GENETIC POTENTIAL OF HIGH FORAGE YIELDING SORGHUM X SUDANGRASS HYBRIDS FOR RESISTANCE TO STEM BORER (*CHILO PARTELLUS*) AND SHOOT FLY (*ATHERIGONA SOCCATA*)

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ABSTRACT

Ten sorghum sudangrass interspecific hybrids developed for high forage yield and better nutritional quality were grown in the field and evaluated for resistance to stem borer (*Chilo partellus*) and shoot fly (*Atherigona soccata*). These hybrids were raised in field that has not been sprayed for the last three years and no measure was adopted to control the insects. The data on number of insects on 25 selected plants from each hybrid in each replication were recorded 15, 30, 45, 60, and 75 days after sowing. Plant height, number of leaves per plant, leaf area, green forage yield, crude protein and nitrogen free extract ranged from 120.4 – 170.3 cm, 10.87 – 12.2, 151.48 – 204.88 cm^2, 42.23 – 87.24 t ha^{-1}, 7.09 – 7.99 %, and 53.24 – 54.07 %, respectively in sorghum x sudangrass hybrids. The hybrids PBG-CMS-8 X Succro and PBG-CMS-2 X 4158 showed better performance for forage yield and quality characters under study and also had minimum attack of the insects. Results indicated that insect population had adverse effects on forage yield and quality related plant traits. The maximum infestation of *Chilo partellus* and *Atherigona soccata* on the hybrids was observed 30 and 45 days after sowing.

Keywords: sorghum sudangrass hybrids; *Chilo partellus*; *Atherigona soccata*; forage yield; crude protein

INTRODUCTION

Milk and meat are important sources of proteins and energy in human diet. The Government of Pakistan is spending more than 700 million rupees every year on import of milk and milk by products (Government of Pakistan, 2004) to meet the domestic requirements. Due to the poor availability of nutritious green forage (Sarwar *et al*. 2002) the livestock of the country is not expressing full potential in terms of milk and meat. It is estimated that 155.85 M tons of total digestible nutrients (TDN) and 12.68 M tons of digestible protein (DP) are required to meet the nutritional requirements of 134.1 M animal heads in the country (Government of Pakistan, 2004). The shortage of TDN is about 30.85 M tons and that of DP about 2.99 M tons (Government of Pakistan, 2005). Improving the yield of high quality forage could enhance livestock production up to 50% (Hasnain, 1983). Therefore, concrete efforts are needed to increase the yield and quality of the forage to enhance the milk and meat production in the country.

Most livestock producers need high quantity of quality forage during mid to late summer months because a consistent supply of high quality forage is essential to maintain high levels of milk and meat production. Sorghum and sudangrass help maintain a high level of production during the summer months when unfavourable climatic conditions often bring about a decrease in the production and quality of other forages (Beuerlein *et al*. 1968; Creel & Fribourg 1981; Bhatt 1995; Fribourg 1995; Shehu *et al.* 1999) and provide palatable green fodder over a longer period than maize and other forages do.

The introduction of Hybrid Seed Technology has revolutionized the production of agricultural crops in the world. The hybrid crops are higher yielder than the crops sown with the conventional seeds. Pakistan has only recently entered into this field and therefore, the hybrid cultivars approved for general cultivation could be counted on fingers. Presently in almost all crops the hybrid seed is being imported with huge amount of foreign exchange.

Sorghum (*Sorghum bicolor*) and sudangrass (*Sorghum sudanense*) hybrids are known for being upright growing, leafy, drought tolerant and responsive to N fertilization (Fribourg, 1995). They are more efficient in water absorption because they have twice as many secondary roots per unit of primary root as corn and have only half as much leaf area as corn for evapo-transpiration. Their water requirements are the same as corn but they have the ability to go dormant during extended drought periods. Growth begins when the rains come (Wheeler and McKinlay, 1998). These features make the plant superior to that of maize, contemporary fodder crop species which has almost similar seasonal requirements.

