I. NONSTRUCTURAL CARBOHYDRATE RESERVES OF BLACKBERRY (*Rubus* sp.) AND MULTIFLORA ROSE (*Rosa multiflora* Thunb.)

II. CHEMICAL CONTROL OF BLACKBERRY (*Rubus* sp.) WITH FOLIAR HERBICIDES

by

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I. Blackberry and Multiflora Rose Growth

Blackberry

Blackberries belong to the genus Rubus, a large genus of deciduous or evergreen shrubby and many times prickly plants, some of which are erect and some decumbent. They are most abundant in the north temperate zones of both the northern and southern hemispheres (Braun 1961).

The 3 species of Rubus native to Kansas are the black raspberry (R. occidentalis L.), dewberry (R. flagellaris Willd), and highbush blackberry (R. ostryifolius Rydb.) (Stephens 1969). The black raspberry exhibits a decumbent stem, while the highbush blackberry has an arching or erect stem and the dewberry may be slightly arched or decumbent.

The roots of these 3 species are very similar with a swollen zone that is 5 to 7.5 cm long with few lateral roots that are approximately 7 mm in diameter. These lateral roots can and do give rise to new plants with their own root system, which increases cane densities. All 3 of these species are deciduous. Several Rubus species similar to highbush blackberry are cultivated in Kansas (Stephens 1969).

The 3 Rubus species native to Kansas have biennial stems and perennial roots. The first year canes, called primo canes, are normally unbranched and bear no fruit. In the second year, the canes known as floricanes, branch and produce fruit. Floricanes do not increase in length and may or may not die at the end of the growing season (Braun 1961, Stephens 1969). Black raspberry and dewberry floricanes may take root when in contact with the soil.

Multiflora Rose

Multiflora rose (Rosa multiflora Thunb.) was introduced into the United States from Japan in 1886. It was used initially as hardy root stock for ornamental roses (Wyman 1969). Today the Soil Conservation Service has recommended it for wildlife cover and soil stabilization. It is being used as live fencing and highway median barriers in some states (Wharton and Barbour 1973).

Multiflora rose has become a problem because it can spread from seed (Wharton and Barbour 1973) which remain viable for a number of years (Sherrick and Holt 1977). The fruit of multiflora rose are relished in winter by many bird species, and the seeds germinate more readily after passing through their digestive tracts (Wharton and Barbour 1973, Sherrick and Holt 1977). After a plant becomes established it develops a strong root system that has a large swollen area at or just below the soil surface at the acropetal end of a large taproot. This crown area sprouts readily and produces a dense clump of stems (Wharton and Barbour 1973).

Because of its value as a conservation planting, the Soil Conservation Service has made attempts to develop a strain of multiflora rose that does not spread (Wharton and Barbour 1973). Because this plant, the hardiest of the rose family, is capable of enduring a wide range of soil and environmental conditions and has no serious pest problems, it has become widespread in the United States both as an unwanted species and as a desirable planting (Wyman 1969).

II. Carbohydrate Storage and Translocation in Woody Plants

Carbohydrate Storage

Carbohydrates such as starch and sugars are the organic building blocks of plant life. These products of photosynthesis are the basic substances from which all other organic substances within a plant are formed (Kramer and Kozlowski 1960). When photosynthesis of carbohydrates exceeds a plants' demand for growth, maintenance, and reproduction, carbohydrate reserves are created. These reserves in turn may be used by the plant during periods when plant demands cannot be met by photosynthesis alone (Mooney, 1972). Reserves are needed for initiation of early spring growth and are also used for respiration in winter (Cook 1966).

Carbohydrate reserves fluctuate during the yearly growth cycle of perennial plants. Generally, carbohydrate reserve levels of perennial plants follow a -V- or -U- shaped annual cycle (Trlica 1977). For many plant species the lowest reserve levels occur during early growth (Jameson 1963). Coyne and Cook (1970) reported that the root reserves of shadscale (*Atriplex confertifolia* (Torr. & Frem.) Wats.) went from 8.2% total available carbohydrates (TAC) in early March to a low of 4.5% in mid-May and then followed an increasing trend through the first part of November. Donart (1969) while comparing the carbohydrate reserve cycles of 6 mountain range species as related to growth, found that the perennial grasses, shrubs, and forbs he examined all had a significant loss of carbohydrate reserves during early growth.

Timing of high and low points in root reserves may vary from species to species. Aldous (1934) reported that reserves in buckbrush (*Symphoricarpos orbiculatus* Moench) reached their low point in mid-May and their high point in early October while smooth sumac (*Rhus glabra* L.) root reserves reached their low point nearly a month later and their high point a month earlier than did buckbrush during the same growing periods.

Coyne (1963) observed that the low point in tamarisk (Tamarix pentandra Pall.) carbohydrate reserves was from 21 March to 16 May in Arizona, and 29 April to 25 June in New Mexico. These variations were attributed to variations in the time of initiation of spring growth.

Carbohydrate Translocation

Carbohydrates are transported in a plant via the phloem. About 90% of the materials transported in the phloem are carbohydrates (Zimmerman 1960). They normally move from a source to a sink within the plant. A source is a storage organ such as a root or rhizome, or photosynthesizing leaves, and sinks are sites of rapid growth, such as developing leaves, fruits, and growing portions of the plant, or storage organs when photosynthesis exceeds metabolic demands.

The most abundant form of carbohydrate found in phloem transport is sucrose (MacRobbie 1971), although other important forms of carbohydrates are translocated. A very small percentage of hexose sugars are found in phloem transport (Wardlaw 1974). The direction of movement of sucrose is determined by a concentration gradient (Canny 1962). The stronger the sink, or the closer to the source, the stronger the gradient. Strong gradients along the translocation pathway will result in one-way translocation while a weak gradient will allow bidirectional movement (MacRobbie 1971).

