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Approach to study of pigeonpea leaf webber [*Grapholita critica (*Meyr.)] damage dynamics and its relation to weather

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ABSTRACT

Investigation of the published data of a field experiment on assessment of damage due to leaf webber (*Grapholita critica* (Meyr.)Torticidae:Lepidoptera) under seven different sowing periods at weekly intervals between June IV to August II weeks of 2013-14 at Gulbarga (Karnataka) and observations on leaf webber damage recorded on weekly basis between 32 and 42 standard meteorological weeks (SMW) was done to demonstrate appropriate analytical methodology for an improved understanding of seasonal dynamics of *G. critica* damage and its relation to weather. Approach to analyses included reporting of calendar (SMW) based observations of *G. critica* damage on crop age basis, one way ANOVA for testing differences in damage levels amongst sowing periods, SMWs and crop age besides description of relations of damage with crop age and weather variables. Seasonal damage levels of *G. critica* for sowing periods were non-significant but significant ($P<0.05$) across SMWs and crop age with reduced damage during early and late crop stages irrespective of sowing periods. Seven and four weeks of higher damage and the best fit of polynomial relations of second order in respect of crop age over calendar based periods signified crop stage dependent damage due to *G. critica*. While MLR revealed significant influence of all weather and crop age variables (R^2: 0.79), non-parametric regression revealed that less than 30°C of maximum temperature and greater than 23°C of minimum temperature to be favourable for *G. critica* damage. Crop age and calendar based observations have their importance for an area wide and field basis management of *G. critica* respectively.

Key words: Crop age, Damage dynamics, Leaf webber, Pigeonpea, Weather.

INTRODUCTION

Leaf webber also referred as 'leaf tier' (Lateef and Reed,1983) [*Grapholita critica* (Meyr.); Tortricidae: Lepidoptera] is one of the primary foliage feeders on pigeonpea and attack reproductive structures (flower and pods) to become 'pod borer' when infestation occurs at late stages of crop. Larvae cause damage by webbing terminal leaves using silken threads and feed on chlorophyll. While the symptoms of infestation are very conspicuous, yield loss under caged conditions was estimated around 5.7 per cent at a larval population of 10/plant (Kumar *et al.* 2014b). Hitherto considered as a minor pest (Narendra *et al.*1998),*G. critica* is an emerging pest and has drawn attention across pigeonpea growing are assince dawn of 21st century (Sahoo and Senapati, 2000; Sinam and Singh, 2004; Singh *et al.* 2013, Sahoo *et al.*, 2014 and Gayatree Sahoo and Sahoo, 2016). Elaborate studies on *G. critica* on its nature of damage and biology, assessment of crop losses, damage-weather relations and screening of genotypes of pigeonpea (Kumar *et al.* 2014a,b,c) from Karnataka have been the latest in India.

Understanding the dynamics of damage and their interaction with biotic and abiotic factors require not only generation of data through carefully planned experiments under field conditions but also a robust approach to analyses of data obtained. Treatment of data generated based on planned experiments through setting of different hypotheses results in inferences of realistic value. Crop-pest interactions are highly influenced by weather and when pest-weather relations are quantified using appropriate models it is possible to predict the impending damage. Present study accounts the published data of Kumar *et al.*(2014c) for further investigations into establishing better understanding of favourable crop stage and weather conditions in addition to development of an improved weather prediction model of damage due to *G. critica*.

MATERIALS AND METHODS

Data on damage due to leaf webber *G. critica* were generated from field trials taken up using pigeonpea *cv.* Maruthi (ICP 8863) with seven different dates of sowing between fourth week of June and first week of August exactly at weekly intervals in three replicates at Agricultural College,

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Gulbarga, Karnataka during *kharif* of 2012-13. Each replicate had 150 plants grown at a spacing of 90X30cm. Sampling for damage due to *G. critica* was made at weekly intervals between first week of August and mid-October by counting number of webs with live larvae of *G. critica* on whole plant basis from among 50 randomly selected plants per plot. While data on damage due to *G. critica* (webs/50 plants) furnished along the Standard Meteorological Weeks (SMW) in respect of seven sowing periods was considered from the published data of Kumar *et al.*(2014c), SMW based weather data for the corresponding period (32-42SMW) obtained from meteorological observatory of ARS, Gulbarga as a part of National Innovations in Climate Resilient Agriculture project was used to work out relations between G. *critica* damage and weather.

