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THE AUTECOLOGY OF *ASPHODELUS FISTULOSUS*, L.

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of Adelaide for the Degree of
Doctor of Philosophy

by

Bruce Roark

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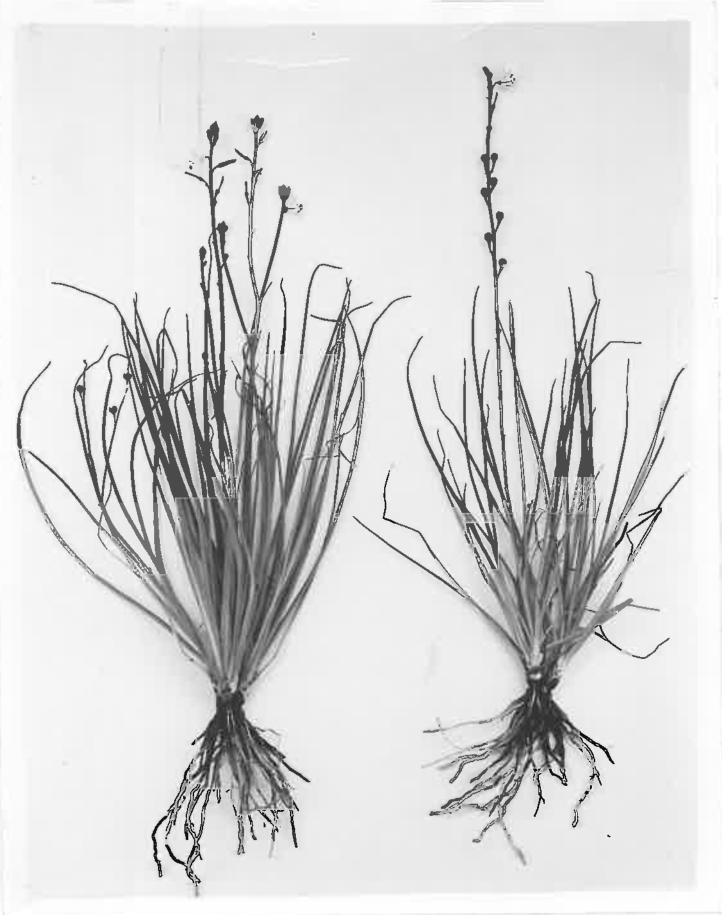

Figure I-1

Onion Weed (Asphodelus fistulosus, L.). The flower stalk is about 14 inches tall.

I. Introduction

This paper presents the results of four seasons of work in field, glass-house and laboratory with Asphodelus fistulosus, L. In Australia the most widely used common name for this plant is "onion weed". Onion weed is well known in southern Australia because of its lack of palatability to livestock and its occupation of hundreds of thousands of acres of grazing land, sometimes to the exclusion of all other species of higher plants. The present investigation was begun in 1950. It has shown how onion weed established and spread in its new environment. It embodies new experimental data which will enable a sounder application of standard control measures to the onion weed problem. The study of this problem has been approached ecologically, so that the total environment of onion weed, including man and his livelihood from the soil, is within its scope.

A. Previous Australian work prior to 1949.

Before the end of the 19th century Asphodelus fistulosus was declared a noxious weed in South Australia. From such time onward it became the duty of the District Councils in this state to enforce its destruction. In 1897 cultivation and hand grubbing were the recommended control measures (Anon., 1897a). This is still the principal control method (Orchard, 1951) although the effects are seldom lasting. A number of discussions of the onion weed problem appeared in print from time to time (Anon., 1897b; Anon., 1907; Clarke, 1937; Davey, 1922; Gardner, 1929; Richardson, 1953; etc.) but in spite of increasing concern over its spread through the lower rainfall districts little real progress was made in the development of new methods for the control of onion weed during the intervening time.

Advisory work on weed control is carried out by the South Australian Department of Agriculture. In recent years trials with weedicides have been conducted and observations have been made in respect to the control of onion weed (Orchard, 1950). The most recent recommendations are those of Richardson (1953) who discusses the value of cultivation, burning, and spraying with arsenic compounds, power kerosene and hormone-like substances. The intention of the present study has been to complement and not to duplicate the work of the South Australian Department of Agriculture.

B. Previous investigations, by the University of Adelaide, 1949.

In 1949 a series of preliminary investigations on onion weed was initiated at the Waite Agricultural Research Institute by E. D. Carter (1950). A comprehensive summary of his work is presented here to make it available in a convenient form and because of its bearing on the course of the present investigation.

1. Factors affecting germination and emergence: Carter studied the effect of temperature and soil moisture on germination and the effect of depth of planting on emergence. He found that germination occurred at all temperatures between 6° C. and 39° C. with high germination between 18° C. and 35° C. and most rapid germination at 18.9° C. He concluded that soil temperature is not likely to be of importance in the general distribution of onion weed in southern Australia.

At 20%, 40%, 60% and 80% of water holding capacity germination was very low and the difference apparently insignificant. These results on the effect of soil moisture were inconclusive and Carter attributed the low germination to an induced dormancy due to inadequate aeration. Doneen and MacGillivray (1943) using a similar but not identical technique found that for the seeds of 21 species of vegetables germination was high at soil moisture contents near the permanent wilting point. It is not possible to tell the post-harvest age of Carter's seed at the time the experiment was carried out but the results of germination trials described later in this thesis suggest that the dormancy he found may have been that normally found in recently harvested seed.

In experiments on depth of planting in sand it was found by Carter that emergence was 64% at 0.5 cm. depth of planting but declined rapidly below that depth to 16% at 3 cm.

2. Life history: Carter has adequately summarized what is known about the life history and gross morphology of onion weed. He gives a fine series of photographs of the weed at numerous stages of its growth. The points which are not peculiar to Carter's study have been incorporated at the pertinent places in the present paper without further acknowledgment.

Growth studies were carried out on seedling onion weed plants in pot culture using sand from Avon, South Australia and Waite loam as growth media and $(NH_4)_2SO_4$ and KH_2PO_4 as fertilizers. The data from the two soil types were similar and Carter obtained an increased yield from the use of each fertilizer.

Additional growth studies were made in the field with plants in their second year by harvesting from a natural infestation. There was a marked decline in dry weight of vegetative parts and storage organs during the period August to December when the inflorescence was being developed. Following the maturity of the inflorescence, vigorous new growth commenced about January and presumably food reserves are built up again between January and June.

3. Transpiration: Carter determined the transpiration curve and the transpiration ratio for four pots of seedling onion weed plants over a period of 8 months. Between the 100th and the 249th day (September to January, inclusive) transpiration proceeded at a constant rate. At the close of the 1st

growing season (December) the ratio of total water transpired to total dry matter was approximately 300. There is considerable evidence (Russell, 1950a; Curtis and Clark, 1950) to suggest that there is no close relationship between water transpired and dry matter produced. As Carter points out, any value which the transpiration ratio may have lies in making comparisons between species of similar maturity and grown under identical environmental conditions.

4. Effect of herbicides: Carter's investigations on the effect of herbicides involved many spraying tests with hormone-like substances and oils in glasshouse and field experiments. The glasshouse spraying trials were carried out with various concentrations and spray volumes of seven hormone-like substances and eight oils and related substances singly and in combination and with and without the addition of common synergistic agents. The treatments involved plants at several growth stages and under different environmental conditions. Field trials were carried out at two geographical centers with different concentrations of three promising hormone-like substances on natural infestations at several growth stages.

The overall results of the experiments with herbicides stresses these points. Of the hormone-like substances, Methoxone (sodium salt of 4-chloro, 2 methyl phenoxyacetic acid or M.C.P.A.), Chloroxone (sodium-2,4-dichloro phenoxyacetic acid), Weedone (ethyl ester of 2,4-dichloro phenoxyacetic acid), and Weedar-77 (triethanolamine salt of 2,4-dichloro phenoxyacetic acid) showed greatest promise for control of onion weed. Actually onion weed was found to be fairly resistant to hormone-like herbicides. A recommended application for common South Australian weeds in wheat, oats and barley crops is 1/2 gal. of Methoxone per acre (Orchard and Warner, 1952). The minimum recommended application of Methoxone for onion weed control is 3 3/4 to 5 gal. per acre. Even at this concentration there was considerable regrowth and recovery of older plants. In one experiment Carter sprayed an infestation of seedling onion weed before flowering commenced (30-7-49) with 125 gal. per acre of 0.4% M.C.P.A. (= 5 gal. Methoxone) and with the same volume of 0.3% ethyl-ester 2,4 D (nearly = 4 gal. Weedone standard) and "although the weeds were greatly retarded and considerably thinned they set ample seed for regeneration".

These herbicides do not kill the ungerminated seeds in the soil and the seeds may germinate at a later date and make further control measures necessary. Carter concludes that the use of hormone-like herbicides for the control of onion weed is likely to be restricted to non-arable land.

Of the oils and related substances, "light oil ex cracking plant" caused especially rapid wilting, while Dow general weed killer (2,4-dinitro-o-secondary butyl phenol) and power kerosene were also highly effective. These substances are not selective in their action.

5. Plant competition: Carter considered the role of competitive pasture plants in controlling onion weed. He noted the success of Mr. Clive Duval in controlling onion weed at Morphett Vale through the establishment of a sub-clover-*Phalaris tuberosa* pasture after 2 consecutive years of cultivation. He also laid down 2 field trials at Avon designed to test the value of a perennial veldt grass (*Ehrharta calycina*)--barrel medic (*Medicago tribuloides*) pasture in the control of onion weed. The plots were sown in June, 1949, and a good establishment was obtained. Due to its usual slow growth the competitive effect of veldt grass was not apparent during the year of establishment. The sites of these experiments were visited by the writer on the 23rd of May, 1950. Experiment 1 had been completely destroyed by drought and rabbits. There was no evidence of veldt grass, barrel medic or any other desirable plant species on any plot and all plots carried a uniform cover of onion weed seedlings and no distinction between treatments was apparent. In experiment 2

which consisted of a single 2 acre plot sown to pasture the veldt grass was well established. Very little barrel medic was evident although numerous seedlings of woolly burr medic (Medicago minima) were just emerging. Seedling onion weed plants were numerous and vigorous on the sown area. The site was not available for further experimental work.

6. Carter discussed the distribution of onion weed only in very general terms. This subject will be discussed in greater detail in the present paper.

This finishes the summary of Carter's studies on onion weed.

C. The life history of Asphodelus fistulosus.

The seed of onion weed germinates in the Autumn beginning with the opening seasonal rains. Growth of vegetative parts proceeds during the colder winter months. During August the flower stalk first appears above the tip of the crown stem and it then elongates fairly rapidly. About 12 days elapse between the appearance of the flower stalk and the opening of the first flower. Flowering is continuous from late August through mid-November. The lowest flower on the stalk opens first, remains open for a day, then incloses and quickly forms the seeds. Meanwhile the higher flowers on the inflorescence open successively as the stalk elongates. This process continues for 2 or 3 months. In a large infestation a few plants can usually be found in flower out of season.

The flowers are often visited by bees. The pollen is not readily scraped from the anthers so that pollination by wind is most unlikely. A number of flowers were enclosed in cellophane bags several days before they were due to open. Each bag was left in place until after the flower had opened and had closed tightly once more. All such flowers set seed in the normal way showing that self-pollination is possible. A number of flowers were emasculated several days before they opened. Some of these were cross-pollinated and others left as controls. Some of the cross-pollinated flowers set seed but none of the controls did so. This suggests that cross-pollination is possible. The bagging emasculation and crossing were carried out on glasshouse grown plants.

Seeds are borne in capsules of 6 seeds each. One "typical mature plant" was found by Carter to have 13,200 seeds. The seed counts made during the present study showed a mean of 2,325 seeds per plant for plants of all ages in 1/400 acre of a typical natural infestation at Avon, South Australia. This is equal to 26,035,200 seeds per acre or 260 seeds per square link or 170 lbs. of seed per acre. The production of these seeds apparently draws heavily upon the food reserves of the plant. In one of Carter's growth study experiments the inflorescence of a seedling plant comprised 31% the total plant. During the development of the inflorescence there is a decline in dry weight of vegetative parts presumably because food reserves are being channeled into the production of flower stalks and floral parts.

During December the seed shatters over a relatively short period of time. Shattering is brought about by wind action or by some other disturbance. At first the seed lies on the surface of the ground near the parent plant but it may later be covered through trampling or soil movement by wind or water. The seed lies on or under the surface of the ground until the opening rains in April or May whereupon germination takes place once again.

After the seeds are shattered vegetative development of the parent plant begins anew. The crown stem divides during the flowering period into 2 or more parts each of which can produce leaves and roots. A seedling plant before flowering has only one crown stem, after flowering it may have 2 or 3 crown stems while a plant several years old may have many more. Each crown stem bears leaves, roots and flower stalks and is capable of independent growth.

Sometimes, especially in the drier parts of its range, where apparently reserves of soil moisture are inadequate to support further vegetative development, the onion weed plants die after their seed is shattered. In this event the plant behaves as an annual. It is not rare to see large infestations entirely composed of seedling plants even in the absence of cultivation.

Figure I-2 illustrates graphically the life cycle of onion weed. The vertical axis above the horizontal axis shows the proportion of leaves on a dry weight basis and of the crown stems and roots below the horizontal axis. The horizontal axis itself shows the time in months of the year. When plotted in this fashion the changes which take place during an annual growth cycle are readily visualized. The values for dry weight are from Carter's (1950) growth studies. The roots and crown stems have been considered the main storage organs but these growth studies have shown that there is considerable weight loss by the leaves also during the development of the inflorescence. Most of the other life history data shown in figure I-2 appear in the literature but have been varified so far as possible by observation. The inset shows the gross structure of the plant.

One feature of the life history which has not been mentioned in the literature is the dormant period immediately following the shattering of the seed. Nearly all of the seeds are dormant immediately after ripening. The number of non-dormant seeds increases with the post-ripening time. By the time the autumn rains are due the seeds are 95% to 100% germinable. Evidence for this dormancy is presented in Chapter II along with other experimental findings.

The root system of onion weed is confined to the area immediately adjacent to the plant and appears to extend downwards for several feet, usually into the calcareous C horizon. Figure I-3 illustrates diagramatically an

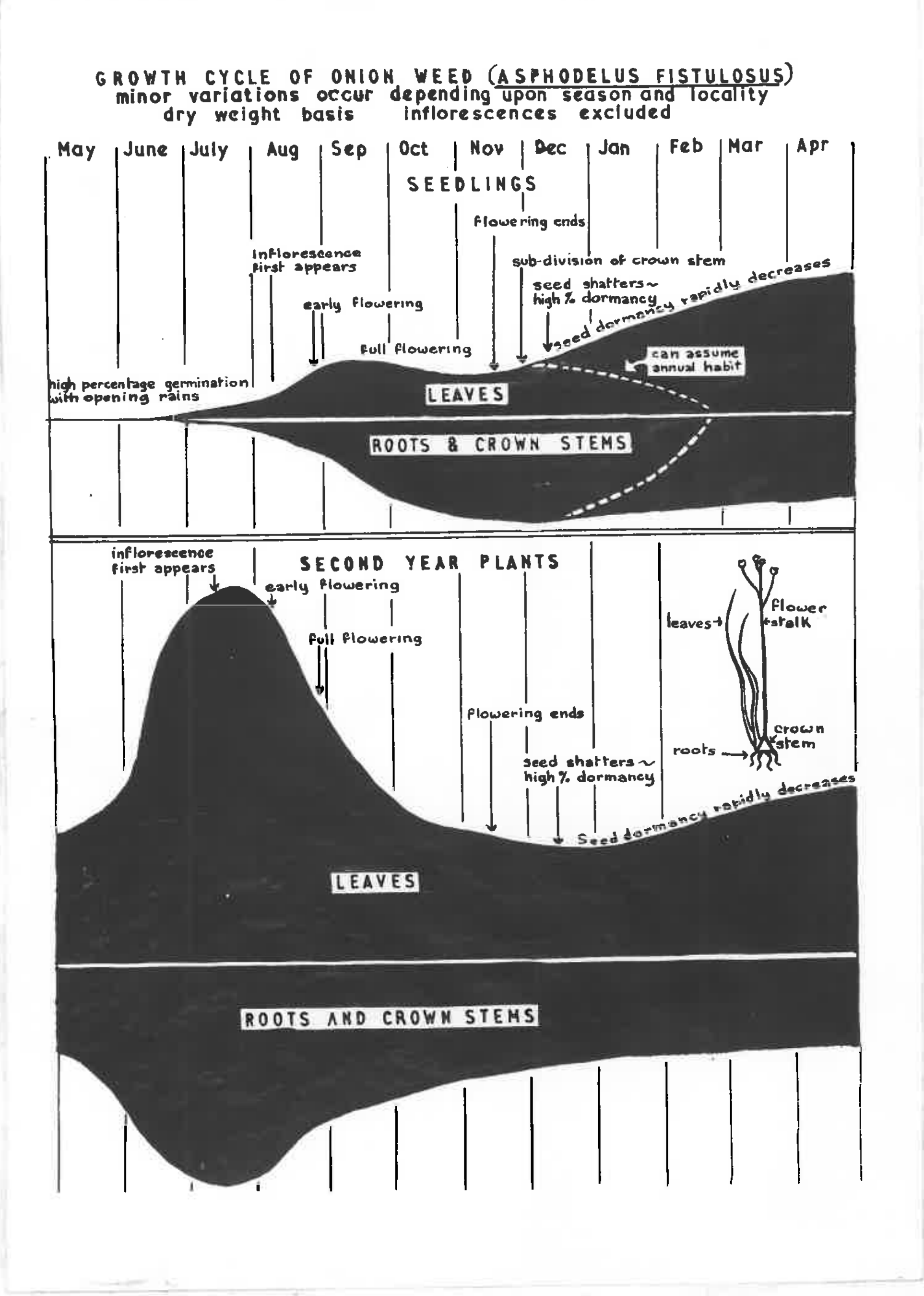

Figure I-2

The life history of onion weed.

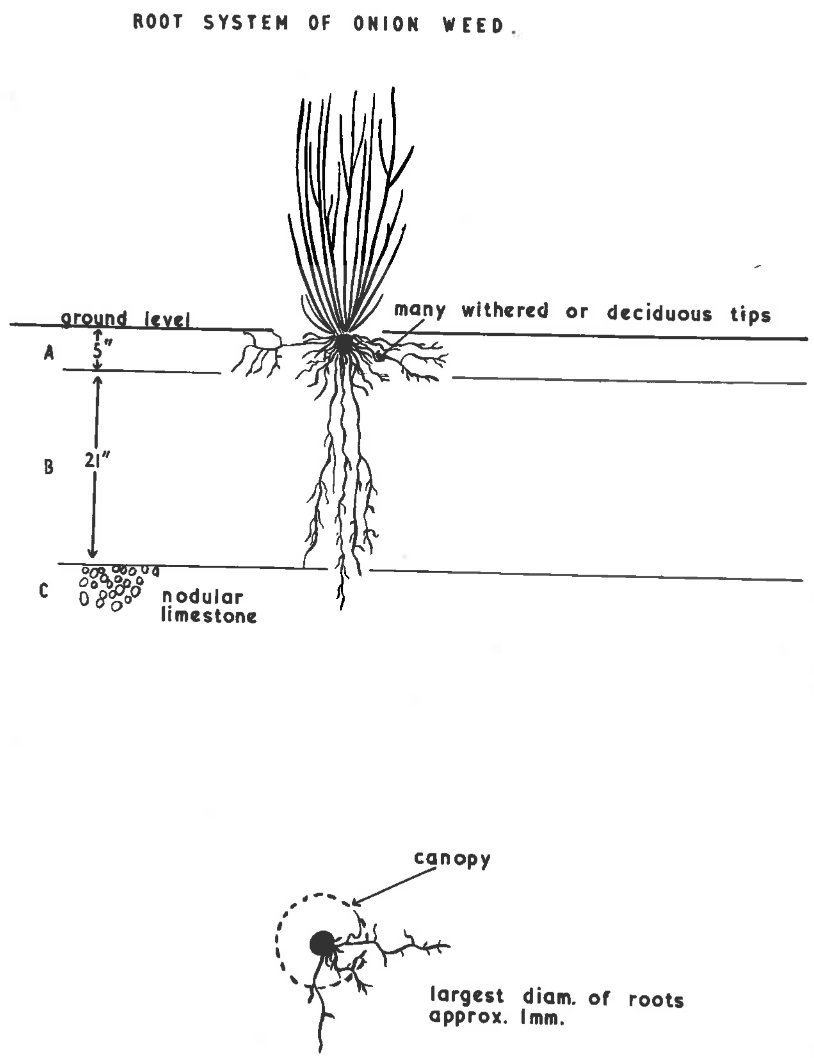

Figure I-3

The root system of onion weed diagramatically illustrated.

in-situ root excavation carried out on a solonized brown soil in the northern suburbs of Adelaide. From the degree of crown stem development this plant was adjudged to be about 2 1/2 years old at the time of excavation (November, 1953) and the distribution appeared to be representative of others which were excavated at other sites.

D. The introduction of Asphodelus fistulosus into Australia.

Plants from the Mediterranean region are prominant in the naturalized flora of southern Australia and many of these have played an important part in the development of Australian agriculture. Asphodelus fistulosus, L. is authoritatively noted (Roxburgh, 1832; Boissier, 1884; Duthie, 1911; Hutchinson and Dalziel, 1936; Loscos and Pardo, 1867; Tornabene, 1891) as occurring in the old world in Mauritania, central Sahara, eastern Sudan, Egypt, Canary Islands, Spain, Sicily, France, Greece, Crete, Cyprus, Palestine, western Himalayas up to 7,000 feet, Punjab, interior Bengal and Burma.