During the growth of a plant the relationship between source and sink are constantly changing. Roots and stems of perennials provide the only source of carbohydrates for early spring growth. After the photosynthetic rate in an expanding leaf exceeds the requirements of that leaf for growth and respiration it becomes a source of translocated carbohydrates. A leaf begins to export carbohydrates when it reaches one third to one half of its final area (Wardlaw, 1968). Once a leaf begins to export carbohydrates it becomes a source for expanding leaves, roots, and other sink sites, depending on the stage of morphological development of the plant. Begg and Wright (1964) proposed that an order of priority for photosynthate allocation occurs in reed canarygrass (*Phalaris arundinacea* L.) shoots. The first priority is initiation and development of leaves, second priority is an increase in dry weight of shoots and stem elongation and the third priority is carbohydrate reserve formation. When a leaf is fully expanded it can no longer function as a sink (Wardlaw 1968).

III. Chemical Control of Blackberry and Multiflora Rose

Blackberry

Chemical control of perennial plants is often difficult because of resprouting that occurs utilizing energy from stores of carbohydrates in roots and stems. Blackberries are in this group of plants. It is often difficult to get enough herbicide translocated to root tissues to prevent growth of dormant root buds (Richardson 1976). Some herbicides may, in sublethal doses, even stimulate suckering (Amor 1974).

The best control of woody plants is obtained after the first leaves have fully expanded, but before shoot elongation has ceased (Upchurch et al. 1968). As blackberry plants age their resistance to 2,4,5-T [(2,4,5-trichlorophenoxy) acetic acid] and picloram (4-amino-3,5,6-trichloro-2-pyridinecarboxylic acid) increases. When plants are treated just prior to flowering the suppression of suckering is very poor due to little downward translocation at that stage of phenological development (Amor 1974).

Much of the efficacy of foliar herbicides is due to uptake through the cuticle of the treated plant and subsequent translocation from the foliage to roots and other parts of the plant. Upchurch et al. (1968) indicated that a reduction in herbicide effectiveness can be associated with a reduction in carbohydrate movement from shoots to roots, making herbicide application timing critical. Leonard et al. (1966) stated that the best time to treat with phloem translocated herbicides is a compromise between downward translocation and decreasing sensitivity.

A second period of herbicide effectiveness may occur during the latter part of the growing season (Coulter 1954, Dalrymple and Basler 1963). This second period is usually observed as an incidental aspect of other research and has not been specifically investigated (Upchurch et al. 1968).

The most commonly used herbicide for control of blackberries is 2,4,5-T, but repeated applications are necessary for eradication (Amor 1975). Amor and Harris (1977) reported that 2,4,5-T ester was significantly more effective than 2,4,5-T amine for blackberry control but still reduced live canes by only 38% with one application. The limiting factor in 2,4,5-T control of blackberry appears to be poor translocation to the roots since an increase in concentration of the butyl ester from 0.29 kg to 0.9 kg of active ingredient per 378 L of solution did not increase its efficacy (Richardson 1976). Richardson and Grant (1977) found that the highest concentration of 2,4,5-T in the treated plant, other than the treated leaf, was always near the treated leaf even though 2,4,5-T could be found throughout the plant 6 hours after application. They speculated that this poor translocation was due to leakage from the phloem to the xylem. It was also found that a large concentration gradient of 2,4,5-T existed across the crown of treated plants.

Picloram is another chemical that is commonly used for blackberry control. It is generally more effective than 2,4,5-T but it can present residue problems and is more costly (Amor and Harris 1977). Amor (1975) reported that picloram at sublethal rates will stimulate suckering.

A mixture of 2,4,5-T and picloram used in Victoria, Australia, appeared to have a synergistic effect. As the concentration of picloram was increased from zero to about 0.2% active ingredient in a 0.067% solution of 2,4,5-T, the percent reduction of live canes was increased from 0 to 80%. Picloram alone at the lower concentrations actually caused an increase in the number of live canes (Amor and Harris, 1977).

Multiflora Rose

Multiflora rose is another perennial plant that resists eradication with a single herbicide application. Most research indicates that treatment over 2 or 3 years is necessary to kill established plants because of root resprouting and because of the need for thorough coverage of vegetation to kill living canes and roots.

Gogan et al. (1977) found that 2,4,5-T at 1.8 kg acid equivalent per 378 L of solution, with thorough wetting, would give 100% control in Iowa while Reed and Fitzgerald (1979) found that 0.9 kg per 378 L, applied in the same manner, obtained variable results, ranging from 75 to 95% control. The combination of 2,4,5-T and 2,4-D [(2,4-dichlorophenoxy) acetic acid] gave 98% control (Gogan et al. 1977, Creswell and Fawcett 1981). Dicamba (3,6-dichloro-o-anisic acid) solutions of 1 and 4% gave 90 to 100% control, although control from September treatment tended to be slightly higher than from treatment in mid-August. Creswell and Fawcet (1981) found that a 1% solution of 2,4-D ester alone gave 89% control. Tryclopyr ([(3,5,6-trichloro-2-pyridinyl)oxy] acetic acid) in both the amine and ester formulations reportedly gave 90 to 100% control (Creswell and Fawcett 1981, Reed and Fitzgerald 1979). Fick et al. (1983) also reported 100% control of multiflora rose treated with a 0.5% solution of triclopyr ester at the flowering stage.

Other methods of multiflora rose control, such as cutting and treating the stumps with 2,4,5-T were effective but very time consuming and labor intensive. One method that may be of practical importance is prescribed burning followed by an application of granular picloram. Results from this method might be expected to be very similar to those obtained by Gordon and Scifres (1976) in controlling McCartney rose (Rosa bracteata Wendli) with no regrowth evident 6 months after application of picloram granules. Pelleted formulations of picloram, tebuthiuron [N-[5-(1,1-dimethyl)-1,3,4-thiadiazol-2-y,l]-N, N^1-dimethyl urea], and hexazinone [3-cyclohexyl-6-(dimethylamino)-1-methyl-1,3,5-triazine-2,4(1H,3H)-dione] applied at 2.2 kg/ha in the spring gave 75 to 100% control of multiflora rose (Fick et al. 1983).

IV. Mode of Action of Herbicides

In the last 30 years many herbicides have been introduced into the market place. As in any industry, competition has forced continual improvements. Each new herbicide developed is for a specific use and in general is more selective.

