Ramana et al., Biological Forum -An International Journal 13(4): 900-907(2021) 900 Evaluation of the effect of different Dates of Sowing Regimes in Chickpea against Legume Pod Bore...

Biological Forum – An International Journal 13(4): 900-907(2021)

ISSN No. (Print): 0975-1130
ISSN No. (Online): 2249-3239

Evaluation of the effect of different Dates of Sowing Regimes in Chickpea against Legume Pod Borer, *Helicoverpa armigera* (Hubner)

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(Received 25 September 2021, Accepted 17 November, 2021)
(Published by Research Trend, Website: www.researchtrend.net)

ABSTRACT: Effect of different sowing dates on chickpea crop and varietal factors against the incidence of legume pod borer *Helicoverpa armigera*, pod damage and yield were studied at the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru, Hyderabad, Telangana during the post rainy seasons of 2019-20, and 2020-21. Ten Chickpea genotypes were sown at monthly intervals during first weeks of September, October and November. Each entry was sown in a 6 row plots, with 10 x 30 cm spacing. There were four replications in a split plot design. Among the different sowing regimes tested, November sown crop was found to be optimal and right time for sowing of the chickpea genotype to evade the pod borer coincidence. The borer population fluctuated with the change in dates of sowing. Pod borer population was higher in the early sown crop (September) and with delayed dates of sowing in October and November population decreased. There were significant differences in percent pod damage across genotypes ranging from 10.50 to 40.66 per cent. Minimum pod damage was observed in ICCV 10 and maximum pod damage was observed in ICC 3137. The grain yield ranged from 316.4 kg/ha to 836.1 kg/ha. The highest grain yield was recorded in ICCV 10 and lowest in ICC 3137. Correlation results of pod borer incidence in ICC 3137 showed positive correlation with maximum, minimum temperature and solar radiation, while rainfall and humidity were negatively correlated. Screening the different chickpea genotypes for resistance or tolerance to *H. armigera* allowed us in detection of a resistant/tolerant varieties which has shown the minimum level of damage in pods and further for ensuring higher yield with less pod borer damage, November is the optimal time for sowing of Chickpea.

Keywords: Chickpea genotypes, Temporal factors, Varietal performance, Pod borer, *H. armigera*.

INTRODUCTION

Pulses are important sources of proteins, vitamins and minerals and are popularly known as “Poor man’s meat”. The chickpea plays a vital role to address the Indian national food and nutritional security due to its high protein content and is being categorised as “smart-food” for its critical role to food basket. India is the major producer and consumer of chickpea, followed by Myanmar, Turkey, Pakistan, Australia and other African countries (FAOSTAT, 2019). In India, about 10.56 M ha of area is under chickpea cultivation with production of 11.38 MT (Annon, 2018).

The legume pod borer (*Helicoverpa armigera* Hub.) is the most important pest of chickpea (*Cicer arietinum* L.). This insect is an insatiable feeder on chickpea plant. It infests at the seedling stage and continues to devour flowers, pods and seeds until crop maturity (Reed *et al.*, 1982). The *H. armigera* larvae prefer nitrogen rich plant parts such as flowers and pods (Fitt, 1989). The extent of damage inflicted by *H. armigera* to chickpea depends not only on number of larvae but also on the developmental stages of crop (Shah and Shahzad, 2005). Time fitted cultivation as a part of modern IPM is thus found indispensable to minimize *H. armigera* infestation (Muchhadiya *et al*., 2014).

Management of this insect pest through manipulation of cultural operations is considered as one of the possible cost-effective option. Majority of the insects infest crop at particular stage and time, which can be changed by a good agronomical tool i.e. adjusting the dates of sowing could minimize the damage caused and appropriate sowing dates can help in pest escape by crop during the vulnerable stages of crop growth. Persistent nature of *H. armigera* results in substantial yield losses (Ahmad *et al*., 2016). But pest appearance, population fluctuation, infestation rate and yield could be altered towards a profitable court can be done by optimizing the time of sowing.

Insecticide application for pod borer control is uneconomical under subsistence farming, and is beyond the means of resource poor farmers in the semi-arid tropics. Host plant resistance (HPR) can play a major role in controlling *H. armigera* damage in combination with other methods of pest control. In view of limited success in developing crop cultivars with resistance to this pest, there is a need to identify genotypes with great tolerance mechanisms and with remarkable capacity to recover from *H. armigera* damage by producing more vegetative growth and through a second flush of flowers and pods. In the light of aforesaid concepts, the present research was carried out to evaluate a diverse array of chickpea genotypes for optimizing the appropriate time of sowing to tackle the damage caused by *H. armigera.*

MATERIALS AND METHODS

Study site and weather. The experiments were conducted at International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru (17.51ºN, 78.27ºE and 545 m), India. The area receives an annual mean rainfall greater than 750 mm, with main rainy season between June to September. The study area has mosaic landscape and suitable to grow most of semi-arid tropics crops; however, ICRISAT has the mandate of six crops chickpea, groundnut, pigeonpea, sorghum, pearl millet and finger millet. The current study focuses on *H. armigera* infestations in chickpea crop.