Several species of Asphodelus including A. fistulosus were growing in the Melbourne Botanic Garden in 1883 (Guilfoyle, 1883). In 1893 it was first reported as being among plants naturalized in Victoria (Mueller, 1893). The first volume of the Journal of Agriculture and Industry of South Australia (Anon., 1897a) devotes three pages to a discussion of onion weed and it is thus the first noxious weed to be described in that journal. The description is in part as follows: Onion weed "takes entire possession of the land wherever it obtains a footing and no animal is known to eat it". It appears that onion weed has been well established in southern Australia as a pest of pasture land for more than 57 years. Its invasion occurred at a time when sheep numbers were attaining maximum density in most states and also during the years when the rabbit was first spreading across the wheat growing districts of South Australia (Taylor, 1949). In view of the total unpalatability of onion weed it is interesting that its initial spread over large areas in southern Australia coincided with a time when pastures were being subjected to their severest attack by grazing animals.

At an Agricultural Bureau Meeting in Whyte Yarcowie in 1909 (Anon.) onion weed "was quoted as an instance of the way in which a weed originally planted as a garden flower had got away and for years was allowed to spread without any serious attempt being made to eradicate it or to brand it as a noxious weed. On one farm in this district this weed had now such a hold that it was almost impossible to get rid of it". From this and similar reports, and considering that the plant was in the Melbourne Botanic Gardens at least 10 years prior to the first report of its naturalization in the state of Victoria, it seems probable that onion weed was intentionally introduced at least once. In view of its ready establishment in southern Australia it is also probable that it became an escapee.

Many other important pasture plants from the Mediterranean region, including several important annual legumes and annual grasses were apparently introduced into Australia through accidental circumstances and it would seem unwise to preclude the possibility of one or more accidental introductions for onion weed as well.

E. The present distribution of A. fistulosus in South Australia.

In 1953 a survey was undertaken to determine the areas where onion weed occurs in South Australia. Information was solicited from each of the 100 district councils inside the counties and from members of the South Australian Stockowners Association. These correspondents reported on onion weed in their own localities and gave virtual state-wide coverage. Reports from 89 district councils and 224 stockowners may be summarized as follows:

no. of district councils reporting absence of onion weed	4
" " " " " occurrence of " "	85
" " " " " widespread occurrence of onion weed	31
" " stockowners reporting absence of onion weed in their locality	76
" " " " occurrence " " " " " "	148
" " " " widespread occurrence of onion weed in their locality	51

Among the 11 district councils from which no reports were received were several known to have heavy infestations of onion weed.

Figure I-4 illustrates the distribution of onion weed in South Australia. It is compiled from the reports of the district councils and stockowners, from unsolicited reports and from notes made following first hand observations.

Comparison of the geographical distribution in figure I-4 with Prescott's (1944) soil map suggests that most of the onion weed lies within the solonized brown soil group. Field observations confirm this. On Kangaroo Island the infested areas occur mainly on soils of this group (Carter, 1953). The occurrence of onion weed on solonized brown soils extends into the northern suburbs of Adelaide. Solonized brown soils occupy about 5.5% of the total land area of Australia or some 164,000 square miles (Taylor, 1950). In the state of South Australia, these soils carry over 1/3 of the sheep and contain over 1/2 of the wheat acreage.

Before being cleared for development the dominant plant species were small trees of the genus Eucalyptus having the mallee habit (Wood, 1929). The understory consisted of sclerophyllous shrubs of the genera Atriplex (saltbushes), Kochia (bluebushes) and Acacia with very little grass.

In southern Australia most of these soils have been under cultivation for less than 100 years. Wheat has been the main crop and sheep are kept for fat lambs and wool. Grazing is provided in the wheat stubbles by volunteer

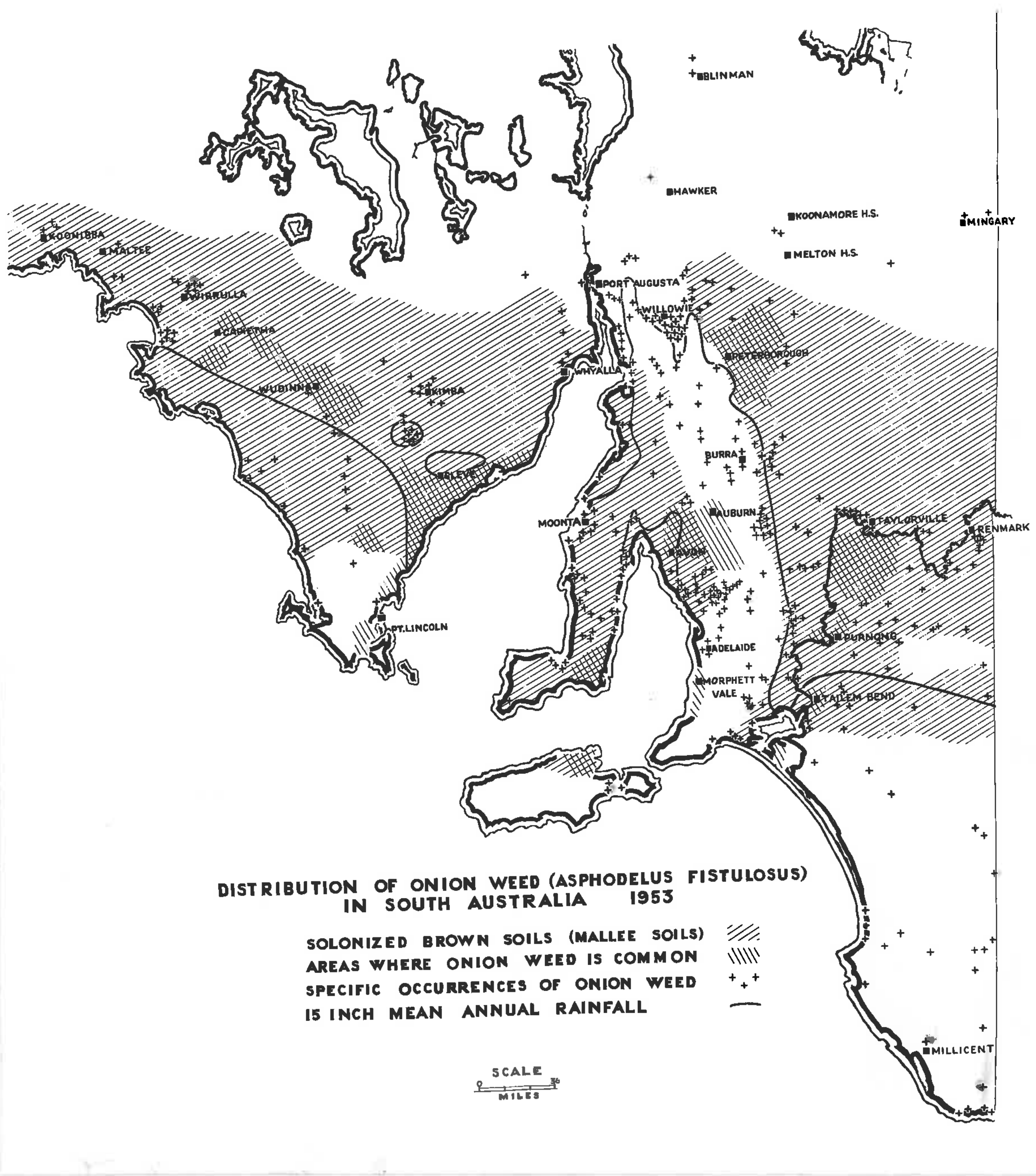

Figure I-4

The distribution of onion weed in South Australia in 1953.

annual species of grasses, legumes and forbes. Reference to the flora of South Australia (Black, 1948, 1924, 1926, 1929) indicates that the important volunteer annuals are nearly all exotics frequently of Mediterranean origin. At Avon, South Australia, in experiment no. P190 a, 20 volunteer pasture plots on ploughed up rye stubble were composed of the following species:

Species	Origin
Sisymbrium orientale	Mediterranean region
Hordeum murinum	Europe and Asia
Avena fatua	Probably Mediterranean
Bromus rigidus	Mediterranean region
B. rubens	Mediterranean region
Medicago minima	Europe, Western Asia
M. denticulata	West Europe to Mediterranean region
Melilotus indica	Mediterranean region Southern Asia
Trifolium tomentosum	Mediterranean region
Lithospermum arvense	Europe, Asia
Heliotropeum europaeum	Australia, Mediterranean region
Emex australis	South Africa
Cryptostemma calendulaceum	South Africa
Anagalis femina	Europe
Spergula arvensis	Almost cosmopolitan
Papaver dubium	Europe, Asia
Stachys arvensis	Europe
Silene nocturna	Mediterranean region
Asphodelus fistulosus	Mediterranean region to north India

On uncultivated grazing land native perennial grasses such as *Danthonia* spp. and *Stipa* spp. are important pasture grasses. Figures I-5 and I-6 show typical agricultural development of solonized brown soils.

Morphologically the solonized brown soils are characterized by a large accumulation of lime in the lower part of the profile. They vary in depth from 2 to 3 inches to several feet. Depending upon the degree of solonization and the amount of wind sorting the texture varies from medium loams to coarse sands. The "A" and "B" horizons are generally weakly differentiated and the amount of clay increases with depth. The "C" horizon may consist of nodular or travertine limestone (Prescott and Piper, 1932).

Figure I-5

A roadway near Avon, South Australia, showing a small relic community of mallee eucalypt trees on solonized brown soil. Foreground shows sward of native perennial grass which develops in cleared areas in the absence of cultivation.

Figure I-6

The wheat stubble beyond the fence shows how solonized brown soils were developed for cereal culture.

These soils have had a history of decreasing soil fertility. Nitrogen has been the nutrient most often limiting yields. Nitrogenous fertilizers are not used and the production of crops has been carried out mainly at the expense of the nitrogen reserves of the soil (Cornish, 1949). Solonized brown soils are considered low in organic matter. Actual loss of the more fertile surface layers of the soil through erosion encouraged by fallow is an additional factor which may also contribute to lower yields (Woodroffe, 1949).

The average annual rainfall over the region occupied by these soils varies between 20 inches and 8 inches per year. Nearly all of the rain falls during the winter months from May through October. Drought frequency is high due to the very variable quantity of seasonal rainfall. Consequently partial or complete crop failure and wind erosion of the soil are common features of the region. Summer evaporation rates are high. Most of the serious infestations of onion weed appear to lie on the dry side of the 15 inch isohyet.

Mean temperatures during the coldest months are generally above 50° F. which is adequate to maintain growth. Frosts in winter are seldom severe. In summer mean temperatures may exceed 75° F. while temperatures in excess of 100° F. are fairly common. Summer growth of many species is limited by lack of available soil moisture.

Future agricultural trends on these soils would appear to include the increased stocking of wheat farms and consequent increase of land under pasture enabling longer rotations to be maintained. This trend is being accompanied by increased use of improved pasture plants and by an increase in the use of phosphatic fertilizers on pasture land. More forage of higher quality, increased amounts of available soil nutrients including nitrogen and improvement in soil texture can be anticipated from the trends. Greater carrying capacity and increased grain yields should result.

A smaller but very notable infestation of onion weed in South Australia is found on desert loams immediately north of the solonized brown soils. Preliminary observations have been made at Koonamore station (figures I-7, I-8). The desert loams are similar to the solonized brown soils (Wood, 1929). They have approximately the same water retaining capacity and pH. Both contain consolidated limestone and the desert loams may even exhibit evidence of solonization as a result of clay particle dispersion by sodium ions. Desert loams grade gradually into solonized brown soils (Crocker, 1946).

In their native state in South Australia these desert loams grow low perennial shrubs such as Atriplex spp. (salt bushes), Kochia spp. (bluebushes) and Acacia spp. These may be widely interspersed with small trees. Ephemerals are prominent in the vegetation following rains.

The natural vegetation may be stocked with sheep for wool production and this is the principal agricultural use made of desert loams. The ephemerals are consumed in preference to the perennial shrubs which are thus available to carry over the stock during dry periods. Carrying capacity is low averaging about 40 sheep per square mile but falling considerably below this number in some cases. Individual holdings are large usually comprising several hundred square miles. On many properties the number of watering places for the sheep are sparsely spaced. This causes the animals to congregate on relatively small areas and results in over-grazing near the water holes. Because of adquate natural fertility or low per acre returns, commercial fertilizers are not used.

Average annual rainfall ranges between 10 and 5 inches (Stephens, 1953). Mostly the rain comes in the winter months but occasional summer monsoonal showers sweep in from the north. Rainfall is very variable and annual

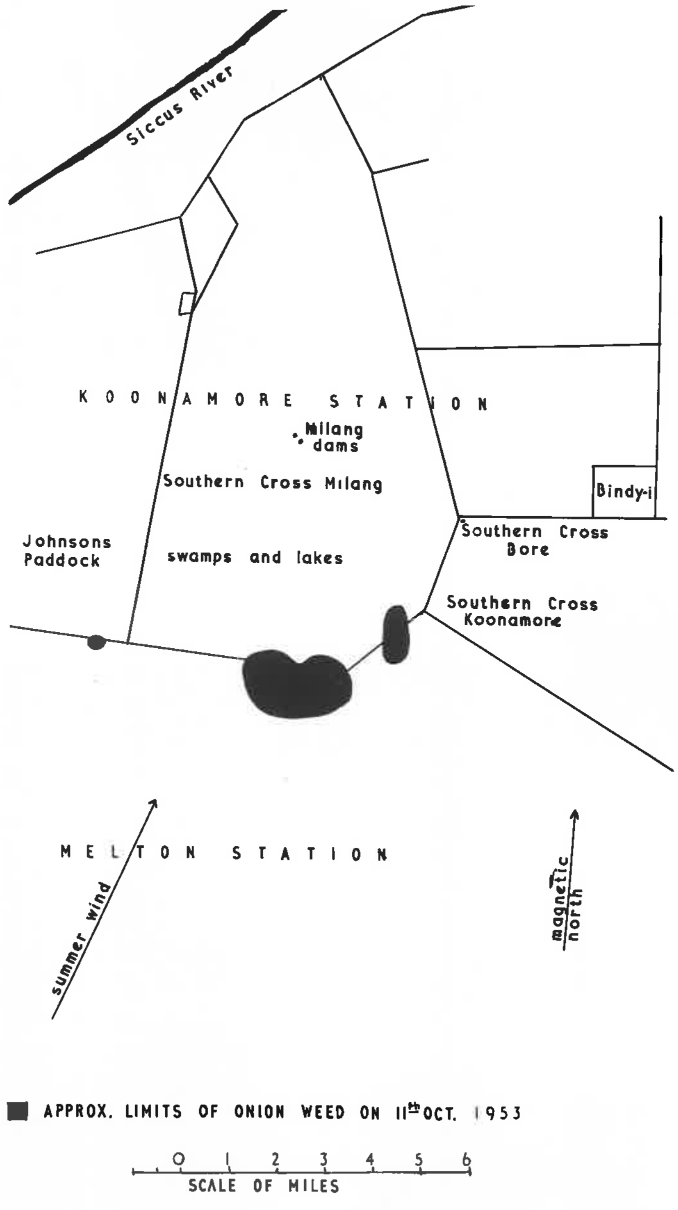

Figure I-7.

The approximate limits of onion weed infestations on Koonamore Station in 1953.

Figure I-8.

An infestation of onion weed on Koonamore Station in northern South Australia.

rainfalls up to 20 inches have been recorded. Winter temperatures are adequate to maintain growth which varies in accordance with available moisture.

Future agricultural development on desert loams in South Australia promises to be maintained along present lines. Better distribution of watering places and closer adjustment of stocking rates to the long-term capacity of the natural vegetation would seem to be necessary adjustments if a healthy situation is to be attained.

Onion weed also occurs on other soil types in South Australia. It is common on coastal sands in many parts of the state. It occurs to a much lesser degree on heavier calcimorphic soils in the vicinity of Adelaide and at Morphett Vale. The occurrences of onion weed shown in figure I-2 in the lower south east of South Australia are relatively small in extent and of minor importance relative to the infestations which occur in more northern areas. This lesser development is more likely due to relatively unfavorable environmental conditions for its development there than to its more recent introduction into that part of the state. Reports of onion weed occurring at Millicent in the lower south east in 1901 (Anon.) and in 1906 (Anon.) are on record. After the lapse of over 50 years onion weed is found only on several small areas in this district (private communication, 1953, from District Council of Millicent).

F. Distribution in other Australian states:

At the present time onion weed occurs in suitable habitats in all Australian states. It also occurs in New Zealand and in England. No reference has been found to its occurrence in the United States of America in spite of the existence of an apparently suitable Mediterranean type climate in southern California.

In northwest Victoria officers of the Department of Lands have estimated the area infested with onion weed to be greater than 200,000 acres. A preliminary survey of onion weed infestations in northwest and northern areas of Victoria was made during mid-May of 1950. There are two major infestations of onion weed in Northern Victoria. One of these is centered in the Mildura-Redcliffs region and extends westwards with decreasing density to a point some 6 miles east of Cullulleraine and southward to the vicinity of Carwarp. The other infestation is centered in the Piangle-Swan Hill region and extends westward from Piangle to the vicinity of Bolton and Koimba and southward into the Ultima and Lake Boga districts. These two major infestations are separated by a belt of low quality land held by the Crown and by forest reserves which still retain their original cover of mallee eucalypts. The infestations seem not to have reached their natural limits of distribution and smaller and widely spaced occurrences are known south and west of these 2 major infestations. These infestations in northern and northwest Victoria occur on solonized brown soils. Minor infestations occur in southern Victoria near Melbourne.

In New South Wales onion weed is spreading throughout an area between the northwest slopes and the western Riverina.

In western Australia onion weed occurs in the vicinity of Perth often associated with coastal limestone. The major occurrence is in the Geraldton area (Meadley, 1952) where limestone soils predominate. It also occurs at Esperence, Bunbury, and on Rottnest Island (Gardner, 1929). The general lack of concern over this weed in Western Australia is probably due to the fact that the wheat and sheep lands which provide suitable conditions for the spread of onion weed in more eastern states are principally on acid sands in Western Australia. No extensive occurrences of onion weed on acid sands occur in any state.

G. Agronomic aspects.

Observations of onion weed in Victoria, South Australia and West Australia indicate that it is only where the land has felt the impact of man's activities that onion weed becomes a problem. Virgin country does not support onion weed which seems to be unable to compete with the extensive surface feeding root systems of the mallee eucalypts which are native over much of the solonized brown soils (figure I-9). The pastures of Danthonia spp. and Stipa spp. which develop naturally when the mallee eucalypts are cleared have a high power of resistance. Pastures dominated by these perennial grasses are sometimes found to be completely free of onion weed in the midst of an otherwise heavily infested area. Onion weed establishes and persists where the native vegetation has been removed or disabled through disturbance of the soil or unduly severe grazing. Much of the region where the solonized brown soils occur has been broken for the cultivation of cereals and both solonized brown soils and desert loams have had to bear the brunt of too-severe grazing by sheep and rabbits. In the upper Gangetic Plain (India) onion weed is known as a weed of cultivation (Duthie, 1911). In Palestine the closely related unpalatable Asphodelus microcarpus is very prevalent on rendzina and terra rosa soils and is there regarded as an indicator of overgrazing (Dovrat, 1953).

Part of the questionnaire submitted to the district councils and the stockowners was designed to assess the nature of the damage caused by onion weed in South Australia. Correspondents were asked to indicate whether the weed interfered with crop yields or carrying capacity of pastures in their own locality:

Figure I-9

An infestation of onion weed near Redcliffs in north-west Victoria. The onion weed appears unable to invade the area near the mallee eucalypts.

number of district councils reporting reduction of crop yields	17
" " " " " " " carrying capacity	40
" " stockowners reporting reduction of crop yields	26
" " " " " " carrying capacity	64

The concensus of opinion supports the view that the principal noxious quality of onion weed is to reduce carrying capacity. The questionnaire did not distinguish the degree of noxiousness on cropland and pasture land. A number of correspondents indicated that onion weed is less troublesome on cropland than on pasture land. Experienced inspectors of the Victorian Department of Lands also consider that onion weed is more objectionable in pasture land than in cropland. Infestations on pasture land are fairly common in which onion weed is the only species of higher plant present (figures I-10, I-11). In such instances the grazing value of the land is nil, since onion weed itself is seldom if ever eaten by stock. In northwest Victoria it is estimated (Chant, 1950) that the grazing value of infested land is frequently reduced by 80%.

Sometimes onion weed occurs in strictly pastoral areas. In the drier country it has a tendency to invade the watercourse communities and to grow in the moister places which carry the best feed. The peculiar susceptibility of this habitat to capture by alien plants has been noted by Wood (1936). In "good" years onion weed may spread from the watercourses onto higher ground.

On Koonamore Station onion weed actively competes with the saltbush dominants. Osborn, Wood and Paltridge (1932) mention the tendency of debris and seeds to collect around the bases of the saltbushes. Near the margins of infested land on Koonamore Station onion weed plants can be seen clustered at the base of single saltbushes and saltbush plants can be observed in all stages of dying off due to the excessive competition provided by the numerous onion weed plants (figure I-12). Under such conditions even moderate grazing by sheep, kangaroos or rabbits may have a greatly intensified effect upon the

Figure I-10

Close-up view of an extensive uncultivated onion weed infestation near Taylorville, South Australia, in which palatable plants are completely absent.

Figure I-11

Close-up view of an extensive uncultivated onion weed infestation in northwest Victoria. The small clumps on the ground are groups of onion weed seedlings. No other species of higher plants were germinating.

Figure I-12

Dead saltbush plant near the margin of an onion weed infestation at Koonamore Station showing onion weed plants clustered at its base.

