SELECTIVE CHEMICAL CONTROL OF QUACK GRASS *AGROPYRON REPENS* (L.) BEAUV. IN SEED PRODUCTION FIELDS OF BIRDSFOOT TREFOIL *LOTUS CORNICULATUS* (L.) CV. LEO

by

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Short title

CONTROL OF QUACK GRASS IN BIRDSFOOT TREFOIL

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ABSTRACT

M.Sc. J.A. MACQUARRIE Plant Science

CONTROL OF QUACK GRASS IN BIRDSFOOT TREFOIL

Various chemicals were evaluated at Macdonald College for the selective control of quack grass (Agropyron repens. L. Beauv.) within stands of birdsfoot trefoil (Lotus corniculatus L. cv. Leo). Broad applications of the selective herbicides pronamide, dalapon, sethoxydim, fluazifop-butyl, haloxyfop-methyl, and directed applications of the non-selective herbicide glyphosate were compared. Evaluation parameters consisted of first season control of both rhizome and foliar populations of quack grass and foliar populations the following season. In addition to quack grass control, possible phytotoxic effects of the herbicides on the foliar growth and seed production of birdsfoot trefoil were examined.

Two directional rope-wick applications of glyphosate were superior in reducing quack grass foliar and rhizome populations when applied at an early stage of quack grass growth. There was no significant difference among the three concentrations of glyphosate to water (1:1, 1:2, and 1:3). It was concluded that the lowest concentration glyphosate to water (1:3) would be most economical. Slight damage occurred to the trefoil due to dripping of glyphosate from the wick apparatus although dripping was reduced with a polyester/acrylic type wick.

Among the selective herbicides, sethoxydim and fluazifop-

butyl were superior with the former providing somewhat better control. Fall applied sethoxydim at 0.8 kg/ha was the most effective in reducing quack grass populations the following spring. Fall applied fluazifop-butyl at 0.6 kg/ha was less effective. Early spring applications to the 3-4 quack grass leaf stage of the two herbicides at the same fall rates provided some short term control with later applications (5-leaf and later) being ineffective. Spring applications resulted in early stunting of the quack grass with some reduction in fall regrowth.

Pronamide resulted in inferior quack grass control when applied both in fall and spring at the recommended rate. While fall applied pronamide caused some reduction in the following year's quack grass, spring applied pronamide was totally ineffective.

Dalapon was basically an ineffective treatment in the absence of cultivation. It is suggested that some control with dalapon may result where post treatment cultivation is possible.

Haloxyfop-methyl was evaluated less extensively, therefore no conclusions were drawn. However, some preliminary results from early spring applications of 0.15 to 0.5 kg/ha indicate that this herbicide has potential.

None of the birdsfoot trefoil vegetative or seed production parameters were adversely affected by any of the selective herbicides.

RESUME

M.Sc. J.A. MACQUARRIE Plant Science

LE CONTROLE DU CHIENDENT DANS LOTIER

Au college Macdonald différents produits chimiques furent evalués quant à leur efficacité de contrôle sélectif du chiendent (Agropyron repens (L.) Beauv.) à l'intérieur de populations de lotier (Lotus corniculatus L.) Leo cultivar. La comparaison fut faite entre l'application générale des herbicides à titre sélectifs - pronamide, dalapon, sethoxydim, fluazifop-butyl, haloxyfop-methyl- et de l'application dirigée de l'herbicide non-sélectif glyphosate. Les paramètres évalués consistaient du contrôle de chiendent à l'interieur des populations rhizome et feuillée durant leur première saison de croissance et la saison suivante, le contrôle de chiendent dans les populations feuillées seulement. Ainsi que le contrôle de chiendent, les effets phytotoxiques de ces herbicides sur la croissance du lotier et sur sa production de graines furent examinés.

Ce fut surtont l'herbicide glyphosate, appliqué par moyen de mèche à deux sens au tont premier stage de croissance du chiendent, qui fut le plus efficace à contrôler celui-ci dans les populations rhizome et feuillée. La disparité fut minime dans les résultats rapportés par les concentrations de solutions 1:1, 1:2 et 1:3 de glyphosate et eau. Il a donc fallu conclure que la concentration basse 1:3 de glyphosate et eau sera la plus économique.

L'égonttement de glyphosate de la mèche endomnageait un peu le lotier mais ce dommage fut réduit en remplaçant la mèche de nylon par une mèche en polyester/acrylique.

De tons les herbicides sélectifs essayés, le sethoxydim et le fluazifop-butyl étaient supérieurs en efficacité, le premier étant même plus efficace que le deuxième. Les applications à l'automme plutot que celles du printemps, appliqueés à 0.8 kg/ha, étaient les plus effectines à réduire la croissance de chiendent. Le fluazifop-butyl appliqué de la même manière fut moins efficace. L'application tot le printemps de ces deux herbicides au stage 3-4 feuilles de chiendent donna du contrôle à court-terme tandis que les applications plus tardives (stage 5 feuilles on plus) furent tont à fait inefficaces. Les applications printanières réussisèrent à rabougrir bien vite la croissance de chien-dent et à rèduire un peu la croissance nouvelle de l'automme.

L'herbicide pronamide appliqueé au printemps et a l'automme tel que recommandé donna de pauvres résultats. Tandis que l' application à l'automme réussit à reduire la croissance de chiendent l'année suivante, l'application au printemps eut aucun effet.

Le traitement avec dalapon fut tout à fait ineffectif dans l'absence de cultivation. Il fut suggéré que le contrôle avec dalapon pourrait réussir là où le traitement sera suivi par la cultivation.

L'évaluation de l'herbicide haloxyfop-methyl fut moins elaborée donc on arrivait à aucune conclusion. Toutefois quelques résultats préliminaires rapportés par les applications de 0.15 à 0.5 kg/ha indiquent que cet herbicide a du potentiel.

Les paramètres végétatives et reproductives du lotier ne subirent aucuns effets adverses dus à l'usage de ces herbicides sélectifs.

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CHAPTER I

INTRODUCTION

It is the responsibility of the Plant Science Department of Macdonald College to maintain stocks of "Leo" birdsfoot trefoil breeder seed. In 1979 the size of the Leo breeder seed production plot was increased for greater seed production purposes. The site chosen was an isolated hay meadow located in the Macdonald College Arboretum. Initial cultivation and planting of the trefoil occurred in the same growing season, therefore there was not sufficient time for proper weed control. The trefoil was row seeded in widths of 20, 40, and 100 cm in different areas of the plot. In the resulting stand of birdsfoot trefoil, there was a severe infestation of quack grass. Between row cultivation was possible at the wider spacings, but not at the narrow spacings. Applications of dalapon in the early spring of 1980 did not suppress the quack grass sufficiently.

In the autumn of 1980, a preliminary experiment was established in the field to compare efficacy of several herbicides in the control of quack grass. In addition, possible phytotoxic effects of the herbicides on the birdsfoot trefoil were examined.

The objectives of this project were to evaluate the efficacy of the herbicides pronamide, dalapon, sethoxydim, fluazifop-butyl, rope-wick applied glyphosate and haloxyfop-methyl for quack grass control in established birdsfoot trefoil breeder seed production plots. Although control of the quack grass was the main priority, evaluation of possible phytotoxic effects on the trefoil was also an important consideration.

As the trefoil was being grown for seed production, forage yield of the trefoil was not considered. It was expected that if the quack grass was effectively controlled, seed yield of the trefoil should increase due to the absence of competition from the quack grass. In order to fully evaluate the control of quack grass, rhizome populations as well as top growth were compared among treatment plots. The evaluation criteria consisted of quantitative measurements of above ground populations of quack grass rhizome populations among check and treatment plots. Effects of treatments on the birdsfoot trefoil were evaluated after quantitative measurements of seed yield, seed germination, seedling vigor, number of flowers initiated, and pollen fertility were analyzed.

CHAPTER II

LITERATURE REVIEW

1. Birdsfoot trefoil

Seaney and Henson (1970) have described in detail, birdsfoot trefoil. The genus Lotus consists of a diverse group of annual and perennial species widely distributed throughout the world. The most important species used for forage production in Canada and the United States is birdsfoot trefoil, Lotus corniculatus L.

Birdsfoot trefoil is a broad leaved, long lived herbaceous perennial with a well developed, branching taproot, and few to many stems developing from each crown. It is generally similar to alfalfa, although differences in rooting depth and distribution may result in birdsfoot trefoil being more persistent than alfalfa on shallow poorly drained soils.

1.1 Morphology

There is considerable variation in leaf and stem morphology within L. corniculatus. Growth habit of stems may be prostrate, ascending, or erect. Branching always occurs at the leaf axis of main and secondary stems, and the amount and symmetry of branching varies. Under good growing conditions stems may reach 90 to 120 cm in length.

Each leaf consists of five leaflets, three attached to the terminal end of the petiole and two at the base. Leaves are found alternately on opposite sides of the stem.

The flowers, which number from two to six, are borne in umbels at the extremity of a long peduncle arising from the leaf axil. The flowers, which resemble those on peas (<u>Pisum</u> <u>sativum</u> L.) are yellow with faint red or orange stripes present in young flowers. Two to six legumes or pods are borne at right angles to the tip of the peduncle, thus the appearance of a bird's foot. Pods are long, cylindrical and brown to almost black containing 15 to 20 seeds attached to the ventral suture. When mature they split along both sutures and twist spirally to discharge seed.

1.2 Cultivar "Leo"

In this research project, the birdsfoot trefoil cultivar Leo was used. Leo was bred by J.S. Bubar, at the Department of Agronomy, Macdonald College, Quebec, and was licensed March 5, 1963. The original breeding stock is described as Morshansk 528 originating from the All Union Institute of Plant Industry, Leningrad, U.S.S.R. (Bubar, 1964).

Leo is described as being intermediate between Empire and Viking in maturity and in flowering habit. It goes dormant in the fall earlier than other varieties and is similar to Viking in spring growth, but slower in recovery after cutting. Although quite suitable for pasture, this cultivar appears to exhibit a greater superiority over other cultivars when managed as hay. Leo appears will suited to all conditions where Empire is adapted, and it has the same range of pest problems (Bubar, 1964).

1.3 Culture

Birdsfoot trefoil is slow to establish, but lasts for years. Its excellent feed quality, combined with long term persistence makes it an attractive crop to many farmers. In places where alfalfa (*Medicago* spp) cannot be established, birdsfoot trefoil may be the answer to the need for a long term high protein forage (Madill and Skepasts, 1978).

Seedling plants of birdsfoot trefoil are generally lacking in vigor when compared to alfalfa and red clover (*Trifolium pratense* L.), and stands may be lost due to shading or competition from other species. Good stands of birdsfoot trefoil may be obtained if proper care is taken towards seed bed preparation, date, rate, and depth of seeding, grass associations, and weed control (Seaney and Henson, 1970). Winch (1976) adds that birdsfoot trefoil may be grown alone or in simple mixtures with one grass, however trefoil should never be grown in mixtures with other legumes, as these tend to be too competitive and trefoil establishment is markedly reduced. The lack of seedling vigor in birdsfoot trefoil makes good weed control a high priority in any trefoil management program. Successful establishment should be obtained by eliminating competition from weeds (Laskey and Wakefield, 1978, Madill and Skepasts, 1978). Control of weeds during establishment often results in larger trefoil plants, more plants per unit area, and higher yields.

1.4 Seed production

Under optimal environmental conditions, trefoil plants have the capacity to produce large quantities of seed. Seaney and Henson (1970) estimate a potential yield capacity of 600 to 1,000 pounds of seed per acre. Difficulties harvesting the seed including pod dehiscence and indeterminate flowering significantly reduce the actual amount of seed harvested.

Studies comparing seed yields of clear stands of trefoil and trefoil/grass mixtures indicate that seed yields were reduced when trefoil was grown in mixtures with various forage grasses. Pure stands of trefoil seeded without grasses usually gave better seed yields and seed of higher purity (Seaney and Henson, 1970).

Indeterminate flowering and seed development cause the timing of harvest to be critical, too early results in the harvest of many immature pods, while too late results in seed loss from pod dehiscence or shattering (Seaney and Henson, 1970).

Seed set in trefoil is dependent on pollination of flowers primarily by various species of Hymenoptera. Both pollen and nectar collecting honey bees are capable of tripping the pollinating mechanism (Seaney and Henson, 1970).

When harvesting trefoil, the area swathed should be able to be combined in a short time. Large amounts usually dry excessively and shattering in the swath results. If shattering losses are expected, it is best to combine in the early morning before the dew has dried (Madill and Skepasts, 1978). Direct combining of trefoil is possible when a defoliant or dessicent is utilized. Such treatments make direct combining faster and significantly reduce the seed loss which occurs when combining green material (Seaney and Henson, 1970).

Seaney and Henson (1970) report that trefoil seed yield can be increased by controlling weeds in established stands. Early spring applications of dalapon have reduced competition from perennial grasses and resulted in significant increases in seed yield.

2. Quack grass

Quack grass, Agropyron repens (L.) Beauv. is a rhizomatous perennial grass that is a serious international weed problem in agronomic crops (Westra and Wyse, 1981) and on the Macdonald College farm, quack grass has been a serious problem in birdsfoot trefoil seed production plots. Quack grass is noted for its competitive growth habit, difficulty to control, and allelopathic potential (Mueller-Warrant and Koch, 1980).

2.1 Morphology

Quack grass disseminates by both seeds and rhizomes. The leaves are long, finely pointed, flat, green, sometimes glaucous, scabrous at the margin and on the upper surface. The leaf sheaths are round, split, short with overlapping hyaline margins; ligules membranous, obtuse and sometimes ciliated. Stems range from 30 to 120 cm long, are hollow, round, slender to somewhat stout with three to five nodes. The spikes may be green or sometimes bluish-green, loose or compact with the axis hard. Spikelets contain three to eight sessile flowers. Quack grass is hexaploid (2n=42) for Canadian material. The combination of matted, whitish rhizomes, auricles, hairy lower sheaths and heads resembling a slender head of wheat distinguish quack grass from most other grasses (Werner and Rioux, 1977).

2.2 Distribution

In Canada quack grass occurs from coast to coast, as far north as Nastaguan, Quebec, Goose Bay, Labrador and Fort Smith, Northwest Territories. It also occurs in Greenland and Alaska. It is especially common in southeastern Canada (Werner and Rioux, 1977). Quack grass is also found in every state of the United States of America, but is reported to be rarely troublesome as a crop weed south of Washington and St. Louis.

2.3 Reproduction

Werner and Rioux (1977) discuss the reproduction of quack grass. Quack grass is wind-pollinated and self-sterile. Seed production is highly variable, 15 to 400 seeds per plant stem with the average being 25 to 40. It has been suggested that, since plants tend to be self-sterile and large stands may be a single clone as the result of vegetative reproduction, seed formation should be much higher at the margin of a clone where there is a higher instance of cross-pollination.

It has been reported that seeds may be dormant for two to three years and retain their viability for a maximum of four years. The seeds are not morphologically adapted for dispersal and simply fall passively from the plant (Werner and Rioux, 1967).

Considering the low volume of seeds produced, and the generally high probability of survival of vegetatively produced plants, it may be concluded that vegetative reproduction is more important than sexual reproduction in the maintenance of a stand.

Flowering shoots produce the same amount of rhizome material as do vegetative shoots. Westra and Wyse (1981) found that seedlings and clones of quack grass with a high rhizome weight often had a low shoot weight, suggesting a negative correlation between quack grass shoot growth and rhizome growth. Potentially every mature rhizome bud is capable of establishing a new plant, however, most buds along an intact rhizome are dormant and do not initiate any growth (Werner and Rioux, 1977). Harvey and Baker (1974) reported that the persistance of quack grass is related to its extensive rhizome system.

Quack grass growth occurs mostly in the spring from buds of rhizomes produced the previous year and in the fall during which time it is an effective competitor in forage legume stands (Fawcett et al., 1978). The longevity of legume stands is often reduced by the presence of quack grass. In many cases, herbicides produce excellent shoot control, but a large number of dormant buds on the rhizomes provide a constant source of material for reinfestation (Harvey and Baker, 1974, Ryan 1972). Dutt et al. (1979) explains that since many mechanical and chemical weed control practices may not be used in legume stands without causing injury to the legume, quack grass infestations in already established stands cause particular problems. In a solid stand of birdsfoot trefoil, mechanical measures of quack grass control, for example, cultivation, are not possible, thus, chemical measures appear to be the only practical method of control.

3. <u>Herbicides for post-emergence selective quack grass control</u>

3.1 Glyphosate

The introduction of glyphosate (N-phosphonomethyl glycine), an aliphatic type herbicide, has provided a herbicide for which post-emergence activity could control quack grass without causing residue problems to rotation crops (Ivany, 1981, Rioux *et al.*, 1974).

3.1.1 Herbicidal use

Glyphosate, a broad spectrum herbicide, is relatively non-selective, and provides effective control of deep-rooted perennial species, as well as annual and biennial species. In order to obtain selectivity with this herbicide, directional applications must be used (W.S.S.A., 1979).

3.1.2 Application

Wilkins (1981) found that weed control with a rope-wick applicator ranged from 75% to 85% for annual grasses. Wilkins (1981) adds that the rope-wick is inexpensive, ranging from $700 to $800 for a commercial model, and less for a homemade model. Although weed control may be slightly less with the rope-wick than in the other types, the lower cost may make it the best choice. Height difference between crop and weeds is important, especially for perennials such as quack grass. The rope-wick application has been used successfully to control quack grass using 1:1, 1:2, and 1:3 solutions of glyphosate and water with the 1:2 solution superior (Wilkins, 1981).

3.1.3 Physiological and biochemical behaviour

Glyphosate is absorbed through foliage and translocated throughout the plant. Visual effects normally occur on perennial species in seven to ten days. However, cool or cloudy weather following treatment may delay visual symptoms of activity. Rainfall occurring within six hours of treatment may reduce the effectiveness of the treatment (W.S.S.A., 1979).

Glyphosate is translocated readily both acropetally and basipetally in quack grass, but in order for sufficient basipetal translocation to rhizomes, application must be made at the proper stage of growth (Clause and Behrens, 1976, Brockman _et al_., 1972). Glyphosate should be applied to quack grass with at least four new leaves on each emerged shoot (Ontario Herbicide Committee, 1980).

The exact mechanism of action of glyphosate is not known at this time, but the herbicide appears to inhibit the aromatic amino acid biosynthetic pathway and may inhibit or repress chlorismate mutase and/or prephenate dehydratase. Studies with 14 C-labeled glyphosate indicate that metabolism of glyphosate within the plant does not occur (W.S.S.A., 1979).

3.2 Pronamide

Smith _et al_. (1971) reports that pronamide, (3,5-dichloro (N-1, 1-dimethyl-2-propynyl) benzamide) N-(1,1-dimethylpropyny 1)-e, 5-dichlorobenzamide, is of particular interest with respect to its use as a post-emergent herbicide for control of quack grass.

3.2.1 Herbicidal use

Pronamide is effective for the control of quack grass in alfalfa and other established forage legumes when autumn or spring applied (Fawcett et al., 1978). However, pronamide is ineffective when applied to the foliage of quack grass plants, but is effective when applied to the soil surface (Smith et al., 1971).

3.2.2 Physiological and biochemical behaviour

To obtain activity from pronamide, the herbicide must move into the root zone of the quack grass, little activity is obtained from foliar activity alone. Pronamide is readily absorbed by plants through the root system, translocated acropetally and distributed into the entire plant. The degree of translocation from foliar absorption is negligible. With respect to the mechanism of action of pronamide, it is thought to be a strong inhibitor of mitosis (W.S.S.A., 1979). Peterson and Smith (1971) found that there is considerable radical enlargement of cells in the apex. An enlargement of nuclei was a consistant feature of cells in meristematic regions of treated plants.

3.3 Dalapon

3.3.1 Herbicidal use

Dalapon (2,2 dichloropropionic acid) is used for selective grass weed control in forage legume establishment. Results have been promising and alfalfa yields of three to five tonnes per hectare have been produced during the year of establishment (Scholl, 1969).

A negative aspect to the use of dalapon in birdsfoot trefoil is that a pre-emergence application of 5.5 kg/ha will reduce the percent germination of the trefoil, and also reduce the number of rhizobium nodules produced (Turkington and Franko, 1980). Dalapon is recommended on birdsfoot trefoil seed fields in the fall (4 kg/ha) when growth is about 15 cm high. Spring treatments when the trefoil is actively growing may result in seed yield reduction (Ontario Herbicide Committee, 1980).