Screening for *H. armigera* in different cultivars of chickpea. The studies on screening of different Chickpea cultivars were carried at ICRISAT, Hyderabad, Patancheru to evaluate the varietal performance and to assess the effect of temporal factors on the incidence of chickpea pests. Ten cultivars of chickpea were planted in the field during 2019-2020 and 2020-2021 *Rabi* seasons. Each entry was sown in a 6 row plots, with 10 × 30 cm spacing. There were four replications in a split plot design. Normal agronomic practices with intercultural and weeding operations were carried out as and when needed without any insecticidal application.

Observations recorded. Ten plants were selected randomly from each plot and tagged. Observation on eggs and larval population of *H. armigera* were recorded at 15 days intervals (15, 30, 45, 60, 75 and 90 days after sowing. The per cent pod damage by gram pod borer, *H. armigera* was estimated from tagged plants at the time of harvest to assess, the extent of pod damage. Every pod was critically examined for *H. armigera* damage. Pods attacked by *H. armigera* having big circular holes without larval exuviae on the pods were considered as damaged pods. Number of healthy and damaged pods were recorded separately for each genotype and for each date of sowing and the pod damage was estimated by using the following formula (1) and expressed in percentages. The total yield per plot including the yield of tagged plants sampled was taken and compared in kg/ha.

$$\text{Percent pod damage} = \frac{\text{Number of damaged pods}}{\text{Total Number of pods}} \times 100 \quad (1)$$

The percentage of pod damage at maturity of genotypes was compared with that of the check varieties. The test genotypes were then graded by using the following formula.

Pest resistance % =

$$\frac{\text{\% PD in Check genotype} - \text{\% PD in Test genotype}}{\text{\% PD in Check genotype}} \times 100 \quad (2)$$

Where, PD = Pod damage.

The pest resistance percentage was converted to 1-9 scale as follows:

Pest Resistance	Resistance category	Pest Resistance Susceptible Rating (PRSR)
100%	1	Immune
75 to 99%	2	Highly resistant
50 to75%	3	Resistant
25 to 50%	4	Moderately Resistant
10 to 25%	5	Intermediate
-10 to 10%	6	Equal to susceptible check
-25 to-10%	7	Moderately susceptible
-50 to-25%	8	Susceptible
<-50% or less	9	Highly susceptible

STATISTICAL ANALYSIS

Ten genotypes were screened in split plot design by considering genotypes as sub plots and time (date of sowing) as main plots. The data from the two rabi seasons was square root transformed and subjected to pooled analysis of variance (ANOVA) for assessing the performance of genotypes against relative resistance or susceptibility to pod borer, *H. armigera* using a Statistical Analysis System package (SAS). Simple correlation was worked out for only the susceptible genotype pooled data i.e. ICC 3137. The data provided in this research was of pooled data of two seasons.

RESULTS AND DISCUSSION

Varietal performance against legume pod borer eggs
Results showed that sowing dates significantly ($P<0.05$) affected the incidence of *H. armigera*. Data presented in the Tables 1a and 1b represents that, during the crop period (15 to 90 days after sowing) there was a significant difference between dates of sowing and genotypes. The interaction effects, results revealed that there was a significant difference up to 45 DAS and 75 DAS.

Table 1a: Response of different Genotypes of Chickpea against the Infestation of *H. armigera* eggs (15-45 DAS).

