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Effect of different sowing dates on the incidence of fall armyworm, *Spodoptera frugiperda* (J. E. Smith) in *Rabi* maize

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Abstract
An investigation on effect of different sowing dates on the incidence of fall armyworm *Spodoptera frugiperda* (J. E. Smith) in *rabi* maize was undertaken at MPKV, Rahuri during *rabi* 2021. Among the five sowing dates *viz*., October 2nd fortnight, November 1st fortnight, November 2nd fortnight, December 1st fortnight, December 2nd fortnight. October 2nd fortnight sown crop recorded lowest mean per cent infestation (33.55%) and mean larval population (0.63 larvae/plant) and it was moderately higher November 1st fortnight sown crop (42.36% infestation; 1.01 larvae/plant). This was followed by November 2nd fortnight (52.89% infestation; 1.41 larvae/plant) and December 2nd fortnight sown crop (53.08% infestation; 1.37 larvae/plant). Whereas, December 1st fortnight sown crop recorded highest mean per cent infestation (61.51%) and mean larval population (1.78 larvae/plant) indicating that late sown crops were highly infested when compared to the early sown crops. However, the highest yield of 53.61 was recorded in October 2nd fortnight sown crop. The incidence of fall armyworm at different dates of sowing correlated with weather parameters indicated the negative influence with respect to rainfall, relative humidity and minimum temperature whereas, maximum temperature exhibited positive correlation on the activity of the fall armyworm.

Keywords: Fall armyworm, SMW, maize, DAS (Days after sowing)

Introduction
Maize (*Zea mays* L.) being one of the most important and versatile crops is cultivated both in the tropical and subtropical climatic conditions of the world. It is known as queen of cereals because of its highest genetic yield potential among the cereals (Parihar *et al*., 2011) [11]. It is a multi-faceted crop used for various purposes and it is also known as "poor man's nutri-cereal" (Maqbool *et al*., 2021) [9]. Now-a-days, maize cultivation is challenged by various biotic limitations to attend fullest yield potential. Among them, fall armyworm, *Spodoptera frugiperda* (J.E. Smith) is of a serious concern because of its notorious and polyphagous behaviour. It is a lepidopteran pest belonging to Noctuidae family and sporadic pest native to tropical and subtropical regions of the America. Several environmental factors play a significant role in determining the size of population and the extent of damage caused by a pest (Becker, 1974) [2]. Therefore, knowledge about influence of weather parameters on the seasonal incidence and population dynamics of pest is important in developing a suitable management technique. Considering the above facts, the present study was formulated to assess the effect of different sowing dates on the incidence of fall armyworm (*Spodoptera frugiperda*) in *rabi* maize.

Materials and Methods
The experiment was conducted at the Instructional Farm, Post Graduate Institute, Mahatma Phule Krishi Vidyapeeth, Rahuri during *Rabi* 2021-22. The experiment was conducted in Randomised Block Design (RBD) which had 5 treatments and 4 replications where the maize variety Eco-91 (Parameshwar) was grown at a spacing of 75×20 cm in a plot size of 5×3.75 m^2. The treatments comprised of 5 different dates of sowing where the crop was sown at fortnightly interval starting from 2nd fortnight of October to 2nd fortnight of December and incidence of fall armyworm was recorded. In each plot, the observation on per cent plant infestation and number of larvae per plant were recorded at weekly intervals. Further, these observations were correlated with different weather parameters, *viz*., maximum temperature, minimum temperature, morning relative humidity, evening relative humidity and rainfall.