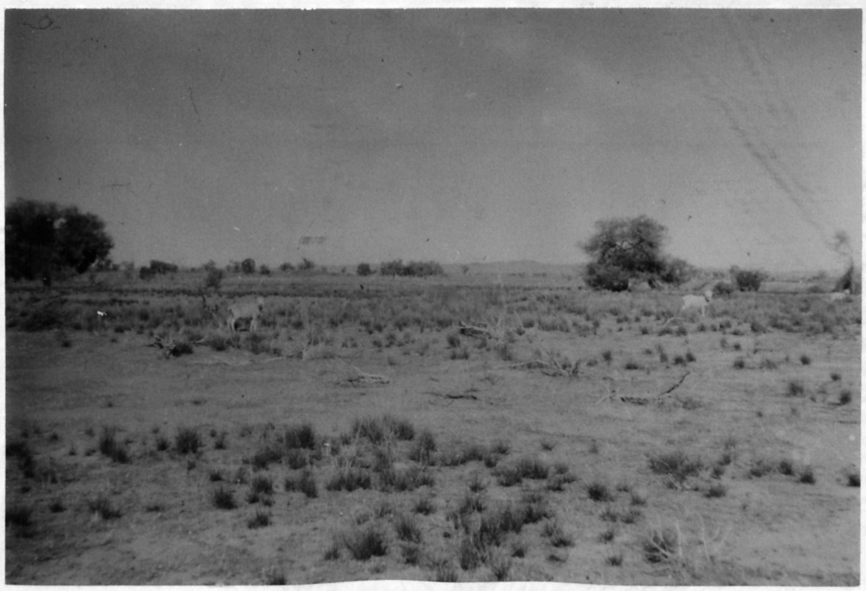

Figure I-13

Sheep grazing on Melton Station, South Australia, in an onion weed infestation on newly germinated grasses and forbes.

survival of the saltbush community. Near the centers of the onion weed infestations at Koonamore saltbushes do not occur (figure I-8).

The dry northern country characterized by low carrying capacity and large properties is especially susceptible to overstocking. On Melton Station the writer saw sheep grazing in a heavy onion weed infestation on seedling grasses and forbes scarcely 1/2 inch high (figure I-13).

Consideration of the life history of onion weed (figure I-2) suggests that the weed is well adapted to coexistence with the wheat crop. It germinates at seeding time and is protected from effective control measures by the presence of the crop. Seed of onion weed matures at about the same time as that of the wheat crop and the harvesting activity helps to distribute the seed of onion weed. An important growth period takes place in the stubble after competition from the crop has ceased. Subsequent grazing of the stubble reduces competition from volunteer growth of other species to the advantage of the onion weed which is not eaten by stock or rabbits. Regular cultivation for cropping purposes prevents the establishment of desirable native perennials. Onion weed appears to have encountered a familiar environment in the wheat lands of southern Australia. Ghose (1902) reports that in India onion weed "is almost as common as the wheat stalks on some of the poorer cultivated lands in the southern Siwaliks".

There are claims that onion weed will "choke itself out" if left alone. No such area has been observed by the writer. Frequent cultivation or disturbance of the soil is not necessary for the establishment, persistence and spread of onion weed. On allotments 1 and 2, Parish of Tulillah in northwest Victoria (figure I-14) the course of the weed has been noted for 15 years. In 1935 2 plants were observed. By 1950 onion weed had spread from this spot and covered more than 100 acres. There was no cultivation during

Figure I-14

15-year-old stand of onion weed on uncultivated land allotments 1 and 2, Parish of Tulillah, northwest Victoria. Onion weed is thick on both sides of the fence.

this period (Moss, 1950). Block 27 Piangle West in N.W. Victoria carried a thriving stand of onion weed for 9 years without cultivation and without diminution of the infestation (Chant, 1950). It is not known to what extent grazing has been a factor in the maintenance of these infestations but in each case rabbits were in evidence when the infestations were visited in 1950.

In its initial stages of establishment in a new area onion weed is frequently overlooked, so that it becomes well established before control measures are attempted. The seeds contain no wings, hairs, plumes, spines, hooks, or special means of dispersal. However the weight and surface texture of the seed and the location of the inflorescence on the plant are such that the seed is easily dislodged into machinery, automobiles, wool, fur, or clothing where it may be carried for considerable distances. The high seed numbers increase the opportunity for such lodgement. Everything of sufficient size that moves in onion weed country may be suspected of being an agent in its dispersal.

There are many reports of onion weed seeds having been first carried into an area in seed wheat or feed. Other reports credit the dispersal agents with being open water channels and mallee roots which are carted for firewood. An important agent for local dispersal appears to be windborne sand. Blocks 25 and 26, Parish of Prooinga are considered to be the origin of onion weed in the Manangatang and Piangle Inspectorates of Victoria, the onion weed seed having originally arrived in seed wheat. After the 1943-1944 drought onion weed spread to many new areas in sand drifts but only in the direction of the prevailing wind. Similar reports have been received from widely separated regions and they suggest that onion weed seed is spread locally in sand drift especially during drought years.

Reports have been received of onion weed having been introduced to control sand drift and this ability to hold soil on drifts and flooded country is sometimes considered to be a redeeming feature of the weed. However it is more likely the unpalatability of onion weed which protects it from rabbits and stock rather than its drought resistance which makes it useful for this purpose. If grazing were effectively controlled other plants might do a better job of erosion control and provide valuable feed during good years.

Ghose (1902) reports on the value of onion weed for human food (seeds), for pigeon food (seeds), for glue ("bulbs") and for paper manufacture (leaves and stalks). The seeds, leaves and bulbs are said to have a diuretic action when consumed. Ghose gives a partial analysis of the seed and reports that the seeds yield a good drying oil. Several samples of onion weed seed from southern Australia were analyzed by R. E. Shapter of the C.S.I.R.O. (Waite Institute) and were found to contain from 18% to 24% of oil.

H. The control of *Asphodelus fistulosus*.

The well-known measures used for the control and eradication of weeds fall into four categories:

1. Mechanical methods include pulling, hoeing, tillage, mowing, rolling or burning. Hand pulling and tillage are the main control measures used against onion weed and other methods are seldom tried (figures I-15, I-16). A certain amount of extra cultivation is sometimes used to clear onion weed land prior to the sowing of a crop. A mouldboard plough is often used initially and the land is then cultivated 3 or 4 times before a satisfactory seedbed is obtained. The additional working tends to eliminate other weeds more competitive to the crop than onion weed and this may give rise to the claim that higher yields are obtained from such land.

Ordinary cropping sequences are not adequate to eliminate onion weed permanently. Allotments 22 and 35 Piangle West (Victoria) are worked on

Figure I-15

Control of onion weed through tillage in northwest Victoria. The land is being prepared for wheat. The previous year the land was ploughed (right). Now it is being worked again (left).

Figure I-16

Close up of onion weed stand (right in figure I-15) one year after deep ploughing with a mouldboard plough.

a rotation of wheat, oats, fallow, fallow and it is reported that after 2 years of "fallow" they are "a green mass of onion weed" (Chant, 1950). A reliable report suggests that onion weed seed can remain viable in the ground for 10 years. It is estimated that 4 or 5 consecutive years of cultivation are required to eliminate a heavy infestation of onion weed. Such prolonged treatment is seldom practical due to the very real danger from wind erosion when typical onion weed soils are exposed to excessive cultivation and also because the cost of maintaining the cultivation in the absence of any return from cropping may be prohibitive. If the land is cropped and even a few plants are able to set seed in the crop, these may be sufficient to nullify all previous gains through cultivation. A dozen plants per square chain produce sufficient seeds in their first year to provide an infestation of one plant per square link the following year.

2. Chemical methods of weed control consist of soil or foliar applications of selective or non-selective toxic substances. Petroleum oils, sodium chlorate, arsenic pentoxide and hormone-like substances have been used successfully to kill onion weed (Anon., 1937; Richardson, 1953). The use of arsenic is limited to areas from which stock can be excluded. Onion weed is not very susceptible to hormone-like herbicides so that relatively high concentrations must be used. Onion weed infestations typically occur on land with a low per acre value which cannot reimburse the expense of large scale spraying with even the cheapest of these substances. For these reasons the use of chemical sprays may be limited to small portions of an infestation such as fence lines (figure I-17) and rough or stoney patches which cannot be attacked by cheaper methods.

Figure I-17

Uncontrolled onion weed plants along a fence line may be a source of reinfestation. Such plants may be controlled best by spraying. Halbury, South Australia.

3. Methods utilizing the superior competitive ability of desirable pasture plants have seldom been tried on onion weed. Prior to the present study little information was available as to the relative merits of the various pasture species as competitors of onion weed. Wimmera rye grass, *Phalaris tuberosa*, subterranean clover and lucerne have been recommended for the control of onion weed at Booleroo Center (Anon., 1937) but the experimental basis of this recommendation is not given. Klau (1949) reports having used wimmera rye grass, *Phalaris tuberosa*, lucerne and oats for control of onion weed. The effect of these pasture plants on the onion weed is not clearly stated but the trial seems not to have been wholly successful. Mr. Clive Duval of Pembury, Morphett Vale (mean annual rainfall 22.65 inches) has used a *Phalaris tuberosa*-subterranean clover pasture effectively in the control of onion weed but under rainfall conditions more favorable than those of typical onion weed country. Major onion weed infestations occur on soils too alkaline for the successful growth of subterranean clover and too dry for the successful growth of *P. tuberosa*.

4. Biological control methods which utilize highly specific predators to destroy a weed species have achieved spectacular success in relatively few instances. This type of control has no significance for the vast majority of weeds in the foreseeable future. Exhaustive study involving considerable expense must yield favorable results before the deliberate introduction of any predaceous organism can be considered sufficiently promising to incur the risks involved and funds are available to initiate such study only in the most promising cases. In Palestine *Asphodelus microcarpus* (*A. aestivus*, Brot.) has a leaf eating insect predator (Dovrat, 1953).

Often not one but several methods in combination are best for the control of a given weed species in a particular circumstance. Whatever method of control is chosen some knowledge of the autecology of the weeds and of their associated crop and pasture plants is essential for its efficient application. That is to say that it is necessary to appreciate at least in part the way in which the structure and function of the species are governed by the edaphic, climatic, and biotic and the chemical and physical factors of the environment (Daubenmire, 1947). This study is not new. The lore of husbandry is based upon many an autecological observation. The soundest systems of husbandry are based upon experimental findings. The main purpose of the series of investigations described in this paper has been to add to this stock of lore for the case of onion weed.

The foregoing account is an appraisal of the situation which existed in respect to onion weed at the beginning of the present investigations. This appraisal itself and the studies on which it is based form an important part of the investigations.

II. Experimental

The preliminary reconnaissance and a consideration of the previous work stressed the lack of information as to the relative merits of the various adapted pasture plants as competitors of onion weed and as to the feasibility of plant competition as a control measure, especially on solonized brown soils. In May, 1951, two series of trial plots were initiated to study the development and persistence of onion weed in a number of pasture communities. One series was at Avon, in the South Australian Mallee and the other was at the Waite Institute.

A. Experiment no. P190 a.

This experiment was carried out on a typical wheat and sheep property at Avon, South Australia. Avon lies inside the boundary of the solonized brown soil group as delimited by Prescott (1944). These soils carry the most extensive and the most serious infestations of onion weed. Examination of the soil profile at the site of the experiment showed it to conform to soils in this group described by Prescott and Piper (1932). The surface soil was a friable brown loam with a pH of about 7. The soil increased in clay content, limestone and pH with depth, finally abutting on massive travertine limestone. There was considerable variation in the depth of the massive limestone under the plots. Along the northern edge it occurred at about 8 inches and gradually increased in depth to four feet or more along the southern edge of the plots.

There is no official weather recording station at Avon. It lies slightly on the dry side of the mean annual 15 inch isohyet (Trumble, 1948).

Avon is approximately midway between Port Wakefield with a mean annual rainfall of 13.14 inches and Balaklava with a mean annual rainfall of 15.44 inches. Local opinion places the mean annual rainfall at Avon at about 14 inches. The rainfall in inches near the site of the experiment during the years of the experiment was as given below:

	1951	1952	1953
Jan.)	Approximately	1.74	0.00
Feb.)	0.50	0.00	0.00
Mar.)		0.04	0.25
Apr.	1.80	2.06	0.30
May	1.96	4.81	0.32
June	3.49	0.90	1.91
July	3.37	0.67	1.03
Aug.	1.95	2.08	1.42
Sept.	0.64	1.88	1.25
Oct.	2.36	0.86	1.58
Nov.	0.00	2.70	0.63
Dec.	1.31	0.19	To Nov. 23rd
Total	17.38	17.93	9.39 To Nov. 23rd

Other climatic values for Avon which have been obtained by interpolation of data for stations at Port Wakefield and Balaklava are as follows:

Mean rainfall season	5.7 months
Frequency of drought years	45%
Mean air temperature for coldest month	51° F.

The mean P/E^m for Avon as calculated from interpolated data is:

Annual	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
0.62	0.13	0.13	0.18	0.38	0.73	1.02	0.88	0.78	0.50	0.31	0.17	0.12

$m = 0.73$

Data for mean rainfall season, frequency of drought years, mean air temperature of coldest month, precipitation (P) and evaporation (E) for Port Wakefield and Balaklava are from Trumble (1948).

The mean rainfall season in months indicates the number of months with effective rainfall and provides "a measure of the average length of the growing season for surface-rooted annual plants". Effective rainfall is rainfall in excess of 1/3 of the standard evaporation for months having evaporation of 6 inches or less and 1/4 of the standard evaporation for months having evaporation in excess of 6 inches.

The frequency of drought years indicates "the number of years in 100 in which the season of continuously effective rainfall is less than 5 months". The best of the wheat growing areas of South Australia have a drought frequency of 20-30% while the marginal wheat areas show values of 60-70% (Trumble, 1948).

50° F. is taken as the threshold value for growth in mid winter. Below this value there is a "substantial check" to growth while above this value active growth may still be made (Trumble, 1948).

Prescott (1949) considers P/E^m to be the most efficient single climatic index where:

P	represents	precipitation
E	"	evaporation from a free water surface
m	"	a constant with a mean value of 0.73

For this index a monthly value of 0.54 is adequate "to start and maintain growth after the break of drought". The grey and brown soils lie between annual values of 0.47 and 0.92.

At the time the ground was prepared for the experiment the area was carrying a uniform cover of onion weed plants one year old. The previous autumn the area had been sown to cereal rye in an attempt to control the onion weed. The rye had not been harvested but had been allowed to stand in the field.

Aim: To study the establishment and persistence of onion weed in several types of pasture and to study the effect of soil applications of ammonium sulphate on the establishment and persistence of onion weed. The ammonium sulphate was applied to enable the role of nutrient nitrogen to be assessed.

Design: A factorial design with randomized blocks was chosen for the experiment. There were 25 treatments in all. Five of the treatments consisted of 5 different types of pasture:

1. Volunteer pasture: no grass or legume seeds sown.
2. Wimmera rye grass (_Lolium rigidum_) pasture: 6 lbs. of wimmera rye grass seed per acre.
3. Perennial veldt grass (_Ehrharta calycina_) pasture: 3 lbs. of perennial veldt grass seed per acre.
4. Lucerne (_Medicago sativa_) pasture: 3 lbs. of lucerne seed per acre.
5. Mixed pasture:
   1/2 lb. wimmera rye grass seed per acre.
   2 lbs. barrel medic (_Medicago tribuloides_) seed per acre.
   1 lb. perennial veldt grass seed per acre.
   1 lb. lucerne seed per acre.

Each pasture treatment received 5 different rates of ammonium sulphate:

N1 :	0	lbs.	ammonium	sulphate	per	acre	or	0	lbs.	nitrogen	per	acre.
N2 :	28	lbs.	"	"	"	"	"	5.6	lbs.	"	"	"
N3 :	56	lbs.	"	"	"	"	"	11.2	lbs.	"	"	"
N4 :	112	lbs.	"	"	"	"	"	22.4	lbs.	"	"	"
N5 :	224	lbs.	"	"	"	"	"	44.8	lbs.	"	"	"

There were 4 replications of each of these 25 treatments making 100 plots in all.

All plots received basal dressings of 112 lbs. of commercial superphosphate per acre and 1 lb. of onion weed seed per acre (1.45 viable seeds per square link). The onion weed seed was a bulked sample of seed from four localities in northwest Victoria. It was planned to top-dress the plots with fertilizer each year. The size of one plot was 1/200 acre.

Soil preparation: An area approximately 2 3/4 chains x 3 1/4 chains (0.9 acres) was cultivated with a rotary hoe to a depth of about 6 inches. This gave a fine even seedbed. The area was then marked off into 100 rectangular plots each 20 links by 25 links. Pathways 5 links wide were left between all plots and a headland 15 links wide was left around the outside of the plots. The plots were numbered consecutively from 1 to 100 and apportioned into 4 blocks. The 25 treatments were randomized against the plot numbers in each block.

Planting data: On the 17th of May, 1951, the seed and fertilizer was broadcast on the plots by hand in strict accordance with the above plan. The plots were raked lightly to cover the seed. On the 13th, 14th, and 15th of May the area had had 0.89 inches of rain. An additional 0.72 inches fell before the end of the month. An inspection of the plots on the 3rd of July, 1951, indicated that the seed of all sown species had germinated well.

Post-planting care: Soon after sowing the plots the experimental area was fenced with barbed wire and rabbit-proof netting to protect the plots from grazing by livestock and rabbits. In order to control the growth of weeds on the pathways and headlands they were cultivated once or twice each season with a rotary hoe. Some cereal rye volunteered in the plots and this was removed during the first few months of the experiment by hand weeding in order to prevent its interference with the pasture treatments. This was done with only minor disturbance to the other species present.

The appearance of the experiment is shown in figures II-1, II-2 and II-3.

The operations which were carried out in order to determine the trends of this experiment are discussed in chronological order.

Figure II-1

Foreground shows experiment no. P190 a. at Avon looking toward southwest corner. Background shows sand ridge beyond. Note onion weed ascending ridge.

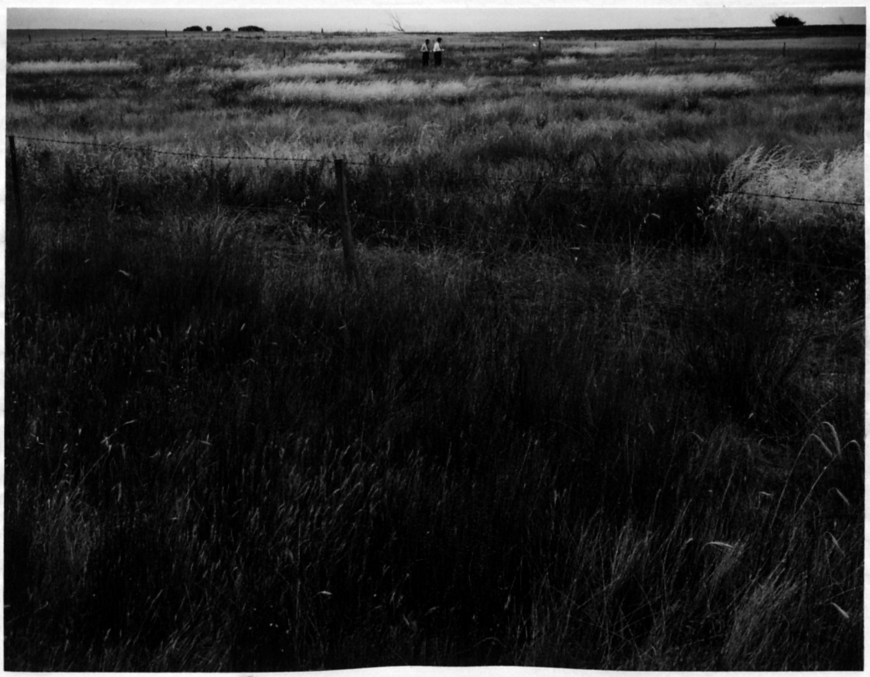

Figure II-2

Experiment no. P190 a. looking toward distant northwest corner. Foreground shows dense stand of onion weed outside of the experimental area. Background shows general view of plots inside of experimental area.

Figure II-3

Experiment no. P190 a. Three plots in block B. Foreground shows an N1 lucerne pasture. Middle shows an N4 volunteer pasture and the background shows an N5 perennial veldt grass pasture.

Establishment counts: To discover the way in which the sown species were becoming established on the plots they were counted on a portion of each plot. A quadrat 2 links square was used. This was placed uniformly in three pre-determined positions on each plot. All seedlings of the sown species which lay within the quadrat were counted. In this manner 6 square links of each plot were counted from the 7th to the 24th of August, 1951. Table 1 summarizes these results.

Examination of this table indicates that the experimental area contained a high natural population of Wimmera rye grass. In a number of cases treatments which did not include Wimmera rye grass do not differ significantly in number of rye grass plants from the treatments which received 6 lbs. of this seed per acre. One of the highest counts of Wimmera rye grass seedlings (19.5 seedlings per square link) was obtained on plot no. 80 which was sown only to onion weed and perennial veldt grass. An inspection of the site revealed a uniformly dense sward of Wimmera rye grass at its eastern end involving blocks B and D. A band of drill width could be discerned to form an arc across this end of the experiment suggesting a partial sowing of a portion of the paddock to Wimmera rye grass one or two years previously. The mean number of Wimmera rye grass plants per block was:

Block no.	A	B	C	D
Plants/square link	1.63	4.46	1.59	4.28

Difference for significance: 5% 2.56
2% 2.80

This shows that blocks B and D contained over 2 1/2 times as many plants as blocks A and C. It was considered that the large number of Wimmera rye grass plants on blocks B and D was not typical and that they would confuse the interpretation of the experiment by preventing the establishment of less vigorous species and by interacting with their effects. For this reason data for

Table 1

Experiment No. P190 a - Avon, S. A.

Number of plants per square link. August 1951.

Mean of blocks A, B, C, and D.

