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IMPACT OF DATE OF SOWING ON THE INCIDENCE OF SORGHUM STEM BORER, *CHILO PARTELLUS* AND SORGHUM SHOOT FLY, *ATHERIGONA SOCCATA* IN DUAL PURPOSE SORGHUM

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SUMMARY

Present investigation was carried out in dual purpose sorghum, HC 308 during *Kharif*, 2021 at CCS HAU, Hisar in replicated four times at four successive date of sowing at seven days interval to study the impact of date of sowing on incidence of sorghum stem borer and shoot fly in sorghum crop. Number of eggs laid by sorghum shoot fly at 7 and 14 days after emergence (DAE) was lowest in the crop sown on 21st July (0.67 and 1.33, respectively) and was highest in the crop sown on 11th August *i.e.,* 3.00 and 4.00, respectively. Sorghum crop sown on 21st July showed significantly lowest per cent of deadheart incidence (12.33 and 15.39%) while, crop sown on 11th August showed higher per cent of deadheart incidence i.e., 25.52% and 29.78% at 21 and 28 DAE, respectively. Deadheart per cent by sorghum stem borer was recorded lower (16.42%) in crop sown on 21st July as compare to crop sown on 11th August (27.79%) at 45 DAE. Therefore, rather than rushing to apply different insecticides, date sowing of sorghum crop should primarily be kept in mind to avoid the more of an attack from sorghum shoot fly and stem borer.

Key words: Sorghum, sowing dates, sorghum stem borer, *Chilo partellus*, sorghum shoot fly, *Atherigona soccata*

Sorghum [*Sorghum bicolor* (L.) Moench] also known as Jowar, belongs to family Poaceae. It was originated in North East Africa and grown all over the world as a staple food and fodder crop. Sorghum is a short day C_4tillering grass having fibrous root system that grows vigorously and can attain a height of up to 5 m (Badigannavar *et al.,* 2018). It can tolerate extremities of temperature and water scarcity that makes it a climate change- compliant crop (Abreha *et al.,* 2022). Among cereals, sorghum is the fourth most important crop after rice, wheat and maize in India (Dehinwal *et al*., 2016). Globally, Sorghum production was 62 million tonnes in 2020. United States of America stands first in sorghum production with 9.4 million tonnes (15%) followed by Nigeria, Ethiopia, Sudan. India ranks fifth in total sorghum production with 3.47 million tonnes (Anonymous, 2020). In India, a total of 3.47 million tonnes of sorghum grains were produced over the acreage of 4.07 mha with productivity of 852.57 kg/ha during 2020 (FAO, 2021) which is well below world's average (1444.6 kg/ha). Major sorghum growing areas in India are states of Maharashtra, Andhra Pradesh, Karnataka, Gujarat, Tamil Nadu and Rajasthan. In Haryana, it is grown mainly for fodder purpose. The sorghum grain is used in many forms as roti or bhakri, malted, popped with several local preparations (Devi *et al.,* 2011). Green and dried fodder is the most important roughage for feeding cattle throughout the country.

More than 150 insect pest species known to damage sorghum plant from germination to crop harvest (Verma and Singh, 2000) acting as a major limiting factor in achieving target production and productivity of sorghum. Among these diverse population of insect pests, the sorghum spotted stem borer, *Chilo partellus* Swinhoe, shoot fly, *Atherigona soccata* Rondani, ear head bug, *Calocoris angustatus* Leth. and ear head worm, *Cryptoblebes gnidiella* Mab. are some of the few quintessential insect pests attacking sorghum crop at various stages of the crop growth (Patidar *et al.,* 2019). Under late sown crop conditions, the sorghum spotted stem borer, survives

up to sub-zero temperature in diapause in dry and attacks sorghum from two weeks after germination until crop harvest and except roots, all plant parts are affected, while in case of shoot fly, sorghum is highly vulnerable to it's damage in the initial stages of crop growth, particularly the late planted crop *i.e.,* 5 to 25 days after germination as adult fly are active during the morning and evening hours (Patil and Bagde, 2017). In India, *Atherigona soccata* cause losses upto 80-90 per cent in grain yield and 68 per cent in fodder yield (Balikai and Bhagwat, 2009; Kahate *et al.,* 2014). Spotted stem borer, *Chilo partellus* infest both maize and sorghum crops and results in yield reduction ranging from 18-25 per cent in Asia (Dhaliwal *et al.,* 2015). Early sowing is an effective strategy for controlling damage by shoot fly, *A. soccata* (Kahate *et al.*, 2014). Keeping in the view of importance of time of sowingin sorghum crop, a field experiment entitled "Impact of date of sowing on the incidence of sorghum stem borer, *Chilo partellus* and sorghum shoot fly, *Atherigona soccata* in dual purpose sorghum" was carried out at CCS Haryana Agricultural University, Hisar.