Selectivity is achieved in various manners. Some chemicals interact with enzymes of specific plants, which causes blocking of normal physiological processes, whereas others depend on directed placement for selectivity. Timing is another important means of achieving desired selectivity. If a plant is not actively growing at the time of treatment, it may be spared the phytotoxic effects of a particular chemical. Differential absorption, translocation, and metabolism also account for selectivity of herbicides.

Compounds such as 2,4-D, 2,4,5-T, dichlorprop (2-(2,4-dichlorophenoxy) propionic acid) and MCPA ([(4-chloro-o-tolyl)oxy]acetic acid) are members of the chlorophenoxy herbicide family. This is one of the oldest families of selective herbicides, yet very little is known about their mode of action. These herbicides affect almost every biological activity of a plant (Crafts 1961). Ashton and Crafts (1973) state that the complete foliar action of 2,4-D involves penetration of the leaves, stems, and roots, absorption into the symplast, migration across parenchymatous tissues to the vascular channels, translocation from sources to sinks along with plant foods and finally the herbicidal response. Final death of plant tissues may result from contact action, extreme hormone-like response, excessive production of buds or root initials, softening of root cortex and degeneration or crushing and plugging of vascular tissues.

It is thought that 2,4-D may inhibit respiration in mitochondria by affecting a reaction involved in coupling phosphorylation with electron transport (Lotlikar et al. 1968). It also inhibits translocation by causing a build-up of callose tissue on phloem seive plates. This is thought to be induced by the over-production of messenger RNA.

Dicamba is a member of the benzoic acid family of herbicides. It is readily taken up by plant foliage and is readily translocated via both symplastic and apoplastic systems. Keitt and Baker (1969) reported that dicamba promoted cell division in the prescence of kinetin and an increase in cell size, leading them to conclude that it has auxin-like properties. Dicamba also promotes cell elongation, proliferation of tissue, induction of adventitious roots and epinastic responses. In addition, it inhibits both phototropic and geotropic responses in susceptible plants (Vander Beek 1967, Schrank 1964).

Picloram is an extremely mobile compound. It is readily adsorbed by both leaves and roots, and is translocated throughout the plant by both the phloem and xylem (Ashton and Crafts 1973). Picloram causes epinasty, bending and splitting of stems and root deterioration. Scifres and McCarty (1968) determined that picloram has its main effect through stimulation of prolific growth, causing the destruction of phloem parenchyma, seive elements and companion cells.

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II. Nonstructural Carbohydrate Reserves of Blackberry (*Rubus* sp.) and Multiflora Rose (*Rosa multiflora* Thunb.)

ABSTRACT

Blackberries (Rubus sp.) and multiflora rose (Rosa multiflora Thunb.) invade rangelands and reduce grazing capacity. The effectiveness of chemicals for the control of many woody species is linked to the nonstructural carbohydrate cycle of each species. Little is known of the carbohydrate cycle of blackberry and multiflora rose. Root total nonstructural carbohydrate (TNC) levels were examined in relation to phenological development of blackberries and multiflora rose for 2 growing seasons. Blackberry root TNC followed a pattern similar to many perennial species with the lowest levels occurring at seed maturity followed by a 6 to 8 week period of TNC increase. The highest levels of TNC occurred in September of both years. A decline in TNC was noted in September of both years and was attributed to TNC involvement in root growth. Multiflora rose root TNC changed little during the sampling periods. The lack of TNC variation in multilfora rose roots was attributed to significant TNC storage in other plant tissues.

Introduction

Blackberries (Rubus sp.) are found in 47 of the 105 counties in Kansas in primarily the eastern one-half of the state (Stephens 1969). Many of the species of blackberry that are found in Kansas are native and are very well adapted to climatic conditions and soil types, and therefore very well suited to invade overgrazed rangelands.

Invasion of rangeland by blackberry constitutes an economic problem due to the loss of grazing capacity. Few mechanical or chemical control methods provide more than suppression of growth. Blackberries resist long term control by mechanical methods because of crown buds. Most of the available herbicides provide temporary top kill but very little root kill. Effective control is dependent on destruction of basal buds.

Multiflora rose (Rosa multiflora Thunb.) is another woody plant that has become a problem on grazing lands. Multiflora rose seed remain viable for several years and are spread by birds. This plant was introduced into the United States from Japan as a root stock for many ornamental roses (Wyman 1969). It later was used by the Soil Conservation Service for wildlife cover and soil stabilization.

Studies have shown that herbicides move in the same translocation stream with sugars in plants (Mitchell and Brown 1946). Consequently, carbohydrates are frequently studied to indicate the direction of herbicide translocation. Little or no information exists on the nonstructural carbohydrate movement of blackberry or multiflora rose. The purpose of this study was to examine root carbohydrate levels in relation to phenological development of blackberry and multiflora rose. Information gained from this study will be used to determine optimal timing of herbicide application based on carbohydrate reserves.

Materials and Methods

The site for this study was located in northwestern Linn County, Kansas. The topography of the site was a 1 to 3% sloping upland prairie with bedrock at 15 to 60 cm of depth. The soil type in this area is a Catoosa silt loam (fine-silty, mixed, thermic Typic Argiudolls) with a pH of 6.3 and moderate levels of organic matter (Penner 1981). The vegetation is characteristic of the southeast Kansas tall-grass prairie. Big bluestem (*Andropogon geradi* Vitman) and indiangrass (*Sorghastrum nutans* (L.) Nash) were the predominant grass species while western ironweed (*Vernonia baldwinii* Torr.), and western ragweed (*Ambrosia psilostachya* DC.) were the predominant forbs.

The main shrubs in the study area were blackberry, multiflora rose, and buckbrush (*Symphoricarpos orbiculatus* Moench.). The average annual rainfall in the area is 980 mm, with 85% falling between 1 April and 1 November. The frost-free dates are 28 April through 9 October.

Root samples of blackberry and multiflora rose were collected at approximately 2 week intervals from early April to mid-October in 1981 and from early May through late September in 1982. Four samples of each species were collected on all sample dates and consisted of the plant crown and the top 6 to 10 cm of the taproot. Once collected, the samples were frozen to stop enzymatic activity during transport. The samples were dried in a forced-air oven at 70°C for a minimum of 48 hours. After drying, the samples were ground in a Wiley Mill to pass a 20-mesh screen. Phenological development of each species was determined for each sampling date.