Treatment		Onion weed	Wimmera rye grass	Perennial veldt grass	Barrel medic	Lucerne
Volunteer pasture	N1	1.21	0.00	0.00	0.10	0.00
	N2	0.85	0.35	0.00	0.06	0.00
	N3	0.62	2.79	0.00	0.06	0.00
	N4	0.85	0.08	0.00	0.10	0.00
	N5	0.71	0.00	0.00	0.02	0.00
Wimmera rye grass pasture	N1	0.42	9.27	0.00	0.06	0.00
	N2	0.67	6.33	0.00	0.10	0.00
	N3	0.62	10.75	0.00	0.06	0.00
	N4	0.65	8.21	0.00	0.02	0.00
	N5	0.25	7.69	0.00	0.06	0.00
Perennial veldt grass pasture	N1	0.81	1.17	2.16	0.10	0.00
	N2	0.75	0.27	1.21	0.06	0.00
	N3	0.83	3.67	1.21	0.02	0.00
	N4	0.73	2.58	1.04	0.13	0.00
	N5	0.69	4.94	1.52	0.19	0.00
Lucerne pasture	N1	1.10	0.13	0.00	0.02	3.91
	N2	0.71	1.44	0.00	0.08	3.46
	N3	1.06	0.08	0.00	0.08	3.21
	N4	0.75	0.69	0.00	0.00	2.87
	N5	0.60	0.06	0.00	0.02	3.29
Mixed pasture	N1	0.94	0.71	0.29	0.90	0.92
	N2	0.79	0.81	0.23	0.94	1.25
	N3	0.62	4.63	0.52	0.96	1.25
	N4	0.54	3.81	0.40	0.73	0.94
	N5	0.50	3.63	0.23	0.77	1.02
Difference for significance	5%	0.43	5.27			
	1%	n.s.	7.00			
	0.1%	n.s.	9.07			

blocks B and D are excluded from consideration in the present paper. Data on all four blocks are presented in most of the tables but only blocks A and C are analyzed or discussed. Data for establishment counts on blocks A and C only are summarized in table 2.

Harvest, 1951: Samples of the herbage were taken from the several plots in order to estimate their yield and botanical composition. A strip 2 1/2 links wide just inside the border of each plot was eliminated from the sampling. The remainder of each plot was considered to be divided into 48 sections each 2 1/2 x 5 links. Two of these sections were randomly selected for harvest on each plot. A rectangular quadrat 2 1/2 x 5 links was used to define the edges of the section to be cut. A portable sheep-shearing plant was used to cut the herbage close to the ground. Hand shears were used to cut a few plots. The sample so cut was placed in a numbered bag for transportation to the laboratory. Two such samples were cut from each plot to make the area sampled from each plot total 25 square links.

In the laboratory the samples were weighed and if large they were subsampled. The samples and subsamples were then placed in an oven and dried at approximately 90° C. under forced draught to constant weight. Drying was commenced within 24 hours of cutting the samples and was completed after 12 to 24 hours in the oven. The samples and subsamples were cooled in the oven and weighed immediately after cooling. From this data it was possible to calculate the yield in dry weight per acre. This is shown to the nearest pound in table 3.

The dried samples and subsamples were separated into the following 8 groups according to species:

Table 2

Experiment No. P190 a - Avon, S. A.

Number of plants per square link. August 1951.

Mean of blocks A and C.

Treatment		Onion weed	Wimmera rye grass	Perennial veldt grass	Barrel medic	Lucerne
Volunteer pasture	N1	0.88	0.00	0.00	0.04	0.00
	N2	0.88	0.38	0.00	0.00	0.00
	N3	0.63	0.17	0.00	0.13	0.00
	N4	0.67	0.13	0.00	0.08	0.00
	N5	0.96	0.00	0.00	0.04	0.00
Wimmera rye grass pasture	N1	0.33	7.63	0.00	0.04	0.00
	N2	0.63	6.75	0.00	0.08	0.00
	N3	0.67	7.00	0.00	0.00	0.00
	N4	0.67	7.17	0.00	0.00	0.00
	N5	0.29	6.25	0.00	0.13	0.00
Perennial veldt grass pasture	N1	0.83	0.04	2.58	0.08	0.00
	N2	0.54	0.13	0.83	0.00	0.00
	N3	0.92	0.00	1.54	0.04	0.00
	N4	0.88	0.21	1.04	0.21	0.00
	N5	0.88	0.04	2.42	0.38	0.00
Lucerne pasture	N1	1.29	0.17	0.00	0.00	4.54
	N2	0.50	0.04	0.00	0.17	3.00
	N3	0.92	0.00	0.00	0.13	2.58
	N4	1.13	0.04	0.00	0.00	3.42
	N5	0.54	0.13	0.00	0.04	3.46
Mixed pasture	N1	0.96	0.63	0.25	1.04	1.04
	N2	0.83	0.75	0.25	0.88	1.13
	N3	0.46	0.79	0.42	0.75	1.41
	N4	0.33	0.88	0.29	0.63	1.00
	N5	0.58	0.96	0.25	0.75	1.08
Difference for significance	5%	0.40	1.61			
	1%	0.54	2.18			
	0.1%	n.s.	2.92			

Table 3

Experiment No. P190 a - Avon, S. A.
Yield of all species in lbs. oven dry weight per acre.
29th October, 1951.

Treatment		Block A	Block B	Block C	Block D	Mean A & C
Volunteer pasture	N1	2088	1490	2421	1962	2255
	N2	1944	2047	1936	1463	1940
	N3	1489	1619	1620	1789	1555
	N4	1304	1882	1659	2118	1482
	N5	1693	1669	1933	1956	1813
	mean					1809
Wimmera rye grass pasture	N1	1866	2527	2983	1718	2425
	N2	1264	2260	2547	1925	1906
	N3	2518	2173	3083	1643	2801
	N4	2892	2054	1841	1947	2367
	N5	4009	2861	4357	2124	4183
	mean					2736
Perennial veldt grass pasture	N1	1531	1933	1532	1803	1532
	N2	1693	1929	1982	1786	1838
	N3	1660	1680	1164	1448	1412
	N4	1757	1864	1885	1708	1821
	N5	1300	1459	1276	2381	1288
	mean					1578
Lucerne pasture	N1	1747	1737	1672	1725	1710
	N2	1089	2121	1994	1782	1542
	N3	1736	1432	2379	2164	2058
	N4	1961	1797	1837	1905	1899
	N5	1080	2082	1849	1468	1465
	mean					1735
Mixed pasture	N1	2325	2042	2147	2232	2236
	N2	3130	2193	2569	1857	2850
	N3	1362	2353	2476	2038	1919
	N4	2052	1620	2115	1810	2084
	N5	1790	1654	2785	2409	2288
	mean					2275
	MEAN	1891	1939	2162	1886	2027

Means for Nitrogen

	N1	N2	N3	N4	N5
Blocks A and C	2032	2015	1949	1931	2208

Analysis of variance for blocks A & C; Difference for significance

Variance due to:	Variance ratio:			means of 2	means of 10
Treatments	4.47	***		2	10
Nitrogen	less than 1				
Pasture	13.54	***	5%	815	364
Nitrogen x Pasture	3.14	**	1%	1087	486
Blocks	4.97	*	0.1%	1423	636

1. Onion weed.

2. Wimmera rye grass.

3. Other annual grasses. These were mainly barley grass (Hordeum murinum), rigid brome (Bromus rigidus), red brome (B. rubens), Bromus spp., wild oats (Avena fatua), Vulpia sp., and cereal rye (Secale cereale).

4. Barrel medic (Medicago tribuloides).

5. Other annual legumes. These were mainly woolly burr medic (Medicago minima), burr medic (M. denticulata), King Island melilot (Melilotus indica), and woolly clover (Trifolium tomentosum).

6. Perennial veldt grass.

7. Lucerne.

8. Miscellaneous species. These were mainly wild mustard (Sisymbrium orientale), ice plant (Cryophytum crystallinum), cape weed (Cryptostemma calendulaceum), 3-cornered jack (Emex Australis), sheep weed (Lithospermum arvinse), heliotrope (Heliotropium europaeum), blue pimpernel (Anagalis femina), corn spurry (Spergula arvensis), wild poppy (Papaver spp.), stagger weed (Stachys arvensis), and Silene nocturna.

After separation each group from each sample was weighed. A correction was applied to convert the hand separated groups from air dry weight to oven dry weight.

The exact amount of onion weed was difficult to determine because small pieces could not be identified confidently in a dried condition by ordinary methods. Direct examination of the plots indicated that small amounts of onion weed were present on all of them. The hand separation of the harvested samples indicated that plot no. 79 (Block D N1 mixed pasture) contained a trace of onion weed and that plot no. 99 (Block D NO lucerne pasture) contained 7 lbs. per acre.

The mean yield of each group in lbs. per acre for blocks A and C is presented in Table 4.

Table 4

Experiment No. P190 a - Avon, S. A.

Yield in lbs. oven dry weight per acre - 29th October, 1951.

Mean of blocks A and C only.

Treatment		Onion weed	Wimmera rye grass	Other annual grasses	Barrel medic	Other annual legumes	Perennial veldt grass	Lucerne	Misc. species	Total
Volunteer pasture	N1	0	103	273	40	538	0	0	1301	2255
	N2	0	79	382	4	430	0	0	1047	1940
	N3	0	7	196	107	269	0	0	977	1555
	N4	0	34	127	5	293	0	0	1024	1482
	N5	0	7	573	7	218	0	0	1010	1813
	Mean	0	46	310	33	350	0	0	1072	1809
Wimmera rye grass pasture	N1	0	887	34	1	408	0	0	1096	2425
	N2	0	1352	54	13	135	0	0	354	1906
	N3	0	1553	474	0	249	0	0	526	2801
	N4	0	1823	197	9	136	0	0	202	2367
	N5	0	2840	623	23	99	0	0	599	4183
	Mean	0	1691	276	9	205	0	0	555	2736
Perennial veldt grass pasture	N1	0	27	88	82	347	9	0	980	1532
	N2	0	102	136	24	417	17	0	1142	1838
	N3	0	40	299	0	285	11	0	778	1412
	N4	0	12	210	83	355	20	0	1143	1821
	N5	0	109	179	118	197	12	0	675	1288
	Mean	0	58	182	61	320	14	0	944	1578
Lucerne pasture	N1	0	140	180	0	250	0	192	949	1710
	N2	0	2	48	49	165	0	272	1007	1542
	N3	0	82	101	157	446	0	159	1115	2058
	N4	0	0	158	10	409	0	213	1110	1899
	N5	0	12	249	43	207	0	175	780	1465
	Mean	0	47	147	52	295	0	202	992	1735
Mixed pasture	N1	0	292	290	484	322	2	52	769	2236
	N2	0	228	480	309	578	4	26	1226	2850
	N3	0	261	61	567	110	3	88	831	1919
	N4	0	525	234	449	160	2	53	661	2084
	N5	0	430	71	208	282	0	34	1263	2288
	Mean	0	347	227	403	290	2	51	955	2275
	MEAN	0	438	228	112	292	3	51	904	2027

Top dressing the plots, 1952: Additional fertilizer treatments were applied to the plots on the 24th of April, 1952. 112 pounds of superphosphate per acre were applied to all plots. The rate of application of ammonium sulphate was double that of the previous year and conformed to the following amounts:

N1 plots	nil.
N2 plots	56 lbs./acre.
N3 plots	112 lbs./acre.
N4 plots	224 lbs./acre.
N5 plots	448 lbs./acre.

The fertilizer was broadcast evenly on the plots by hand.

Relative frequancy of onion weed: On 30th May, 1952, the point method of pasture analysis of Levy and Madden (1933) was applied to assess the relative frequency of onion weed under the several treatments. The validity of this technique has been confirmed by Crocker and Tiver (1948) and by Tiver and Crocker (1951). The technique relies upon the number of times a species is hit by the point of a brass rod when it is lowered vertically through the pasture sward. In this analysis extreme care was taken to use only well sharpened points and to record only those vegetational hits in the direct path of the point, thus virtually nullifying one of the criticisms of Goodall (1952) concerning the effect of rod diameter. During this analysis the sward was fairly sparse and a high standard of accuracy was maintained. When the sward is dense some disturbance of the adjacent vegetation is almost certain to occur while observing the point during its descent. This results in loss of accuracy.

A ten hole frame was used to guide the brass rod. Ten evenly spaced groups of 10 points each (100 points in all) were taken on each plot. Only the onion weed was analyzed. Table 5 shows the number of hits on onion weed per 100 points. This is a measure of relative frequency. Table 6 shows the number of points which contacted onion weed per 100 points. This measures the per cent of ground covered by onion weed.

Table 5

Experiment No. P190 a - Avon, S. A.

Number of hits on onion weed per 100 points

30th May, 1952

Treatment		Block A	Block B	Block C	Block D	Mean A & C
Volunteer pasture	N1	10	40	6	29	8.0
	N2	18	6	15	11	16.5
	N3	9	25	35	5	22.0
	N4	14	43	9	7	11.5
	N5	13	14	6	17	9.5
	mean					13.5
Wimmera rye grass pasture	N1	5	5	2	9	3.5
	N2	11	4	3	0	7.0
	N3	8	12	2	1	5.0
	N4	6	8	7	0	6.5
	N5	8	3	2	0	5.0
	mean					5.4
Perennial veldt grass pasture	N1	0	6	16	9	8.0
	N2	36	8	7	8	21.5
	N3	10	4	2	15	6.0
	N4	9	2	7	22	8.0
	N5	7	13	8	1	7.5
	mean					10.2
Lucerne pasture	N1	0	4	2	2	1.0
	N2	1	0	0	0	0.5
	N3	1	1	0	0	0.5
	N4	2	0	0	0	1.0
	N5	3	2	2	0	2.5
	mean					1.1
Mixed pasture	N1	1	1	0	1	0.5
	N2	2	1	0	2	1.0
	N3	2	0	1	0	1.5
	N4	3	0	1	0	2.0
	N5	2	1	0	0	1.0
	mean					1.2
	MEAN	7.2	8.1	5.3	5.6	6.3

Means for nitrogen

	N1	N2	N3	N4	N5
Blocks A and C	4.2	9.3	7.0	5.8	5.1

Table 6

Experiment No. P190 a - Avon, S. A.

Percentage cover of onion weed.

30th May, 1952

Treatment		Block A	B	C	D	Mean A & C
Volunteer pasture	N1	7	25	6	19	6.5
	N2	10	5	13	9	11.5
	N3	8	14	15	4	11.5
	N4	7	30	9	7	8.0
	N5	8	9	6	13	7.0
	mean					8.9
Wimmera rye grass pasture	N1	5	5	2	3	3.5
	N2	8	3	3	0	5.5
	N3	6	10	2	1	4.0
	N4	4	7	5	0	4.5
	N5	4	3	2	0	3.0
	mean					4.1
Perennial veldt grass pasture	N1	0	4	9	8	4.5
	N2	21	6	3	8	12.0
	N3	6	3	2	12	4.0
	N4	6	1	5	15	5.5
	N5	4	10	5	1	4.5
	mean					6.1
Lucerne pasture	N1	0	3	2	2	1.0
	N2	1	0	0	0	0.5
	N3	1	1	0	0	0.5
	N4	2	0	0	0	1.0
	N5	2	2	2	0	2.0
	mean					1.0
Mixed pasture	N1	1	1	0	1	0.5
	N2	2	1	0	2	1.0
	N3	2	0	1	0	1.5
	N4	3	0	1	0	2.0
	N5	2	1	0	0	1.0
	mean					1.2
	MEAN	4.8	5.8	3.7	4.2	4.3

Means for nitrogen

	N1	N2	N3	N4	N5
Blocks A and C	3.2	6.1	4.3	4.2	3.5

To enable a comparison of these values with a natural infestation 400 points were taken in a similar way across a portion of the paddock surrounding the experiment. This supported a typical 2-year old stand of onion weed. A mean of 17 hits per 100 points or 13.75% cover was obtained. Another 400 points were taken in a heavily infested paddock of long established plants located about 1/4 mile N.W. of the experimental site. This gave a mean of 45 hits per 100 points or 25.5% cover.

Botanical composition, 1952: On the 6th of August the point method of pasture analysis was applied to assess the botanical composition of the plots. Instead of using groups of 10 points the frame was moved to a new position after every point following a suggestion made by Goodall (1952). Forty-five systematically spaced points were taken in a uniform manner on each plot. The most efficient number of points had been determined previously using plots of comparable botanical variability at the Waite Institute. Twenty-five points per plot yielded 5 species, 45 points per plot yielded 6 species, and 85 points per plot yielded 7 species. It was then empirically concluded that more than 45 points per plot were not justified in assessing the major trends of the experiments. For convenience of presentation and evaluation the species were divided into the same 8 classes used for the 1951 harvest. In addition the number of hits on bare ground are recorded. The data for number of hits per 45 points (relative frequency) for each group are presented in table 7.

Harvest, 1952: Two samples of the herbage were taken from each plot on the 8th of December, 1952, using the same methods as employed in the 1951 harvest except that the position of the quadrat was not randomized. Instead the two quadrats were placed uniformly for all plots in predetermined positions. This was done to save sampling time.

Table 7

Experiment No. P190 a - Avon, S. A.

Number of hits per 45 systematically spaced points per plot.

6th August, 1952

Mean of blocks A and C only

Treatment		Onion weed	Wimmera rye grass	Other annual grasses	Barrel medic	Other annual legumes	Perennial veldt grass	Lucerne	Misc. species	Total	Bare ground
Volunteer pasture	N1	5.5	10.5	21.0	0	50.0	0	0	7.5	94.5	3.5
	N2	8.0	4.5	22.5	0	38.5	0	0	20.0	93.5	4.0
	N3	5.0	5.0	25.5	0	40.5	0	0	24.0	100.0	2.5
	N4	6.5	7.5	33.0	0	23.0	0	0	5.5	75.5	8.5
	N5	7.0	15.5	25.5	0	18.5	0	0	7.5	74.0	9.5
	Mean	6.4	8.6	25.5	0	34.1	0	0	12.9	87.5	5.6
Wimmera rye grass pasture	N1	2.5	78.5	1.0	0	2.0	0	0	1.0	85.0	4.0
	N2	3.0	60.5	0.0	0	7.0	0	0	0.0	70.5	8.0
	N3	0.0	92.5	1.5	0	1.0	0	0	0.5	95.5	5.0
	N4	0.5	90.0	3.0	0	1.0	0	0	0.5	95.0	4.5
	N5	0.0	190.0	4.0	0	0.0	0	0	1.0	195.0	0.5
	mean	1.2	102.3	1.9	0	2.2	0	0	0.6	108.2	4.4
Perennial veldt grass pasture	N1	5.5	1.5	3.5	0	16.5	25.0	0	4.0	56.0	12.5
	N2	10.0	8.0	3.0	0	17.5	34.5	0	5.5	78.5	7.0
	N3	5.5	1.0	5.5	0	21.0	46.0	0	1.5	80.5	8.0
	N4	4.0	3.5	7.5	0	13.0	48.5	0	2.0	78.5	9.0
	N5	4.5	4.0	3.0	0	9.5	51.5	0	5.5	78.0	12.0
	mean	5.9	3.6	4.5	0	15.5	41.1	0	3.7	74.3	9.7
Lucerne pasture	N1	1.5	4.5	2.5	1.0	17.0	0	48.0	1.5	76.0	7.5
	N2	0.0	24.5	2.5	0.0	7.5	0	51.0	1.0	86.5	6.5
	N3	0.5	12.0	5.0	0.0	12.5	0	65.0	3.0	98.0	4.0
	N4	1.0	3.0	8.0	1.0	9.0	0	60.0	4.5	86.5	5.5
	N5	0.5	8.0	6.5	0.0	2.5	0	53.5	2.5	73.5	8.5
	mean	0.7	10.4	4.9	0.4	9.7	0	55.5	2.5	84.1	6.4
Mixed pasture	N1	0.0	18.0	3.0	11.5	9.5	1.5	26.5	3.0	73.0	6.5
	N2	0.0	33.0	7.5	1.5	13.5	3.5	31.5	2.5	93.0	3.0
	N3	1.0	15.0	1.5	6.0	11.0	5.5	22.0	3.0	65.0	12.0
	N4	1.0	31.5	2.5	0.5	3.0	2.0	16.5	0.0	57.0	9.0
	N5	0.5	64.5	3.0	0.0	2.0	5.5	18.5	0.5	94.5	6.5
	mean	0.5	32.4	3.5	3.9	7.8	3.6	23.0	1.8	76.5	7.4
	MEAN	2.94	31.46	8.06	0.86	13.86	8.94	15.70	4.30	86.12	6.70

In the laboratory the samples were dried (as in 1951) to constant weight at 90° C. and then weighed. None of the samples were subsampled. The yields were calculated in oven dry weight per acre and are presented in table 8.

A ranking method was employed to estimate the botanical composition of the plots in order to eliminate the very considerable time and labor required for hand separation of the sample. The two samples from each plot were bulked prior to ranking. The same species classes were employed as in the 1951 harvest. Each species class was ranked for each bulked sample on a scale from 0 - 10. This corresponded to the proportion of each species group present in the bulked sample on a dry weight basis. Ranking was carried out independently by 2 or more workers. The median rating was utilized. Whenever the discrepancy between the ratings seemed excessive (usually greater than 1 for any one species class) the bulked samples were subsampled and the subsample was hand separated into its component species classes. The values found by hand separation were then adhered to. A little practice is sufficient to develop confidence in the usefulness of this ranking technique for comparing major ecological trends. Sound judgment must be applied in order not to push the interpretation of data so obtained beyond the limitations inherent in the method.

From the ranking data and total yield data the yield of each species class was calculated on a dry weight basis. These data are presented in table 9. A new class was created for inert matter.

Typical N1 and N5 plots from each of the 5 types of pasture are shown in figure II-4 through figure II-13. The photographs were taken just prior to the 1952 harvest.

Table 8

Experiment No. P190 a - Avon, S. A.
Yield of all species in lbs. oven dry weight per acre.
8th December, 1952.