	Mean *H. armigera* eggs (10 Plants) 15 DAS				Mean *H. armigera* eggs (10 Plants) 30 DAS				Mean *H. armigera* eggs (10 Plants) 45 DAS			
Genotype/Sub plots	**September**	**October**	**November**	**SPM**	**September**	**October**	**November**	**SPM**	**September**	**October**	**November**	**SPM**
ICC 506EB	1.497^{cdefg}	1.477^{fghij}	1.449^{k}	1.475^{cd}	1.512^{cdefg}	1.500^{defghi}	1.463^{ij}	1.491^{b}	1.499^{defghij}	1.471^{hijklmn}	1.452^{mn}	1.474^{cd}
ICCV 10	1.521^{bc}	1.48^{fghij}	1.48^{fghij}	1.494^{b}	1.511^{cdefgh}	1.514^{cdef}	1.482^{fghij}	1.502^{b}	1.505^{cdefghi}	1.510^{cdefg}	1.470^{ijklmn}	1.495^{b}
ICC 3137	1.509^{bcde}	1.574^{a}	1.510^{bcde}	1.531^{a}	1.563^{ab}	1.567^{a}	1.499^{defghi}	1.543^{a}	1.547^{ab}	1.565^{a}	1.508^{cdefgh}	1.54a
ICCL 86111	1.478^{fghij}	1.481^{fghij}	1.477^{fghij}	1.479^{bcd}	1.494^{defghi}	1.494^{defghi}	1.475^{ghij}	1.488^{b}	1.488^{efghijklm}	1.508^{cdefgh}	1.459^{klmn}	1.485^{bcd}
ICCV 92944	1.490^{defgh}	1.459jk	1.454jk	1.468^{d}	1.500^{defghi}	1.497^{defghi}	1.505^{cdefgh}	1.501^{b}	1.502^{defghi}	1.495^{defghijk}	1.452^{mn}	1.483^{bcd}
ICCV 95334	1.492^{defgh}	1.504^{bcdef}	1.468^{hijk}	1.488^{bc}	1.500^{defghi}	1.513^{cdef}	1.444^{j}	1.486^{b}	1.519bcde	1.502^{defghi}	1.46^{klmn}	1.494^{bc}
JG 11	1.514^{bcde}	1.475^{ghijk}	1.466^{hijk}	1.485^{bc}	1.503^{defgh}	1.524^{cde}	1.475^{fghij}	1.501^{b}	1.541abc	1.463^{jklmn}	1.448^{n}	1.484^{bcd}
JG 62	1.523^{bc}	1.474^{ghijk}	1.458^{jk}	1.485^{bc}	1.525^{bcd}	1.486^{efghi}	1.464^{ij}	1.492^{b}	1.492^{efghijkl}	1.514^{bcdef}	1.47^{ijklmn}	1.492^{bc}
KAK 2	1.515^{bcd}	1.487^{efghi}	1.465^{hijk}	1.489^{bc}	1.493^{defghi}	1.507^{cdefgh}	1.478^{fghij}	1.493^{b}	1.529^{bcd}	1.476^{ghijklmn}	1.466^{jklmn}	1.49^{bc}
NBeG 47	1.527^{b}	1.476^{ghijk}	1.462^{ijk}	1.488^{bc}	1.473^{hij}	1.494^{defghi}	1.542^{abc}	1.503^{b}	1.478^{fghijklmn}	1.462^{klmn}	1.457^{lmn}	1.466^{d}
MPM	1.506^{a}	1.488^{b}	1.468^{c}		1.507^{a}	1.509^{a}	1.482^{b}		1.509^{a}	1.496^{a}	1.464^{b}	
	P value	**CD**	**CV**		**P value**	**CD**	**CV**		**P value**	**CD**	**CV**	
Main plots	0.004	0.0168	2.1		0.005	0.0135	1.7		0.017	0.0278	3.4	
Sub plots	0.000	0.0160	1.3		0.000	0.0220	1.8		0.000	0.0209	1.7	
Interactions	0.000	0.0277			0.000	0.0382			0.026	0.0362		

Treatments with same alphabet are not significantly different; SPM-Sub plot Means, MPM-Main plot means

Table 1b: Response of Different Genotypes of Chickpea Against the Infestation of *H. armigera* eggs (60-75 DAS).

	Mean *H. armigera* eggs (10 Plants) 60 DAS				Mean *H. armigera* eggs (10 Plants) 75 DAS				Mean *H. armigera* eggs (10 Plants) 90 DAS			
Genotype/Sub plots	**September**	**October**	**November**	**SPM**	**September**	**October**	**November**	**SPM**	**September**	**October**	**November**	**SPM**
ICC 506EB	1.598^{a}	1.536^{cde}	1.483^{ghij}	1.494^{de}	1.529^{hij}	1.528^{hij}	1.469^{no}	1.509^{d}	1.516^{efg}	1.463^{jk}	1.463^{jk}	1.481^{ef}
ICCV 10	1.587^{ab}	1.534^{cde}	1.482^{hij}	1.517^{bcd}	1.575^{de}	1.565^{ef}	1.491^{lmn}	1.544^{c}	1.511^{efgh}	1.477^{jk}	1.477^{jk}	1.488^{de}
ICC 3137	1.558^{abc}	1.528^{cdef}	1.48^{hij}	1.575^{a}	1.647^{a}	1.622^{ab}	1.508^{jklm}	1.592^{a}	1.573^{a}	1.549^{abcd}	1.559^{ab}	1.56^{a}
ICCL 86111	1.555^{bc}	1.523^{cdefg}	1.476^{ij}	1.491^{e}	1.556^{efgh}	1.578^{de}	1.498^{klm}	1.544^{c}	1.523^{defg}	1.48^{ij}	1.477^{jk}	1.493^{de}
ICCV 92944	1.555^{bc}	1.52^{cdefgh}	1.474^{ij}	1.529^{b}	1.578^{de}	1.559^{ef}	1.488^{mn}	1.542^{c}	1.529^{cdefg}	1.51^{fgh}	1.507^{fgh}	1.515^{c}
ICCV 95334	1.553^{bc}	1.519^{cdefgh}	1.474^{ij}	1.522^{bc}	1.593^{cd}	1.606^{bc}	1.508^{jklm}	1.569^{b}	1.554^{abc}	1.537^{bcde}	1.528^{cdefg}	1.539^{b}
JG 11	1.549^{bc}	1.5^{defghi}	1.472^{ij}	1.5^{cde}	1.547^{fghi}	1.563^{ef}	1.499^{klm}	1.536^{c}	1.524^{defg}	1.504^{ghi}	1.507^{fgh}	1.512^{c}
JG 62	1.546^{c}	1.497^{efghi}	1.468^{ij}	1.493^{de}	1.601^{bcd}	1.558^{efg}	1.528^{hij}	1.562^{b}	1.512^{efgh}	1.452^{k}	1.452^{k}	1.472^{f}
KAK 2	1.54^{cd}	1.491^{fghi}	1.467^{ij}	1.525^{b}	1.634^{a}	1.624^{ab}	1.517^{jkl}	1.592^{a}	1.546^{bcd}	1.487^{hij}	1.474^{jk}	1.502^{cd}
NBeG 47	1.539^{cd}	1.485^{ghi}	1.445^{j}	1.5^{cde}	1.524^{ijk}	1.53^{ghij}	1.451^{o}	1.502^{d}		1.48^{ij}	1.474^{jk}	1.496^{de}
MPM	1.5155^{b}	1.5481^{a}	1.4799^{c}		1.578^{a}	1.573^{a}	1.495^{b}		1.531a	1.493^{b}	1.491^{b}	
	P value	**CD**	**CV**		**P value**	**CD**	**CV**		**P value**	**CD**	**CV**	
Main plots	0.001	0.0251	3		0.000	0.0094	1.1		0.000	0.0119	1.4	
Sub plots	0.000	0.0235	1.9		0.000	0.0160	1.3		0.000	0.0153	1.3	
Interactions	0.537	0.0407			0.0002	0.0278			0.138	0.0265		