Results and Discussion

Per cent infestation of fall armyworm

It was observed from the data (Table 2) that the infestation of fall armyworm started from 15 DAS in all the 5 treatments (different dates of sowing). However, the peak level of infestation was observed at 57 DAS with an infestation of 88.91,79.75, 79.62, 68.12 and 52.94 per cent in fourth, fifth, third, second and first sown crops, respectively. The mean per cent infestation of fall armyworm in the first sown crop was found to be significantly lower with an infestation level of 33.55 per cent and it was moderately higher in the second sown crop (42.36%). Whereas, the third and fifth sown crops showed mean per cent infestation of 52.89 and 53.08 per cent, respectively which were statistically on par with each other. However, the mean infestation was significantly higher in the fourth sown crop (61.51%) indicating that late sown crops were highly infested when compared to the early sown crops. One of the possible reasons might be due to escape of pest damage by the early planted maize crops. And also, late sown crops (3rd, 4th, and 5th) might get the pest population from early sown crops and constant food availability favours the pest establishment. As a result, the peak infestation of the pest differs with the planting dates. The results of the present work are in accordance with the findings Canico *et al*. (2020) [3] who stated that the early sowing of maize in the cropping season might effectively decrease fall armyworm infestation and damage as compared to the late sown crop. Similar kind of results were reported by Darshan (2020) [4] who stated that the late sown maize crop suffered significantly greater damage by fall armyworm as compared to the early sown maize crop.

Larval load of fall army worm:

The mean of fall armyworm larvae per plant in different sowing dates (Table 3) revealed that the first sown crop had significantly least larvae per plant (0.63 larvae/plant) followed by second sown crop which recorded 1.01 larvae per plant. While, the number of larvae per plant was moderately higher in the third (1.41 larvae/plant) and fifth sown crop (1.37 larvae/plant), which were statistically on par with each other. Whereas, fourth sown crop recorded significantly highest number of larvae per plant (1.78 larvae/plant). The current results are in line with Waddill *et al*. (1982) [15], who noticed that rainfall killed a considerable proportion of early instar larvae of fall armyworm, thus reducing the adult population. They reported that severe rainfall was fatal to the pest because raindrops accumulated in whorls, causes asphyxia in the larvae and ultimately kills the larvae.

In the present study, October 2nd fortnight sown crop was best as it recorded least fall armyworm infestation. These findings are in corroboration with Sowmiya *et al*. (2022) [14] who reported that the maize sown during October month (early sown) had reported less fall armyworm infestation and provided a higher grain yield than the rest of the sowing windows (late sown) taken in *rabi* season. Similar type of results were reported by Darshan (2020) [4], Gebreziher (2020) [5] and Kandel and Poudel (2020) [6] who reported that late planted maize plants were highly infested by FAW as late planted maize crop attracts more female fall armyworm moths, thus increasing egg laying and infestation.

Grain yield

Significantly highest yield of maize crop was recorded in first date of sowing (53.61 q/ha) followed by second date of sowing (49.30 q/ha). This was followed by third and fifth sown crop recording yield of 45.27 and 44.50 q/ha, respectively. Whereas, the fourth date of sowing recorded lowest grain yield of 42.41 q/ha. The maize yield was consistent with the infestation rate and increased as the rate of infestation decreased and vice versa. Early sown crops recorded lesser fall armyworm infestation and damage thus registering higher grain yield when compared to late sown crops. The present findings are in accordance with Darshan (2020) [4] who reported higher grain yield in early sown maize crops due to lesser fall armyworm damage.

Effect of weather parameters on fall armyworm infestation

The fall armyworm infestation was correlated with the weather parameters (Table 1 and 4) and it clearly indicated that in the first date of sowing (October 2nd fortnight), maximum temperature (r = 0.172) showed a non-significant positive correlation with fall armyworm infestation. Whereas, minimum temperature (r = -0.222), morning relative humidity (r = -0.307), evening relative humidity (r = -0.582) and rainfall (r = -0.514) showed a non-significant negative correlation with fall armyworm infestation. The similar trend was noticed even in second, third, fourth and fifth sowing dates.

