AN ABSTRACT OF THE THESIS OF

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(Name) (Degree)

in Farm Crops presented on May 8, 1969
(Major) (Date)

Title: The Influence of Herbicides, Phosphorus Fertilization, and Mechanical and Chemical Seedbed Preparation on the Establishment of Alfalfa (*Medicago sativa* L.) and Birdsfoot Trefoil (*Lotus corniculatus* L.)

Abstract approved: Redacted for privacy
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Initial establishment of legume forage crops is of prime importance in determining future forage and seed production. The objective of this study was to determine the influence of herbicides, phosphorus fertilization, and seedbed preparation on the establishment of alfalfa and birdsfoot trefoil.

Experiments were designed to study the influence of herbicides applied alone or in combination with phosphorus fertilization on the establishment of alfalfa and birdsfoot trefoil. The phosphorus treatments consisted of different levels of P_2O_5 (0-50-100 pounds per acre) using two methods of application, broadcast and band.

The herbicide treatments included Ethyl N, N-dipropylthiolcarbamate (EPTC) at 3 pounds active ingredient per acre (lb. ai/A) + 4-(2,4-dichlorophenoxy) butyric acid (2,4-DB amine) at 1 lb. ai/A; EPTC 3 lb. ai/A + 2-sec-butyl-4,6-dinitrophenol (DNBP amine) at 2 lb. ai/A; 2,2-dichloropropionic acid (dalapon) 5 lb. ai/A + 2,4-DB amine 1 lb. ai/A; and an untreated control. EPTC was applied as a pre-plant incorporated treatment, whereas DNBP, 2,4-DB, and dalapon were applied when the legumes were in the two to four true leaf stage of growth.

Results for both alfalfa and birdsfoot trefoil were similar. Phosphorus applications did not enhance the establishment of the legumes. This may have been due to an adequate phosphorus supply already present in the soil. Phosphorus application without herbicide application resulted in weedy stands in which the legume yield was greatly reduced. The addition of phosphorus to herbicide treatments did not enhance the yield of alfalfa or birdsfoot trefoil any more than did the herbicide treatments alone.

The effectiveness of herbicide applications in eliminating weed competition from the legume seedlings varied considerably. The best treatment for the establishment of both alfalfa and birdsfoot trefoil was the combination of EPTC + DNBP amine. This treatment gave good to excellent control of oats (*Avena* spp.), ryegrass (*Lolium* spp.), cornflower (*Centaurea cyanus* L.), burnet

(*Sanguisorba* spp.), henbit (*Lamium amplexicaule* L.), and mayweed (*Anthemis cotula* L.); fair control of wild radish (*Raphanus raphanistrum* L.), and wild mustard (*Brassica kaber* (D.C.) Wheeler var. *pinnatifida* (Stokes) Wheeler); and poor control of vetch (*Vicia* spp.). EPTC + 2,4-DB amine was significantly better than dalapon + 2,4-DB or the untreated control. This combination gave good to excellent control of oats, ryegrass, burnet, henbit, and mayweed, but poor control of wild radish, wild mustard, cornflower, and vetch. The dalapon + 2,4-DB amine treatment was not significantly different from the check and resulted in poor control of all weed species.

Two experiments were designed to compare the effectiveness of chemical seedbed preparation using 1,1'-dimethyl-4,4'-dipyridylium salt (Paraquat), mechanical seedbed preparation by use of a rotary tiller or a rake, and the chemical treatment of EPTC 3 lb. ai/A + DNBP amine 2 lb. ai/A on the establishment of alfalfa and birdsfoot trefoil. Duplicate experiments were conducted on alfalfa and birdsfoot trefoil. The treatment involving EPTC + DNBP amine was the most effective treatment for the establishment of both alfalfa and birdsfoot trefoil. Paraquat and rototilling or raking were ineffective in controlling weeds. In each case, the high weed population greatly decreased the alfalfa or birdsfoot trefoil yields. The poor results obtained with paraquat were due to poor weed emergence prior to the application of the chemical. Raking gave poor control of germinating weed seeds present in the top inches of the soil. The rotary tilling may have brought dormant weed seeds to the surface where they germinated and emerged after the tillage treatment.

The Influence of Herbicides, Phosphorus Fertilization, and Mechanical and Chemical Seedbed Preparation on the Establishment of Alfalfa (*Medicago sativa* L.) and Birdsfoot Trefoil (*Lotus corniculatus* L.)

by

Ramon Valdes Lamar

A THESIS

submitted to

Oregon State University

in partial fulfillment of

the requirements for the

degree of

Master of Science

June 1967

APPROVED:

Redacted for privacy

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Date thesis is presented May 8, 1967

Typed by Bernice Caceres Ramon Valdes Lamar

To my Mother

To Nancy, Marisol and Nita Maria.

ACKNOWLEDGMENT

My sincere appreciation to Dr. William R. Furtick for his assistance in preparation of this thesis and his guidance in my graduate program.

My gratitude to Drs. Arnold Appleby, Orvid Lee and Juan Cardenas for their critical review of this manuscript and many excellent suggestions in the writing of the thesis.

Special thanks to Dr. J. Ritchie Cowan for his encouragement during my studies and to Dr. William Chilcote who served on my graduate advisory committee.

Appreciation is also extended to many other staff members of the Farm Crops Department who made this work more expeditious by providing the facilities and help in the field.

The author is also grateful to the Rockefeller Foundation and the University of Chile who made possible my studies at Oregon State University.

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INTRODUCTION

Weed control is a major problem in growing alfalfa and birdsfoot trefoil. If weeds are not controlled at an early stage of crop establishment weed competition can cause a partial or complete stand failure. Thin or spotty legume stands are poor competitors to weeds. Such fields will never reach their potential production capacity but instead will be plagued by continued low production and low quality forage.

It is not uncommon to experience partial or complete failures in stands of forage crops due to weed infestation. In fact, this has been almost accepted as a likely possibility in many areas. The hazards of establishing forage crops can be reduced only by careful attention to a multitude of details. Some of these details such as seedbed preparation, fertilization, and chemical weed control are important in the germination, establishment and competitive ability of the legume seedlings.

The purpose of this investigation was to study the effect of these factors on the establishment of two legume forage crops, alfalfa and birdsfoot trefoil.

LITERATURE REVIEW

Weed competition in new legume stands often causes such severe retarding and weakening of these plants that the stand may be lost or several months may elapse before the crop becomes well established. Seedbed preparation, fertilization, and use of herbicides can be very important in overcoming such problems in establishing forage crops, such as alfalfa and birdsfoot trefoil.

Alfalfa (Medicago sativa L.) is generally regarded as one of the world's most valuable cultivated forage crops. In the United States, alfalfa is the most important forage crop, having a total acreage of over 40 million acres. It is often referred to as the "queen of the forage crops" because of its many advantages relative to other species. In western Oregon, alfalfa is an important crop with over 40 thousand acres in production (49).

Birdsfoot trefoil (Lotus corniculatus L.) has been grown in small plantings in the British Isles and in western European countries for more than 100 years. In the United States, however, it is a relatively new legume and extensive evaluation of its use for forage production has been confined to the last twenty years (17). It is apparent that birdsfoot trefoil cannot be expected to compete with alfalfa or red clover for hay production on the better soils and under a short-rotation system of farming. It does, however, present distinct possibilities for hay and pasture production on the secondary, or poorer soils where alfalfa is not successful, where red clover is too short-lived for the rotation used, and where summer conditions are too droughty for the persistence of white clover (49). One of the main problems with this legume in all areas where it is being recommended is that it is slow to establish and is more sensitive to competition than other commonly recommended forage legumes.

Competition between Legume Crops and Weeds

Competition between crop plants and weeds for light, water and nutrients is a critical factor in the establishment and growth of the crop. Light competition is critical for the successful establishment and development of small seeded legumes and the ability to compete for light with weeds varies between legume species.

A number of factors have been reported to be influenced by light. Under low light intensities, birdsfoot trefoil has a lower proportion of leaves to stem than does red clover or alfalfa and the CO_2 "fixation" ability of birdsfoot trefoil is lower than that of red clover and alfalfa at all light levels (84, 85). Leaf area per plant has also been reported to be affected by light. Pennscott red clover often has a greater leaf area per plant under low light intensities than at higher light intensities while alfalfa is unaffected. Birdsfoot trefoil shows a drastic decrease in leaf area at lower light intensities (70).

The growth response of alfalfa, red clover and birdsfoot trefoil to increasing light intensities from 2,400 to 14,400 foot-candle-hours per day is linear, although the rate of growth of the different legumes is not the same. During the first 40 days after emergence, top and root growth of alfalfa slightly exceeded that of red clover and was approximately three times greater than was the top and root growth of birdsfoot trefoil (38). Increasing temperature from 60° to 90°F reduced legume seedlings growth. Decreasing soil moisture reduced seedling growth correspondingly (39).

Some authors have suggested that the relatively slow establishment and seedling failures of birdsfoot trefoil and, to a lesser extent, of alfalfa, may be due to inadequate nodulation and a subsequent nitrogen deficiency. A number of factors such as light, pH, soil moisture and nutrients have been reported to influence nodulation.

At low light intensities, alfalfa exhibited a decrease in nodulation, nodulation being proportional to light intensity (83). At least 25 percent of daylight was shown to be required by alfalfa and birdsfoot trefoil to be functionally nodulated and 50 percent to be adequately nodulated (70).

The pH of the soil affects the degree of nodulation to a great extent. The pH limits for nodulation in birdsfoot trefoil have been reported to be 4.5 and 7.9; however, adequate growth and nodulation of the seedlings occur within a range of pH from 6.2 to 7.5 (71). Other factors that have been reported to affect nodulation are nutrient content and moisture levels of the soil. On relatively dry, acid and infertile soils, the growth of the birdsfoot trefoil seedlings is depressed by lack of soil fertility and soil moisture particularly when there is competition from other plants. Under these conditions, the birdsfoot trefoil seedlings may not nodulate and may later suffer from a deficiency of nitrogen.