As a first step, crop age (in weeks) corresponding to each SMW based observation on *G. critica* damage in respect of different sowing periods was calculated. Secondly, data sets were grouped along similar SMWs and crop age (in days) across sowing periods. One way analysis of variance ANOVA was performed on *G. critica* damage dynamics calculated across categories of seven sowing periods in respect of each SMW and crop age basis with their pairwise mean comparisons made through Duncan's multiple range test (DMRT) using SAS 9.4®. Considering the damage dynamics with single peak observed along SMW and crop age, a first order polynomial model was fitted for *G. critica* damage with crop age as a response variable. Multiple regression model was used to describe *G. critica* damage – weather relations using maximum and minimum temperature (°C),morning and evening relative humidity (%) and rainy days (nos) as explanatory variables in addition to crop age.Non parametric regression was applied to find out the role of any other variable other than that in the MLR influencing damage due to *G. critica*. Both the regressions were run using SAS 9.4®.

RESULTS AND DISCUSSION

G.*critica* damage in relation to sowing periods, calendar and crop age based observations: Seven different sowing periods of pigeonpea had just three different onset periods for seasonal dynamics based on calendar weeks (SMWs) (Fig. 1). Onset of *G. critica* damage varied with sowing periods and was simultaneous during SMWs of 32 (August II week) and 34 (August IV week) for the crop sown during June IV - July III and July IV – August I weeks, respectively. August II week sown crop had *G. critica* damage from 35 SMW (August last week). On the other hand peak damage occurred only during two periods of SMWs *viz.*, 36 (September I week) and 38 (September II week) in respect of June IV-July I and July II-August II sowing periods. Dynamics of *G. critica* damage plotted on crop age (Fig.2) indicated that early sown (June IV week) crop had onset at seventh week of crop age with each of the successive sowing periods *viz.*, July I and II weeks having onset periods during sixth and fifth weeks, respectively. Sowing periods beyond July III week had onset coinciding with four weeks of crop age indicating the exposure of crop to early infestations by *G. critica* with delayed sowing periods. While seasonal damage levels of *G. critica* for sowing periods were non-significant, statistically significant differences were observed for the SMW and crop age based analyses (Table 1).

Comparisons of damage on calendar (SMW) basis indicated significantly higher damage between 36 and 39 SMWs with first and last three weeks with lower and on par damage. Higher but overlapping damage were noticed between7th and 13th week of crop age with early and late crop stages having reduced damage indicating the capability of *G. critica* to cause higher damage over one month period, and damage levels were largely crop stage dependent. Longer duration (seven weeks) along crop growth over calendar based periods (four weeks) signified crop stage dependent