3.3.2 Application

Since dalapon may reduce seed yield when applied to actively growing trefoil, and since control is unsatisfactory when treatments are made without tillage (Carder, 1967), dalapon may not be an effective post-emergent herbicide for control of quack grass in birdsfoot trefoil seed production.

3.3.3 Physiological and biochemical behaviour

Dalapon is readily absorbed by both roots and leaves of plants. Translocation throughout the plant occurs shortly after application. Apparently dalapon is not degraded or metabolized in plants (W.S.S.A., 1979).

3.4 Sethoxydim

Sethoxydim, 2-(1-(ethoxyimino)butyl)-6-(2-ethylthio)-propyl)-3-hydroxy-2-cyclohexene-1-one, is a relatively new herbicide for post-emergence control of grasses in broadleaf crops.

3.4.1 Herbicidal use

Perennial grass control with sethoxydim required between 0.2 and 0.5 kg/ha depending upon the species, environmental factors and cultural practices. Reduction in the perennial grass population was noted in the spring plots treated with sethoxydim the previous year (McAvoy, 1982).

Optimum environmental conditions for control occur with good soil moisture (not drought stressed), high temperatures, and high humidity. If such conditions do not prevail, control will be slower and may not reach the maximum level (McAvoy, 1982).

Label instructions for quack grass control with sethoxydim indicate that for best results, rhizomes should be thoroughly fragmented. Depending upon environmental conditions and crop cultural system, season-long control may not always be obtained. However, competition of quack grass with the crop will be reduced. In the sethoxydim Technical Information Bulletin (1981), it is stressed that a surfactant must be added to all applications of the herbicide. Gillespie and Nalewaja (1986) suggest sethoxydim will have some phytotoxic effects on susceptable plants when applied to the soil at post-emergent rates.

3.4.2 Physiological and biochemical behaviour

In grass plants, sethoxydim is absorbed very rapidly by foliage, and within an hour, most of the herbicide will be in the plant. This characteristic is especially desirable for a post-emergence herbicide when rainfall is possible shortly after application. Once in the grass plant, sethoxydim will translocate rapidly both acropetally and basipetally to the site of action, the meristematic regions (McAvoy, 1982). Stollenberg and Wyse (1986) conclude that applications to the 8-leaf stage will result in reduced translocation to crown tissue, from which significant regrowth will occur. Increased translocation to crown tissue will occur with applications of sethoxydim to earlier growth stages of quack grass. Regrowth from crown buds following application of sethoxydim to quack grass in later stages of development can contribute substantially to reinfestation. Hatzios (1982) suggests that sethoxydim could exhibit its phytotoxic action by altering or modifying the lipid composition of plant membranes. Jain and Vanden Born (1983) report that on wild oats (Avena fatua), sethoxydim caused an inhibition of stem elongation resulting from an inhibition of both cell division and cell elongation at the base of the internodes. Maximum injury occurred to the meristematic cells in the cortex and between the xylem and phloem.

3.5 Fluazifop-butyl

Fluazifop-butyl, 2-(4-(5-triflurometHyl-2-pyridyloxy) phenoxy) propionate, is a new selective post-emergence grass herbicide for use in broad leaf crops.

3.5.1 Herbicidal use

It is stated in the Fusilade Technical Data Sheet (1981) quack grass rhizomes which have been fragmented by discing or some other form of cultivation are controlled at rates of 0.5 to 0.75 kg/ha, while unfragmented rhizomes require higher rates of up to 1.0 kg/ha. It is also stressed that a surfactant must be added, i.e., Agral 90 at 0.1% of spray volume. Wagner and Letendre (1982) state that fluazifop-butyl applied at 2.0 kg/ha to plants at the 4 to 5-leaf stage provided excellent control in a field of alfalfa. It is apparent that the phytotoxicity of fluazifop-butyl on quack grass is increased when treated plants are exposed to higher temperatures (30°C versus 20°C) and when plants are maintained under adequate moisture compared to plants under moisture stress (Kells et al., 1984). Gillespie and Nalewaja (1986) found that soil applied fluazifop controlled emerging grass seedlings when applied at rates much higher than post-emergence rates.

3.5.2 Physiological and biochemical behaviour

Fluazifop-butyl is a systemic herbicide which translocates in both the xylem and phloem. When applied as a post-emergent, it translocates into the roots and rhizomes of perennial grasses and results in complete control (Ready, 1982). Limited field evidence indicates that fluazifop-butyl penetrates rapidly as rain falling only one hour after the application resulted in only a slight loss of activity (Fusilade Technical Data Sheet, 1981).

In most sensitive species, symptoms are not evident until a week after application, although growth ceases within one or two days. The first symptoms are necrosis in the young leaves, with decay appearing at nodes and growing points. Loss of vigor and senescence, occurring initially in young leaves, spreads quickly to the whole plant (Fusilade Technical Data Sheet, 1981). Fluazifop-butyl is readily translocated and accumulated in meristematic areas of both tolerant and susceptable plants indicating differential absorption and translocation are not selectivity mechanisms (Kells *et al.*, 1984). While the exact mechanism of action of this new compound is not precisely known, Jain and Vanden Born (1983) report that on wild oats (*Avena fatua*), inhibition of stem elongation was due to inhibition of both cell division and cell elongation at the base of the internodes. Maximum injury occurred to the meristematic cells in the cortex and between the xylem and phloem.

3.6 Haloxyfop-methyl

Haloxyfop-methyl (methyl 2-(4-((3-chloro-5-(trifluro-methyl)-2-pyridinyl)oxy)phenoxy)propanoate) is an experimental post-emergence herbicide for control of annual and perennial grasses in broad leaf crops (Ryder, 1982).

3.6.1 Herbicidal use

In areas where plants are not continually drought stressed, perennial grasses may be controlled using haloxyfop-methyl at rates of 0.25 to 0.50 kg/ha, although it may be necessary to use higher rates under dry conditions. The use of a surfactant is recommended and the herbicide should be sprayed on quack grass when 10 to 20 cm tall (Ryder, 1982). Harrison and Wax (1986) conclude that the addition of 1.0% (V/V) petroleum oil concentrate (POC) to the treatment solution resulted in greater foliar absorption and translocation of ^{14}C.

McCully (1981) found that good quack grass control was obtained in established alfalfa when the quack grass was sprayed with 0.25 to 1.00 kg/ha of haloxyfop-methyl at the 2 to 4-leaf stage. Recent research has suggested that post-emergent rates of haloxyfop-methyl applied to the soil will cause phytotoxicity to susceptable plants. Exposure of shoots and seeds to the herbicides in the soil resulted in greater phytotoxicity than exposure of roots only (Gillespie and Nalewaja, 1986).

3.6.2 Physiological and biochemical behaviour

This being a new type of compound, the mechanism of action is not entirely known. Gronwald (1986) reports that most evidence suggests that haloxyfop-methyl is rapidly absorbed by the foliage of both grasses and dicots and hydrolyzed to its acid metabolite, haloxyfop. Haloxyfop is translocated in the phloem to meristematic regions of both grasses and dicots. To date no major differences in absorption, translocation or metabolism of haloxyfop-methyl have been found between grasses and dicots. This suggests that selectivity is expressed at the site of action which has not yet been identified. Jain and Vanden Born (1983) reported that on wild oats (Avena fatua L.) elongation of internodes was inhibited within five days. It was concluded this was due to inhibition of both cell division and cell elongation at the base of the internodes. Maximum injury occurred to the meristematic cells in the cortex between the xylem and phloem.

CHAPTER III

MATERIALS AND METHODS

1. Experimental areas

The first four of the five experiments were located in an isolated field in the Macdonald College Morgan Arboretum, Ste. Anne de Bellevue, Quebec. The soil type in this location has been classified as a Dalhousie clay. Experiments 1, 2 and 3 were set up in an area seeded to Leo birdsfoot trefoil for production of breeder seed. The trefoil was in 20 cm rows seeded August 15, 1979 at 1.5 kg/ha following the application of 500 kg/ha of 5-20-20. The field had been a hay meadow which was sprayed with glyphosate before being cultivated, but this treatment did not control the quack grass. Therefore, in the following season a heavy infestation of quack grass occurred.

Experiment 4 was located in the same general experimental area, but the particular section was a hay field for the previous years. Quack grass was a major component of species present in the field. After a mowing the field was plowed late July and cultivated August 10, 1981. On August 25 it was fertilized with approximately 400 kg/ha of 5-20-20 fertilizer and seeded August 26 with Leo birdsfoot trefoil (pre-inoculated with Rhizobium) in 20 cm rows at a rate of 1.5 kg/ha with a Bolens small plot cone type seeder.

Experiment 5 was located at the Emile Lods Agronomy Research Center of Macdonald College in Ste. Anne de Bellevue, Quebec. The Leo birdsfoot trefoil was solid seeded at 1.5 kg/ha on June 1, 1981 into sandy clay loam (4.0% O.M.). This research plot area had been used as an experimental area for quack grass control in birdsfoot trefoil. Quack grass populations appeared to be less dense than in the first four experiments.

A top dressing of boron (solubor) at 10 kg/ha was applied to experiments 1, 2, 3, and to two blocks of experiment 5, on July 16, 1982.

2. Herbicide application

Since the primary objective of all experiments was to evaluate selective post-emergent applications of herbicides for control of quack grass, herbicide applications were of two types, post-emergent spray applications of selective herbicides, and post-emergent selective application of a non-selective herbicide.

Selective-type sprays were all applied with a small plot compressed air-type sprayer mounted on bicycle wheels. All sprays were mixed with water to a volume of 300 ml and were applied at a pressure of 210 kPa at 300 L/ha^{-1}.

Selective applications of glyphosate were applied with a rope-wick applicator. The applicator was constructed with 10 cm PVC pipe 1.0 m in length and closed with a PVC cap at both ends. A plastic funnel with cap was affixed at one end. Two rows of wicks were staggered so wick facings overlapped to allow continuous exposure of wick along the entire length. The initial material used for wicking was nylon sailing rope. This rope was replaced with a new type polyester/acrylic rope, and plastic compression fittings replaced the original rubber grommets. During use, the reservoir was filled with 1.5 L of solution to provide for an even flow. This apparatus was fastened to the front of the bicycle wheel sprayer and was pushed through the plots. Once wicks were well soaked, 200 to 300 ml of solution were required for a single one-way application of four plots. Wicks were angled up or down to allow for decreased or increased exposure. In 1981, one-way applications were used, whereas in 1982, two-way applications were used to provide superior coverage.

3. Experiment 1: Comparison of single applications of dalapon, pronamide, fluazifop-butyl, sethoxydim, and glyphosate for quack grass control.

The purpose of this experiment was to evaluate five herbicides for control of quack grass and their effects on the crop. A randomized complete block design was used with four replications. Plot size was 5.0 m by 2.0 m with a 1.0 m space between blocks. In all experiments, quack grass leaf stages refer to the leaf stage of the quack grass in the control plots.

The treatments were: weedy check; fall applied dalapon (1.5 kg/ha); fall applied pronamide (4.5 kg/ha); rope-wick application of glyphosate (1:3 glyphosate/water) at the 5 to 6-leaf stage of quack grass; spring application sethoxydim (0.8 kg/ha) at the 3 to 6-leaf stage of quack grass; and spring application fluazifop-butyl (0.5 kg/ha) at the 3 to 6-leaf stage of quack grass. Surfactants were added to sethoxydim (Atplus 411F à 2.5 L/ha) and to fluazifop-butyl (Agral 90 @ 0.1% v/v).

The first season application of dalapon and pronamide were mistakenly applied at 1/10 the intended rate. The application of sethoxydim and fluazifop-butyl was made on May 8, 1981 with no surfactant, therefore treatments were re-applied with surfactant on May 27. At this time, the quack grass was at the 3 to 4-leaf stage, the soil was dry, and light showers occurred one hour after treatment. Glyphosate was applied by rope-wick June 10, 1981, the weather was sunny and the soil was moist.

For the second year of the experiment, dalapon and pronamide were applied November 3, 1981 at the rate of 4.5 and 1.5 kg/ha, respectively. Fluazifop-butyl and sethoxydim with surfactants were applied on June 7, 1982 at 0.6 and 0.8 kg/ha. The weather was sunny and the soil was dry. Glyphosate was applied by rop-wick June 3, 1982, when the quack grass was at the 5-leaf stage. The weather was also sunny and soil conditions were very dry. The randomization of treatments was the same in both years to avoid interactions between possible residues from the first year and treatments in the second year.

4. Experiment 2: Effect of rope-wick applied glyphosate on quack grass.

The purpose of this experiment was to assess the control of quack grass using selective applications of glyphosate with a rope wick applicator. A randomized complete block design was used with four replications. Plot size was 5.0 m by 1.5 m with a 1.0 m space between blocks.

The treatments consisted of three dilutions of glyphosate to water, 1:1, 1:2 and 1:3, applied at separate quack grass stages of growth, 3 to 4, 4 to 5, and 5 to 6 leaves. All combinations of leaf-stages and glyphosate dilutions were made resulting in nine treatments, plus one weedy check, per block.

During the summer of 1981, application dates were May 30, June 10, and June 18. All applications were made during sunny days when rain was not expected for at least eight hours after treatment.

Application dates for 1982 were, May 18, June 3, and June 17. Two-way applications were used, here, rather than a single application, as used in 1981. Again, all applications were during sunny days when no rain was expected for at least eight hours.

The randomization of treatments was the same in both years to avoid interactions between possible residues from the first year and treatments in the second year.

5. Experiment 3: Comparison of the efficacy of sethoxydim and fluazifop-butyl for quack grass control.

The objective of this experiment was to compare two herbicides, fluazifop-butyl and sethoxydim, for control of quack grass and to assess their effects on birdsfoot trefoil. A randomized complete block design was used with four replicates and a plot size of 2.0 m by 5.0 m with a 1.0 m space between blocks. Fluazifop-butyl was applied to quack grass at the 3 to 4, and 5 to 6-leaf stage at 0.5 kg/ha. A sequential application of fluazifop-butyl, first, at the 3 to 4-leaf stage (0.3 kg/ha), and, second, at the 5 to 6-leaf stage (0.4 kg/ha), was also done. Leaf stages refer to the developmental stage of quack grass in control plots. Similar applications of sethoxydim were made at 0.8 kg/ha and the sequential applications at 0.5/0.5 kg/ha. Fluazifop-butyl was applied with 0.1% (v/v) Agral 90 and sethoxydim was applied with 2.5 L/ha of Atplus 411F. The experiment was repeated in 1982 with a minor modification in the rate of fluazifop-butyl (from 0.5 to 0.6 kg/ha). Therefore, each replication consisted of six treatments plus one untreated control plot.

In 1981, the 3 to 4 quack grass leaf stage sprays were applied on May 27. The weather was overcast, humid and the soil was dry. However, showers occurred one hour after treatment. The second applications were made June 7 under sunny skies. The soil was moist and no rain occurred for several days.

In 1982, the first applications were on May 18 under sunny skies; the soil was very dry. The second applications were on June 7. Again the weather was sunny, the soil was dry on top and moist below.

The randomization of treatments was the same in both years to avoid interactions between possible residues from the first year and treatments in the second year.

6. Experiment 4: Comparison of the efficacy of pronamide, dalapon, sethoxydim, fluazifop-butyl, glyphosate and haloxyfop-methyl applied to various growth stages of quack grass in newly seeded

birdsfoot trefoil.

The objective of this experiment was to assess several post-emergent controls of quack grass in newly-seeded birdsfoot trefoil. A randomized complete block design with four replicates was used with a plot size of 5.0 m by 2.0 m with a 1.0 m space between blocks.

The treatments consisted of: fall/spring applications of sethoxydim, fluazifop-butyl, and pronamide; fall only applications of pronamide and dalapon; spring only applications of sethoxydim, fluazifop-butyl, haloxyfop-methyl, pronamide, and rope-wick applied glyphosate. Fall applications of fluazifop-butyl and sethoxydim were made September 25, 1981, at 0.6 and 0.8 kg/ha, respectively, with surfactant. Quack grass was at the 2 to 3-leaf stage. Fall only applications of pronamide and dalapon were made November 3, at 1.5 and 4.5 kg/ha, respectively. Fall applications of fall/spring pronamide were made the same date at 0.75 kg/ha. The spring application of fall/spring pronamide (0.75 kg/ha) was made May 6, 1982, when the quack grass was at the 2-leaf stage. The single spring application of pronamide at 1.5 kg/ha was applied the same day. Spring applications of fall/spring and spring only treatments of fluazifop-butyl and sethoxydim were applied June 7 when quack grass was at the 5 to 6-leaf stage. Herbicide concentrations were the same as those used in the fall. Haloxyfop-methyl was applied June 7 at 0.3 kg/ha with a 1% AtPlus 411F. The single rope-wick application of glyphosate was made June 3 with a glyphosate-to-water ratio of 1:2, when the quack grass was at the 5 to 6-leaf stage. Untreated control plots were randomly located within each replicate.

7. Experiment 5: Comparison of the efficacy of single applications of herbicides for control of quack grass on established birdsfoot trefoil.

The objective of this experiment was to compare the efficacy of single spring applications of sethoxydim, fluazifop-butyl, haloxyfop-methyl, and rope-wick applied glyphosate. Nine treatments including a check were arranged in a randomized complete block design. Plot size was 5.0 m by 2.0 m with a 1.0 m space between blocks.

The treatments were: sethoxydim (0.8 and 0.6 kg/ha), haloxyfop-methyl (0.15, 0.3, and 0.5 kg/ha), fluazifop-butyl (0.4 and 0.6 kg/ha). These treatments were sprayed on June 1, 1982 to quack grass at the 5 to 6-leaf stage. The weather was sunny, the soil was dry and no rain was expected for several hours. The single rope-wick application of glyphosate (1 2 dilution with water) was made June 17. Quack grass was at the 5 to 6-leaf stage. The soil was moist and the weather was sunny. Wick contact was mostly with quack grass heads. An untreated check was also included.

8. Data collection

8.1 Visual

Visual observations throughout the growing season were taken for all experiments. These observations were strictly qualitative to support the statistical analysis of quantitative type data.

8.2 Point quadrats

Point quadrat data were taken for each plot at the beginning of the season, and again just prior to harvest. The apparatus used was a point frequency frame consisting of ten pins. Each pin was lowered vertically through vegetation and a species recorded if any part of the plant was touched. If no plant was touched, the hit was recorded as bare ground. To randomize the placing of the frame within a plot, the plot was divided into quadrants, and were numbered accordingly. Coordinates were randomly chosen for the placement of two frames (20 hits) per plot. A border of 0.5 m by 0.75 m was maintained in each plot in order to minimize possible edge effects.

The data from the quadrats were used to calculate the percent cover and percent sward of quack grass, birdsfoot trefoil, and broadleaf weeds. The formulae used were:

$$\% \text{ Cover} = \frac{\text{Number pins which hit the species} \times 100\%}{\text{total pins lowered}}$$

$$\% \text{ Sward} = \frac{\text{Number of contacts with a species} \times 100\%}{\text{total number of contacts}}$$

8.3 Biomass

Two botanical samples (0.25 m by 0.25 m each) were cut from each plot and combined. Coordinates for random placement of the quadrat were randomly selected in a similar manner as for the point quadrat. These samples were individually separated according to species and then were dried in large ovens at 45°C for 24 hours. After weighing, the dry weight of each species was compared to the total dry weight of the sample to determine the percent of each species in the sward. In 1982, some botanical samples had to be discarded after spoilage due to an accidental shut-down of a storage freezer.

8.4 Birdsfoot trefoil flower counts

To assess the birdsfoot trefoil seed production potential of the plot, flower counts were taken. At approximately the 50% bloomstage, a quadrat (0.25 m by 0.25 m) was randomly placed within each plot, and all birdsfoot trefoil flowers were counted within the quadrat. Two quadrat counts per plot were taken.

8.5 Birdsfoot trefoil seed yield

Plots were sprayed August 27, 1981 with the dessicant diquat at 2.2 kg/ha. A 1.0 m swath was cut through each plot using a small plot Gravely harvester. The material from each plot was bagged separately and dried at 38°C. After seven days, the material was threshed in a small plot combine harvester. The material collected from the harvester was cleaned using an aspirator type seed cleaner. In addition to determining the yield (g) of seed for each plot, germination tests were conducted. From each plot, 100 seeds were placed between two pieces of blotter paper in boxes (11 cm by 11 cm). The paper was moistened and boxes placed in an incubator set for 16 hours light, 20°C, and eight hours darkness, 15°C. After five days a count was made of any seeds which had germinated. These data were used to compare any differences in germinability of seed among treatments. After 12 days a final count of germinated seed, hard seed, and non-viable seed was made.

