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Effect of *Spodoptera litura* (Fab.) on Soybean Growth and Development under Different Sowing Windows

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A B S T R A C T

Application of Lambda cyhalothrin 5EC@ 1.0 ml l^{-1} for two different varieties under four sowing windows produced significantly higher values of growth characters i.e. Initial (4,43,618) and final (4,41,482) plant population, plant height (60.96), number of branches $plant^{-1}$ (8.94), number of leaves $plant^{-1}$ (19.48), leaf area $plant^{-1}$ (14.80dm^2), leaf area index (6.58), dry matter accumulation (18.04) resulting in significant increase in pod numbers and grain yield during the years 2013 and 2014 as compared to unprotected conditions and delayed sowing windows.

Introduction

Soybean (*Glycine max* (L.) Merrill) is one of the most important leguminous crops and was introduced in India in 1870-80 (Andole, 1984). The soybean play an important role in Indian economy and also in human diet. Among oilseed crops, soybean is rich source of protein and oil producing crop and occupies an important place in international market. The luxuriant crop growth, soft and succulent foliage of soybean attracts many insects and provides unlimited source of food, space and shelter. The tobacco caterpillar, *Spodoptera litura* (Fab.) is a serious and regular pest on soybean. It damages soybean crop from mid August to October in *kharif* and from November to March in *rabi.*

Soybean is easy for cultivation, requiring less N fertilizer, labour and having more benefit: cost ratio. Soybean builds up soil fertility by fixing large amount of atmospheric nitrogen through root nodules and also through leaf fall on the ground, at senescence. It also reduces soil erosion. It has relatively better suitability to most soils. All these qualities make it an ideal crop for inclusion in crop rotation and cropping system under different sowing windows.

Materials and Methods

The present investigation was conducted at Agricultural Meteorology farm, College of Agriculture, Pune during *kharif* 2013 and *kharif* 2014. The experiment was laid out in split split plot design with three replications. There were sixteen treatment combinations formed due to two protection treatments, two varieties and four different sowing windows.

The seeds were treated with *Rhizobium* at the time of sowing. Basal dose of half N and full dose of P was applied at sowing. The remaining quantity of nitrogen was given 15 days after sowing. Main plot treatment includes two protection treatments i.e. P_1: Protected (Lambda cyhalothrin 5EC@ 1.0 ml l^{-1}) and P_2: Unprotected (Without chemical). Sub plot treatment includes two varieties i.e. V_1: JS-335 (Jawahar Soybean) and V_2: KDS-344 (Phule Agrani) and sub sub plot treatment includes four different sowing windows i.e. S_1-MW-24 (11 Jun.-17 June), S_2-MW-26 (25 Jun.-1 July), S_3-MW-28 (9 July-15 July) and S_4 -MW-30 (23 July -29 July). The recommended dose of fertilizer for soybean is 50: 75: 00 NPK kg ha^{-1}.

The topography of the experimental field was leveled and uniform in depth up to 60 cm. The soil comes under order vertisol (medium black), clayey in texture. The gross and net plot sizes were 4.50 x 4.05m^2 and 3.90 x 3.15m^2, respectively.The average rainfall of about 734 mm, The annual mean maximum temperature during growing period (2012-13) and (2013-2014) was 32°C with a range from 27 to 40.2°C. The annual mean minimum temperature during growing period was 18.6^{o}C with a range from 9.9 to 24.7°C. The annual mean relative humidity at 7.30 hrs (RH-I) was75% and ranged from 54 to 95 per cent and at 14.30 hrs (RH-II) 46%, ranged from 17 to 84. The annual average solar radiation was 20.50 M J m^{-2} d^{-1}. The average annual wind speed was 5.3 km/h. The weekly photoperiod i.e. maximum possible sunshine hours was fixed for the particular day in a year and ranged from 10.38 to 13.87.

