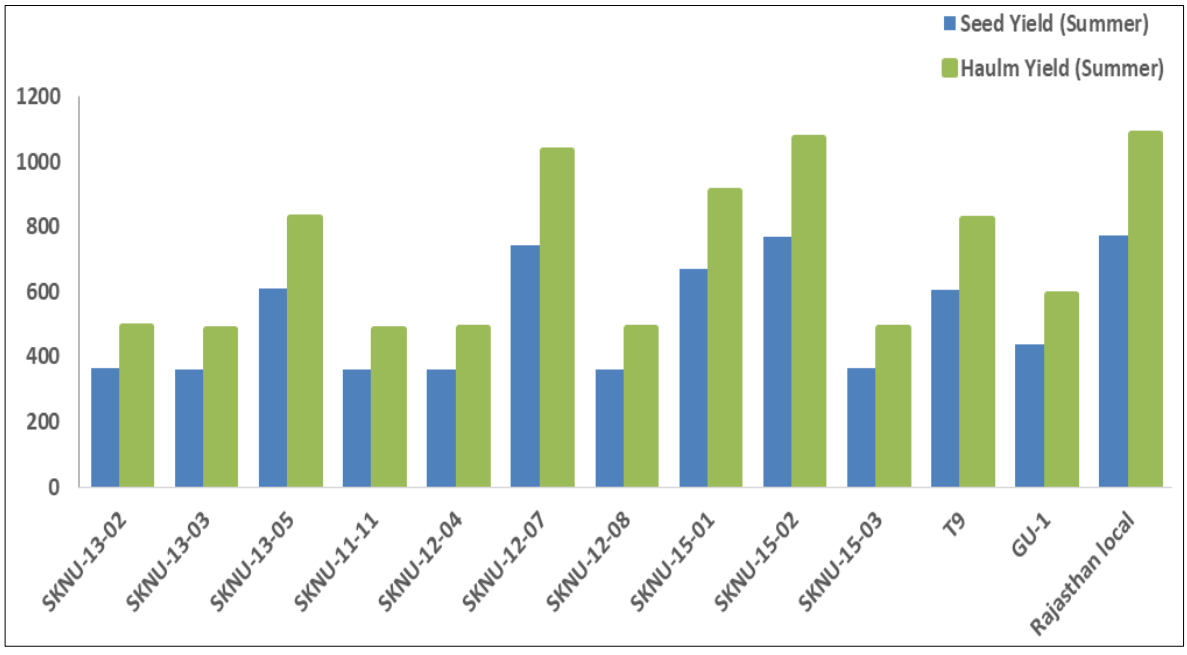

Fig 2: Yield of different genotypes/cultivars of black gram evaluated for their susceptibility against stem fly, *M. sojae* (Summer, 2017)

Conclusion

The genotypes/ cultivars *i.e*. SKNU-15-02 (23.88%), SKNU-15-01 (27.50%) and SKNU-12-07 (27.58%) exhibited less infestation of stem fly which reflected on yield and found resistant to stem fly. SKNU-12-08 (45.43%), SKNU-13-05 (45.47%) and Rajasthan local (50.21%) found moderately resistant. GU 1 (60.21%), SKNU-13-02 (65.90%), SKNU-12-04 (66.26%), T9 (67.05%) and SKNU-15-03 (68.86%) categorised as moderately susceptible, whereas SKNU-11-11 (71.02%) and SKNU-13-03 (71.04%) categorized as susceptible against stem fly. Maximum seed yield was obtained from the cultivar Rajasthan local (775 kg/ha) followed by SKNU 15-02 (767 kg/ha) and SKNU-12-07 (741 kg/ha).

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