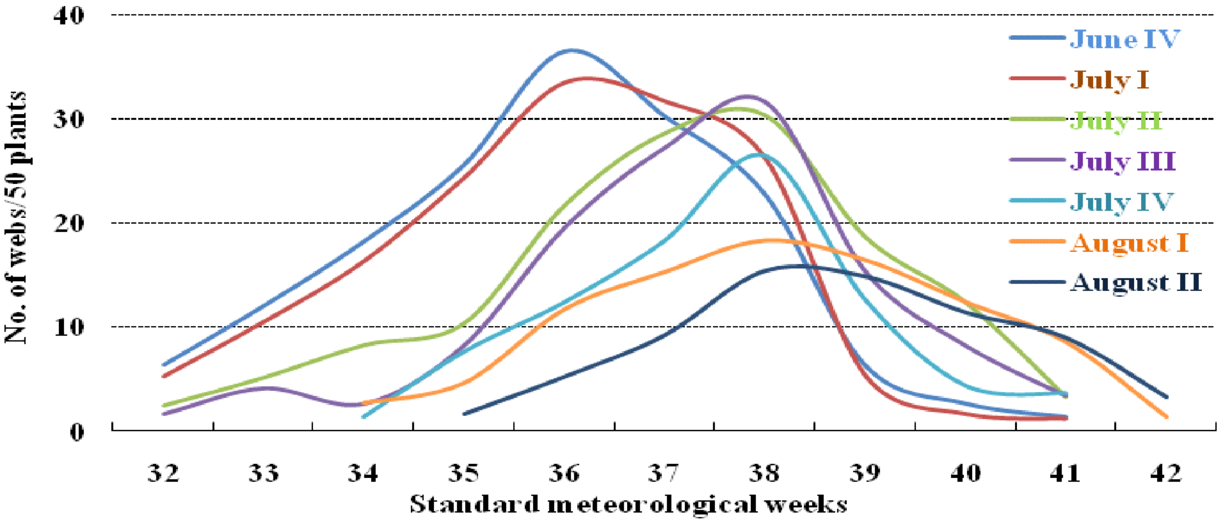

Fig.1: Calendar based *G. critica* damage dynamics in relation to sowing periods

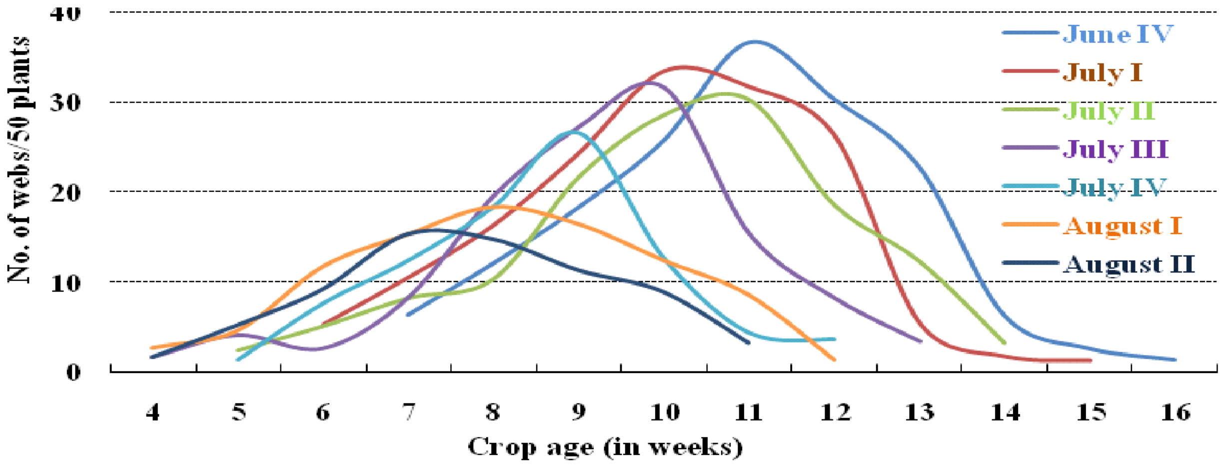

Fig.2: Crop age based *G. critica* damage dynamics in relationto sowing periods

Table-1. Damage due to *G. critica* (No. of webs/50 plants) in relation to sowing periods, calendar and crop age

