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Evaluation for Biomass Production Related Traits along with Impact of Weather Parameters on Insect-Pest Incidence in Sweet Sorghum Genotypes

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Abstract Sweet sorghum [*Sorghum bicolor* (L.) Moench] like Jatropha, Pongamia and sugarbeet is among the under exploited crops for biofuel (ethanol and biodiesel) production. It accumulates directly fermentable sugars (10-20%) in the stalk and thus, has an advantage for producing grain for food and bioethanol from stalk juice without compromising food security under low-input production systems like less nitrogen requirement and water and is relatively more tolerant to drought and salinity hence, suitable for semi-arid climate. So keeping these in view eleven sorghum genotypes were evaluated alongwith five checks for resistance against insect pest for two successive years in relation to several weather parameters alongwith agronomic traits which affect biomass production directly and indirectly. ANOVA has indicated significant differences among the genotypes for all agronomic traits under study. High GCV and PCV were reported for some agronomic traits which indicate that the genotype performance could be reflected by the phenotype and selection based on the phenotypic performance coulld be effective for traits under study. Correlation analysis among agronomic traits evaluated in this study showed positive and significant correlation among plant height, biomass yield and days to 50% flowering. The significant positive correlation among these traits suggests that these traits could be simultaneously improved without any compensatory negative effects. As far as weather parameters are concerned, relative humidity and rainfall had affected the insect population over both the years. Shoot fly incidences was increased with rise in relative humidity for both years i.e. the humid environment favor the time, adult longevity, potential fecundity and realized fecundity of the pest.

Keywords Sweet sorghum, Biomass, Stem borer, Relative humidity.

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Introduction

Sorghum bicolor (L.) Moench is the fifth most important cereal crop in the world and can tolerate harsh climatic conditions of arid and semi-arid environments [1]. Sorghum has significant amount of genetic diversity for traits of agronomic importance

[2], which makes it a good source of food, fuel, and feed for livestock. Sweet sorghum may potentially become a biomass as well as with bioenergy source because of high sugar content in its juicy stem under favorable conditions. A sweet sorghum crop is capable of producing upto 13.2 metric tons per hectare of total sugars, which is equivalent to 7682 liters of ethanol per hectare [3]. But several biotic and abiotic factors hampers quality and quantity of the green as well as dry fodder yield and grain yield which causes huge economic loss to farmers and one of the most important factors which are responsible for low yields is losses resulting from insect-pest attack. Sorghum is grown in warm and humid environments that often favor the proliferation of many insect-pests.

Sorghum is being attacked by nearly 150 insect species but the most damaging are *Chilo partellus, Atherigona soccata* Rondani, *Busseola fusa and Eldana saccharina* [4]. In India, a number of stem borer species have been reported as serious pests of sorghum of which spotted stem borer (*Chilo partellus* (Swinhoe), Lepidoptera : Pyralidae) is the most damaging insect which causes 45% losses in fodder yield of sorghum [5] during *kharif* and *rabi* seasons. Hisar has been identified as hot spot for stem borer infestation and screening. Apart from this, shoot fly is also widely distributed in Asia and Africa. It has been reported in almost all sorghum growing areas of the world [6]. It attacks sorghum from 1 to 4 weeks after seedling emergence and damage is caused by the larvae which after hatching, crawl along the leaf sheath then upwards into the plant whorl from where it migrates downwards until it reaches the growing point. Feeding at this point results in death of the central whorl leaf and the typical symptom which is referred to as “deadheart”.

Sustainable production of sorghum depends on effective control of major insect-pests as they continue to compeete with sorghum production potential. However, there is no permanent solution to control these deadly pests except chemical control but detrimental effect of these chemicals on the environment and human is also a matter of concern. One of the best methods which will be followed to reduce infestation is breeding for host-plant resistance against insect-pests. Use of resisant cultivar will not only suppress pests but also reduce production costs, conserve natural enemies, preserve the environment and reduce the rate of development of insecticide-resistant pest strains [7].

Thus, keeping this in view, sixteen sorghum genotypes were evaluated for two successive seasons in relation to several weather parameters alongwith agronomic traits which affect biomass production directly and indirectly with following objectives : (i) to study the various morphological traits like plant height, total fresh biomass and TSS% affecting biomass production and (ii) to study incidence of various insect-pests on sweet sorghum genotypes in relation to weather parameters that affect the biomass quantity as well as its quality.

Materials and Methods

Eleven sweet sorghum genotypes alongwith three resistant checks; IS 2205, IS 18551 and ICSV 745 and two susceptible checks; DJ 6514 and Swarna were evaluated for morphological and insect resistance traits in Forage Research Area of CCS Haryana Agricultural University, Hisar during *kharif* of 2013 and 2014. All the genotypes were planted in 4 row of 2 m length, with 45 cm apart, in a Randomized complete block design with 3 replications and all agronomic practices were followed to raise the crop for both the years. The crop was planted on 17 July and and 7 July during *kharif* of 2013 and 2014 respectively.