MATERIALS AND METHODS

Experiment was conducted during *Kharif*, 2021 at the research area of Forage Section, Department of Genetics & Plant Breeding, CCS Haryana Agricultural University, Hisar, situated at 29.1492°N,75.7217°E at an elevation of 215 m above sea level. Recommended agronomic practices were followed to raise the healthy crop as per package of practices of CCSHAU for *Kharif* crop except plant. Experimental studies were undertaken to assess the impact of date of sowing on incidence of sorghum stem borer, *Chilo partellu s*and sorghum shoot fly, *Atherigona soccata*. Four replications of the sorghum variety, HC 308 were sown on a plot size of 15 m x 10 m from 21st July, 2021 onwards at a successive interval of 7 days up to mid of August.

Observations recorded for shoot fly infestation

Plant vigour, glossiness of leaves, shape of plant canopy, number of eggs per five plants at 7 and 14 days after emergence (DAE) and the mean deadheart (%) at 21 and 28 DAE were recorded.

Plant vigour (visual basis)

The plants were assessed visually for vigour in morning hours from 6.00 to 9.00 A.M. for clear vision at 12 days after seedling emergence and vigour rating (1-5) was ascribed to them as per method suggested by Sharma and Nwanze, 1997.

Plant vigour Scale	Plant characteristics
1	Highly vigorous, plants having maximum height, more number of fully expanded leaves, good adaptation, and robust seedlings
2	Vigorous, good plant height, good number of fully expanded leaves, good adaptation And good seedlings growth
3	Moderately vigorous, moderate plant height with moderate number of fully expanded Leaves and fairly good seedlings growth
4	Less vigorous, less plant height with poor leaf expansion and poor adaptation
5	Poor seedling vigour, plants howing poor growth and weak seedlings

Glossiness of leaves (visual basis)

Five randomly selected and tagged plants from each genotype were used to assess the glossiness of leaves at 12th DAE in the morning hours between 6.00 to 9.00 A.M. and glossiness rating (1-5) were ascribed to them as per method suggested by Sharma and Nwanze, 1997.

Glossiness of leaves (Scale 1-5)	Leaves characteristics
1	Highly glossy, light green, shining, narrow and erect leaves
2	Glossy, light green, less shining, narrow and erect leaves
3	Moderateglossy, fairgreen, lightshining, medium leaf width and less dropping leaves
4	Moderate non glossy, green, pseudo-shine, broad and drooping leaves
5	Non-glossy, dark green, dull, broad and drooping leaves

Shape of canopy (visual basis)

Five plants per plot were randomly selected and tagged to conclude whether plant canopy is closed or open at maturity.

Number of eggs per plant

Numbers of eggs laid by sorghum shoot fly underneath of the leaves of five randomly selected and tagged plants were recorded at 7 and 14 days after emergence.

Deadheart (%)

In the experimental plots, observations on deadheart (%) caused by shoot fly were made at 21 and 28 DAE using the following formula in each plot.

$$\text{Deadheart (\%) due to shootfly} = \frac{\text{Number of plants with deadheart}}{\text{Total number of plants observed}} \times 100$$

Observations recorded for sorghum stem borer, *Chilo partellus* infestation
No. of pin hole per plant

Pin hole count were made and recorded per plant from five randomly selected and tagged plants at 30-35 DAE.

Deadheart (%) at 45 days after emergence

Observations on deadheart caused by stem borer were made at 45 DAE and deadheart (%) was calculated as per following formula:

$$\text{Deadheart (\%) due to stem borer} = \frac{\text{Number of plants with deadheart}}{\text{Total number of plants observed}} \times 100$$

Yield at 85 days after emergence

Green fodder yield from each treatment was recorded at 85days after emergence.