The production capacity of sorghum sudangrass hybrids used as fodder is lower than sweet sorghum hybrids, but better in some aspects, such as early-maturity, high quality, etc. Some hybrids are better than sweet sorghum hybrids in production capacity (ShouJun *et al*., 1999). Sorghum-sudangrass hybrids contribute to the development of year round forage systems where forage quality is very important, such as with lactating dairy cows or rapidly growing animals (Fribourg, 1995).

The production of the sorghum-sudangrass hybrids is reduced by the attack of insect pests. Nearly 150 species of insect have been recorded as pest of sorghum, of which Stem borer (*Chilo partellus*) and (*Atherigona soccata*) are major pest of sorghum (Sharma, 1993) resulting economical losses to the plant (Berg *et al.* 2005). Therefore, the hybrids resistant to the attack of these insects will attract more attention of the growers to get higher yields of nutritious green forage. Unfortunately less information is available on the levels of resistance of sorghum, sudangrass and sorghum-sudangrass hybrids against shoot fly and stem borer. Duale (1999) reported information on the incidence of stem borer on sorghum in two provinces of India. Significant differences for resistance against shoot fly in 25 varieties of sorghum have been reported by Berg *et al.* (2005). Bhatt *et al.* (2004) developed molecular markers and mapped QTLs for resistance against shoot fly in sorghum.

This situation emphasizes on the development of sorghum sudangrass hybrids with higher yields of quality forage and also resistant to insects to feed our livestock to get maximum yields of milk and meat. The study presented in this paper was planned to assess performance of high yielding sorghum-sudangrass hybrids for resistance against stem borer and shoot fly. The information obtained will be helpful in selecting hybrids resistant to these insects to get higher yields of quality forage.

MATERIALS AND METHODS

The experiment was conducted in the research fields of the Department of Plant Breeding and Genetics, University of Agriculture, Faisalabad during the year 2004. The experiment was laid out in a randomized complete block design with three replications. The experimental material comprised of ten sorghum-sudangrass interspecific hybrids viz. 1) PBG-CMS-1 X 4158, 2) PBG-CMS-2 X 4158, 3) PBG-CMS-1 X 337, 4) PBG-CMS-3 X HOK, 5) PBG-CMS-3 X 337, 6) PBG-CMS-3 X Low HCN, 7) PBG-CMS-5 X 4158, 8) PBG-CMS-6 X Succro, 9) PBG-CMS-8 X Succro, and 10) PBG-CMS-8 X 4158. Each entry was sown in a 5 x 5 m^2 plot in each replication keeping plant to plant and row to row distances of 15 cm and 60 cm, respectively in field where no insecticide had been sprayed for the last three years. All the recommended agronomic and cultural practices were followed uniformly.

After the emergence of seedlings, five plants of each hybrid were taken randomly at five different locations in a plot in each replication by throwing the stick. The infestation of stem borer (*Chilo partellus*) and shoot fly (*Atherigona soccata*) was recorded 15, 30, 45, 60, and 75 days after sowing by counting the number of insects on these selected plants. At the emergence of 50% panicles the data were recorded on plant height (cm), number of leaves per plant, leaf area (cm^2), green forage yield ($t\ ha^{-1}$) from 10 random plants of each hybrid in each replication. Plant samples consisting of leaves and stem were collected from 10 plants of each hybrid in a replication. These samples were, dried, chopped, mixed thoroughly and ground to fine powder and were used for estimation of crude protein, and nitrogen free extract (NFE) following proximate analysis (AOAC, 1996).

The data recorded were subjected to analysis of variance according to Steel and Torrie (1980) using computer based statistical software SAS. Duncan's New Multiple Range Test was applied for pairwise mean comparisons.