Treatments with same alphabet are not significantly different; SPM-Sub plot Means, MPM-Main plot means

Table 2a: Mean larval population of gram pod borer, *H. armigera* on different genotypes of Chickpea (15-45 DAS).

	Mean *H. armigera larvae* (10 Plants) 15 DAS				**Mean *H. armigera larvae* (10 Plants) 30 DAS**				**Mean *H. armigera larvae* (10 Plants) 45 DAS**			
Genotype/Sub plots	**September**	**October**	**November**	**SPM**	**September**	**October**	**November**	**SPM**	**September**	**October**	**November**	**SPM**
ICC 506EB	1.485^{i}	1.633^{defg}	1.56^{ghi}	1.559^{d}	$1.595^{defghijk}$	1.552^{hijk}	1.549^{ijk}	1.565^{de}	1.593^{cde}	1.493^{gh}	1.527^{efgh}	1.538^{cd}
ICCV 10	1.529^{hi}	1.728^{abc}	1.567^{ghi}	1.608^{cd}	$1.606^{defghijk}$	1.642^{cdefg}	1.569^{ghijk}	1.606^{cd}	1.615^{bcd}	1.589^{cde}	1.563^{cdefgh}	1.589^{ab}
ICC 3137	1.63^{defg}	1.749^{ab}	1.607^{defgh}	1.662^{ab}	1.64^{cdefg}	1.712^{bc}	1.567^{ghijk}	1.64^{bc}	1.717^{a}	1.583^{cde}	1.546^{defgh}	1.615^{a}
ICCL 86111	1.522^{hi}	1.693^{abcd}	1.602^{efgh}	1.60^{cd}	1.643^{cdefg}	1.739^{b}	1.659^{bcdef}	1.68^{ab}	1.637^{bc}	1.613^{bcd}	1.601^{cde}	1.617^{a}
ICCV 92944	1.623^{defg}	1.748^{ab}	1.627^{defg}	1.666^{a}	$1.601^{defghijk}$	$1.627^{cdefghij}$	1.545^{jk}	1.591^{cde}	1.579^{cde}	1.581^{cde}	1.547^{defgh}	1.569^{bcd}
ICCV 95334	1.665^{bcdef}	1.774^{a}	1.629^{defg}	1.689^{a}	$1.634^{cdefghi}$	1.855^{a}	1.646^{cdefg}	1.711^{a}	1.683^{ab}	1.572^{cdef}	1.542^{defgh}	1.599^{ab}
JG 11	1.643^{cdefg}	1.625^{defg}	1.57^{ghi}	1.613^{bc}	$1.626^{cdefghij}$	1.68^{bcd}	1.584^{fghijk}	1.630^{bc}	1.606^{bcd}	1.594^{cde}	1.542^{defgh}	1.581^{ab}c
JG 62	1.606^{efgh}	1.625^{defg}	1.557^{ghi}	1.596^{cd}	$1.591^{efghijk}$	1.53^{k}	1.522^{k}	1.548^{e}	1.577^{cde}	1.594^{cde}	1.573^{cdef}	1.582^{abc}
KAK 2	1.586^{fgh}	1.625^{defg}	1.56^{ghi}	1.59^{cd}	1.575^{fghijk}	$1.628^{cdefghij}$	1.568^{ghijk}	1.59^{cde}	1.611^{bcd}	1.616^{bcd}	1.568^{cdefg}	1.598^{ab}
NBeG 47	1.678^{bcde}	1.744^{ab}	1.588^{fgh}	1.67^{a}	1.582^{fghijk}	1.676^{bcde}	1.638^{cdefgh}	1.632^{bc}	1.591^{cde}	1.488^{h}	1.499^{fgh}	1.526^{d}
MPM	1.596^{b}	1.694^{a}	1.586^{a}		1.609^{b}	1.664^{a}	1.584^{c}		1.620^{a}	1.572^{b}	1.550^{c}	
	P value	**CD**	**CV**		**P value**	**CD**	**CV**		**P value**	**CD**	**CV**	
Main plots	0.000	0.0390	4.4		0.000	0.0231	2.6		0.000	0.0197	2.3	
Sub plots	0.000	0.0495	3.8		0.000	0.0505	3.8		0.000	0.0447	3.5	
Interactions	0.040	0.0858			0.017	0.0875			0.138	0.0774		

