Growth, Production, and Wildlife Use of Delta Duckpotatoes in Louisiana

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Abstract: Field studies of delta duckpotatoes (*Sagittaria graminae* var. *platyphylla*) disclosed that plant density was 1.5 times greater in wildlife exclosures than in control areas. Tuber production where nutrias (*Myocastor coypus*) and ducks were excluded was 652.3 g/m^2. Tuber production was considerably less in plots subjected to foraging by wildlife (nutria foraging only: 104.7 g/m^2, duck foraging only: 75.8 g/m^2, nutria and duck foraging: 64.8 g/m^2). Tubers were found to a soil depth of 30 cm but where animals were excluded greatest production (40.3%) was at the 10–15 cm depth. Nutrias foraged to the 30 cm depth but most duck foraging was from the 0–15 cm depth. Tank studies disclosed that a deep (30 cm), constant water depth produced taller plants and enhanced seed production, but water depth variation had no effect on tuber production. Constant 20 and 30 cm water depths encouraged above-ground biomass production. Of seed storage methods examined, air-dried seed retained viability better than seeds not dried. Air-dried and refrigerated seeds germinated better than those stored at room temperature. Chilling and gibberrellic acid treatment enhanced germination. Germination was better in low salinities (<5.0 ppt). Tubers stored moist at 3° C sprouted best (43.0%), while no air-dried tubers sprouted.

Proc. Annu. Conf. Southeast. Assoc. Fish and Wildl. Agencies 37:56–66

Delta duckpotatoes are a locally important food of ducks (Martin and Uhler 1939) and nutrias in Louisiana. Vast stands of the species are present on the deltas of the Mississippi and Atchafalaya rivers. Also, isolated stands grow in fresh marshes elsewhere along the Louisiana coast. However, little is

known regarding growth, tuber production, effect of animal feeding, and management of the plant.

The potential for crayfish (*Procambarus spp.*) farming and waterfowl hunting on the same impoundment provides the opportunity for multiple returns to impoundment owners. Vegetation that is utilized by both crayfish and waterfowl for food would be desirable for these impoundments. Since the use of agricultural crops can be expensive, the ideal management technique would be to encourage the growth of selected natural plants that could be easily and economically managed and readily utilized by both crayfish and waterfowl. Duckpotatoes, tuber-producing *Sagittaria,* appear to be such plants. Johnson (1980) evaluated the delta duckpotato (*S. graminea* var. *platyphylla*) as crayfish forage and found no difference between crayfish production in impoundments containing rice and delta duckpotatoes.

Uhler and Hotchkiss (1968) found duck potato in shallow fresh marshes where the soil was always water logged and was sometimes covered with as much as 15 cm of water at high tide. Schulthorpe (1967) stated that *S. sagittifolia* required at least some silt and would not grow in more than a slow current. Wooten (1970) discovered that some populations of *S. graminea* were widely adapted to water depth fluctuations and others were not.

Propagation of the plant has not been studied with the exception of a few observations on the soil condition where delta duckpotatoes occur. The objectives of this study were to determine production and wildlife use in natural stands, to evaluate the effects of different water regimes on growth and tuber production in tanks, and to evaluate storage methods to preserve seeds and tubers for planting.

The authors acknowledge the assistance of Dr. Leslie L. Glasgow in designing the studies and assisting in data collection. Also, Dr. Kenneth Koonce assisted in data analysis and wildlife students helped in field work.

Methods

Field Studies

Studies were conducted in natural stands of delta duckpotatoes to determine plant density, tuber production, and wildlife use. The study was conducted on Pass a loutre Wildlife Management Area near the mouth of the Mississippi River on an active delta. The study area consisted of fresh marsh as described by Chabreck (1972) and was subjected to overbank flooding during the spring.

The study area is a major wintering site for migratory waterfowl. Common duck species in the area that fed on tubers of delta duckpotatoes were mallards (*Anas platyrhynchos*), pintails (*A. acutus*), and mottled ducks (*A. fulvigula*).

Nutria were introduced into Louisiana in 1938 (Ensminger and Linscombe 1980) and were abundant on the study area during the investigation. Muskrats (*Ondatra zibethicus*) were present in the vicinity but were not observed on the study area. Swamp rabbits (*Sylvilagus aquaticus*) were common on the study area.