8.6 Pollen fertility

To further assess birdsfoot trefoil performance, comparisons of the pollen fertility of untreated trefoil flower buds with those which had been sprayed with pronamide, dalapon, sethoxydim, fluzifop-butyl, and where glyphosate had been applied to the quack grass with a rope-wick were made.

The method of measuring the pollen fertility was suggested by Dr. W. Grant (personal communication). Flower buds containing mature pollen were collected from various plots of the above treatments. Anthers were removed, squashed, and stained with dilute fast green in lactophenol. The slides were allowed to stand for 24 hours. One thousand cells were examined from each slide. Viable pollen appeared round in shape and had fully taken up the stain; whereas non-viable pollen did not stain and in some cases the central portion was shrunken. Percent viable pollen was determined from four of the 1000 cell samples for each treatment.

8.7 Rhizome populations

Subterranean sampling of quack grass rhizome populations was conducted. The sampler used was a 15 cm x 15 cm x 15 cm box equipped with a handle which was driven into the soil and then removed with the intact soil sample inside. A description of this sampler was given by Gutman and Watson (1980). Samples were removed in the late summer after trefoil seed harvest. In the first year, a single sample was removed so as not to damage the permanent plots. In the second year, two samples per plot were taken. The samples were cleaned, rhizomes removed, dried, weighed, and the total number of buds per sample was recorded.

9. Statistical analysis

The analysis procedure utilized was the same for all quantitative data in all experiments. Analysis of variance was conducted. If significant differences (P=0.05) were not found with the F test, no futher analysis was conducted. If there was significance (P=0.05), Duncan's Multiple Range test was used to test the differences among treatments means.

Due to the fact that data for quadrat samples, botanical separations, birdsfoot trefoil pollen viability, and seed germinability were expressed as percentages, the arcsin transformation was applied to all data prior to the analysis of variance. Steel and Torrie (1980) state that this transformation is especially recommended when the percentages cover a wide range of values, such as in these experiments. The mechanics of the transformation require decimal fractions, but tables of the arcsin transformation are usually entered with percentages. All means were transformed back to the original scale for presentation in tables.

Data from both years were not combined for analysis, rather differing weather patterns from year 1 to year 2 resulted in somewhat different reactions of the quack grass to the herbicides; therefore, to isolate these differences, separate analysis of each years data was necessary. Differing rates of herbicide application also prevented the combining of both years data.

CHAPTER IV

RESULTS

1. Experiment 1. Comparison of single applications of dalapon, pronamide, fluazifop-butyl, sethoxydim, and glyphosate for quack grass control.

In 1981 data for the dalapon and pronamide treatments were deleted because they had been mistakenly applied at 1/10 the recommended rate. Fluazifop-butyl and rope-wick applied glyphosate reduced the percent contribution of quack grass to the total biomass, whereas sethoxydim did not (Table 1). While all treatments were equal in reducing the population of headed quack grass, no treatments had any effect on quack grass rhizomes or new growth at the end of the season.

With respect to birdsfoot trefoil performance, there was greater flowering in the glyphosate treated plots, with no significant differences among other treatments (Table 2). No significant differences were found in seed yield, seed germination, seedling vigor, percent cover and percent sward of the trefoil among the various treatments. Check and sethoxydim plots contained the least amount of trefoil by dry weight.

In the spring of 1982, the population of birdsfoot trefoil was very sparse, possibly due to winterkill. There were no significant differences among treatments with respect to the

TABLE 1. THE EFFECTS OF SINGLE APPLICATIONS OF SETHOXYDIM, FLUAZIFOP-BUTYL AND ROPE-WICK GLYPHOSATE ON QUACK GRASS POPULATIONS (1981).

TREATMENT (kg/ha)	TOTAL QUACK GRASS % Cover	TOTAL QUACK GRASS % Sward	% Contribution to Total Biomass	RHIZOMES Node Number (#/.5m²)	RHIZOMES Dry Weight (g/.5m²)	HEADED PLANTS % Sward	HEADED PLANTS % Cover	NEW GROWTH % Sward	NEW GROWTH % Cover
CHECK	83.2	35.7	26.7 a	37.0	3.6	1.7 a	7.8 a	34.0	75.4
Sethoxydim (.8)	59.6	19.6	13.9 ab	68.5	3.4	0 b	0 b	19.6	59.6
Fluazifop-butyl (.5)	62.7	20.7	7.9 b	38.2	2.1	.1 b	1.2 b	20.4	61.5
Glyphosate (1:3)*	65.2	11.9	9.9 b	50.0	3.1	.3 b	1.2 b	12.4	61.0
C.V.	49.3	48.9	51.0	43.7	55.2	90.1	77.0	55.1	46.8

Means followed by the same letter within a column do not significantly differ at the 5% level according to Duncans Multiple Range Test.

* 1:3/glyphosate:water

TABLE 2. A COMPARISON OF THE EFFECTS OF SINGLE APPLICATIONS OF SETHOXYDIM, FLUAZIFOP-BUTYL AND ROPE-WICK GLYPHOSATE ON BIRDSFOOT TREFOIL POPULATIONS (1981).

TREATMENT (kg/ha)	Flower Counts (#/.5m²)	Seed Yield (g/4m²)	% Germination	Seedling Vigor*	% Cover	% Sward	% Contribution to total Biomass
CHECK	16.5 b	1.6	37.5	31.0	85.2	59.9	72.4 c
Sethoxydim (.8)	12.2 b	2.4	35.7	30.2	97.6	75.6	81.9 abc
Fluazifop-butyl (.5)	3.8 b	2.8	42.3	36.3	93.9	71.7	90.0 a
Glyphosate (1 3)**	205.0 a	3.2	35.2	26.8	92.8	81.9	87.2 b
C.V.	108.9	45.5	23.6	26.1	12.1	21.6	14.0

Means followed by the same letter within a column do not significantly differ at the 5% level according to Duncans Multiple Range Test.

* Percent germination after five (5) days.

** 1:3/glyphosate:water

initial percent cover and percent sward (Table 3). Mid season quadrats indicate that pronamide, sethoxydim and fluazifop-butyl treatments resulted in a significantly greater cover of trefoil than the check, while there were no differences in trefoil percent sward. Final quadrats revealed that only the pronamide treated plots had a greater percent cover of trefoil over check plots. Glyphosate and sethoxydim treatments resulted in an increased percent sward of trefoil as compared to checks. Pollen fertility was not significantly affected by any of the treatments.

Initial quadrats in 1982 indicate that the percent cover of quack grass was less in dalapon and pronamide treated plots (Table 4). Glyphosate, dalapon and pronamide all reduced the percent of quack grass over check plots. There were no differences at mid season in any of the plots. However, at the end of the season, dalapon, pronamide, and glyphosate reduced the percent sward of the total quack grass population. Glyphosate and pronamide were the only treatments to reduce the percent sward of the total quack grass population at the end of the season. Samples of quack grass rhizomes revealed that glyphosate significantly reduced the total number of nodes per sample. Both fluazifop-butyl and glyphosate reduced the dry weight of the rhizome sample over the check plots.

At the end of the 1982 growing season, there were three distinct growth types of quack grass: headed, stunted, and new growth. All treatments reduced the final percent cover and percent sward of quack grass which had headed (Table 5). Sethoxydim and fluazifop-butyl caused severe quack grass

TABLE 3. POPULATIONS OF BIRDSFOOT TREFOIL AFTER APPLICATION OF SETHOXYDIM, FLUAZIFOP-BUTYL, GLYPHOSATE, FALL DALAPON AND FALL PRONAMIDE (1982).

TREATMENT (kg/ha)	INITIAL % Cover	INITIAL % Sward	MID-SEASON % Cover	MID-SEASON % Sward	FINAL % Cover	FINAL % Sward	% Fertile Pollen
CHECK	2.5	1.5	21.7 c	37.7	61.3 bc	30.4 bc	92.4
Sethoxydim (.8)	1.2	0.8	50.2 ab	38.0	59.2 bc	82.0 bc	93.9
Fluazifop-butyl (.6)	3.8	2.4	31.1 ab	21.5	12.8 c	20.4 c	93.2
Glyphosate (1:3)**	1.2	.6	16.5 c	32.5	81.7 ab	56.3 a	*
Dalapon (4.5)	6.3	5.5	30.1 bc	23.2	76.0 b	40.2 b	95.2
Pronamide (1.5)	7.5	6.4	55.5 a	12.3	95.7 a	59.6 a	93.6
C.V.	144.2	148.6	16.0	77.3	28.1	21.9	14.5

Means followed by the same letter within a column do not significantly differ at the 5% level according to Duncan's Multiple Range Test.

* Not tested as glyphosate had not been applied to the birdsfoot trefoil.

** 1:3/glyphosate:water

TABLE 4. THE EFFECTS OF SETHOXYDIM, FLUAZIFOP-BUTYL, ROPE-WICK GLYPHOSATE, DALAPON AND AND PRONAMIDE ON QUACK GRASS POPULATIONS (1982).

TREATMENT (kg/ha)	INITIAL		MID-SEASON		FINAL		QUACK GRASS RHIZOMES	
	% Cover	% Sward	% Cover	% Sward	% Cover	% Sward	Number of Nodes (#/.5m²)	Biomass (Dry Wt.) (g/.5m²)
CHECK	80.6 a	81.5 a	73.5 a	48.9	99.7 ab	68.5 ab	159.0 a	26.7 a
Sethoxydim (.8)	73.4 a	68.6 ab	61.4 a	42.1	91.3 ab	67.6 ab	111.0 ab	17.1 abc
Fluazifop-butyl (.6)	74.5 a	67.9 ab	71.2 a	57.7	96.3 ab	79.1 a	146.0 ab	15.7 bc
Glyphosate (1:3)*	67.9 a	58.9 b	21.3 b	38.3	72.9 cd	11.5 cd	80.0 b	8.4 c
Dalapon (4.5)	46.4 b	60.2 b	67.1 a	53.4	88.1 bc	55.7 bc	178.0 a	20.7 ab
Pronamide (1.5)	29.0 b	32.3 c	19.1 ab	38.4	63.1 d	31.1 d	205.0 a	24.9 ab
C.V.	21.6	23.9	39.1	50.0	19.2	21.1	30.0	31.1

Means followed by the same letter within a column do not significantly differ at the 5% level according to Duncans Multiple Range Test.

* 1:3/glyphosate:water

TABLE 5. GROWTH TYPES OF QUACK GRASS PRESENT AT THE END OF A SEASON AFTER APPLICATIONS OF SETHOXYDIM, FLUAZIFOP-BUTYL, GLYPHOSATE, DALAPON, AND PRONAMIDE (1982).

TREATMENT (kg/ha)	HEADED		STUNTED		NEW GROWTH	
	% Cover	% Sward	% Cover	% Sward	% Cover	% Sward
CHECK	48.9 a	21.1 a	0 b	0 c	91.9 a	17.6 abc
Sethoxydim (.8)	0 b	0 b	31.5 a	11.9 ab	91.3 a	55.4 ab
Fluazifop-butyl (.6)	0 b	0 b	27.9 a	12.5 a	93.7 a	66.3 a
Glyphosate (1:3)*	3.8 b	1.8 b	11.4 b	50.2 bc	66.5 b	37.6 cd
Dalapon (4.5)	12.6 b	5.0 b	0 b	0 c	80.2 ab	50.1 bc
Pronamide (1.5)	6.3 b	1.8 b	0 b	0 c	61.4 b	29.5 d
C.V.	64.7	81.6	91.7	92.2	23.0	23.5

Means followed by the same letter within a column do not significantly differ at the 5% level according to Duncans Multiple Range Test.

* 1:3/glyphosate:water

stunting, while glyphosate caused moderate to severe stunting. Glyphosate reduced the final percent cover of quack grass new growth, while pronamide reduced both percent cover and percent sward of quack grass new growth. However, fluazifop-butyl and sethoxydim had no effect on the new growth of quack grass.

2. Experiment 2. Effect of rope-wick applied glyphosate on quack grass.

At the end of the 1981 season, there were no significant differences in either quack grass foliar or rhizome growth as compared to checks (Table 6). Similarly, there were no significant differences in birdsfoot trefoil vegetative growth or seed production parameters (Table 7).

Early spring quadrats in 1982 indicate no differences in early quack grass growth. Late season quadrats showed that all applications of glyphosate significantly reduced the percent cover and percent sward of quack grass, although there were no differences among treatments (Table 8). While there were no differences in the percent cover of trefoil, early applications of glyphosate at the 3 to 4 and 4 to 5-leaf stage of quack grass resulted in increased percent sward of birdsfoot trefoil.

Quadrat analysis also proved that, apart from the total population of quack grass being reduced, both headed and new growth populations of quack grass were reduced (Table 9). Rhizome biomass was reduced by all treatments and rhizome node number was reduced by all applications except the 1:1 and 1:3 dilution of glyphosate at the 5 to 6-leaf stage.

TABLE 6. QUACK GRASS POPULATION AT THE END OF THE SEASON RESULTING FROM THREE DILUTIONS OF GLYPHOSATE APPLIED BY A ROPE-WICK TO THREE GROWTH STAGES OF QUACK GRASS (1981).

TREATMENT				RHIZOMES	
Gly:H_2O	Leaf Stage	% Cover	% Sward	Number of Nodes (#/.5m²)	Biomass Dry Wt. (gm/.5m²)
CHECK		50.6	18.8	18.8	78.3
1.1	3-4	34.2	1.0	39.8	11.8
1.2	3-4	24.1	7.1	33.0	80.9
1.3	3-4	33.9	10.3	23.0	93.6
1.1	4-5	33.9	15.5	19.8	81.9
1.2	4-5	30.3	9.1	3.0	24.7
1.3	4-5	47.7	12.3	19.8	96.1
1.1	5-6	20.1	7.7	21.5	87.7
1.2	5-6	19.0	11.5	8.8	60.5
1.3	5-6	26.3	9.88	16.8	83.1
C.V.		63.7	16.8	102.8	112.8

TABLE 7. BIRDSFOOT TREFOIL POPULATION RESULTING FROM THREE DILUTIONS OF GLYPHOSATE APPLIED BY ROPE-WICK TO THREE GROWTH STAGES OF QUACK GRASS (1981).

TREATMENT						Seed Yield		
Gly:H_2O	Leaf Stage	% Cover	% Sward	Flowers (#/.5m²)	Pods (#/.5m²)	Seed Yield (g/1m²)	% Germ.	Seedling Vigour*
CHECK		98.2	77.8	78.5	16.5	10.1	53.5	50.3
1.1	3-4	100.0	90.1	172.0	12.8	29.5	30.0	37.8
1.2	3-4	99.7	94.2	106.8	1.5	10.5	49.3	40.8
1.3	3-4	99.7	87.2	121.0	11.0	28.1	46.3	48.5
1.1	4-5	99.7	82.0	101.3	15.0	15.9	39.5	48.0
1.2	4-5	99.0	86.1	221.5	25.0	13.4	47.0	40.0
1.3	4-5	97.1	81.2	87.3	13.5	19.5	11.3	13.5
1.1	5-6	99.7	85.6	110.0	17.5	19.0	11.3	38.3
1.2	5-6	100.0	83.2	111.5	19.8	11.8	12.5	41.0
1.3	5-6	97.6	87.3	218.8	19.8	16.8	[illegible]	11.0
C.V.		12.6	15.0	56.5	51.5	[illegible]	20.2	26.9

* Percent germination after five (5) days.

TABLE 8. INITIAL AND FINAL POPULATIONS OF QUACK GRASS AND FINAL POPULATIONS OF BIRDSFOOT TREFOIL RESULTING FROM THREE DILUTIONS OF GLYPHOSATE ROPE-WICK APPLIED TO THREE GROWTH STAGES OF QUACK GRASS (1982).

TREATMENT		INITIAL QUACK GRASS		FINAL QUACK GRASS		FINAL BIRDSFOOT TREFOIL	
Gly:H_2O	Leaf Stage	% Cover	% Sward	% Cover	% Sward	% Cover	% Sward
CHECK		38.4	31.9	80.0 a	45.5 a	91.1	52.7 d
1.1	3-4	73.4	59.8	1.2 b	0.1 b	96.9	79.6 abc
1.2	3-4	60.4	50.6	7.5 b	2.3 b	99.7	87.5 abc
1.3	3-4	64.4	57.1	5.0 b	1.1 b	100.0	93.2 a
1.1	4-5	51.1	40.9	5.0 b	1.7 b	96.2	83.1 abc
1.2	4-5	59.6	17.6	5.0 b	1.5 b	97.6	89.4 ab
1.3	4-5	62.1	42.5	21.0 b	8.8 b	99.1	89.8-ab
1.1	5-6	44.4	31.6	28.8 b	11.7 b	85.9	64.7 cd
1.2	5-6	65.0	16.5	20.2 b	7.5 b	93.9	77.0 abcd
1.3	5-6	64.3	17.2	29.1 b	11.9 b	93.8	70.3 bcd
C.V.		40.5	16.2	77.3	98.9	22.5	24.4

Means followed by the same letter within a column do not significantly differ at the 5% level according to Duncans Multiple Range Test.

TABLE 9. THE EFFECTS OF THREE DILUTIONS OF GLYPHOSATE ROPE-WICK APPLIED TO THREE GROWTH STAGES OF QUACK GRASS ON RESULTING QUACK GRASS GROWTH STAGES AND RHIZOME BIOMASS AT THE END OF THE SEASON (1982).

TREATMENT		HEADED		NEW GROWTH		RHIZOMES	
Gly:H_2O	Leaf Stage	% Cover	% Stand	% Cover	% Stand	Number of Nodes (#/.5m²)	Biomass Dry Wt.(g/.5m²)
CHECK		11.0 a	14.3 a	67.8 a	30.7 a	79.3 a	10.1 a
1.1	3-4	0 b	0 b	5.0 b	1.7 b	1.8 c	0.5 c
1.2	3-4	0 b	0 b	7.5 b	2.3 b	3.8 c	0.2 c
1.2	3-4	0 b	0 b	5.0 b	1.1 b	0.8 c	0.01 c
1.1	4-5	0 b	0 b	5.0 b	1.7 b	13.0 c	0.9 c
1.2	4-5	1.2 b	0.1 b	3.8 b	1.2 b	8.5 c	0.7 c
1.3	4-5	8.8 b	2.4 b	16.5 b	6.1 b	36.5 b	2.5 bc
1.1	5-6	5.0 b	2.0 b	25.0 b	12.6 b	61.3 ab	5.9 b
1.2	5-6	11.3 b	3.9 b	8.8 b	3.5 b	22.5 c	2.6 bc
1.3	5-6	12.6 b	1.7 b	20.5 b	7.1 b	81.0 a	1.0 bc
C.V.		126.7	131.6	185.3	101.0	76.1	104.0

Means followed by the same letter within a column do not significantly differ at the 5% level according to Duncans Multiple Range Test.

3. Experiment 3. Comparison of the efficacy of sethoxydim and fluazifop-butyl for quack grass control.

The percent cover of quack grass remained unaffected by any treatments at the end of the 1981 season (Table 10). However, the percent sward of quack grass was significantly reduced by all treatments except fluazifop-butyl at the 5 to 6-leaf stage. The percent composition (dry weight) of quack grass was reduced in all treatment plots, although there were no differences among treatments. No treatments resulted in any significant effects to the birdsfoot trefoil population.

Quack grass rhizome excavations taken at the end of the 1981 growing season indicated that there were no differences in either the dry weight or the number of nodes among treatment and check plots (Table 11). Early applications of fluazifop-butyl at the 3 to 4-leaf stage of quack grass resulted in a greater number of flowers and seed pods of the trefoil. There were no differences in final seed yield, percent germination, or seedling vigour of the trefoil among the various treatment and check plots.

All treatments caused severe stunting of the quack grass and at the end of the season no quack grass had headed in any treatment plot (Table 12). Later applications of fluazifop-butyl at the 5 to 6-leaf stage of quack grass stunted quack grass more than other treatments. Neither sethoxydim or fluazifop-butyl had any effect on new growth of quack grass at the end of the growing season.