Treatments with same alphabet are not significantly different; SPM-Sub plot Means, MPM-Main plot means.

Table 2b: Mean larval population of gram pod borer, *H. armigera* on different genotypes of Chickpea (60-90 DAS).

	Mean *H. armigera larvae* (10 Plants) 60 DAS				**Mean *H. armigera larvae* (10 Plants) 75 DAS**				**Mean *H. armigera larvae* (10 Plants) 90 DAS**			
Genotype/Sub plots	**September**	**October**	**November**	**SPM**	**September**	**October**	**November**	**SPM**	**September**	**October**	**November**	**September**
ICC 506EB	1.561^{fghi}	1.499^{jk}	1.535^{ghijk}	1.532^{fg}	1.545^{fghi}	1.543^{fghi}	1.522^{i}	1.537^{cd}	1.63^{a}	1.522^{ghij}	1.524^{ghi}	1.559^{b}
ICCV 10	1.574^{cdefgh}	1.545^{ghij}	1.619^{bcde}	1.579^{bcd}	1.542^{fgh}i	1.529^{hi}	1.54^{ghi}	1.537^{cd}	1.57^{bcdef}	1.487^{k}	1.487^{k}	1.515^{cd}
ICC 3137	1.626^{bc}	1.545^{ghij}	1.654^{b}	1.608^{ab}	1.634^{ab}	1.623^{abc}	1.585^{cdefg}	1.614^{b}	1.572^{bcde}	1.543^{defg}	1.523^{ghij}	1.546^{b}
ICCL 86111	1.502^{jk}	1.497^{jk}	1.602^{bcdef}	1.534^{fg}	1.564^{efghi}	1.543^{fghi}	1.542^{fghi}	1.55^{cd}	1.591^{bc}	1.548^{defg}	1.548^{defg}	1.562^{b}
ICCV 92944	1.571^{cdefgh}	1.48^{k}	1.588^{cdefg}	1.546^{ef}	1.59^{bcdef}	1.551^{fghi}	1.538^{ghi}	1.56^{c}	1.586^{bc}	1.551^{defg}	1.551^{defg}	1.563^{b}
ICCV 95334	1.617^{bcdef}	1.591^{cdefg}	1.712^{a}	1.64^{a}	1.663^{a}	1.662^{a}	1.615^{abcd}	1.647^{a}	1.601^{ab}	1.575^{bcd}	1.575^{bcd}	1.584^{a}
JG 11	1.569^{defgh}	1.573^{cdefgh}	1.624^{bcd}	1.589^{bc}	1.603^{bcde}	1.615^{abcd}	1.566^{defghi}	1.595^{b}	1.567^{cdef}	1.533^{gh}	1.533^{gh}	1.544^{b}
JG 62	1.493^{jk}	1.492^{jk}	1.536^{ghijk}	1.507^{g}	1.572^{defgh}	1.524^{hi}	1.526^{h}i	1.541^{cd}	1.538^{fg}	1.487^{k}	1.49^{jk}	1.505^{d}
KAK 2	1.568^{efghi}	1.524^{hijk}	1.621^{bcde}	1.571^{cde}	1.591^{bcdef}	1.559^{efghi}	1.545^{fghi}	1.565^{c}	1.572^{bcde}	1.501^{hijk}	1.501^{hijk}	1.524^{c}
NBeG 47	1.513^{ijk}	1.565^{efghi}	1.575^{cdefgh}	1.551^{def}	1.525^{h}i	1.52^{i}	1.526^{hi}	1.524^{d}	1.541^{efg}	1.483^{k}	1.497^{ijk}	1.507^{cd}
MPM	1.559^{b}	1.531^{c}	1.606^{a}		1.582^{a}	1.567^{ab}	1.550^{b}		1.576^{a}	1.523^{b}	1.522^{b}	
	P value	**CD**	**CV**		**P value**	**CD**	**CV**		**P value**	**CD**	**CV**	
Main plots	0.000	0.014	1.7		0.018	0.019	2.3		0.000	0.009	1.1	
Sub plots	0.000	0.032	2.6		0.000	0.028	2.3		0.000	0.018	1.5	
Interactions	0.023	0.056			0.836	0.049			0.047	0.032		