Total nonstructural carbohydrate (TNC) was determined by extracting a 500 mg sample using an alpha amylase enzyme hydrolysis of disaccharides and starches and copperiodometric titration (Smith 1969). Total nonstructural carbohydrate concentration was expressed as % TNC on a glucose equivalent basis.

Root TNC was analyzed separately for each species and year using a completely randomlized design. Means were separated using Duncan's Multiple Range Test following a significant (P<0.10) F-test (Snedecore and Cochran 1980).

Results and Discussion

Blackberry

The highest level of TNC in blackberry roots, 156 mg/g in 1981 and 82 mg/g in 1982, occurred in September of both years, while the low points, 31 and 38 mg/g occurred in July of 1981 and June of 1982, respectively (Fig. 1).

Phenological development progressed at nearly the same rate in both years. The development process was about 2 weeks earlier in 1982 than in 1981 as illustrated by the fact that in 1981 most blackberry plants were not in full bloom until May 15 but in 1982 they were in full bloom on May 2. Berry set and seed maturation were both approximately 2 weeks earlier in 1982 than in 1981. The earlier development in 1982 could be due to climatic conditions as the latter half of April and all of May of 1982 were warmer and wetter than the corresponding time period in 1981 (Table 1).

Root TNC decreased 10 mg/g as new growth was initiated in the spring (2 April to 19 April, 1981). The decreasing trend in root TNC was reversed when new foliage had expanded enough to supply carbohydrates for the growth process and root storage.

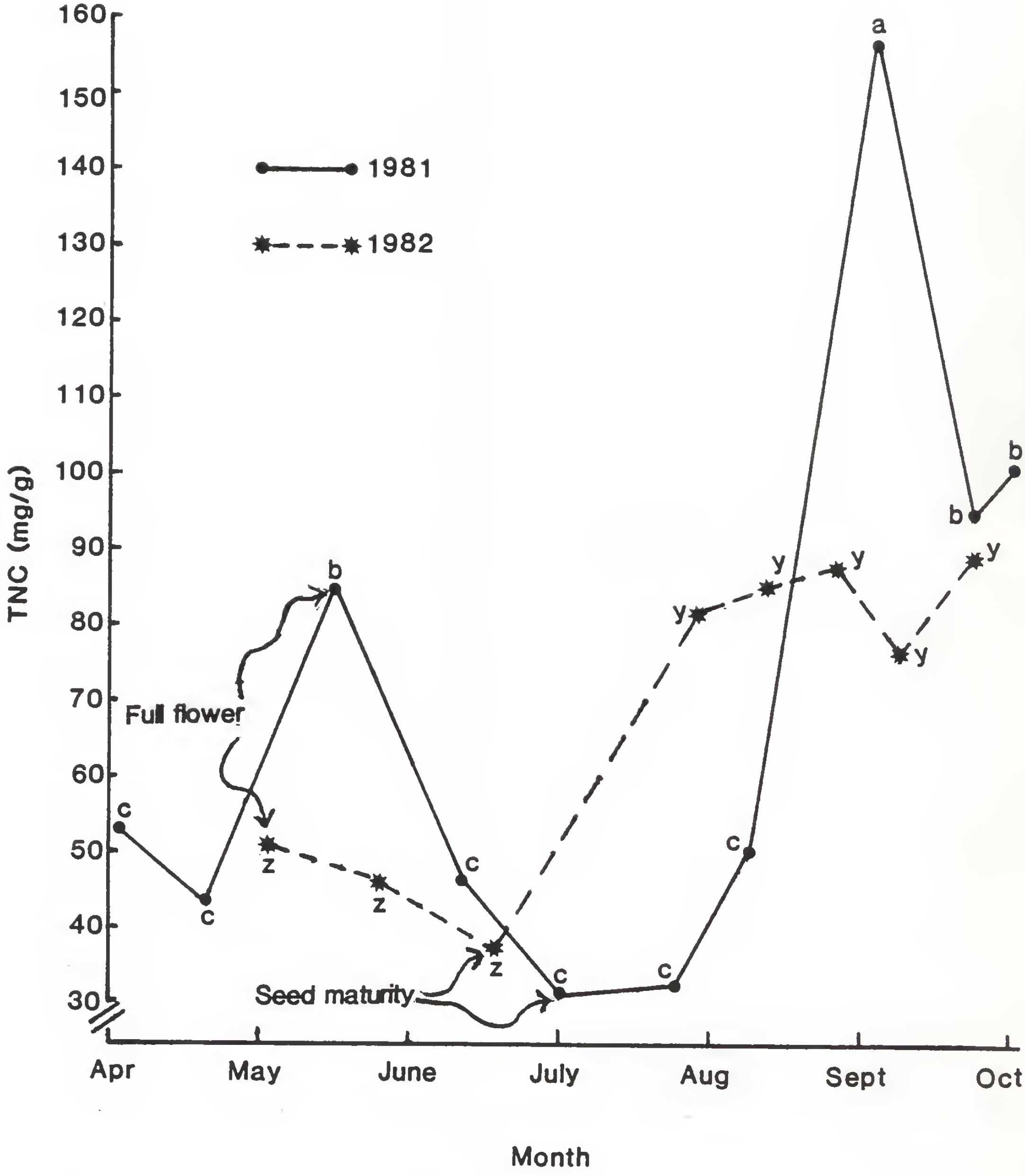

Fig. 1. Total nonstructural carbohydrates (TNC) in blackberry roots.

Sample dates within years followed by similar letters are not different ($P > 0.10$).

Table 1. Temperature and moisture for 1981 and 1982[1].

	1981				1982			
	Precip.[2]	Temp.[3]			Precip.[2]		Temp.[3]	
Month	Avg.	1981	max	min		max	min	avg.
March	5.36	15.78	2.17	9.00	6.71	15.83	0.17	8.00
April	2.54	24.83	11.28	18.11	5.46	19.56	4.33	11.94
May	19.58	22.94	9.72	16.33	22.99	24.72	13.39	19.06
June	32.16	30.00	17.17	23.61	9.19	26.78	14.72	20.78
July	14.20	32.56	20.61	26.61	2.03	32.78	20.39	26.61
August	9.55	30.06	17.67	23.89	15.65	31.17	19.78	25.50
September	4.32	28.00	14.61	21.33	1.42	27.61	14.33	21.00
October	13.56	19.89	8.11	14.00	9.55	22.39	6.61	14.50

[1] Weather data collected Garnett, Kansas weather reporting station.