Exclosures were constructed at 9 sites on the study area in natural stands of delta duckpotatoes. Exclosures were of 3 types: a) those that excluded nutria and ducks, b) those that permitted only nutria to enter (duck exclosures), and c) those that permitted only ducks to enter (nutria exclosures). An unfenced control was placed at each study site near the exclosures and was subjected to foraging by nutria and ducks. All exclosures were 4 m^2 in size except those that ducks were permitted to enter. They were 0.4 ha in size and ducks entered by flying into the exclosures.

The exclosures were constructed in March 1962 at sites previously containing stands of delta duckpotatoes and sampled in March of 1963, 1964, and 1965. Each year, 4 soil samples were taken at random in each exclosure type and the control area at the 9 study sites ($N = 36$). Each soil sample was taken to a depth of 30 cm with a cylinder 10.7 cm in diameter. Each sample was then sectioned into 5 cm long segments and washed through a screen to remove all delta duckpotato tubers. The tubers from each subsample were counted and weighed.

Tank Studies

The effects of selected hydrologic regimes on growth and tuber production of delta duckpotatoes were determined at Ben Hur Farm in Baton Rouge, Louisiana. Twenty-one round metal stock tanks, approximately 270 cm in diameter, were used in the study. The interior of each tank was coated with epoxy paint, then filled to a depth of 15 cm with clay topsoil obtained from adjacent farmland. On 16 May 1978, 1 delta duckpotato tuber was planted 2 cm deep in the center of each tank, and the soil was then covered with 10 cm of water. When all tanks contained at least 1 plant 10 cm in height, treatments were initiated. The treatments were: (1) constant 10 cm water depth; (2) constant 20 cm water depth; (3) constant 30 cm water depth; (4) fluctuating water depth whereby tanks were flooded to a depth of 10 cm, then drained and reflooded on a 5 to 10 day cycle; and (5) the traditional crayfish farm hydrologic cycle whereby the water was drained from 16 May until 1 October and then flooded. Each treatment contained 3 replications.

Plant measurements included plant density, leaf length, rachis length, seed head production, above ground biomass production, and tuber production. Samples were taken at 3-week intervals from 28 July to 5 December 1978. A wooden frame with wire grids (grid square = 0.25 m^2) was laid over each tank, and the number of plants and rachises were counted in 4 randomly

selected grid squares. A plant with the longest leaf length (petiole and blade combined) was located at a pre-selected corner of each of the 4 grid squares and measured. The closest rachis to each of those corners was measured for length and the number of seed heads were counted.

Above-ground biomass was sampled on 12 October 1978. One plant closest to each of 10 randomly selected points on the tank was clipped at ground level, oven-dried at 70° C for 72 hours, and weighed to the nearest 0.01 g.

Tuber biomass was sampled on 5 December 1978. Thirty-two core samples per tank were taken with a 10.8 cm diameter stainless steel pipe. The sample points were arranged around the tank center in 3 concentric bands to determine whether the proximity to tank walls affected tuber production. Outer radii of the bands were 26.6, 66.2, and 102.7 cm. Samples were washed through 3 stacked screens of successively smaller mesh (12, 6, and 2 mm). All tubers in a sample were collected from the screens, weighed collectively on a wet weight basis to the nearest 0.01 g, and counted.

Seed and Tuber Storage

The effect of various seed and tuber storage methods on germination and sprouting was examined. Tubers were collected on 4 January 1978 and stored until 23 May 1978 by the following methods: (1) in water and refrigerated at 3° C, (2) air-dried and refrigerated at 3° C, (3) moist and refrigerated at 3° C, and (4) air-dried and stored at room temperature (20° to 26° C). Ten replications of each treatment with 20 tubers per replication were planted on 23 May, 1 cm deep, in clay pots filled with clay topsoil. The pots were placed in metal tubs and the soil was covered with water to a depth of 10 cm. The tubs were maintained for 29 days in a greenhouse. Tubers were checked for sprouting on 21 June.

Seeds collected on 13 October 1977 were stored until 12 May 1978 by the following methods: (1) air-dried and stored at room temperature, (2) air-dried and stored at 3° C, and (3) stored in water at 3° C. Ripe seeds were stripped from seed heads and stored by all 3 methods. Whole seed heads were collected in all stages of maturation and stored by the second and third methods. For the germination test, 100 seeds from each treatment were placed in a Petri dish on filter paper moistened with distilled water. Each treatment contained 3 replications. The dishes were maintained in a germinator for 1 month on a cycle of 14 hours light at 30° C and 10 hours darkness at 15° C to approximate natural conditions in southern Louisiana. The number of germinated seeds in each replication was recorded.