RESULTS AND DISCUSSION

Observations were made on the sorghum shoot fly, *Atherigona soccata* with respect to plant vigour, glossiness of leaves, shape of canopy, number of eggs per plant at 7 and 14 days after emergence (DAE) and per cent deadheart formation at 21 and 28 days after emergence in genotype HC 308.

Impact of date of sowing on ovipositional preference at 7 and 14 DAE by sorghum shoot fly, *Atherigona soccata*

Average numbers of eggs laid per plant by shoot fly were 1.83 and 4.83 at 7 and 14 days after crop emergence, respectively during *Kharif*, 2021. Minimum number of eggs laid by sorghum shoot fly was recorded in sorghum crop sown on 21stof July *i.e.,* 0.67 at 7 DAE and 1.33 at 14 DAE which were statistically at par with crop sown on 28th July *i.e.,* 1.33 at 7 DAE and 2.00 at 14 DAE, respectively. Maximum number of eggs *i.e.,* 3.00 and 4.00 were recorded on crop sown on 11th August at 7 and 14 DAE, respectively which was statistically at par with the crop sown on 4th August that recorded a value of 2.33 and 3.33 at 7 and 14 DAE, respectively (Table 1). There was a significant difference in number of eggs laid in late sown crop *i.e.,* 11th August compared to early sown *i.e.,* 21st July, 2021. An increase in number of eggs by delayed sowing can be attributed to the possibility of more congenial environmental conditions that help in flourishing sorghum shoot fly as reported by Todkar *et al.* (2022) who studied the effect of six sowing dates in sorghum crop similar to result of present investigation. Anandan *et al.* (2009) and Subbaraydu *et al.* (2011) also during the screening of sorghum genotypes found to have low ovipostion in early sown sorghum plants compared to late sown by shootfly.

Deadheart (%) at 21 and 28 days after emergence

Deadheart (%) incidence due to sorghum shoot fly was recorded highest in crop sown on 11th of August (26.41 and 29.51%) followed by crop sown on 4th August (22.34 and 23.55%) at 21 and 28 days after crop emergence, respectively. Least deadheart per cent was recorded in crop sown on 21st July (12.37 and 15.49%) was statistically at par with crop sown on 28th of July (14.35 and 19.52%) at 21 and 28 days after emergence of crop, respectively. Average number of deadheart (%) due to sorghum shoot fly was recorded 18.87 and 22.02 at 21 and 28 DAE, respectively (Table 1). Ahlawat and Kumar (2021), Salman and Moniem (2008) and Todkar *et al.* (2022) also recorded the similar observations of numbers of deadheart increases owing to infestation of sorghum shoot fly as the sowing of crop delayed and or under late sown conditions in sorghum crop.

Glossiness of leaves, plant vigour and shape of canopy

Observations on glossiness of leaves in dual purpose sorghum variety, HC 308 were recorded at 12 days after germination of seedling on a scale of 1-

TABLE 1
Impact of date of sowing on ovipositional preference, glossiness of leaves and deadheart formation by sorghum shoot fly in dual purpose sorghum, HC 308

S. No.	Date of sowing	No. of eggs 7 DAE	No. of eggs 14 DAE	Deadheart (%) 21 DAE	Deadheart (%) 28 DAE	Glossiness of leaves
1.	21st July, 2021	0.67[a]	1.33[a]	12.37[a]	15.49[a]	1.33[a]
		(1.28)	(1.52)	(20.53)	(23.13)	
2.	28th July, 2021	1.33[a,b]	2.00[a,b]	14.35[a]	19.52[a]	2.00[a,b]
		(1.52)	(1.72)	(22.22)	(26.18)	
3.	4th August, 2021	2.33[b,c]	3.33[b,c]	22.34[b]	23.55[b,c]	3.00[b,c]
		(1.82)	(2.08)	(28.78)	(29.00)	
4.	11th August, 2021	3.00[c]	4.00[c]	26.41[b]	29.51[c]	3.67[c]
		(1.99)	(2.23)	(30.91)	(32.88)	
	Mean	1.83	4.83	18.87	22.02	2.50
	C. D. (P=0.05)	0.40	0.50	2.16	3.17	1.13

DAE = Days after emergence, Glossiness of leaves = scale 1-5, Fig. in parenthesis are square transformed values (number of eggs) and angular transformed values (deadheart %), Figures with the same alphabet in same column are statistically at par.

