do not. This can be attributed to resonance stabilization which decreases the double bond character of the carbonyl group. Keeping in view that singlet oxygen plays a part in the reaction, the following mechanism is postulated (scheme II). This envisages the formation of an intermediate (VI) devoid of any resonance stabilization, thereby facilitating ring opening by methanolysis.

Generally, the greater the electron density at the benzylic carbon, the more favoured is the formation of the intermediate and the faster is the rate of the reaction.

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TANNIN CONTENT AT DIFFERENT STAGES OF GRAIN DEVELOPMENT IN SOME BIRD SUSCEPTIBLE AND RESISTANT SORGHUMS

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THE *Quelea quelea* are migratory birds in East Africa which feed on the exposed grain cereals. The damage caused to sorghum by these birds is extremely ravaging as compared to residential birds. Brown grain varieties are grown in these areas which are nutritionally inferior. The birds show a high degree of selectivity between sorghum lines differing in polyphenol content[1]. Therefore, some bird susceptible and resistant varieties were analyzed to establish the genotypic difference in tannin content at different stages of grain development.

The material comprised five bird susceptible varieties (CSH-5, CSH-6, 2Kx17, Lulu D, Muvemba Local), three moderately resistant varieties (E525 HR, V2 and V70) and three resistant varieties (Serena, Hijak and Sabina). Except CSH-5 and CSH-6 hybrids of Indian origin, the rest of the varieties originated in East Africa. The trial was conducted at Alupe Agricultural Research Station, Busia (Western Kenya) in an equatorial climate (Latitude 0° 28′N, Longitude 34° 07′E) during 1980 long rains (March–July) with three replications. The varieties were grown at a spacing of 60 cm × 15 cm.

Five normal earheads were selected from each variety at four different stages (S) of grain development. First earhead sample was taken after 6 days of anthesis and the rest of the samples at 12 day intervals. The observation on 6,18,30 and 42 days after anthesis represented milk stage (S_1), soft dough stage (S_2), dough stage (S_3) and maturity (S_4) respectively. The composite samples of each variety were analysed. The tannin content was expressed as catechin equivalent mg/100 mg of sorghum grain[2].

Variability among varieties:

The tannin content per 100 mg grain varied from 0.236–1.2 mg in S_1, 0.18–1.267 mg in S_2, 0.227–0.793 mg in S_3 and 0.21–0.607 mg in S_4 (table 1). The differences among varieties were significant at all the stages. The Indian white grain hybrids, CSH-5 and

TABLE 1

Tannin content of some susceptible and resistant varieties from India and East Africa (EA) at four stages (S) of grain development in sorghum.

Variety	Seed Colour	Tannin content (catechin equivalent mg/100 mg grain)			
		S_1	S_2	S_3	S_4
Susceptible (India)					
CSH-5	WP	0.32	0.28	0.247	0.21
CSH-6	WP	0.236	0.18	0.227	0.22
Susceptible (EA)					
2Kx17	WP	0.373	0.36	0.330	0.233
Lulu D	WC	0.43	0.26	0.257	0.223
Muvemba Local	WC	0.463	0.32	0.277	0.223
Moderately resistant (EA)					
E 525 HR	B	0.656	0.703	0.473	0.343
V2	DB	0.83	0.647	0.473	0.353
V70	DB	0.823	0.817	0.363	0.327
Resistant (EA)					
Serena	B	1.01	0.813	0.573	0.39
Hijak	B	1.0	0.82	0.607	0.477
Sabina	DB	1.2	1.267	0.793	0.607
Mean		0.668	0.589	0.42	0.328
SEM		0.062	0.048	0.050	0.048

Seed colour: WP–White pearly, WC–White chalky, B–Brown, DB–Dark Brown.
Grain development stage: S_1–Milk, S_2–Early dough, S_3–Dough and S_4–Maturity.

CSH-6, were not significantly different in the tannin content at any stage. At S_1, these hybrids were significantly lower than the East African (EA) white grain varieties but were at par at other stages. Within group differences of EA, white grain varieties were significant only at S_3 stage. Tannin content of Lulu D (0.363 mg) was slightly lower than 2Kx17 (0.473 mg) and Muvamba Local (0.473 mg) at S_3. However, white grain Indian and EA varieties were lower in tannin content as compared to brown grain varieties at all the stages. The differences were much higher at S_1.