RESULTS AND DISCUSSION

Mean performance of sorghum x sudangrass hybrids for forage yield and forage quality related traits and infestation of insects is presented in Table 1. Plant height ranged from 120.4 cm to 170.3 cm among the hybrids. Hybrid PBG-CMS-3 X 337 followed by PBG-CMS-2 X 4158 had the maximum height, respectively, whereas, the shortest plants were found in PBG-CMS-3 X Low HCN. Average number of leaves per plant ranged from 10.87 to 12.2. Maximum number of leaves was recorded in hybrid PBG-CMS-2 X 4158 followed by PBG-CMS-8 X Succro. Average leaf area of sorghum x sudangrass hybrids ranged from 151.48 to 204.88 cm^2. Hybrid PBG-CMS-8 X Succro followed by PBG-CMS-2 X 4158 and PBG-CMS-1 X 337 had the highest values of leaf area, respectively. Green forage yield ranged from 42.23 to 87.24 $t\ ha^{-1}$. The hybrids under study had crude protein contents ranging from 7.09 to 7.99%. The highest crude protein percentage was recorded in hybrid PBG-CMS-8 X 4158 followed by PBG-CMS-3 X Low HCN. Nitrogen free extract (NFE) percentage that represent the carbohydrates and starches ranged between 53.24 to 54.07. The highest NFE was found in hybrid PBG-CMS-6 X Succro while PBG-CMS-5 X 4158 was second. The highest infestation of stem borer (*Chilo partellus*) was noted in hybrid PBG-CMS-3 X Low HCN (36.53 %) followed by PBG-CMS-5 X 4158 (33.33 %) and PBG-CMS-3 X 337 (30.13 %), respectively. The lowest percent population of stem borer (8.00 %) was recorded in PBG-CMS-8 X Succro.

In the present study, the population of shoot fly was negatively correlated with the plant height and number of leaves. More plant height shows the vigor of the hybrid i.e., plant growth is faster. Although plant is attacked by the shoot fly, yet it escapes the attack due to rapid growth. Table.1 depicts that fodder yield was more in hybrid having more vigor and ultimately less shoot fly population. Tiller survival is related to rate of tiller growth, faster the tiller growth greater the chances to escape shoot fly infestation. Tall seedlings and high-plant recovery were reported as the characteristics of resistant varieties (Sharma *et al.*1977). Percent population of shoot fly (*Atherigona soccata*) ranged from 6.22 to 20.44 % on sorghum x sudangrass hybrids. Shoot fly population also indirectly depicts the number of damaged plants because damage would prevail at the plant where the insects were feeding and showing the dead heart symptom. The minimum population of shoot fly was observed on hybrid PBG-CMS-2 X 4158 (6.22 %) followed by PBG-CMS-8 X Succro (7.11 %). The hybrid PBG-CMS-3 X Low HCN had the highest population of shoot fly (20.44 %) followed by PBG-CMS-5 X 4158 (18.67 %). These results indicate that the hybrids PBG-CMS-8 X Succro and PBG-CMS-2 X 4158 have better performance for forage yield and quality characters. These hybrids also had minimum attack of the insects under study. The results suggest the use of these two hybrids for higher yield of green forage and resistance to shoot fly and stem borer. Non-preference by insects is often projected as property of the plant to render it unattractive for feeding, oviposition and shelter. Non- preference for oviposition is one of primary mechanism of resistance to shoot fly in sorghum (Singh and Jotwani, 1980a). Under no-choice conditions in the cage, there were no differences in oviposition on resistant and susceptible genotypes (Soto, 1974). Resistant genotype having less population is also due to the antibiosis (Singh and Jotwani, 1980b; Raina *et al.*, 1981). Antibiosis of shoot fly offers exciting possibilities of exerting biotic pressure against insect feeding and development, resulting in low-larval survival in resistant varieties (Soto, 1974).

The results indicate that forage yield of sorghum x sudangrass hybrids reduced where infestation of stem borer and shoot fly was high. Fig. 1 also depicts that as the population of insects increases the green forage yield of the hybrids is reduced. Negative and significant correlation of green forage yield with the percent population of the insects (Table 2) shows the effect of insect population on forage yield. This can be explained on the basis that under the stress the physiological processes of plant leading to yield are affected.