Based on the characteristics reviewed, several workers have concluded that birdsfoot trefoil is less competitive than alfalfa and is slower to be established (49).

Seedbed Preparation and Fertilization in the Establishment of Alfalfa and Birdsfoot Trefoil

The research findings reported in pasture establishment during the past 25 years have been very few in number when compared with the advances in improved varieties, fertilizer requirements, harvesting methods, improved forage quality and production techniques. Seedbed preparation and fertilization are two important factors which have been largely overlooked in the production of forage crops.

A principle of plant competition is that the first plants to occupy any area of soil, small or large, tends to exclude other plants.

This principle finds application in practical weed control. Practices should be such that crop plants occupy the soil before the weeds. Thus, seedbed preparation plays an important role in making it possible for crop plants to evade competition with weeds. Tillage practices and chemical seedbed preparation are two important ways by which this can be accomplished.

Several benefits have been reported to be due to tillage, but numerous field experiments using various crops indicate that the main benefit derived from tillage is the removal of the competition furnished by weeds and reduction of weed seeds in the soil rather than its effects on the physical properties of the soil and its effect on the chemical and biological activity in the soil (18).

In studies concerning tillage practices for the establishment of birdsfoot trefoil, summer tillage with intensively cultivated plots had an average of 106 birdsfoot trefoil seedlings per square yard compared with 173 seedlings per square yard in the plowed plots, demonstrating a marked negative response of birdsfoot trefoil to increasing intensity of tillage. With spring tillage, the population of birdsfoot trefoil plants was one plant per square yard for the check plots and up to 75 plants per square yard in the plowed plots. The correlation coefficient for the association between the stand of birdsfoot trefoil and the percent bare surface was 0.97, a highly significant value. This indicates that there is a close relationship between the reduction in competition from the original vegetation and for the success of establishing an adequate seedling stand (108).

It has been demonstrated that dormant weed seeds in the soil profile, if brought to the surface by tillage, are often encouraged to germinate. Heavy and light discing treatments applied to moist soil with depths of tillage of 3 and 6 inches showed that the number of weed seedlings increased in the 1/2- to 3-inch area. The area had been grazed continuously with beef cattle for the previous 35 years and had been renovated with a herbicide about 6 years prior to the study (96).

The use of herbicides as an aid to seedbed preparation and crop establishment has been widely investigated in recent years. Chemical seedbed preparation involves the destruction of existing vegetation by chemical means and seeding to a crop with minimum or no additional seedbed preparation. The most widespread investigations of this method have been for the purpose of renovation and reseeding of perennial pastures, or for production of crops after pasture (48, 60, 95, 107).

Jones (52) stated that the most important and difficult item the farmer has to contend with is timeliness of operations. Because of weeds, seedbeds for many crops are prepared immediately before planting causing delayed seeding and sometimes resulting in poor stands and low production. The use of herbicides to kill weeds just prior to ideal planting date would solve this problem.

Several years of work at Mount Vernon, Washington, using chemicals in what has been called the "stale seedbed method" showed in 1962 that the application of 1, 1'-ethylene-2, 2'-dipyridylium dibromide (diquat) to emerged weed seedlings resulted in almost 100 percent kill of annual weeds within a 24-hour period (77). One year later, the control was inadequate due to an infestation of prostrate knotweed (*Polygonum aviculare* L.) which was not affected by diquat or 1, 1'dimethyl-4, 4'-dipyridylium salt (paraquat) applications. Since the main detriment to this method had been surface soil conditions at seeding time, one more operation was included in the 1964 test. This was a light scarification of the seedbed with a spike-tooth harrow immediately prior to seeding. This practice loosened enough soil to adequately cover the seed, giving good germination of the crop, but did not bring undue weed seeds to the surface so that weed control was maintained. As a result, the following schedule of stale seedbed preparation has shown the best results: (1) soil worked to the final stage for planting, (2) three to four weeks waiting period for weed seed germination and growth, (3) application of diquat or paraquat, (4) after one to three days, spike-tooth harrowing, and (5) sowing of forage with Brillion type seeder (78, 79).

In New Zealand, only one third of the agriculture land is capable of being cultivated either by ploughing or discing. Results of trials on cropping without cultivation showed that the chemicals used to destroy the turf were 2, 2-dichloroproprionic acid (dalapon) plus 3-amino-1, 2, 4-triazole (amitrole) (66). In 1961 and 1962, Bramley (10, 11) reported the results of trials using five new chemicals, 2-(2, 4, 5-trichlorophenoxy) ethyl 2, 2-dichloropropionate (erbon), 2, 3, 6-trichlorophenylacetic acid (fenac), dalapon + 2, 4, 5-trichlorophenoxy acetic acid (2, 4, 5-T), diquat and paraquat. He concluded that paraquat appeared to be the most promising alternative to the dalapon + amitrole mixture. Thompson (98) in 1962 confirmed that the chemical method, in general, and paraquat in particular showed considerable promise.

Sprague et al. (96), following 12 years of research, reported that chemicals had been successfully used since 1949 in seedbed preparation in New Jersey. During the course of these tests in different regions, varying degrees of success were obtained depending on the effectiveness of the chemicals on the troublesome species present, the timeliness with which herbicides and tillage were employed in relation to soil moisture and time of seeding, the method of tillage, and the placement of the seed.

Phosphorus, nitrogen and potassium are considered to be major nutrient elements for plants. Alfalfa and birdsfoot trefoil are heavy phosphorus feeders and this element is a major fertilizer requirement in the western states.

One of the most significant improvements in seeding methods has been the development of band seeding of forage crops. This is merely the drilling of seed 1/4 to 1/2 inch deep directly over bands of fertilizer drilled 1 to 2 inches beneath the soil surface (103). The placement of water-soluble phosphate in a band tends to reduce contact with the soil and results in less loss of phosphorus by soil fixation than occur following broadcast application. Results of radioactive phosphorus studies indicate that with the more soluble materials, such as monocalcium phosphate, there is greater uptake from band placement. With the less soluble sources, such as di- or tricalcium phosphates, there is a greater uptake when the material is fixed in the soil (99).

Several workers have reported the results obtained by using the band application method. In Ohio, band seeding gave a 50 percent greater yield of alfalfa hay compared with the broadcast application of the fertilizer (45, 46, 47). In Michigan, 22 percent more alfalfa and birdsfoot trefoil seedlings were obtained when the seed was banded on top of the ground directly over fertilizer drilled 1-1/2 inches deep (97). Band-placed applications of alfalfa and superphosphate in Connecticut favored seedling development, but no differences were found in subsequent yields of forage (13). In Illinois, the alfalfa yield was increased by the band-placement of seed and fertilizer when adverse weather conditions followed seeding. Under conditions favorable for the growth and establishment of this legume, no yield increase occurred. The level of intra-crop competition was influenced by conditions following the seeding. There was less competition among plants within rows when adverse conditions followed the seeding than when the environment was more favorable. Yield increases due to band placement of seed and fertilizer were obtained only when the level of competition among plants was relatively low. At higher levels of competition, reduction in individual plant size may not allow any increase in yield (15).

Duell (24) in experiments conducted on loam soils of low fertility in New Brunswich found that alfalfa was superior to birdsfoot trefoil in germination, seedling emergence, height and weight. Alfalfa seedlings took up more phosphorus than birdsfoot trefoil seedlings and birdsfoot trefoil took up more potassium than alfalfa seedlings. Band seeding did not enhance the establishment of birdsfoot trefoil to the same degree as it did in alfalfa. No explanation was presented.

The relationship between fertilization and herbicides may be very important in the establishment of legume forage crops. Furtick et al. (37) reported from work done in Chile that wherever complete weed control was obtained with herbicides in the establishment of alfalfa, there was a marked decrease in need for phosphate fertilizer. Without an herbicide treatment 150 units of phosphate fertilizer were required to bring the yield of these plots to the yield of unfertilized alfalfa plots treated with herbicides. At the 200 units phosphate level, there was a 3-ton increase in alfalfa yield for the herbicide treated plots compared to the untreated plots. The results of this work are very significant as a means of improving alfalfa establishment with minimum cost for the phosphate fertilizer.

The interaction between phosphorus fertilizer and soil-applied herbicides has been investigated in field, greenhouse and controlled environment chambers. Amitrole was consistently more toxic to plants grown under high phosphorus level than under low phosphorus conditions. The phytotoxicity of ten other herbicides was not influenced by the phosphorus content of the soil, among them, ethyl N, N-dipropylthiolcarbamate (EPTC), dalapon, and 2-sec-butyl-4, 6-dinitrophenol (DNBP) (101).

Herbicides Used in the Establishment of Small Seeded Legumes

Present-day agriculture, with its specialized crops and cropping methods, its rapid mechanization and its efficient handling of diseases and insect pests, demands adequate weed control. Though hand pulling, hand hoeing and small-scale spraying have sufficed in the past, the decreasing numbers of hand laborers and the narrowing margins of profit require more effective methods for controlling weeds. Chemical methods have received increasing attention and have become an important factor in the mechanization of agriculture. Use of selective herbicides has increased steadily since the introduction of the phenoxy compounds and a host of newer compounds are currently coming into use. Some of these compounds, such as EPTC, dalapon, DNBP, 2,4-DB and paraquat, the ones used in this work, will be briefly reviewed.

