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NP Pathan
Assistant Professor, Department of Plant Protection, College of Horticulture, S.D.A.U., Jagudan, Gujarat, India

DB Sisodiya
Professor and Head, Department of Entomology, BACA, A.A.U., Anand, Gujarat, India

NM Gohel
Associate Professor, Department of Plant Pathology, BACA, A.A.U., Anand, Gujarat, India

AR Mohapatra
Ph.D. Scholar, Department of Entomology, BACA, A.A.U., Anand, Gujarat, India

Corresponding Author:
NP Pathan
Assistant Professor, Department of Plant Protection, College of Horticulture, S.D.A.U., Jagudan, Gujarat, India

Impact of sowing periods on incidence of stem fly, *Melanagromyza sojae* (Zehntner) in summer black gram

NP Pathan, DB Sisodiya, NM Gohel and AR Mohapatra

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Abstract
Six sowing periods during summer (4th week of February, 1st week of March, 2nd week of March, 3rd week of March, 4th week of March and 1st week of April) was evaluated for its impact on incidence of stem fly, *Melanagromyza sojae* (Zehntner) infesting black gram at Entomology Farm, B. A. College of Agriculture, Anand Agricultural University, Anand. The black gram crop sown during 1st and 2nd week of March exhibited low larval (0.22 and 0.26 /plant), pupal (0.22 and 0.27 /plant) counts of the pest as well as less infestation (28.38 and 29.73%, respectively) and tunnelling (8.92 and 9.45%, respectively) than rest of the sowing periods during summer season. Maximum seed yield was recorded in the crop sown during 2nd week of March (597 kg/ha) followed by 1st week of March (564 kg/ha).

Keywords: Black gram, infestation, stem fly, sowing periods and tunnelling

Introduction
Pulses are an important source of protein, vitamins and minerals. Blackgram or urd is one of the important pulse crop in India. Black gram (*Vigna mungo* L.) reported to be 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) [7]. 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.
Stem fly, *M. sojae* (Diptera: Agromyzidae) is an emerging pest of black gram in Gujarat. In the present scenario, effective management techniques other than insecticidal application against the pest are not available. Under these circumstances, it becomes necessary to find out some eco-friendly alternative methods for insect-pest management which include the manipulation of the cultural practices like deviating the period of sowing. Secondly day by day, organic farming as well as natural farming is gaining the importance where one can not use chemical insecticides. Keeping these points in view, detail investigations were undertaken to observe the impact of date of sowing on incidence of stem fly, *M. sojae* in summer black gram.

Materials and Methods
With a view to examine the effect of sowing periods on infestation of stem fly in black gram, an experiment was laid out during summer, 2017 and 2021 at Entomology farm, B. A. College of Agriculture, Anand Agricultural University, Anand. Black gram variety GU 1 was grown in a gross plot of 3.15 m × 5.0 m with Net plot size of 2.25 × 4.80 m at 45 × 10 cm spacing in a

Randomized Block Design with four replications at six different periods of sowing (4th week of February, 1st week of March, 2nd week of March, 3rd week of March, 4th week of March and 1st week of April). All the recommended agronomical practices were adopted to raise the crop.

In order to record the stem fly infestation, ten randomly selected plants 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 the number of larva (e) and pupa (e) present in the stem as well as length of stem and length of tunnel 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) [8]. The seed and haulm yield (kg/plot) were also recorded from the net plot area and were converted to kg/ha.

$$\text{Infestation (\%)} = \frac{\text{No. of plants infested}}{\text{Total no. of uprooted plants}} \times 100$$

$$\text{Tunnelling (\%)} = \frac{\text{Length of tunnel}}{\text{Length of total stem}} \times 100$$

Result and Discussion

Infestation and tunnelling caused by the *M. sojae* to the black gram were commenced from one week after germination and continued till the crop was harvested. 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.

Plant infestation (%)

The data on infestation of stem fly, *M. sojae* infesting black gram recorded during summer season of 2017 and 2021 as well as pooled are presented in Table 1. Data recorded during 2017 indicated that there was significant variation in infestation due to *M. sojae* in different treatments. Significantly, least incidence of the pest was noticed in the crop sown during 1st week of March (27.53%) followed by 2nd week of March (28.92%). Both these treatments registered significantly low infestation over rest of the treatments. The treatments of 3rd week of March (44.58%) and 4th week of February (46.22%) found statistically at par. Significantly highest infestation (64.02%) was registered in crop sown during 1st week of April followed by 4th week of March (62.40%). Similar trend of treatment effect was observed during 2021 as noticed during 2017.