Data on seed germination and tuber sprouting were tested by an analysis of variance in a randomized block design, using SAS General Linear Model procedure and Duncan's Multiple Range Test (Helwig and Council 1979).

Miscellaneous Germination Trials

The effect of chilling, water salinity, and gibberrellic acid treatment on germination of seeds was examined. Chilled and unchilled seeds were germinated in Petri dishes on filter paper moistened with water with salinity levels of 0, 2.5, 5.0, 7.5, and 10.0 ppt. Seeds were chilled by storing them at 3° C for 5 days before the test. Other seeds were soaked in 1%, 3%, and 5% gibberrellic acid solutions and distilled water for 11 hours to examine the effects of the acid on germination. The seeds were then placed on moist filter paper. All treatments were replicated 3 times with 100 seeds/replication and were tested in a germinator maintained with cycles of 14 hours light at 30° C and 10 hours darkness at 15° C for 15 weeks. The number of seeds germinated after 1 month were tabulated.

Results and Discussion

Field Studies

Plant density.—The number of plants of delta duckpotato inside animal exclosures ($\bar{x} = 160.3/m^2$) was 1.5 times greater than the number outside exclosures ($\bar{x} = 104.4/m^2$) ($P < 0.05$). Nutria and other herbivores fed on plants during the growing season and apparently caused the reduced density.

Tuber production.—Tuber production in animal exclosures ($N = 9$) averaged 652.3 g/m² the 1st year after construction. After the second year, production averaged 1372.2 g/m², an increase of 110.4%. After the third year, tuber production averaged 664.7 g/m², a decline of 51.6% from the previous year.

The greater production of tubers in exclosures the second year probably resulted from the greater number of tubers present in the soil prior to the growing season. The first year exclosures were subjected to animal foraging the previous year and fewer tubers were present. However, tuber production during the second year was from plants that grew from tubers produced the first year, hence the greater production. An even greater number of tubers were present for sprouting and plant production during the third year and the reason for the decline in tuber production is unknown. Insect damage to plants and improper hydrologic cycles were believed to be major causes for the lower tuber production the third year. Production in exclosures was similar the 1st and 3rd years after construction. The mean weight/tuber was 1.40 g and did not differ among years.

Wildlife use.—Exclosures constructed to exclude nutrias and ducks produced 652.3 g/m² of delta duckpotato tubers after 1 year (see previous discussion). Exclosures constructed to permit only nutria foraging contained 104.7 g/m² of tubers, and exclosures to permit only duck foraging contained 75.8 g/m² (Table 1). Areas nearby without exclosures were subjected to for-

Table 1. Mean weight of delta duckpotato tubers to a depth of 30 cm and percent distribution of tubers by soil depth classes in exclosures ($N = 9$) constructed to permit foraging by certain wildlife, Pass a loutre Wildlife Management Area, 14 March 1964. Samples were taken 1 year after exclosures were constructed.

Wildlife foraging	Mean wt. of tubers (g/m²)[a]	Percent distribution by soil depth classes (cm)					
		0.5	5–10	10–15	15–20	20–25	25–30
None	652.3 A	1.5	25.6	40.3	22.4	7.1	3.1
Nutrias only	104.7 B	0	6.6	40.5	39.4	10.4	3.7
Ducks only	75.8 B	0	0	4.0	79.2	12.9	4.0
Nutrias & ducks	64.8 B	1.4	12.2	54.9	9.1	7.6	15.0

[a] Means followed by a different letter are statistically different ($P < 0.05$).

aging by ducks and nutrias and contained only 64.8 g/m². All exclosures were sampled at the end of the winter season.

Exclosures that excluded all animals produced tubers at all 6 of the soil depth classes sampled (Table 1). However, greatest production was at the 10 to 15 cm depth, which contained 40.3% of the tubers. Tuber depth in these exclosures was used as a standard for comparison of feeding depths by ducks and nutrias. In exclosures that permitted only nutria foraging, the distribution of tubers was similar to that of exclosures with all wildlife excluded. However, in exclosures that permitted only duck foraging, practically all tubers were removed down to a depth of 15 cm. The distribution of tubers in areas subjected to both nutria and duck foraging was similar to that in exclosures excluding all animals, with the greatest concentration of tubers at the 10 to 15 cm depth.

The density of delta duckpotato plants was 1.5 greater in areas where all wildlife was excluded than in areas without exclosures (see previous discussion). We were unable to determine the extent to which this affected tuber production; however, we believe that fewer tubers were produced in areas subjected to animal foraging. Nevertheless, the data suggested that nutrias and ducks effectively removed most delta duckpotato tubers in the study area.