EPTC

The herbicidal properties of carbamate-type materials were first reported in 1945. Since that time, a number of carbamates, thiolcarbamates and dithiocarbamates have proven to be excellent herbicides (4). EPTC is an herbicide which has shown considerable herbicidal activity toward grasses and many broadleaf plants. EPTC has proved useful in corn, sugar beets, beans, small seed legumes, flax, sunflower, tobacco and a number of vegetable crops (3, 18).

EPTC has been found to be quite volatile. Soil moisture at the time of application plays an important role in the rapidity of loss of this herbicide. Several workers have reported that EPTC is lost more readily from wet soils than from dry ones, being adsorbed to a much greater extent by air dry soils than by soils at or near field capacity. At field capacity each soil particle is surrounded by a film of water and, therefore, the slightly water soluble EPTC may not be able to come into intimate contact with the individual soil particles as in the air-dry soils (2, 7, 40, 76). During the first 15 minutes after spraying on the soil surface, 20 percent of the applied EPTC disappeared from dry soil, 27 percent from moist soil and 44 percent from wet soil. The losses were 23, 49, and 69 percent after one day and 44, 68, and 90 percent after six days on dry, moist, and wet soils, respectively (41). Under moist conditions, there is a marked movement of the herbicide to the soil surface with a subsequent loss by evaporation. This loss is greatest in light soils and least in heavy soils (44). The greater the evaporation of water from the soil, the greater the loss of EPTC from all soil types (26). The loss is faster on sunny than on cloudy days; increasing the temperature from 32° to 60°F increased the rate of EPTC vaporization from moist soil but had no effect on the loss from dry soil (41).

Several workers have reported good to excellent results in minimizing evaporation losses by using adequate incorporation and irrigation practices (24, 74). Prior to these findings, results obtained from surface pre-emergence applications of EPTC were extremely erratic (21, 31, 50, 91, 92). Incorporation into the upper two inches of the soil increased the weed control effectiveness by 100 percent (2, 14, 33). Deeper incorporation reduced effectiveness because the soil acted as a dilution medium, reducing the actual concentration of the herbicides in the vicinity of the germinating weed seeds (6). Shallow soil incorporation has been suggested for barnyardgrass (Echinochloa crusgalli (L.) Beauv.) and wild oats (Avena fatua L.) control. Research has shown that with these species the coleoptile is the site of herbicide uptake and shallow incorporation results in a concentrated herbicide layer through which the emerging coleoptile must pass (4, 20).

Several devices have been developed for placing this volatile herbicide in the soil, such as band application below the surface of the soil at the time of planting (63, 65, 82), subsurface application (27, 43, 112, 113, 114) and other similar methods, generally with good results.

Sub-irrigation has been reported to increase the effectiveness and persistence of EPTC when compared to overhead irrigation. It is possible that the EPTC moved with the water front which, under sub-irrigation, resulted in a greater concentration of herbicide in the region of the coleoptile while overhead irrigation carried the chemical downward into the root zone which may be less effective (19, 53, 54, 73).

EPTC has been tested extensively in forage legumes for control of weeds which emerge along with the crop (106). Several investigators have reported good to excellent results when this herbicide was incorporated into the soil, controlling many grasses and some broadleaf weeds, at rates from two to four pounds of active ingredient per acre (lb. ai/A) (42, 61, 80, 109). In Oregon, EPTC is recommended at 3 lb. ai/A as a pre-plant, soil incorporated application for control of weeds in new seedings of birdsfoot trefoil. The field should be disced in two directions immediately after application to incorporate the herbicide to a depth of two to three inches. For alfalfa establishment, 2 to 4 lb. ai/A are recommended, with the low rate on light sandy soils and the high rate on heavy soils (34).

In summary, EPTC is an herbicide which has shown considerable activity toward grasses and many broadleaf weeds. Since EPTC is a volatile compound, a pre-plant application on a dry soil surface with immediate incorporation is recommended.

Paraquat

Paraquat is a non-residual, non-selective contact herbicide which rapidly kills green plant material with which it comes into contact. It is believed that its toxic effects are exerted by virtue of its reduction to the corresponding stable free radical as a result of photosynthetic activity in plants. This free radical subsequently reacts with oxygen regenerating paraquat and giving rise to peroxides which are considered to be the actual phytotoxic agents. The effectiveness of paraquat depends mainly on three factors: light, chlorophyll and oxygen (12, 94).

The use of paraquat on alfalfa has been reported, in which mouse-eared chickweed (*Cerastium vulgatum* L.), common chickweed (*Stellaria media* (L.) Cyrill), storksbill (*Erodium moschatum* L.), speedwell (*Veronica persica* L.) and annual bluegrass (*Poa annua* L.) were controlled as young plants but only partially controlled at rates of up to eight ounces per acre when mature. The tolerance of young alfalfa to paraquat needs further evaluation but the tolerance of mature alfalfa treated during dormancy seemed quite satisfactory (62).

DNBP

The sodium salt of a dinitro compound was first used to selectively remove broadleaf weeds from small grains in France in about 1933. Since then, different and more effective forms of dinitro have been developed (59).

Weather conditions play an important role in the selectivity and phytotoxicity of dinitro compounds. Several investigators have reported poor weed control when low temperatures prevailed after treatment and excessive crop injury when high temperatures occurred following treatment. The activity of DNBP increased as temperature after treatment increased from 60° to 96°F; however, the activity was lower under growing temperature of 60° and 90°F prior to treatment than with temperatures of 70° and 80°F prior to the application. Light prior to treatment had no effect whereas light following treatment reduced the apparent activity of DNBP. Plants grown under low light intensities were injured more than those grown under higher light intensities (72).

Humidity also affects the toxicity of DNBP salts. When the plant is dry, absorption takes place very slowly, whereas high humidity moistens both chemical and plant and speeds up the rate of absorption. Observations indicate that plants are more susceptible after periods of cloudy weather. This may be because the plants are more succulent and develop a thin cuticle under such conditions (59). When using salts of DNBP, the length of time the salts remain on the plant before a rain is very important. This period varies with temperature, humidity, rate of treatment and susceptibility of the species. Under favorable conditions at least 6 hours are required for herbicidal activity, but 24 hours usually gives better results.

In seeding legumes, such as alfalfa and birdsfoot trefoil, post-emergence applications of DNBP are applied to control many broadleaf weeds. The herbicide appears to be more effective as a post-emergence treatment to the weeds due to the fact that it acts by contact. It should be applied when the legumes are in the two to four true leaf stage of growth. A single application of dinitro in oil to seedling alfalfa, increased yields 2,400 pounds of dry weight per acre in four cuttings (35, 93). During the summer, or under high temperatures, weed control obtained was good but injury to the legumes occurred sometimes; however, plant recovery in most cases was very rapid and the temporary retardation was not reflected in total yields (5, 64, 93). The recommended rates vary from 3/4 to 3 lb. ai/A. Some lack of control has been reported on wild turnip (Brassica campestris L.) (88), lambsquarter (Chenopodium album L.), and late emerging ragweed (Ambrosia spp.) (9).

In summary, DNBP is an important herbicide for controlling broadleaf weeds. The type of dinitro compound used, the species present, stage of growth, soil and climatic factors, specially temperature, light intensity, relative humidity and rainfall, are important considerations in DNBP performance.

Dalapon

Dalapon is selectively toxic to grasses in much the same way that 2,4-dichlorophenoxy acetic acid (2,4-D) is to broadleaf plants. It is a growth regulator and phytotoxicant that produces formative effects on grass plants at a distance from the point of application. Dalapon has proved to be very resistant to breakdown in plants and instances have been noted of the carrying of dalapon toxicity symptoms through three generations of wheat; corn, however, has not responded in the same way (18, 32).

Studies have shown that dalapon is most effective on young plants, on plants actively growing and on plants having an adequate suppy of water. Studies with C^{14}- and C^{36}-labeled dalapon showed that dalapon has a marked tendency to accumulate in tops rather than in the roots of grass plants, and it is able to retranslocate continuously to young growing organs. The inability of grass roots to produce buds to regenerate themselves, coupled with the strong tendency of dalapon to retranslocate to meristematic regions, including shoot tips and buds, may provide a key to the selectivity of this compound (1).

Several workers have reported the use of dalapon for controlling weed grasses in forage legumes (57, 90). The best time for application is when legumes are in the two to four true leaf stage of growth and weeds in the small seedling stage of growth (58, 102). Rates from 1 to 8 lb. ai/A have been used although some injury has been reported at the higher rates (5, 67, 87, 102). Wakefield and Pearson (105) reported that nitrogen application in the establishment of alfalfa decreased the effectiveness of dalapon due to a substantial increase in the growth of weed grasses.

4-(2,4-dichlorophenoxy) Butyric Acid (2,4-DB)

The herbicide 2,4-DB, a derivative from the phenoxy family, is recommended for the control of many broadleaf weeds in several crops, such as peas, alfalfa, red clover, birdsfoot trefoil, alsike clover, ladino clover (59), and in celery, parsnip and flax (104).

The original molecular structure of 2,4-DB has a low toxicity to most plants. Scientists have shown that many of the legumes convert 2,4-DB into 2,4-D very slowly. In such plants, the concentration of 2,4-D is never sufficient to cause serious plant injury. Most other plants make the convertion to 2,4-D rather rapidly providing a concentration of 2,4-D high enough to kill the plant. Therefore, the legume plant can escape injury while some weeds are killed (28, 59, 71).

Fossee (30) stated that with 2,4-DB applications, three factors have to be considered: (1) proper timing of treatments because annual weeds which will be controlled with one-half pound of 2,4-DB when they are under two inches tall may not be controlled with two pounds of the same material when they are six inches tall; (2) possible contamination of 2,4-DB with 2,4-D; the selectivity of the 2,4-DB will be lost; (3) an even application.