Sowing period (SMW)	Damage*	SMW	Damage*	CA (in weeks)	Damage*
June IV week (26)	16.2^{a}(2.51)	32	3.9^{f}(1.51)	4	1.9^{de}(1.03)
July I week (27)	15.6 $^{a(}$2.46)	33	7.9^{cdef}(2.11)	5	4.9^{cde}(1.45)
July II week (28)	14.1 ^{a}(2.43)	34	8.2^{def}(1.91)	6	7.4^{bcd}(1.99)
July III week (29)	12.2 ^{a}(2.25)	35	11.8^{bcde}(2.28)	7	10.9^{ab}(2.43)
July IV week (30)	10.8 ^{a}(2.21)	36	20.7^{abc}(2.89)	8	6.32^{ab}(2.79)
August I week (31)	10.1 ^{a}(2.20)	37	22.9^{ab}(3.10)	9	20.82^{a}(3.04)
August II week (32)	8.7 ^{a}(2.11)	38	24.4^{a}(3.21)	10	19.29^{a}(3.02)
		39	12.7^{abcd}(2.54)	11	15.79^{ab}(2.67)
		40	7.5^{def}(1.97)	12	14.71^{abc}(2.38)
		41	4.3^{ef}(1.52)	13	10.96^{abc}(2.27)
		42	2.3^{f}(1.14)	14	3.73^{cde}(1.47)
				15	1.90^{de}(0.03)

* Means followed by the superscript of same letters in all three columns are not significantly different based on DMRT at P <0.05 in ANOVA performed on the log (X+1) transformed values; Figures in parentheses are mean of log (X+1) transformed values.

damage due to *G. critica*. Best fit of polynomial relations of second order also indicated importance of crop age over SMWs (Fig.3 and 4) signifying. The nature of damage by *G. critica* is highly dominant on vegetative plant parts (leaves) for all larval stages (Kumar *et al.*2014a) and that pigeonpea crop continually possesses vegetative terminals offer prolonged periods of food availability along crop age. Secondly the differentials of pigeonpea genotypes for resistance to *G. critica* and crop maturity (early/medium/late) determine the onset and period of damage, respectively under field conditions although peak damage can be simultaneous across cultivars, periods and growing locations of pigeonpea. September peaks have been common between UPAS 120, an extra early maturing (120-125 days) (Akhilesh and Nath,2003) and Maruthi (IC 8863), a medium duration (150-160 days) (Kumar *et al.* 2014c) cultivar at hot semi-arid locations of Varanasi (UP) and Gulbarga(KA), respectively. The foregoing results and discussion imply the presence of damage due to *G. critica* on pigeonpea once initiation of the insect starts and continues along different stages of crop during the season with the degree of damage dependent largely on crop age over calendar dates.

***G.critica* damage weather relations:** Role of weather factors in the buildup of damage due to *G. critica* was estimated through multiple linear regression (MLR) considering variables of maximum and minimum temperature, morning and evening relative humidityand rainy days. Based on the significant impact of crop age on the damage dynamics of *G. critica* found through earlier analyses (Fig.3&4), the linear and quadratic effect of crop age (CA) (i.e. CA and CA^2) were also used as response variables in MLR. The results indicated on the significant influence of totality of all the factors ($F_{(7,55)}$=29.81, P<0.001) with value of R^2 as 0.79 indicating that the damage was explained about 79% by all the regressors variables used in the model. The fitted MLR model is:

G. critica damage (Nos/50 webs) = -145.33 +2.58 MaxT*+1.62 MinT* -1.39MRH** +1.77 ERH** -2.47Rainyday** +1.60 CA**-0.01 CA^{2**} (R^2 = 0.79)
(* and ** denotes significance of partial regression coefficients at 5% and 1% level respectively)

The adequacy of fitted model investigated in terms of residual diagnostics indicated independent and normal distribution of data sets as depicted in Fig. 5. Both the plots