The second sowing showed significant negative correlation with minimum temperature, evening relative humidity and rainfall with r values -0.712*, -0.615* and -0.877**, respectively. In the third sowing, correlation coefficient values (r) for maximum temperature, minimum temperature, RH I, RH II and rainfall was found to be 0.176, -0.807**, -0.142, -0.349 and -0.654*, respectively, where minimum temperature and rainfall had significant negative correlation. Whereas, fourth sowing showed non-significant positive correlation with maximum temperature (r=0.166) and non-significant negative correlation with minimum temperature (r=0.400), RH I (r= -0.239) and RH II (r= -0.424). In the fifth sowing, the r values for maximum temperature, minimum temperature, RH I, RH II was found to be 0.688*, 0.165, -0.676* and 0.769**, respectively where, maximum temperature showed significant positive correlation and morning and evening relative humidity showed significant negative correlation. Exception to other dates of sowing, in the fifth sowing, minimum temperature had a positive correlation (r= 0.165) with fall armyworm infestation.

The regression equation for fall armyworm infestation indicated that, the weather parameters influenced up to 41 per cent during first sowing whereas, 87, 84, 69 and 61 per cent during second, third, fourth and fifth sowing, respectively.

The present results are in accordance with Manohar (2020) [8] who reported that maximum temperature (r= 0.581*) had a significant positive correlation with fall armyworm infestation. Whereas, a non-significant negative correlation with both morning (r= -0.507) and evening (r= 0.410) relative humidity. Similar type of studies was also conducted by Rajisha *et al*. (2021) [12] who noticed a non-significant positive relationship between fall armyworm population and maximum temperature (r= 0.127) as well as a significant negative relationship between evening RH (r= -0.714) and rainfall (r= -0.763).

Similar kind of results were reported by Anil (2021) [1] where he found a non-significant negative association between evening relative humidity (r= -0.410), rainfall (r= -0.530) and fall armyworm infestation, but it had a significant positive correlation with maximum temperature (r= 0.780). Reddy *et al*. (2020) [13] observed that during *kharif* 2019, the maximum temperature had a non-significant positive correlation with fall armyworm damage, but relative humidity and rainfall had non-significant negative correlation with fall armyworm infestation. Whereas during *rabi*, 2019-20, relative humidity was found to be highly negatively correlated with fall armyworm infestation. All these reports lend support to the present finding.

Effect of weather parameters on fall armyworm larval population

The fall armyworm larval population was correlated with different weather parameters (Table 1 and 5) and it clearly indicated that, in the first date of sowing, maximum temperature (r = 0.231) showed a non-significant positive correlation with fall armyworm larval population. Whereas, minimum temperature (r = -0.026), morning relative humidity (r = -0.214), evening relative humidity (r = -0.598) and rainfall (r = -0.375) showed a non-significant negative correlation. The similar trend was noticed even in second, third, fourth and fifth sowing dates where in second date of sowing, maximum temperature (r = 0.406) showed a non-significant positive correlation with fall armyworm larval population. Whereas, minimum temperature (r = -0.219), morning relative humidity (r = -0.352), evening relative humidity (r = -0.366) showed a non-significant negative correlation and rainfall (r= -0.620*) showed significant negative correlation with the larval population of fall armyworm.

There was no significant correlation observed for any parameters in third, fourth and fifth sowing with r values for maximum temperature, minimum temperature, RH I, RH II and rainfall was 0.471, -0.485, -0.015, -0.055 and -0.495, respectively in third date of sowing and 0.166, -0.436, -0.055, -0.123 and 0.00, respectively in fourth date of sowing whereas, 0.242, -0.039, -0.059, -0.297 and 0.00, respectively in fifth date of sowing.

The regression equation for fall armyworm larval population indicated that, the weather parameters influenced up to 45 per cent during first sowing whereas, 44, 83, 65 and 57 per cent during second, third, fourth and fifth sowing, respectively.

The current findings are in accordance with the results of Madhubhashini (2021) [16], who found that fall armyworm larval population had a significant negative correlation with minimum temperature (r= -0.549) and total rainfall (r= -0.548). Similar kind of results were also reported by Bhede *et al*. (2021) [17] who stated that fall armyworm larval population had a significant positive correlation with maximum temperature (r = 0.694), whereas it had a significant negative correlation with morning RH (r = -0.799) and evening RH (r = -0.664).