Numerous workers have reported on the use of 2,4-DB in the establishment of legume forage crops (22, 23, 56, 69). The application is made when the legumes are in the one to four true leaf stage of growth (29, 36, 86) or when weeds are in the one to three leaf stage (100). Rates of application range from 3/4 to 4 lb.

ai/A (18, 51, 105), although some weed species such as wild radish are not controlled at these rates (9).

To obtain control of both broadleaf weeds and weedy grasses, combinations of herbicides appear to be necessary (68, 89). EPTC as a pre-plant incorporated treatment plus 2,4-DB (25, 34, 65, 80, 106) or DNBP (21, 34) as a post-emergence application have been reported to give good to excellent weed control. As a post-emergence application in seedling legumes, the most common treatment reported is dalapon plus 2,4-DB (16, 50, 81). DNBP plus dalapon has also been satisfactory on alfalfa and birdsfoot trefoil seedlings but occasional injury to the legumes has been reported (64).

Competition between crop plants and weeds is a critical factor in the establishment of legume forage crops. Among legume forage crops, birdsfoot trefoil is generally considered slower to establish than alfalfa. Management practices during establishment such as seedbed preparation, fertilization, and chemical weed control play an important role in reducing the competition due to weeds and favoring the growth of the legume plants. Based on these concepts, the present research was designed to study the influence of chemical and mechanical seedbed preparation of the soil, phosphorus fertilization, and herbicides on the establishment of alfalfa and birdsfoot trefoil.

EXPERIMENTAL METHODS AND RESULTS

Four field trials were conducted during 1966 to compare pre- and post-emergence herbicides, phosphorus fertilization, tillage practices and chemical seedbed preparation for the establishment of alfalfa and birdsfoot trefoil.

The experiments were conducted on the Schmidt Agronomy Farm of Oregon State University, near Corvallis, Oregon. The vegetation present on April 18 before the experiments were started consisted of: oats (Avena spp.), ryegrass (Lolium spp.), cornflower (Centaurea cyanus L.), common groundsel (Senecio vulgaris L.), shepherdspurse (Capsella bursa-pastoris (L.) Medic.), common chickweed (Stellaria media (L.) Cyrill.), burnet (Sanguisorba spp.), mayweed (Anthemis cotula L.), henbit (Lamium amplexicaule L.), wild mustard (Brassica kaber (DC.) L. C. Wheeler var. pinnatifida (Stokes) L. C. Wheeler) and wild radish (Raphanus raphanistrum L.). The soil type at the test site was a Woodburn silt loam, moderately acid (pH 6.0), relatively adequate in phosphorus content (27 ppm) with 3.37 percent organic matter.

The climate of Corvallis, which is fairly representative of much of the Willamette Valley, may be described as a mild Sub-coastal climate with moist open winters, a dry harvest period in the late summer and a fairly long growing season. A summary of air and soil temperatures and rainfall for the 1966 growing season is shown in Appendix, Tables A, B, and C.

On April 18, the field was plowed to incorporate all the vegetation present. Four days later, the land was worked twice with a spike-toothed harrow and then the field was divided into four areas for the different experiments.

The Influence of Herbicides and Phosphorus Fertilization on the Establishment of Alfalfa and Birdsfoot Trefoil

Initial establishment of legume forage crops is of prime importance in determining future forage and seed production. For this reason, the objective of these experiments was to study the influence of pre- and post-emergence herbicides applied alone or in combination with phosphorus fertilization on the establishment of alfalfa and birdsfoot trefoil.

Materials and Methods

On May 10, the field was disced and worked with a disc-roller combination. Two days later, Du Puits alfalfa (Experiment 1) and Cascade birdsfoot trefoil (Experiment 2) were seeded with a grain drill (6-in. rows) at the rates of 14 and 7 pounds, respectively, of inoculated seed per acre. The experimental design consisted of a randomized block design with 20 treatments, each replicated three times. The size of the plots was 8 ft. wide by 20 ft. long with 2 ft. between plots. The treatments consisted of different herbicides and/or different levels and methods of application of phosphorus fertilizer. The rate of herbicide in pounds of active ingredient per acre (lb. ai/A), and the dates of application are shown in Table 1.

Table 1. Herbicides, rate and dates of application.

Treatments	Rate lb. ai/A	Date of Application Alfalfa	Birdsfoot Trefoil
H-1. EPTC +	3	May 12	May 12
DNBP amine	2	June 16	June 23
H-2. EPTC +	3	May 12	May 12
2,4-DB amine	1	June 16	June 23
H-3. Dalapon +	5	June 16	June 23
2,4-DB amine	1	June 16	June 23
H-4. Check	-	-	-

EPTC was applied as a pre-plant treatment on a dry soil surface and immediately incorporated with a tractor-rotary tiller to a depth of three to four inches. Dalapon, DNBP, and 2,4-DB were applied as post-emergence treatments when the legumes were in the two to four leaf stage of growth; this occurred on June 16 for alfalfa and on June 23 for birdsfoot trefoil. All herbicide applications were made with an experimental plot sprayer, bicycle-type, with a ten-foot boom. The volume of water used was equivalent to 30 gallons per acre and the climatic conditions during the applications are shown in Table 2.

Table 2. Climatic conditions during herbicide application.

Date	Wind Velocity miles/hr.	Air Temp. °F	Soil Temp. °F	Observations
May 12	0	60	64	Cloudy, misty
June 16	5	72	78	Semi-cloudy
June 23	5	61	69	Cloudy, slight rainfall

The phosphorus fertilizer treatments and the dates of application are shown in Table 3.

Table 3. Phosphorus rates and dates of application.

Treatment lb. P_2O_5/A	Date of Application
P-1. 0	-
P-2. 50 broadcast	May 11
P-3. 50 band	May 12 and June 26
P-4. 100 broadcast	May 11
P-5. 100 band	May 12 and June 26

The broadcast application of phosphorus was done before seeding using superphosphate (20 percent P_2O_5). It was incorporated with a tractor mounted rotary tiller. The band applications were made on two dates: the first application was made during drilling (May 12) at rates of 10 and 20 lb. of P_2O_5 per acre for treatments P-3 and P-5, respectively; the second application to the same plots was made on June 26. Enough superphosphate was applied with an experimental Planet Jr. seeder to bring the total P_2O_5 to 50 and 100 pounds/A, respectively. The same procedure was followed for both alfalfa and birdsfoot trefoil.

On June 15, Diazinon at 1 lb. ai/A was applied to alfalfa to control a slight attack of flea beetles (Phyllotreta cruciferae). Six sprinkler irrigations were applied during the growing season.

The two experiments were harvested in September using an experimental National mower. An area 3 ft. wide by 15 ft. long was harvested. Alfalfa or birdsfoot trefoil and weeds were hand-separated, placed in cloth bags and dried in a dryer at $180^{\circ}F$ for 14 hours. Dry matter of alfalfa or birdsfoot trefoil and weeds harvested from each of the plots was recorded. The dry weight of alfalfa and birdsfoot trefoil was analyzed statistically.

Results and Discussion

The statistical analysis of alfalfa showed no significant difference between fertilizer treatments or for the interaction between fertilizer and herbicides. However, herbicide applications were significantly different (Tables 4 and 5).

Table 4. Dry weight of alfalfa and weeds in grams per 45 sq. ft. Average of 3 replications.

Ferti-lizer	Alfalfa					Weeds				
	Herbicides					Herbicides				
	H-1	H-2	H-3	H-4	Ave.	H-1	H-2	H-3	H-4	Ave.
P-1.	639	669	346	380	509	10	110	257	421	200
P-2.	881	624	347	403	564	14	57	314	344	182
P-3.	856	531	430	359	544	14	85	282	276	164
P-4.	757	634	375	363	532	15	119	255	291	170
P-5.	976	681	386	298	585	18	171	175	299	163
Ave.	822	628	377	361		14	108	257	326	

Table 5. Analysis of variance. Alfalfa dry weight.

Source of Variation	SS	df	MS	F 1%
Replications	29,646	2	14,823	0.94
Treatments	2,461,119	19	129,532	8.27**
Fertilizer	41,565	4	10,391	0.66
Herbicides	2,188,127	3	729,375	46.58**
Fert. & Herb.	231,427	12	19,285	1.23
Error	595,002	38	15,657	
Total	3,085,767	59		

The results of the birdsfoot trefoil experiment were similar to those of the alfalfa experiment, that is, there was no significant difference between fertilizer treatments or for the interaction between herbicides and fertilizer; however, the herbicide treatments were significantly different (Tables 6 and 7).

Table 6. Dry weight of birdsfoot trefoil and weeds in grams per 45 sq. ft. Average of 3 replications.

Fertilizer	Birdsfoot Trefoil					Weeds				
	Herbicides					Herbicides				
	H-1	H-2	H-3	H-4	Ave.	H-1	H-2	H-3	H-4	Ave.
P-1.	1.028	638	576	437	670	17	221	251	221	178
P-2.	779	705	588	298	593	81	257	328	421	272
P-3.	1.041	573	517	265	599	40	185	331	663	305
P-4.	1.245	918	524	379	767	12	256	291	391	238
P-5.	1.241	902	380	166	672	35	139	366	545	272
Ave.	1.115	781	517	309		37	212	313	448	

Table 7. Analysis of variance. Birdsfoot trefoil dry weight.

