Impact of climate variability on recent and future status of jassid infestation in groundnut at Kadiri, a hot arid region of A.P. State

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Groundnut (*Arachis hypogaea* L.) is an important oilseed crop grown in India over 4.56 mha with production and productivity of 6.77 mt and 1486 kg/ha, respectively with Andhra Pradesh accounting for 17.0% of area and 11.8% of production. Anantapur district of Andhra Pradesh situated in agro ecoregion of Deccan plateau and central highland hot ecoregion of India is the largest producer (0.11mt) in the State from an area of 0.89 mha (Anonymous, 2017). Groundnut crop suffers attack from variety of insect pests, pathogens and weeds that cause heavy yield and monetary losses (Dhaliwal *et al*., 2010). Among sap feeding insects, jassids (*Empoasca kerri* Singh-Pruthi) occur regularly on groundnut. Jassid infested plants show yellowing on leaf tips with typical V shaped mark resulting in 'hopper burn' under favourable weather conditions and cultural practices (Mer *et al*., 2016). Jassid infestation alone cause up to 22% yield loss in groundnut (Vyas 1984). Understanding the influence of weather fluctuations and climate variability on dynamics of *E. kerri* infestation aids in strategizing adaptive management practices in the climate change era.

The present study was a part of information and communication technology (ICT) based pest surveillance implemented to study pest dynamics in relation to climate change on groundnut during *Kharif* 2011-16 under National Innovations in Climate Resilient Agriculture (NICRA). Observations on jassid infestations were made from two fields of one acre each across 10 villages located within 30 km radius of meteorological observatory of Agricultural Research Station, Kadiri of Anantapur (AP) (14°06'N & 78°08'E) . Five spots/field were randomly selected with observations made on ten plants selected per spot right from vegetative stage till crop harvest (29-47 standard meteorological weeks (SMWs)). Cultivar Kadiri 6 was grown with sowing dates spread between June and July during all seasons. Farmers followed standard package of practices of groundnut cultivation of the State (Anonymous, 2009). Weekly counts of the number of plants showing symptoms of jassids (jassid infestation) per spot were recorded. Meteorological variables *viz*., maximum and minimum temperature (MaxT & MinT in ^{0}C) and total rainfall (RF in mm) from Agricultural Research Station, Kadiri based on SMWs pertaining to *kharif* of 2011-2016 were collected. 'Normals' in respect of weather variables *viz.,* MaxT, MinT and RF based on 40 years average for Kadiri location were obtained from All India Co-ordinated Project on Agro Meteorology, Central Research Institute for Dryland Agriculture, Hyderabad. Mean jassid infestation (%) worked out for each period of observation for individual and across fields of each season was calculated in respect of different seasons. One way ANOVA was performed to assess seasonal variability of jassid infestations, weather fluctuations and climatic deviations across seasons. 't' test to signify magnitude of climate variability and and Kendall's 'tau' correlations to infer influence of climatic variations on jassid infestations, respectively were used. Future scenario of jassid infestation under changing climate using representative concentration pathway 4.5 scenario was understood through Kendall's 'tau' correlations between jassid infestation dynamics of current period with the projected climatic variables.

Inter-seasonal variability of jassid infestations was significant and followed the order of 2013 (46.8%)>2014 (38.1%)>2011 (34.7%) &2016 (33.4%) >2012 (30.3%)> 2015 (20.8%). Seasonal variations for weather fluctuations was significant only for maximum temperature (Max T). Long-term climatic variability had shown significance for both maximum and minimum temperature. Significantly higher maximum temperature (33.3°C) recorded in 2011 was 2.9°C above normal. Lowest maximum temperature was in 2013 and 2012 (29.7 & 30.4°C) that had least increase of 0.02 and 0.69°C, respectively over normal. Minimum temperature (Min T) variability was lowest in 2011 (0.11 °C) and on par amongst 2012-16 that had a range of 0.84 to 1.47°C. Impact of weather fluctuations on

Table 1. Inter-seasonal variability of jassid infestations, weather and climate during *kharif* at Kadiri (AP)