In the spring of 1982, pre-treatment quadrats indicated that no treatments from the previous year had any carry over effect on the populations of quack grass or any other plant species (Table 13)

TABLE 10. THE EFFECTS OF EARLY, LATE, AND SPLIT APPLICATIONS OF SETHOXYDIM AND FLUAZIFOP-BUTYL ON POPULATION DENSITIES OF QUACK GRASS AND BIRDSFOOT TREFOIL IN A MIXED SWARD (1981).

		QUACK GRASS			BIRDSFOOT TREFOIL		
TREATMENT (kg/ha)	Leaf Stage	% Cover	% Sward	% Contribution to Tot. Plot Biomass	% Cover	% Sward	% Contribution to Tot. Plot Biomass
CHECK		33.9	24.6 a	18.1 a	98.7	73.3	82.8
Sethoxydim (.8)	3-4	19.0	7.1 b	2.0 b	97.2	81.2	96.9
Sethoxydim (.8)	5-6	31.7	10.6 b	5.9 b	100.0	83.1	91.7
Sethoxydim (.5/.5)	3-4/5-6	21.0	10.0 b	2.6 b	98.7	80.2	94.9
Fluazifop-butyl (.5)	3-4	15.0	5.0 b	7.2 b	99.1	87.8	91.4
Fluazifop-butyl (.5)	5-6	38.6	11.9 ab	9.0 b	98.7	80.8	92.5
Fluazifop butyl (.3/.4)	3-4/5-6	21.4	10.4 b	1.6 b	89.7	75.6	91.8
C.V.		53.9	61.0	87.9	12.3	14.3	11.9

Means followed by the same letter within a column do not significantly differ at the 5% level according to Duncans Multiple Range Test.

TABLE 11. THE EFFECTS OF EARLY, LATE, AND SPLIT APPLICATIONS OF SETHOXYDIM AND FLUAZIFOP-BUTYL ON LATE SEASON QUACK GRASS RHIZOME BIOMASS AND BIRDSFOOT TREFOIL SEED YIELD COMPONENTS (1981).

TREATMENT (kg/ha)	Leaf Stage	RHIZOME Total Nodes/.5m²	RHIZOME Dry Wt. (g/.5m²)	BIRDSFOOT TREFOIL Flower (#/.5m²)	BIRDSFOOT TREFOIL Pods (#/.5m²)	BIRDSFOOT TREFOIL Seed Yield (g/1m²)	BIRDSFOOT TREFOIL % Germ.	BIRDSFOOT TREFOIL Seedling Vigour*
CHECK		16.8	1.0	52.2 b	11.8 b	32.9	45.7	32.8
Sethoxydim (.8)	3-4	27.3	1.0	65.0 ab	31.2 b	11.2	18.0	36.8
Sethoxydim (.8)	5-6	22.0	1.0	71.2 ab	18.8 b	40.1	41.2	29.5
Sethoxydim (.5/.5)	3-4/5-6	20.0	3.7	41.0 b	11.0 b	27.3	50.0	27.0
Fluazifop-butyl (.5)	3-4	34.8	2.3	95.8 a	53.5 a	53.1	41.0	33.2
Fluazifop-butyl (.5)	5-6	39.5	2.2	71.8 ab	21.0 b	53.8	16.2	33.0
Fluazifop-butyl (.3/.4)	3-4/5-6	28.0	1.5	41.2 b	21.2 b	37.7	46.0	32.8
C.V.		92.3	223.7	36.6	59.1	32.6	29.4	24.5

Means followed by the same letter within a column do not significantly differ at the 5% level according to Duncans Multiple Range Test.

* Percent germination after five (5) days.

TABLE 12. A COMPARISON OF QUACK GRASS GROWTH TYPES PRESENT AT THE END OF THE SEASON AFTER EARLY, LATE, AND SPLIT APPLICATIONS OF SETHOXYDIM AND FLUAZIFOP-BUTYL (1981).

TREATMENT (kg/ha)	Leaf Stage	HEADED % Cover	HEADED % Sward	STUNTED % Cover	STUNTED % Sward	NEW GROWTH % Cover	NEW GROWTH % Sward
CHECK		39.2 a	22.1 a	0 b	0 b	26.3	2.1
Sethoxydim (.8)	3-4	0 b	0 b	0 b	0 b	19.0	7.4
Sethoxydim (.8)	5-6	0 b	0 b	6.2 b	2.0 b	23.8	8.0
Sethoxydim (.5/.5)	3-4/5-6	0 b	0 b	2.5 b	0.8 b	18.9	9.2
Fluazifop-butyl (.5)	3-4	0 b	0 b	2.5 b	0.7 b	17.6	5.0
Fluazifop-butyl (.5)	5-6	0 b	0 b	23.9 a	7.7 a	17.6	7.4
Fluazifop-butyl (.5/.5)	3-4/5-6	0 b	0 b	16.3 a	6.3 a	6.3	2.1
C.V.		226.3	260.8	87.1	[illegible]	58.1	65.6

Means followed by the same letter within a column do not significantly differ at the 5% level according to Duncans Multiple Range Test.

TABLE 13. AN INITIAL COMPARISON OF TREATMENT PLOTS A YEAR AFTER TREATMENT WITH SETHOXYDIM AND FLUAZIFOP-BUTYL FOR RESIDUAL CONTROL OF QUACK GRASS (1982).

TREATMENT (kg/ha)	Leaf Stage	QUACK GRASS % Cover	QUACK GRASS % Sward	BIRDSFOOT TREFOIL % Cover	BIRDSFOOT TREFOIL % Sward	BROADLEAF WEEDS % Cover	BROADLEAF WEEDS % Sward
CHECK		75.9	60.4	7.5	1.0	52.2	37.1
Sethoxydim (.8)	3-4	65.7	45.5	16.3	8.5	59.2	46.3
Sethoxydim (.8)	5-6	67.4	47.9	1.2	0.5	79.3	51.6
Sethoxydim (.5/.5)	3-4/5-6	77.8	56.4	7.5	1.2	60.8	39.5
Fluazifop-butyl (.6)	3-4	71.1	58.1	7.6	1.2	61.4	36.6
Fluazifop-butyl (.6)	5-6	72.0	53.0	2.5	0.9	67.5	47.7
Fluazifop-butyl (.3/.4)	3-4/5-6	83.3	60.9	11.3	5.1	59.6	35.0
C.V.		21.6	32.5	122.0	120.6	38.5	35.3

At mid season, there were no significant differences in either trefoil or broadleaf weed species among treatment and check plots (Table 14). Split applications of sethoxydim at the 3 to 4 and 5 to 6-leaf stage of quack grass reduced both the percent cover and percent sward of quack grass. However, no other applications of sethoxydim or fluazifop-butyl had any effect on quack grass populations.

At the end of the 1982 season, the percent cover of quack grass was significantly reduced from early and split applications of sethoxydim only (Table 15). The percent sward of quack grass was significantly reduced by both single applications of sethoxydim and fluazifop-butyl at the 3 to 4-leaf stage, and split applications at the 3 to 4 and 5 to 6-leaf stage. Plots receiving a single application of sethoxydim at the 3 to 4-leaf stage of quack grass had the greatest percent cover of trefoil. The percent sward of trefoil was greatest in plots receiving split applications of sethoxydim at the 3 to 4 and 5 to 6-leaf stage of quack grass. However, no other treatments of either sethoxydim or fluazifop-butyl affected trefoil populations. While the percent sward of broadleaf weeds did not differ among plots, the percent cover of these weeds was greatest in plots receiving sethoxydim or fluazifop-butyl at the 3 to 4-leaf stage of quack grass.

At the end of the 1982 growing season, there were three growth types of quack grass: headed, stunted but not headed, and new growth of quack grass. All treatments eliminated headed quack grass plants from the plots (Table 16). Late applications of both herbicides caused a large amount of stunting in quack

TABLE 14. A COMPARISON OF MID-SEASON SPECIES POPULATIONS AFTER EARLY, LATE, AND SPLIT APPLICATIONS OF SETHOXYDIM AND FLUAZIFOP-BUTYL (1982).

TREATMENT (kg/ha)	Leaf Stage	QUACK GRASS % Cover	QUACK GRASS % Sward	BIRDSFOOT TREFOIL % Cover	BIRDSFOOT TREFOIL % Sward	BROADLEAF WEEDS % Cover	BROADLEAF WEEDS % Sward
CHECK		78.8 ab	60.6 abc	17.8	11.1	55.1	28.6
Sethoxydim (.8)	3-4	15.0 bc	39.7 cd	20.1	13.7	60.5	48.5
Sethoxydim (.8).	5-6	79.1 ab	56.8 abc	17.6	13.8	57.2	29.8
Sethoxydim (.5/.5)	3-4/5-6	43.9 c	29.9 d	39.1	29.6	63.8	41.5
Fluazifop-butyl (.6)	3-4	64.2 abc	11.8 bcd	26.6	18.3	61.5	38.3
Fluazifop-butyl (.6)	5-6	85.4 a	68.5 a	25.3	11.8	26.2	16.7
Fluazifop-butyl (.3/.4)	3-4/5-6	78.8 ab	66.7 ab	8.8	1.1	15.5	29.7
C.V.		33.4	31.8	68.2	80.3	34.2	41.7

Means followed by the same letter within a column do not significantly differ at the 5% level according to Duncans Multiple Range Test.

TABLE 15. A COMPARISON OF FINAL SPECIES POPULATION AFTER EARLY, LATE AND SPLIT APPLICATIONS OF SETHOXYDIM AND FLUAZIFOP-BUTYL (1982).

TREATMENT (kg/ha)	Leaf Stage	QUACK GRASS % Cover	QUACK GRASS % Sward	BIRDSFOOT TREFOIL % Cover	BIRDSFOOT TREFOIL % Sward	BROADLEAF WEEDS % Cover	BROADLEAF WEEDS % Sward
CHECK		100.0 a	80.4 a	17.7 bcd	15.6 c	13.9 b	4.1
Sethoxydim (.8)	3-4	53.9 c	30.6 c	85.5 a	50.7 a	33.8 a	20.1
Sethoxydim (.8)	5-6	97.6 ab	75.1 ab	49.9 bcd	21.3 bc	9.98 b	3.8
Sethoxydim (.5/.5)	3-4/5-6	89.8 b	57.2 bc	73.2 ab	36.8 ab	15.0 b	6.0
Fluazifop-butyl (.6)	3-4	90.8 ab	56.1 bc	57.9 bc	27.5 bc	12.8 a	17.2
Fluazifop-butyl (.6)	5-6	98.7 ab	82.6 a	30.3 d	12.1 c	15.0 b	5.3
Fluazifop-butyl (.3/.4)	3-4/5-6	94.6 ab	56.1 bc	25.1 cd	11.0 c	22.8 ab	29.7
C.V.		22.2	27.4	37.3	45.1	70.9	151.6

Means followed by the same letter within a column do not significantly differ at the 5% level according to Duncans Multiple Range Test.

TABLE 16. A COMPARISON OF FINAL GROWTH STAGES OF QUACK GRASS POPULATIONS AFTER EARLY, LATE, AND SPLIT APPLICATIONS OF SETHOXYDIM AND FLUAZIFOP-BUTYL (1982).

TREATMENT (kg/ha)	Leaf Stage	HEADED		STUNTED		NEW GROWTH	
		% Cover	% Sward	% Cover	% Sward	% Cover	% Sward
CHECK		60.3 a	21.1 a	0 b	0 b	97.5 a	56.3
Sethoxydim (.8)	3-4	0 b	0 b	0 b	0 b	53.9 b	30.6
Sethoxydim (.8)	5-6	0 b	0 b	46.1 a	18.7 a	89.2 a	56.4
Sethoxydim (.5/.5)	3-4/5-6	0 b	0 b	0 b	0 b	89.8 a	57.2
Fluazifop-butyl (.6)	3-4	0 b	0 b	0 b	0 b	90.8 a	56.1
Fluazifop-butyl (.6)	5-6	0 b	0 b	17.9 a	21.0 a	91.7 a	60.8
Fluazifop-butyl (.3/.4)	3-4/5-6	0 b	0 b	1.2 b	0.6 b	91.6 a	55.7
C.V.		46.9	47.6	10.8	61.0	21.5	33.2

Means followed by the same letter within a column do not significantly differ at the 5% level according to Duncans Multiple Range Test.

grass. The percent cover of new growth of quack grass was significantly less in plots receiving the 3 to 4-leaf stage application of sethoxydim, although no other treatments affected the new growth. The percent sward of quack grass new growth did not significantly differ from check plots among the treatments.

Analyses of data from quack grass rhizome excavations revealed that none of the treatments affected the number of nodes per rhizome sample. All applications of sethoxydim and fluazifop-butyl at the 3 to 4-leaf stage reduced the rhizome biomass. Late and split applications of fluazifop-butyl had no affect on rhizome biomass (Table 17).

The percent composition (dry weight) of quack grass was significantly less with early and split applications of sethoxydim, and early applications of fluazifop-butyl. Early applications of sethoxydim resulted in the greatest proportion of trefoil, whereas all other treatment plots were equal to checks.

4. <u>Experiment 4. Comparison of the efficacy of pronamide, dalapon, sethoxydim, fluazifop-butyl, glyphosate and haloxyfop-methyl applied to various growth stages of quack grass in newly seeded birdsfoot trefoil</u>.

Early spring evaluations of fall herbicide applications indicated that sethoxydim reduced both the percent cover and percent sward of quack grass while fluazifop-butyl reduced the percent sward only of quack grass (Table 18). Birdsfoot trefoil populations, while being very low, did not significantly vary among plots, however, plots treated with sethoxydim had the greatest population of broadleaf weeds.

TABLE 17. A COMPARISON OF QUACK GRASS RHIZOME BIOMASS AND PERCENT CONTRIBUTION OF SPECIES TO TOTAL ABOVE GROUND BIOMASS AFTER EARLY, LATE, AND SPLIT APPLICATIONS OF SETHOXYDIM AND FLUAZIFOP-BUTYL (1982).

TREATMENT (kg/ha)	Leaf Stage	Nodes (#/.5m²)	Biomass Dry Wt. (g/.5m²)	% CONTRIBUTION OF SPECIES TO TOTAL BIOMASS (Dry Weight)		
				Quack Grass	B.F.T.	Broadleaf Weeds
CHECK		192.7	23.6 a	86.1 ab	13.2 bc	0.6
Sethoxydim (.8)	3-4	147.0	13.5 b	39.0 d	52.8 a	3.2
Sethoxydim (.8)	5-6	115.2	9.9 b	78.2 abc	19.0 bc	2.9
Sethoxydim (.5/.5)	3-4/5-6	124.2	11.2 b	58.6 cd	34.5 ab	6.9
Fluazifop-butyl (.6)	3-4	104.0	10.7 b	55.6 cd	42.1 ab	2.0
Fluazifop-butyl (.6)	5-6	192.0	22.2 a	91.6 a	2.8 c	2.6
Fluazifop-butyl (.3/.4)	3-4/5-6	194.7	16.5 ab	74.1 bc	25.8 bc	0.1
C.V.		33.6	36.1	29.5	60.9	71.1

Means followed by the same letter within a column do not significantly differ at the 5% level according to Duncans Multiple Range Test.

TABLE 18. SPRING POPULATIONS OF SPECIES RESULTING FROM FALL TREATMENTS OF DALAPON, PRONAMIDE, SETHOXYDIM AND FLUAZIFOP-BUTYL.

TREATMENT (kg/ha)	QUACK GRASS % Cover	QUACK GRASS % Sward	BIRDSFOOT TREFOIL % Cover	BIRDSFOOT TREFOIL % Sward	BROADLEAF WEEDS % Cover	BROADLEAF WEEDS % Sward
CHECK	44.8 ab	60.0 a	2.5	3.3	33.9	38.8 b
Dalapon (4.5)	55.8 a	60.9 a	2.5	4.8	15.7	36.0 b
Sethoxydim (.8)	10.1 c	17.1 c	2.5	1.1	56.0	78.8 a
Fluazifop-butyl (.6)	24.0 bc	27.6 bc	2.5	6.3	39.3	66.1 ab
Pronamide (1.5)	41.5 ab	48.6 ab	0	5.0	17.7	52.3 b
Pronamide (F/S)*(.5/.5)	53.3 a	56.8 a	2.5	1.7	16.6	41.5 b
C.V.	38.0	41.3	177.1	198.1	18.1	43.1

Means followed by the same letter within a column do not significantly differ at the 5% level according to Duncans Multiple Range Test.

* F/S = fall-spring split application

At the end of the growing season, fall/spring sethoxydim, fall/spring fluazifop-butyl, spring only fluazifop-butyl, and rope-wick applied glyphosate treatments had significantly less quack grass cover (Table 19). Fall/spring sethoxydim and fluazifop-butyl, and rope-wick applied glyphosate reduced the percent sward of the quack grass when compared to the check plots. Similarly, fall/spring sethoxydim and rope-wick applied glyphosate resulted in the greatest cover of trefoil. Glyphosate was the only treatment which resulted in an increase in the percent sward of the trefoil. Only fall/spring fluazifop-butyl treatments resulted in a greater percent cover and sward of broadleaf weeds.

As in the previous experiments, the growth types of quack grass were analyzed separately. Spring applications of pronamide resulted in the greatest percent cover of headed quack grass (Table 20). All sethoxydim, fluazifop-butyl, glyphosate, and haloxyfop-methyl treatments reduced the percent cover and percent sward of headed quack grass. Spring applications of sethoxydim, fluazifop-butyl, and haloxyfop-methyl caused stunting in quack grass, thus plots receiving these treatments had the greatest percent cover of stunted quack grass. However, only spring haloxyfop-methyl and fluazifop-butyl increased the percent sward of stunted quack grass.

The percent cover and percent sward of new quack grass growth at the end of the season were equally reduced by fall/spring sethoxydim and fluazifop-butyl, rope-wick applied glyphosate, and spring applied haloxyfop-methyl. Spring

TABLE 19. FINAL POPULATIONS OF SPECIES IN A MIXED SWARD RESULTING FROM VARIOUS TREATMENTS WITH DALAPON, GLYPHOSATE, PRONAMIDE, SETHOXYDIM, FLUAZIFOP-BUTYL AND HALOXYFOP-METHYL.

TREATMENT (kg/ha)	QUACK GRASS % Cover	QUACK GRASS % Sward	BIRDSFOOT TREFOIL % Cover	BIRDSFOOT TREFOIL % Sward	BROADLEAF WEEDS % Cover	BROADLEAF WEEDS % Sward
CHECK	92.1 ab	60.4 ab	15.0 c	6.0 bc	61.1 bc	33.6 bcd
Sethoxydim (F/S)* (.8/.8)	28.4 d	15.5 c	11.3 b	21.7 b	88.1 ab	59.7 ab
Sethoxydim (S) (.8)	80.4 abc	57.1 ab	25.0 bc	11.3 bc	55.8 c	28.4 bcd
Fluazifop-butyl (F/S) (.6/.6)	25.4 d	15.3 c	25.1 bc	15.5 bc	89.9 a	69.1 a
Fluazifop-butyl (S) (.6)	65.5 bc	50.0 b	30.5 bc	16.7 bc	51.8 c	33.2 bcd
Pronamide (F/S) (.75/.75)	70.6 abc	45.6 b	21.3 bc	11.6 bc	66.2 abc	12.9 abcd
Pronamide (F) (1.5)	67.9 bc	43.6 b	15.0 c	8.1 bc	70.9 bc	18.0 abcd
Pronamide (S) (1.5)	94.3 a	71.2 a	8.8 c	3.6 c	19.3 c	22.2 cd
Dalapon (F) (4.5)	85.2 abc	51.1 ab	21.7 bc	15.0 bc	53.7 c	30.9 bcd
Glyphosate (S) (1.3)**	2.5 d	1.0 c	63.5 a	18.6 a	57.8 c	50.1 ab
Haloxyfop-methyl (S) (.3)	72.0 abc	17.1 b	32.7 bc	20.9 bc	52.6 c	31.6 bcd
C.V.	38.1	38.9	51.3	66.5	36.8	47.3

Means followed by the same letter within a column do not significantly differ at the 5% level according to Duncans Multiple Range Test.

* F = fall applied S = spring applied F/S = fall-spring split application

** 1:3/glyphosate:water

TABLE 20. A COMPARISON OF FINAL QUACK GRASS GROWTH TYPES RESULTING FROM VARIOUS TREATMENTS WITH SETHOXYDIM, FLUAZIFOP-BUTYL, PRONAMIDE, DALAPON, ROPE-WICK APPLIED GLYPHOSATE AND HALOXYFOP-METHYL (1982).