[2] Precipitation in centimeters.

[3] Temperature °Centrigrade.

An increasing trend in root TNC continued from the spring low point until plants began to flower. As berries began to develop, root TNC levels declined until the berries matured. This decline may be due to upward translocation from the roots to supply the energy demands for the seed production, since developing seeds are known to be a strong sink. Downward translocation of TNC to an expanding sink (root system) may also result in a decreasing concentration of carbohydrate reserves in the storage organ (Fick and Sosebee 1981).

Root TNC increased sharply during the first 3 to 6 weeks after berry maturity. Dalrymple and Basler (1963) found that blackjack oak (Quercus velutina Lam.) had an increase in the absorption and translocation of ^{14}C-labelled 2,4,5-T [(2,4,5-trichlorophenoxy) acetic acid] in August and September indicating a strong downward translocation. Herbicidal root kill in other woody species with similar carbohydrate reserve cycles, such as honey mesquite (Prosopsis glandulosa var. glandulosa), has been achieved at levels comparable to early season application during this period of strong downward translocation in the late summer (Arnold and Burzlaff 1978).

Root TNC levels continued to increase until mid-September, when a decline again occurred. There was a 62 mg/g decrease in root TNC from mid-September 1981 to the end of September 1981 which was a statistically significant reduction (Fig. 1). A net reduction in root TNC occurred from 25 August to 8 September, 1982. Although the reduction in 1982 was not statistically significant, the time at which it occurred corresponded, in the seasonal cycle, very closely to the reduction in 1981. Drier conditions in 1982 may have reduced root growth relative to 1981 (Table 1) as this period is believed to be one of root growth activity and may be controlled by soil moisture and temperature conditions. Once the root TNC reduction ceases, reserve levels increase until plant dormancy occurs.

Proper timing in the use of foliage-applied herbicides for effective root kill can be aided by the use of root TNC information. Root TNC is not always known and can only be determined by laboratory procedure. However, increasing and decreasing trends can usually be predicted by noting the phenological development of the plant. In blackberries, initial spring growth requires the use of energy stored in the roots and stems of the plant resulting in a decreasing percentage of root TNC. The translocation of stored carbohydrates from roots to shoots restricts the downward movement of foliage-applied herbicides, and reduces the possible concentration of herbicides in roots.

The next change in root TNC occurs during the development of the first leaves. As leaves reach one-third to one-half of their final area they begin to export carbohydrates and by the time the first leaves are fully expanded root TNC is beginning to increase (Wardlaw 1968). Downward translocation of TNC increased in blackberry as leaves matured, as indicated by the increase in root TNC between early spring growth and flowering, 19 April and 15 May, 1981 (Fig. 1). This period occurred prior to sampling in 1982, but corresponds with other research done with blackberries (Amor 1974). When leaves are three-fourths to fully developed is an effective time for the use of foliage-applied herbicides. The plants' TNC reserves are relatively low and translocation to the roots is high, therefore herbicides are more efficiently transported from the leaves to the roots than when translocation is limited or not occurring. Root growth is unlikely during this period of rapid foliar development because a strong aerial sink exists and some woody plants alternate between top and root growth (Head 1967).

As the plant begins to flower, downward translocation decreases. If the carbohydrate demands of seed production exceed the supply provided by the leaves the balance is supplied by upward translocation of carbohydrates stored in the roots and stems. This is demonstrated by the decline in root TNC during berry maturation (Fig. 1). Root TNC was reduced 54 mg/g in 1981 and 14 mg/g in 1982 during this stage of growth. Since the utilization of root TNC for seed production was in progress when the first root samples were taken in 1982 the total reduction in root TNC was not fully documented. In both 1981 and 1982 the lowest percentage of root TNC measured was at the end of berry maturation. The upward translocation of root TNC between flowering and seed maturity indicated that the reproductive portion of the plant's phenological development would be a relatively ineffective time for the use of foliar herbicides.

Once the reproductive phase is completed, the plant begins to replenish root TNC. The increase in root reserves continues into the latter portions of the growing season, lasting 7 to 8 weeks after seed maturity. The sharp increase of root TNC from the seasonal low during late summer indicates a strong potential for translocation of toxic amounts of foliar herbicides into the roots during the 7 to 8 week period after seed maturity. The limiting factor at this point in the growth cycle would be the plant cuticle. The cuticle, in this portion of the growing season, is relatively thick, to protect the plant from hot, dry climatic conditions, therefore, it is difficult to penetrate when using water as a herbicide carrier.

Multiflora Rose

Multiflora rose root TNC was examined simultaneously with the blackberry root studies. The findings of this study indicate that the roots of multiflora rose have a nearly constant TNC level throughout the growing season with the only significantly different TNC level occurring 11 September, 1981 (Fig. 2). Therefore, multiflora rose with a nearly constant root carbohydrate reserve level differs from perennial plants that have a typical -V- or -U- shaped annual carbohydrate reserve cycles. Plants with a -V- shaped annual carbohydrate reserve are characterized by a rapid draw-down of reserves for initiation of spring growth with a rapid restoration of reserves after the low point has been reached. Plants with a -U- shaped annual carbohydrate reserve cycle maintain a low level of carbohydrate reserve during active growth (Menke and Trlica 1981). Plants with either a -U- or -V- shaped carbohydrate reserve cycle display times when foliar-herbicide application would be most effective due to rapid downward translocation (Mitchell and Brown 1946). Therefore, no inferences could be made from the data in relation to optimum timing of root kill of multiflora rose through the use of foliarly-appied herbicides.

Further studies should be initiated to determine if other plant parts, in particular the stems, show seasonal TNC cycles to aid in timing herbicidal applications for the most effective root kills.