Table 2 indicates that the plant height, number of leaves and green forage yield were negatively correlated with the *Chilo partellus and* Atherigona *soccata* population on the hybrids. Table 3 gives the data for the PBG-CMS-2 X 4158 population of borers and shoot fly. It depicts that hybrid was more vigor and having more plant height and green forage yield. It also had less infestation of borer due to non-preference. Plant height, stem thickness, number of leaves, and leaf length, width, thickness and strength are negatively associated with dead heart formation (Khurana and Verma, 1985). Genotypes with early panicles initiation escape dead heart formation due to the inability of the larvae to reach the growing point. Faster internode elongations is associated with borer resistance; the growing point is pushed upward, thereby hampering the ability of the larvae to reach the growing point, and preventing dead heart formation. PBG-CMS-8 X Succro although has less height, yet it was less attacked by the borer and shoot fly. It was also due to the non-preference of female for oviposition. In a study on the effect of sorghum genotypes on stem borer biology, the most significant parameters affected by resistant genotypes were first-instar larval establishment, time interval between larval hatching and boring into the stem , larval mass, and survival rate (Taneja and Woodhead, 1989). Jotwani (1978) reported significantly lower grain yield loss due to stem borer in sorghum selections and he attributed this to the tolerance mechanism. In spite of severe leaf injury and stem tunneling in these selections, the final plant stand was good and most of the plants produced normal panicles.

The results pertaining to the percent population of the two insects (*Chilo partellus* and *Atherigona soccata*) on sorghum x sudangrass hybrids at different intervals are presented in Table 3. The highest infestation of *Chilo partellus* on sorghum x sudangrass hybrids was observed 30 and 45 days after sowing. The highest population of *Atherigona soccata* was found 30 days after sowing.

The present study suggests the use of hybrids resistant to *Chilo partellus* and *Atherigona soccata* to get higher yields of better quality green fodder yield to feed our livestock. Such efforts will contribute to excel the production of milk and meat to feed constantly increasing population of the country. Furthermore, measures should be adopted to control the insects at the time when infestation of these insects is high.

REFERENCES

Association of Official Analytical Chemists (AOAC). 1996. Official Methods of Analysis. 16th ed. AOAC, Arligton, VA.

Berg, J.V.D., L. Bronkhorst, M. Mgonja and A.B. Obilana. 2005. Resistance of sorghum varieties to the shoot fly, Atherigona soccata Rondani (Diptera: Muscidae) in Southern Africa. Int. J. Pest Manag. 51(1): 1-5.

Table 1. Mean performance of sorghum x sudangrass hybrids for forage yield and quality related traits and resistance to *Chilo partellus* and *Atherigona soccata*

Hybrids	PH (cm)	NL	LA (cm^2)	GFY ($t\ ha^{-1}$)	CP (%)	NFE (%)	C. par (%)	A.soc (%)
1	124.4	12.2	200.79	73.35	7.43	53.64	22.4	15.56
2	164.83	11.67	215.75	81.68	7.56	53.42	13.33	6.22
3	140.9	11.4	210.16	70.57	7.7	53.33	26.4	15.11
4	149.5	11.67	185.95	77.24	7.63	53.97	20.00	8.00
5	170.3	11.13	167.59	51.68	7.57	53.82	30.13	15.56
6	120.4	11.27	196.45	42.23	7.73	53.63	36.53	20.44
7	147.5	10.87	192.16	59.46	7.47	54.00	33.33	18.67
8	125.5	11.53	151.48	78.35	7.09	54.07	14.4	9.33
9	122.83	11.72	192.3	87.24	7.72	53.44	8.00	7.11
10	128.73	11.6	204.88	73.35	7.99	53.24	22.93	15.11

PH = Plant height, NL = Number of leaves per plant, LA = Leaf area, GFY = Green forage yield, CP = Crude protein, NFE = Nitrogen free extract, C. par and A.soc stand for mean percent population of *Chilo partellus* and *Atherigona soccata*.