Source of Variation	SS	df	MS	F 1%
Replications	7,504	2	3,752	0.06
Treatments	6,372,314	19	335,384	5.64**
Fertilizer	229,999	4	57,499	0.96
Herbicides	5,451,672	3	1,817,224	30.60**
Fert. & Herb.	690,643	12	57,553	0.96
Error	2,256,577	38	59,383	
Total	8,636,395	59		

The results obtained indicate that under the conditions tested, the application of 50 or 100 pounds of P_2O_5 per acre, applied broadcast or in a band, gave the same results as no P_2O_5 application at all. These results may indicate that: (1) the phosphorus content of the soil and the soil pH under these conditions were sufficient for the establishment of alfalfa or birdsfoot trefoil; (2) nitrogen could act as a limiting factor. A lack of nodulation both in alfalfa and birdsfoot trefoil was observed although the seed was inoculated before seeding. This effect was very clear in the border lines of the plots which presented a greener color compared with slightly chlorotic areas through the centers of the plots. This could be due to conditions that affected the bacterial development. Seeding was done on May 12 and only a slight rainfall fell before the first sprinkle irrigation was applied (May 25). Also the seeding was too shallow and most of the inoculated seed was above the soil surface. Legume bacteria readily succumb to high temperatures and varying degrees of soil dryness, which was the case in these experiments. Some authors have suggested that the relatively slow establishment of birdsfoot trefoil seedlings may be due to inadequate nodulation and a subsequent nitrogen deficiency. As it will be discussed later, the weed competition problem may be more important because when the weeds were controlled a good establishment was obtained although the central part of the plots showed a slight chlorosis; (3) fertilizer placement, competition among legume plants, competition among legume crop and weeds and weather conditions following seeding could influence the fertilizer band application and the results obtained.

The best herbicide treatment for the establishment of both alfalfa and birdsfoot trefoil was the combination of EPTC + DNBP amine. This treatment was significantly better than the others. EPTC + 2,4-DB was significantly better than the combination of dalapon + 2,4-DB and the check plots. The dalapon + 2,4-DB treatment was not significantly different from the check (Tables 8 and 9).

Table 8. Duncan's Multiple Range Test on herbicide forage yield means. Alfalfa. (Dry matter in grams per 45 sq. ft.)

Herbicide Treatment	Forage Yield	
	Means	1%*
EPTC + DNBP	821.8	a
EPTC + 2,4-DB	627.7	b
Dalapon + 2,4-DB	376.6	c
Check	360.5	c

*Any two treatments followed by the same letter are not significantly different from one another.

Table 9. Duncan's Multiple Range Test on herbicide forage yield means. Birdsfoot trefoil. (Dry matter in grams per 45 sq. ft.)

Herbicide Treatment	Forage Yield	
	Means	1%*
EPTC + DNBP	1,114.8	a
EPTC + 2,4-DB	780.5	b
Dalapon + 2,4-DB	517.1	c
Check	308.9	c

*Any two treatments followed by the same letter are not significantly different from one another.

EPTC applied as a pre-plant soil incorporated treatment at 3 lb. ai/A incorporated with a rotary tiller gave excellent control of grasses, especially of oats and ryegrass, the most common grass weed species in these experiments. It also gave some control of burnet, henbit, and mayweed (Tables 10 and 11). It has been shown that the best results are obtained when EPTC is applied on a dry soil surface, under cloudy skies and when it is incorporated immediately after application. Those conditions were present at time of treatment and this can account for the excellent weed control obtained.

DNBP amine at 2 lb. ai/A applied when alfalfa or birdsfoot trefoil were in the 2-4 true leaf stage of growth gave very good to excellent control of such broadleaf weeds as cornflower, burnet, henbit, mayweed, mallow, lambsquarters and pigweed; poor control of wild radish, flax, and vetch was obtained (Tables 10 and 11). Although DNBP applications on alfalfa resulted in good weed control, it was also injurious to the legume. The injury was evaluated at 10 to 20 percent. However, recovery of the plants in most cases was rapid and the temporary retardation was not reflected in total yields.

The DNBP applications did not injure birdsfoot trefoil and did provide excellent weed control. This difference between injury to alfalfa and no injury to birdsfoot trefoil can be explained on the basis of weather conditions that prevailed during and after the

Table 10. Weed species present per plot[1/] Average of 3 replications. Experiment 1. August 5, 1966.

Treatments	Oats	Rye-grass	Wild radish	Corn-flower	Burnet	Henbit	Vetch	May-weed	Flax
0 P_2O_5 - EPTC + DNBP	0.3	-	0.3	-	-	-	-	-	0.6
0 P_2O_5 - EPTC + 2,4-DB	0.6	0.3	2.6	1.6	-	-	0.3	1.0	0.3
0 P_2O_5 - Dalapon + 2,4-DB	3.0	2.6	3.0	1.3	-	1.3	0.6	0.6	1.0
0 P_2O_5 - No Application	3.0	3.0	2.6	2.0	2.0	1.6	1.0	1.6	-
50 broad. - EPTC + DNBP	0.3	-	0.6	-	-	-	-	-	0.3
50 broad. - EPTC + 2,4-DB	2.0	-	1.6	2.0	-	-	-	0.3	1.3
50 broad. - Dalapon + 2,4-DB	3.0	3.0	3.0	1.6	0.3	1.6	1.6	1.0	0.6
50 broad. - No application	3.0	3.0	2.3	2.0	3.0	1.0	0.6	1.0	2.3
50 band - EPTC + DNBP	0.3	0.3	0.3	-	-	-	0.3	-	1.0
50 band - EPTC + 2,4-DB	0.3	-	2.0	1.0	-	-	-	-	0.3
50 band - Dalapon + 2,4-DB	3.0	3.0	3.0	1.0	-	-	1.0	0.6	1.0
50 band - No application	3.0	3.0	2.6	2.3	2.6	0.3	1.3	1.3	2.0
100 broad. - EPTC + DNBP	-	-	-	-	-	-	0.6	-	0.6
100 broad. - EPTC + 2,4-DB	0.6	1.3	1.3	1.3	-	-	0.3	0.6	1.6
100 broad. - Dalapon + 2,4-DB	3.0	2.6	2.6	1.6	-	0.6	1.3	0.6	1.3
100 broad. - No Application	3.0	2.6	2.6	1.6	3.0	1.0	2.0	-	0.3
100 band - EPTC + DNBP	0.3	0.3	0.3	-	-	-	0.6	-	1.3
100 band - EPTC + 2,4-DB	0.6	2.6	2.6	2.0	-	-	-	-	0.6
100 band - Dalapon + 2,4-DB	2.6	2.6	2.6	0.6	0.3	-	0.6	0.6	2.6
100 band - No Application	3.0	3.0	3.0	1.3	1.6	1.0	1.3	0.3	1.3

1/ Scale 1-3: 1 = 1 to 2 weed plants of a given species per plot.
2 = 2 to 5 weed plants of a given species per plot.
3 = more than 5 weed plants of a given species per plot.

Table 11. Weed species present per plot[1/] Average of 3 replications. Experiment 2. August 5, 1966.

Treatments	Oats	Rye-grass	Wild radish	Corn-flower	Burnet	Henbit	Vetch	May-weed	Flax
0 P_2O_5 - EPTC + DNBP	0.6	-	0.3	-	-	-	0.3	-	1.0
0 P_2O_5 - EPTC + 2,4-DB	0.3	0.3	3.0	1.6	-	-	-	-	0.3
0 P_2O_5 - Dalapon + 2,4-DB	1.6	3.0	3.0	0.3	1.0	-	2.0	0.3	0.3
0 P_2O_5 - No application	3.0	3.0	3.0	2.3	3.0	1.3	3.0	-	-
50 broad. - EPTC + DNBP	0.3	-	1.3	1.3	-	-	-	-	0.3
50 broad. - EPTC + 2,4-DB	0.3	-	2.0	2.3	-	-	0.3	0.3	-
50 broad. - Dalapon + 2,4-DB	3.0	3.0	3.0	2.0	0.6	1.0	2.3	1.0	-
50 broad. - No application	3.0	3.0	3.0	2.3	3.0	2.0	1.0	1.0	1.0
50 band - EPTC + DNBP	0.3	-	1.0	-	-	-	-	-	-
50 band - EPTC + 2,4-DB	0.6	-	3.0	2.0	-	-	0.3	-	-
50 band - Dalapon + 2,4-DB	3.0	3.0	2.3	2.3	0.6	-	2.3	1.0	-
50 band - No application	3.0	3.0	3.0	2.6	2.6	1.0	1.6	0.6	0.6
100 broad. - EPTC + DNBP	1.0	-	0.6	-	-	-	0.6	-	0.6
100 broad. - EPTC + 2,4-DB	0.3	-	3.0	2.0	-	-	-	1.0	-
100 broad. - Dalapon + 2,4-DB	3.0	3.0	3.0	1.0	1.3	1.0	1.6	0.6	-
100 broad. - No application	3.0	3.0	2.6	1.6	2.3	1.0	2.0	0.3	-
100 band - EPTC + DNBP	-	-	0.3	-	-	-	1.6	-	1.3
100 band - EPTC + 2,4-DB	-	-	2.6	1.6	-	-	-	-	-
100 band - Dalapon + 2,4-DB	3.0	3.0	3.0	1.3	1.6	1.0	1.3	0.3	0.3
100 band - No application	3.0	3.0	3.0	1.6	2.3	1.0	1.6	1.0	0.3

1/ Scale 1-3: 1 = 1 to 2 weed plants of a given species per plot.
2 = 2 to 5 weed plants of a given species per plot.
3 = more than 5 weed plants of a given species per plot.

applications. The application on alfalfa was made on June 16. The air temperature during application was 72°F (Table 2), with a maximum for that day of 98°F, a minimum of 59°F and semi-cloudy skies (Appendix, Table A). According to Meggitt et al. (78) all these factors could have contributed to the injury on alfalfa. On birdsfoot trefoil, the application was made on June 23. Air temperature at the time of application was 61.5°F (Table 2), a maximum of 74°F, a minimum of 51°F and cloudy skies weather with slight rainfall followed the application (Appendix, Tables A. and C). The low temperature, plus the slight rainfall after the application, could have contributed to the lack of injury from DNBP on birdsfoot trefoil without reducing weed control.