TREATMENT (kg/ha)	HEADED		STUNTED		NEW GROWTH	
	% Cover	% Sward	% Cover	% Sward	% Cover	% Sward
CHECK	25.0 b	12.2 bc	0 b	0 b	79.3 a	47.9 a
Sethoxydim (F/S)* (.8/.8)	1.2 c	0.5 d	1.2 b	0.1 c	28.1 de	14.6 cd
Sethoxydim (S) (.8)	0 c	0 d	28.3 a	15.6 abc	65.3 abc	40.6 a
Fluazifop-butyl (F/S) (.6/.6)	0 c	0 d	5.0 b	3.8 bc	21.3 de	11.1 cd
Fluazifop-butyl (S) (.6)	0 c	0 d	27.0 a	20.3 ab	46.4 abcd	23.1 abc
Pronamide (F) (1.5)	8.8 bc	3.7 cd	0 b	0 c	61.0 abc	38.3 ab
Pronamide (F/S) (.75/.75)	21.9 bc	8.7 bcd	0 b	0 c	62.0 abc	36.9 ab
Pronamide (S) (1.5)	56.3 a	29.6 a	0 b	0 c	73.6 ab	44.8 a
Dalapon (F) (4.5)	24.6 b	15.1 b	0 b	0 c	61.3 abc	43.0 a
Glyphosate (S) (1:3)**	0 c	0 d	0 b	0 c	2.5 e	1.0 d
Haloxyfop-methyl (S) (.3)	1.2 c	0.5 d	17.7 a	28.0 a	31.8 cde	18.6 bcd
C.V.	107.3	111.5	111.5	160.6	11.5	46.5

Means followed by the same letter within a column do not significantly differ at the 5% level according to Duncans Multiple Range Test.

* F = fall applied S = spring applied F/S = fall-spring split application
** 1:3/glyphosate:water

fluazifop-butyl, while reducing the percent cover of quack grass new growth, did not significantly affect the percent sward.

5. Experiment 5. Comparison of the efficacy of single applications of herbicides for control of quack grass in established birdsfoot trefoil.

At mid season, there were no significant differences in either the percent cover or percent sward of quack grass among treatment plots (Table 21). With respect to birdsfoot trefoil, the percent cover was reduced in glyphosate treatment plots. No other treatments affected the percent cover of the trefoil and the percent sward was unaffected by all treatments.

At the end of the growing season, there were no differences in the percent cover of quack grass, although all treatments reduced the percent sward (Table 22). The percent cover of birdsfoot trefoil populations did not differ, but the percent sward of the trefoil was greater in all treatment plots as compared to checks with glyphosate being somewhat superior. There were no significant differences in either the percent contribution of quack grass or birdsfoot trefoil to the total sample biomass.

All treatments reduced both the percent cover and percent sward of headed quack grass with rope-wick applied glyphosate being less effective than the other treatments (Table 23). Sethoxydim (both rates) and haloxyfop-methyl (all rates) treatments caused stunting to the quack grass with the percent cover and percent sward of stunted quack grass being highest in these treatment plots. Rope-wick applied glyphosate, haloxyfop-

TABLE 21. MID-SEASON COMPARISONS OF QUACK GRASS AND BIRDSFOOT TREFOIL POPULATIONS RESULTING FROM VARIOUS APPLICATIONS OF ROPE-WICK APPLIED GLYPHOSATE, SETHOXYDIM, FLUAZIFOP-BUTYL, AND HALOXYFOP-METHYL (1982).

TREATMENT (kg/ha)	QUACK GRASS		BIRDSFOOT TREFOIL	
	% Cover	% Sward	% Cover	% Sward
CHECK	83.1	12.1	91.9 abc	57.5
Glyphosate (1:3)*	44.7	38.9	71.1 d	61.2
Sethoxydim (0.6)	56.5	28.2	96.3 ab	71.8
Sethoxydim (0.8)	70.3	39.2	89.7 abcd	45.0
Haloxyfop-methyl (0.15)	66.5	31.5	96.8 ab	67.4
Haloxyfop-methyl (0.3)	57.4	33.1	89.0 abcd	64.6
Haloxyfop-methyl (0.5)	80.6	18.6	71.7 cd	51.1
Fluazifop-butyl (0.4)	68.8	36.4	83.8 bcd	61.8
Fluazifop-butyl (0.6)	61.7	27.5	99.7 a	70.3
C.V.	30.1	53.0	21.2	31.4

Means followed by the same letter within a column do not significantly differ at the 5% level according to Duncans Multiple Range Test.

* 1:3/glyphosate:water

TABLE 22. END OF SEASON COMPARISON OF QUACK GRASS AND BIRDSFOOT TREFOIL POPULATIONS RESULTING FROM VARIOUS APPLICATIONS OF ROPE-WICK APPLIED GLYPHOSATE, SETHOXYDIM, FLUAZIFOP-BUTYL, AND HALOXYFOP-METHYL (1982).

TREATMENT (kg/ha)	QUACK GRASS		BIRDSFOOT TREFOIL		% CONTRIBUTION TO TOTAL BIOMASS	
	% Cover	% Sward	% Cover	% Sward	Quack Grass	Birdsfoot Treforl
CHECK	85.2	56.4 a	80.6	15.5 c	35.1	64.9
Glyphosate (1:3)*	43.5	16.1 b	100.0	81.9 a	17.9	82.1
Sethoxydim (0.6)	75.7	29.1 b	99.7	71.1 b	16.5	83.5
Sethoxydim (0.8)	69.8	29.1 b	99.7	71.0 b	17.1	82.9
Haloxyfop-methyl (0.15)	60.0	27.1 b	99.7	72.8 b	20.2	79.8
Haloxyfop-methyl (0.3)	41.7	15.1 b	99.7	81.6 ab	11.2	88.8
Haloxyfop-methyl (0.5)	63.1	26.2 b	97.1	71.7 ab	22.5	77.5
Fluazifop-butyl (0.1)	72.6	27.0 b	98.7	73.1 b	19.9	80.1
Fluazifop-butyl (0.6)	57.4	23.3 b	100.0	77.1 ab	15.3	81.7
C.V.	11.0	36.9	19.8	18.5	53.6	16.6

Means followed by the same letter within a column do not significantly differ at the 5% level according to Duncans Multiple Range Test.

* 1:3/glyphosate:water

TABLE 23. A COMPARISON OF THE EFFECTS OF GLYPHOSATE, SETHOXYDIM, HALOXYFOP-METHYL, AND FLUAZIFOP-BUTYL ON FINAL GROWTH TYPES OF QUACK GRASS.

TREATMENT (kg/ha)	HEADED		STUNTED		NEW GROWTH	
	% Cover	% Sward	% Cover	% Sward	% Cover	% Sward
CHECK	70.3 a	27.1 a	0 c	0 c	70.9 a	29.3 a
Glyphosate (1:3)*	28.1 b	8.7 b	0 c	0 c	20.2 e	7.4 c
Sethoxydim (0.6)	0 c	0 c	28.9 ab	9.2 ab	55.6 abcd	19.9 abc
Sethoxydim (0.8)	0 c	0 c	18.8 bc	5.7 bc	62.1 ab	21.7 ab
Haloxyfop-methyl (0.15)	0 c	0 c	25.1 ab	9.7 ab	41.3 bcde	15.8 abc
Haloxyfop-methyl (0.3)	3.8 c	1.2 c	16.1 b	6.7 b	17.6 e	7.6 c
Haloxyfop-methyl (0.5)	0 c	0 c	41.9 a	14.0 a	37.3 cde	12.2 bc
Fluazifop-butyl (0.4)	0 c	0 c	18.9 bc	5.5 bc	60.3 abc	21.5 ab
Fluazifop-butyl (0.6)	10.3 c	4.0 c	20.1 bc	6.1 bc	33.2 de	13.2 bc
C.V.	82.5	92.6	66.7	57.3	38.4	48.9

Means followed by the same letter within a column do not significantly differ at the 5% level according to Duncans Multiple Range Test.

* 1:3/glyphosate:water

methyl (all rates) and fluazifop-butyl (0.6) treatments all reduced the percent cover of new growth of quack grass at the end of the season. Rope-wick applied glyphosate, haloxyfop-methyl (0.3 and 0.5) and fluazifop-butyl (0.6) treatments all equally reduced the percent sward of quack grass new growth.

CHAPTER V

DISCUSSION

Throughout the two years this project was conducted, there were certain uncontrollable influences on the projects outcome worth noting. As this was the first time a rope-wick apparatus had been tested at Macdonald College, there were some problems encountered which were not anticipated. For instance, a two directional application in the second year appeared to be superior to a single directional application as used in the first year.

All plots in all experiments were permanent plots such that the same treatments were applied to the same plots in the second year; therefore, destructive sampling such as quack grass rhizome sampling was kept to a minimum the first year. This alone accounts for the high coefficient of variation in rhizome data in the first year collections.

Weather patterns were a significant influence in the second year of the project. The drought conditions apparently reduced the efficacy of some of the herbicides. A suspected boron deficiency in the birdsfoot trefoil in the second year was also attributed to the drought conditions. This deficiency caused severe flower abortion throughout the birdsfoot trefoil, therefore, no seed production parameters were measured. Apart from the negative effects of the drought on the birdsfoot trefoil, it provided a good opportunity to evaluate the various herbicides under extreme conditions.

A single experiment (number 4) was conducted to evaluate all herbicides used throughout this project on the establishment of new birdsfoot trefoil. The resulting population of trefoil was extremely poor, and in fact, there were no significant differences in any birdsfoot trefoil quadrat data (Table 21). All trefoil data in this single experiment is considered to be non-conclusive due to poor establishment of the crop.

In the same experiment, fall applications of pronamide and dalapon were made with the spray boom too low to the ground. The result was incomplete coverage of herbicide and the following spring, distinct rows of quack grass were visible.

1. Glyphosate

All data indicate that as long as the birdsfoot trefoil plants did not come in contact with the rope-wick apparatus, there were no adverse affects from the herbicide. Visually, it was noted that applications at the 5 to 6-leaf stage of quack grass resulted in some phytotoxicity to the trefoil. At the 5 to 6-leaf stage of quack grass, the distance between the trefoil and the quack grass tops was insufficient for a selective application of glyphosate. Although Claus and Behrens (1976) conclude that this is the optimum leaf stage for quack grass control with glyphosate, the disadvantages of application at this stage are apparent.

Winterkill of birdsfoot trefoil between the first and second year of the experiment resulted in low trefoil populations during the second year. Final quadrats in the second season indicate that the growth (percent sward) of trefoil was improved in plots where the quack grass was controlled (Tables 4 and 8).

Data from 1981 would suggest that control of quack grass was poor with glyphosate, while 1982 data indicates good control. A superior wick and a two directional application of glyphosate in 1982 would account for this.

Early spring quadrats in the second season show that there was no significant control of quack grass from the previous year. Glyphosate successfully controlled quack grass foliar growth the end of the season as expressed by quadrat data (Tables 5, 10, 11 and 21). The same level of foliar control was obtained with all concentrations of glyphosate at all treatment dates. However, applications at the 2 to 4-leaf stage of quack grass reduced the total number of rhizome nodes more than later applications. This data is consistent with that of Claus and Behrens (1976) as they report that glyphosate is translocated to the rhizomes when applied to shoots at the 3 and 4-leaf stage. Differences in total rhizome weight tended to follow the same pattern as shown in Table 11. It is therefore apparent that basipetal translocation of the glyphosate reduces both node number and weight of quack grass rhizomes. This will in turn reduce the potential of the quack grass to produce new growth as shown in Table 9. Claus and Behrens (1976) add that buds near the mother shoot may be more tolerant of glyphosate, although there is no data in this experiment to support this.

Poor control of quack grass in the first year may well be attributed to a combination of an inferior wick and poorer wick:weed contact with the uni-directional application.

Good control of quack grass shoot growth and a reduction in rhizome weight and node number when glyphosate was wick applied at the 3 to 4-leaf stage is apparent. Brockman et al. (1972) support this and conclude that maximal activity of glyphosate is obtained when: (a) there is sufficient leaf area for adequate herbicide interception; (b) flow of carbohydrates is basipetal; and (c) seasonal temperatures are sufficiently high. Similar to the data obtained in this experiment, Brockman et al. (1972) did not find a rate response with spring applications of glyphosate, although a response was evident for fall treatments.

2. Pronamide

Conclusions on the efficacy of pronamide are based on the second year of the project only. All applications of pronamide in the first year were mistakenly made at one tenth the intended rate. The data indicated no significant effect on quack grass populations when applied at such a reduced rate.

The results of two application dates were compared in two complete experiments. Both fall and spring applications were compared with varying results. In a single experiment (Tables 4 and 5), fall pronamide applications were effective in reducing the top growth of quack grass the following year. In a second experiment (Tables 18 and 19) quadrat results indicated that there was no significant control of quack grass by the fall pronamide applications. This is explained by the fact that in this second experiment, it was visually noted in the spring that quack grass was growing in prominent rows within each plot. This may well be a result of poor spray coverage with fall (i.e., boom too low).

Significant control in one experiment and visually noted control in strips in a second experiment may indicate that pronamide is immobile in the soil. Some control is possible, however, complete coverage is imperative.

Within the literature there is contradictory evidence with respect to the efficacy of spring applied pronamide. Smith et al. (1971) maintain that pronamide is ineffective when applied to spring quack grass foliage. However, Fawcett et al. (1978) reported pronamide is effective for the control of quack grass in alfalfa and other established forage legumes when autumn or spring applied. The results of this experiment (Table 20) indicate that spring applications of pronamide will result in populations of mature quack grass later in the season equal to or even greater than check plots. This phenomenon may be explained by Smith et al. (1971) who stated that pronamide applied to the foliage results in older leaves remaining green and quite unaffected for at least six weeks. Ryan (1972) found that pronamide actually prevents mature rhizome buds from entering their natural dormancy during the early summer months, therefore, there is foliar regrowth during this period. Thus, it is possible that in the present experiment, some rhizome buds were affected by the spring applied pronamide, and did not remain dormant during the early summer as would normally occur. There was an increase in the population of mature quack grass at the end of the season in treated plots. It may be concluded that spring applications of pronamide may do more harm than good in that during the summer months, there will actually be a greater population of quack grass, creating increased competition for the crop plant.

Table 7 indicates that neither total rhizome dry weight, nor total node number per rhizome sample were affected by pronamide. This differs from Ryan (1972) who found that although fresh weight of new rhizomes had increased at the end of the season (treatment and sample dates were similar), the total weight of rhizomes was reduced. However, mature rhizomes were not separated from new rhizomes in this experiment, therefore a reduction or increase in either population cannot be concluded. The extreme dry weather conditions throughout the season may have affected the ability of pronamide to control quack grass.

Point quadrat data and birdsfoot trefoil pollen fertility data indicate that pronamide had no deleterious effects on the trefoil.

3. Dalapon

Similar to pronamide, dalapon applications the first year of study were at one tenth the intended rate. Thus no conclusions may be drawn on the first years data.

Fall applied dalapon was successful in reducing the spring foliar growth of quack grass in treatment plots (Table 5). Similar to pronamide, fall applications of dalapon in experiment 4 were made with the spray boom too low resulting in poor coverage and prominent rows of quack grass growth the following spring. Quack grass growth was visually noted to be reduced in strips, however quadrat data did not support this observation.

For dalapon it may also be concluded that complete coverage is necessary and that perhaps translocation to sister shoots of quack grass on the same rhizome does not occur.

Mid and end of season quadrats indicate that dalapon was not effective in controlling quack grass throughout the season (Tables 4 and 19). Neither the dry weight of quack grass rhizomes nor the number of nodes were significantly affected by dalapon (Table 4). The fact that rhizomes were not affected would account for a reduced spring population with an increase in the population later in the season as unaffected rhizome buds broke dormancy. It would appear that dalapon provides inferior control of quack grass. Carder (1967) found that dalapon was not effective as a post-emergent herbicide for control of quack grass in birdsfoot trefoil seed production, unless tillage operations could be incorporated.

The control of quack grass with dalapon in the absence of cultivation is not likely. Hall and Parochetti (1974) concluded that a single application of dalapon will not provide 100% control of quack grass, even in conjunction with cultivation. The inclusion of cultivation as a supplement to herbicide application for post-emergent control in a solid stand of birdsfoot trefoil is not usually practiced.

Dalapon did not have any effect on birdsfoot trefoil populations in 1982 and pollen fertility of birdsfoot trefoil was not adversely affected (Table 3). It was suggested by Turkington and Franko (1980) that a pre-emergent application of 5.5 kg/ha will reduce the percent germination of the trefoil and the number of <u>Rhizobium</u> nodules produced. No data from this experiment may be used to support or deny these statements.

4. Sethoxydim

All measurements of trefoil seed yield parameters (flower counts, pollen fertility, seed yield, and seed germinability) indicate that sethoxydim up to 0.8 kg/ha did not have any deleterious affects on the seed production potential of the birdsfoot trefoil (Tables 2, 3, and 10). In two separate experiments (Tables 15 and 19), fall-spring and early spring applications of sethoxydim resulted in populations of trefoil greater than in check plots. Therefore, it appears that sethoxydim has no adverse effects on trefoil vegetative growth. Davidson et al. (1985) conclude that birdsfoot trefoil can tolerate high rates of sethoxydim over a wide range of development stages with no effect on ground cover or subsequent seed yield.

Spring and summer applications of sethoxydim at various rates and growth stages of quack grass yielded consistent results among all experiments. All applications (0.8 kg/ha) at the 3 to 4 and 5 to 6-leaf stages of quack grass caused significant stunting. While end of season quadrat data indicated that the total population of quack grass in treatment plots was not different from check plots, there were definite differences in populations of mature headed quack grass between treatment and check plots. Although the stunted quack grass generally did not head out and develop seed, populations of young quack grass resulting from rhizome buds did not differ among treatment and check plots. Wyse et al. (1985) similarly conclude that while sethoxydim stops seed head formation, the quack grass is not eradicated. Quack grass rhizomes were generally unaffected by sethoxydim, therefore it follows that late summer populations of new growth of quack grass would not be affected. Westra and Wyse (1977) state that seed production is not as important as vegetative reproduction in the maintenance of a quack grass stand. It therefore appears that spring and summer applications of sethoxydim, while stunting the quack grass, provides a limited and insignificant control of quack grass. The results here correspond with those of MacDonald (1981) in that spring applied sethoxydim (up to 0.8 kg/ha at the 3 to 6-leaf stage) provided some initial control, but notable regrowth occurred later in the season. As well, Ivany (1982) found there was little difference in level of control between applications at the 3-leaf or 6-leaf stage of growth.

Poor control of quack grass, especially in the second year of study may partially be due to the drought conditions which were experienced. Watson (1982) found that dry weather resulted in poor quack grass control with sethoxydim. McAvoy (1982) explained that optimum conditions for control with sethoxydim occur with good soil moisture, high temperatures, and high humidity. If such conditions do not prevail, control will be slower and may not reach the maximum level. However, a fall-spring split application of sethoxydim (Tables 18, 19 and 20) appears to be quite effective in controlling quack grass. Spring and end of season quadrat data indicate that the total population of quack grass had been reduced. It appears that a fall application incorporated with a spring application will provide reliable control of quack grass. This conclusion is consistent with Ivany (1982) who found that fall applied sethoxydim at the 3 to 4-leaf stage of quack grass provided a measurable level of control the following season.

5. Fluazifop-butyl

Over the two years of study, all measurements of trefoil seed yield parameters (flower counts, pollen fertility, seed yield, and seed germinability) indicate that fluazifop-butyl did not have any deleterious affects on these parameters (Tables 2, 3 and 10). With respect to potential effects on the vegetative growth of birdsfoot trefoil, there were no instances throughout any of the experiments where trefoil populations were decreased. It may therefore be concluded that applications up to 0.6 kg/ha of fluazifop-butyl do not adversely affect the vegetative growth or seed production potential of birdsfoot trefoil.