Results and Discussion

Growth characters

All growth characters were significantly influenced due to different protection treatments, varieties and sowing windows during both the years of experimentation i.e. 2013 and 2014., Initial (4,43,618) and final (4,41,482) plant population, plant height (60.96), number of branches $plant^{-1}$ (8.94),number of leaves $plant^{-1}$ (19.48), leaf area $plant^{-1}$ (14.80dm^2), leaf area index (6.58), dry matter accumulation (18.04) in protected treatment (Lambda cyhalothrin 5EC@ 1.0 ml l^{-1}) were significantly superior than unprotected treatment during both the years. Initial (4,43,546 and final (4,41,560) plant population, plant height (63.10), number of branches $plant^{-1}$(9.16),number of leaves $plant^{-1}$ (18.98), leaf area $plant^{-1}$(14.28dm^2),leaf area index (6.35), dry matter accumulation (17.62) in variety (V_2-KDS-344) were significantly superior than variety (V_1-JS-335). The S_1 -(24th MW) sowing window recorded higher values of initial (4,43,676)and final(4,41,486) plant population, plant height (62.64), number of branches $plant^{-1}$(9.11), number of leaves $plant^{-1}$ (19.48), leaf area $plant^{-1}$ (14.49dm^2), leaf area index (6.44), dry matter accumulation (17.23) over rest of the sowing windows and it was statistically at par with S_2-(26th MW).Statistically the lowest values of above parameters were recorded at S_4-(30th MW) during both the years. It could be observed that at all the stages of growth protection treatment (P_1) (Lambda cyhalothrin 5EC @ 1.0 ml l^{-1}) recorded significantly higher plant height (58.79 and 63.13 cm) as compared to unprotected treatment (P_2) (56.05 and 58.68 cm) during both the years of 2013 and 2014, respectively (Table 1 and 2).

Table.1 Mean initial and final plant count, plant height and number of branches as influenced by different treatments, varieties and sowing windows

Treatments	Initial plant count			Final plant count			Plant height (cm) 84 DAS			Number of branches 84 DAS		
	2013	2014	Pooled	2013	2014	Pooled	2013	2014	Pooled	2013	2014	Pooled
A) Protection (P)												
P_1:Protected	4,43,608	4,43,628	4,43,618	4,41,430	4,41,464	4,41,482	58.79	63.13	60.96	8.52	9.37	8.94
P_2:Unprotected	4,43,456	4,43,460	4,43,458	4,41,228	4,41,258	4,41,243	56.05	58.68	57.36	8.10	9.13	8.61
S. E.m ±	23.48	40.09	40.23	27.03	32.91	37.43	0.27	0.68	0.63	0.07	0.02	0.06
C. D. at 5%	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	1.64	4.15	2.49	0.40	0.13	0.24
B) Varieties (V)												
V_1:JS-335	4,43,516	4,43,524	4,43,520	4,41,114	4,41,144	4,41,128	53.63	56.81	55.22	7.98	8.81	8.39
V_2:KDS-344	4,43,548	4,43,544	4,43,546	4,41,544	4,41,578	4,41,560	61.20	65.00	63.10	8.64	9.69	9.16
S. E.m ±	19.84	29.08	30.49	32.18	41.86	43.35	0.34	0.51	0.53	0.12	0.09	0.13
C. D. at 5%	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	1.32	2.00	1.72	0.47	0.35	0.42
C) Sowing windows (S)												
S_1:24 MW	4,43,666	4,43,686	4,43,676	4,41,464	4,41,508	4,41,486	60.93	64.35	62.64	8.68	9.55	9.11
S_2:26 MW	4,43,596	4,43,604	4,43,600	4,41,392	4,41,436	4,41,414	58.08	61.51	59.79	8.48	9.36	8.92
S_3:28 MW	4,43,478	4,43,490	4,43,484	4,41,298	4,41,316	4,41,306	56.87	60.56	58.71	8.22	9.21	8.71
S_4:30 MW	4,43,392	4,43,396	4,43,394	4,41,168	4,41,184	4,41,176	53.80	57.20	55.50	7.86	8.88	8.37
S. E.m ±	45.12	54.13	61.03	26.83	32.84	38.94	0.52	0.53	0.64	0.13	0.13	0.16
C. D. at 5%	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	1.51	1.55	1.83	0.37	0.39	0.45
Interactions												
P×V												
S. E. m 1 ±	28.06	41.13	43.12	36.11	59.19	59.48	0.47	0.72	0.75	0.17	0.13	0.18
C. D. at 5%	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
S. E.m 2 ±	30.74	49.53	50.48	36.89	53.24	59.62	0.43	0.85	0.83	0.14	0.09	0.14
C. D. at 5%	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
P×S												
S. E. m 1 ±	63.81	76.55	86.31	41.02	46.44	52.29	0.73	0.75	0.91	0.18	0.19	0.22