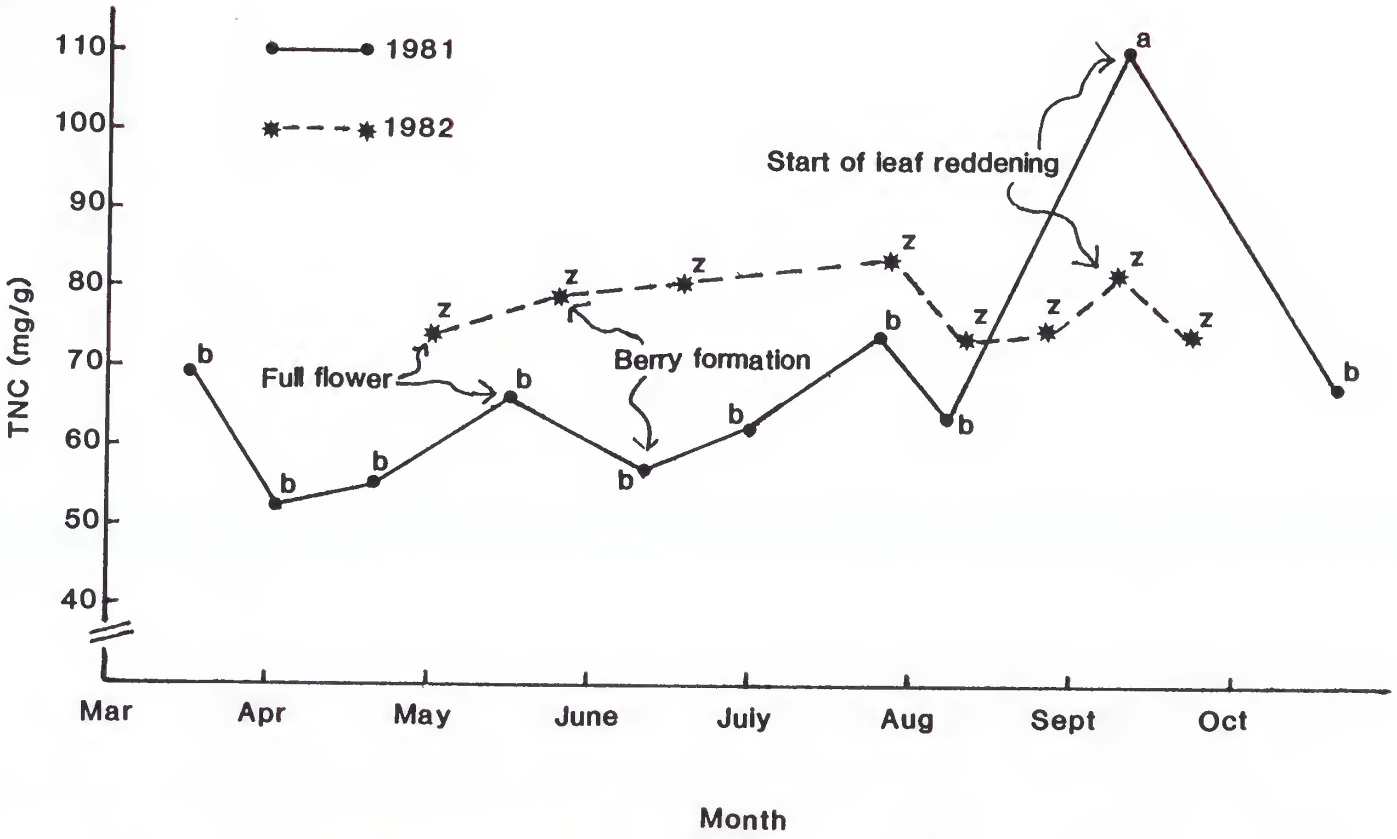

Fig. 2. Total nonstructural carbohydrates (TNC) in multiflora rose roots. Sample dates within years followed by similar letters are not different (P> 0.10).

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III. Chemical Control of Blackberry

ABSTRACT

Herbicides were applied foliarly to blackberries on 2 dates, 15 May and 9 June 1981. The herbicides were applied in 936 L of water/ha to thoroughly wet the foliage. When evaluated 15 months after treatment dicamba (3,6-dichloro-o-anisic acid) + 2,4-D [(2,4-dichlorophenoxy) acetic acid] (.6 kg a.e. + 2.2 kg a.e./ha) gave better control when applied 15 May whereas picloram (4-amino-3,5,6 trichloro-2-pyridinecarboxylic acid) (.6 kg a.e./ha) gave better control when applied 9 June. Both the ester and amine formulation of triclopyr ([(3,5,6-trichloro-2-pyridinyl)oxy] acetic acid), and 2,4,5-T [(2,4,5-trichlorophenoxy) acetic acid] gave good control regardless of treatment date. Other herbicides or combinations of herbicides provided poor control when applied on either treatment date.

Introduction

Blackberries (Rubus sp.) cause a problem in several areas of the world by removing grazing lands from peak production. Blackberries are spread by birds and other wildlife that eat the seeds. Blackberries are also spread by lateral roots that increase cane densities within colonies and increase the area occupied by cane colonies. Some species of blackberry are deciduous while other species are evergreens. All species found in Kansas are deciduous (Stephens 1969).

Although blackberries have been a problem for many years, little work on their control has been reported. The most commonly recommended herbicide for control of blackberry has been 2,4,5-T (Launchbaugh and Owensby 1978) but repeated applications are necessary for eradication (Amor 1975). The decreased availability and use of 2,4,5-T for rangeland brush control necessitates screening of other potential herbicides for control purposes. Therefore, research was initiated to determine an effective means to control blackberries with foliar herbicides.

Materials and Methods

Foliar herbicide studies were conducted in northwestern Linn County, Kansas. The topography of the site was a 1 to 3% sloping upland prairie. The soil type in this area is a Catoosa Silt loam (fine-silty, mixed, thermic typic Argiudolls) (Penner 1981). The vegetation is characteristic of the southeast Kansas tall-grass prairie. Big bluestem (Andropogon gerardi Vitman) and indiangrass (Sorghastrum nutans (L.) Nash) were the predominant grass species while western ironweed (Vernonia baldwini Torr.), and western ragweed (Ambrosia psilostachya DC), were the predominant forbs. The main shrubs in the area were blackberry, multiflora rose (Rosa multiflora Thunb.) and buckbrush (Symphoricarpos orbiculatus Moench.).