The tannin content per 100 mg grain EA brown varieties ranged from 0.656–1.2 mg in S_1 0.647–1.267 mg in S_2, 0.363–0.793 mg in S_3 and 0.327–0.607 mg in S_4. Differences among them were significant at all the stages. Within the group differences among moderately resistant varieties (V2, V70 and E525 HR) were significant at $P=0.05$ but not at $P=0.01$. The EA improved cultivars, Serena and Hijak, were similar at all the stages. In S_3 and S_4, tannin content of Serena was similar to the moderately resistant varieties. Tannin content per 100 mg grain of Local West Kenyan Variety, Sabina, was 1.2 mg in S_1, 1.267 mg in S_2, 0.793 mg in S_3 and 0.607 mg in S_4 and significantly higher than other varieties at all the stages.

Changes in tannin content over different stages:

The average tannin content was highest at S_1 which decreased gradually over stages (table 1). However, these changes were dissimilar in different groups of varieties. The tannin contents per 100 mg of Muvamba Local and Lulu D were 0.43 mg and 0.463 mg in S_1 and 0.26 mg and 0.32 mg in S_2 respectively. These differences between S_1 and S_2 stages were significant indicating a reduction after S_1 in Muvamba Local and Lulu D varieties. The reduction in tannin content of E525 HR, V70 and Sabina cultivars was observed after S_2. But the tannin content of V2, Serena and Hijak declined after each stage.

