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Effect of some Weather Factors on Pink Sugarcane Mealybug, *Saccharicoccus sacchari* Ckll. (Homoptera: Pseudococcidae)

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Abstract: Three insect expressions were utilized *i.e.* Intensity Y_1, incidence Y_2 and insects number/20 stalk Y_3 to recognize simple correlation and regression (R^2) between plant age and the three infestation parameters. In addition to multiple regression equations which applied using six independent variables (High and low temperature, high and low relative humidity, wind speed and period of daylight) and infestation incidence were carried out. Results obtained revealed: Simple correlation between plant age and infested intensity, incidence and insect no. were positive for most cultivars in the three seasons. All the coefficient of determination (R^2) between dependent variables (Y_1, Y_2 and Y_3) and independent ones (cultivars) were significant in the 1st and 2nd ratoon. However, for infested intensity (Y_1) only G 99-103 (69.32), GT 54-9 (57.75) and PH 8013 (48.57) cultivars gave significant R^2 values in plant cane. Meantime, R^2 of infested incidence (Y_2) was significant for all cultivars except GT 54-9 in plant cane. The highest R^2 was of the 2nd ratoon for all cultivars, the relation during plant cane and 1st ratoon varied for all cultivars except G 84-47. The same trend was recorded in the three seasons. Infested incidence (Y_2) gave the good relations with plant age. The response of sugarcane cultivars of the tested weather factors increased by increasing the plant age (positive effect). Therefore, cultivars according to its resistant (R^2 values) to mealybug infestation could be arranged in descending order as follows: G 84-47, G 98-28, PH 8013, G 99-103 and GT 54-9. Values of R^2 for the weather factors cleared that Wind speed (Spe) had the effective role during plant cane and 1st ratoon for mealybug incidence, respectively. However, in the second ratoon Low Relative Humidity (LRH) and Low Temperature (LT) greatly affected the mealybug incidence.

Key words: Cultivars · Sugarcane · Mealybug · Infestation · Weather factors · Regression

INTRODUCTION

Climate and weather can substantially influence the development and distribution of insects. Anthropogenically induced climatic change arising from increasing levels of atmospheric greenhouse gases would, therefore, be likely to have a significant effect on agricultural insect pests. Current best estimates of changes in climate indicate an increase in global mean annual temperatures of 1°C by 2025 and 3°C by the end of the next century. Such increases in temperature have a number of implications for temperature-dependent insect pests in mid-latitude regions. Changes in climate may result in changes in geographical distribution, increased over wintering, changes in population growth rates, increases in the number of generations, extension of the development season, changes in crop-pest synchrony, changes in inter-specific interactions and increased risk of invasion by migrant pests [1]. Ebieda *et al.* [2] found that there were positive relationships between the mean temperature or the possible sunshine duration and aphid number/100 sugar beet leaves as well as infestation percentage of cotton aphid. The mean relative humidity had a little effect on aphid number/100 leaves or infestation percentage of cotton aphid on sugar beet. The timing of attack by pest insects can vary greatly both from region to region and from year to year because the rates at which insects complete their life cycles depend mainly on temperature [3]. Samson [4] accomplished that temperature and cultivar may influence the harmful effect of soldier fly larvae *Inopus rubriceps* (Macquart) on