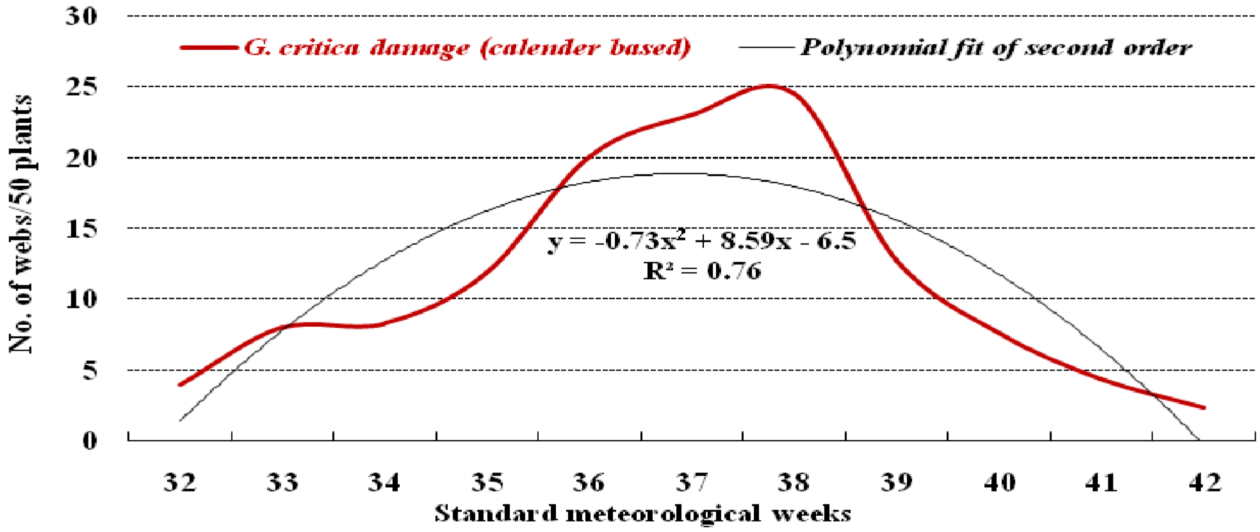

Fig 3: Polynomial fit for calendar based *G. critica* damage dynamics

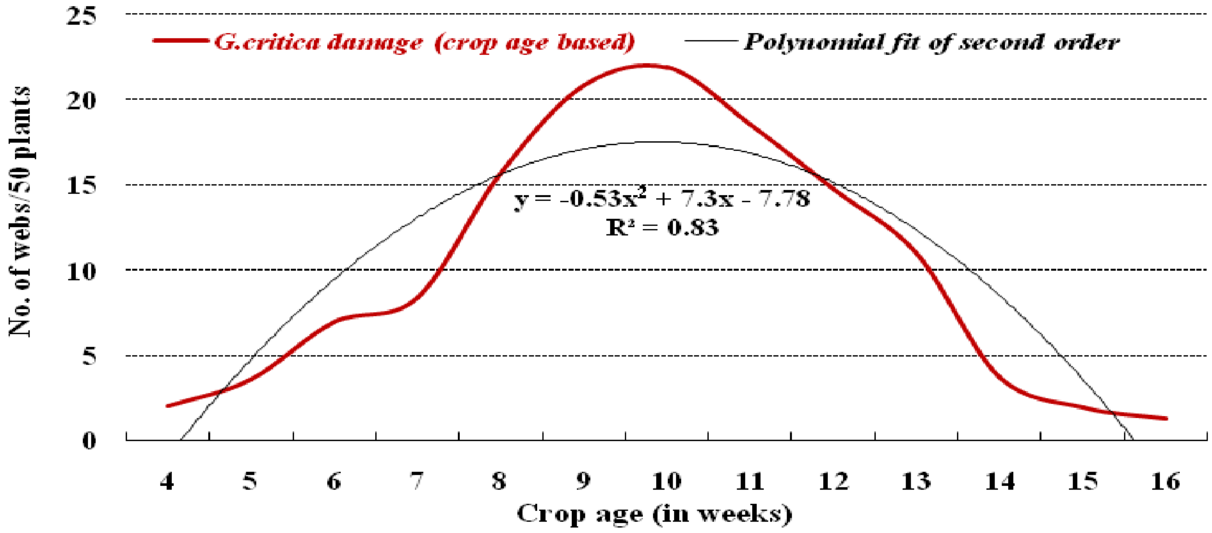

Fig 4: Polynomial fit for crop age based *G. critica* damage dynamics

in left side reveal the approximate normality of the residuals computed from the fitted MLR and plots in the right indicate the goodness of fit. It is to be mentioned that the fit is quite good as seen from the plot that the predicted line passed through maximum number of observations besides a higher R^2 (0.79).