Variables	2011	2012	2013	2014	2015	2016	F value & significance
Jassid infestation (%)	34.7[c]	30.3[d]	46.8[a]	38.1[b]	20.8[e]	33.4[c]	146.0
A. Weather fluctuations							
MaxT (°C)	33.3[a]	30.4[bc]	29.7[c]	31.5[b]	30.9[b]	31.0[b]	8.5***
MinT (°C)	21.3	22.0	22.05	22.6	22.6	22.1	1.4 ^{NS}
RF (mm/week)	14.6	24.8	19.6	8.5	22.5	9.1	1.5 ^{NS}
B. Climatic deviations							
MaxT (°C)	2.9[a]	-0.02[cd]	-0.69[d]	1.10[b]	0.58[bc]	0.63[bc]	11.4 ***
MinT (°C)	0.11[b]	0.84[a]	0.85[a]	1.37[a]	1.47[a]	0.87[a]	3.9 **
RF (mm/week)	-3.80	6.51	1.23	-9.92	4.12	-9.32	1.3 ^{NS}
C. Kendall's correlation coefficients (r) between jassid infestations and climatic variability							
MaxT (°C)	-0.10***	0.27***	0.01	-0.28***	-0.12***	0.06	-
MinT (°C)	-0.09**	0.39***	-0.08	-0.05	-0.29***	0.37***	-

For A &B, means in row followed by the same letter are not significantly different based on DMRT following one way ANOVA; For C. values and significance pertain to correlation between jassid infestations and climatic variability; ** *significance at p<01.*; *** *significant at p<0.001*

Table 2. Magnitude of climatic variability and its relation to jassid infestations

Climatic variables	Actual means of weather (2011-16)	Quantified Climatic variability[$]	Correlation coefficients (tau) [@]
Max T. (°C)	31.1	0.76***	-0.09***
Min T. (°C)	22.1	0.92***	-0.01 ^{NS}

[$] climatic variability of 2011-16 calculated over normals of 40 years *based on 't' test between actual and deviations of respective weather variables from normals over 2011-16*; [@] values pertain to Kendall correlations between jassid infestations and climatic variability over 2011-16; *** *significant at p<0.001*

Table 3. Future status of jassid infestations on groundnut at Kadiri (AP) under RCP 4.5 scenario

Climatic variables	Future periods		
	2020	2050	2080
Max T. (°C)	0.14 ^{NS} (32.4)	-0.16 ^{NS} (32.6)	0.01 ^{NS} (36.9)
Min T. (°C)	-0.05 ^{NS} (23.6)	-0.50 ^{NS} (26.2)	-0.07 ^{NS} (26.9)

[#:] Values outside brackets are Kendall correlations between jassid infestations and climatic projections; ^{NS} *Non significant.* Values within brackets are projected means of Max T and MinT in °C jassid infestations indicated differences amongst seasons implying maximum temperature fluctuations in particular in combination with other system factors affecting the season-to-season variations in jassid infestations (Table 1). Actual values and quantified variability (deviations from normal) of Max T (in °C) and MinT (in °C) for 2011-16 period of groundnut cropping season at Kadiri (AP) was 31.1 and 21.1 and 0.76 and 0.92, respectively with deviations being highly significant. Significantly increasing trends of maximum and minimum temperature had negative associations with jassid infestations although Kendall 'tau' was significant for Max T and non-significant with MinT. This again reiterates that increasing maximum temperature with no significant change in minimum temperature in recent years had a reducing effect on jassid infestations (Table 2). The negative effect of maximum temperature was reported on cotton jassids (Mer *et al*., 2016) in Gujarat and on Okra (Sandhi and Sindhu, 2018) in Punjab.

Kendall's 'tau' correlation coefficients worked out between current dynamics of jassid infestations and Max T and Min T projections under 4.5 level of representative concentration pathway (RCP) (radiative forcing level of 4.5 W/m² with stabilization after 2100) of future periods *viz.,* 2020, 2050 and 2080 had shown non-significant associations implying absence of climate change impacts on jassid infestation.

From pest management perspective, the significant variations across seasons due to short-term weather fluctuations would make jassid infestation forecasts unreliable. On long term basis, the climate change effects on jassid infestations are insignificant and decreasing jassid infestations on groundnut with current and future periods with magnitudes of increasing temperature (MaxT & Min T) at Kadiri (AP) is expected to reduce the load of insecticides on the crop. It remains to be seen the adaptability of jassids under future climate change scenarios and response to uncertain weather aberrations that may arise. Systematic field based real time pest surveillance put in place for decision making on pest management options in conjunction with economic thresholds would prove to be highly effective under all scenarios of climate and pest dynamics.

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