CALORIC ANALYSIS OF THE DISTRIBUTION OF ENERGY IN RIPENED COTTON

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Abstract

Caloric analyses of the distribution of energy were carried out for Suregrow 125 and DPL-50 cotton plants 40, 101, and 115 days after emergence and for ripened cotton. For these analyses, plants were harvested, dried, weighed, and subsequently they were analyzed for protein, crude fat, lignin, cellulose, hemicellulose, nitrogen-free solubles, and total gossypol by standard AOAC methods. In ripened cotton, approximately twice as much caloric energy was apportioned to seed in comparison with lint. About half of the caloric content was constituted in lint and seed, the remainder apportioned to vegetative tissues. With 40 day plants, the content of nitrogen-free solubles was high and decreased steadily through the 101st and 115th days with a concominant increase in cellulose, hemicellulose and lignin. Higher lint production might be achieved with a concominant decrease in seed production, perhaps as the result of some genetic strategy.

Introduction

Research has shown that each square on the cotton plant does not contribute equally to yield. Bolls from first position squares contribute 66 to 75% and bolls from second position squares contribute 18 to 21% to total yield of modern cultivars when plants are spaced three to four per row foot (Jenkins et al., 1990a, b; Kerby et al., 1987).

Modern cultivars as compared to obsolete cultivars make an earlier transition from vegetative to reproductive development during the time when maximal leaf mass and area are present (Wells and Meredith 1984 a,b). Management of cotton growth and development can be greatly aided by a quantification of the contribution of various fruiting sites in cultivars of various maturities. The weight of seed cotton in a boll also varies among fruiting sites in a cotton plant. In a study of eight cultivars, bolls from position 1 were 14% larger than bolls from position 3 (Jenkins et al., 1990b). Boll weights at each fruiting position also varied among nodes in a curve linear fashion. Weights of bolls at position 1 increased from node 6 to node 12 and then decreased for the remaining nodes (Jenkins et al., 1990b). Meredith and Bridge (1973) reported that as the season progresses, the bolls that set and mature are smaller. Recently, Jenkins and McCarty (1995) compared selected current cultivars, experimental lines, and selected F_2's from hybrid lines for the contribution of each fruiting site to yield using data generated from plant maps of plants at harvest. They confirmed the previous findings and also showed that differences among their lines were not large. The need for full-season management was confirmed. A longer growing season did not contribute to greater yields.

In this present study, previous data on weights of lint, seed, burs, stems, and branches were integrated with analyses of these plant parts for protein, fat, lignin, cellulose, hemicellulose, and nitrogen-free solubles to provide a caloric analysis of the distribution of energy in ripened cotton. This information could contribute to a more favorably engineered cotton plant in which the ratios of lint, seed, and vegetative tissues could be manipulated to develop optimal relationships. For comparison and as background, caloric analyses of cotton plants at 40, 101, and 115 days after emergence were also carried out.

Materials and Methods

Plant tissues were harvested at 40, 101, 115, and 130 days (ripened) after emergence, as appropriate, weighed, and analyzed for protein, crude fat, lignin, hemicellulose, cellulose, nitrogen-free solubles as determined by difference from 100 of the sum of the preceeding, and for total gossypol. Bolls were ginned to give seed, lint and burs. The analyses were performed using standard AOAC methods. The cotton lines were Suregrow 125 and DPL-50. Caloric calculations were based on standard caloric values per gram: protein = 5.6, crude fat = 9.3, insoluble carbohydrates (lignin, hemicellulose, cellulose) = 4.3, soluble carbohydrate = 4.3, and gossypol (estimate) = 7.9 (Crampton and Harris 1969). Statistical data were processed using standard procedures (SAS Institute 1991). Tabular information is available upon request.

Results and Discussion

A caloric analysis was determined of energy distribution in ripened cotton (130 days). Burs and branches accounted for about 49% of the weight with seed (31%) and lint (20%) accounting for the remainder, suggesting that the plant is an efficient producer of this product.

As expected, the lint is about 95% cellulose and accounts for about 17% of the total calories of the ripened cotton plant. Seed accounts for about 35% of the total calories (164/466), apportioned mainly as 44 calories of cellulose, 42 calories of fat, 33 calories of protein and 26 calories of the nitrogen free solubles. About twice as many calories (164) are used by the plant for seed production as for lint production (85). Only 3.7 calories were apportioned to gossypol production, suggesting that lint yield is not decreased by apportionment of energy to gossypol biosynthesis, although it is generally understood that insect resistant plants are often not good producers of lint.

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Caloric analyses of energy distribution of cotton plants was also determined at 40, 101, and 115 days after emergence. Calculation of the distribution in roots was obtained at 40 days when they can still be harvested relatively efficiently. In 40 day old plants, the normalized energy distribution is apportioned mostly to leaves (244 calories) and stems (125 calories) with 19% apportioned to roots (87 calories). At this stage, nitrogen-free solubles (210 calories), cellulose calories (87), and protein calories (78) are most prevalent.

Caloric energy apportionments were also determined at 101 and 115 days, times when the plant is nearing completion of lint and seed production. As could be expected, total cellulose calories are higher in lint at 115 days (37 versus 12 calories), but lower in unopened bolls (the dissected lint and seed less burs) as compared with 101 day plants. At both dates, much of the caloric energy is still present as nitrogen-free solubles, but further conversion to cellulose calories will occur as the plant ripens.

The total caloric content per 100 grams is nearly constant over the period from 40 days until ripening at about 460. This reflects a fairly constant ratio of constituents (protein, fat, and the several categories of carbohydrates) with cellulose increasing as the plant reaches maturity. It is noteworthy that about twice as many calories (164 versus 85) are apportioned to seed as to lint. It is generally recognized that increased lint production might be feasible if seed production could be decreased. This outcome conceivably could be achieved by selection of lines producing smaller or less seed per boll, perhaps as the result of some genetic strategy.

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