Treatments with same alphabet are not significantly different; SPM-Sub plot Means, MPM-Main plot means

Late sowing (November, M3) was found as the best time for sowing chickpea genotypes followed by October and September based on the low mean egg populations. Among the genotypes evaluated ICC 3137 was found as the most susceptible genotype as it recorded highest mean egg population (1.531-1.592) throughout the cropping period. The genotypes NBeG 47 and ICCL 86111 were found to be resistant genotypes with low mean egg population during 45, 60 and 75 DAS. During Vegetative stage, the genotypes ICCV 92944 and ICCV 95334 were found as best genotypes in resistance pod borer with low egg density.

Varietal performance against gram pod borer larvae:

Results (Tables 2a and 2b) showed that during the crop period (15 to 90 days after sowing) average larval population of *H. armigera* varied significantly ($P<0.05$) with different sowing dates in two cropping seasons and there was a significant difference between dates of sowing and genotypes. Interaction effect, results revealed that there was a significant difference during 15, 30, 60 and 90 DAS. None of the genotypes were free from pod borer larval incidence. In early sown crop (September) larval appearance was recorded after 30 DAS. Late sowing (November, M3) was found to be the best time for sowing chickpea genotypes followed by October and M1 September based on the low mean larval populations. However, initial larval infestation (up to 30 DAS) was higher in October sown crop. Number of larvae was increased gradually with crop growth. The genotypes ICCV 95334 and ICC 3137 are found as susceptible genotypes with greater larval infestation from the vegetative to pod maturity stage. Genotypes JG 62 and NBeG 47 were found as promising cultivars against pod borer larval resistance during the pod maturity and flowering stages. Whereas, ICC 506EB was found to be tolerant during vegetative stage of the chickpea crop.

The current research results of chickpea genotypes evaluated under different dates of sowing regimes are in corroboration with the findings of Pavani *et al*., (2019) where the *H. armigera* oviposition decreased across sowing dates from October to December. The genotype ICC 3137 was most preferred for egg laying (9.5 eggs/5 plants), followed by KAK 2 (6.8 eggs/5 plants) and they concluded that, the *H. armigera* incidence was decreased with a delay in time of sowing (60.0 larvae/5plants in the October sown crop to 21.9 larvae/5plants in the December sown crop). Similar results were obtained for larval incidence. ICC 3137 was found as susceptible one and these results are in line with Pavani *et al.* (2019) wherein highest incidence of *H. armigera* larvae were recorded on ICC 3137 (55.1 larvae/5plants), and the lowest on ICCV 10 (29.9 larvae/5plants). Contradictorily Choudhary *et al*., (2014) experimental findings revealed that early sown crop (5th October) had the lowest gram pod borer larval population (2.50 larvae/five plants) and minimum pod damage (14.50%) with relatively better yield (13.04 q ha-1) as compared to late sown (20th November) crop.

Pod damage: There were significant difference across genotypes. Percent pod damage across genotypes ranging from 10.50 to 40.66 percent. Minimum pod damage was observed in ICCV 10 (10.50%), followed by ICCL 86111 and ICC 506EB with 12.64 % and, 14.01% respectively. The per cent pod damage in NBeG 47 (19.43 %) was statistically at par with JG 11 (22.76 %). However, maximum pod damage was observed in ICC 3137 (40.66 %), followed by ICCV 95334 (31.88 %), ICCV 92944, KAK 2 and JG 62 (29.48 %, 28.78 and 27.10 %) respectively. Pod damage percentage results of the current study are in corroboration with the findings of Shankar *et al*., (2014) who evaluated a diverse array of chickpea genotypes for resistance against *H. armigera* and reported that, significantly lower numbers of *H. armigera* larvae were on ICCL 86111 and ICCV 10, compared to ICC 3137 during vegetative and flowering stages in one or both sowings/seasons. The grain yield of these genotypes was also significantly greater than that of ICC 3137 in one or both sowings/seasons. Chandile *et al*., (2017) has also reported that the lowest grain damage was recorded on ICCL-86111 (4.92 per cent). However, ICC-3137 recorded maximum *H. armigera* population (1.51 larvae per plant) highest pod damage (10.14 %). Experimental findings of the present study are in line and supported by the findings of Sehgal and Ujagir (1990) who reported 42.6 to 90.0 % percent pod damage in chickpea by *H. armigera* at Pantnagar. Similar results were also reported by Jaba *et al*., (2017) where the percent mean pod damage ranged from 68.49 to 100.0 %

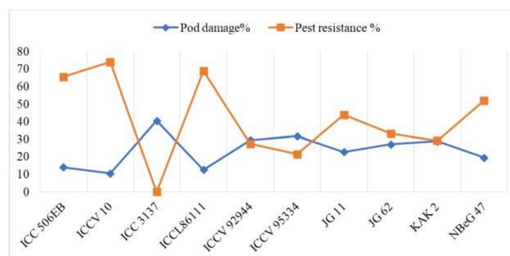

Fig. 1. Pod damage and Pest resistance against *H. armigera* in test genotypes.

