Developmental Variation in Carbohydrates of Purple Nutsedge[1]

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Highlight

Carbohydrate analysis of purple nutsedge (*Cyperus rotundus* L.) foliage and subterranean organs harvested over a 130 day period after planting tubers indicated that this species accumulates starch as a storge product. Glucose and fructose appeared to be the major monosaccharides and sucrose was the only disaccharide in foliage and tuber samples. Purple nutsedge appeared to maintain a tremendous capacity for starch metabolism and storage which explains, in part, the ability of this species to resist most control practices.

Purple nutsedge (*Cyperus rotundus* L.) is considered among the most difficult to control weeds in the southern United States and other areas throughout the world. The selective control of nutsedge in established bermudagrass (*Cynodon dactylon* (L.) Pers.) has been the objective of a number of studies (Allen et al., 1960; Burt, 1955; Long and Holt, 1959; Long et al., 1962). However, the presence of this weed in established pastures in the southeastern United States has received little recognition. Though the problem is, generally, not considered of major importance, there are isolated areas in which nutsedge is considered a problem weed in pastures.

Rapid tuber formation, depth of tuber formation in the soil, and tuber dormancy serve to effectively perpetuate this weed in agricultural soils. Because of their extraordinary regenerative capacity, a high degree of tuber control is desired. A factor often related to effectiveness of herbicides in the control of perennial weed species is the level of reserve carbohydrates. However, studies attempting to relate carbohydrate levels with herbicide susceptibility have not been clearly successful (Linscott and McCarty, 1962 and McWhorter, 1961). Hauser (1962) and Smith and Fick (1937) described the developmental morphology of purple nutsedge and Taylorson (1967), in his study on seasonal variation in sprouting and available carbohydrates in yellow nutsedge tubers, found little relationship between total reducing sugars and sprouting.

The purpose of this study was to quantitatively determine types of carbohydrates present in foliage and subterranean organs and to relate changes in carbohydrate fractions to accompanying changes in phenological development.

Methods and Materials

Purple nutsedge tubers, collected during the fall of 1970 were planted in flats (32 cm × 21 cm × 10 cm deep) filled with Cecil sandy loam soil and placed in the greenhouse on November 25, 1970. Six healthy tubers were planted in each flat at a depth of 2.5 cm. All flats were watered daily throughout the ex-

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Table 1. Dry weight and carbohydrate concentration (μg/g dry material) of plant material harvested at 10 time intervals.

Days after planting	Dry Wt (g) of sample	Total free reducing	Free glucose equivs.	Free fructose equivs.	Bound glucose equivs.	Bound fructose equivs.	Bound Glu/Fru ratio	Starch
				Foliage				
29	0.35e[1]	–	–	–	–	–	–	–
44	0.95c	35.0a	0.5b	30.0b	16.3a	9.0b	1.8b	16.0c
56	1.75d	35.2a	0.7b	32.8b	17.2a	4.3c	4.0a	18.3c
71	2.45cd	36.8a	1.3ab	35.6a	15.8a	10.8a	1.4b	26.0b
85	3.25c	36.2a	0.4b	39.7a	16.1a	12.2a	1.3b	29.5b
99	3.90bc	34.6a	0.3b	34.3ab	17.7a	12.0a	1.5b	42.3a
113	4.90b	34.9a	2.8a	32.1b	12.8b	9.6ab	1.3b	52.0a
130	6.00a	33.6a	2.6a	30.5b	10.9b	10.2a	1.0b	54.1a
				Tubers				
0	5.00e	56.1c	34.2ab	21.9b	2.0b	1.8b	1.1a	378.5a
14	4.66ef	94.9ab	42.5a	52.2a	3.2b	2.9b	1.1a	345.2a
29	2.40fgh	106.6a	50.4a	56.2a	2.5b	2.3b	1.1a	274.5b
44	3.25fg	107.9a	45.0a	73.2a	3.6b	3.4b	1.1a	125.0e
56	4.30ef	72.9b	35.1a	38.6b	7.6a	7.5a	1.0a	142.8e
71	5.70e	64.0bc	30.5b	33.7b	8.5a	8.3a	1.0a	188.8d
85	10.43d	53.1c	21.7bc	35.2b	8.1a	8.3a	1.0a	191.5cd
99	19.65c	47.8cd	10.7c	37.1b	7.7a	7.9a	1.0a	200.2c
113	43.98b	35.7d	8.2c	32.5b	3.2b	3.0b	1.1a	205.1c
130	50.12a	24.3e	2.1c	22.1b	2.5b	2.1b	1.2a	207.2c

[1]Means in each column having different letters differ significantly $P < .05$.