Treatment		Block A	Block B	Block C	Block D	Mean A & C
Volunteer pasture	N1	3016	1605	2831	3527	2924
	N2	2037	3025	4656	2513	3347
	N3	2707	2884	2046	2743	2377
	N4	2169	2637	2822	4012	2496
	N5	2557	3131	2478	2302	2518
	mean					2732
Wimmera rye grass pasture	N1	3254	4321	4683	1931	3969
	N2	1711	2769	4109	4039	2910
	N3	2725	3104	4612	3545	3669
	N4	2328	4268	4286	4162	3307
	N5	5441	4436	5653	4780	5547
	mean					3880
Perennial veldt grass pasture	N1	2011	2707	3448	2531	2730
	N2	3836	2672	4965	3095	4401
	N3	2796	3536	2901	3104	2849
	N4	4004	3254	3060	3713	3532
	N5	2848	3316	4101	4233	3475
	mean					3397
Lucerne pasture	N1	1667	1314	1349	1032	1508
	N2	891	2310	3166	1676	2029
	N3	1111	908	4039	2116	2575
	N4	2381	2734	2108	1940	2245
	N5	1825	1614	2363	1252	2094
	mean					2090
Mixed pasture	N1	1817	2848	3307	2743	2562
	N2	3342	1676	2725	1958	3034
	N3	2945	3501	2602	2478	2774
	N4	2258	1922	3157	2416	2708
	N5	3880	2425	4824	3933	4352
	mean					3086
	MEAN	2622	2757	3452	2871	3037

Means for nitrogen

	N1	N2	N3	N4	N5
Blocks A & C	2739	3144	2849	2858	3597

Analysis of variance for blocks A & C

Variance due to:	Variance ratio:
Treatments	2.43 *
nitrogen	1.96 n.s.
pasture	7.28 ***
nitrogen x pasture	1.34 n.s.
Blocks	13.65 **

Difference for significance

	means of 2	means of 10
5%	1595	713
1%	n.s.	951
0.1%	n.s.	1246

Table 9

Experiment No. P190 a - Avon, S. A.

Estimated yield in lbs. oven dry weight per acre.

8th December, 1952.

Mean of blocks A and C only

Treatment		Onion weed	Wimmera rye grass	Other annual grasses	Barrel medic	Other annual legumes	Perennial veldt grass	Lucerne	Misc. species	Inert matter	Total
Volunteer pasture	N1	146	868	1396	+	222	0	0	292	+	2924
	N2	400	509	589	+	218	0	0	1630	+	3347
	N3	289	119	1155	+	305	0	0	508	+	2377
	N4	542	282	1492	0	+	0	0	179	0	2496
	N5	827	188	1311	0	128	0	0	64	+	2518
	mean	441	393	1189	+	175	0	0	535	+	2732
Wimmera rye grass pasture	N1	81	3887	+	+	+	0	0	+	+	3969
	N2	+	2910	+	0	+	0	0	+	+	2910
	N3	+	3669	+	+	+	0	0	+	+	3669
	N4	+	3307	+	0	+	0	0	+	+	3307
	N5	0	5547	+	0	+	0	0	+	+	5547
	mean	16	3864	+	+	+	0	0	+	+	3880
Perennial veldt grass pasture	N1	524	+	+	0	+	1946	0	259	+	2730
	N2	288	1738	+	0	+	1963	0	412	+	4401
	N3	495	+	+	0	+	1859	0	495	+	2849
	N4	530	+	100	0	+	2902	0	+	+	3532
	N5	245	142	+	0	+	3087	0	+	+	3475
	mean	416	376	20	0	+	2351	0	233	+	3397
Lucerne pasture	N1	+	442	143	+	42	0	671	109	101	1508
	N2	+	1266	101	0	+	0	581	79	+	2029
	N3	+	396	404	0	+	0	1343	432	+	2575
	N4	+	833	+	0	+	0	952	595	+	2245
	N5	+	424	355	+	+	0	1211	105	+	2094
	mean	+	672	201	+	8	0	952	264	20	2090
Mixed pasture	N1	+	1641	+	+	+	302	355	264	+	2562
	N2	0	2086	136	0	+	356	387	68	+	3034
	N3	+	1214	+	+	+	628	646	286	+	2774
	N4	0	2358	+	+	+	158	192	+	+	2708
	N5	+	4014	121	0	+	+	218	+	+	4352
	mean	+	2263	51	+	+	289	360	124	+	3086
	MEAN	175	1514	292	+	37	528	262	231	4	3037

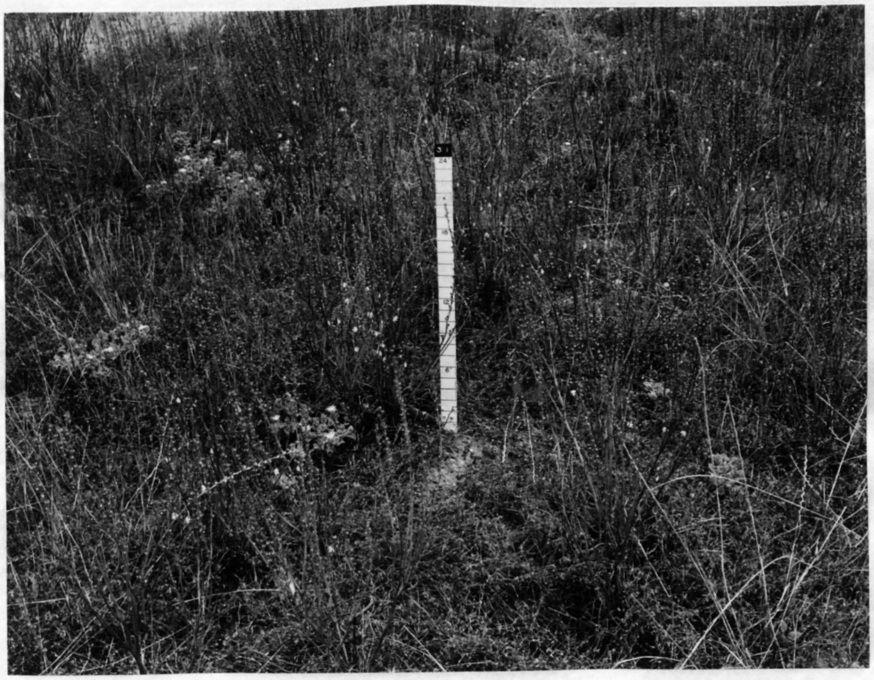

Figure II-4

Experiment No. P190 a: A typical N1 volunteer pasture plot.

Figure II-5

Experiment No. P190 a: A typical N5 volunteer pasture plot.

Figure II-6

Experiment No. P190 a: A typical N1 Wimmera rye grass pasture plot.

Figure II-7

Experiment No. P190 a: A typical N5 Wimmera rye grass pasture plot.

Figure II-8

Experiment No. P190 a: A typical N1 perennial veldt grass pasture plot.

Figure II-9

Experiment No. P190 a: A typical N5 perennial veldt grass pasture plot.

Figure II-10

Experiment No. P190 a: A typical N1 lucerne pasture plot.

Figure II-11

Experiment No. P190 a: A typical N5 lucerne pasture plot.

Figure II-12

Experiment No. P190 a: A typical N1 mixed pasture plot.

Figure II-13

Experiment No. P190 a: A typical N5 mixed pasture plot.

Persistence of onion weed, December, 1952: A ranking method was employed in the field for estimating the quantity and vigor of onion weed on the plots. This enabled information to be obtained from a consideration of the whole of each plot. Ranking was carried out independently by 3 observers on a scale ranging from 0 to 10. The final value utilized for each plot was the sum of the ratings of the 3 observers. Prior to ranking the plots 6 of them were chosen as standards for comparison so as to represent values of 0, 2, 4, 6, 8 and 10. The standard plot rated 0 contained no onion weed at all. The standard plot rated 10 was chosen for the densest and most vigorous stand of onion weed. The intermediate plots rated 2, 4, 6 and 8 represented as nearly as possible even gradations between 0 and 10. The remaining 94 plots were then rated by comparing them with the standards. Table 10 shows the sum of the ratings of the 3 observers on the 23rd of December, 1952.

Top dressing the plots, 1953: On the 12th of June, 1953, the plots were top dressed with superphosphate and ammonium sulphate at the same rate and in the same manner as was done on the 24th of April, 1952.

Persistence of onion weed, June, 1953: Also on the 12th of June, 1953, the plots were analyzed for quantity and vigor of onion weed using the same ranking method as employed in December, 1952. The plots were ranked by the same 3 observers. The results of this analysis are presented in table 11.

Mowing and raking: Between the 16th and 18th of June, 1953, all the plots were mown with a power scythe to within 2 inches of the ground. The mowings were raked clear of the plots and burned. Mowing and raking were carried out to prevent the heavy growth standing from the growing season of 1952 from being added to the yield data to be obtained at the end of the 1953 growing season. Mowing was carried out after the onion weed had completed its summer growth cycle but before the new season's growth of pasture had been initiated. Mowing was carried out at this time in the belief that

Table 10
Experiment No. P190 a - Avon, S. A.
Ranking of onion weed in the field by three observers.
23rd December, 1952.
Scale from 0 to 30.

Treatment		Block A	Block B	Block C	Block D	Mean A & C
Volunteer pasture	N1	18.0	30.0	9.5	24.0	13.75
	N2	12.5	9.0	17.5	12.0	15.00
	N3	12.5	30.0	8.5	7.0	10.50
	N4	19.0	28.5	7.0	9.0	13.00
	N5	21.5	23.0	11.0	20.5	16.25
	mean					13.70
Wimmera rye grass pasture	N1	6.5	8.5	1.0	6.5	3.75
	N2	7.0	8.5	1.0	2.5	4.00
	N3	6.0	9.5	2.0	6.0	4.00
	N4	3.5	5.5	3.0	3.0	3.25
	N5	0.5	3.0	1.0	1.5	0.75
	mean					3.15
Perennial veldt grass pasture	N1	9.5	9.0	9.5	9.0	9.50
	N2	17.5	7.0	10.5	10.0	14.00
	N3	10.5	8.0	9.0	9.5	9.75
	N4	9.0	6.0	9.5	8.0	9.25
	N5	10.0	12.0	10.0	3.5	10.00
	mean					10.00
Lucerne pasture	N1	0.5	3.5	0.0	0.0	0.25
	N2	1.0	0.5	1.0	0.0	1.00
	N3	2.0	1.0	0.0	0.0	1.00
	N4	0.5	2.0	1.0	0.5	0.75
	N5	1.0	2.5	0.5	0.0	0.75
	mean					0.75
Mixed pasture	N1	1.5	4.5	0.5	2.0	1.00
	N2	0.5	1.0	0.0	1.0	0.25
	N3	2.5	2.5	1.5	0.5	2.00
	N4	3.0	3.0	1.0	0.0	2.00
	N5	2.0	5.0	0.0	1.5	1.00
	mean					1.25
	MEAN	7.12	8.92	4.62	5.50	5.87

Means for nitrogen

	N1	N2	N3	N4	N5
Blocks A & C	5.65	6.85	5.45	5.65	5.75

Analysis of variance for blocks A & C

Variance due to:	Variance ratio:
Treatments	8.136 ***
nitrogen	less than 1 n.s.
pasture	45.837 ***
nitrogen x pasture	less than 1 n.s.
Blocks	10.402 **

Difference for significance

	means of 2	means of 10
5%	5.645	2.525
1%	7.675	3.432
0.1%	10.275	4.595

Table 11
Experiment No. P190 a - Avon, S. A.
Ranking of onion weed in the field by three observers.
12th June, 1953.
Scale from 0 to 30.

Treatment		Block A	B	C	D	Mean A & C
Volunteer pasture	N1	22.0	30.0	14.5	26.5	18.25
	N2	21.5	16.0	16.5	19.5	19.00
	N3	16.0	28.5	11.5	10.0	13.75
	N4	19.0	29.5	7.0	7.5	13.00
	N5	24.0	23.0	13.0	22.5	18.50
	mean					16.50
Wimmera rye grass pasture	N1	10.5	18.0	8.0	10.0	9.25
	N2	12.0	12.5	1.0	7.0	6.50
	N3	13.5	17.5	1.5	9.5	7.50
	N4	6.5	7.0	3.0	4.5	4.75
	N5	3.5	10.5	2.0	5.0	2.75
	mean					6.15
Perennial veldt grass pasture	N1	12.5	18.5	10.5	8.0	11.50
	N2	12.5	10.0	6.0	9.5	9.25
	N3	15.5	15.0	6.5	9.5	11.00
	N4	12.0	10.0	4.5	8.0	8.25
	N5	12.5	12.0	5.0	6.0	8.75
	mean					9.75
Lucerne pasture	N1	2.5	5.0	0.0	0.5	1.25
	N2	2.5	1.5	1.0	1.5	1.75
	N3	4.5	1.0	0.5	0.5	2.50
	N4	0.0	2.5	0.5	1.5	0.25
	N5	1.5	3.5	2.0	0.0	1.75
	mean					1.50
Mixed pasture	N1	2.0	7.0	0.5	2.0	1.25
	N2	1.5	1.5	1.0	2.5	1.25
	N3	3.5	2.5	2.0	2.5	2.75
	N4	2.5	3.5	2.0	1.5	2.25
	N5	3.5	8.0	0.0	2.0	1.75
	mean					1.85
	MEAN	9.50	11.76	4.80	7.12	7.15

Means for nitrogen

	N1	N2	N3	N4	N5
Blocks A & C	8.30	7.55	7.50	5.70	6.70

Analysis of variance for blocks A & C

Variance due to:	Variance ratio:
Treatments	8.867 ***
nitrogen	1.228 n.s.
pasture	48.753 ***
nitrogen x pasture	less than 1 n.s.
Blocks	34.696 ***

Difference for significance

	means of 2	means of 10
5%	5.81	2.598
1%	7.90	3.533
0.1%	10.58	4.732

it would then have the minimum effect possible on the subsequent botanical composition of the plots.

Persistence of onion weed, October, 1953: On the 14th of October, 1953, the plots were again analyzed for quantity and vigor of onion weed using the ranking methods first employed in December, 1952. The plots were ranked by the same 3 observers. The data are presented in table 12.

Harvest, 1953: Two samples of the herbage were taken from each plot using the same methods as employed in the 1952 harvest except that the sample size was doubled. Two samples each 5 links square were taken from each plot making the total area sampled 50 square links per plot. Only blocks A and C were sampled.

In the laboratory the onion weed was hand separated from the rest of the sample while fresh. The samples were not subsampled. The onion weed fraction and the non-onion weed fraction were dried separately to constant weight at 90° C under forced draught. The samples were processed quickly and weighed in the same manner as in the two previous harvests. The yields of both fractions were calculated to oven dry weight per acre and are presented in tables 13 and 14. The total yield as presented in table 13 is the sum of both fractions.

The non-onion weed fraction was analyzed for botanical composition using the same ranking method as that employed for the 1952 harvest. These data are presented in table 15. There was a negligible amount of inert matter in the samples.

Nitrogen content of wimmera rye grass: The wimmera rye grass fraction of each sample taken from the wimmera rye grass plots of experiment no. P190 a during the 1953 harvest was subsampled. These subsamples were analyzed for total nitrogen. The dried subsamples were ground in a C. & N. mill to pass

Table 12
Experiment No. F190 a - Avon, S. A.
Ranking of onion weed in the field by three observers.
14th October, 1953.
Scale from 0 to 30.

Treatment		Block A	B	C	D	Mean A & C
Volunteer pasture	N1	20.5	17.5	18.5	24.5	19.50
	N2	21.5	24.0	13.5	15.5	17.50
	N3	21.5	17.5	13.0	19.5	17.25
	N4	12.0	14.5	9.0	12.0	10.50
	N5	25.0	12.0	16.0	21.5	20.50
	mean					17.05
Wimmera rye grass pasture	N1	20.5	26.5	14.0	23.0	17.25
	N2	21.5	27.5	1.5	16.5	11.50
	N3	23.0	27.5	1.5	17.5	12.25
	N4	8.5	18.0	7.0	10.5	7.75
	N5	1.0	12.5	3.0	6.0	2.00
	mean					10.15
Perennial veldt grass pasture	N1	14.5	24.0	10.0	9.0	12.25
	N2	15.5	14.0	11.5	9.5	13.50
	N3	12.5	30.0	6.0	10.0	9.25
	N4	11.0	17.0	2.0	8.0	6.50
	N5	10.5	13.0	7.0	12.0	8.75
	mean					10.05
Lucerne pasture	N1	1.0	4.0	1.0	0.5	1.00
	N2	3.0	0.5	1.0	1.0	2.00
	N3	2.0	1.5	0.0	1.0	1.00
	N4	0.5	2.0	0.5	1.5	0.50
	N5	2.5	3.5	1.5	1.0	2.00
	mean					1.30
Mixed pasture	N1	2.5	6.5	1.5	1.5	2.00
	N2	1.5	2.0	0.0	1.0	0.75
	N3	4.0	2.0	2.5	1.5	3.25
	N4	6.5	3.0	1.5	1.5	4.00
	N5	2.5	6.0	0.0	2.5	1.25
	mean					2.25
	MEAN	10.60	13.06	5.72	9.12	8.16

Means for nitrogen

	N1	N2	N3	N4	N5
Blocks A & C	10.50	9.05	8.60	5.85	6.90

Analysis of variance for blocks A & C

Variance due to:	Variance ratio:
Treatments	5.627 ***
nitrogen	2.033 n.s.
pasture	26.504 ***
nitrogen x pasture	1.306 n.s.
Blocks	18.723 ***

Difference for significance

	means of 2	means of 10
5%	8.215	3.674
1%	11.165	4.993
0.1%	14.950	6.686

Table 13
Experiment No. P190 a - Avon, S. A.
Yield of all species in lbs. oven dry weight per acre.
21st October, 1953.

Treatment		Block A	Block C	Mean
Volunteer pasture	N1	1861	2605	2233
	N2	2134	2818	2476
	N3	3131	2439	2785
	N4	2231	3119	2675
	N5	2192	3285	2738
	mean			2581
Wimmera rye grass pasture	N1	1393	2153	1773
	N2	1120	2058	1589
	N3	1812	3020	2416
	N4	2591	2825	2708
	N5	3422	3382	3402
	mean			2378
Perennial veldt grass pasture	N1	1273	1372	1322
	N2	1597	1435	1516
	N3	1737	2054	1895
	N4	1529	2188	1859
	N5	1187	2294	1740
	mean			1667
Lucerne pasture	N1	934	773	853
	N2	681	1274	977
	N3	1170	1212	1191
	N4	1172	1328	1250
	N5	1044	1120	1082
	mean			1071
Mixed pasture	N1	1132	1609	1371
	N2	1380	1777	1579
	N3	1706	1235	1471
	N4	1605	1527	1566
	N5	1689	2108	1899
	mean			1577
	MEAN	1669	2041	1855

Means for nitrogen

N1	N2	N3	N4	N5
1510	1627	1952	2011	2172

Analysis of variance

Variance due to:	Variance ratio:
Treatments	7.00 ***
nitrogen	6.01 **
pasture	30.61 ***
nitrogen x pasture	1.34 n.s.
Blocks	13.80 **

Difference for significance

	means of 2	means of 10
5%	711	318
1%	948	424
0.1%	1241	555

Table 14
Experiment No. P190 a - Avon, S. A.
Yield of onion weed in lbs. oven dry weight per acre.
21st October, 1953.

Treatment		Block A	Block C	Mean
Volunteer pasture	N1	388	722	555
	N2	613	269	441
	N3	1116	437	776
	N4	326	77	202
	N5	512	308	410
	mean			477
Wimmera rye grass pasture	N1	586	120	353
	N2	318	3	160
	N3	392	0	196
	N4	56	3	29
	N5	0	0	0
	mean			148
Perennial veldt grass pasture	N1	131	36	83
	N2	115	64	90
	N3	128	39	83
	N4	61	23	42
	N5	116	76	96
	mean			79
Lucerne pasture	N1	4	1	2
	N2	15	0	7
	N3	10	4	7
	N4	4	1	3
	N5	17	+	9
	mean			5
Mixed pasture	N1	21	4	13
	N2	0	0	0
	N3	66	9	38
	N4	26	6	16
	N5	+	0	+
	mean			13
	MEAN	201	88	144

Means for nitrogen

N1	N2	N3	N4	N5
201	140	220	58	103

Table 15

Experiment No. P190 a - Avon, S. A.

Estimated yield in lbs. oven dry weight per acre.

21st October, 1953.

Blocks A and C.

Treatment		Onion weed	Wimmera rye grass	Other annual grasses	Barrel medic	Other annual legumes	Perennial veldt grass	Lucerne	Misc. species	Total
Volunteer pasture	N1	555	1201	393	0	47	0	0	37	2233
	N2	441	865	1056	0	38	0	0	76	2476
	N3	776	1107	852	0	50	0	0	+	2785
	N4	202	1483	943	0	+	0	0	48	2675
	N5	410	424	1862	+	+	0	0	42	2738
	mean	477	1016	1021	+	27	0	0	41	2581
Wimmera rye grass pasture	N1	353	1380	+	0	40	0	0	+	1773
	N2	160	1408	+	+	20	0	0	+	1589
	N3	196	2220	+	0	+	0	0	0	2416
	N4	29	2679	+	0	0	0	0	0	2708
	N5	0	3402	+	0	0	0	0	0	3402
	mean	148	2218	+	+	12	0	0	+	2378
Perennial veldt grass pasture	N1	83	33	+	+	+	1206	0	+	1322
	N2	90	37	106	+	+	1284	0	0	1516
	N3	83	50	50	0	+	1711	0	+	1895
	N4	42	128	145	+	+	1507	0	37	1859
	N5	96	111	109	0	+	1425	0	+	1740
	mean	79	72	82	+	+	1427	0	7	1667
Lucerne pasture	N1	2	140	124	0	+	0	588	0	853
	N2	7	324	224	0	+	0	421	0	977
	N3	7	503	324	0	+	0	358	0	1191
	N4	3	96	608	0	+	0	544	0	1250
	N5	9	413	26	0	+	0	635	0	1082
	mean	5	295	261	0	+	0	509	0	1071
Mixed pasture	N1	13	599	136	+	+	+	623	0	1371
	N2	0	537	622	+	0	+	419	+	1579
	N3	38	860	82	+	+	72	420	0	1471
	N4	16	1242	+	+	+	+	309	0	1566
	N5	+	1076	253	+	+	+	570	0	1899
	mean	13	863	219	+	+	14	468	+	1577
	MEAN	144	893	317	+	8	288	195	10	1855

through a sieve with round holes 0.5 mm. in diameter. Approximately 1 gram of the ground subsample was dried in an oven at 90° C. to constant weight, cooled in a desiccator, weighed and used for analysis of total nitrogen. Essentially the same method was used for analysis as that described in section F of this chapter. The gram of plant material was transferred to a 300 c.c. Kjeldahl flask and digested with sulphuric acid. The ammonia so formed was liberated in a Parnas-Wagner steam distillation unit and was trapped in 2% boric acid plus bromcresol green-methyl red indicator. The boric acid was titrated with 0.01 N. hydrochloric acid to match a blank containing only boric acid and indicator. A correction was made for a reagent blank. The amount of nitrogen in the wimmera rye grass fraction only was calculated for each plot on a pound per acre basis. The results are presented in table 16. The N5 plots contained only wimmera rye grass. The rest of the wimmera rye grass plots were mostly wimmera rye grass and onion weed (Table 15). Because of its complete lack of palatability the onion weed would not make a contribution to the feed value of the pasture and for this reason it was not analyzed for nitrogen. The differences between the blocks at low rates of ammonium sulphate may be related to the fact that block C was on a deep phase of solonized brown soil while block A was on a shallow phase.