Pest Resistance Susceptible Rating: PRSR was recorded on the scale of 1-9 by comparing pod damage in test chickpea genotypes with the susceptible check ICC3137. The PRSR ranged from 3-6. Out of ten test genotypes evaluated, four genotypes *viz.* ICC 506 EB, ICCV 10, ICCL 86111and NBeG 47 recorded PRSR of 3 and were resistant to pod borer. Whereas, ICCV 92944, JG 11, JG 62 and KAK 2 recorded PRSR of 4 and ICCV 95334 recorded PRSR of 5 as compared to 6 in susceptible check ICC 3137. Results of the PRSR are agreement with the experimental findings of Reddy and Agnihotri (2018) wherein test genotype ICCL 86111 was categorised as resistant, JG 11 as moderately resistant as it recorded PRSR rating 4 when compared to 6 in susceptible genotype ICC 3137.

Grain yield: The grain yield ranged from 316.4 kg/ha to 836.1 kg/ha. The highest grain yield was recorded in ICCV 10 (836.1 kg/ha) followed by ICCL 86111, NBeG 47 and ICC 506 EB (785.0, 758.0 and 714.0 kg/ha respectively). Lowest yield was recorded in ICC 3137 (316.4 kg/ha) followed by ICCV 95334 (486.0 kg/ha), JG 62 (496.0 kg/ha), ICCV 92944 (541.0 kg/ha) and JG 11 (634.0 kg/ha) as compared to 316.4 kg/ha in the susceptible check ICC 3137. The grain yield results of the present study are in corroboration with Shankar *et al*., (2014) wherein the grain yield of ICCL 86111 was significantly greater than that of ICC 3137 in one or both sowings/seasons. Studies of Chandile *et al*., (2017) also revealed that the lowest grain damage was recorded on ICCL 86111 (4.92 per cent) with maximum grain yield of 24.40 q/ha. However, ICC 3137 recorded maximum grain damage (15.74 per cent) and lowest grain yield (10.27 q/ha).

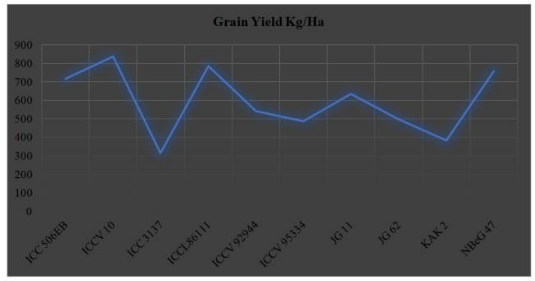

Fig. 2. Pooled grain yield recorded of the test genotypes.

Table 3: Per cent pod damage and grain yield of chickpea on different genotypes During rabi, pooled.

Genotype	Total No of Pods (10 plants)	Total infested No of pods (10 plants)	Pod damage %	Pest resistance %	PRSR	Total grain yield (Kg)
ICC 506EB	392	95	14.01	65.54	3	714.6
ICCV 10	3028	318	10.50	74.17	3	836.1
ICC 3137	1124	457	40.66	0.00	6	316.4
ICCL86111	2108	266	12.64	68.92	3	785
ICCV 92944	2025	597	29.48	27.50	4	541
ICCV 95334	1016	324	31.88	21.59	5	486
JG 11	1314	487	22.76	44.03	4	634
JG 62	2145	356	27.10	33.34	4	496
KAK 2	986	284	28.78	29.21	4	382
NBeG 47	1699	330	19.43	52.20	3	758

Correlation between *H. armigera* infestations and meteorological parameters:

High level of temperature and rainfall were the two critical environmental factors that influences the incidence rates and performance of the cultivars in the field conditions. Correlation between *H. armigera* eggs and weather factors showed that the minimum temperature, had a significant positive correlation in all three months of sown crop but in the early sown crop the rainfall, maximum temperature and relative humidity morning were showed negative correlation with *H. armigera* egg count. Irrespective of the date and time of sowing rainfall showed a significant negative correlation and solar radiation showed positive correlation. Correlation studies of Parmar *et al*., (2015) had also reported that larval population with sunshine hours exhibited positive correlation in November sown crop. Maximum temperature showed positive correlation with egg count in October and November sown crops. Whereas, relative humidity evening showed negative correlation with egg count in October and November sown crops. Experimental findings of the present correlation results are in line with the results of Shahzad *et al.,* (2003), wherein population of *H. armigera* was significantly positively correlated with temperature, solar radiation and significantly negatively correlated with morning RH and insignificantly negatively correlated with evening RH. Studies of Reddy *et al.*, (2009) has also confirmed that population has significantly positive correlation with temperature. The rainfall and larval population showed positive correlation coefficient (0.03) but it was non-significant. The sunshine hours showed positive and non-significant correlation with larval population.