perimental period. On the planting date and on successive 15 day intervals, 3 flats were taken from the greenhouse and plant material removed by carefully washing the soil from the subterranean organs. Collected plant material was immediately washed free of soil, frozen, and stored at –10 C for subsequent carbohydrate analyses. The frozen tillers were partitioned into subterranean organs (Tubers) and foliage prior to drying. All plant samples were placed in an oven at 100 C for 1 hr for enzyme inactivation. Plant material was dried at 70 C in a forced draft oven and weighed prior to grinding with a Wiley mill to pass a 40 mesh screen. Five hundred mg of ground plant material were extracted successively with 95.0, 92.5, 90.0, 85.0, 80.0, 60.0, 30.0, and 0% ethanol solutions made from 95% ethanol. Samples were mechanically shaken at room temperature beginning with the most concentrated ethanol dilution. Plant material and eluent were centrifuged and eluent removed for hydrolysis and subsequent carbohydrate analyses. Plant residues were returned to the flask using next lower ethanol concentration. This procedure was repeated throughout the concentration gradient.

The alcohol solution was replaced with water during evaporation on a hot plate and the solution clarified with lead acetate (Ting, 1956). Aliquots of the clarified plant extracts were analyzed for reducing carbohydrates and aliquots were hydrolyzed with 1N H_2SO_4 and the cooled hydrolysate neutralized with 1N NaOH (Smith, 1967) diluted to volume with water, and an aliquot used for colorimetric analysis and referred to as nonreducing carbohydrates. Residue from the final ethanol extraction was analyzed for starch content using clarase "900" enzyme extraction and titrimetrically quantified according to the method presented by Smith (1969). Differential colorimetric analyses of hydrolyzed and non-hydrolyzed extracts were carried out as described by Ting (1956) with the following modification: A Beckman model DB-G spectrophotometer was used to measure absorbance at 745 mμ wavelength using 1.00 cm silica cells and 2 ml sample aliquots. Glucose, fructose, and total reducing carbohydrates were determined from standard curves. The experiment was repeated twice with three replications. Data were analyzed by analysis of variance and mean differences determined by Duncan's Multiple Range Tests (Steele and Torrie, 1960).

To determine the feasibility of using the ferrocyanide-arsenomolybdate colorimetric method for accurately quantifying carbohydrate fractions in purple nutsedge plants, foliar and root sample extracts were paper chromatographed according

to the method of Sunderwirth et al. (1964).

Results and Discussion

Chromatograph results indicated fructose and glucose to be the major monosaccharides and sucrose to be the major disaccharide present in these plant organs. Slight traces of galactose were detected in the foliage samples and were determined as glucose equivalents. The method efficiently resolved glucose and fructose moieties occurring as monosaccharides or as hydrolysate products of disaccharides.

All data are summarized in Table 1. Carbohydrates were not detected in extracts obtained with ethanol concentrations of less than 92.5% indicating the absence of fructosans in these plant samples. Foliage sample dry weights steadily increased throughout the sampling period in response to tuber germination and plant growth. Conversely weights of subterranean organs (referred to as tubers) decreased up to 29 days post planting. This period of decrease was followed by a period of rapid increase in dry weights of these organs. Carbohydrates in the foliage material throughout the 130 day experimental period consisted of free sugars, sucrose, and starch. Only the starch content showed consistent changes which steadily increased with increased time post planting and was probably a response to plant maturity.

Fluctuations in tuber carbohydrates followed a trend more closely associated with phenological development. The concentration of total free reducing carbohydrates increased with corresponding decreases in dry weight and starch content up to 44 days post planting. This phenomenon is probably a response to starch catabolism to free reducing carbohydrates as an energy source utilized for respiration and tissue building. The major disaccharide present in all foliage and root samples was sucrose as indicated by a bound glucose/fructose (Glu/Fru) ratio of approximately 1. However, the non-fluctuating and relatively low sucrose concentration, derived from the sum of bound glucose and fructose equivalents, did not indicate the presence of a functional sucrose pool in the tuber samples.

Starch was the only non-structural polysaccharide found in this species indicating this to be the major carbohydrate stored. Tuber starch content reached a minimum and began increasing 44 days after planting indicating availability of photosynthate in excess of plant requirements. The intermediate accumulation products of starch metabolism appeared to be free reducing carbohydrates in the tubers and sucrose in the foliage. The higher sucrose concentration in the foliage, when compared with sucrose concentration in the tubers, would indicate a possible form of carbohydrate transported.

Results of this study indicate that the high starch content of purple nutsedge tubers along with the physiological ability to utilize and restore reserve carbohydrate is an additional factor that adds to the persistence of this species to control methods primarily aimed at reducing photosynthesis capacity.

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We have a long way to go before we achieve the ultimate in developing our native rangeland resources. The world watches our methods, hoping that we can lead the way to more abundant living. (*Vernon A. Young*. J. Range Manage. 14:236.)