Fig. 1. Mean percent population of *Chilo partellus* and *Atherigona soccata* in sorghum-sudangrass hybrids

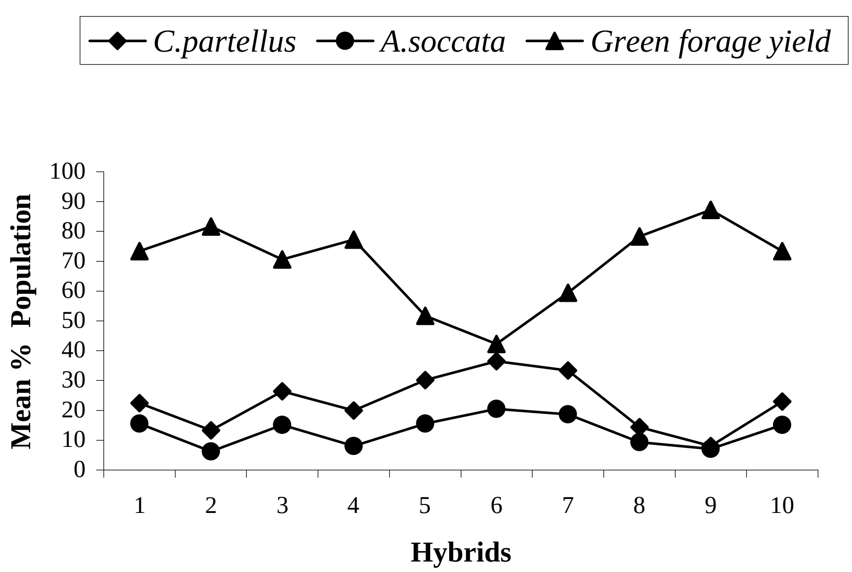

Table 2: Correlation coefficients of various forage yield and quality related traits and insect population

	NL	LA	GFY	CP	NFE	C. par	A. soc
PH	-0.368	0.007	-0.105	-0.039	0.156	-0.103*	-0.181
NL		0.240	0.640	-0.022	-0.320	-0.622*	-0.473
LA			0.123	0.631*	-0.761*	0.047	0.085
GFY				-0.113	-0.219	-0.931**	-0.849**
CP					-0.733*	0.179	0.191
NFE						0.176	0.262
C. par							0.923**

PH = Plant height, NL = Number of leaves per plant, LA = Leaf area, GFY = Green forage yield, CP = Crude protein, NFE = Nitrogen free extract, C. par and A.soc stand for mean percent population of *Chilo partellus* and *Atherigona soccata*.

Table 3: Percent population of *Chilo partellus* and *Atherigona soccata* on sorghum x sudangrass hybrids

Hybrids	Percent population of *Chilo partellus*					Percent population of *Atherigona soccata*		
	15 DAS	30 DAS	45 DAS	60 DAS	75 DAS	15 DAS	30 DAS	45 DAS
1	16.00	25.33	36.00	21.33	13.33	12.00	20.00	6.67
2	14.67	24.00	16.00	9.33	2.67	0.00	2.67	0.00
3	28.00	32.00	32.00	25.33	14.67	20.00	13.33	6.67
4	25.33	24.00	22.67	17.33	10.67	6.67	4.00	4.00
5	24.00	36.00	38.67	28.00	24.00	14.67	13.33	8.00
6	30.67	42.67	48.00	40.00	21.33	17.33	22.67	10.67
7	41.33	40.00	42.67	28.00	14.67	12.00	21.33	12.00
8	16.00	28.00	13.33	10.67	4.00	2.67	9.33	2.67
9	14.67	9.33	8.00	5.33	2.67	1.33	6.67	1.33
10	21.33	26.67	26.67	26.67	13.33	10.67	14.67	4.00
Mean	23.20	28.80	28.40	21.20	12.13	9.73	12.80	5.60

DAS stands for days after sowing

Beuerlein, J.E., H.A. Fribourg and F. Bell. 1968. Effect of environment and cutting on the regrowth of a sorghum x sudangrass hybrid. Crop Sci. 8: 152-155.

Bhatt, B.V., D.B. Krishna, K. Sateesh, G. Srinivas and N. Seetharama. 2004. Molecular marker-aided approaches for sorghum improvement. AgBiotechNet 6:13.