The data were recorded on five random plants from each genotype in each replication for days to fifty per cent flowering, plant heightr, total soluble sugar (%), biomass yield and data for stem borer deadhearts and shoot fly deadhearts were recorded after 15, 30, 45 and 60 days of sowing and expressed in percentages.

$$\text{Parcent stem borer deadhearts} = \frac{\text{No. of plants showing stem borer dead hearts}}{\text{Total no. of plants in the plot}} \times 100$$

Table 1. Analysis of variance for different agronomic and pest incidence traits in sweet sorghum.

Source of Variation	Degree of freedom	Days to 50% flowering	plant height (cm)	Total biomass (q/ha)	TSS (%)	Stem borer deadhearts (%)	Shoot fly dead hearts (%)
Replication	2	19.29	175.35	175.35	0.10	17.13	7.40
Treatment	15	208.1**	3190.09**	103190.9**	165.7**	928.1**	1066.6**
Error	30	24.0	226.9	826.9	2.9	129.7	32.7
Total	47	251.3	4417.8	104193.1	168.7	1075.0	1106.8

$$\text{Percent shoot fly deadhearts} = \frac{\text{No. of plants showing shoot fly dead hearts}}{\text{Total no. of plants in the plot}} \times 100$$

Data were subjected to analysis of variance and the significance of differences between the genotypes was tested by *F*-test, whilst the genotype means were compared with least significant difference (LSD) at $p = 0.05$. Correlation study was carried out to understand the association among the agronomic traits under study and their association with stem borer and shoot fly damage. Statistical analysis was carried out and correlation among insect pest incidence and weather parameters was plotted in the form of bar diagram to study their correlation.

Results and Discussion

Analysis of variation

Data of morphological traits was pooled for both the years and then analysed for variance, phenotypic and genotypic coefficients of variation, heritability and genetic advance and correlation studies. Analysis of variance for days to 50% flowering, plant height, total biomass, total soluble sugar, stem borer dead hearts and shoot fly dead heart indicated significant differences among the genotypes for these traits (Table 1). The results are in conformity with findings of [8—12] whom reported significant differences among genotypes of sorghum for days to 50% flowering, plant height and biological yield. The extent of variability in respect of range, mean, phenotypic and genotypic coefficients of variation, heritability and genetic advance has been given in Table 1.

Genotypic and phenotypic coefficient of variation

Relatively higher genotypic variance values of 20.18, 25.7 and 19.24 were obtained for plant height, biomass yield and total soluble sugars, respectively (Table 2). Similarly, the phenotypic variances of these agronomic traits were also high, indicating that the genotype could be reflected by the phenotype and the effectiveness of selection based on the phenotypic performance of these traits could be achieved Manonmani et al. [13] reported similar results in red grain sorghum genotypes whereas Malik et al. [12] observed same trend in forage sorghum. Differences between GCV and PCV for the agronomic traits studied were found to be less indicating that these traits were less affected by environmental fluctuations (Table 3). This is in agreement with the results earlier [14, 15] in *H.vulgare* landraces and accessions of garden eggplant, respectively. Differences between GCV and PCV for the agronomic traits were found to be less indicating that these traits were less affected by environmental fluctuations (Table 2). PCV and GCV values were categorized into following classes; high (>20%), medium (10-20%) and low (<10%) [16]. PCV and GCV for traits under study were given in Table 2 and biomass yield had highest GCV and PCV among all traits. However other agronomic traits evaluated recorded values of GCV and PCV well above the medium range. This suggests the sufficient genetic variability to facilitate improvement through selection of these agronomic traits. The development of effective breeding program depends on existence of genetic variability.

Estimates of heritability

The efficiency with which genotypic variability can

Table 2. Genetic parameters contributing yield for agronomic traits in sweet sorhgum genotypes.

Sl. No.	Characters	Mean ± SE	Range	GCV	PCV	h^2b	GA as % mean
1	Days to 50% flowering	78 ± 0.31	75—82	20.51	21.63	91.41	30.88
2	Plant height (cm)	236.7 ± 3.02	105.6 -288.5	20.18	22.30	98.81	27.86
3	Biomass yield (q/ha)	332.7 ± 7.8	224.3 - 500.3	25.7	27.08	97.07	73.55
4	TSS (%)	8.9 ± 0.12	5.6- 12.3	19.24	21.52	97.44	3.88
5	Stem borer deadhearts (%)	9.38 ± 4.34	0.38-27.4	16.41	18.16	81.61	8.15
6	Shoot fly deadhearts (%)	7.69 ± 5.12	0.16-27.61	17.81	20.27	95.54	9.73

be exploited by selection depends upon heritability of individual traits [17]. In addition, it gives an indication as to how a given trait or agronomic character will respond to selection. In the present study, high heritability value was recorded for number of days to flowering, biomass yield, plant height and total soluble sugars shown in Table 2. High GCV and heritability was also reported for these traits along with high genetic advance reflecting the importance of additive gene effects in their inheritance and their expression. Similar results were reported by [11]. Breeding methods based on progeny testing and mass selection could be useful in improving these traits.