Soil moisture: On the 20th of July, 1951, the soil profile in the S.W. corner headland was examined to a depth of 50 inches using a soil auger. Samples of soil weighing about 30 grams were retained for moisture determinations. For each range of depth where moisture values are recorded all of the soil over the specified range of depth was removed and thoroughly mixed on a rubber sheet prior to sampling. The moisture values obtained represent mean values over the recorded range of depth. Soil samples were transported to the laboratory in air-tight containers, weighed, dried under forced draught at

Table 16

Experiment No. P190 a - Avon, S. A.

Nitrogen content of wimmera rye grass.

21st October, 1953.

	Block	Nitrogen added at beginning of season lbs. per acre	Yield of Wimmera rye grass lbs. per acre	Nitrogen content of rye grass lbs. per lb.	Nitrogen content of rye grass lbs. per acre
N1	A	0	726	0.0099	7.19
	C	0	2033	0.0088	17.89
	mean				12.54
N2	A	11.2	762	0.0084	6.40
	C	11.2	2055	0.0091	18.70
	mean				12.55
N3	A	22.4	1420	0.0095	13.49
	C	22.4	3020	0.0092	27.78
	mean				20.64
N4	A	44.8	2535	0.0104	26.36
	C	44.8	2822	0.0111	31.32
	mean				28.84
N5	A	89.6	3422	0.0182	62.28
	C	89.6	3382	0.0153	51.74
	mean				57.01

105° C. to constant weight, cooled in a desiccator and weighed again. Loss of weight was assumed to be due to loss of moisture. The moisture content was expressed as a percentage of the oven dry soil on a weight basis. Results are given below together with a brief description of the profile.

Horizon	Depth in inches	Description	% moisture
A	0-12	Brown loam	25.9
A-B	12-18	Light brown loam	26.5
B	18-21	Clay	26.0
B-C	21-24	Discarded	--
B-C	24-40	Clay with limestone flecked bright red light in color drier to feel than above	19.7
B-C	40-42	--	14.0
C	42-50	Massive limestone Dry to feel	--

Approximately 10.53 inches of rain had fallen since the beginning of the year.

On the 13th of June, 1952, the soil under the plots in block C was sampled for moisture content. One sample was taken with a soil auger from near the center of each plot. Soil lying between 12 inches and 16 inches below the surface was thoroughly mixed in the field on a rubber sheet and then subsampled for moisture content. Subsamples were transported to the laboratory in air-tight containers and handled in a manner identical to that of the moisture samples taken on the 20th of July, 1951. Results are presented in table 17.

On the 21st of April, 1953, prior to the opening seasonal rains, the soil under the plots in block C was again sampled for moisture. Since the beginning of the year 0.25 inches of rain had fallen on 20th of March. The same procedure was followed as on the 13th of June, 1952 except that samples were taken

Table 17
Experiment No. P190 a - Avon, S. A.
Mean moisture content of soil under block C between 12 inches and 16 inches below the surface.
13th June, 1952.

	N1	N2	N3	N4	N5	Mean
Volunteer pasture	24.9	24.4	24.2	25.9	26.3	25.1
Wimmera rye grass pasture	25.8	25.3	24.7	23.8	24.5	24.8
Perennial veldt grass pasture	22.5	22.5	23.7	22.5	22.0	22.6
Lucerne pasture	22.9	24.2	25.1	25.2	18.5	23.2
Mixed pasture	23.9	25.4	21.2	20.8	23.2	22.9
Mean	24.0	24.4	23.8	23.6	22.9	23.7

Table 18
Experiment No. P190 a - Avon, S. A.
Mean moisture content of soil under block C between 15 inches and 21 inches below the surface.
21st April, 1953.

	N1	N2	N3	N4	N5	Mean
Volunteer pasture	15.3	13.3	13.9	15.7	13.6	14.4
Wimmera rye grass pasture	15.4	16.5	16.1	16.1	14.1	15.6
Perennial veldt grass pasture	14.1	14.0	13.0	12.4	11.2	12.9
Lucerne pasture	11.8	9.2	10.8	13.1	12.9	11.6
Mixed pasture	12.7	13.2	12.1	11.7	13.6	12.7
Mean	13.9	13.2	13.2	13.8	13.1	13.4

from between 15 inches and 21 inches below the surface. Results are presented in table 18.

The samples of soil between 15 and 21 inches which remained after the subsamples were removed were bulked and transported to the laboratory for determination of the permanent wilting percentage. The soil was thoroughly mixed and placed in heavily glazed porcelain pots without external drainage and tomato plants were grown from seed until they attained a suitable size. The pot was then carefully sealed with wax at the soil surface to prevent water loss directly from the soil and set aside without further additions of water. When the leaves of the plants in each pot wilted to the stage where they could not recover their turgor in an atmosphere approximately saturated with moisture, the soil was removed from the pots, weighed, dried at 105° C. to constant weight and weighed again. From the data so obtained the percentage of moisture in the soil at the time of permanent wilting was calculated. The mean of four replications was found to be 13.5%.

When the plants used in this determination were about 1 inch high they showed acute symptoms of phosphorus deficiency as indicated by highly pigmented purplish red leaves and stems. This condition responded immediately to applications of dilute phosphoric acid and subsequent recovery by the plants appeared to be 100%. Two control pots which did not receive phosphoric acid did not recover. This indicates an acute deficiency of available phosphorus under the plots at a depth of 15 inches.

B. Experiment no. P190 b.

This experiment was carried out at the Waite Institute on an area which had previously supported wheat trials for several years and consequently was fairly low in available nutrient nitrogen.

The soils at the Waite Institute are red-brown earths. The surface soils are loamy with clay in the B horizon and lime in the B_2 horizon. They are representative of the best wheat growing soils in South Australia but do not often support serious infestations of onion weed. Onion weed does not occur naturally at the Waite Institute.

The mean annual rainfall at the Waite Institute lies between 24 inches and 25 inches. During the year this experiment was established the rainfall at the Waite Institute was 31.3 inches. Other climatic data for the Waite Institute are:

mean rainfall season	7.5 months
frequency of drought years	14%
mean air temperature for coldest month	51° F.
(Trumble, 1948)	

The mean P/E^m for the Waite Institute is:

Annual	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1.27	0.23	0.30	0.23	0.73	1.44	1.47	2.04	1.68	1.16	0.56	0.38	0.25

P/E^m of 1.70 is the upper limit for black and red-brown soils (Prescott, 1949).

Aim: (As in experiment no. P190 a) To study the establishment and persistence of onion weed in several types of pasture and to study the effect of soil applications of ammonium sulphate on the establishment and persistence of onion weed.

Design: A factorial design with 25 treatments in randomized blocks.

There were 5 pasture treatments:

1. Volunteer pasture:- no grass or legume seeds sown.
2. Wimmera rye grass pasture:-6 lbs. of wimmera rye grass seed per acre.

3. Perennial rye grass (<u>Lolium perenne</u>) pasture: 6 lbs. of perennial rye grass seed per acre.

4. <u>Phalaris tuberosa</u> pasture: 3 lbs. of <u>P. tuberosa</u> seed per acre.

5. Mixed pasture:
6 lbs. Bacchus Marsh subterranean clover (<u>Trifolium subterraneum</u>) seed per acre.
1/2 lb. wimmera rye grass seed per acre.
1 lb. lucerne seed per acre.
3 lbs. <u>Phalaris tuberosa</u> seed per acre.

Each pasture treatment received 5 levels of ammonium sulphate applied annually to the surface of the soil at the break of the season:

1.	N1	0	lbs.	ammonium	sulphate.		
2.	N2	28	lbs.	"	"	per	acre.
3.	N3	56	lbs.	"	"	"	"
4.	N4	112	lbs.	"	"	"	"
5.	N5	224	lbs.	"	"	"	"

These 25 treatments were randomized in each of 4 blocks making 100 plots in all.

Each plot received a basal dressing of 224 lbs. of superphosphate per acre annually and one lb. of onion weed seed per acre (1.45 seeds per square link) in the year of establishment only.

Soil preparation: An area approximately 1 1/2 chains x 6 1/2 chains (0.975 acres) was ploughed with a mouldboard plough and cultivated to give a fine seed bed. The area was marked out into 100 rectangular plots each 20 links x 25 links and separated by 5 link pathways as for experiment P190 a. A suitable headland was left around the plots. The plots were numbered from 1 to 100 and apportioned into 4 blocks. The 25 treatments were randomized against the plot numbers in each block.

Planting data: On the 22nd of May, 1951, the seed and fertilizer were broadcast on the plots by hand in strict accordance with the above plan. The plots were harrowed to cover the seed. Good opening rains were received. The plots were inspected frequently and it was observed that all species had germinated in a satisfactory manner. The plots were fenced to protect them from grazing by stock and as necessary the pathways were cultivated with a rotary hoe to control weed growth.

Establishment counts: Establishment counts were carried out between the 24th of July and the 6th of August, 1951. These were done in the manner already described for the establishment counts of experiment no. P190 a. The results are presented in table 19. It was not always possible to distinguish seedlings of perennial rye grass from those of wimmera rye grass and the counts for these two species were combined. Subsequent examination of the plots indicated that all of the perennial rye grass was confined to the plots in which it had been planted and that a natural population of wimmera rye grass occurred on all plots.

Harvest, 1951: Samples were cut from each plot in a manner identical with that described for the 1951 harvest of experiment no. P190 a. The Waite Institute plots were sampled on the 23rd of October, 1951.

In the laboratory the fresh samples were weighed and divided by hand into the following species classes in order to determine the botanical composition of each plot:

1. Onion weed.
2. Wimmera rye grass.
3. Other annual grasses. These were mainly Poa annua, wild oat (Avena fatua), Phalaris minor, barley-grass (Hordeum murinum), and Bromus sp.
4. Phalaris tuberosa.
5. Perennial rye grass.
6. Subterranean clover.
7. Other annual legumes. These were mainly narrow-leaved clover (Trifolium angustifolium), haresfoot clover (T. arvense), hop clover (T. procumbens), suckling clover (T. dubium) and Vicia sp.
8. Lucerne.

Table 19

Experiment No. P190 b - Waite Institute

Number of plants per square link

July - August, 1951

Means of four blocks.

Treatment		Onion weed	*Lolium* spp.	*Phalaris tuberosa*	Sub. clover	Lucerne
Volunteer pasture	N1	0.73	0.48	0.00	0.00	0.00
	N2	0.83	0.88	0.00	0.00	0.00
	N3	0.83	1.10	0.00	0.00	0.00
	N4	0.73	2.19	0.00	0.00	0.00
	N5	0.63	0.19	0.00	0.00	0.00
	mean	0.75	0.97	0.00	0.00	0.00
Wimmera rye grass pasture	N1	0.81	8.08	0.00	+	0.00
	N2	0.33	6.17	0.00	0.00	0.00
	N3	0.38	5.85	0.00	0.00	0.00
	N4	0.40	6.85	0.00	0.00	0.00
	N5	0.44	6.23	0.00	0.00	0.00
	mean	0.47	6.64	0.00	+	0.00
Perennial rye grass pasture	N1	0.73	5.17	0.00	0.00	0.00
	N2	0.48	5.10	0.00	0.00	0.00
	N3	0.58	5.62	0.00	0.00	0.00
	N4	0.75	6.44	0.00	0.00	0.00
	N5	0.54	5.98	0.00	0.00	0.00
	mean	0.62	5.66	0.00	0.00	0.00
Phalaris tuberosa pasture	N1	0.63	0.42	2.73	0.00	0.00
	N2	1.04	0.42	2.71	0.00	0.00
	N3	0.90	0.52	2.29	0.00	0.00
	N4	0.65	0.40	2.88	0.00	0.00
	N5	0.85	1.00	2.88	0.00	0.00
	mean	0.81	0.55	2.70	0.00	0.00
Mixed pasture	N1	0.50	2.60	1.77	1.25	0.19
	N2	0.92	1.48	2.27	1.46	0.31
	N3	0.50	2.50	1.85	1.02	0.35
	N4	0.67	2.54	1.98	1.31	0.19
	N5	0.88	0.98	2.63	1.19	0.42
	mean	0.69	2.02	2.10	1.25	0.29
	MEAN	0.67	3.17	0.96	0.25	0.06

9. Miscellaneous species. These were mainly sour sob (*Oxalis cernua*), wild poppy (*Papaver hybridum*), *Erodium botrys*, *Cerastium* sp., *Polygonum aviculare*, *Stachys arvensis* and *Sisymbrium orientale*.

Perennial rye grass was distinguished from wimmera rye grass by means of its folded leaf lamina. The lamina of wimmera rye grass is rolled. Frequent examination of the plots suggested that this was a valid distinction.

Some of the larger samples were subsampled prior to hand separation.

Since freshly cut herbage loses dry weight rapidly through respiration a large number of workers were employed for the hand separation in order to shorten the time between cutting the samples and placing them in the oven. Most of the samples were in the oven within 24 hours of cutting. The species classes from each sample (subsample) were kept separate in paper bags and dried in an oven at approximately 90° C. under forced draught to constant weight. They were stored and weighed subsequently as circumstances permitted. A correction was determined and applied to convert the value so obtained from air dry weight to oven dry weight. The total yield was determined from the sum of the species classes for each plot.

The results for total yield are presented in table 20 and for each of the species classes in table 21. No lucerne was found in the samples.

In order to supplement the harvest data for onion weed the plants of this species were counted on a portion of each plot. A quadrat 2 1/2 x 5 links was used. Two quadrats were counted on each plot. The quadrats were placed on that portion of each plot from which the harvest samples had been removed. The onion weed plants made more rapid growth at this season than most of the other species present and were readily distinguished. They were counted between the 14th and the 19th of November, 1951. The results are presented in table 22.

Table 20
Experiment No. P190 b - Waite Institute
Yield of all species in lbs. oven dry weight per acre.
23rd October, 1951

Treatment		Block A	B	C	D	Mean
Volunteer pasture	N1	1099	1781	1969	1625	1618
	N2	1650	1133	3243	2528	2138
	N3	2626	969	1294	2715	1901
	N4	1955	3103	3756	3755	3142
	N5	2542	1683	3042	5128	3099
	mean					2380
Wimmera rye grass pasture	N1	2971	1806	2703	2785	2566
	N2	5736	2929	2910	3785	3840
	N3	6745	4161	2372	4195	4368
	N4	5354	3811	4250	4006	4355
	N5	7604	6213	4786	5446	6012
	mean					4228
Perennial rye grass pasture	N1	1560	567	2505	2743	1844
	N2	2781	1809	1957	2162	2177
	N3	2318	1830	2238	3411	2449
	N4	2006	1262	3535	3585	2597
	N5	3688	3403	7273	3256	4455
	mean					2704
Phalaris tuberosa pasture	N1	2378	1662	4271	1324	2409
	N2	3439	512	1393	1527	1718
	N3	1867	4222	1439	1963	2366
	N4	1191	2294	2953	2068	2127
	N5	2012	1489	7271	3585	3589
	mean					2442
Mixed pasture	N1	3967	5954	4266	5796	4996
	N2	6227	5655	4803	5003	5422
	N3	5923	4871	4577	5205	5144
	N4	5438	4222	6966	6560	5796
	N5	5490	5915	8434	6294	6533
	mean					5578
	MEAN	3551	2930	3768	3617	3467

Means for nitrogen

N1	N2	N3	N4	N5
2689	3059	3246	3603	4738

Analysis of variance

Variance due to:	Variance ratio:	
Treatments	6.807	***
Nitrogen	9.139	***
pasture	29.166	***
nitrogen x pasture	less than 1	n.s.
Blocks	2.528	n.s.

Difference for significance

	means of 4	means of 20
5%	1637	732
1%	2171	971
0.1%	2789	1247

Table 21

Experiment No. P190 b - Waite Institute
Yield in lbs. oven dry weight per acre.
23rd October, 1951.
Means of four blocks.

Treatment		Onion weed	Wimmera rye grass	Other annual grasses	*Phalaris tuberosa*	Perennial rye grass	sub clover	Other annual legumes	Misc. species	Total
Volunteer pasture	N1	66	595	48	0	0	+	4	908	1618
	N2	20	970	47	0	0	0	6	1096	2138
	N3	43	899	195	0	0	0	3	761	1901
	N4	25	1843	616	0	0	0	0	659	3142
	N5	65	1008	397	0	0	+	1	1630	3099
	mean	44	1063	261	0	0	+	3	1011	2380
Wimmera rye grass pasture	N1	1	2022	149	0	0	6	0	385	2566
	N2	0	3243	156	0	0	0	35	407	3840
	N3	2	3835	12	0	0	0	0	521	4368
	N4	0	3788	101	0	0	+	1	466	4355
	N5	0	5398	24	0	0	0	0	588	6012
	mean	1	3657	88	0	0	1	7	473	4228
Perennial rye grass pasture	N1	30	567	23	0	289	1	0	936	1844
	N2	0	723	217	0	309	0	1	929	2177
	N3	9	661	44	0	355	0	3	1378	2449
	N4	12	797	55	0	538	0	0	1196	2597
	N5	0	2709	35	0	339	5	0	1367	4455
	mean	10	1091	75	0	366	1	1	1161	2704
Phalaris tuberosa pasture	N1	15	298	571	116	0	0	0	1409	2409
	N2	5	512	92	114	0	1	12	982	1718
	N3	20	1009	125	108	0	4	0	1099	2366
	N4	34	628	224	308	0	0	2	931	2127
	N5	61	1923	40	316	0	1	0	1249	3589
	mean	27	874	210	192	0	1	3	1134	2442
Mixed pasture	N1	0	1647	527	35	0	2112	1	675	4996
	N2	0	2479	21	192	0	1787	5	939	5422
	N3	0	1330	97	52	0	2832	0	833	5144
	N4	0	2361	19	203	0	2377	0	837	5796
	N5	0	3375	261	183	0	1446	8	1261	6533
	mean	0	2238	185	133	0	2111	3	909	5578
	MEAN	16	1785	164	65	73	423	3	938	3467

Table 22

Experiment No. P190 b - Waite Institute
Number of onion weed plants per square link.

14th - 19th November, 1951.

Treatment		Block A	B	C	D	Mean
Volunteer pasture	N1	1.16	0.80	0.68	0.68	0.83
	N2	0.84	1.00	0.76	0.76	0.84
	N3	1.36	1.24	0.48	1.04	1.03
	N4	1.08	1.48	0.68	0.44	0.92
	N5	0.96	0.84	0.56	0.56	0.73
	mean					0.87
Wimmera rye grass pasture	N1	0.48	0.44	0.68	1.08	0.67
	N2	0.32	0.36	0.28	0.52	0.37
	N3	0.40	0.60	0.68	0.28	0.49
	N4	0.36	0.52	0.64	0.28	0.45
	N5	0.80	0.92	0.32	0.48	0.63
	mean					0.52
Perennial rye grass pasture	N1	0.28	0.72	1.44	0.56	0.75
	N2	1.32	0.44	0.36	0.80	0.73
	N3	0.60	0.52	0.24	0.28	0.41
	N4	0.40	0.32	0.64	0.76	0.53
	N5	0.24	0.64	0.52	0.40	0.45
	mean					0.57
Phalaris tuberosa pasture	N1	0.76	0.76	0.44	1.68	0.91
	N2	0.92	0.36	0.76	0.40	0.61
	N3	0.64	0.84	0.96	0.44	0.72
	N4	0.88	1.24	0.64	0.52	0.82
	N5	1.24	0.88	0.52	0.56	0.80
	mean					0.77
Mixed pasture	N1	0.56	1.20	0.36	0.24	0.59
	N2	0.32	0.56	0.12	0.72	0.43
	N3	0.68	0.44	0.32	0.44	0.47
	N4	1.08	0.64	1.00	0.08	0.70
	N5	0.48	0.68	0.36	0.52	0.51
	mean					0.54
	MEAN	0.73	0.74	0.58	0.58	0.66

Means for nitrogen

N1	N2	N3	N4	N5
0.75	0.60	0.62	0.68	0.62

Additional ammonium sulphate was applied to the plots on the 22nd of April, 1952. The rate applied in 1952 was double that of the previous year and conformed to the amounts indicated below:

N1	nil
N2	56 lbs. per acre
N3	112 lbs. " "
N4	224 lbs. " "
N5	448 lbs. " "

224 lbs. per acre of commercial superphosphate had been applied a few days earlier to all of the plots with a spreader.