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sugarcane planting pieces (sets) germination by changing the differential rates of plant growth and larval feeding. Venäläinen and Heikinheimo [5] concluded that many agricultural applications are based on meteorological data. For example estimation of surface moisture, crop yield or forecasting of outbreak of crop diseases or insect pests is largely dependent on meteorological conditions. Abdel-Moniem [6] reported that the effect of weather factors on the population density of the *P. tenuivalvata* (the correlation between the total number of pests and temperature or relative humidity) were positive to both seasons. Yadav *et al.* [7] found that the average number of mealy bugs (*D. mangiferae*) per panicle as well as per trunk were recorded and correlated with a biotic factors *i.e.* average temperature, relative humidity and rain. The highest population (17.50) of mango mealy bug per panicle was recorded on 5 April 2000 at an average temperature and relative humidity of 27.43 degrees C and 46.57%, respectively. A decreasing population trend *i.e.* 8.25 and 4.75 was observed on 26 April and 3 May 2000 at an average temperature of 31.31 and 31.55 degrees C and relative humidity of 48.35 and 49.80%, respectively, due to increasing temperature and relative humidity. The lowest population (1.50) of mango mealy bug was recorded on 24 May 2000 at an average temperature and relative humidity of 33.03 degrees C and 56.75%, respectively. No infestation was recorded on 31 May 2000 due to an increase of temperature (33.55 degrees C) and relative humidity (63.05%). A similar trend of increase and decrease of mealy bug population on the tree trunk was observed with increase and decrease of temperature and relative humidity. The bug population on the tree trunk came to nil on 17 May 2000 on wards. Pandey and Kant [8] concluded that significant and positive correlation (r ranging from 0.465 to 0.541 for the crops) existed between the pest population and the maximum temperature whereas minimum temperature correlated negatively. A highly significant positive correlation with relative humidity (r ranging from 0.71 to 0.84) clearly showed a major role in pest build up. Moral García [9] reported the non-existence of correlations between temperature and relative humidity, with insect populations of *Helicoverpa armigera* in tomato field.

Climate change will increase the recurrence of extreme weather events such as drought and heavy rainfall [10]. Woolly aphid, *Ceratovacuna lanigera* (Homoptera: Aphididae) of sugarcane was recorded in Sugarcane Research Station, Bethuadahiri, Nadia and West Bengal, India during 2003-04, 2004- 05 and 2005-06 on BO140 genotype. Santanu and Jha [11] stated that pest population was recorded as maximum in September and minimum in January due to low temperature conditions during those periods. Correlation Coefficient (r) showed that there was positive significant relationship with maximum temperature, minimum temperature, relative humidity and rainfall during that period. This climate changes effected on sugarcane woolly aphid in SriLanka in 2006 [12]. Hu *et al.* [13] indicated that organisms can respond to variation in temperature through the direct effect of temperature on phenotypes (phenotypic plasticity), or through long-term adaptation to temperature (and thus evolution of either mean size or thermal reaction norm).

MATERIALS AND METHODS

Field trial was carried out at Mallawi Agricultural Research Station, El-Minia Governorate, Middle Egypt during the three successive seasons, 2006/2007 as plant cane (first growing season), 2007/2008 as 1st ratoon cane (second growing season) and 2008/2009 as 2nd ratoon cane (third growing season) to study the effect of weather factors on the of pink sugarcane mealybug, *Sacchariacoccus sacchari* infestation on some sugarcane cultivars. Therefore, four new promising sugarcane cultivars *i.e.* PH (Philippine) 8013, G. (Giza) 84-47, G.98-28 and G.99-103 in addition to the main commercial sugarcane cultivar named Giza-Taiwan (G.T.) 54/9 known as C9 were used, under natural infestation (without insect control program). Cultivars were distributed in a randomized complete block design (RCBD) with four replicates. Plot area was 42 m^2 (1/100 Feddan, one Feddan = 4200 m^2), each plot consists of 6 ridges, 7 m long and one meter apart. Cultivars were planted on February 14, 2006, using fixed number of three budded cane sets free of pests and diseases. The experiment was received the usual recommended agricultural practices and no insecticides were applied for pest control throughout the whole seasons. A sample of 20 guarded sugarcane plants (stalks) of each cultivar was randomly taken from each plot at 14 days interval up to harvest. Plant cane samples were begun from May 2, 2006 up to harvest on March 20, 2007, while, samples of 1st ratoon cane and 2ndratoon crops were from April 4, 2007 and 2008 to March 20, 2008 and 2009, respectively. (It should be noted that harvest date of plant cane (first season) was considered approximately the sowing dates of ratoon crops). Sample were carefully examined to determine number of infested stalk, total number of internodes, number of infested internodes and number of individual mealybug insects (nymphs and adult) per 20 stalks and the following parameters were calculated:

- The percentage of infested stalk (infestation incidence).
- The percentage of infested internodes (infestation intensity).