Table. 4. Correlation between *H. armigera* incidence and weather factors for the pooled Susceptible genotype ICC 3137 data.

Parameter	Month of sowing	Rainfall	Max Temp	Min Temp	RH morning	RH evening	Solar Radiation
H. armigera eggs	September	0.559	-.421	0.978**	-.908**	.924**	0.856**
	October	-.501	.510	0.023	.047	-.684*	0.545
	November	-.459	.300	0.151	-.402	-.350	0.212
H. armigera larvae	September	0.559	-.421	0.978**	-.908**	0.924**	0.856**
	October	0.620*	.392	0.388	0.317	0.404	0.328
	November	0.273	-.749**	-.215	0.317	0.661*	-.573

*. Correlation is significant at the 0.05 level; **. Correlation is significant at the 0.01 level

Gram pod borer, *H. armigera* larval population was correlated with the same weather parameters, and the results were contradictorily showed that rainfall is positively correlated with the larval incidence of *H. armigera* in all three months sown crop, irrespective of the sowing dates. Maximum temperature also negatively correlated with the larval incidence in the September and November sown crops, while it exhibited the positive correlation with the October sown crop. These results were supported Spoorthi *et al*., (2017) where the larval population exhibited positive correlation with maximum (r = 0.5133).

Minimum temperature showed positive correlation with larval incidence in the September and October sown crops and it showed negative correlation with the late sown crop. Correlation results of this study are supported by Kumar *et al*., (2018) with the findings of maximum temperature and sunshine hours had significant positive correlation (r =0.89) and (r =0.69) respectively. The other weather parameters *viz* relative humidity morning, relative humidity evening and solar radiation were positively correlated. Correlation results of larval population of the present research are in line and matched with the studies of (Khorasiya *et al*., 2016) indicated that maximum temperature exerted very high negative direct effect while morning relative humidity registered positive and high direct effect. Our experimental results are supported by the studies of Bajya *et al.*, (2010); Pandey *et al.*, (2014) reported that the where minimum temperature, rainfall and relative humidity in the morning and evening were positively correlated with the increase in *H. armigera* larval population.

Correlation results pertaining to *H. armigera* eggs of the current research are in confirmation with the findings of Shah and Shahzad (2005) where, a negative correlation existed between the eggs, larval instars of *H. armigera* with the average morning per cent relative humidity. The eggs and larval instars of *H. armigera* held no relationship with evening percent relative humidity. Correlation studies of Bahadur *et al*., (2018) had also revealed that there was a positive association with maximum temperature (r = 0.636), sunshine (r = 0.595) and minimum temperature (r =.0.580). However, during the year 2017 morning relative humidity (r = -0.399), and evening relative humidity (r = -0.761) showed negative correlation and these results are in match with the present research.

CONCLUSIONS AND FUTURE PERSPECTIVE

In the present study, ten Chickpea accessions were screened under different dates of sowing regimes against pod borer, *H. armigera*. Based on the pooled data analysis results, November sown crop was found optimal and right time for sowing to escape the pod borer coincidence and among the tested genotypes, percent pod damage observed in ICCV 10 was minimum and maximum in ICC 3137 and correlation results of ICC 3137 genotype incidence data showed positive correlation with maximum, minimum temperature, solar radiation, rainfall and with humidity larval population showed negative correlation. Furthermore, future studies should be engrossed on evaluating different elite varieties of chickpea against *H. armigera and S. exigua* under natural and laboratory conditions by evaluating biochemical components and agronomic characters like trichome density which are responsible for their susceptibility/resistance and more attention should be devoted to study the demographic parameters of this pest under field conditions for developing effectual management strategies.

Acknowledgement. This work was supported by the grants from the Department of Science &Technology-Climate change, Government of India**.** The authors are also thankful to Integrated Crop Management, Entomology, ICRISAT, Patancheru, Hyderabad, Telangana. India for providing us necessary facilities to undertake the studies.

Conflict of Interest. None.

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How to cite this article: Ramana, N., Kumar, S. R. D.V.; Jaba, J.; Kumar, A. P.; Rao V. S.; Prashad S. M. and Bhatnagar, P. M. (2021). Evaluation of the effect of Different Dates of Sowing Regimes in Chickpea against Legume Pod Borer, *Helicoverpa armigera* (Hubner). *Biological Forum – An International Journal*, *13*(4): 900-907.