Madhu Kumari (2020) [7] reported that during *kharif* season of 2019, fall armyworm population showed a significant positive correlation with maximum temperature (r= 0.516*). While, it had a significant inverse relationship with relative humidity (r= -0.519*). Nandita (2020) [10] reported that fall armyworm larval population had a negative correlation with evening relative humidity (r= -0.233) and total rainfall (r=-0.320). However, maximum temperature was significant and positively correlated with fall armyworm larval population (r= 0.586). Kumar *et al*. (2020) [7] reported that larval population had a significant positive correlation (r= 0.720) with maximum temperature and a significant negative correlation with relative humidity (r= -0.673) and rainfall (r=-0.829). Studies of Darshan (2020) [4] also confirmed that fall armyworm larval population during 2019-20, had no significant correlation between any of the observed weather parameters. All these reports lend support to the present finding.

Table 1: Weekly meteorological data during *rabi s*eason 2021-22 at MPKV, Rahuri

SMW	Duration	Temperature (ºC)		Humidity (%)		Rainfall
		Maximum	Minimum	Morning	Evening	
43	22-28 Oct	32.2	18.4	89	34	0.00
44	29-04 Nov	31.3	17.0	83	36	0.00
45	5-11 Nov	28.2	17.4	85	42	0.00
46	12-18 Nov	30.4	15.5	84	50	0.00
47	19-25 Nov	27.1	19.7	91	56	50.4
48	26-02 Dec	28.3	19.5	90	44	23.2
49	03-09 Dec	26.2	17.7	91	46	47.4
50	10-16 Dec	28.3	19.1	77	46	0.00
51	17-23 Dec	27.2	20.1	87	39	0.00
52	24-31 Dec	29.8	13.8	84	33	0.00
1	01-07 Jan	28.3	15.0	91	42	0.00
2	08-14 Jan	29.1	14.6	74	42	0.00
3	15-21 Jan	27.2	14.0	89	44	0.00
4	22-28 Jan	24.7	12.0	92	42	0.00
5	29-04 Feb	28.7	15.2	82	24	0.00
6	05-11 Feb	27.3	14.2	81	33	0.00
7	12-18 Feb	29.2	15.7	80	30	0.00
8	19-25 Feb	33.0	16.1	63	23	0.00
9	26-04 Mar	33.1	18.1	55	21	0.00
10	05-11 Mar	30.3	16.2	73	30	0.00
11	12-18 Mar	32.7	18.7	59	18	0.00
12	19-25 Mar	34.2	19.2	55	16	0.00
13	26-01 Apr	38.2	22.3	55	14	0.00

Table 2: Effect of different dates of sowing on the per cent infestation of fall armyworm (*S. frugiperda*) in maize

Treatments		Per cent infestation											
		15 DAS	22 DAS	29 DAS	36 DAS	43 DAS	50 DAS	57 DAS	64 DAS	71 DAS	78 DAS	85 DAS	Mean
T_1	1st Sowing (October II fortnight)	9.26 (17.69)	23.65 (29.00)	19.37 (26.08)	24.60 (29.69)	21.39 (27.51)	45.66 (42.52)	52.94 (46.74)	50.10 (45.06)	46.31 (42.88)	40.35 (39.44)	35.39 (36.50)	33.55[a] (35.39)
T_2	2nd Sowing (November I fortnight)	6.35 (14.58)	10.69 (19.08)	14.47 (22.34)	36.40 (37.08)	50.15 (45.14)	57.56 (49.42)	68.12 (55.83)	61.30 (51.56)	59.45 (50.45)	54.33 (47.52)	47.23 (43.41)	42.36[b] (40.60)
T_3	3rd Sowing (November II fortnight)	8.71 (17.13)	25.35 (30.22)	29.69 (33.01)	49.52 (44.74)	60.09 (50.84)	67.11 (55.25)	79.62 (63.20)	73.51 (59.13)	69.40 (56.49)	60.30 (50.95)	58.44 (49.94)	52.89[c] (46.67)
T_4	4th Sowing (December I fortnight)	15.38 (23.06)	30.71 (33.63)	44.34 (41.75)	51.2 (45.71)	68.02 (55.76)	73.59 (59.26)	88.91 (72.42)	83.20 (66.06)	79.83 (63.34)	74.22 (59.57)	67.19 (55.07)	61.51[e] (51.65)
T_5	5th Sowing (December II fortnight)	13.38 (21.42)	18.34 (25.35)	28.75 (32.38)	36.53 (37.17)	58.42 (49.88)	65.90 (54.48)	79.75 (64.40)	78.94 (62.89)	73.03 (58.76)	69.34 (56.44)	61.50 (51.65)	53.08[c] (46.78)