The removal rate by both groups was similar. Apparently, the animals fed on tubers to a point where the energy required for additional searching would not be provided by the additional tubers recovered. In areas where both groups foraged, the amount of tubers was similar at the end of the winter season to areas where each group foraged individually.

Tank Studies

Plant growth.—Plant densities average 31.1 plants/m² and did not differ among treatments ($P > 0.05$), but the mean number of rachises and seed heads differed among treatments ($P < 0.05$). Constant water depths generally

produced more seed heads than fluctuating water depths. The mean number of seed heads/m^2/sample date ranged from 317.7 to 443.2 for constant water depths and was directly related to water depth. The mean number of seed heads/m^2/sample date ranged from 203.9 to 267.7 in tanks with fluctuating water levels but was only 138.6 for the crayfish cycle.

Each rachis grew, flowered, and produced seeds in 2 to 3 weeks. Although samples provide only point estimates in time, we believe that the results from all sample dates, when totaled, provided a reliable estimate of total seed heads produced. Sample dates were spaced so that most rachises were counted.

Leaf length differed among treatments ($P < 0.01$). Leaf length was always greater than rachis length, a characteristic of the species. Deeper water produced taller plants, and leaf length in the constant 30 cm water depth averaged 68.2 cm, in the constant 20 cm averaged 52.4 cm, and in the constant 10 cm averaged 44.6 cm. Fluctuating water produced leaves averaging 42.2 cm.

Above-ground biomass was sampled in October. Transition to a winter growth form, referred to as a winter rosette, began in mid-October in Louisiana and by December all plants exhibited the winter form.

Delta duckpotato renews itself throughout the year. Older leaves die and are replaced by new ones throughout the growing season. Therefore, a point in time estimate must be thought of as minimum estimate of biomass production.

The treatments produced different ($P < 0.01$) weights of above-ground biomass. Constant 20 cm and constant 30 cm water depths produced the greatest biomass (130.5 and 194.9 g/m^2, respectively). Biomass production in tanks with fluctuating water levels ranged from 68.3 to 100.8 g/m^2 and the traditional crayfish cycle averaged 58.8 g/m^2 biomass.

Avault (1973) stated that plant material composed the bulk of the crayfish diet, so plant biomass production is an important factor in crayfish production. No biomass data are available in the literature for delta duckpotato. Our biomass measurement in October of 58.8 g/m^2 may reflect as much annual biomass production as Chien's (1978) mean rice (*Oryza sativa*) biomass yield of 340.2 g/m^2, since duckpotato renews itself many times per year as older leaves die.

Johnson (1980) experienced difficulty in establishing duckpotato in experimental ponds (probably due to improperly stored duckpotato tubers). This may have affected the biomass production of delta duckpotato and ultimately crayfish production; nevertheless, he found no difference in crayfish production between ponds containing delta duckpotato and rice.

Tuber production.—Tuber production by weight and number (Table 2) did not differ among water level treatments ($P > 0.05$). Treatment means for number of tubers ranged from 290.4 to 396.3/m^2 and tuber weight ranged from 265.3 to 462.8 g/m^2. No other duckpotato tuber biomass determinations

Table 2. Range of delta duckpotato tuber production by treatment in stock tanks, Ben Hur Farm, Baton Rouge, Louisiana, 1978.

Treatment	*N* tubers/m²	Tuber weight (g/m²)
Constant 10 cm water depth	281–354	226–460
Constant 20 cm water depth	173–345	122–458
Constant 30 cm water depth	115–618	165–307
Fluctuating water depth	227–424	272–480
Traditional crayfish cycle	120–437	90–385

existed in the literature for comparison. Under a multiple-use system managed for crayfish and waterfowl production, the waterfowl manager will be interested in maximum tuber production and the crayfish manager will be interested in maximum above-ground biomass production. The absence tuber production differences with water levels thus allows the crayfish manager to hold water at depths necessary for maximum above-ground biomass production.

Tuber production differed ($P < 0.001$) within tanks with production generally in the outer one-third of the tanks and similar in the 2 inner rings (422.0, 338.0, and 327.0 g/m² outside to inside sample ring means, respectively). Observation suggested some crowding of roots and greater tuber production within 15 cm of the tank walls.

Seed Germination Tests

Effects of chilling, salinity, and gibberrellic acid on germination of freshly collected, mature seed of delta duckpotato were examined (Table 3). The germination rate of chilled seeds (23.3%) was more than twice that of unchilled seeds (11.7%) ($P < 0.01$). Germination rates varied among salinity levels with lower salinities generally producing better germination ($P < 0.01$). No chilling-salinity interaction effects were noted.