In order to study the effect of weather conditions on DNBP application, a preliminary experiment was carried out in a growth chamber using alfalfa, birdsfoot trefoil and mustard plants. These were treated with DNBP at 2 lb. ai/A with a lab sprayer and placed at different temperatures (50°, 70° and 90°F), under low (30-40 percent) or high (70-80 percent) relative humidity, and under three different light intensities (light, shade, and dark). This was done with plants at two different stages of growth, cotyledon stage and two to four true leaf stage. The preliminary data indicated that in the cotyledon stage all plants, alfalfa, birdsfoot trefoil, and mustard, were killed by all the treatments used. At the two to four true leaf stage, the mustard was also killed by all the treatments; alfalfa was injured more at high temperature (90°F), high moisture and when exposed to full light; birdsfoot trefoil injury was similar to the alfalfa injury. At 50°F, there was practically no effect on either alfalfa or birdsfoot trefoil.

Dalapon at 5 lb. ai/A applied when the legumes were in the two to four true leaf stage in the field gave poor control of oats and ryegrass (Tables 10 and 11). The rates of application usually recommended for dalapon in alfalfa and birdsfoot trefoil range from 1 to 8 lb. ai/A. Some authors recommend the addition of a surfactant to the spray to increase the absorption and toxicity of this compound. In the present experiments, no surfactant was used and the rate of application was 5 lb. ai/A. It is possible that this dosage, without surfactant, was too low to control oats and ryegrass, which within annual grasses are recognized as being difficult to control.

The herbicide 2,4-DB applied when the legumes were in the two to four true leaf stage gave fair to poor control of broadleaf weeds. The weed species which were susceptible or semi-resistant included burnet, henbit, groundsel, mayweed, lambsquarter, pigweed and mallow. The most resistant weeds were wild radish, cornflower, vetch and flax (Tables 10 and 11). When 2,4-DB was applied to complement EPTC, broadleaf weeds were controlled more effectively than when 2,4-DB was applied with dalapon. This could be due to the greater effectiveness of EPTC on grasses and also over some of the broadleaf weeds present such as burnet, henbit, and some control of mayweed. In terms of forage yield, dalapon + 2,4-DB gave no significant difference in yield when compared with the non-treated plots. In this treatment, dalapon and 2,4-DB were applied as a mixture; it is possible that the mixture had an antagonistic effect.

The interaction between fertilizer and herbicides was not significant. The addition of phosphorus to herbicide treatments did not enhance the yield of alfalfa or birdsfoot trefoil any more than did the herbicide treatment alone.

The Influence of Mechanical and Chemical Seedbed Preparation on the Establishment of Alfalfa and Birdsfoot Trefoil

The use of herbicides as an aid to seedbed preparation and crop establishment has been widely investigated in recent years. The objective of these experiments was to study the influence of chemical and mechanical methods of seedbed preparation on the establishment of alfalfa and birdsfoot trefoil.

Materials and Methods

On April 22, a field was worked twice with a spike-toothed harrow. On May 12, two experiments were seeded without further soil preparation. One of them was seeded to alfalfa (Experiment 3) and the other to birdsfoot trefoil (Experiment 4), both with the same treatments. Du Puits alfalfa and Cascade birdsfoot trefoil were seeded with a cereal grain drill (6-in. rows) at the rates of 14 and 7 pounds, respectively, of inoculated seed per acre. At the same time, 100 pounds per acre of superphosphate was applied in band during drilling.

The experimental design consisted of a randomized block with five treatments, each replicated three times. The size of each plot was 8 ft. wide by 20 ft. long, with a separation of 2 ft. between plots. The rates and dates of application are shown in Table 12.

Table 12. Mechanical and chemical seedbed preparation treatments, rates and dates of application.

Treatment		Rate lb. ai/A	Date of Application Alfalfa	Birdsfoot Trefoil
T-1.	Paraquat	1/2	May 12	May 12
T-2.	Paraquat +	1/2	May 16	May 16
	wetting agent	1%	May 16	May 16
T-3.	EPTC +	3	May 12	May 12
	DNBP amine	2	June 16	June 23
T-4.	Rotary tiller	-	May 12	May 12
T-5.	Rake	-	May 12	May 12

Paraquat in treatment 1 was applied just before seeding. Treatment 2, paraquat + wetting agent, was applied after seeding but before legume emergence. Treatment 3 consisted of EPTC as a pre-plant incorporated treatment and DNBP amine applied when the legume crops were in the two to four true leaf stage of growth. All herbicide applications were made with an experimental plot sprayer, bicycle type, with a ten-foot boom. The volume of water used was equivalent to 30 gallons per acre. The climatic conditions during the applications are shown in Table 13.

Table 13. Weather conditions during herbicide applications.

Date	Wind Velocity miles/hr.	Air Temp. ^{o}F	Soil Temp. ^{o}F	Observations
May 12	0	60	64	Cloudy, misty
May 16	0	59	61	Cloudy
June 16	5	72	78	Semi-cloudy
June 23	5	61	69	Cloudy, slight rainfall

The rotary tiller treatment (T-4) was considered as a deep seeded preparation and was done using a tractor mounted rotary tiller at a depth of about four inches; in contrast, treatment 5 was considered to be a shallow seedbed preparation which was done using a hand-rake at a depth of about one inch.

On June 15, Diazinon at 1 lb. ai/A was applied to alfalfa to control a slight attack of flea beetle (Phyllotreta cruciferae). Six sprinkler irrigations were applied during the season to both alfalfa and birdsfoot trefoil.

The experiments were harvested in September using a National mower. An area 3 ft. wide by 15 ft. long was harvested. Alfalfa or birdsfoot trefoil and weeds were hand-separated, placed in cloth bags and dried in a crop dryer at 180^{o}F for 14 hours. The dry matter of alfalfa or birdsfoot trefoil and weeds harvested from each of the plots was recorded. The dry weights of alfalfa and birdsfoot trefoil were analyzed statistically.

Results and Discussion

The dry weights of the alfalfa and of the weeds in the alfalfa are shown in Table 14. The statistical analysis of the alfalfa data is shown in Table 15.

Table 14. Dry weight of alfalfa and weeds in grams per 45 sq. ft. Average of 3 replications.

Treatment	Alfalfa	Weeds
Paraquat	276	639
Paraquat + w. a.	285	709
EPTC + DNBP	627	46
Rotary tiller	313	435
Rake	268	571

The dry weights of the birdsfoot trefoil and of the weeds in the birdsfoot trefoil experiment are shown in Table 16. The statistical analysis of birdsfoot trefoil is shown in Table 17.

Table 15. Analysis of variance. Alfalfa dry weight.

Source of Variation	SS	df	MS	F 5%
Replications	24,523	2	12,261	1.17
Treatments	283,696	4	70,924	6.81**
Error	83,239	8	10,404	
Total	391,458	14		

Table 16. Dry weight of birdsfoot trefoil and weeds in grams per 45 sq. ft. Average of 3 replications.

Treatment	Birdsfoot Trefoil	Weeds
Paraquat	92	738
Paraquat + w. a.	162	600
EPTC + DNBP	840	60
Rotary tiller	363	488
Rake	181	509

Table 17. Analysis of variance. Birdsfoot trefoil dry weight.

Source of Variation	SS	df	MS	F 5%
Replications	95,160	2	47,580	1.1
Treatments	1,103,913	4	275,978	5.93**
Error	372,315	8	46,539	
Total	1,571,388	14		

The treatment of EPTC + DNBP was the most effective treatment for the establishment of alfalfa and birdsfoot trefoil. Chemical means of seedbed preparation using paraquat showed no significant differences compared with rotary tilling or raking tillage (Tables 18 and 19).

Table 18. Duncan's Multiple Range Test. Alfalfa. (Dry matter in grams per 45 sq. ft.)

Treatment	Forage Yield Means	5%*
EPTC + DNBP	627.3	a
Rotary tiller	313.3	b
Paraquat + w. a.	285.3	b
Paraquat	276.3	b
Rake	267.7	b

* Any two treatments followed by the same letter are not significantly different from one another.

Table 19. Duncan's Multiple Range Test. Birdsfoot trefoil. (Dry matter in grams per 45 sq. ft.)

Treatment	Forage Yield Means	5%*
EPTC + DNBP	839.7	a
Rotary tiller	363.3	b
Rake	181.3	b
Paraquat + w. a.	162.0	b
Paraquat	91.7	b

* Any two treatments followed by the same letter are not significantly different from one another.

EPTC + DNBP gave good to excellent control of oats, ryegrass, cornflower, burnet, henbit, and mayweed and fair control of wild radish (Table 20).

The poor results obtained with paraquat were due to failure of the weeds to emerge prior to paraquat application (Tables 14, 16, and 20). The last cultivation of the soil was made on April 22 and paraquat applications were made on May 12 and May 16 (treatments 1 and 2, respectively). Because of the extremely dry weather and low soil moisture, few weeds had germinated. Being a contact herbicide, the effectiveness of paraquat is greater when the weeds have emerged. There was no difference between paraquat applied alone just before seeding or applied with a surfactant after seeding but before legume emergence. In each case, weed control was very poor giving a high yield of weeds but a low yield of alfalfa or birdsfoot trefoil (Tables 14 and 16).

The poor results obtained with a rake as a means of shallow seedbed preparation were due to failure of the weed seeds to germinate before the treatment was made. When conditions became favorable, germination occurred and the previous treatment had little lasting effect. Although the rotary tiller treatment was slightly better than rake and paraquat applications, these differences were not statistically significant.

Alfalfa is considered to have a more rapid seedling growth

Table 20. Weed species present per plot.[1/] Average of 3 replications. Experiments 3 and 4. August 5, 1966.