C. D. at 5%	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
S. E.m 2 ±	58.71	72.40	80.72	41.24	58.05	62.46	0.72	0.83	0.95	0.19	0.18	0.23
C. D. at 5%	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
V×S												
S. E. m 1 ±	63.81	76.55	86.31	41.02	46.44	48.29	0.73	0.75	0.91	0.18	0.19	0.22
C. D. at 5%	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
S. E.m 2 ±	58.71	72.40	80.72	41.24	58.05	62.46	0.72	0.83	0.95	0.19	0.18	0.23
C. D. at 5%	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
P×V×S												
S. E. m 1 ±	90.24	108.26	122.06	47.22	65.68	67.54	1.03	1.06	1.28	0.25	0.26	0.31
C. D. at 5%	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
S. E.m 2 ±	83.04	102.38	114.16	47.96	82.09	88.04	1.01	1.17	1.34	0.27	0.26	0.32
C. D. at 5%	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
S. E.m 3 ±	126.47	165.51	180.39	109.58	133.46	139.72	1.53	2.14	2.28	0.41	0.37	0.48
C. D. at 5%	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
General mean	4,43,533	4,43,544	4,43,543	4,41,331	4,41,361	4,41,346	57.42	60.90	59.16	8.31	9.25	8.78

Table.2 Mean number of leaves plant^{-1}, leaf area plant^{-1}, leaf area index and total dry matter accumulation as influenced by different treatments, varieties and sowing windows