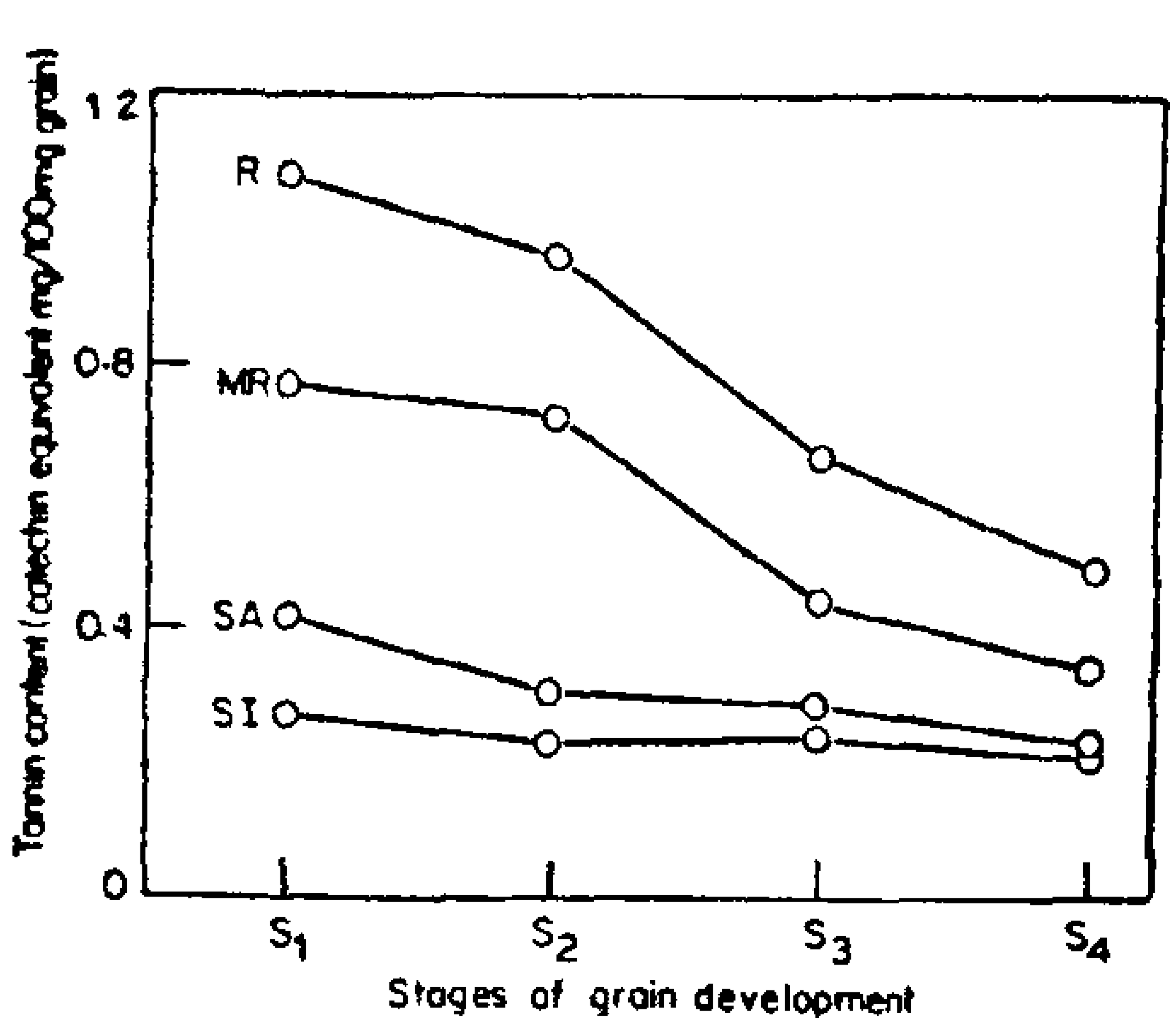

Figure 1. Average tannin content of bird resistant (R), moderately resistant (MR) and susceptible varieties of East African (SA) and India (SI) varieties at milk (S_1), soft dough (S_2), dought (S_3) and maturity (S_4) stages.

A comparison of the group means shows that tannin content of Indian hybrids was the lowest and fairly stable over the stages of grain development (figure 1). But after the initial reduction in mean tannin content of EA white grain varieties from 0.422 mg to 0.313 mg per 100 mg grain, the tannin content did not change significantly. In bird-tolerant brown grain varieties, significant reduction in tannin content was observed after both S_2 and S_3. The bird resistant varieties exhibited sharp decline in tannin content after each stage.

The tannin content per 100 mg grain of resistant, moderately resistant and susceptible varieties was 1.07 mg, 0.77 mg and 0.35 mg at milk stage and 0.658 mg, 0.436 mg and 0.262 mg at dough stage respectively. The white rain varieties from India and East Africa are not much different in tannin content at latter stages of grain development but differences between white and brown varieties are remarkably high. Within the group, differences do occur among brown grain varieties, but the bird-resistant varieties are higher in tannin content as compared to moderately resistant varieties. Although decline of tannins over stages is higher in bird-resistant varieties, their tannin content remains higher at all the stages of grain development.

The tannins are agronomically important in the field to impart resistance to birds[1], insects[3] and diseases[4] but nutritionally harmful. The tannins can be removed by processing. Dehulling and antitoxication are costly processes and require organized efforts. While brown testa offers insufficient repellency to birds, the varieties which potentially repel the birds, have high level of tannins from milk stage to maturity. The bird-resistant varieties show significant decline in tannin content after each stage. Should it degrade much faster, to reach the level of white grain varieties at maturity, this mechanism can ensure the resistance to birds up to dough stage and acceptable nutritional quality at maturity.

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WATER HYACINTH AS A PROSPECTIVE SOURCE OF STIGMASTEROL

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Stigmasterol is an important starting material for conversion to biologically active steroids. Because of the presence of a double bond in the side chain, it is relatively easy to remove the side chain for conversion to steroid hormones[1]. It is estimated that stigmasterol accounts for 15% of the total steriod precursors used in the world[2]. The principal commercial sources of stigmasterol are calabar or ordeal bean (*Physostigma venenosum* Salf) and soybean oil (*Glycine max* Merril syn. *G.soja* Sieb & Zucc)[3]. Though soybean seeds contain only 0.030–0.035% (dry weight basis) stigmasterol, soap stock or foot containing 25% stigmasterol is available as a by-product of alkali refining of soybean oil from which stigmasterol is recovered com-