Pooled data (Table 1) clearly indicated that the crop sown during 1st week (28.38%) and 2nd week (29.73%) of March registered significantly lower infestation than rest of the sowing periods. The treatments of sowing period i.e., 3rd week of March and 4th week of February exhibited 45.02 and 46.44% infestation, respectively and found mediocre in their impact on stem fly infestation. On the other hand, the crop sown late i.e., 1st week of April showed significantly highest infestation (64.28%) of *M. sojae* followed by the crop sown during 4th week of March (62.80%). In general, the black gram crop sown during first fortnight of March exhibited significantly low infestation of the pest than rest of the sowing periods evaluated in present study.

Stem tunnelling (%)

The data on infestation of stem fly, *M. sojae* caused in the form of tunnelling in black gram crop recorded during summer 2017 and 2021 are furnished in Table 1. Plant infestation recorded during 2017 indicated that the crop sown during 1st and 2nd week of March registered 8.55 and 9.07% infestation in tunnel. Both these treatments found at par and exhibited significantly low level infestation than rest of the treatments. The crop sown during 3rd week of March and 4th week of February showed 14.02 and 14.51% infestation and exhibited moderate impact of sowing period. Late sown (1st week of April) crop registered maximum (21.62%) plant infestation in tunnelling followed by the crop sown during 4th week of March (21.04%). More or less similar trend of treatment effect was noticed during 2021 as noticed during 2017.

Pooled data (Table 1) calculated for the year 2017 and 2021 indicated that least infestation of stem fly to black gram crop was observed in the crop sown during 1st week of March (8.92%) followed by 2nd week of March (9.45%). Both these treatments found at par and proved significantly superior over rest of the treatments by exhibiting low level of plant infestation. The crop sown during 3rd week of March and 4th week of February exhibited 14.37 and 14.84% infestation in stem tunnel, respectively. On the other hand black gram crop sown late i.e., 1st week of April showed significantly highest stem tunnelling (22.26%) followed by the crop sown during 4th week of March (21.58%). Both these treatments of sowing periods found at par. The data clearly indicated that the crop sown during first fortnight of March exhibited low level of infestation of *M. sojae* in stem of black gram and increased in subsequent weeks.

Table 1: Impact of sowing period on infestation and tunneling due to stem fly, *M. sojae* in black gram (Summer)

Tr. No.	Treatments	Infestation (%)			Tunneling (%)		
		2017	2021	Pooled	2017	2021	Pooled
T_1	4th week of February	42.83 (46.22)	43.08 (46.65)	42.96 (46.44)	22.39 (14.51)	22.92 (15.17)	22.66 (14.84)
T_2	1st week of March	31.65 (27.53)	32.72 (29.22)	32.19 (28.38)	17.00 (8.55)	17.75 (9.29)	17.38 (8.92)
T_3	2nd week of March	32.53 (28.92)	33.54 (30.53)	33.04 (29.73)	17.53 (9.07)	18.26 (9.82)	17.90 (9.45)
T_4	3rd week of March	41.89 (44.58)	42.39 (45.45)	42.14 (45.02)	21.99 (14.02)	22.58 (14.74)	22.28 (14.37)
T_5	4th week of March	52.18 (62.40)	52.71 (63.29)	52.45 (62.86)	27.30 (21.04)	28.06 (22.13)	27.68 (21.58)
T_6	1st week of April	53.14 (64.02)	53.46 (64.55)	53.30 (64.28)	27.71 (21.62)	28.58 (22.89)	28.15 (22.26)
S. Em. ± Treatment (T)		0.86	0.83	0.60	0.42	0.45	0.31

Period (P)	1.11	1.08	1.07	0.54	0.58	0.40
Year (Y)	-	-	0.35	-	-	0.18
T x P	2.74	2.65	1.90	1.34	1.43	0.98
T x Y	-	-	0.85	-	-	0.44
P x Y	-	-	1.10	-	-	0.56
T x P x Y	-	-	2.69	-	-	1.39
C. D. at 5% T	2.40	2.32	1.40	1.17	1.26	0.72
P	3.10	2.99	2.78	1.51	1.62	0.93
Y	-	-	NS	-	-	0.41
T x P	NS	NS	NS	3.72	3.98	NS
T x Y	-	-	NS	-	-	NS
P x Y	-	-	2.56	-	-	NS
T x P x Y	-	-	NS	-	-	NS
C.V. (%)	12.93	12.32	12.63	12.02	12.49	12.26

Note: 1. Figures in parentheses are retransformed values and those outside are arc sine transformed values
2. NS = Not Significant

Number of larva/plant

Data on larval population of stem fly *M. sojae* infesting black gram recorded in different treatments of crop sown during summer, 2017 and 2021 as well as its pooled are presented in Table 2. Data recorded during summer, 2017 indicated that the larval count was ranged from 0.16 to 0.19 per plant in the crop sown during first fortnight of March. Both these sowing periods were found at par and differed significantly from rest of the treatments (sowing periods). The crop sown during 3rd week of March and 4th week of February registered 0.40 and 0.42 larva per plant, respectively. Among the sowing periods evaluated, the crop sown late *i.e.* during 1st week of April registered significantly highest count (0.71 larva/plant) followed by the crop sown during 4th week of March (0.69 larva/plant). The trend of impact of sowing period on larval population recorded during 2021 was similar to that of 2017.