The effects of spring-summer applied fluazifop-butyl on quack grass were consistent among the experiments over the two years of study. All applications at the 3 to 4 and 5 to 6-leaf stage of quack grass, while not eradicating the target weed, caused severe stunting. Tables 5, 12, 16 and 20 all indicate that at the end of season, the quack grass vegetative growth which had directly been sprayed was stunted and did not head out. No significant effects were caused to new growth of quack grass from rhizome buds during the latter part of the growing season. The conclusion from these data is that fluazifop-butyl up to 0.6 kg/ha applied to quack grass at the 3 to 6-leaf stage is rather ineffective in controlling the weed. Incomplete control in the form of stunting is noticed, but this is apparently a short term effect, and populations of new growth of quack grass at the end of the season are not different from check plots. The fact that significant regrowth occurred would suggest that fluazifop-butyl did not adversely affect the quack grass rhizomes. The data in Tables 4 and 17 are consistent and indicate that while the dry weight of the rhizomes was reduced in plots receiving 0.6 kg/ha of fluazifop-butyl at the 3 to 4-leaf stage, the number of nodes was not. This apparently is an insignificant effect as regrowth in these plots was equal to check plots at the end of the season. The observed increased activity of fluazifop-butyl when applied to early growth stages of quack grass is consistent with contemporary research. Kells et al. (1984) note that radioautographs of treated plants suggest distribution of the herbicide was greater at the 2 to 3-leaf stage than at the 5 to 6-leaf stage. This mild effect on the rhizomes is explained by Ready (1982) who stated that fluazifop-butyl is a systemic herbicide which translocates in both the xylem and phloem. When applied as a post-emergent, it translocates into the roots and rhizomes of perennial grasses. While these results correspond with those of Watson (1982) and Jensen (1981), there is a contradiction with Wagner and Letendre (1982) who state that fluazifop-butyl at 0.5 kg/ha resulted in excellent control when applied at the 4 to 5-leaf stage. We can present no explanation for this discrepancy.

Results from a fall application (0.6 kg/ha), followed by a spring application (0.6 kg/ha) at the 3 to 4-leaf stage were superior to single spring-summer applications. The data in

Tables 19 and 20 indicate that the fall-spring split applications significantly reduced populations of quack grass. Not only were populations of native quack grass reduced, but the regrowth of quack grass was significantly reduced at the end of the growth season.

It is concluded that spring-summer applications up to 0.6 kg/ha provide an insignificant control of quack grass. However, a fall-spring successive application of 0.6 kg/ha will result in a measureable level of quack grass control.

6. Haloxyfop-methyl

Haloxyfop-methyl, the most recently developed and least known experimental herbicide, was incorporated in the second year of study (1982) to provide preliminary data for future trials.

Application rates from 0.15 to 0.5 kg/ha all reduced the total percent sward of quack grass at the end of the season (Table 22), with a corresponding increase in the percent sward of trefoil. Similar to sethoxydim and fluazifop-butyl, some quack grass was stunted and very little quack grass in treatment plots reached the heading stage. Ryder (1982) found that in areas where drought stress is not a problem, perennial grasses may be controlled using haloxyfop-methyl at 0.25 to 0.50 kg/ha, however, it is stated that it might be necessary to use higher rates under dry conditions.

Data in Tables 20 and 23 indicate that haloxyfop-methyl controlled new growth of quack grass at the end of the season. The fact that new growth was controlled, is an indicator that translocation to quack grass rhizomes of the herbicide may have occurred. Stollenberg and Wyse (1986) conclude that translocation of ^{14}C-haloxyfop into the crown region of quack grass from lower leaves is significantly reduced at the 8-leaf stage compared to the 4-leaf stage, whereas translocation into rhizome tissue is not affected by growth stage.

A measureable level of quack grass control occurring from relatively low application rates of herbicide during a season of drought stress is certainly a preliminary indicator that haloxyfop-methyl has potential as a quack grass herbicide. Vegetative growth of birdsfoot trefoil was not adversely affected by haloxyfop-methyl, therefore, further testing of the efficacy of this product in controlling quack grass in birdsfoot trefoil is recommended.

7. <u>Relative performance of treatments</u>

Overall, the superior herbicide treatment was a rope-wick application of glyphosate. In the 1982 season where early summer dry months prevented other treatments from effectively controlling quack grass, glyphosate provided good control.

The results obtained in 1982 may be more significant due to the fact that better coverage was obtained with the new wick system, and the two directional applications. Although early 1982 spring data does not indicate a residual effect from the previous year, this may not be conclusive. The better coverage in 1982, which reduced both the rhizome node number and weight, the only herbicide tested to cause such an effect, may have provided a residual effect in the spring of 1983. Early applications tended to be more effective due to better translocation of the herbicide. These findings are consistent with those of Rioux et al. (1974) where they found that when a shoot was treated at the 2-leaf stage with 0.11 kg/ha of glyphosate, leaf production was inhibited on other shoots supported by the same rhizome. But when the shoots were at the 4 or 5-leaf stage, leaf production on shoots supported by the same rhizome was as high as on the control. Early applications offer the advantage of better clearance height between the top of the trefoil and the top of the quack grass.

Considering the data from this experiment, and that of Carder (1967) where it is stated that dalapon may reduce seed yield when applied to actively growing trefoil and control is unsatisfactory when treatments are made without tillage, dalapon is not recommended as an effective post-emergent herbicide for control of quack grass in birdsfoot trefoil seed production.

Only 1982 results from pronamide may be compared with other treatments, as 1981 data were invalid due to application error. Pronamide applied in the fall of 1981 did not affect rhizome weight or node number at the end of the following growing season. Therefore pronamide was not as effective as glyphosate, or sethoxydim and fluazifop-butyl. Spring applied pronamide was not an effective treatment. Although pronamide proved to be measureably effective in contolling quack grass foliar growth the following season, it is far from being an effective treatment. Hall and Parochetti (1974) similarly concluded that pronamide (similar application rates to this experiment) provided inferior quack grass control.

Of the two newer herbicides, sethoxydim and fluazifop-butyl, sethoxydim appears to be slightly superior though still not totally effective. Spring applied sethoxydim was more effective in reducing quack grass rhizome weight than spring applied fluazifop-butyl (Table 17). Sethoxydim, especially in 1982 where dry weather prevailed, was superior to fluazifop-butyl in reducing quack grass populations at the end of the season.

Fall applications of sethoxydim were quite effective in reducing early spring populations of quack grass, whereas applications of fluazifop-butyl were less effective.

Both herbicides were similar in that application at the 4 to 5-leaf stage of quack grass were not effective, and in both cases, successive applications at the 3 to 4 and 5 to 6-leaf stages were not superior to a single heavier application at the 3 to 4-leaf stage. Quack grass control from spring applications of both sethoxydim and fluazifop-butyl was limited to severe stunting of the target weed with considerable regrowth occurring later in the season (Table 15). Fall-spring successive applications of both herbicides resulted in a measureable level of control, with a reduction in the regrowth of the quack grass at the end of the season. Similarly, Hicks and Jordan (1984) report fluazifop and sethoxydim at 1.1 or 2.2 kg/ha provided excellent initial control, however, significant regrowth from rhizomes occurred after 42 days.

Other research with similar treatments yielded results similar to the present experiment. Brown and Swanton (1982) found that both sethoxydim and fluazifop-butyl gave inferior control when compared to glyphosate. Jensen (1981) found that after treatment, injury symptoms on quack grass induced by fluazifop-butyl progressed faster than those of sethoxydim. However, both resulted in inferior control when compared to glyphosate.

In the present study, neither the vegetative growth nor the seed production potential of birdsfoot trefoil were adversely affected by any of the selective herbicides (dalapon, pronamide, sethoxydim and fluazifop-butyl). Where the wick apparatus applying glyphosate directly contacted the trefoil, necrosis occurred. While providing far superior control of quack grass, there is a potential for some trefoil to be killed due to dripping of glyphosate or improper wick height adjustment.

Haloxyfop-methyl was not tested as extensively as the other herbicides in this study, therefore, conclusions with respect to its relative performance cannot be made. Preliminary results indicate that this herbicide may be more effective than pronamide, dalapon, sethoxydim, or fluazifop-butyl. Watson (1982) found haloxyfop-methyl at 0.5 kg/ha to be superior to all applications of sethoxydim and fluazifop-butyl in controlling quack grass where cultivation was not done.

The results of the present experiment indicate that the order of effectiveness (best to least effective) of the test herbicides with respect to quack grass control and effect on quack grass is: (1) rope-wick applied glyphosate at the 3 to 4-leaf stage of quack grass; (2) fall/early spring sethoxydim (0.8 + 0.8 kg/ha) and fall/early spring fluazifop-butyl (0.6 + 0.6 kg/ha); (3) spring applied sethoxydim, 0.8 kg/ha at the 3 to 4-leaf stage; (4) spring applied fluazifop-butyl, 0.6 kg/ha at the 3 to 4-leaf stage; and (5) all other applications of dalapon, pronamide, sethoxydim, and fluazifop-butyl.

CHAPTER VI

CONCLUSIONS

The objective of this study was to compare various post-emergent herbicides for the control of quack grass in birdsfoot trefoil seed production plots. Obviously, seed yield and seed yield parameters were important comparative measurements among treatment plots. In the first year, 1981, there were no significant differences with respect to seed yield parameters among treatments. In the second year, 1982, a boron deficiency (MacQuarrie et al. 1983) enhanced by drought conditions resulted in abortion of trefoil flowers, thus, very little seed was produced, and accurate comparisons of seed yield could not be made. While seed yield comparisons were not possible, potential adverse effects on the trefoil, as caused by the herbicides, were investigated. Measurements of trefoil populations, fertility of trefoil pollen, germinability of seed, and flower counts indicate that none of these parameters were affected by any of the herbicide treatments.

As there were certain inconsistencies with the birdsfoot trefoil populations (i.e., boron deficiency, poor winter survival, and poor seedling establishment) final birdsfoot trefoil population data were at times non-conclusive. However, more precise conclusions can be drawn on the control of quack grass populations.

In some of the preceding tables, there are large non significant differences in parameters measured (e.g., quack grass rhizome weight and node number, percent sward, and percent cover of population). In many cases these differences are not significant, as there is a very large coefficient of variation involved in these measurements. In the first year of study (1981), coefficients of variation in quack grass rhizome measurements were consistently high due to the fact that only a single excavation was taken from each plot. These were permanent plots and it was felt that further excavations would damage the plots. The second year of study (1982), two excavations were taken from each plot and coefficients of variation were considerably reduced. Apart from rhizome measurements, large coefficients of variation occurred in percent cover and percent sward calculations. This is most likely a factor of the manner in which the point quadrat frame was randomly placed within each plot. Rather than randomly placing the frame in the plot for each successive series of points, as was done in this experiment, Goodall (1952) mentioned the superiority of successive observations at fixed points (comparable with permanent quadrats) over successive series of independently randomized points. The random method of placing the frame within plots coupled with the fact that the population of quack grass was naturally occurring and varied somewhat over experimental areas would at least partly account for the high coefficients of variation.

Although sampling methods could have been improved, and some coefficients of variation are somewhat high, definite trends and conclusions can be drawn.

Of all the treatments tested, rope-wick applied glyphosate at an early growth stage of quack grass (2 to 4 leaves) resulted in the most effective control of the weed. No significant differences were noted in glyphosate concentrations (1:1, 1:2, and 1:3, glyphosate:water). Spring applications were effective in reducing both rhizome node number and dry weight the following fall. Although the quack grass was drought stressed in 1982 and other herbicidal treatments resulted in poor control, the selectively applied glyphosate was apparently translocated and resulted in excellent control. An application of glyphosate in one direction immediately followed by a second application in the opposite direction is recommended.

Compared to glyphosate, sethoxydim and fluazifop-butyl provided inferior quack grass control. Sethoxydim and fluazifop-butyl were approximately equal in control with the former showing a slight advantage in certain applications. Similarities were noticed in the reaction of quack grass to both herbicides. Spring applications were rather slow in affecting the quack grass, in most instances control consisted of a stunting effect in direct treated plants with no effect on new growth appearing later in the season. In the drought stressed 1982 season, the stunting effects of both sethoxydim and fluazifop-butyl were very slow in appearing. When quack grass was not stressed, fall/spring successive applications were quite effective in controlling the weed. This would suggest that for a superior level of translocation and control, sethoxydim and fluazifop-butyl should be applied to actively growing quack grass.

Although it cannot be concluded here, perhaps superior control would be obtained in a cropping system where cultivation can be incorporated, and where the crop plant is more aggressive than birdsfoot trefoil. An aggressive crop plant could possibly outcompete the stunted quack grass after treatment with sethoxydim or fluazifop-butyl.

Pronamide was less effective than sethoxydim, fluazifop-butyl, or glyphosate. Whereas fair control was observed in the early spring from fall applications, regrowth later on in the season was not reduced. The observance of distinct rows of quack grass in the spring suggests that less than complete coverage was obtained. Perhaps better control may have been obtained if plots had received complete coverage of the herbicide, thus, further comparative studies may be of interest. Spring applications of pronamide may in fact result in increased quack grass populations at the end of the season. This may be due to the prevention of quack grass rhizome buds from entering a natural spring dormancy.

Dalapon was the least effective tested herbicide for controlling quack grass. All results indicate dalapon is completely ineffective in controlling quack grass when cultivation is not possible.

No conclusions with respect to the relative activity of haloxyfop-methyl on quack grass can be drawn. The preliminary data obtained here suggests that haloxyfop-methyl may provide effective quack grass control. The results obtained with low application rates indicate haloxyfop-methyl may be more effective than either sethoxydim or fluazifop-butyl, especially during drought stressed growth periods. In a recent comparative test, Hicks and Jordan (1984) found that haloxyfop-methyl had the highest unit activity on quack grass relative to both sethoxydim and fluazifop-butyl. Further comparative testing with this herbicide is necessary including fall applications and spring applications to various leaf stages of the quack grass. Quack grass rhizome population data should also be obtained.

While it was not possible to assess the efficacy of the herbicidal treatments on quack grass in conjunction with cultivation, further experimentation in this area would be of interest. Cultivation would be possible during the establishment of trefoil and may enhance the effects of the treatments. Quack grass rhizome excavations late in the season yielded interesting data and provided a definite indication of the superior activity of glyphosate. However, it is suggested that excavations at regular intervals during the growing season where weight, node number, and node viability of rhizomes are measured would be of interest. While it was concluded that a two-way rope-wick application of glyphosate controlled both foliar and rhizome growth of quack grass, further data with respect to residual control the year following application is suggested. The lowest concentration of glyphosate tested was 1:3 glyphosate to water, and this concentration was equally effective as 1:1 glyphosate to water. Considering the economics of this method, further dilutions of glyphosate:water in conjunction with surfactants should be evaluated.

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APPENDIX

TABLE 1. THE EFFECTS OF SINGLE APPLICATIONS OF SETHOXYDIM, FLUAZIFOP-BUTYL, AND ROPE-WICK GLYPHOSATE ON QUACK GRASS POPULATION (1981).

FINAL PERCENT COVER OF TOTAL QUACK GRASS POPULATIONS.

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	15	1.680				49.3
BLOCK	3	0.154	0.051	0.38	0.769	
TREAT	3	0.314	0.104	0.78	0.536	
ERROR	9	1.212	0.135			

FINAL PERCENT SWARD OF TOTAL QUACKGRASS POPULATIONS.

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	15	0.237				48.9
BLOCK	3	0.003	0.001	0.08	0.968	
TREAT	3	0.128	0.043	3.58	0.059	
ERROR	9	0.107	0.012			

FINAL PERCENT CONTRIBUTION OF QUACK GRASS TO TOTAL SPECIES BIOMASS.

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	23	0.251				51.0
BLOCK	3	0.033	0.011	1.51	0.253	
TREAT	5	0.107	0.021	2.90	0.050	
ERROR	15	0.111	0.007			

TOTAL NODE NUMBER OF RHIZOME EXCAVATIONS.

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	23	12907.83				43.7
BLOCK	3	2540.17	846.723	1.71	0.208	
TREAT	5	2944.33	588.866	1.19	0.360	
ERROR	15	7423.33	494.889			

DRY WEIGHT OF RHIZOME EXCAVATIONS.

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	23	94.41				55.2
BLOCK	3	13.90	4.633	1.17	0.352	
TREAT	5	21.31	4.262	1.08	0.410	
ERROR	15	59.20	3.947			

FINAL PERCENT SWARD OF HEADED QUACK GRASS.

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	15	0.0070				90.1
BLOCK	3	0.0005	0.0001	1.23	0.3541	
TREAT	3	0.0053	0.0018	13.19	0.0012	
ERROR	9	0.0012	0.0001			

FINAL PERCENT COVER OF HEADED QUACK GRASS.

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	15	0.053				77.0
BLOCK	3	0.004	0.0013	1.50	0.2797	
TREAT	3	0.041	0.0140	16.49		
ERROR	9	0.008	0.0011			

FINAL PERCENT SWARD OF NEW GROWTH OF QUACK GRASS.

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	15	0.242				55.1
BLOCK	3	0.007	0.002	0.16	0.921	
TREAT	3	0.105	0.035	2.41	0.134	
ERROR	9	0.131	0.014			

FINAL PERCENT COVER OF NEW GROWTH OF QUACK GRASS.

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	15	1.379				46.8
BLOCK	3	0.233	0.078	0.82	0.514	
TREAT	3	0.297	0.099	1.05	0.417	
ERROR	9	0.850	0.094			

TABLE 2. A COMPARISON OF THE EFFECTS OF SINGLE APPLICATIONS OF SETHOXYDIM, FLUAZIFOP-BUTYL, AND ROPE-WICK GLYPHOSATE ON BIRDSFOOT TREFOIL POPULATIONS (1981).

BIRDSFOOT TREFOIL FLOWER COUNTS (#/m²).

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	23	165571.95				108.9
BLOCK	3	2296.46	765.487	0.25	0.8600	
TREAT	5	117381.71	234.763	7.57	0.0009	
ERROR	15	45893.79	3059.586			

SEED YIELD OF BIRDSFOOT TREFOIL (gm/4m²).

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	21	41.31				45.4
BLOCK	3	20.80	6.933	6.98	0.0048	
TREAT	5	7.60	1.520	1.53	0.2473	
ERROR	13	12.91	0.993			

PERCENT GERMINATION OF BIRDSFOOT TREFOIL SEED.

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	21	1323.82				23.6
BLOCK	3	163.78	54.593	0.71	0.561	
TREAT	5	163.68	32.716	0.43	0.822	
ERROR	13	996.45	76.650			

SEEDING VIGOUR OF GERMINATED BIRDSFOOT TREFOIL SEED.

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	21	1334.95				26.4
BLOCK	3	227.69	75.897	1.14	0.370	
TREAT	5	240.0	48.000	0.72	0.620	
ERROR	13	867.26	66.712			

FINAL PERCENT COVER OF BIRDSFOOT TREFOIL POPULATIONS.

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	15	2.897				42.1
BLOCK	3	0.390	0.130	0.51	0.683	
TREAT	3	0.226	0.075	0.30	0.827	
ERROR	9	2.281	0.253			

FINAL PERCENT SWARD OF BIRDSFOOT TREFOIL POPULATIONS.

SOURCE	DF	SS	MS	F	PR>F	CC
TOTAL	15	0.509				21.6
BLOCK	3	0.010	0.003	0.11	0.954	
TREAT	3	0.212	0.071	2.23	0.154	
ERROR	9	0.286	0.032			

END OF SEASON PERCENT CONTRIBUTION OF BIRDSFOOT TREFOIL TO TOTAL SPECIES BIOMASS.

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	23	0.610				14.0
BLOCK	3	0.075	0.025	1.39	0.284	
TREAT	5	0.266	0.053	2.96	0.047	
ERROR	15	0.269	0.018			

TABLE 3. POPULATIONS OF BIRDSFOOT TREFOIL AFTER APPLICATIONS OF SETHOXYDIM, FLUAZIFOP-BUTYL, GLYPHOSATE, FALL DALAPON AND FALL PRONAMIDE (1982).

INITIAL PERCENT COVER OF BIRDSFOOT TREFOIL.

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	23	0.077				144.2
BLOCK	3	0.019	0.006	2.14	0.138	
TREAT	5	0.014	0.003	0.94	0.481	
ERROR	15	0.044	0.003			

INITIAL PERCENT SWARD OF BIRDSFOOT TREFOIL.

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	23	0.052				148.6
BLOCK	3	0.012	0.004	2.23	0.127	
TREAT	5	0.013	0.003	1.37	0.291	
ERROR	15	0.027	0.002			

MID-SEASON PERCENT COVER OF BIRDSFOOT TREFOIL.

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	23	0.995				46.0
BLOCK	3	0.026	0.009	0.32	0.808	
TREAT	5	0.560	0.112	4.12	0.015	
ERROR	15	0.408	0.027			

MID-SEASON PERCENT SWARD OF BIRDSFOOT TREFOIL.