Bhatt, R.K. 1995. Light interception, leaf area index and dry matter yield in fodder sorghum at different plant populations. J. Agron. Crop Sci. 174: 287-290.

Creel, R.J. and H.A. Fribourg. 1981. Interactions between forage sorghum cultivars and defoliation management. Agron. J. 73: 463-469.

Duale, A.H. 1999. Incidence and distribution in sorghum for the spotted stem borer Chilo partellus and associated natural enemies in farmers' fields in Andhra Pradesh and Maharashtra states. Int. J. Pest Manag. 45(1): 3-7.

Fribourg, H.A. 1995. Summer annual grasses. In: R.F. Barnes, D.A. Miller and C.J. Nelson (eds), Forages, 5th ed. Iowa State University Press, Ames, IA. pp: 463-471.

Govt. of Pakistan. 2004. Economic Survey of Pakistan, Government of Pakistan, Finance division, Economic Advisor's Wing, Islamabad.

Govt. of Pakistan. 2005. Economic Survey of Pakistan, Government of Pakistan, Finance division, Economic Advisor's Wing, Islamabad.

Hasnain, H. 1983. Feed – the key to more food in Pakistan. Proc. FAO PARC Workshop on Least Cost Formulation, Islamabad March 12-14, 1983.

Jotwani, M.G. 1978. Investigations on insect pests of sorghum and millets with special reference ot host plant resistance (1972-1977). Final Tech. Rep. IARI Res. Bull. (New series) No.2. New Delhi, India: Indian Agri. Res. Instt. Pp.114.

Khurana, A.D. and A.N. Verma. 1985. Some physical plant characters in relation to stem borer and shoot fly resistance in sorghum. Indian J. Entomol. 47:14-19.

Raina, A.K., H.Z. Thindwa, S.M. Othieno and R.T. Corkhill. 1981. Resistance insorghum to shoot fly: Larval development and adult longevity and fecundity on selected cultivars. Insect Sci. Applic. 2:99-103.

Sing, S.P. and M.G. Jatwani. 1980a. Mechanisms of resistance in sorghum to shoot fly.I. Ovipositional non-preference. Indian J. Entomol. 42:353-360.

Singh, S.P. and M.G. Jotwani. 1980b. Mechanisms of resistance in sorghum to shoot fly.II Antibiosis.Indian J. Entomol. 42:240-247.

Sharma, H.C. 1993. Host plant resistance to insects in sorghum and its role in integrated pest management. Crop Protection12:11–34.

Sharma, G.C., M.G. Jotwani, B.S. Rana and N.G.P. Rao,=. 1977. Resistance to the sorghum shoot fly, *Atherigona soccata* (Rond.) and its genetic analysis .J. Entomol. Res. 1:1-12.

Shehu, Y., W.S. Alhassan and U.R. Pal. 1999. The effect of intercropping *Lab Lab purpureus* L. with sorghum on yield and chemical composition of fodder. J. Agron. Crop Sci. 183: 73-79.

ShouJun, S., W. Yun, Z. GenChang, Z. YunHua, L. FengShan, S.J. Sun, Y. Wang, G.C. Zheng, Y.H. Zhang and F.S. Li. 1999. Feasibility research of breeding and application of sorghum-sudangrass hybrids. Acta Prataculturae Sinica 8(3): 39-45.

Soto, P.E. 1974.Ovipositional preference and antibiosis in relation to resistance to sorghum shoot fly. J. Econ. Entomol. 67:265-267.

Steel, R.G.D. and J.H. Torrie. 1980. Principles and Procedures of Statistics: A biometrical approach. McGraw Hill Book Co., New York.

Taneja, S.L. and S. Woodhead. 1989. Mechanisms of stem borer resistance in sorghum. In: Proc. Intel. Workshop Sorghum stem borers, 17-20 Nov. 1987, ICRISAT Center, Patancheru, Andhra Pradesh, India: Intel. Crops Res. Instt. Semi-Arid Tropics. Pp.137-144.

Wheeler, B. and J. McKinlay. 1998. Forage sorghum-sudangrass. Agdex No.126.