Treatment	Oats	Rye-grass	Wild radish	Corn-flower	Burnet	Henbit	Vetch	May-weed	Flax
				Alfalfa (Experiment 3)					
Paraquat	3.0	3.0	3.0	2.0	3.0	1.0	-	1.0	0.3
Paraquat + w.a.	3.0	3.0	3.0	2.3	3.0	0.3	1.0	0.3	0.6
EPTC + DNBP	0.6	0.3	1.0	-	-	-	-	-	0.3
Rotary tiller	3.0	3.0	2.6	2.3	1.3	2.0	0.3	0.3	1.3
Rake	3.0	3.0	2.3	2.3	3.0	0.6	0.3	1.0	1.0
				Birdsfoot Trefoil (Experiment 4)					
Paraquat	3.0	3.0	3.0	2.3	3.0	1.0	1.0	0.3	0.6
Paraquat + w.a.	3.0	3.0	3.0	1.3	3.0	1.0	0.3	0.3	1.3
EPTC + DNBP	0.6	-	1.0	-	-	-	-	-	0.6
Rotary tiller	3.0	3.0	3.0	1.3	2.0	0.3	1.0	1.6	-
Rake	3.0	3.0	3.0	1.3	3.0	1.0	0.3	1.0	-

1/ Scale 1-3: 1 = 1 to 2 weed plants of a given species per plot.
2 = 2 to 5 weed plants of a given species per plot.
3 = more than 5 weed plants of a given species per plot.

rate than birdsfoot trefoil and thus is better able to withstand unfavorable conditions. This difference was evident in these experiments. The stand, vigor and number of plants per three linear inches were higher in alfalfa than in birdsfoot trefoil (Appendix, Tables D and E), especially when high weed populations were present (Appendix, Tables F and G).

From the results and discussion already presented for the four experiments that were conducted, the following conclusions are made:

1. EPTC applied as a pre-plant, soil incorporated treatment was the best treatment compared in these studies. It gave excellent control of all grass species present and also controlled certain broadleaf weeds. It did not injury either alfalfa or birdsfoot trefoil.
2. DNBP amine applied when the legumes were in the two to four leaf stage gave the best broadleaf weed control.
3. The herbicide 2, 4-DB controlled certain broadleaf weed but failed to control wild radish and cornflower. This herbicide might be used to complement an EPTC treatment when only susceptible species are present.
4. Dalapon was much less effective than EPTC in controlling grasses.
5. The best treatment compared for control of both grasses and

broadleaf weeds in alfalfa and birdsfoot trefoil was EPTC at 3 lb. ai/A applied as a pre-plant, soil incorporated treatment followed by DNBP at 2 lb. ai/A applied at the two to four leaf stage of the legumes. This treatment, while quite effective, did not control all weeds and thus a search should be continued for more effective treatments.

6. Under the extreme drought conditions which persisted in 1966, paraquat was not effective in controlling weeds in the legumes. In years when normal rainfall occurs so that weeds can be encouraged to emerge before the crop plants, this herbicide would probably be more efficient.

7. Under the conditions which existed in these studies, phosphorus application did not influence legume establishment. Phosphorus applications need further studies, especially under high weed population conditions and different levels of soil phosphorus content.

SUMMARY AND CONCLUSIONS

Four field trials were conducted at the Schmidt Agronomy Farm, near Corvallis, Oregon, during the 1966 season. The purpose of these studies was to evaluate the effectiveness of pre-plant, incorporated (PPI) and post-emergence (PE) herbicide treatments and combinations of the two, the effect of phosphorus fertilization alone and in combination with herbicides, and the influence of tillage as compared with the use of herbicides in preparing a seedbed for the establishment of alfalfa and birdsfoot trefoil.

Superphosphate was applied broadcast and as a band application on a silt loam soil at rates of 50 and 100 pounds of P_2O_5 per acre. EPTC (Ethyl N, N-dipropylthiolcarbamate) PPI + 2,4-DB (4-(2,4-dichlorophenoxy) butyric acid) PE; EPTC, PPI + DNBP (2-sec-butyl-4,6-dinitrophenol) PE; and dalapon (2,2-dichloropropionic acid) PE + 2,4-DB, PE, combinations were used. Paraquat (1,1'-dimethyl-4,4'-dipyridylium salt) for chemical seedbed preparation was compared with mechanical means of weed destruction through use of a rotary tiller or a rake.

The best treatment for the establishment of both alfalfa and birdsfoot trefoil was EPTC 3 lb. ai/A, PPI + DNBP amine 2 lb. ai/A applied when the legumes were in the two to four true leaf stage of growth. EPTC gave excellent control of oats (*Avena* spp.)

and ryegrass (*Lolium* spp.) and also of some of the broadleaf weeds, such as burnet (*Sanguisorba* spp.), henbit (*Lamium amplexicaule* L.) and mayweed (*Anthemis cotula* L.). DNBP gave good to excellent control of burnet, mayweed, henbit, cornflower (*Centaurea cyanus* L.), and fair control of wild radish (*Raphanus raphanistrum* L.) and wild mustard (*Brassica kaber* (DC.) Wheeler var. *pinnatifida* (Stokes) Wheeler).

Dalapon at 5 lb. ai/A gave poor control of oats and ryegrass. The 2,4-DB when applied in mixture with dalapon gave fair to poor control of broadleaf weeds. The susceptible to semi-resistant weed species to 2,4-DB were burnet, henbit and mayweed. The most resistant were wild radish, cornflower, vetch and flax. When 2,4-DB was applied as a complement to EPTC, the weed control obtained was significantly better than when used with dalapon. This could be due to the EPTC effect on grasses and also on some of the broadleaf weeds.

Phosphorus application did not influence legume production. This may have been due to an adequate phosphorus supply in the soil, or to a poor nodulation and subsequent high competition for nitrogen. Phosphorus application without herbicide application resulted in weedy stands in which the legume yield was greatly reduced. The addition of phosphorus to herbicide treatments did not enhance the yield of alfalfa or birdsfoot trefoil any more than did the herbicide treatment alone.

Seedbed preparation methods comparing paraquat, raking, or rotary tiller were not effective in controlling weeds. The poor results obtained were probably due to unfavorable conditions for weed emergence before treatment. Few weeds were killed by the treatments and thus weed seeds were still present in the soil which germinated when conditions became favorable to nullify any control achieved by the earlier treatments.

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APPENDIX

Table A. Daily air temperature from May 1, 1966, to September 30, 1966.

Date	May		June		July		August		September	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
1	67	44	57	33	72	50	84	54	79	48
2	74	38	64	45	60	45	88	55	80	53
3	77	47	64	43	61	51	92	50	80	55
4	81	54	61	38	69	47	89	56	85	50
5	79	52	68	44	80	51	82	54	92	51
6	76	47	78	55	80	55	83	53	88	46
7	63	43	79	50	66	55	86	52	78	53
8	73	42	76	51	75	50	90	48	81	52
9	77	45	78	51	85	52	80	54	78	45
10	70	37	77	54	85	56	81	53	77	48
11	60	33	66	47	70	45	81	50	75	48
12	67	42	65	42	80	50	81	48	65	47
13	62	43	71	45	77	54	85	53	69	43
14	55	38	82	51	71	56	80	54	73	47
15	58	42	85	57	73	52	84	55	61	46
16	53	40	98	59	77	54	87	52	72	48
17	61	38	73	56	78	52	82	49	75	50
18	64	44	75	47	83	47	85	46	72	55
19	79	47	82	51	82	57	86	45	69	46
20	78	43	72	53	76	48	88	53	73	49
21	75	46	71	48	79	51	92	55	81	51
22	58	38	70	48	89	48	88	48	88	53
23	61	40	74	51	89	48	71	43	70	45
24	72	45	69	37	85	56	78	48	75	47
25	81	48	71	47	72	42	78	51	71	51
26	86	47	80	43	78	52	75	56	69	55
27	68	33	80	60	84	54	64	57	71	47
28	66	38	81	57	90	48	74	47	75	47
29	72	40	75	42	90	52	72	44	80	54
30	73	35	70	43	94	48	68	43	79	61
31	57	38	-	-	85	52	74	46	-	-
Ave.	69.1	42.2	73.7	48.3	78.5	50.9	81.6	50.7	76.0	49.7

Table B. Daily soil temperature taken at 2 in. deep from May 1, 1966, to September 30, 1966.

Date	May		June		July		August		September	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
1	74	51	65	47	85	60	92	68	83	57
2	80	53	75	49	65	57	93	68	83	58
3	84	51	78	54	61	58	95	68	84	61
4	84	56	68	49	70	57	94	68	86	64
5	87	58	79	49	84	62	92	68	90	69
6	83	57	85	55	90	61	91	67	86	64
7	68	53	85	61	74	65	90	67	85	63
8	78	53	87	62	88	67	92	68	85	63
9	79	56	90	65	93	62	85	62	83	62
10	81	56	90	65	94	66	92	67	83	60
11	65	48	76	59	80	62	91	65	78	58
12	78	48	69	55	90	62	88	63	70	56
13	70	54	84	58	87	64	90	63	73	54
14	64	50	90	59	82	68	85	66	77	53
15	68	56	90	63	82	67	91	67	61	55
16	56	47	96	66	89	66	90	66	71	54
17	64	46	91	69	89	65	85	64	-	58
18	73	45	92	65	95	64	86	64	63	58
19	80	50	92	64	91	65	90	63	68	54
20	83	55	87	66	91	63	89	63	67	53
21	86	56	86	65	89	62	90	68	73	53
22	69	53	80	63	93	63	89	65	80	57
23	76	52	86	63	93	66	81	61	74	55
24	80	52	74	55	94	66	86	61	71	54
25	86	55	82	55	82	62	82	65	70	59
26	90	58	84	59	90	61	83	65	65	59
27	80	52	92	70	90	65	78	66	71	56
28	76	50	91	68	94	66	77	60	71	55
29	78	52	83	61	94	66	80	58	76	54
30	81	54	81	60	94	67	74	53	76	61
31	66	52	-	-	91	67	81	53	-	-
Ave.	74.6	52.5	83.6	60.0	85.6	63.6	86.8	64.2	76.0	57.9

Table C. Daily precipitation from May 1, 1966, to September 30, 1966.