In this connection, many authors used different insect expressions, which articulated the population density of mealybug. In this investigation, three insect expressions were utilized, *i.e.*, Intensity (Y_1), Incidence (Y_2) and insect numbers (Y_3). To recognize among these expression, simple correlation values were calculated between age of plant X and Y_1, Y_2 or Y_3. In addition, the multiple linear regression equations were applied by using 6 independent variables (X's) and three dependent variables (Y's). The independent variables were High Temperature (HT) (X_1), Low Temperature (LT.) (X_2), High Relative Humidity (HRH) (X_3), Low Relative Humidity (LRH) (X_4), Wind Speed (SPE) (X_5) and Period of Day Light (PE) (X_6), while the dependent ones were Y_1, Y_2 and Y_3. The multiple liner regression equations were established for each dependent variable. Simple correlation and coefficient of determination (R^2) values were compared among all tested insect expressions to select the best term. All these values were applied on five promising sugarcane cutivars during the plant cane, 1st and 2nd ratoon. Data were recorded every 14 days (as mentioned before), percentage data were transformed to Arc-sine before the statistical analysis. Statistical analysis was carried out according to Steel and Torrie [14] and computed by Costat 2.00 program (Copyright 1986 Cohort Software). Weather factors were obtained from the locally stationed meteorological observatory in Mallawi (El-Minia Governorate) for the periods under study.

RESULTS AND DISCUSSION

Recognition of the Tested Insect Expressions: Data presented in Table 1 summarized the simple correlation (r) between age of plant (X) and Intensity (Y_1), Incidence (Y_2) or insect numbers (Y_3). All correlation values between age of plant (X) and Y_1 or Y_3 were positive but insignificantly for most cultivars in plant cane, 1st and 2nd ratoon, respectively. However, the correlation with Y_2 gave positive and significant effects for all tested sugarcane cultivars except G 98-28, further, this correlation was insignificant for both PH 8013 and G 99-103 cultivars in plant cane only. Regarding to the significantly of the coefficient of determination (R^2) values between dependent variable (Y_1, Y_2 and Y_3) and independent variable (all tested cultivars) in Table 2 and graphically illustrated in Fig. 1, all these values had significant influences during the 1st and 2nd ratoon for all independent variables. However, for Y_1 dependent variable, only G 99-103 (69.32), GT 54-9 (57.75) and PH 8013 (48.57) had the significant values during plant cane period. Nevertheless, for Y_2 dependent

Table 1: Simple correlation between age of plant (X) with intensity (Y_1), incidence (Y_2) or insect numbers (Y_3) through three sequence seasons from 2006 to 2009

Cultivars	Seasons	X Y_1	X Y_2	X Y_3
GT 54-9	Plant cane 06-07	0.297	0.443*	0.182
	1st Ratoon 07-08	0.179	0.529**	0.144
	2nd Ratoon 08-09	0.373	0.516**	0.156
PH 8013	Plant cane 06-07	-0.033	0.299	-0.276
	1st Ratoon 07-08	0.122	0.596**	0.151
	2nd Ratoon 08-09	0.136	0.571**	0.072
G 84-47	Plant cane 06-07	0.005	0.505*	-0.163
	1st Ratoon 07-08	0.333	0.631**	0.142
	2nd Ratoon 08-09	0.305	0.643**	-0.008
G 98-28	Plant cane 06-07	-0.116	-0.257	-0.138
	1st Ratoon 07-08	0.241	-0.258	0.273
	2nd Ratoon 08-09	0.257	0.299	0.335
G 99-103	Plant cane 06-07	-0.077	0.323	-0.050
	1st Ratoon 07-08	0.324	0.563**	0.090
	2nd Ratoon 08-09	0.147	0.548**	0.127

* Significant at 0.05

** Significant at 0.01

Table 2: Coefficient of determination ($R^2 \times 100$) of three dependent variables; Intensity (Y_1), Incidence (Y_2) or insect numbers (Y_3) with some meteorological factors through three sequence seasons