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	23	1.218				77.3
BLOCK	3	0.063	0.021	0.32	0.813	
TREAT	5	0.161	0.032	0.49	0.781	
ERROR	15	0.993	0.066			

FINAL PERCENT COVER OF BIRDSFOOT TREFOIL.

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	23	2.979				28.4
BLOCK	3	0.401	0.134	2.46	0.103	
TREAT	5	1.763	0.353	6.49	0.002	
ERROR	15	0.816	0.054			

FINAL PERCENT SWARD OF BIRDSFOOT TREFOIL.

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	23	0.792				24.9
BLOCK	3	0.044	0.015	1.37	0.2894	
TREAT	5	0.588	0.118	10.98	0.0001	
ERROR	15	0.161	0.011			

BIRDSFOOT TREFOIL POLLEN FERTILITY.

SOURCE	DF	SS	MS	F	PR>F	CC
TOTAL	23	0.509				14.5
BLOCK	3	0.010	0.003	0.11	0.954	
TREAT	5	0.212	0.071	2.23	0.154	
ERROR	15	0.286	0.032			

TABLE 4. THE AFFECTS OF SETHOXYDIM, FLUAZIFOP-BUTYL, ROPE-WICK GLYPHOSATE, DALAPON AND PRONAMIDE ON QUACK GRASS POPULATIONS (1982).

INITIAL PERCENT COVER OF QUACK GRASS.

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	23	1.598				21.6
BLOCK	3	0.048	0.016	0.73	0.5503	
TREAT	5	1.217	0.243	11.00	0.0001	
ERROR	15	0.332	0.022			

INITIAL PERCENT SWARD OF QUACK GRASS.

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	23	1.334				23.9
BLOCK	3	0.097	0.032	1.24	0.331	
TREAT	5	0.846	0.169	6.48	0.002	
ERROR	15	0.392	0.026			

MID-SEASON PERCENT COVER OF QUACK GRASS.

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	23	2.125				39.1
BLOCK	3	0.184	0.061	1.03	0.408	
TREAT	5	1.049	0.210	3.53	0.026	
ERROR	15	0.892	0.059			

MID-SEASON PERCENT SWARD OF QUACK GRASS.

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	23	1.113				50.0
BLOCK	3	0.005	0.002	0.03	0.992	
TREAT	5	0.286	0.057	1.05	0.427	
ERROR	15	0.821	0.055			

FINAL PERCENT COVER OF TOTAL QUACK GRASS.

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	23	2.624				19.2
BLOCK	3	0.225	0.075	1.66	0.2173	
TREAT	5	1.723	0.345	7.65	0.0009	
ERROR	15	0.676	0.045			

FINAL PERCENT SWARD OF TOTAL QUACK GRASS.

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	23	1.277				21.1
BLOCK	3	0.073	0.024	1.37	0.2891	
TREAT	5	0.939	0.188	10.64	0.0002	
ERROR	15	0.265	0.018			

QUACK GRASS RHIZOME NODE NUMBER PER EXCAVATION.

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	23	84252.63				30.0
BLOCK	3	17437.12	5812.373	2.79	0.076	
TREAT	5	35591.88	7118.376	3.42	0.029	
ERROR	15	31223.62	2051.575			

TOTAL QUACK GRASS RHIZOME BIOMASS PER EXCAVATION.

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	23	1583.34				31.1
BLOCK	3	169.35	56.450	1.63	0.2297	
TREAT	5	895.70	179.140	5.18	0.0058	
ERROR	15	518.28	34.552			

TABLE 5. GROWTH TYPES OF QUACK GRASS PRESENT AT THE END OF A SEASON AFTER APPLICATIONS OF SETHOXYDIM, FLUAZIFOP-BUTYL, GLYPHOSATE, DALAPON, AND PRONAMIDE (1982).

FINAL PERCENT COVER OF HEADED QUACK GRASS.

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	23	0.891				64.7
BLOCK	3	0.028	0.009	1.46	0.2663	
TREAT	5	0.768	0.154	24.23	0.0001	
ERROR	15	0.095	0.006			

FINAL PERCENT SWARD OF HEADED QUACK GRASS.

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	23	0.165				81.6
BLOCK	3	0.006	0.002	1.17	0.3552	
TREAT	5	0.134	0.027	16.24	0.0001	
ERROR	15	0.025	0.002			

FINAL PERCENT COVER OF STUNTED QUACK GRASS.

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	23	0.711				91.7
BLOCK	3	0.091	0.030	2.52	0.0975	
TREAT	5	0.439	0.088	7.30	0.0012	
ERROR	15	0.180	0.012			

FINAL PERCENT SWARD OF STUNTED QUACK GRASS.

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	23	0.123				92.2
BLOCK	3	0.019	0.006	3.08	0.0594	
TREAT	5	0.072	0.014	6.92	0.0016	
ERROR	15	0.031	0.002			

FINAL PERCENT COVER OF NEW GROWTH OF QUACK GRASS.

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	23	2.098				23.0
BLOCK	3	0.044	0.015	0.29	0.8353	
TREAT	5	1.281	0.256	4.98	0.0069	
ERROR	15	0.773	0.052			

FINAL PERCENT SWARD OF NEW GROWTH OF QUACK GRASS.

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	23	0.693				23.5
BLOCK	3	0.036	0.012	0.85	0.4874	
TREAT	5	0.448	0.090	6.41	0.0022	
ERROR	15	0.210	0.014			

TABLE 6. QUACK GRASS POPULATION AT THE END OF SEASON RESULTING FROM THREE DILUTIONS OF GLYPHOSATE APPLIED BY A ROPE-WICK TO THE THREE GROWTH STAGES OF QUACK GRASS (1981).

FINAL PERCENT COVER OF TOTAL QUACK GRASS POPULATION.

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	39	1.834				63.7
BLOCK	3	0.205	0.068	1.58	0.2179	
TREAT	9	0.457	0.051	1.17	0.3530	
ERROR	27	1.172	0.043			

FINAL PERCENT SWARD OF TOTAL QUACK GRASS POPULATION.

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	39	0.141				46.8
BLOCK	3	0.019	0.006	2.33	0.0970	
TREAT	9	0.047	0.005	1.87	0.1015	
ERROR	27	0.075	0.003			

QUACK GRASS RHIZOME NODE NUMBER (#/.5m²).

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	39	16329.6				102.8
BLOCK	3	469.0	156.333	0.36	0.7856	
TREAT	9	3986.1	442.900	1.01	0.4585	
ERROR	27	11874.5	439.796			

QUACK GRASS RHIZOME BIOMASS WEIGHT (gm/.5m²).

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	39	86.87				112.8
BLOCK	3	8.56	2.853	1.34	0.2836	
TREAT	9	20.61	2.290	1.07	0.4140	
ERROR	27	57.70	2.137			

TABLE 7. BIRDSFOOT TREFOIL POPULATION RESULTING FROM THREE DILUTIONS OF GLYPHOSATE APPLIED BY ROPE-WICK TO THREE GROWTH STAGES OF QUACK GRASS (1981).

FINAL PERCENT COVER OF BIRDSFOOT TREFOIL.

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	39	1.449				12.6
BLOCK	3	0.284	0.095	2.82	0.0578	
TREAT	9	0.026	0.003	0.85	0.5801	
ERROR	27	0.908	0.034			

FINAL PERCENT SWARD OF BIRDSFOOT TREFOIL.

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	39	1.045				15.0
BLOCK	3	0.069	0.023	0.97	0.4202	
TREAT	9	0.331	0.037	1.54	0.1834	
ERROR	27	0.644	0.024			

BIRDSFOOT TREFOIL FLOWER COUNTS.

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	39	280469.9				56.5
BLOCK	3	22251.5	7417.167	1.25	0.3120	
TREAT	9	97691.9	10854.656	1.83	0.1094	
ERROR	27	160526.5	5945.426			

BIRDSFOOT TREFOIL POD NUMBER (50% BLOOM).

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	39	56206.9				54.5
BLOCK	3	3479.7	1159.900	0.98	0.4157	
TREAT	9	20846.2	2316.244	1.96	0.0851	
ERROR	27	31881.1	1180.782			

BIRDSFOOT TREFOIL SEED YIELD.

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	39	4795.1				55.9
BLOCK	3	527.8	175.993	1.78	0.1749	
TREAT	9	1597.5	177.500	1.80	0.1157	
ERROR	27	2669.7	98.878			

PERCENT GERMINATION OF BIRDSFOOT TREFOIL SEED.

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	39	3878.4				20.2
BLOCK	3	342.6	114.200	1.46	0.2465	
TREAT	9	1429.4	158.822	2.04	0.0742	
ERROR	27	2106.4	78.015			

SEEDLING VIGOUR OF GERMINATED BIRDSFOOT TREFOIL SEED.

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	39	0.514				26.9
BLOCK	3	0.031	0.010	0.70	0.5609	
TREAT	9	0.086	0.010	0.65	0.7437	
ERROR	27	0.397	0.015			

FINAL PERCENT CONTRIBUTION OF BIRDSFOOT TREFOIL TO TOTAL SPECIES BIOMASS.

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	39	1.926				16.9
BLOCK	3	0.087	0.029	0.72	0.5468	
TREAT	9	0.761	0.085	2.12	0.0638	
ERROR	27	1.078	0.040			

TABLE 8. INITIAL AND FINAL POPULATIONS OF QUACK GRASS AND FINAL POPULATIONS OF BIRDSFOOT TREFOIL RESULTING FROM THREE DILUTIONS OF GLYPHOSATE ROPE-WICK APPLIED TO THREE GROWTH STAGES OF QUACK GRASS (1982).

INITIAL PERCENT COVER OF QUACK GRASS.

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	39	2.576				40.5
BLOCK	3	0.340	0.113	1.70	0.1911	
TREAT	9	0.430	0.048	0.71	0.6912	
ERROR	27	1.805	0.036			

INITIAL PERCENT SWARD OF QUACK GRASS.

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	39	1.924				46.2
BLOCK	3	0.259	0.086	1.74	0.1819	
TREAT	9	0.327	0.036	0.73	0.6757	
ERROR	27	1.338	0.050			

FINAL PERCENT COVER OF TOTAL QUACK GRASS POPULATION.

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	39	3.465				77.3
BLOCK	3	0.018	0.006	0.31	0.8166	
TREAT	9	0.715	0.079	10.18	0.0001	
ERROR	27	0.783	0.030			

FINAL PERCENT SWARD OF TOTAL QUACK GRASS POPULATION.

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	39	0.983				98.9
BLOCK	3	0.018	0.006	0.65	0.5913	
TREAT	9	0.715	0.079	8.56	0.0001	
ERROR	27	0.250	0.009			

FINAL PERCENT COVER OF BIRDSFOOT TREFOIL.

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	39	3.349				22.5
BLOCK	3	0.034	0.011	0.13	0.9409	
TREAT	9	0.962	0.107	1.23	0.3206	
ERROR	27	2.353	0.087			

FINAL PERCENT SWARD OF BIRDSFOOT TREFOIL.

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	39	3.016				24.4
BLOCK	3	0.122	0.041	0.79	0.5106	
TREAT	9	1.504	0.167	3.24	0.0085	
ERROR	27	1.390	0.052			

TABLE 9. THE EFFECTS OF THREE DILUTIONS OF GLYPHOSATE ROPE-WICK APPLIED TO THREE GROWTH STAGES OF QUACK GRASS ON RESULTING QUACK GRASS, GROWTH STAGES AND RHIZOME BIOMASS AT THE END OF SEASON (1982).

FINAL PERCENT COVER OF HEADED QUACK GRASS.

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	39	0.896				126.7
BLOCK	3	0.007	0.002	0.23	0.8760	
TREAT	9	0.604	0.067	6.35	0.0001	
ERROR	27	0.285	0.011			

FINAL PERCENT SWARD OF HEADED QUACK GRASS.

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	39	0.106				131.6
BLOCK	3	0.001	0.003	0.24	0.8680	
TREAT	9	0.070	0.008	5.82	0.0002	
ERROR	27	0.036	0.001			

FINAL PERCENT COVER OF NEW GROWTH OF QUACK GRASS.

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	39	2.336				85.3
BLOCK	3	0.094	0.031	1.46	0.2482	
TREAT	9	1.661	0.185	8.56	0.0001	
ERROR	27	0.581	0.022			

FINAL PERCENT SWARD OF NEW GROWTH OF QUACK GRASS.

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	39	0.461				101.0
BLOCK	3	0.019	0.006	1.29	0.2971	
TREAT	9	0.310	0.034	7.05	0.0001	
ERROR	27	0.132	0.005			

QUACK GRASS RHIZOME NODE NUMBER (#/.5m²).

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	39	53873.8				76.4
BLOCK	3	1000.9	333.644	0.58	0.6357	
TREAT	9	37319.0	4146.556	7.20	0.0001	
ERROR	27	15553.9	576.070			

QUACK GRASS RHIZOME BIOMASS (gm/.5m²).

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	39	614.89				104.0
BLOCK	3	24.38	8.127	0.99	0.4102	
TREAT	9	369.97	41.108	5.03	0.0005	
ERROR	27	220.55	8.168			

TABLE 10. THE EFFECTS OF EARLY, LATE, AND SPLIT APPLICATIONS OF SETHOXYDIM AND FLUAZIFOP-BUTYL ON LATE SEASON QUACK GRASS RHIZOME BIOMASS AND BIRDSFOOT TREFOIL SEED YIELD COMPONENTS (1981).

QUACK GRASS RHIZOME NODE NUMBER (#/.5m²).

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	27	10826.65				92.3
BLOCK	3	211.74	70.158	0.11	0.9502	
TREAT	6	1378.17	229.695	0.32	0.9334	
ERROR	18	9236.75	615.781			

QUACK GRASS RHIZOME BIOMASS (gms/.5m²).

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	27	41993.17				223.7
BLOCK	3	4697.70	1565.900	0.93	0.4505	
TREAT	6	9064.00	1510.667	1.12	0.3988	
ERROR	18	28281.48	1568.416			

BIRDSFOOT TREFOIL FLOWER COUNTS (#/.5m²).

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	27	19634.68				36.6
BLOCK	3	1011.82	337.273	0.64	0.5977	
TREAT	6	9170.93	1528.488	2.91	0.0365	
ERROR	18	9451.93	525.107			

BIRDSFOOT TREFOIL POD COUNTS (50% BLOOM) (#/.5m²).

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	27	10685.86				59.4
BLOCK	3	1[illegible]79.57	559.857	2.55	0.0880	
TREAT	6	5053.86	842.310	3.84	0.0122	
ERROR	18	3952.43	219.579			

BIRDSFOOT TREFOIL SEED YIELD (gm/.4m²).

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	27	6916.51				32.6
BLOCK	3	1384.56	461.520	2.59	0.0816	
TREAT	6	2326.53	387.755	2.18	0.0938	
ERROR	18	3205.42	178.079			

PERCENT GERMINATION OF BIRDSFOOT TREFOIL SEED.

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	27	3708.96				29.1
BLOCK	3	229.25	76.427	0.43	0.7357	
TREAT	6	262.71	43.785	0.24	0.9551	
ERROR	18	3217.00	178.722			

SEEDLING VIGOUR OF GERMINATED BIRDSFOOT TREFOIL SEED.

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	27	2163.42				24.5
BLOCK	3	817.14	272.38	4.39	0.0174	
TREAT	6	229.43	38.238	0.62	0.7147	
ERROR	18	1116.86	62.048			

TABLE 11. THE EFFECTS OF EARLY, LATE, AND SPLIT APPLICATIONS OF SETHOXYDIM AND FLUAZIFOP-BUTYL ON POPULATION DENSITIES OF QUACK GRASS AND BIRDSFOOT TREFOIL IN A MIXED SWARD (1981).

FINAL PERCENT COVER OF TOTAL QUACK GRASS POPULATION.

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	27	0.6026				53.9
BLOCK	3	0.0743	0.025	1.23	0.3303	
TREAT	6	0.1851	0.031	1.53	0.2286	
ERROR	18	0.3432	0.020			

FINAL PERCENT SWARD OF TOTAL QUACK GRASS POPULATION.

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	27	0.2377				61.0
BLOCK	3	0.0492	0.016	3.18	0.0507	
TREAT	6	0.1009	0.017	3.26	0.0255	
ERROR	18	0.0876	0.005			

PERCENT CONTRIBUTION OF QUACK GRASS TO TOTAL SPECIES BIOMASS.

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	27	0.1503				87.9
BLOCK	3	0.0077	0.003	0.66	0.5872	
TREAT	6	0.0731	0.012	3.15	0.0272	
ERROR	18	0.0696	0.004			

FINAL PERCENT COVER OF BIRDSFOOT TREFOIL.

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	27	1.2644				12.3
BLOCK	3	0.3311	0.110	3.81	0.0296	
TREAT	6	0.4407	0.073	2.53	0.0613	
ERROR	18	0.4926	0.029			

FINAL PERCENT SWARD OF BIRDSFOOT TREFOIL.

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	27	0.5476				13.3
BLOCK	3	0.1078	0.036	2.29	0.1149	
TREAT	6	0.1732	0.029	1.84	0.1506	
ERROR	18	0.2667	0.016			

PERCENT CONTRIBUTION OF BIRDSFOOT TREFOIL TO TOTAL SPECIES BIOMASS.

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	27	0.9135				14.9
BLOCK	3	0.0475	0.016	0.50	0.6859	
TREAT	6	0.2970	0.050	1.57	0.2138	
ERROR	18	0.5688	0.032			

TABLE 12. A COMPARISON OF QUACK GRASS GROWTH TYPES PRESENT AT THE END OF SEASON AFTER EARLY, LATE, AND SPLIT APPLICATIONS OF SETHOXYDIM AND FLUAZIFOP-BUTYL (1981).

FINAL PERCENT COVER OF HEADED QUACK GRASS.

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	27	0.9116				226.3
BLOCK	3	0.0508	0.017	1.00	0.4155	
TREAT	6	0.5570	0.093	5.47	0.0023	
ERROR	18	0.3050	0.017			

FINAL PERCENT SWARD OF HEADED QUACK GRASS.

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	27	0.3234				260.8
BLOCK	3	0.0212	0.007	1.00	0.4155	
TREAT	6	0.1748	0.029	4.11	0.0090	
ERROR	18	0.1274	0.007			

FINAL PERCENT COVER OF STUNTED QUACK GRASS.

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	27	0.3062				85.1
BLOCK	3	0.0275	0.009	2.32	0.1102	
TREAT	6	0.2074	0.035	8.73	0.0002	
ERROR	18	0.0713	0.004			

FINAL PERCENT SWARD OF STUNTED QUACK GRASS.

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	27	0.0478				92.8
BLOCK	3	0.0051	0.0017	2.57	0.0861	
TREAT	6	0.0309	0.0050	7.85	0.0003	
ERROR	18	0.0118	0.0010			

FINAL PERCENT COVER OF END-OF-SEASON NEW GROWTH OF QUACK GRASS.

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	27	0.3350				58.4
BLOCK	3	0.0236	0.008	0.67	0.5840	
TREAT	6	0.0489	0.008	1.40	0.2694	
ERROR	18	0.2125	0.012			

FINAL PERCENT SWARD OF END-OF-SEASON NEW GROWTH OF QUACK GRASS.

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	27	0.0859				65.6
BLOCK	3	0.0070	0.002	0.93	0.4484	
TREAT	6	0.0336	0.006	2.22	0.0884	
ERROR	18	0.0454	0.002			

TABLE 13. AN INITIAL COMPARISON OF TREATMENT PLOTS A YEAR AFTER TREATMENT WITH SETHOXYDIM AND FLUAZIFOP-BUTYL FOR RESIDUAL CONTROL OF QUACK GRASS (1982).

INITIAL PERCENT COVER OF QUACK GRASS.

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	27	0.9917				24.6
BLOCK	3	0.0432	0.014	0.35	0.7903	
TREAT	6	0.2059	0.034	0.83	0.5607	
ERROR	18	0.7426	0.041			

INITIAL PERCENT SWARD OF QUACK GRASS.

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	27	0.8502				32.5
BLOCK	3	0.0869	0.029	0.82	0.5019	
TREAT	6	0.1241	0.021	0.58	0.7396	
ERROR	18	0.6392	0.036			

INITIAL PERCENT COVER OF BIRDSFOOT TREFOIL.