Positive influence of temperature (maximum and minimum), evening relative humidity and crop age (CA) and negative influence of morning relative humidity, rainy day and quadratic form of crop age (CA^2) were all found significant. While higher temperature could increase the rate of development of larvae feeding inside the webs continuous rains on many days could cause direct mortality of larvae that reduce the damage due to *G. critica*.Kumar *et al.* (2014c) reported maximum temperature as the only variable significant on *G. critica* damage based on the same data sets with $R^2 = 0.16$. However incorporation of linear as well as quadratic effect of crop age as response variables in MLR had improved the predictability by 63% reiterating the crop age as a major factor of importance towards damage by *G. critica*.

Non parametric regression was used in order to find out effect of any regressor variables other than the linear effect estimated using MLR. It was found that the maximum and minimum temperature had significant nonlinear effect towards *G. critica* damage. The estimated nonlinear effect along with 95% confidence intervals is plotted in Fig.6. Damage due to *G. critica* increased up to a maximum temperature of around 30° C and thereafter declined. On the contrary the case of minimum temperature was just the opposite with reduced damage up to 23°C followed by a rapidly increasing damage as minimum temperature increased indicating less than 30 and greater than 23°C of

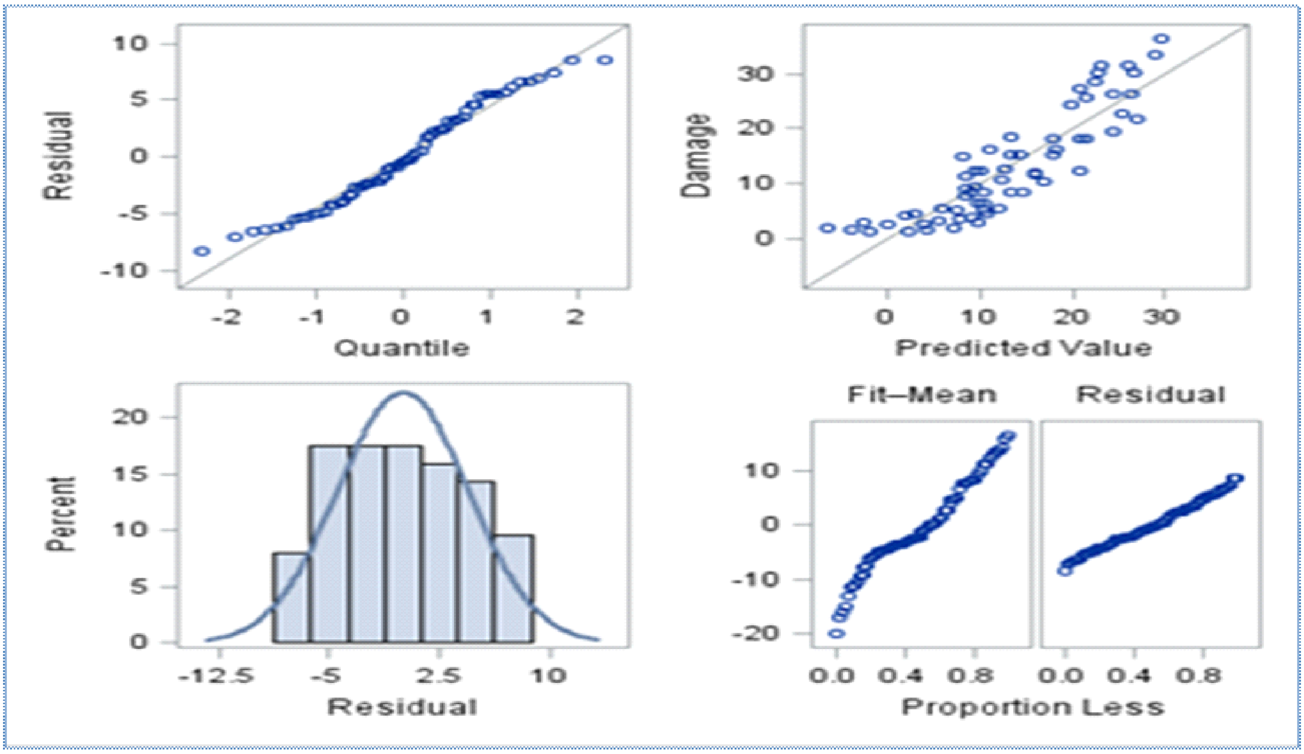

Fig-5: Diagnostics of residuals of fitted MLR

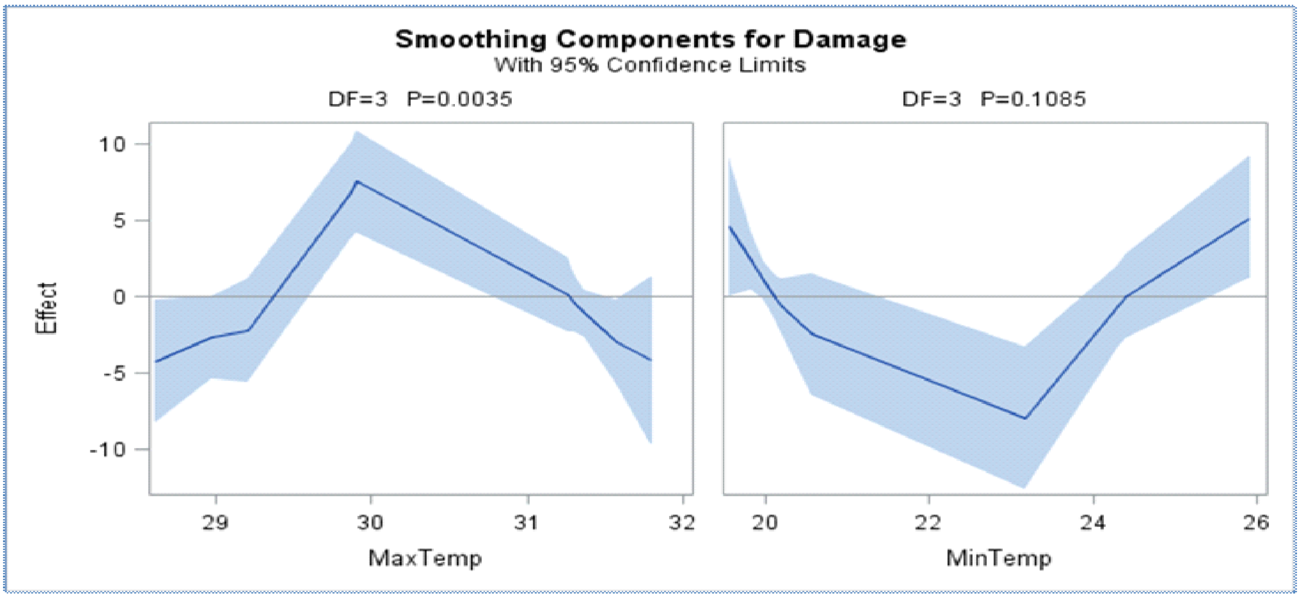

Fig-6: Effect of maximum and minimum temperature on *G. critica*damage

maximum and minimum temperatures, respectively congenial for higher damage due to *G. critica*.

CONCLUSION

Significance of description of damage along crop age and use of relevant analytical approach towards unravelling the most important information influencing damage caused by *G. critica* which otherwise gets masked and remains unknown has been demonstrated through present study. Since the crop age at a given point of time among different fields are varied and that crop growth and development is a manifestation of prevalent edaphic and atmospheric environmental conditions along crop stage it is more prudent to use the scale of crop age along with the calendar based observation of damage due to insect pests to draw valid inferences. However, it is also incumbent upon the study objective to determine the weightage given to variables of weather and crop along the calendar or crop age based seasonal dynamics.From plant protection perspective considerations of real time calendar based *G. critica* management on field basis and of crop stage for an area wide management are a must.

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