	Y_1			Y_2			Y_3		
Sugarcane cultivars	Plant cane	1st ratoon	2nd ratoon	Plant cane	1st ratoon	2nd ratoon	Plant cane	1st ratoon	2nd ratoon
GT 54-9	57.75**	48.79*	85.65***	44.42	68.49***	76.42***	58.91**	50.93*	76.84***
PH 8013	48.57*	53.08*	85.04***	49.49*	66.15***	84.58***	57.84*	54.34*	78.32***
G. 84-47	43.67	45.45*	74.79***	57.45**	64.53***	82.79***	55.96*	70.62***	75.17***
G 98-28	44.28	45.37*	70.60***	52.92*	71.18***	80.08***	69.00**	67.52***	80.25***
G 99-103	69.32**	59.54**	86.90***	50.31*	69.00***	76.90***	59.89*	47.17*	63.34**

• Significant at 0.05, **Significant at 0.01, ***Significant at 0.001

variables for all tested cultivars (independent variable) gave significant values except G.T.54-9 (44.42) during plant cane period. These R^2 values during the 2nd ratoon for all independent variable (cultivars) were exhibited the highest R^2 values in comparison with the other two seasons. In addition, the relations during the plant cane and 1st ratoon varied for all tested sugarcane cultivars except G 84-47, where the same relations were recorded for three seasons. The R^2 values of independent variables for the previous cultivar increased with increasing the age of plant. In regards to the rest of cultivars, they got the same sequence for two years and varied in one year. However, PH 8013 and G 98-28 followed the same sequence for the plant cane and 1st ratoon. In comparison with all independent variables, only the order of significance values of Y_2 (Fig. 1) for three seasons were similar, where the significance values increased gradually from plant cane to 2nd ratoon, while this trend was not observed for Y_1 and Y_3 (Fig. 1).

Perusal of data in Tables 1 and 2 and Fig. 1, it is clear that Y_2 gave the good relations with age of plant according to simple correlation values (Table 1). Regarding to R^2 values in Table 2 and Fig. 1, no definite conclusions about the tested independent variables (cultivars) could yet be made but the constant behavior of R^2 values for Y_2 corroborated that Y_2 was the best expression for mealybugs.

Simultaneous Effect of Some Weather Factors on the Infestation with Mealybugs: Data concerning the effect of High Temperature (HT) (X_1), Low Temperature (LT.) (X_2), High Relative Humidity (HRT) (X_3), Low Relative Humidity (LRT) (X_4), Wind Speed (Spe) (X_5) and Period of Day Light (Pe) (X_6), on Incidence (Y_2) of mealybugs were recorded in Table 3. It is noticed that all R^2 values were significance except G.T.54-9 during plant cane period. The lowest R^2 values were recorded during the plant cane and then increased gradually in the 1st and 2nd ratoons for all tested sugarcane cultivars. Those results showed that the response of sugarcane cultivars of the tested weather factors increased by increasing the age of plant (positive effect). Based on, the resistant of tested cultivars could be arranged in the following descending order according to R^2 values: G84-47 > G98-28>PH8013 > G99-103 > GT54-9.

In general, Although Pe had the highest (*b*) value (slope), Pe did not have an effect on the Incidence of mealybug during three tested seasons except for G 84-47 cultivar in the second ratoon. Also, HT had no effect on the used cultivars and the three seasons except PH 8013 in plant cane. Moreover, during the plant cane, HRH effect was observed for GT 54-9, PH 8013 and G 84-47. While during the 1st ratoon, only the Wind Speed (Spe) was significant for all tested sugarcane cultivars. Also, LT factor had significant influence on G.T.54-9 (for both 1st and 2nd ratoon), G 84-47 (for 2nd ratoon) and G 99-103 (for 1st ratoon and 2nd ratoon). While, in the 2nd ratoon, LRH gave the significant effect on GT 54-9, PH 8013, G 84-47 and G 98-28. Therefore, the response of the sugarcane cultivars varied from season to season as well as within cultivars. Based on, it is claimed that Wind speed had the effective role during plant cane and 1st ratoon, respectively. At the same time in 2nd ratoon, LRH and LT may be greatly affected the incidence of mealybugs. Weather factors such as maximum and minimum temperature, rainfall, relative humidity, possible sunshine duration were correlated with infestation percent or pests population and number of pests [2-6, 8]. Moreover, Hu *et al.* [13] indicated that organisms can respond to variation in temperature through the direct effect of temperature on phenotypes (phenotypic plasticity), or through long-term adaptation to temperature.