	S.Em. ±	0.75	0.94	1.02	1.40	2.56	1.62	2.00	1.77	1.89	1.42	1.69	1.38
	CD at 5%	2.31	2.91	3.16	4.31	7.91	4.99	6.18	5.47	5.82	4.37	5.19	4.26

*Figures in the parenthesis are arc sin transformed values.
*Values with similar alphabets in each column do not vary significantly at 5% level.

Table 3: Effect of different dates of sowing on the larval population of fall armyworm (*S. frugiperda*) in maize

Treatments		Number of FAW larvae/plant											
		15 DAS	22 DAS	29 DAS	36 DAS	43 DAS	50 DAS	57 DAS	64 DAS	71 DAS	78 DAS	85 DAS	Mean
T_1	1st Sowing (October II fortnight)	0.30 (0.89)	0.45 (0.97)	0.40 (0.95)	0.50 (1.00)	0.43 (0.96)	1.03 (1.24)	0.98 (1.22)	1.28 (1.33)	0.68 (1.09)	0.40 (0.95)	0.48 (0.99)	0.63[a] (1.05)
T_2	2[nd] Sowing (November I fortnight)	0.23 (0.85)	0.33 (0.91)	0.53 (1.01)	1.58 (1.44)	1.53 (1.42)	2.13 (1.62)	1.68 (1.48)	1.08 (1.25)	0.43 (0.96)	1.00 (1.22)	0.68 (1.09)	1.01[b] (1.22)
T_3	3[rd] Sowing (November II fortnight)	0.38 (0.94)	1.00 (1.22)	0.93 (1.20)	2.35 (1.69)	2.28 (1.67)	2.00 (1.58)	2.20 (1.64)	1.10 (1.26)	1.60 (1.45)	0.93 (1.20)	0.80 (1.14)	1.41[c] (1.38)
T_4	4[th] Sowing (December I fortnight)	0.50 (1.00)	2.10 (1.61)	1.13 (1.28)	2.88 (1.84)	2.03 (1.59)	1.13 (1.28)	2.83 (1.82)	2.00 (1.58)	2.40 (1.70)	1.43 (1.39)	1.23 (1.32)	1.78[d] (1.50)
T_5	5[th] Sowing (December II fortnight)	0.33 (0.91)	0.30 (0.89)	1.53 (1.42)	1.43 (1.39)	2.28 (1.67)	2.13 (1.62)	2.28 (1.67)	1.98 (1.57)	1.13 (1.27)	0.90 (1.17)	0.83 (1.15)	1.37[c] (1.36)
	S.Em. ±	0.03	0.03	0.03	0.05	0.05	0.05	0.05	0.05	0.06	0.05	0.04	0.04
	CD at 5%	0.09	0.10	0.09	0.15	0.14	0.15	0.15	0.14	0.17	0.15	0.12	0.11

*Figures in the parenthesis are square root transformed values ($\sqrt{X + 0.5}$).
*Values with similar alphabets in each column do not vary significantly at 5% level.