Correlation coefficient

Yield is the result of combined effects of several component characters and environment. Understanding the interaction of characters among themselves and with the environment is of great importance in plant breeding. Correlation studies provide information on the nature and extent of association between any two pairs of metric characters. Hence, it could be possible to bring genetic improvement in one characters by selection of the other traits. Thus, correlation analysis among agronomic traits evaluated in this study showed positive and significant ($p<0.05$) correlation among plant height, biomass yield and days to 50% flowering. The significant positive correlation among these traits suggests that these traits could simultaneously be improved without any compensatory negative effects. For instance, there was also a positive and significant correlation of total soluble solids with stem borer deadhearts (0.775) and shoot fly deadhearts (0.761) as shown in Table 3 which indicates that more the total soluble solids more will be the severity of insect-pest incidence in forage sorghum. Similarly [18] through biochemical analysis observed that low total sugar, reducing sugar (and higher phenol), neutral detergent fiber, acid detergent fiber, lignin, silica and cellulose contents in the shoot tissues of sugarcane increased its resistance to early shoot borer by influencing the biology, establishment of early shoot borer and played an important role in the antibiosis mechanism.

Table 3. Correlation coefficient among agronomic traits and insect-pest incidence.

Characters	Days to 50% flowering	Plant height (cm)	Total flesh biomass q/ha	TSS %	Stem borer deadhearts (%)	Shoot fly dead heart (%)
Days to 50 % flowering	1					
Plant height (cm)	0.127^{NS}	1				
Total fresh biomass q/ha	0.324*	0.593**	1			
TSS %	0.032^{NS}	0.400**	0.392**	1		
Stem borer deadhearts (%)	-0.133^{NS}	0.151^{NS}	0.134^{NS}	0.775**	1	
Shoot fly dead heart %	0.114^{NS}	0.094^{NS}	0.425**	0.761**	0.639**	1

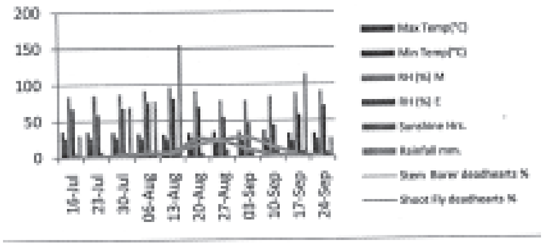

Fig. 1. Effect of weather parameters on incidence insect pest attack during *kharif* 2013, RH (%) M : Relative humidity at morning, RH (%) E : Relative humidity at evening.

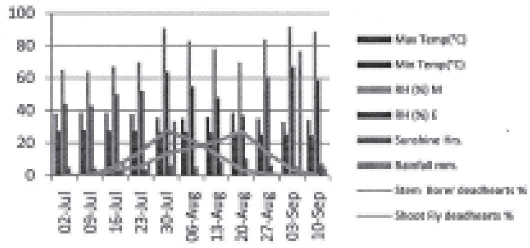

Fig.2. Effect of weather parameters on incidence insect pest attack during *kharif* 2014, RH (%) M : Relative humidity at morning, RH (%) E : Relative humidity at evening.

Effect of weather parameters on disease incidence

In the current study, field investigations were carried out to determine the combined effect of varying levels of temperature regimes, relative humidity, sunshine hours and rainfall on the development and fecundity of stem borer and shoot fly, as these physical factors are known to play an important role in the life cycle of insects and adaptability to local climate. For two consecutive years data of stem borer and shoot fly dead hearts were taken after 15, 30, 45 and 60 days after sowning and correlated that with various weather parameters like temperature (minimum and maximum), relative humidity (morning and evening), sunshine hours and rainfall. For both years relative humidity and rainfall affected the insect population over both the years. Shoot fly incidences were increased with relative humidity for both years i.e. the humid environment favor the time, adult longevity, potential fecundity and realized fecundity of the pest and most favorable temperature and relative humidity for shoot fly was 30-37 °C and 70-90% RH levels. For stem borer incidences most favorable conditions were 35-37 °C temperatures regimes and 70-80% RH levels. Similarly, [19] reported that temperature, relative humidity (RH) and their interaction significantly affected the developmental time, adult longevity, potential fecundity and realized fecundity of the pest. Developmental time was inversely related to temperature and most suitable conditions for stem borer development and fecundity were 26-30 °C temperature regimes and 60-80% RH levels (Figs.1 and 2). Correlation studies were also carried out among weather parameters and stem borer and shoot fly incidence in forage sorghum during *kharif* of 2013 and 2014 and positive significant correlation was observed for crop duration with stem borer (0.655) and shoot fly incidence (0.970) for both years which indicates that disease incidence had correlation with crop duration. Correlation was also estimated among all weather parameters under study with insect-pest incidence and negative correlation was observed among relative humidity (0.368) and rainfall (0.155) with stem borer attack and maximum temperature (0.161) and relative humidity (0.344) had correlation with shoot fly deadhearts but it was non-significant.

Conclusion

On the basis of above study, it is concluded that wide range of diversity observed among agronomic traits would be helpful in sorghum improvement program and presence of total soluble solids and relative humidity had great effect on pest incidence in sweet sorghum which deteriorates the biomass quality.

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