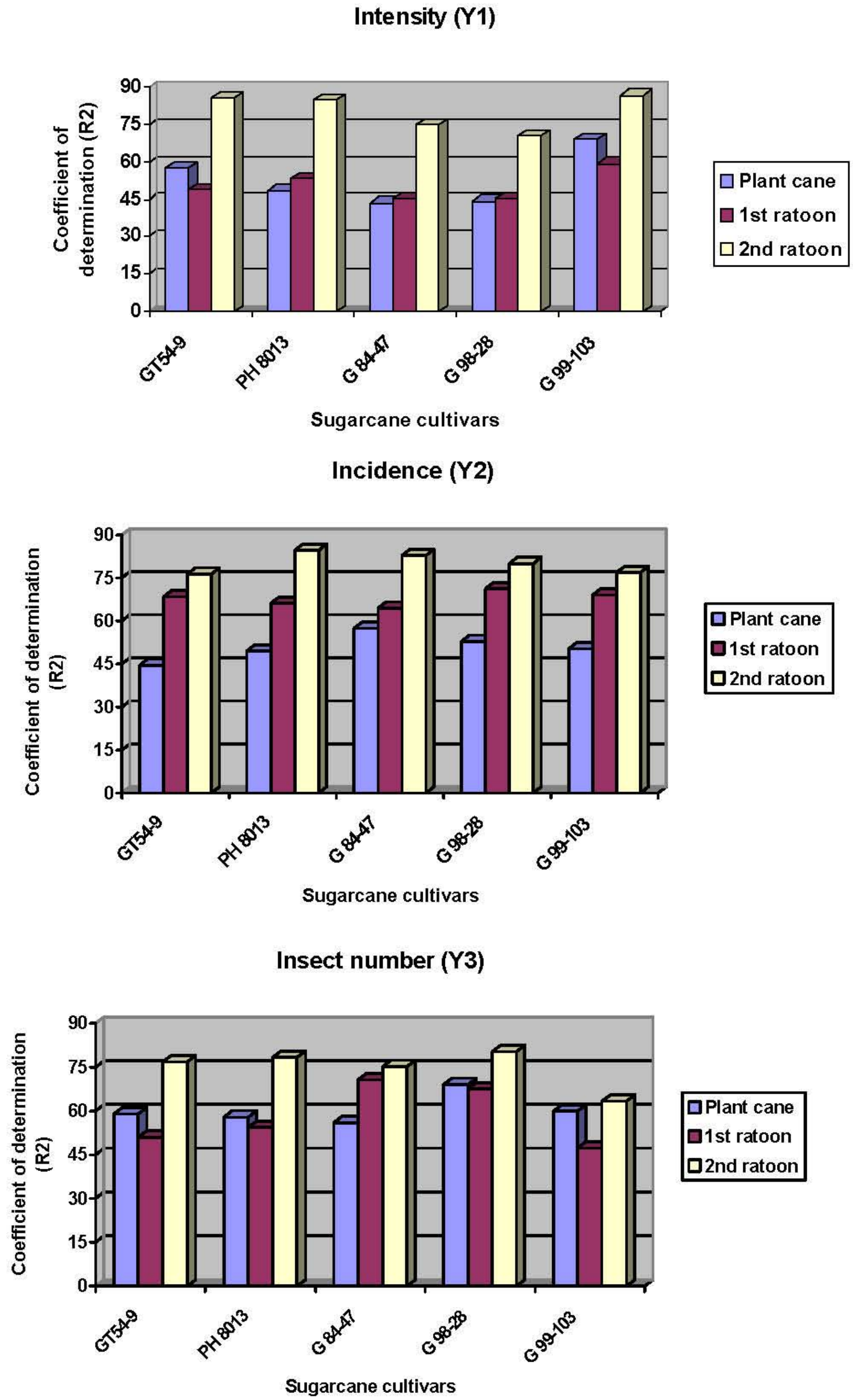

Fig. 1: Coefficient of determination (R^2) of three dependent variables with some meteorological factors through three sequence seasons

Table 3: Regression model using Incidence (Y_2) as dependent variable and some meteorological parameters as independent variables