Day	May	June	July	August	September
1	--	0.17	0.02	--	--
2	--	0.08	0.30	--	--
3	--	0.19	0.17	--	--
4	--	0.05	T *	--	--
5	--	--	--	--	--
6	0.30	--	--	--	--
7	T	--	--	--	--
8	--	--	--	--	--
9	--	--	--	--	--
10	--	0.03	T	--	--
11	--	0.06	--	--	0.24
12	--	0.10	--	--	0.04
13	--	--	--	--	--
14	T	--	--	--	T
15	0.07	--	--	--	0.11
16	0.10	--	--	--	0.03
17	T	--	--	--	T
18	--	--	--	--	0.92
19	--	--	--	--	T
20	--	--	--	--	--
21	--	--	--	--	--
22	T	--	--	--	--
23	T	0.04	--	--	0.12
24	--	0.04	--	--	0.01
25	--	--	--	--	0.04
26	--	--	--	--	0.20
27	--	--	--	0.01	T
28	--	T	--	0.10	--
29	--	--	--	--	--
30	--	--	--	0.16	--
31	0.02	--	--	--	--
Total	0.49	0.76	0.49	0.27	1.71

* T = Traces.

Table D. Observations on legume stand[1/] and weed count[2/] Experiments 1 and 2. June 15 and June 24, 1966.

Treatments		Alfalfa*			Birdsfoot Trefoil**		
P_2O_5	Herbicides	Stand	Grasses	Broad.	Stand	Grasses	Broad.
0	-EPTC + DNBP	7.3	0	0.5	6.6	0	0.2
0	-EPTC + 2,4-DB	7.6	0	0.7	4.6	0	0.9
0	-Dalapon + 2,4-DB	6.6	1.6	1.5	7.3	1.2	0.9
0	-No application	6.3	1.2	1.3	6.6	0.8	1.8
50 broad.	-EPTC + DNBP	7.6	0	0.7	6.3	0	0.6
50 broad.	-EPTC + 2,4-DB	8.6	0.4	0.7	7.0	0.1	0.6
50 broad.	-Dalapon + 2,4-DB	6.3	1.4	1.7	8.3	1.2	1.5
50 broad.	-No application	6.6	0.8	1.4	6.6	0.8	2.0
50 band	-EPTC + DNBP	7.0	0	0.8	7.0	0	0.4
50 band	-EPTC + 2,4-DB	8.0	0	0.8	6.0	0	0.3
50 band	-Dalapon + 2,4-DB	6.3	1.1	1.7	7.6	1.0	1.8
50 band	-No application	7.3	1.2	1.2	5.6	0.6	1.6
100 broad.	-EPTC + DNBP	8.3	0.1	0.6	6.6	0	0.3
100 broad.	-EPTC + 2,4-DB	8.3	0.1	0.9	7.0	0	0.7
100 broad.	-Dalapon + 2,4-DB	7.6	0.9	1.4	7.6	1.3	1.8
100 broad.	-No Application	8.3	1.0	1.2	6.3	1.1	1.7
100 band	-EPTC + DNBP	7.6	0.3	0.9	6.0	0.3	0.3
100 band	-EPTC + 2,4-DB	8.0	0	0.8	7.0	0.1	0.3
100 band	-Dalapon + 2,4-DB	7.6	1.1	1.2	5.6	0.8	1.2
100 band	-No application	7.6	0.9	1.3	6.3	1.0	2.3
Average		7.4	0.6	1.1	6.5	0.5	1.1

1/ Average 3 replications. Scale 1-10; 1 = bare soil, 10 = complete cover. 2/ Quadrat method (1 sq. ft.). Average 3 counts per plot and 3 replications. Determination for grasses and broad-leaf weeds. * June 15, 1966. ** June 24, 1966.

Table E. Observations on vigor of legumes,[1] number of legume plants per 3 linear inches[2] and weed count.[3] Experiments 1 and 2. July 14, 1966.

Treatments P_2O_5	Herbicides	Alfalfa Vigor	Alfalfa No. Plants	Alfalfa Grass.	Alfalfa Broad.	Birdsfoot Trefoil Vigor	Birdsfoot Trefoil No. Plants	Birdsfoot Trefoil Grass.	Birdsfoot Trefoil Broad.
0	-EPTC + DNBP	4.0	2.8	0.1	0	4.6	3.3	0.1	0.2
0	-EPTC + 2,4-DB	6.6	5.0	0.1	0.6	4.6	2.7	0.1	0.9
0	-Dalapon + 2,4-DB	3.0	3.7	0.9	1.0	5.6	4.1	1.1	1.1
0	-No application	6.3	4.4	1.5	1.9	5.3	4.3	1.5	1.7
50 broad.	-EPTC + DNBP	5.3	3.5	0.1	0.1	6.0	3.6	0.1	0.6
50 broad.	-EPTC + 2,4-DB	8.0	6.7	0.2	0.5	6.6	3.7	0.6	0.9
50 broad.	-Dalapon + 2,4-DB	4.3	4.0	0.8	1.1	6.6	4.9	0.9	1.5
50 broad.	-No application	7.0	4.8	1.7	2.4	6.6	4.2	1.8	2.4
50 band	-EPTC + DNBP	4.6	2.5	0.1	0.2	5.3	3.3	0.3	0.3
50 band	-EPTC + 2,4-DB	7.6	4.3	0.3	0.6	5.6	2.9	0.2	0.6
50 band	-Dalapon + 2,4-DB	5.0	3.7	0.7	1.2	6.0	3.8	0.7	1.1
50 band	-No application	7.3	5.6	1.8	1.3	5.6	4.5	1.6	1.6
100 broad.	-EPTC + DNBP	7.0	4.8	0.1	0.2	6.3	3.6	0.2	0.1
100 broad.	-EPTC + 2,4-DB	9.0	6.7	0.1	0.5	6.6	4.1	0.3	0.8
100 broad.	-Dalapon + 2,4-DB	4.6	4.3	1.5	1.0	6.3	5.3	1.5	0.9
100 broad.	-No application	8.6	5.6	2.1	1.6	6.0	4.8	1.5	1.0
100 band	-EPTC + DNBP	5.0	2.8	0.1	0.4	4.6	2.9	0.2	0.4
100 band	-EPTC + ,4-DB	8.0	4.8	0	0.9	5.6	3.1	0.1	0.8
100 band	-Dalapon + 2,4-DB	4.0	3.3	0.9	0.8	6.0	4.0	1.4	0.8
100 band	-No application	7.6	6.0	1.8	1.6	6.0	3.9	2.2	2.0
Average		6.1	4.5	0.7	0.9	5.8	3.9	0.8	1.0

1/ Average 3 replications. Scale 1-10; 1 = less vigorous and 10 the most. 2/ Average 3 replications and 3 observations per plot. 3/ Quadrat method (1 sq. ft.). Average 3 counts per plot and 3 replications. Determination for grasses and broadleaf weeds.

Table F. Observations on legume stand[1/] and weed count[2/] Experiments 3 and 4. June 15 and June 24, 1966.

Treatments	Alfalfa*			Birdsfoot Trefoil**		
	Stand	Grasses	Broad.	Stand	Grasses	Broad.
Paraquat	6.0	1.7	0.7	3.3	2.3	1.3
Paraquat + w.a.	6.0	1.6	0.8	4.3	2.2	1.8
EPTC + DNBP	7.3	0	0.4	4.0	0	0.2
Rotary tiller	6.0	1.0	0.5	5.3	0.9	0.9
Rake	6.3	1.6	0.9	4.3	1.6	0.9
Average	6.3	1.2	0.7	4.2	1.4	1.0

1/ Average 3 replications. Scale 1-10; 1 = bare soil, 10 = complete cover.

2/ Quadrat method (1 sq. ft.). Average 3 counts per plot and 3 replications. Determination for grasses and broadleaf weeds.

* June 15, 1966.

** June 24, 1966.

Table G. Observations on vigor of legumes,[1/] number of legume plants per 3 linear inches[2/] and weed count.[3/] Experiments 3 and 4. July 14, 1966.

Treatments	Alfalfa				Birdsfoot Trefoil			
	Vigor	No. Plants	Grass.	Broad.	Vigor	No. Plants	Grass.	Broad.
Paraquat	6.6	5.3	1.8	1.0	4.6	2.0	2.7	1.3
Paraquat + w.a.	7.6	5.8	1.8	1.1	4.6	2.8	2.5	1.3
EPTC + DNBP	5.6	3.2	0	0.1	3.6	1.6	0.5	0.2
Rotary tiller	7.0	5.2	1.4	0.9	5.6	3.3	1.3	1.1
Rake	8.0	5.0	2.3	1.2	5.0	2.4	2.3	1.4
Average	7.0	4.9	1.5	0.9	4.7	2.4	1.9	1.1

1/ Average 3 replications. Scale 1-10; 1 = less vigorous, 10 the most.

2/ Average 3 replications and 3 observations per plot.

3/ Quadrat method (1 sq. ft.). Average 3 counts per plot and 3 replications. Determination for grasses and broadleaf weeds.

Figure 1. EPTC + DNBP application on alfalfa. Experiment 1.

Figure 2. EPTC + DNBP application on birdsfoot trefoil. Experiment 2.