Table 4: Correlation and regression analysis between per cent infestation of fall armyworm (*S. frugiperda*) on maize and weather parameters at different dates of sowing

Treatments		r values					Regression equation	R^2 value
		Max. Temp (X_1)	Min. Temp (X_2)	R.H I (X_3)	R.H II (X_4)	Rainfall (X_5)		
T_1:	1st Sowing (October II fortnight)	0.172	-0.222	-0.307	-0.582	-0.514	$Y = 171.60-2.07 X_1 + 0.22 X_2-0.40 X_3-1.06X_4-0.22 X_5$	0.41
T_2:	2[nd] Sowing (November I fortnight)	0.225	-0.712*	-0.300	-0.615*	-0.877**	$Y = 104.65 + 1.78 X_1-2.93 X_2 + 0.32X_3 + 0.36 X_4-0.84 X_5$	0.87
T_3:	3[rd] Sowing (November II fortnight)	0.176	-0.807**	-0.142	-0.349	-0.654*	$Y = 184.08-1.00X_1-5.98X_2+ 0.14X_3-0.21 X_4-0.73 X_5$	0.84
T_4:	4[th] Sowing (December I fortnight)	0.166	-0.400	-0.239	-0.424	0.00	$Y = 577.79-8.32X_1-6.17X_2-1.34X_3-2.18 X_4$	0.69
T_5:	5[th] Sowing (December II fortnight)	0.688*	0.165	-0.676*	-0.769**	0.00	$Y = 187.36 +1.01X_1-4.40X_2-0.51X_3-1.94 X_4$	0.61

Note: 1. *Indicates correlation is significant at 5% (p=0.05).
2. **Indicates correlation is significant at 1% (p=0.01).

Table 5: Correlation and regression analysis between larval population of fall armyworm (*S. frugiperda*) on maize and weather parameters at different dates of sowing

Treatments		r values					Regression equation	R^2 value
		Max. Temp (X_1)	Min. Temp (X_2)	R.H I (X_3)	R.H II (X_4)	Rainfall (X_5)		
T_1:	1st Sowing (October II fortnight)	0.231	-0.026	-0.214	-0.598	-0.375	$Y = 0.01 + 0.06 X_1 + 0.05 X_2-0.01 X_3-0.04X_4 + 0.01 X_5$	0.45
T_2:	2[nd] Sowing (November I fortnight)	0.406	-0.219	-0.352	-0.366	-0.620*	$Y = -4.04 + 0.14 X_1 + 0.02 X_2 + 0.02X_3 + 0.01 X_4-0.03 X_5$	0.44
T_3:	3[rd] Sowing (November II fortnight)	0.471	-0.485	-0.015	-0.055	-0.495	$Y = -15.49 + 0.45X_1-0.14X_2 + 0.07X_3 + 0.05 X_4-0.02 X_5$	0.83
T_4:	4[th] Sowing (December I fortnight)	0.166	-0.436	-0.055	-0.123	0.00	$Y = 4.16 + 0.05X_1-0.21X_2-0.01X_3-0.02 X_4$	0.65
T_5:	5[th] Sowing (December II fortnight)	0.242	-0.039	-0.059	-0.297	0.00	$Y = 19.54-0.12X_1-0.52X_2-0.05X_3-0.11 X_4$	0.57

Note: 1. *Indicates correlation is significant at 5% (p=0.05)

Conclusion

Generally, farmers rely heavily on the chemical control to combat fall armyworm in maize. However, its indiscriminate use usually leads to a more complex scenario characterized by loss of its effectiveness due to development of resistance of insect pest, emergence of secondary pests, reduction of the population of natural enemies and also occurrence of residues in food commodities. Pest management by cultural practices reduces pesticide burden in the agro-ecosystem, the technique will help to conserve the environment. However, manipulation of sowing dates as a sole control technique against fall armyworm may not be sufficient to achieve desirable yield. As a result, it should be considered as one of the low-input component of a long-term management strategy.