5 on visual basis (Table 1). Sorghum crop sown on 21st July (1.33) recorded maximum glossiness compared to crop sown on 4th (3.00) and 11th of August (3.67) and was statistically at par with the crop sown on 28th July (2.00). There was an increase in glossiness of leaves as per scale as date of sowing progressed to the late of season. Significant difference observed in glossiness of leaves when crop sown on 21st July and 11th August, 2021.

Lower the scale of plant vigour stands for higher of the vigoursity of plant and higher of the scale, lower of the vigoursity. Plant vigour is considered an important element in determining susceptibility and or resistance to sorghum shoot fly. As per the data collected during *Kharif,* 2021, crop sown on 21st July recorded highest plant vigour *i.e.,* 1.67 which was statistically similar to crop sown on 28th July (2.33). Lowest plant vigour was recorded in crop sown on 11th August *i.e.,* 4.00 which was statistically at par with crop sown on 4th August (3.33) (Table 2). Average plant vigour of sorghum plants was observed as 2.83 on the basis of 1-5 scale.

Crop canopy trait can be determined by observing leaf angle variation across the plant. Sorghum plant having lesser angle of leaf inclination at point of attachment with main stem are supposed to have closer canopy and those with greater angle of leaf inclination have open canopy. Dual purpose sorghum variety, HC 308 remained as open canopy as presented in Table 2 during the crop growth season.

TABLE 2
Impact of date of sowing on plant vigour, shape of canopy and deadheart formation by shoot fly in dual purpose sorghum, HC 308

S. No.	Date of sowing	Deadheart (%) 21 DAE	Deadheart (%) 28 DAE	Plant vigour	Shape of Canopy
1.	21st July, 2021	12.37[a]	15.49[a]	1.67[a]	Open
		(20.53)	(23.13)		
2.	28th July, 2021	14.35[a]	19.52[a,b]	2.33[a,b]	Open
		(22.22)	(26.18)		
3.	4th August, 2021	22.34[b]	23.55[b,c]	3.33[b,c]	Open
		(28.78)	(29.00)		
4.	11th August, 2021	26.41[b]	29.51[c]	4.00[c]	Open
		(30.91)	(32.88)		
	Mean	18.87	22.02	2.83	
	C. D. (P=0.05)	2.16	3.17	1.40	

DAE = Days after emergence, Plant vigour = scale 1-5, Figures with the same alphabet in same column are statistically at par.

Present results supported by the findings of Angood and Hubaishan (1985), Raut *et al.* (2015) and Bhan *et al*. (2018) sorghum plants with high plant vigour, more leaf glossiness correlated with less activity of sorghum shoot fly, *Atherigona soccata* as crop sown on 26th August recorded higher glossiness of leaves and plant vigour (1.33 and 1.00, respectively) compared to crop sown on 16th September (3.33 and 4.00, respectively).Kumar *et al.* (2018) also demonstrated less attack of early shoot borer, *Chilo infuscatellus* in sugarcane plants having glossy and erect canopy. Plant canopy of sorghum variety HC 308, being a genetically controlled trait was open.

Impact of date of sowing on sorghum stem borer, *Chilo partellus* in sorghum

Observations on deadheart (%) at 45 DAE, number of pin holes at 30-35 DAE owing to the infestation of sorghum stem borer, *Chilo partellus* and yield of dual purpose sorghum variety, HC 308 were recorded at harvesting.

Deadheart (%) at 45 DAE

Infestation of sorghum stem borer, *Chilo partellus* in term of deadheart (%) was recorded at 45 DAE (Table 3, Fig 3) and mean deadheart 21.16 per cent was observed. Crop sown on 21st July during *Kharif,* 2021 recorded lowest per cent of deadheart (16.42%) compared to crop sown on 4th (22.09%) and 11th of August (27.79%) and was statistically similar to crop sown on 28th July (18.35%). Patidar *et al.* (2019) inferred that least number of deadhearts due to stem borer at 45 days after crop emergence was recorded in timely sown conditions (11.67%) as compared to late sown crop (45.33%) in sorghum crop. Similarly, Hakeem *et al.* (2020) reported that if maize crop sown late *i.e.,* 1st May recorded higher borer infestation (63.2 %) as compared to early sown (29.4 %) maize *i.e.,* 1stMarchduring 2016 and 2017 during the maize crop season.