Botanical composition, 1952: On the 30th of July, 1952 the point method of pasture analysis was applied to assess the botanical composition of the plots. The method was identical with that used for experiment no. P190 a on the 6th of August and previously described. Figure II-14 illustrates the use of this technique in the field. Only blocks A and B were sampled. For convenience of presentation and interpretation the species are divided into the same groups as those used to express the results of the 1951 harvest of experiment no. P190 b. These data are presented in table 23. No lucerne plants were encountered during the pointing. The appearance of typical N1 and N5 plots at this time is shown in figures II-15 to II-24.

Harvest 1952: Sampling of the plots for determination of yield and botanical composition was carried out between the 18th and 26th of August, 1952. The methods were the same as those described for the 1952 harvest of experiment no. P190 a except that the greater growth of herbage at the Waite Institute made it necessary to subsample some of the larger samples in order to economize on oven space. The yields of herbage were calculated in oven dry weight per acre and are presented in table 24. The same ranking method as used for the 1952 harvest of experiment no. P190a was used to estimate

Figure II-14

Use of the point method of pasture analysis on an N2 Phalaris tuberosa plot (Experiment no. P190 b) at the Waite Institute on 30th July, 1952.

Table 23
Experiment No. P190 b - Waite Institute
Number of hits per 45 systematically spaced points per plot.
Mean of blocks A and B only. 30th July, 1952

Treatment		Onion weed	Wimmera rye grass	Other annual grasses	*Phalaris tuberosa*	Perennial rye grass	Sub clover	Other annual legumes	Lucerne	Misc. species	Total	Bare ground
Volunteer pasture	N1	2.5	0.5	4.0	0.0	0.0	0.0	1.0	0.0	16.5	24.5	26.0
	N2	4.0	5.0	2.5	0.0	0.0	0.0	1.0	0.0	20.0	32.5	22.5
	N3	9.5	19.0	14.5	0.0	0.0	0.0	0.0	0.0	23.5	66.5	10.0
	N4	6.0	24.5	20.0	0.0	0.0	0.0	0.0	0.0	31.0	81.5	8.5
	N5	12.5	31.5	6.0	0.0	0.0	0.0	0.0	0.0	128.5	178.5	0.0
	mean	6.9	16.1	9.4	0.0	0.0	0.0	0.4	0.0	43.9	76.7	13.4
Wimmera rye grass pasture	N1	0.5	14.5	0.5	0.0	0.0	0.0	0.0	0.0	9.0	24.5	24.0
	N2	3.0	29.5	0.0	0.0	0.0	0.0	0.0	0.0	3.5	36.0	23.0
	N3	2.5	49.0	0.0	0.0	0.0	0.0	0.0	0.0	2.5	54.0	16.0
	N4	5.0	63.0	0.0	0.0	0.0	0.0	0.0	0.0	11.5	79.5	8.0
	N5	2.0	194.5	0.0	0.0	0.0	0.0	0.0	0.0	41.5	238.0	0.0
	mean	2.6	70.1	0.1	0.0	0.0	0.0	0.0	0.0	13.6	86.4	14.2
Perennial rye grass pasture	N1	1.5	0.0	0.5	0.0	16.0	0.0	0.5	0.0	3.0	21.5	28.0
	N2	1.5	0.0	0.0	0.0	34.5	0.0	0.5	0.0	6.5	43.0	20.5
	N3	2.0	0.0	2.0	0.0	35.0	0.5	0.5	0.0	4.5	44.5	17.5
	N4	0.0	0.0	0.0	0.0	82.5	0.0	0.0	0.0	13.5	96.0	4.5
	N5	0.0	0.0	0.0	0.0	143.0	0.0	0.0	0.0	23.5	166.5	1.0
	mean	1.0	0.0	0.5	0.0	62.2	0.1	0.3	0.0	10.2	74.3	14.3
Phalaris tuberosa pasture	N1	2.5	4.0	2.0	26.5	0.0	0.0	0.0	0.0	9.5	44.5	19.5
	N2	2.5	2.5	0.5	29.0	0.0	0.0	0.0	0.0	11.5	46.0	19.0
	N3	0.0	6.0	4.5	30.5	0.0	6.0	0.0	0.0	6.0	53.0	18.5
	N4	3.0	15.5	1.5	56.0	0.0	0.0	0.0	0.0	23.5	99.5	2.0
	N5	1.0	7.5	0.0	131.5	0.0	0.0	0.0	0.0	48.5	188.5	1.5
	mean	1.8	7.1	1.7	54.7	0.0	1.2	0.0	0.0	19.8	86.3	12.1
Mixed pasture	N1	0.5	14.0	0.5	25.0	0.0	131.5	0.0	0.0	8.0	179.5	0.0
	N2	0.5	32.5	0.0	24.0	0.0	98.5	0.0	0.0	6.0	161.5	1.0
	N3	0.0	46.0	0.0	30.0	0.0	88.5	0.0	0.0	20.5	185.0	0.5
	N4	3.5	75.0	0.0	39.0	0.0	37.0	0.0	0.0	29.5	184.0	0.0
	N5	0.0	137.5	0.0	55.0	0.0	7.5	0.0	0.0	36.0	236.0	0.0
	mean	0.9	61.0	0.1	34.6	0.0	72.6	0.0	0.0	20.0	189.2	0.3
	MEAN	2.6	30.9	2.4	17.9	12.4	14.8	0.1	0.0	21.5	102.6	10.9

Figure II-15

Experiment No. P190 b: A typical N1 volunteer pasture plot.

Figure II-16

Experiment No. P190 b: A typical N5 volunteer pasture plot.

Figure II-17

Experiment No. P190 b: A typical N1 wimmera rye grass pasture plot.

Figure II-18

Experiment No. P190 b: A typical N5 wimmera rye grass pasture plot.

Figure II-19

Experiment No. P190 b: A typical N1 perennial rye grass pasture plot.

Figure II-20

Experiment No. P190 b: A typical N5 perennial rye grass pasture plot.

Figure II-21

Experiment No. P190 b: A typical N1 Phalaris tuberosa pasture plot.

Figure II-22

Experiment No. P190 b: A typical N5 Phalaris tuberosa pasture plot.

Figure II-23

Experiment No. P190 b: A typical N1 mixed pasture plot.

Figure II-24

Experiment No. P190 b: A typical N5 mixed pasture plot.

Table 24
Experiment No. P190 b - Waite Institute
Yield of all species in lbs. oven dry weight per acre
18th and 26th August, 1952.

Treatment		Block A	Block B	Block C	Block D	Mean
Volunteer pasture	N1	1256	2338	1848	1159	1650
	N2	1280	1633	1056	1385	1339
	N3	2220	3397	1288	2169	2269
	N4	2534	2500	4021	3445	3125
	N5	3882	5131	3667	7112	4948
	mean					2666
Wimmera rye grass pasture	N1	1482	1885	3825	1509	2175
	N2	1577	2259	2044	2158	2010
	N3	1626	3250	2199	2683	2440
	N4	3734	3798	3729	3118	3595
	N5	4875	5616	5499	6422	5603
	mean					3165
Perennial rye grass pasture	N1	1539	1764	929	1329	1390
	N2	1869	2164	1157	1861	1763
	N3	2310	1792	1338	2054	1874
	N4	3041	2922	3558	2811	3083
	N5	4260	5297	5195	5139	4973
	mean					2617
<u>Phalaris tuberosa</u> pasture	N1	1667	1796	800	1433	1424
	N2	1970	1846	1510	1584	1728
	N3	2106	2452	1554	1642	1939
	N4	3310	3365	1008	3085	2692
	N5	4030	3803	5289	5268	4598
	mean					2476
Mixed pasture	N1	4938	5127	3916	5641	4906
	N2	4519	4621	3993	5226	4590
	N3	3899	4643	5239	5707	4872
	N4	4628	5186	3842	5826	4871
	N5	4257	4945	4845	5630	4919
	mean					4832
	MEAN	2912	3341	2934	3416	3151

Means for nitrogen

N1	N2	N3	N4	N5
2309	2286	2679	3473	5008

Analysis of variance

Variance due to:	Variance ratio:
Treatments	19.283***
Nitrogen	58.817***
pasture	42.714***
nitrogen x pasture	3.5 n.s.
Blocks	3.940 *

Difference for significance

	means of 4	means of 20
5%	941	421
1%	1248	558
0.1%	1604	717

the botanical composition of the 1952 harvest of experiment no. P190 b. The species classes used to express the botanical composition are the same as those used for the 1951 harvest of the Waite Institute plots. The two rye grasses were not readily distinguished in an oven dry state so results for these two species have been bulked. The data obtained for botanical composition are presented in table 25.

On August 19th a mob of sheep were turned on the plots and they were given a quick hard graze. This was done to remove the dense growth of herbage which would otherwise interfere with the growth of pasture in 1953 and confuse the interpretation of the harvest yields.

Top dressing, 1953: On the 20th of April, 1953 the plots were top dressed at the rate of 224 lbs. of commercial superphosphate per acre. The same amounts of ammonium sulphate were applied to each plot as on the 22nd of April, 1952.

Persistence of onion weed, May, 1953: In order to assess the persistence of onion weed under the several treatments by the end of the second summer the plants present on a portion of each plot were counted. The number of onion weed plants inside a quadrat 5 links square located in the center of each plot was taken as a measure of persistence. During the growing season the heavy growth of herbage on the plots rendered this method unsuitable for the analysis of onion weed. At the time of this quadrat count even small onion weed plants were discernable. The plants were counted on the 2nd of May, 1952. The results are presented in table 26.

Persistence of onion weed, September, 1953: The same field ranking method was employed to estimate the quantity and vigor of onion weed as was used for experiment no. P190 a, on 23rd of December, 1952. The plots were rated by four observers on the 4th of September, 1953. The data obtained are presented in table 27a and analyzed in table 27b.

Table 25
Experiment No. P190 b - Waite Institute
Estimated yield in lbs. oven dry weight per acre.
18th and 26th August, 1952.
Means of 4 blocks

Treatment		Onion weed	Lolium spp.	Other annual grasses	Phalaris tuberosa	Sub clover	Other annual legumes	Lucerne	Misc. spp.	Inert matter	Total
Volunteer pasture	N1	604	+	+	0	+	+	0	61	986	1650
	N2	51	151	16	0	52	29	0	37	1003	1339
	N3	157	807	113	0	+	+	0	70	1122	2269
	N4	32	2213	565	0	+	+	0	63	253	3125
	N5	97	3644	274	0	0	0	0	885	49	4948
	mean	188	1363	194	0	10	6	0	223	683	2666
Wimmera rye grass pasture	N1	47	754	287	0	+	66	0	+	1022	2175
	N2	109	1093	+	0	+	+	0	+	808	2010
	N3	96	1755	+	0	+	+	0	+	589	2440
	N4	48	3501	+	0	+	+	0	+	47	3595
	N5	+	5533	+	0	0	+	0	+	70	5603
	mean	60	2527	57	0	+	13	0	+	507	3165
Perennial rye grass pasture	N1	105	255	0	0	+	+	0	+	1030	1390
	N2	+	1153	+	0	+	+	0	+	609	1763
	N3	+	1246	+	0	+	+	0	+	628	1874
	N4	37	2717	+	0	+	+	0	37	293	3083
	N5	+	4724	0	0	0	0	0	+	249	4973
	mean	28	2019	+	0	+	+	0	7	562	2617
Phalaris tuberosa pasture	N1	90	10	+	334	+	72	0	20	899	1424
	N2	62	193	+	517	+	20	0	+	937	1728
	N3	+	494	31	467	0	31	0	+	917	1939
	N4	51	441	+	1755	13	+	0	+	432	2692
	N5	+	1869	+	2517	+	0	0	117	95	4598
	mean	41	601	6	1118	3	25	0	27	656	2476
Mixed pasture	N1	+	252	+	568	3961	0	0	+	126	4906
	N2	+	1227	0	959	2235	0	+	+	170	4590
	N3	+	1705	0	1465	1489	0	+	58	156	4872
	N4	+	2371	0	1478	899	0	+	65	58	4871
	N5	+	2715	0	1895	124	0	0	132	53	4919
	mean	+	1654	+	1273	1742	0	+	51	113	4832
	MEAN	63	1633	51	478	351	9	+	62	504	3151

Table 26

Experiment No. P190 b - Waite Institute

Number of onion weed plants per square link

2nd May, 1953

Treatment		Block A	B	C	D	Mean
Volunteer pasture	N1	0.36	0.16	0.76	1.00	0.57
	N2	0.72	0.88	0.72	0.36	0.67
	N3	1.16	0.84	0.40	0.64	0.76
	N4	1.32	1.04	0.52	0.68	0.89
	N5	0.76	0.44	0.76	0.08	0.51
	mean					0.68
Wimmera rye grass pasture	N1	0.80	0.84	0.52	0.52	0.67
	N2	0.80	0.52	0.44	0.52	0.57
	N3	0.24	0.28	0.60	0.40	0.38
	N4	0.44	0.44	0.64	0.52	0.51
	N5	0.00	0.08	0.20	0.24	0.13
	mean					0.45
Perennial rye grass pasture	N1	0.00	0.24	0.48	0.36	0.27
	N2	0.12	0.32	0.28	0.32	0.26
	N3	0.00	0.96	0.24	0.52	0.43
	N4	0.12	0.00	0.00	0.04	0.04
	N5	0.00	0.00	0.00	0.00	0.00
	mean					0.20
Phalaris tuberosa pasture	N1	0.20	0.12	0.08	0.12	0.13
	N2	0.16	0.08	0.20	0.08	0.13
	N3	0.20	0.20	0.28	0.08	0.19
	N4	0.04	0.16	0.04	0.20	0.11
	N5	0.00	0.00	0.00	0.00	0.00
	mean					0.11
Mixed pasture	N1	0.16	0.12	0.04	0.00	0.08
	N2	0.00	0.04	0.08	0.04	0.04
	N3	0.00	0.00	0.12	0.24	0.09
	N4	0.04	0.00	0.16	0.00	0.05
	N5	0.00	0.00	0.00	0.08	0.02
	mean					0.06
	MEAN	0.31	0.31	0.30	0.28	0.30

Means for nitrogen

N1	N2	N3	N4	N5
0.34	0.33	0.37	0.32	0.13

Table 27a
Experiment No. P190 b - Waite Institute
Ranking of onion weed in the field by four observers.
4th September, 1953.
Scale 0 to 80.
Original data (see table 27b)

Treatment		Block A	B	C	D	Means
Volunteer pasture	N1	43	31	47	58	44.75
	N2	46	30	58	60	48.50
	N3	37	27	50	65	44.75
	N4	57	35	58	55	51.25
	N5	32	18	42	24	29.00
	mean					43.65
Wimmera rye grass pasture	N1	64	61	63	47	58.75
	N2	74	78	71	68	72.75
	N3	58	71	80	55	66.00
	N4	24	65	67	44	50.00
	N5	4	57	38	66	41.25
	mean					57.75
Perennial rye grass pasture	N1	3	29	27	30	22.25
	N2	10	32	18	28	22.00
	N3	5	29	18	25	19.25
	N4	2	14	13	5	8.25
	N5	0	4	14	0	4.50
	mean					15.30
<u>Phalaris tuberosa</u> pasture	N1	7	14	10	16	11.75
	N2	5	10	12	11	9.50
	N3	2	10	8	11	7.75
	N4	1	4	6	8	4.75
	N5	0	0	5	0	1.25
	mean					7.00
Mixed pasture	N1	2	18	20	33	18.25
	N2	0	9	25	10	11.00
	N3	1	2	3	18	6.00
	N4	0	3	20	0	5.75
	N5	0	0	1	0	0.25
	mean					8.25
	MEAN					26.39

Means for nitrogen

N1	N2	N3	N4	N5
31.15	32.75	28.75	24.05	15.25

Table 27b
Experiment No. P190 b - Waite Institute
Ranking of onion weed in the field by four observers
4th September, 1953
Transformed data from table 27a
log (x + 1)

Treatment		Block A	B	C	D	Totals
Volunteer pasture	N1	1.6435	1.5051	1.6812	1.7709	6.6007
	N2	1.6721	1.4914	1.7709	1.7853	6.7197
	N3	1.5798	1.4472	1.7076	1.8195	6.5541
	N4	1.7634	1.5563	1.7709	1.7482	6.8388
	N5	1.5185	1.2788	1.6335	1.3979	5.8287
Wimmera rye grass pasture	N1	1.8129	1.7924	1.8062	1.6812	7.0927
	N2	1.8751	1.8976	1.8573	1.8388	7.4688
	N3	1.7709	1.8573	1.9085	1.7482	7.2849
	N4	1.3979	1.8195	1.8325	1.6532	6.7031
	N5	0.6990	1.7634	1.5911	1.8261	5.8796
Perennial rye grass pasture	N1	0.6021	1.4771	1.4472	1.4914	5.0178
	N2	1.0414	1.5185	1.2788	1.4624	5.3011
	N3	0.7782	1.4771	1.2788	1.4150	4.9491
	N4	0.4771	1.1761	1.1461	0.7782	3.5775
	N5	0	0.6990	1.1761	0	1.8751
<u>Phalaris tuberosa</u> pasture	N1	0.9031	1.1761	1.0414	1.2304	4.3510
	N2	0.7782	1.0414	1.1139	1.0792	4.0127
	N3	0.4771	1.0414	0.9542	1.0792	3.5519
	N4	0.3010	0.6990	0.8451	0.9542	2.7993
	N5	0	0	0.7782	0	0.7782
Mixed pasture	N1	0.4771	1.2788	1.3222	1.5315	4.6096
	N2	0	1.0000	1.4150	1.0414	3.4564
	N3	0.3010	0.4771	0.6021	1.2788	2.6590
	N4	0	0.6021	1.3222	0	1.9243
	N5	0	0	0.3010	0	0.3010
TOTAL		21.8694	30.0727	33.5820	30.6110	

Analysis of variance

Variance due to:	Variance ratio:
Treatments	15.358 ***
Blocks	14.040 ***

Difference for significance
Totals of 4

5%	1.5080
1%	2.0081
0.1%	2.6067

Harvest, September, 1953: The plots were harvested for yield and botanical composition using the same methods employed for the harvesting, drying and ranking of experiment no. P190 a at Avon in December, 1952. None of the samples were subsampled. The onion weed was separated from the sample by hand prior to drying and was dried and weighed separately. The same species classes were used in ranking the rest of the sample for botanical composition as was employed previously for this experiment. Table 28 shows the yield of all species including onion weed. The yield of onion weed only is given for each plot in table 29. The ranked data for the rest of the species classes are presented in table 30. Between the time of weighing the samples and the time of ranking the samples several of the samples were inadvertently discarded and this accounts for the discrepancy between the total column in table 30 and the data in table 28.

Table 28
Experiment No. P190 b - Waite Institute
Yield of all species in lbs. oven dry weight per acre
7th September, 1953

Treatment		Block A	B	C	D	Mean
Volunteer pasture	N1	1351	1730	2019	2134	1809
	N2	1981	1556	2042	2575	2038
	N3	1820	1579	2272	2716	2097
	N4	3298	3246	3778	3369	3423
	N5	4393	3844	4274	5050	4390
	mean					2751
Wimmera rye grass pasture	N1	2046	2445	1773	1908	2043
	N2	2972	3180	3302	2116	2893
	N3	3143	3756	2864	3626	3348
	N4	3197	4719	5513	2538	3992
	N5	4010	4975	5662	5822	5117
	mean					3479
Perennial rye grass pasture	N1	732	1151	1407	1554	1211
	N2	1502	1519	1598	1616	1558
	N3	1561	1155	2033	1296	1511
	N4	2793	2910	3684	3035	3106
	N5	3402	4198	4719	5102	4355
	mean					2348
<u>Phalaris tuberosa</u> pasture	N1	1649	1425	1487	1163	1431
	N2	595	1270	1534	1391	1198
	N3	2544	2612	2486	4453	3024
	N4	3729	4266	3728	3502	3806
	N5	5222	3959	5145	4743	4767
	mean					2845
Mixed pasture	N1	3388	4121	3769	3588	3716
	N2	3823	3732	4036	3284	3719
	N3	4094	4311	4008	4023	4109
	N4	4131	5551	4488	4607	4694
	N5	6483	4763	4509	5844	5400
	mean					4328
	MEAN	2954	3119	3285	3242	3150

Means for nitrogen

N1	N2	N3	N4	N5
2042	2281	2818	3804	4806

Analysis of variance:

Variance due to:	Variance ratio:
Treatments	22.19 ***
nitrogen	85.58 ***
pasture	38.85 ***
nitrogen x pasture	2.18 *
Blocks	1.79 n.s.

Difference for significance

	means of 4	means of 20
5%	782	350
1%	1038	464
0.1%	1333	596

Table 29
Experiment No. P190 b - Waite Institute
Yield of onion weed in lbs. oven dry weight per acre.
7th September, 1953.

Treatment		Block A	Block E	Block C	Block D	Mean
Volunteer pasture	N1	443	372	1517	1711	1011
	N2	790	198	772	1579	834
	N3	683	335	878	1949	961
	N4	1499	1111	1561	891	1266
	N5	212	71	958	797	509
	mean					916
Wimmera rye grass pasture	N1	1349	1051	1367	1071	1210
	N2	2249	2651	2984	1120	2251
	N3	1261	2212	1700	1226	1600
	N4	624	2469	2898	792	1696
	N5	0	974	626	1494	773
	mean					1506
Perennial rye grass pasture	N1	+	163	499	769	358
	N2	12	169	28	355	141
	N3	0	203	49	194	111
	N4	+	85	72	7	41
	N5	+	+	23	+	6
	mean					131
Phalaris tuberosa pasture	N1	0	138	58	26	55
	N2	24	18	18	15	19
	N3	5	60	14	0	20
	N4	0	0	+	34	8
	N5	0	0	0	12	3
	mean					21
Mixed pasture	N1	0	125	88	60	68
	N2	0	28	64	0	23
	N3	4	0	+	27	8
	N4	4	100	0	+	26
	N5	0	0	0	0	0
	mean					25
	MEAN	366	501	647	565	520

Means for nitrogen

N1	N2	N3	N4	N5
540	654	540	607	258

Table 30
Experiment No. P190 b - Waite Institute
Estimated yield in lbs. oven dry weight per acre.
7th September, 1953.
Means of 4 blocks.