Treatments	Number of leaves plant^{-1}) DAS			Leaf area plant^{-1} 70 DAS			Leaf area index 70 DAS			Total dry matter accumulation 70 DAS		
	2013	2014	Pooled	2013	2014	Pooled	2013	2014	Pooled	2013	2014	Pooled
A) Protection (P)												
P_1:Protected	18.46	20.50	19.48	14.21	15.39	14.80	6.31	6.84	6.58	16.82	19.26	18.04
P_2:Unprotected	15.13	17.13	16.13	11.12	12.09	11.61	4.94	5.37	5.16	12.75	15.54	14.15
S. E.m ±	0.33	0.21	0.34	0.34	0.20	0.34	0.15	0.09	0.15	0.07	0.00	0.06
C. D. at 5%	2.01	1.25	1.32	2.05	1.23	1.34	0.91	0.55	0.60	0.45	0.01	0.25
B) Varieties (V)												
V_1:JS-335	15.43	17.82	16.62	11.51	12.75	12.13	5.12	5.66	5.39	13.31	15.83	14.57
V_2:KDS-344	18.16	19.81	18.98	13.82	14.74	14.28	6.14	6.55	6.35	16.26	18.98	17.62
S. E.m ±	0.36	0.42	0.48	0.35	0.49	0.52	0.15	0.22	0.23	0.31	0.20	0.32
C. D. at 5%	1.40	1.65	1.55	1.37	1.91	1.69	0.61	0.85	0.75	1.23	0.78	1.05
C) Sowing windows (S)												
S_1:24 MW	18.48	20.57	19.53	14.03	14.95	14.49	6.24	6.65	6.44	15.81	18.65	17.23
S_2:26 MW	17.44	19.45	18.45	13.25	14.33	13.79	5.89	6.37	6.13	15.25	17.67	16.46
S_3:28 MW	16.14	18.54	17.34	12.19	13.40	12.80	5.42	5.96	5.69	14.36	16.81	15.59
S_4:30 MW	15.10	16.69	15.90	11.19	12.28	11.73	4.97	5.46	5.21	13.72	16.47	15.10
S. E.m ±	0.40	0.50	0.56	0.36	0.32	0.42	0.16	0.14	0.18	0.31	0.36	0.41
C. D. at 5%	1.17	1.47	1.59	1.05	0.93	1.18	0.47	0.41	0.53	0.90	1.04	1.16
Interactions												
P×V												
S. E. m 1 ±	0.50	0.59	0.67	0.49	0.69	0.73	0.22	0.31	0.33	0.44	0.28	0.45
C. D. at 5%	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	1.61	0.96	1.61
S. E.m 2 ±	0.49	0.47	0.58	0.49	0.53	0.62	0.22	0.23	0.28	0.32	0.20	0.33
C. D. at 5%	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	1.94	1.41	2.02
P×S												
S. E. m 1 ±	0.57	0.71	0.79	0.51	0.45	0.59	0.23	0.20	0.26	0.44	0.50	0.58

C. D. at 5%	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
S. E.m 2 ±	0.61	0.75	0.83	0.56	0.62	0.73	0.25	0.28	0.32	0.49	0.48	0.59
C. D. at 5%	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
V×S												
S. E. m 1 ±	0.57	0.71	0.79	0.51	0.49	0.61	0.23	0.20	0.26	0.44	0.50	0.58
C. D. at 5%	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
S. E.m 2 ±	0.61	0.75	0.83	0.56	0.62	0.73	0.25	0.28	0.32	0.49	0.48	0.59
C. D. at 5%	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
P×V×S												
S. E. m 1 ±	0.80	1.00	1.11	0.72	0.64	0.83	0.32	0.28	0.37	0.62	0.71	0.82
C. D. at 5%	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
S. E.m 2 ±	0.85	1.05	1.17	0.79	0.88	1.03	0.32	0.28	0.37	0.62	0.71	0.82
C. D. at 5%	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
S. E.m 3 ±	1.38	1.55	1.79	1.31	1.31	1.60	0.35	0.39	0.46	0.69	0.68	0.84
C. D. at 5%	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
General mean	16.79	18.81	17.80	12.66	13.74	13.20	0.58	0.58	0.71	0.99	0.96	1.19

These results are in accordance with the findings of Kumawat and Kumar (2007). It could be observed that at all the stages of growth, variety KDS-344 (V_2) recorded significantly higher plant height (61.20 and 65.0cm) as compared to variety JS-335 (V_1) (53.63 and 56.81cm) during both the years. The maximum plant height (60.93 and 64.35 cm) was recorded with 24th MW (S_1) sowing and it was at par with 26th MW i.e. (S_2) These results are in conformity with the findings of Ahmed *et al.*, (2010), Bhatia *et al.*, (1999), Singh (2013).

Statistically the highest mean maximum number of branches plant^{-1} registered under protected condition (Lambda cyhalothrin 5EC @ 1.0 ml l^{-1}) was 8.52 and 9.37 as compared unprotected condition 8.10 and 9.13 at 70 DAS during both the years of 2013 and 2014, respectively. at all the stages of growth, variety KDS-344 (V_2) recorded significantly higher number of branches plant^{-1} (8.64 and 9.69) as compared to variety JS-335 (V_1) (7.98 and 8.81) during both the years. These results are in conformity with the findings of Billore *et al.*, (2000) and Kathmale *et al.*, (2013). Statistically the highest number of branches plant^{-1} (8.68 and 9.55) were recorded with 24th MW (S_1) sowing and at par with 26th MW i.e. (S_2) date of sowing from 56 and 70 DAS.