Number of pin holes per plant at 30-35 DAE

Mean number of pin holes 4.97 per plant was observed irrespective of the different date of sowing of sorghum crop. Minimum numbers of pin holes (2.93/ plant) were recorded in crop sown on 21st of July, which were statistically at par with the crop sown on 28th July (3.72 /plant). Maximum numbers of pin holes were recorded in the crop sown on 11th August *i.e.,* 7.28, which was followed by crop sown on 4th August (5.94/ plant) during *Kharif,* 2021.Results reported by Ullah *et al.* (2010) in their studies corroborated by the obtained outcome that maize planted on 2nd week of June recorded least number of pin holes *i.e.,* 1.51 while, highest pin hole count per plant *i.e.,* 5.8 was observed in crop sown in 2nd week of July.

Yield (t/ha)

Yield of sorghum crop as fodder decreased as sowing time delayed up to 11th August owing to the increased infestation of sorghum shoot flyand sorghum

TABLE 3

Impact of date of sowing on deadhearts formation and number of pin holes by sorghum stem borer and green fodder yield of dual purpose sorghum, HC 308

S. No.	Date of sowing	Deadheart (%) 45 DAE	No. of pin hole/plant 30-35 DAE	Yield (t/ha)
1.	21st July, 2021	16.42[a] (23.88)	2.93[a]	31.69[a]
2.	28th July, 2021	18.35[a] (25.67)	3.72[a]	31.21[a]
3.	4th August, 2021	22.09[b] (28.25)	5.94[b]	30.10[b]
4.	11th August, 2021	27.79[c] (32.10)	7.28[c]	29.51[b]
	Mean	21.16	4.97	30.63
	C. D. (P=0.05)	2.04	0.84	0.60

DAE = Days after emergence, Figures with the same alphabet in same column are statistically at par with each other.

stem borer during *Kharif,* 2021. Average fodder yield of sorghum crop was recorded 30.63 t/ha. Late sowing of crop *i.e.,* on11th August recorded lowest yield (29.51 t/ha) which was statistically at par with the crop sown on 4th August (30.10 t/ha), while early sowing of crop on 21st July recorded highest yield (31.69 t/ha) followed by the crop sown on 28th July (31.21 t/ha) during *Kharif*, 2021 (Table 3). Ameta and Sumeria (2004) also reported substantial losses in grain yield (from 65 to 9 q/ha) and stover yield (from 139 to 53.08 q/ha) in sorghum crop as the sowing delayed from 14th July to 18th August due to incidence of sorghum stem borer, *Chilo partellus*. Patidar *et al.* (2019) also found that maximum green fodder yield *i.e.,* 324 q/ha was obtained when crop sown on 23rd June instead of crop sown on 15th July *i.e.,* 298.5 q/ ha.

CONCLUSION

It is inferred that adeclining trend was observed on glossiness of leaves and plant vigour under late sown conditions due to unfavourable growing conditions experienced by the sorghum crop. Number of eggs laid by sorghum shoot fly at 7 and 14 DAE increased as sowing was delayed from 21st July (0.67and 1.33, respectively) to11th August (3.00 and 4.00, respectively). Deadheart (%)formation recorded higher in late sown crop on 11th August (25.52 and 29.78 %) in comparison to early sown on 21st July (12.33 and 15.39%) at 21st and 28th days after crop emergence, respectively. Time of sowing decide the volume of incidence of sorghum stem borer, *Chilo partellus* in light of aforementioned parameters as deadheart (%) due to sorghum stem borer recorded low (16.42%) in crop seeded on 21st July and higher in crop sown on 11th August (27.79%) at 45 days after crop emergence. Number of pin holes caused by sorghum stem borer increased from 2.93 to7.28 and yield of fodder sorghum declined from 31.69t/ha to 29.51t/ ha as sowing was delayed and progressed from 21stJulyto11thAugust during *Kharif,* 2021. Thus date sowing of sorghum crop should be essentially kept in mind to avoid the more of attack shoot fly and stem borer instead of running to different chemicals.

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