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References

1. Anil KO. Seasonal incidence, biology and management of fall armyworm, *Spodoptera frugiperda* (J.E. Smith) infesting maize. M. Sc. (Ag.) Thesis., Mahatma Phule Krishi Vidyapeeth, Rahuri; c2021.
2. Becker PC. Pest of ornamental plants. Ministry of Agriculture Fisheries and Food, London, 1974, 25-29.
3. Canico A, Mexia A, Santos L. Seasonal dynamics of alien invasive pest *Spodoptera frugiperda* (J.E Smith) (Lepidoptera: Noctuidae) in Manica province, Central Mozambique. Insec. 2020;11(8):512.
4. Darshan R. Population dynamics of fall armyworm, *Spodoptera frugiperda* (J.E. Smith) in maize. MSc (Ag.) Thesis. University of Agricultural Sciences, Dharwad; c2020.
5. Gebreziher HG. Review on management methods of fall armyworm (Spodoptera frugiperda JE Smith) in Sub-Saharan Africa. Int. J Entomol. Res. 2020;7:9-14.
6. Kandel S, Poudel R. Fall armyworm (*Spodoptera frugiperda*) in maize: An emerging threat in Nepal and its management. Int. J Appl. Sci. Biotechnol. 2020;8(3):305-309.
7. Madhu Kumari. Population dynamics and infestation status of fall armyworm, *Spodoptera frugiperda* (J.E Smith) on different maize hybrids and its management through insecticides. M. Sc. (Ag.) Thesis. Indira Gandhi Krishi Vishwavidyalaya, Raipur; c2020.
8. Manohar NJ. Population dynamics of major insect pests of maize and their natural enemies. M.Sc. Thesis, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola; c2020.
9. Maqbool MA, Beshir Issa A, Khokhar ES. Quality protein maize (QPM): Importance, genetics, timeline of different events, breeding strategies and varietal adoption. Plant Breeding. 2021;140(3):375-399.
10. Nandita P. Studies on insect pest complex of maize crop with special reference to pink stem borer, *Sesamia inferens* (Walker) and fall army worm, *Spodoptera frugiperda* (Smith). MSc Thesis, Indira Gandhi Krishi Vishwavidyalaya, Raipur; c2020.
11. Parihar CM, Jat SL, Singh AK, Kumar RS, Hooda, KS, Singh DK. Maize production technologies in India; c2011.
12. Rajisha PS, Muthukrishnan N, Jeyarajan Nelson S, Jerlin R, Karthikeyan R. Population dynamics of fall armyworm, *Spodoptera frugiperda* (J.E. Smith) on maize. Indian J Entomol. 2021;2(1):45-50.
13. Reddy KJM, Kumari K, Saha T, Singh SN. First record, seasonal incidence and life cycle of fall armyworm, *Spodoptera frugiperda* (J.E. Smith) in maize at Sabour, Bhagalpur, Bihar. J of Entomo. Zool. Stud. 2020;8(5):1631-1635.
14. Sowmiya R, Krishnan R, Karthikeyan R, Jeyarani S, Chandrashekar CN. Impact of different sowing windows and legume intercrops on the incidence of fall army worm (FAW) (*Spodoptera frugiperda*) and yield of hybrid maize in western agro-climatic zone of Tamil Nadu. Int. J of Pl. and Soil Sci. 2022;34(2):81-87.
15. Waddill VH, Mitchell ER, Denton WH, Poe SL, Schuster DJ. Seasonal abundance and velvetbean caterpillar (Lepidoptera: Noctuidae) at four locations in Florida. Florida Entomol.; c1982. p. 350-354.
16. Madhubhashini GT. The role of television as an educational medium in empowering rural students in Sri Lanka during COVID 19 pandamic; c2021.
17. Shinde GS, Bhede BV, Rathod VU. Evaluation of different whorl applications for the management of fall armyworm, Spodoptera frugiperda (JE Smith) on maize. J Entomol Zool Stud. 2021;9(1):394-8.