The mean number of leaves plant^{-1} increased with advancement in the age of the soybean. Statistically the highest mean maximum number of leaves plant^{-1} registered under protected condition (Lambda cyhalothrin 5EC @1.0 ml l^{-1}) was 18.46 and 20.50 as compared unprotected condition (15.13 and 17.13) at 70 DAS during both the years of 2013 and 2014, respectively. It could be observed that at all the stages of growth variety KDS-344 (V_2) recorded significantly higher number of leaves plant^{-1}(18.16 and 19.81) as compared to variety JS-335 (V_1) (15.43 and 17.82) at 70 days after sowing during both the years. Statistically the highest number of leaves plant^{-1} (18.48 and 20.57) was recorded with 24th MW (S_1) sowing and it was at par with 26th MW *i.e.* (S_2) date of sowing from 14, 28 to 70 DAS. These results are in conformity with the findings of Ahmed *et al.*, (2010), Bhatia *et al.*, (1999), Singh (2013).

Statistically the highest mean maximum leaf area plant^{-1}registered under protected condition (Lambda cyhalothrin 5EC @ 1.0 ml l^{-1}) was 14.21 and 15.39 dm^2 as compared unprotected condition (11.12 and 12.09 dm^2) at 70 DAS during both the years These results are in accordance with the findings of Kumawat and Kumar (2007).It could be observed that at all the stages of growth, variety KDS-344 (V_2) recorded significantly higher leaf area plant^{-1} (13.82 and 14.74 dm^2) as compared to variety JS-335 (V_1) (11.51 and 12.75 dm^2) at 70 days after sowing during both the years. Statistically the highest leaf area plant^{-1}(14.03 and 14.95 dm^2) was recorded with 24th MW (S_1) sowing and it was at par with 26th MW i.e. (S_2) date of sowing throughout the growth stages of the crop.

Statistically the highest mean maximum leaf area index plant^{-1} registered under protected condition (Lambda cyhalothrin 5EC @ 1.0 ml l^{-1}) (6.31 and 6.84) as compared to unprotected condition (4.94 and 5.37) at 70 DAS during both the years of 2013 and 2014, respectively. Variety KDS-344 (V_2) recorded significantly higher mean leaf area index plant^{-1}(6.14 and 6.55) as compared to variety JS-335 (V_1) (5.12 and 5.66) during both the years. Statistically the highest mean leaf area index plant^{-1}(6.24 and 6.55) was recorded with 24th MW (S_1) sowing and it was at par with 26th MW i.e. (S_2) date of sowing for all the growth stages. This was closely followed by treatment S_2 i.e. sowing during 26thMW

(5.89 and 6.37) which was statistically higher than S_3 (28thMW). Statistically the highest mean dry matter accumulation plant^{-1} (g) registered under protected condition (Lambda cyhalothrin 5EC @ 1.0 ml l^{-1}) (16.82 and 19.26 g) as compared to unprotected condition (12.75 and 15.54 g) at harvest during both the years of 2013 and 2014, respectively. Variety KDS-344 (V_2) recorded significantly higher mean dry matter accumulation plant^{-1} (g) (16.26 and 18.98 g) as compared to variety JS-335 (V_1) (13.31 and 15.83 g) at harvest during both the years. At all the stages of growth, the dry matter weight plant^{-1}(g) showed decreasing trend with late sowings (S_1 to S_4). Statistically the highest mean dry matter accumulation plant^{-1} (15.81 and 15.81 g) was recorded with 24th MW (S_1) sowing and it was at par with 26th MW i.e. (S_2) date of sowing for all the growth stages of crop.

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