Herbicides were applied 15 May, 1981 at the flowering stage and 9 June, 1981 at the berry-formation stage. The individual treatments were applied to $3m^2$ plots with 2 replications of each treatment in a randomized block design.

Herbicides, applied in 936 L of water/ha to thoroughly wet the foliage included the dimethylamine salt of 2,4-D [(2,4-dichlorophenoxy) acetic acid] (2.2 kg a.e./ha); butoxyethanol ester of dichlorprop (2-(2,4-dichlorophenoxy) propionic acid), (4.4 and 6.7 kg a.e./ha); butoxyethanol esters of both diclorprop + 2,4-D, (2.2 + 2.2 and 3.3 + 3.3 kg a.e./ha); monoethanolamine salt of clopyralid (3,6-dichlo-2-pyridinecarboxylic acid) + the dimethylamine salt of 2,4-D (0.3 + 1.1 and 0.6 + 4.4 kg a.e./ha); monoethanolamine salt of clopyralid, (1.1 and 2.2 kg a.e./ha); dimethylamine salt of 2,4,5-T [(2,4,5-trichlorophenoxy) acetic acid], (1.1. kg a.e./ha); dimethylamine salt of dicamba (3,6-dichloro-o-anisic acid), (1.1 kg a.e./ha); dimethylamine salts of dicamba + 2,4-D, (0.6 + 2.2 kg a.e./ha); potassium salt of picloram (4-amino-3,5,6-trichloro-2-pyridinecarboxylic acid) (0.3 and 0.6 kg a.e./ha); triethylamine salt of triclopyr ([(3,5,6-trichloro-2- pyridinyl) oxy] acetic acid), (1.7 and 3.4 kg a.e./ha); ethylene glycol butyl ether ester of triclopyr, (2.2 and 4.4 kg a.e./ha). Applications were made with a pressurized garden-type sprayer.

All treatments were visually evaluated 3 months after treatment based on the reduction in percentage of live canes. Fifteen months after treatment (the end of the second growing season), control was evaluated based on a 0-10 rating scale with 10 being complete control and 0 being no control. Treatments were subjected to a factorial analysis of variance and separated by Duncan's Multiple Range Test (Snedecor and Cochran 1980).

Results and Discussion

Dates did not differ in overall control, however, some herbicides achieved a higher degree of control when applied one date as compared to the other. Consequently, the control achieved with each herbicide is given for both dates of application (Table 1).

When evaluated 3 months after application, treatments made on 15 May were significantly superior to treatments made on 9 June for 2,4-DP at 6.7 kg/ha, triclopyr ester at 2.2 kg/ha, dicamba and the combination of dicamba + 2,4-D, with the triclopyr ester reducing live canes 98% on 15 May treatment and 78% with 9 June treatment. The combination of dicamba + 2,4-D reduced live canes 78% with 15 May treatment and 23% with 9 June treatment. June 9 was a significantly superior date of treatment for the 0.6 kg/ha rate of picloram, both treatment levels of 2,4-D + 2,4-DP and triclopyr amine at 1.7 kg/ha. The 1.7 kg/ha rate of triclopyr amine reduced live canes 100% with 9 June as the treatment date and 78% with treatment on 15 May, while 0.6 kg/ha of picloram reduced live canes 94% with treatment 9 June and 50% with 15 May treatment. The combination of 2,4-D + 2,4-DP (2.2 kg/ha of each) reduced live canes 26% with 9 June treatment and 3% with 15 May treatment. June 9 treatment was also superior to May treatment for the higher rates of 2,4-D + 2,4-DP (3.3 kg/ha of each) with 58% reduction in live canes with 9 June treatment and 35% reduction in live canes with 15 May treatment.

Table 1. Comparison of two application dates (May 15 vs June 9) for herbicidal control of Blackberry (Rubus sp.).

Herbicide	Rate (kg/ha)	3 Mos. Evaluation[1,3]		15 Mos. Evaluation[2,3]	
		May 15	June 9	May 15	June 9
2,4-D	2.2	6.0^{hi}	6.0^{hi}	15.0^{gh}	15.0^{gh}
2,4-DP	4.4	10.0^{g-i}	6.0^{hi}	20.0^{f-h}	15.0^{gh}
	6.7	58.0^{c}	21.0^{fi}	55.0^{b-c}	30.0^{e-h}
2,4-D + 2,4-DP	2.2 + 2.2	3.0^{i}	26.0^{e-g}	10.0^{gh}	30.0^{e-h}
	3.3 + 3.3	35.0^{d-f}	58.0^{c}	40.0^{d-g}	55.0^{b-e}
3,6-D	1.1	6.0^{hi}	3.0^{i}	15.0^{gh}	10.0^{gh}
	2.2	6.0^{hi}	3.0^{i}	15.0^{gh}	10.0^{gh}
3,6-D + 2,4-D	0.3 + 1.1	6.0^{hi}	3.0^{i}	15.0^{gh}	10.0^{gh}
	0.6 + 2.2	3.0^{i}	3.0^{i}	10.0^{gh}	10.0^{gh}
2,4,5-T	1.1	90.0^{ab}	90.0^{ab}	80.0^{a-c}	80.0^{a-c}
Dicamba	1.1	$26.^{e-g}$	5.0^{hi}	30.0^{e-h}	10.0^{gh}
Dicamba + 2,4-D	0.6 + 2.2	78.0^{b}	23.0^{f-h}	70.0^{a-d}	30.0^{e-h}
Picloram	0.3	43.0^{c-e}	28.0^{e-g}	50.0^{c-f}	35.0^{e-g}
	0.6	50.0^{cd}	94.0^{ab}	50.0^{c-f}	85.0^{ab}
Triclopyr ester	2.2	98.0^{a}	78.0^{b}	90.0^{a}	70.0^{a-d}
	4.4	94.0^{ab}	94.0^{ab}	85.0^{ab}	85.0^{ab}
Triclopyr amine	1.7	78.0^{b}	100.0^{a}	70.0^{a-d}	100.0^{a}
	3.3	95.0^{a}	85.0^{ab}	90.0^{a}	75.0^{a-c}

[1] Based on % reduction in live canes/plot.