Pooled data of larval counts computed for the year 2017 and 2021 are presented in Table 2. Significantly least number of larvae registered in crop sown during 1st week of March (0.22 larva/plant) followed by 2nd week of March (0.26 larva/plant). Both these treatments differed significantly from rest of the treatments (sowing periods). Larval population was more or less similar (0.46 to 0.50 larva/plant) in the crop sown during 3rd week of March and 4th week of February. On the other side, crop sown during 4th week of March and 1st week of April registered larval count as 0.78 and 0.80 larva/plant, respectively.

Number of pupae/plant

Pupal population of stem fly, *M. sojae* infesting black gram recorded in different treatments of sowing period during summer season of 2017 and 2021 as well as pooled over years are presented in Table 2. Data clearly highlighted that the treatments (sowing periods) differed significantly. Pupal population recorded during 2017 indicated that significantly least count of pupae were noticed in crop sown during 1st week of March (0.14 pupa/plant) which was followed by the crop sown during 2nd week of March. Both the treatments found at par and registered significantly less number of pupae per plant over other period of sowing. The crop sown during 3rd week of March and 4th week of February exhibited 0.46 and 0.50 pupa /plant, respectively. Significantly higher pupal counts were made in late sown crop (i.e., 4th week of March and 1st week of April) during summer. More or less similar number of pupae in different treatments were found in 2021 as it was observed during 2017.

Pooled over years data indicated that the black gram crop sown during first fortnight of March in summer season, registered significantly less number of pupae (0.22 to 0.27 pupa/plant) in comparison to rest of the treatments of sowing period (Table 2). Both the treatments of sowing period i.e., 3rd week of March and 4th week of February were mediocre in its response and exhibited 0.54 to 0.58 pupa/ plant. Significantly, maximum numbers of pupae (0.89 pupa/ plant) were counted in crop sown during 1st week of April followed by the crop sown during 4th week of March (0.85 pupa/ plant).

Table 2: Impact of sowing period on larval and pupal population of stem fly, *M. sojae* in black gram (Summer)

Tr. No.	Treatments	Larva(e)/plant			Pupa(e)/plant		
		2017	2021	Pooled	2017	2021	Pooled
T_1	4th week of February	0.96 (0.42)	1.03 (0.56)	1.00 (0.50)	1.00 (0.50)	1.08 (0.67)	1.04 (0.58)
T_2	1st week of March	0.81 (0.16)	0.89 (0.29)	0.85 (0.22)	0.80 (0.14)	0.89 (0.29)	0.85 (0.22)
T_3	2nd week of March	0.83 (0.19)	0.91 (0.33)	0.87 (0.26)	0.83 (0.19)	0.92 (0.35)	0.88 (0.27)
T_4	3rd week of March	0.95 (0.40)	1.02 (0.54)	0.98 (0.46)	0.98 (0.46)	1.06 (0.62)	1.02 (0.54)
T_5	4th week of March	1.09 (0.69)	1.17 (0.87)	1.13 (0.78)	1.13 (0.78)	1.20 (0.94)	1.16 (0.85)
T_6	1st week of April	1.10 (0.71)	1.18 (0.89)	1.14 (0.80)	1.15 (0.82)	1.21 (0.96)	1.18 (0.89)
S. Em. ± Treatment (T)		0.018	0.019	0.01	0.016	0.016	0.01
Period (P)		0.018	0.019	0.02	0.017	0.018	0.02
Year (Y)		-	-	0.01	-	-	0.01
T x P		0.043	0.046	0.03	0.041	0.043	0.03
T x Y		-	-	0.02	-	-	0.02
P x Y		-	-	0.02	-	-	0.02

T x P x Y	-	-	0.04	-	-	0.04
C. D. at 5% T	0.041	0.044	0.03	0.043	0.045	0.03
P	0.041	0.044	0.07	0.047	0.049	0.07
Y	-	-	0.02	-	-	0.02
T x P	NS	NS	NS	NS	NS	NS
T x Y	-	-	NS	-	-	NS
P x Y	-	-	0.04	-	-	0.04
T x P x Y	-	-	NS	-	-	NS
C.V. (%)	8.92	8.83	8.88	8.36	8.09	8.22