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	27	0.2527				122.0
BLOCK	3	0.0296	0.010	1.11	0.3716	
TREAT	6	0.0628	0.010	1.18	0.3623	
ERROR	18	0.1602	0.008			

INITIAL PERCENT SWARD OF BIRDSFOOT TREFOIL.

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	27	0.0694				120.6
BLOCK	3	0.0114	0.004	1.69	0.2046	
TREAT	6	0.0175	0.003	1.29	0.3099	
ERROR	18	0.0405	0.002			

INITIAL PERCENT COVER OF BROADLEAF WEEDS.

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	27	1.7419				38.5
BLOCK	3	0.1490	0.050	0.70	0.5653	
TREAT	6	0.3119	0.052	0.73	0.6311	
ERROR	18	1.2809	0.071			

INITIAL PERCENT SWARD OF BROADLEAF WEEDS.

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	27	0.6472				35.3
BLOCK	3	0.0723	0.024	1.01	0.4104	
TREAT	6	0.1461	0.024	1.02	0.4426	
ERROR	18	0.4288	0.024			

TABLE 14. A COMPARISON OF MID-SEASON SPECIES POPULATIONS AFTER EARLY, LATE, AND SPLIT APPLICATIONS OF SETHOXYDIM AND FLUAZIFOP-BUTYL (1982).

MID-SEASON PERCENT COVER OF TOTAL QUACK GRASS POPULATION.

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	27	2.5875				33.4
BLOCK	3	0.2072	0.070	1.03	0.4017	
TREAT	6	1.1764	0.196	2.93	0.0356	
ERROR	18	1.2048	0.067			

MID-SEASON PERCENT SWARD OF TOTAL QUACK GRASS POPULATION.

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	27	1.5357				31.8
BLOCK	3	0.1812	0.060	1.86	0.1721	
TREAT	6	0.7711	0.129	3.96	0.0106	
ERROR	18	0.5835	0.032			

MID-SEASON PERCENT COVER OF BIRDSFOOT TREFOIL.

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	27	0.7260				68.2
BLOCK	3	0.0719	0.024	1.02	0.4069	
TREAT	6	0.2310	0.039	1.64	0.1939	
ERROR	18	0.4230	0.024			

MID-SEASON PERCENT SWARD OF BIRDSFOOT TREFOIL.

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	27	0.4472				80.3
BLOCK	3	0.0324	0.011	0.72	0.5505	
TREAT	6	0.1461	0.024	1.63	0.1960	
ERROR	18	0.2687	0.015			

MID-SEASON PERCENT COVER OF BROADLEAF WEEDS.

SOURCE	DF	SS	MS	F	PR>F	CC
TOTAL	27	1.8538				34.2
BLOCK	3	0.6549	0.218	5.92	0.0054	
TREAT	6	0.5353	0.089	2.42	0.0682	
ERROR	18	0.6636	0.037			

MID-SEASON PERCENT SWARD OF BROADLEAF WEEDS.

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	27	0.9757				41.7
BLOCK	3	0.3197	0.107	5.26	0.0088	
TREAT	6	0.2913	0.049	2.40	0.0704	
ERROR	18	0.3647	0.020			

TABLE 15. A COMPARISON OF FINAL SPECIES POPULATIONS AFTER EARLY, LATE, AND SPLIT APPLICATIONS OF SETHOXYDIM AND FLUAZIFOP-BUTYL (1982).

FINAL PERCENT COVER OF TOTAL QUACK GRASS POPULATION.

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	27	3.9202				22.2
BLOCK	3	0.1689	0.056	0.79	0.5156	
TREAT	6	2.4670	0.411	5.76	0.0017	
ERROR	18	1.2843	0.071			

FINAL PERCENT SWARD OF TOTAL QUACK GRASS POPULATION.

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	27	2.0718				27.4
BLOCK	3	0.0840	0.028	0.81	0.5030	
TREAT	6	1.3262	0.221	6.06	0.0013	
ERROR	18	0.6565	0.036			

FINAL PERCENT COVER OF BIRDSFOOT TREFOIL.

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	27	2.7753				37.3
BLOCK	3	0.1462	0.049	1.05	0.3934	
TREAT	6	1.7961	0.299	6.47	0.0009	
ERROR	18	0.8330	0.046			

FINAL PERCENT SWARD OF BIRDSFOOT TREFOIL.

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	27	0.8466				44.1
BLOCK	3	0.0618	0.021	1.49	0.2498	
TREAT	6	0.5368	0.089	6.49	0.0009	
ERROR	18	0.2480	0.014			

FINAL PERCENT COVER OF BROADLEAF WEEDS.

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	27	0.9559				70.9
BLOCK	3	0.0098	0.003	0.12	0.9463	
TREAT	6	0.4591	0.077	2.83	0.0405	
ERROR	18	0.4870	0.027			

FINAL PERCENT SWARD OF BROADLEAF WEEDS.

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	27	1.6483				151.6
BLOCK	3	0.1257	0.042	0.67	0.5843	
TREAT	6	0.3882	0.065	1.03	0.4399	
ERROR	18	1.1343	0.063			

TABLE 16. A COMPARISON OF FINAL GROWTH STAGES OF QUACK GRASS POPULATION AFTER EARLY, LATE, AND SPLIT APPLICATIONS OF SETHOXYDIM AND FLUAZIFOP-BUTYL (1982).

FINAL PERCENT COVER OF HEADED QUACK GRASS.

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	27	1.4758				46.9
BLOCK	3	0.0056	0.002	1.00	0.4155	
TREAT	6	1.4363	0.239	127.07	0.0001	
ERROR	18	0.0334	0.002			

FINAL PERCENT SWARD OF HEADED QUACK GRASS.

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	27	0.2096				47.6
BLOCK	3	0.0008	0.0002	1.00	0.4155	
TREAT	6	0.2038	0.0340	123.42	0.0001	
ERROR	18	0.0049	0.0010			

FINAL PERCENT COVER OF STUNTED QUACK GRASS.

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	27	1.4441				40.8
BLOCK	3	0.0219	0.007	2.18	0.1262	
TREAT	6	1.3617	0.227	67.56	0.0001	
ERROR	18	0.0605	0.003			

FINAL PERCENT SWARD OF STUNTED QUACK GRASS.

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	27	0.2587				61.0
BLOCK	3	0.0088	0.003	2.33	0.1089	
TREAT	6	0.2274	0.038	30.22	0.0001	
ERROR	18	0.0226	0.001			

FINAL PERCENT COVER OF NEW GROWTH OF QUACK GRASS.

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	27	2.8869				24.5
BLOCK	3	0.1206	0.040	0.56	0.6488	
TREAT	6	1.4718	0.245	3.41	0.0199	
ERROR	18	1.2945	0.072			

FINAL PERCENT SWARD OF NEW GROWTH OF QUACK GRASS.

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	27	1.0212				33.2
BLOCK	3	0.0705	0.024	0.66	0.5846	
TREAT	6	0.3137	0.052	1.48	0.2414	
ERROR	18	0.6370	0.035			

TABLE 17. A COMPARISON OF QUACK GRASS RHIZOME BIOMASS AND PERCENT CONTRIBUTION OF SPECIES TO TOTAL ABOVE GROUND BIOMASS AFTER EARLY, LATE, AND SPLIT APPLICATIONS OF SETHOXYDIM AND FLUAZIFOP-BUTYL (1982).

QUACK GRASS RHIZOME NODE NUMBER PER EXCAVATION.

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	27	95937.86				33.6
BLOCK	3	10290.43	3430.143	1.30	0.3054	
TREAT	6	38107.86	6351.310	2.40	0.0696	
ERROR	18	47539.57	2641.087			

QUACK GRASS RHIZOME BIOMASS PER EXCAVATION.

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	27	1607.32				36.1
BLOCK	3	299.81	99.937	3.25	0.0462	
TREAT	6	753.51	125.585	4.08	0.0093	
ERROR	18	554.01	30.778			

PERCENT CONTRIBUTION OF QUACK GRASS TO TOTAL SPECIES BIOMASS.

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	27	3.8321				29.5
BLOCK	3	0.6853	0.228	4.18	0.0206	
TREAT	6	2.1640	0.361	6.61	0.0008	
ERROR	18	0.9828	0.055			

PERCENT CONTRIBUTION OF BIRDSFOOT TREFOIL TO TOTAL SPECIES BIOMASS.

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	27	1.5492				60.9
BLOCK	3	0.3091	0.103	3.72	0.0306	
TREAT	6	0.7413	0.124	4.46	0.0062	
ERROR	18	0.4988	0.028			

PERCENT CONTRIBUTION OF BROADLEAF WEEDS TO TOTAL SPECIES BIOMASS.

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	27	0.1043				71.1
BLOCK	3	0.0229	0.008	2.62	0.0826	
TREAT	6	0.0290	0.005	1.66	0.1878	
ERROR	18	0.0524	0.003			

TABLE 18. SPRING POPULATIONS OF SPECIES RESULTING FROM FALL TREATMENTS OF DALAPON, PRONAMIDE, SETHOXYDIM, AND FLUAZIFOP-BUTYL (1982).

INITIAL PERCENT COVER OF QUACK GRASS)(FALL SPRAYED).

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	23	1.3208				38.0
BLOCK	3	0.2229	0.074	3.20	0.0536	
TREAT	5	0.7502	0.150	6.47	0.0021	
ERROR	15	0.3477	0.023			

INITIAL PERCENT SWARD OF QUACK GRASS (FALL SPRAYED).

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	23	1.4831				11.3
BLOCK	3	0.0642	0.021	0.55	0.6561	
TREAT	5	0.8355	0.167	4.30	0.0126	
ERROR	15	0.5835	0.039			

INITIAL PERCENT COVER OF BIRDSFOOT TREFOIL (FALL SPRAYED).

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	23	0.0246				177.1
BLOCK	3	0.0021	0.0007	0.51	0.6811	
TREAT	5	0.0021	0.0004	0.31	0.9017	
ERROR	15	0.0205	0.0010			

INITIAL PERCENT SWARD OF BIRDSFOOT TREFOIL (FALL SPRAYED).

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	23	0.0907				198.1
BLOCK	3	0.0132	0.004	0.98	0.4287	
TREAT	5	0.0102	0.002	0.45	0.8037	
ERROR	15	0.0673	0.004			

INITIAL PERCENT COVER OF BROADLEAF WEEDS (FALL SPRAYED).

SOURCE	DF	SS	MS	F	PR>F	CC
TOTAL	23	1.0180				48.4
BLOCK	3	0.1073	0.036	0.70	0.5666	
TREAT	5	0.1439	0.029	0.56	0.7269	
ERROR	15	0.7668	0.051			

INITIAL PERCENT SWARD OF BROADLEAF WEEDS (FALL SPRAYED).

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	23	2.1834				43.1
BLOCK	3	0.1203	0.040	0.64	0.6005	
TREAT	5	1.1240	0.225	3.59	0.0246	
ERROR	15	0.9391	0.063			

TABLE 19. FINAL POPULATIONS OF SPECIES IN A MIXED SWARD RESULTING FROM VARIOUS TREATMENTS WITH DALAPON, GLYPHOSATE, PRONAMIDE, SETHOXYDIM, FLUAZIFOP-BUTYL, AND HALOXYFOP-METHYL (1982).

FINAL PERCENT COVER OF TOTAL QUACK GRASS POPULATION.

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	43	8.6962				38.1
BLOCK	3	0.4167	0.139	1.82	0.1654	
TREAT	10	5.9859	0.599	7.83	0.0001	
ERROR	30	2.2936	0.076			

FINAL PERCENT SWARD OF TOTAL QUACK GRASS POPULATION.

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	43	3.5074				38.9
BLOCK	3	0.1800	0.060	1.97	0.1392	
TREAT	10	2.4156	0.242	7.95	0.0001	
ERROR	30	0.9119	0.030			

FINAL PERCENT COVER OF BIRDSFOOT TREFOIL.

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	43	1.8953				54.3
BLOCK	3	0.0620	0.021	0.88	0.4633	
TREAT	10	1.1270	0.113	4.79	0.0004	
ERROR	30	0.7062	0.024			

FINAL PERCENT SWARD OF BIRDSFOOT TREFOIL.

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	43	1.0512				66.5
BLOCK	3	0.0101	0.003	0.27	0.8465	
TREAT	10	0.6655	0.007	5.32	0.0002	
ERROR	30	0.3755	0.012			

FINAL PERCENT COVER OF BROADLEAF WEEDS.

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	43	4.5198				36.8
BLOCK	3	0.8950	0.298	4.57	0.0094	
TREAT	10	1.6670	0.167	2.55	0.0230	
ERROR	30	1.9578	0.065			

FINAL PERCENT SWARD OF BROADLEAF WEEDS.

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	43	3.2326				47.3
BLOCK	3	0.0598	0.020	0.39	0.7591	
TREAT	10	1.6489	0.165	3.25	0.0060	
ERROR	30	1.5238	0.051			

TABLE 20. A COMPARISON OF FINAL QUACK GRASS GROWTH TYPES RESULTING FROM VARIOUS TREATMENTS WITH SETHOXYDIM, FLUAZIFOP-BUTYL, PRONAMIDE, DALAPON, ROPE-WICK APPLIED GLYPHOSATE, AND HALOXYFOP-METHYL (1982).

FINAL PERCENT COVER OF HEADED QUACK GRASS.

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	43	2.0668				107.3
BLOCK	3	0.0670	0.022	1.14	0.3474	
TREAT	10	1.4138	0.141	7.24	0.0001	
ERROR	30	0.5861	0.020			

FINAL PERCENT SWARD OF HEADED QUACK GRASS.

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	43	0.5631				114.5
BLOCK	3	0.2895	0.097	1.76	0.1766	
TREAT	10	0.3694	0.037	6.73	0.0001	
ERROR	30	0.1647	0.006			

FINAL PERCENT COVER OF STUNTED QUACK GRASS.

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	43	0.5631				114.5
BLOCK	3	0.0289	0.010	1.76	0.1766	
TREAT	10	0.3694	0.037	6.73	0.0001	
ERROR	30	0.1647	0.006			

FINAL PERCENT SWARD OF STUNTED QUACK GRASS.

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	43	0.8484				160.6
BLOCK	3	0.0464	0.015	1.15	0.3454	
TREAT	10	0.3985	0.040	1.96	0.0103	
ERROR	30	0.4035	0.034			

FINAL PERCENT COVER OF NEW GROWTH OF QUACK GRASS.

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	43	5.1251				44.5
BLOCK	3	0.2643	0.088	1.55	0.2214	
TREAT	10	3.1584	0.316	5.57	0.0001	
ERROR	30	1.7024	0.057			

FINAL PERCENT SWARD OF NEW GROWTH OF QUACK GRASS.

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	43	3.1375				46.5
BLOCK	3	0.0276	0.009	0.18	0.9085	
TREAT	10	1.5861	0.159	3.12	0.0076	
ERROR	30	1.5238	0.051			

TABLE 21. MID-SEASON COMPARISON OF QUACK GRASS AND BIRDSFOOT TREFOIL POPULATIONS RESULTING FROM VARIOUS APPLICATIONS OF ROPE-WICK APPLIED GLYPHOSATE, SETHOXYDIM, FLUAZIFOP-BUTYL, AND HALOXYFOP-METHYL (1982).

MID-SEASON PERCENT COVER OF QUACK GRASS.

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	35	2.0551				30.1
BLOCK	3	0.0531	0.018	0.37	0.7728	
TREAT	8	0.8626	0.108	2.27	0.0571	
ERROR	24	1.1392	0.048			

MID-SEASON PERCENT SWARD OF QUACK GRASS.

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	35	1.1899				53.0
BLOCK	3	0.0882	0.029	0.76	0.5273	
TREAT	8	0.1734	0.022	0.56	0.7993	
ERROR	24	0.9283	0.039			

MID-SEASON PERCENT COVER OF BIRDSFOOT TREFOIL.

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	35	3.8829				23.2
BLOCK	3	0.5530	0.184	2.67	0.0703	
TREAT	8	1.6730	0.209	3.03	0.0168	
ERROR	24	1.6587	0.069			

MID-SEASON PERCENT SWARD OF BIRDSFOOT TREFOIL.

SOURCE	DF	SS	MS	F	PR>F	CC
TOTAL	35	1.6992				31.4
BLOCK	3	0.2473	0.082	1.83	0.1678	
TREAT	8	0.3733	0.047	1.04	0.4358	
ERROR	24	1.0785	0.045			

TABLE 22. END-OF-SEASON COMPARISON OF QUACK GRASS AND BIRDSFOOT TREFOIL POPULATIONS RESULTING FROM VARIOUS APPLICATIONS OF ROPE-WICK APPLIED GLYPHOSATE, SETHOXYDIM, FLUAZIFOP-BUTYL, AND HALOXYFOP-METHYL (1982).

END-OF-SEASON PERCENT COVER OF QUACK GRASS.

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	35	3.5369				41.0
BLOCK	3	0.4041	0.135	1.64	0.2061	
TREAT	8	1.1636	0.145	1.77	0.1326	
ERROR	24	1.9692	0.082			

END-OF-SEASON PERCENT SWARD OF QUACK GRASS.

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	35	0.8551				36.9
BLOCK	3	0.0549	0.018	1.66	0.2022	
TREAT	8	0.5353	0.067	6.06	0.0003	
ERROR	24	0.2649	0.011			

END-OF-SEASON PERCENT COVER OF BIRDSFOOT TREFOIL.

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	35	3.2930				19.8
BLOCK	3	0.1659	0.055	0.70	0.5624	
TREAT	8	1.2256	0.153	1.93	0.1011	
ERROR	24	1.9013	0.079			

END-OF-SEASON PERCENT SWARD OF BIRDSFOOT TREFOIL.

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	35	1.5757				18.5
BLOCK	3	0.0693	0.023	0.96	0.4259	
TREAT	8	0.9307	0.116	4.85	0.0012	
ERROR	24	0.5756	0.024			

PERCENT CONTRIBUTION OF QUACK GRASS TO TOTAL SPECIES BIOMASS.

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	35	0.4471				53.6
BLOCK	3	0.0275	0.009	0.82	0.4937	
TREAT	8	0.1522	0.019	1.71	0.1480	
ERROR	24	0.2674	0.011			

PERCENT CONTRIBUTION OF BIRDSFOOT TREFOIL TO TOTAL SPECIES BIOMASS.

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	35	0.9406				16.6
BLOCK	3	0.0436	0.015	0.58	0.6327	
TREAT	8	0.2967	0.137	1.48	0.2151	
ERROR	24	0.6002	0.025			

TABLE 23. A COMPARISON OF THE EFFECTS OF GLYPHOSATE, SETHOXYDIM, HALOXYFOP-METHYL, AND FLUAZIFOP-BUTYL ON FINAL GROWTH TYPES OF QUACK GRASS (1982).

FINAL PERCENT COVER OF HEADED QUACK GRASS.

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	35	2.4971				82.5
BLOCK	3	0.0506	0.017	1.39	0.2712	
TREAT	8	2.1541	0.269	22.10	0.0001	
ERROR	24	0.2924	0.012			

FINAL PERCENT SWARD OF HEADED QUACK GRASS.

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	35	0.3160				92.6
BLOCK	3	0.0103	0.003	1.90	0.1558	
TREAT	8	0.2622	0.033	18.09	0.0001	
ERROR	24	0.0435	0.002			

FINAL PERCENT COVER OF STUNTED QUACK GRASS.

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	35	0.9823				66.7
BLOCK	3	0.0038	0.001	0.08	0.9720	
TREAT	8	0.5859	0.073	3.38	0.0020	
ERROR	24	0.3926	0.016			

FINAL PERCENT SWARD OF STUNTED QUACK GRASS.

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	35	0.0971				57.3
BLOCK	3	0.0018	0.0006	0.47	0.7065	
TREAT	8	0.0638	0.0080	6.49	0.0030	
ERROR	24	0.0315	0.0010			

FINAL PERCENT COVER OF NEW GROWTH OF QUACK GRASS.

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	35	2.3937				38.4
BLOCK	3	0.1227	0.041	1.26	0.3111	
TREAT	8	1.4902	0.186	5.73	0.0004	
ERROR	24	0.7807	0.032			

FINAL PERCENT SWARD OF NEW GROWTH OF QUACK GRASS.

SOURCE	DF	SS	MS	F	PR>F	CV
TOTAL	35	0.3604				48.9
BLOCK	3	0.0187	0.006	0.91	0.4530	
TREAT	8	0.1762	0.022	3.19	0.0130	
ERROR	24	0.1654	0.007			