Cultivars	Season	Equation	$R^2\times100$
GT 54-9	Plant cane	$Y_2 = 61.75 - 0.24x_1 + 0.48x_2 + 0.56x_3^{*} - 0.14x_4 - 1.07x_5 - 5.14x_6$	44.42
	1st ratoon	$Y_2 = 189.79 - 1.23x_1 + 2.56x_2^{*}. - 0.33x_3 - 0.16x_4 - 6.99x_5^{***} - 8.13x_6$	68.49^{***}
	2nd ratoon	$Y_2 = 195.21 + 1.76x_1 + 0.95x_2^{*}. - 0.45x_3 + 0.53x_4{*}. - 3.00x_5 - 15.32x_6$	76.42^{***}
PH 8013	Plant cane	$Y_2 = 91.79 - 0.17x_1^{*} + 0.58x_2 + 0.36x_3^{*} - 0.06x_4 - 0.82x_5 - 6.47x_6$	49.49^{*}
	1st ratoon	$Y_2 = 196.83 - 0.95x_1 + 2.32x_2 - 0.28x_3 - 0.17x_4 - 6.87x_5^{***} - 9.06x_6$	66.15^{***}
	2nd ratoon	$Y_2 = 232.32 + 1.86x_1 + 0.88x_2 - 0.52x_3 + 0.51x_4^{*} - 3.44x_5 - 17.30x_6$	84.58^{***}
G. 84-47	Plant cane	$Y_2 = 59.62 - 0.18x_1 + 1.47x_2 + 1.25x_3^{***} - 0.13x_4 + 0.89x_5 - 10x_6$	57.45^{**}
	1st ratoon	$Y_2 = 185.42 - 0.31x_1 + 1.42x_2 - 0.40x_3 + 0.03x_4 - 4.28x_5^{*} - 7.94x_6$	64.53^{***}
	2nd ratoon	$Y_2 = 203.26 + 1.58x_1 + 1.08x_2^{*} - 0.20x_3 + 0.35x_4^{*} - 2.79x_5 - 16.03x_6^{***}$	82.79^{***}
G 98-28	Plant cane	$Y_2 = 154.21 - 0.75x_1 + 1.67x_2 - 0.10x_3 - 0.20x_4 - 1.68x_5 - 7.46x_6$	52.92^{*}
	1st ratoon	$Y_2 = 235.88 - 0.89x_1 + 2.62x_2 - 0.36x_3 - 0.19x_4 - 6.61x_5^{*} - 11.74x_6$	71.18^{***}
	2nd ratoon	$Y_2 = 234.13 + 2.05x_1 + 1.24x_2 - 0.27x_3 + 0.48x_4^{*} - 3.59x_5 - 19.84x_6$	80.08^{***}
G 99-103	Plant cane	$Y_2 = 132.78 - 0.60x_1 + 1.20x_2 + 9.82x_3 - 0.13x_4 - 1.69x_5 - 5.68x_6$	50.31^{*}
	1st ratoon	$Y_2 = 167.83 - 0.76x_1 + 1.87x_2^{**} - 0.41x_3 - 0.10x_4 - 4.49x_5^{**} - 4.90x_6$	69.00^{***}
	2nd ratoon	$Y_2 = 164.28 + 1.27x_1 + 0.96x_2^{***} - 0.27x_3 + 0.36x_4 - 2.29x_5 - 11.04x_6$	76.90^{***}

* Significant at 0.05 — (x_1) H.T. = High Temperature — (x_2) L.T. = Low Temperature

** Significant at 0.01 — (x_3) H.R.H= High Relative Humidity — (x_4) L.R.H= Low Relative Humidity

*** Significant at 0.001 — (x_5) Spe. = Wind speed — (x_6) Pe. = period of daylight

CONCLUSION

Simple correlation and regression cleared that infested incidence (Y_2) gave the good relation with plant cane and hence was the best expression for mealybug infestation. Moreover, values of multi regression R^2 for the weather factors cleared that Wind speed (Spe) had the effective role during plant cane and 1st ratoon for mealybug incidence, respectively. However, in the second ratoon Low Relative Humidity (LRH) and Low Temperature (LT) greatly affected the mealybug incidence.

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