[2] Based on 0-10 rating scale; 0=no control, 10=100% control.

[3] Values within each evaluation period with different superscripts differ significantly ($P<.05$).

At the 3 month evaluation, triclopyr ester at 4.4 kg/ha 2,4,5-T and triclopyr amine at 3.3 kg/ha gave acceptable control but did not differ in the percentage of cane reduction when comparing one treatment date to the other. Control achieved with 2,4-D and clopyralid alone or in combination with each other was not different from the untreated check on either date of treatment.

When evaluated 15 months after treatment only picloram at 0.6 kg/ha and the combination of dicamba + 2,4-D were significantly different from one treatment date to the other. Picloram rated 85% control for the 9 June treatment and 50% for the 15 May treatment, while the dicamba + 2,4-D combination was provided 70% control for the 15 May treatment date and 30% for the 9 June treatment date.

For some herbicides, the relative control of blackberry due to application date was similar at both the 3 month and 15 month evaluation, however some herbicides maintained a much higher percentage reduction of live canes than did others at the 15 month evaluation. The 3 month evaluation may be of little value due to the time required for plants to resprout. Meyer and Bovey (1984) state that the one year evaluation is the most useful one. It is the shortest time period that gives adequate ratings for maximum canopy reduction and dead plants. Ratings at 2 to 4 months after foliar treatment usually reflect leaf death but not always stem death.

Summary and Conclusions

Dicamba + 2,4-D gave better control when applied 15 May than when applied 9 June. This may be due to better translocation in the plant. At the 15 May application date root reserves were still increasing so that a strong downward translocation was moving the herbicides downward. Picloram at 0.6

kg/ha gave better control when applied 9 June than when applied 15 May. One possible explanation for the difference in control of blackberries with the 0.6 kg/ha rate of picloram when applied 15 May is that this rate caused excessive leaf tissue damage when applied to young newly formed leaves which prohibited movement of the chemical out of the leaves. When applied 9 June the leaves were more protected by the leaf cuticle so that the higher concentration of picloram did less tissue damage but was at a high enough concentration within the plant to be moved against the translocation stream into the roots at sufficient concentrations to kill the plant. A total of 6.7 cm of rainfall occurred during the first 3 days following the 9 June application. This rainfall may have washed the 0.6 kg/ha rate of picloram into the root zone in sufficient quantities to make root uptake responsible for part of the control obtained with the 9 June application.

Other herbicides used in this experiment achieved the same control when applied May 15 or June 9. This indicates that translocation of these herbicides may not necessarily be dependent on the translocation stream within blackberry plants.

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Appendices

Appendix Table 1. Analysis of variance tables for carbohydrate and chemical control data.

Blackberry TNC

1981

Source	df	SS	MS	F	P>F
Model	9	417.267	46.363	4.72	.0016
Error	21	206.259	9.822		

1982

Source	df	SS	MS	F	P>F
Model	7	119.910	17.13	12.10	.0001
Error	24	33.977	1.416		

Multiflora Rose TNC

1981

Source	df	SS	MS	F	P>F
Model	10	96.96	9.7	2.80	.025
Error	31	107.38	3.42		

1982

Source	df	SS	MS	F	P>F
Model	8	12.43	1.55	1.63	.033
Error	27	25.67	0.95		

Chemical Control of Blackberry

Source	df	SS	MS	F	P>F
Model	35	657.819	18.795	17.57	.0001
Error	36	38.500	1.069		
Total	71	696.319			

Appendix Table 2. Rating scale used for 15 month evaluation of chemical control of blackberry.

Numerical Rating	Description of Plant Condition
0	No effect
1	Noticeable but small leaf burn
2	Less than 60% of top growth dead with normal new shoot growth
3	60%-90% of top growth dead with nearly normal new growth
4	Less than 60% of top growth dead with noticeably reduced new shoot growth
5	90%-100% top kill with normal resprouts from trunk or root collor
6	60%-90% of top growth dead and very restricted or abnormal new shoot growth
7	60%-90% top kill with very restricted or grossly abnormal resprouting from root collor or trunk only
8	90%-100% top kill with some abnormal and/or reduced resprouting from trunk or root collor
9	90%-100% top kill with very little resprouting
10	Complete kill (no resprouting)

I. NONSTRUCTURAL CARBOHYDRATE RESERVES OF BLACKBERRY (*Rubus* sp.) AND MULTIFLORA ROSE (*Rosa multiflora* Thunb.)

II. CHEMICAL CONTROL OF BLACKBERRY (*Rubus* sp.) WITH FOLIAR HERBICIDES

by

Howard Leon Stites

B.S., Kansas State University, 1978

AN ABSTRACT OF A MASTER'S THESIS

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MASTER OF SCIENCE

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KANSAS STATE UNIVERSITY
Manhattan, Kansas

1985

Root total nonstructure carbohydrate (TNC) levels were examined in relation to season of the year and to phenological development of blackberry (*Rubus* sp.) and multiflora rose (*Rosa multiflora*) from April through October of 1981 and 1982. Blackberry root TNC followed the same pattern as many perennial species with the lowest levels, 3.13% in July 1981 and 3.79% in June 1982 occurring when the seeds were at maturity. This low point was followed by a 6-8 week period of root TNC increase. The highest levels of root TNC occurred in September of both years (15.6% in 1981 and 8.2% in 1982). There was a decline in root TNC in September of both years attributed to the use of carbohydrate in root growth. Multiflora rose root TNC levels changed very little during the sample period. This may be attributed to significant carbohydrate storage in other portions of multiflora rose plants.

Herbicides were applied foliarly to blackberries on two dates, May 15 and June 9, 1981. The herbicides were applied in 1011 l of water/ha to thoroughly wet the foliage. When evaluated 15 months after treatment dicamba, .56 kg + 2,4-D, 2.2 kg/ha gave better control when applied May 15, while picloram, .56 kg/ha gave better control when applied June 9. Both the ester and amine formulations of triclopyr and 2,4,5-T gave good control regardless of treatment date. Other herbicides or combinations of herbicides used provided poor control when applied on either treatment date.