Note: 1. Figures in parentheses are retransformed values and those outside are $\sqrt{X+0.5}$ transformed values
2. NS = Not Significant

Seed and haulm yield (kg/ha)

Data on seed and haulm yield of black gram recorded in different treatments of sowing period during summer season of 2017 are presented in Table 3. Data indicated that treatments differed significantly. Maximum seed and haulm yield was produced in the crop sown during 2nd week of March (602 and 843 kg/ha, respectively) followed by the crop sown during 1st week of March (570 and 798 kg/ha, respectively). Both these treatments found at par and yielded significantly higher yield over rest of the treatments. On the other hand, minimum seed and haulm yield was harvested from the crop sown during 1st week of April (402 and 539 kg/ha, respectively). The crop sown during 4th week of March produced yield of 404 kg/ha seed and 541 kg/ha haulm. More or less similar trend of treatment effect on seed and haulm yield was noticed during 2021 as observed during 2017. The results show that late sown crop produced poor yield as compared to early sown crop.

Pooled over years data of seed and haulm yield recorded for the years 2017 and 2021 (summer) are presented in Table 3. The crop sown during 2nd week of March (597 kg/ha) produced maximum seed yield followed by the crop sown during 1st week of March (564 kg/ha). Similarly, maximum haulm yield (836 kg/ha) was obtained from the former treatment followed by the latter treatment (789 kg/ha). Both these treatments produced significantly higher yield than rest of the treatments. Significantly minimum grain (312 kg/ha) as well as haulm (528 kg/ha) yield was harvested from the crop sown late i.e., 1st week of April followed by the crop sown during 4th week of March (397 and 534 kg/ha, respectively). Latter both these treatments found at par.

Table 3: Impact of sowing period on yield of black gram (Summer)

Tr. No.	Treatments	Yield (kg/ha)					
		2017		2021		Pooled	
		Seed	Haulm	Seed	Haulm	Seed	Haulm
T_1	4th week of February	471	636	460	626	465	631
T_2	1st week of March	570	798	558	781	564	789
T_3	2nd week of March	602	843	592	829	597	836
T_4	3rd week of March	482	651	475	647	479	649
T_5	4th week of March	404	541	390	527	397	534
T_6	1st week of April	402	539	383	517	392	528
S. Em. ± Treatment (T)		21.72	30.91	19.51	27.67	13.97	19.91
Year (Y)		-	-	-	-	8.07	11.49
T x Y		-	-	-	-	19.76	28.16
C. D. at 5% T		65.46	93.16	58.80	83.38	33.20	47.31
Y		-	-	-	-	NS	NS
T x Y		-	-	-	-	NS	NS
C.V. (%)		8.89	9.25	8.19	8.46	8.19	8.52

This finding is in accordance with the reports of Prodhan *et al.* (2008) [13] as well as Manjula *et al*. (2019) [9] who have reported low infestation of stem fly in black gram crop sown early in comparison to late sown crop. Similarly, many earlier workers have documented that the incidence of *M. sojae* on pea (Kooner *et al*., 1977) [6], bean (Nderitu *et al*., 1990) [11], gram (Prodhan *et al*., 2000) [14], green gram (Oo *et al*., 2004) [12] and soybean (Meena and Shrama, 2006) [10] exhibited low incidence of stem fly, *M. sojae* on respective pulse crop. Manjula *et al*. (2019) [9] stated that the infestation of stem fly (*Ophiomyia phaseoli*) was very high in black gram crop sown early i.e., during February and March as compared to late sown crops. The discrepancy in sowing period noticed in literature may be attributed due to the variation in climatic conditions prevailed in respective study place, crop variety and ecological factors.

Conclusion

Black gram crop sown during first fortnight of March exhibited low infestation of the pest than rest of the sowing periods evaluated in the present study. The least tunnelling (8.92%) caused by stem fly to black gram crop was observed in the crop sown during 1st week of March followed by 2nd week of March (9.45%). Least number of larvae registered in crop sown during 1st week of March (0.22 larva/plant) followed by 2nd week of March (0.26 larva/plant). Similarly, less number of pupae (0.22 to 0.27 pupa/plant) observed in crop sown during first fortnight of March in summer. Both the treatments of sowing period i.e., 3rd week of March and 4th week of February found mediocre in its response and exhibited 0.54 to 0.58 pupa/ plant. Maximum seed and haulm yield was recorded in the crop sown during 2nd week of March (597 and 836 kg/ha) followed by 1st week of March (564 and 789 kg/ha).

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