Fresh seeds were soaked in 0%, 1%, 3%, and 5% gibberrellic acid solutions for 11 hours, then germinated on moist paper. Germination rates were 10.0%, 30.7%, 22.0%, and 18.3%, respectively ($P < 0.05$, according to Duncan's Multiple Range Test). Germination of all acid treatments exceeded that of distilled water, and with the 1% acid solution the germination rate was 3 times that of distilled water.

Seed and Tuber Storage Methods

Delta duckpotato seeds were collected on 13 October 1977 and stored by five methods until 12 May 1978. Germination rate of stored seed was 16.3% or less (Table 3). Air-dried seeds germinated better (11.8%) than those stored wet (2.9%); and ripe, air-dried, refrigerated seeds germinated best (16.3%).

Seeds retained their viability well with storage. Germination of fresh

Table 3. Effects of salinity, gibberrellic acid, chilling, and storage on percent germination of delta duckpotato seeds maintained on a cycle of 14 hours light at 30° C and 10 hours darkness at 15° C.

Treatment	Percent germination by salinity (ppt)				
	0.0	2.5	5.0	7.5	10.0
Chilled 5 days at 3° C	32.0	43.7	23.3	8.7	9.0
Unchilled	12.7	14.3	16.7	6.0	9.0
Gibberrellic acid soaking (11-hour soaking)					
0% Solution	10.0				
1% Solution	30.7				
3% Solution	22.0				
5% Solution	18.3				
Storage methods:					
Ripe seeds, air-dried, stored at 20°–26° C	9.3				
Ripe seeds, air-dried, stored at 3° C	16.3				
Ripe seeds, stored in water at 3° C	1.7				
Mixed ripe and green seeds, air-dried, stored at 20°–26° C	9.7				
Mixed ripe and green seeds, stored in water at 3° C	4.0				

seeds without special germination enhancement (such as chilling) ranged from 10.0% to 12.1%, and germination rates from several of the storage treatments compare favorably with the rates from fresh seeds.

Delta duckpotato tubers were collected 4 January 1978 and stored by 4 methods until 23 May 1978. Treatments and respective sprouting rates were as follows: 1) stored in water at 3° C, 5.5%; 2) air-dried and refrigerated at 3° C, 0.0%; 3) moist and refrigerated at 3° C, 43.0%; and 4) air-dried and stored at room temperature, 0.0%. No air-dried tubers sprouted. Performance differences between those stored moist and those stored in water is not understood.

Conclusions

Natural stands of delta duckpotatoes free from wildlife foraging contained 160.3 plants/m^2. These stands were produced on sites where an estimated 46 tubers remained from the previous year. Stands of the species established in 5.7 m^2 tanks by planting 1 tuber contained 31.1 plants/m^2 after 5 months.

The study indicated that foraging by nutrias and ducks removed a major portion (90.1%) of the tubers present. The tubers were found to a soil depth of 30 cm. The maximum depth at which tubers will grow is not known; however, 30 (65.2%) tubers/m^2 were present at depths less than 15 cm prior to

the growing season in areas subject to animal foraging. Therefore, foraging by wildlife on tubers was not sufficient to effectively reduce stands the following year.

Feeding on above-ground portions of the plants by nutrias and other herbivores reduced stand densities by 35%. Nutrias and swamp rabbits were the main species involved and were present in high densities. Therefore, foraging on above-ground parts of the plant did not appear to affect tuber production on the study area. However, in small stands where the animals may become concentrated, foraging on plants may effectively reduce tuber production.

During the tank studies, insects fed on plants and damage to leaves and seedheads was noted. Insecticides were applied to the plants, thus eliminating the insect problem (Pilcher 1981). In areas managed for waterfowl and crayfish, the use of insecticides may be restricted because of possible harm to crayfish. Under such conditions, insect damage could possibly become severe enough to kill plants and thus reduce plant biomass and tuber production.

Although field plantings were not evaluated, the study indicated that stands can be established by planting tubers. The tubers should be placed 2 to 3 cm below the surface of moist soil and spaced approximately 3 m apart. In natural stands, plants grew without flooding. However, flooding planted areas to a depth of 30 cm after leaves emerge would likely increase plant biomass production.

Tubers for planting should be collected after November and stored at approximately 3° C in sealed plastic bags. Drying of tubers should be avoided.

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