Treatment		Onion weed	*Lolium* spp.	Other annual grasses	*Phalaris tuberosa*	Sub clover	Other annual legumes	Lucerne	Misc. spp.	Inert matter	Total
Volunteer pasture	N1	1011	150	+	0	0	242	0	57	162	1622
	N2	834	793	+	0	50	+	0	177	183	2037
	N3	961	972	10	0	0	+	0	123	31	2097
	N4	1266	1874	+	0	0	0	0	219	184	3543
	N5	509	2453	395	+	0	0	0	909	124	4390
	mean	916	1275	90	+	11	40	0	315	133	2780
Wimmera rye grass pasture	N1	1210	582	+	0	0	+	0	77	175	2044
	N2	2251	536	+	+	+	0	0	55	88	2930
	N3	1600	1325	+	+	0	360	0	19	111	3415
	N4	1696	2007	0	0	+	0	0	43	262	4008
	N5	773	4307	0	0	0	0	0	84	67	5231
	mean	1506	1678	+	+	+	68	0	57	143	3452
Perennial rye grass pasture	N1	358	324	+	0	0	229	0	19	281	1211
	N2	141	823	+	0	0	42	0	45	484	1535
	N3	111	1025	+	0	0	+	0	168	207	1511
	N4	41	2417	+	0	0	0	0	433	215	3106
	N5	6	2187	0	0	0	0	0	1892	155	4240
	mean	131	1338	+	0	0	58	0	461	263	2251
Phalaris tuberosa pasture	N1	55	195	+	811	16	29	0	50	276	1432
	N2	19	434	0	586	0	23	0	35	77	1174
	N3	20	1129	64	1045	+	+	0	95	704	3057
	N4	8	1120	0	2087	0	0	0	124	311	3650
	N5	3	165	0	4609	0	0	0	259	+	5036
	mean	21	615	15	1722	4	11	0	108	299	2795
Mixed pasture	N1	68	1122	0	2075	88	0	88	+	85	3546
	N2	23	1387	0	2178	0	+	50	+	41	3679
	N3	8	806	+	3028	0	0	0	+	272	4114
	N4	26	1477	0	3015	0	0	0	160	77	4755
	N5	0	975	0	4203	0	0	+	141	81	5400
	mean	25	1159	+	2988	11	+	23	65	106	4377
	MEAN	520	1210	22	907	5	36	4	209	191	3104

6. Experiment No. P191 b.

To complement the field experiments some glasshouse trials in pots were undertaken under controlled moisture conditions.

Aim: To study competition between onion weed and wimmera rye grass when the available nutrient nitrogen is varied and the moisture content of the soil is held relatively constant.

Experimental design: There were three sowing treatments:

1. Wimmera rye grass (Lolium rigidum) only.
2. Onion weed (Asphodelus fistulosus) only.
3. Wimmera rye grass plus onion weed.

Each sowing treatment was given soil applications of sodium nitrate at 5 different rates per acre, which are designated N1, N2, N3, N4, and N5.

These 15 treatments were each replicated 3 times necessitating the use of 45 experimental pots. These were arranged in 3 randomised blocks on a glasshouse bench.

Procedure: Soil was collected from a site adjacent to experiment no. P190 a at Avon, South Australia. The top 4 to 6 inches was taken from a deep phase of solonized brown soil. The soil was spread thinly on a concrete floor to dry. When dry it was screened through 1/2 inch square wire mesh and thoroughly mixed.

Forty-five enameled iron pots each of 6 inches internal diameter and 8 1/2 inches internal depth were tared with coarse gravel to 1.200 kilograms. To each pot was added 4.000 kilograms of air dry soil. Samples were taken for moisture determination after filling every 10th pot. Soil moisture at the time of filling the pots was determined by drying the samples to constant weight in an oven at 105° C. The mean weight of oven dry soil per pot as calculated from these determinations was 3.6484 kilograms.

The pots were arranged in numerical order on a glasshouse bench and watered for 8 weeks to stimulate weed growth. Weeds were removed periodically until planting date. After planting weed growth was slight and any weeds which did emerge were removed daily.

The experiment was carried out in the "open" end of a glasshouse having coarse wire mesh sides and a glass roof in order to approximate field conditions in respect to temperature, atmospheric composition and light while maintaining control of soil moisture.

The treatments were randomized against the pot numbers in accordance with the experimental design. On the 6th of September, 1951, the pots were planted appropriately with germinating seeds. A previous trial had indicated that the mean temperature inside the glasshouse was not high enough to permit uniform germination of onion weed. To avoid this difficulty the seeds of both species were placed on moist blotting paper and held for 3 days at a temperature of 21° C. in a germination incubator. At the end of this time nearly all of the radicals had emerged and these germinating seeds were planted in the pots. Five pots in each block received 18 onion weed seeds, another 5 pots in each block received 12 wimmera rye grass seeds and the remaining 5 pots in each block received 18 onion weed seeds plus 12 wimmera rye grass seeds. A high per cent of these seeds emerged in every pot.

The wimmera rye grass seed had been received at the Waite Institute in March, 1951 from a commercial source (W.A.R.I. Seed Index No. 4660). The onion weed seed had been collected from a sand ridge opposite the railway station at Bowmans, South Australia on the 14th of November, 1950.

From 3 weeks before planting date until the termination of the experiment the pots were weighed daily or twice daily and tap water added as necessary to bring the mean moisture content up to 16% of its oven dry weight. The proper moisture level was determined empirically by gradually moistening a sample of the soil until in the opinion of several experienced observers an "ideal" moisture status had been obtained. The moisture content was then determined by drying at 105° C. to constant weight. The "ideal" moisture content so determined was 15% and the soil in the experimental pots was maintained within 1% of this mean value at all times, i.e., between 5.432 kilograms and 5.359 kilograms total pot weight. The water holding capacity of the experimental soil as determined by the method of Keen-Raczkowski (Piper, 1947a) was 41.44%.

The "sticky point" was determined to lie at about 19% of the oven dry weight. The value for sticky point is in general somewhat higher than field capacity (Piper, 1947b). It is probable that during this experiment the soil was held at a moisture content in the vicinity of field capacity.

The permanent wilting percentage of this sample of soil as determined by the pressure membrane method was 6.6% of the oven dry weight. This value was supplied through the courtesy of the Department of Soil Physics of the C.S.I.R.O. Division of Soils, Adelaide. The permanent wilting percentage of a second sample of soil from the same sampling site was determined by the direct method using tomatoes as an indicator plant. The mean of 5 determinations was 6.21% of the oven dry weight.

The mean moisture content maintained during the experiment was about 37% of the water holding capacity. Pot culture experiments are commonly maintained at 50% to 70% of water holding capacity (Piper, 1947a). The value of the empirical method used to determine the soil moisture content to be maintained during this experiment was tested in experiment no. P191 a. There was no significant difference between the growth obtained at soil moisture contents of 37% water holding capacity and 51% water holding capacity using the same growth medium at nitrogen level N3.

On the 20th of September, 1951 (2 weeks after planting) the first application of sodium nitrate was made to the soil. One-sixth of the total fertilizer was applied each week for 6 weeks in an effort to approximate the gradual release of nitrates into the soil by nitrification. The weekly and total amounts of sodium nitrate and nitrogen applied to each pot were:

	Molar concentration of applied solution	Sodium nitrate per pot per week	Total sodium nitrate after 6 weeks	Total nitrogen per pot after 6 weeks	Total nitrogen per acre after 6 weeks
N1	0	0	0	0	0
N2	0.0073	0.031 gms.	0.186 gms.	0.031 gms.	15 lbs.
N3	0.0146	0.062 "	0.372 "	0.061 "	30 "
N4	0.0292	0.124 "	0.745 "	0.123 "	60 "
N5	0.0584	0.248 "	1.490 "	0.246 "	120 "

In each case the nitrogen was applied evenly to the surface of the soil in 50 c.c. of a water solution and the pots were afterward brought up to 16% moisture with additional water. The 6th and final application of sodium nitrate was made on the 21st of October.

On the 11th of October the pots were thinned to 6 plants of each species according to the appropriate treatment. Pots which contained both onion weed and wimmera rye grass were left with 6 plants of each species or 12 plants in all. 250 grams of a fine gravel mulch was added to the surface of the pots to reduce water loss from the surface of the soil. From this time a record of water consumption was maintained for each pot.

The pots were harvested on the 10th of December, 1951. This was 13 1/2 weeks after planting date and 7 weeks after the final application of sodium nitrate. The first of the wimmera rye grass plants had just begun to flower.

For about one hour before the harvesting operation the pots were flooded with water to loosen the soil from the roots and sides of the pot. Soil and plants were dumped out of the pot and the roots were washed free of soil particles under a strong stream of water. The onion weed and wimmera rye grass plants were separated from one another. The roots were cut away from the above ground parts. The latter comprised the leaves plus crown stems of onion weed and leaves plus a few inflorescences of wimmera rye grass. These plant fractions were labeled with the appropriate pot number and dried to constant weight at 105° C. The dry weights so obtained were used to compare the treatments. The data for dry weight and water consumption are presented in tables 31, 32, 33 and 34. The weight of water consumed by each pot has been adjusted by subtracting the mean water consumption per pot of 3 fallow pots in experiment no. P191 a. The value so obtained is considered to approximate the water lost through transpiration. Experiment no. P191 a was on an adjacent bench in the same glasshouse.

Table 31
Experiment No. F191 b - Pot Culture
Yield of onion weed in grams per pot of 6 plants.
Total plant

Onion weed minus competition

	A	B	C	Mean
N1	4.94	6.05	5.71	5.57
N2	5.08	4.46	5.69	5.08
N3	4.23	4.71	5.15	4.70
N4	4.02	4.21	5.26	4.50
N5	3.13	3.22	3.63	3.33
mean				4.63

Onion weed plus competition

	A	B	C	Mean
N1	0.96	0.78	3.35	1.70
N2	1.05	1.16	0.80	1.00
N3	0.94	0.76	0.86	0.85
N4	1.03	0.85	1.06	0.98
N5	0.85	1.01	1.25	1.04
mean				1.11

Means for nitrogen

N1	N2	N3	N4	N5
3.63	3.04	2.78	2.74	2.19

Analysis of variance

Variance due to:	Variance ratio:
Treatments	45.07 ***
nitrogen	6.58 **
competition	366.88 ***
nitrogen x competition	3.10 *
Replicates	4.98 *

Variance ratios of breakdown analysis by nitrogen levels.

	N1	N2	N3	N4	N5
Treatments	21.2 *	84.4 *	170.0 **	95.0 *	786.0 **
Replicates	1.2 n.s.	Less than 1	Less than 1	1.4 n.s.	10.5 n.s.

Variance ratios of breakdown analysis by competition levels.

		minus competition	Plus competition
Treatments		17.5 ***	Less than 1
Replicates		7.4 *	1.1 n.s.
Difference	5%	0.655	
for	1%	0.954	
significance	0.1%	1.431	
means of 3			

Table 32
Experiment No. P191 b - Pot Culture
Yield of wimmera rye grass in grams per pot of 6 plants
Total plant

Wimmera rye grass minus competition

	A	B	C	Mean
N1	13.15	12.32	12.36	12.61
N2	12.85	13.17	15.47	13.83
N3	23.11	16.30	12.36	17.26
N4	15.10	16.08	10.44	13.87
N5	10.64	12.84	10.16	11.21
mean				13.76

Wimmera rye grass plus competition

	A	B	C	Mean
N1	10.54	11.01	6.11	9.22
N2	9.19	11.08	8.98	9.75
N3	11.40	10.27	9.30	10.32
N4	7.21	10.12	8.26	8.53
N5	10.42	9.51	8.44	9.46
mean				9.46

Means for nitrogen

N1	N2	N3	N4	N5
10.92	11.79	13.79	11.20	10.34

Analysis of variance

Variance due to:	Variance ratio:
Treatments	4.996 **
nitrogen	2.333 n.s.
competition	30.502 ***
nitrogen x competition	1.284 n.s.
Replicates	3.33 n.s.

Difference for significance means of 3

5%	=	3.655
1%	=	5.007

Table 33
Experiment No. P191 b - Pot Culture
Yield in grams per pot of 6 plants
Means of 3 pots

	Minus competition				Plus competition			
	Onion weed		Wimmera rye grass		Onion weed		Wimmera rye grass	
	leaves	roots	leaves	roots	leaves	roots	leaves	roots
N1	2.69	2.88	6.45	6.17	0.69	1.01	5.49	3.73
N2	3.00	2.08	7.80	6.03	0.67	0.34	6.13	3.61
N3	2.25	2.45	7.89	9.36	0.61	0.24	5.92	4.40
N4	2.10	2.40	8.41	5.47	0.74	0.24	5.17	3.36
N5	1.63	1.70	6.30	4.92	0.64	0.40	5.69	3.77
	2.33	2.30	7.37	6.39	0.67	0.45	5.68	3.78

Table 34
Experiment No. P191 b - Pot Culture
Amount of water transpired in 25 days
given in grams per pot of 6 plants
Means of 3 pots

Treatment	Wimmera rye grass only	Onion weed only	Wimmera rye grass plus onion weed
N1	2815	1713	2631
N2	2868	1696	2879
N3	2992	1307	2887
N4	2810	1241	2660
N5	2675	937	2626
Mean	2832	1379	2737

D. Experiment No. P191 a.

Aim: To study competition between onion weed and wimmera rye grass when the available soil moisture is varied and the nutrient nitrogen is held relatively constant.

Experimental design: There were 4 sowing treatments:

1. Wimmera rye grass only.
2. Onion weed only.
3. Wimmera rye grass plus onion weed.
4. Fallow pots.

Each sowing treatment was maintained during the later stages of the experiment at 3 different levels of soil moisture which were designated W1, W2, and W3.

These 12 treatments were replicated three times necessitating the use of 36 experimental pots. These were arranged in 3 completely randomized blocks on a glasshouse bench.

Procedure: The experiment was set up concurrently with experiment no. P191 b. The pot preparation, soil preparation, seed source, planting technique, post-planting care and harvesting technique were the same for the two experiments. Experiment no. P191 a was planted the 5th of September, 1951. On the 20th of September the first of 6 weekly applications of sodium nitrate was applied. The rate of application for all pots was the same as that for the N3 treatment of experiment no. P191 b. This was 50 mls. of 0.0146 molar sodium nitrate per pot per week for 6 weeks.

Until the 4th of November the mean moisture level of the soil in the pots was maintained within 1% of the "ideal" value (15% of oven dry weight) used for experiment no. P191 b. At this time the mean soil moisture was adjusted to conform to the following treatment:

W1 pots between 10% and 12% of oven dry wt. or 24% and 29% of W.H.C.
W2 " " 14% " 16% " " " " " 34% and 39% " "
W3 " " 20% " 22% " " " " " 48% and 53% " "

As for experiment no. P191 b the water holding capacity (W.H.C.) was 41.44% of the oven dry weight of the soil, the permanent wilting percentage was 6.6% of the oven dry weight and the sticky point was 19% of the oven dry weight.

On the 10th of December, 1951, the pots were harvested. The dry weight data for total plant roots and tops are presented in tables 35, 36, and 37. The "transpiration" value given in table 38 is the mean water loss per planted pot of the indicated treatment minus the mean water lost by three fallow pots of the same soil moisture treatment.

Table 35
Experiment No. P191a - Pot Culture
Yield of onion weed in grams per pot of 6 plants
Total plant

Onion weed minus competition

	A	B	C	Mean
W1	2.95	3.08	3.44	3.16
W2	5.79	5.07	5.67	5.51
W3	6.34	4.39	4.40	5.04
mean				4.57

Onion weed plus competition

	A	B	C	Mean
W1	0.73	1.06	0.67	0.82
W2	1.09	0.85	0.44	0.79
W3	1.62	1.11	1.03	1.25
mean				0.96

Means for water levels

W1	W2	W3
1.99	3.15	3.15

Analysis of variance

Variation due to:	Variance ratio:
Treatments	54.6 ***
water level	10.75 **
competition	234 ***
w x competition	8.61 **
	1.89 n.s.

Difference for significance
means of 3

5%	0.913
1%	1.298
0.1%	1.878

Table 36
Experiment No. P191 a - Pot Culture
Yield of wimmera rye grass in grams per pot of 6 plants.
Total plant.

Wimmera rye grass minus competition

	A	B	C	Mean
W1	8.59	5.81	6.08	6.83
W2	12.08	11.70	11.45	11.74
W3	13.71	18.92	6.12	12.91
mean				10.50

Wimmera rye grass plus competition

	A	B	C	Mean
W1	5.67	6.48	5.01	5.72
W2	9.01	8.02	10.35	9.13
W3	11.58	11.66	9.34	10.86
mean				8.57

Means for water levels

W1	W2	W3
6.27	10.44	11.89

Analysis of variance

Variation due to:	Variance ratio:
Treatments	3.20 n.s.
Water level	6.77 *
competition	2.22 n.s.
w x competition	less than 1 n.s.
Blocks	1.34 n.s.

Difference for significance
means of 6

5% 3.53

Table 37
Experiment No. P191 a - Pot culture
Yield in grams per pot of 6 plants
means of 3 pots.

	Minus competition				Plus competition			
	Onion weed		Wimmera rye grass		Onion weed		Wimmera rye grass	
	leaves	roots	leaves	roots	leaves	roots	leaves	roots
W1	1.10	2.06	3.66	3.17	0.44	0.38	3.17	2.55
W2	2.52	2.99	6.84	4.91	0.51	0.29	5.78	3.35
W3	2.47	2.57	6.66	6.26	0.88	0.37	7.25	3.61
Mean	2.03	2.54	5.72	4.78	0.61	0.35	5.40	3.17

Table 38
Experiment No. P191a - Pot Culture
Amount of water transpired in 25 days
given in grams per pot of 6 plants
Means of 3 pots

Treatment	Wimmera rye grass only	Onion weed only	Wimmera rye grass plus onion weed
W1	1282	602	1271
W2	2502	1496	2620
W3	2979	1621	3720

E. Experiment No. P191 c.

Aim: To study the effect of the composition of the soil atmosphere on the growth of onion weed at 3 levels of nutrient nitrogen.

Experimental design: Onion weed only was sown at 3 levels of nutrient nitrogen which were designated N1, N3 and N5. At each level of nutrient nitrogen the following 4 conditions in respect to the soil atmosphere were created in the pots:

A1 low O_2 low CO_2
A2 low O_2 high CO_2
A3 high O_2 low CO_2
A4 high O_2 high CO_2

These 12 treatments were replicated 3 times. The 36 pots containing onion weed were arranged in three randomized blocks on a glasshouse bench. In addition there were 4 fallow pots--one for each aeration treatment.

Procedure: More soil was collected from a site adjacent to experiment No. P190a at Avon, S. A. The top 4 to 6 inches was taken from a deep phase of solonized brown soil. The soil was thinly spread on a concrete floor to dry and was subsequently screened through 1/2 inch square wire mesh and thoroughly mixed. The soil was placed in 40 pots of special design. The pots were made from ordinary gallon paint tins without lids. A pattern of small holes was drilled in the bottom of the paint tin to permit the gases to percolate up through the soil. A metal baking dish of suitable size was soldered to the bottom of the paint tin so as to form a gas chamber and this gas chamber was provided with a suitable inlet. The pots were painted white to reflect radiant heat and each was provided with a number.

The inlet to the gas chamber was connected to a metal manifold with plastic tubing. The manifold led from a 200 cu. ft. gas cylinder fitted with a flowmeter and a regulating valve. There were 4 cylinders each containing a different gas mixture in conformity with the experimental design.

One manifold led from each cylinder. Each manifold supplied 10 pots. Between the manifold and the pot the gas mixture was bubbled through water in a glass jar fitted with a gas tight lid. This device was intended to make the humidity of the gas uniform. The gas flow to each pot was measured by counting the number of bubbles passing through the jar in unit time. The gas flow to each pot was regulated by adjusting the head of water in the jar and by means of screw clamps on the plastic tubing. Water was added to the jar as necessary. The experimental set up just described is illustrated in figure II-25.

The pots were tared to 0.650 kilograms with a few pieces of coarse gravel each and 5.000 kilograms of air dry soil were added to each pot. Samples were taken for moisture determination after filling every 5th pot. These were dried to constant weight at 105° C. The mean weight of oven dry soil per pot as calculated from these determinations was 4.648 kilograms. The water holding capacity of this sample of soil as determined by the method of Keen-Raczkowski (Piper, 1947a) was 45.32% of the oven dry weight.

For 5 weeks prior to planting the pots were kept watered and any weeds which emerged were removed.

The experiment was carried out in the "open" end of the same glasshouse as experiment no. P191b. The pots were arranged in numerical order on a glasshouse bench and the treatments were randomized against the pot numbers in accordance with the experimental design. On the 5th of September, 1951, the pots were planted with 18 germinating onion weed seeds each. The seed had been held for 3 days on moist blotting paper in a germination incubator at 21° C. Seed was from the same sample as that used for experiment no. P191 b. Emergence of the seed was prompt and a high percentage of emergence was obtained in each pot.

Figure II-25.

Experiment No. P191 c. Arrangement of pots, bubblers, manifold and gas cylinders. On the near background are experiment no. P191a and experiment no. P191 b.

From 3 weeks before planting until the termination of the experiment the pots were weighed daily or twice daily and tap water was added as necessary to bring the mean moisture content up to 16% of its oven dry weight.

On the 20th of September, 1951 the first application of sodium nitrate was made to the soil. The same method of application was followed as for experiment No. P191 b. There were 6 equal weekly applications. The rates of application were:

	Molar concentration	Sodium nitrate per pot per week	Total sodium nitrate after 6 weeks
N1	0	0	0
N3	0.0146	0.062 grams	0.372 grams
N5	0.0584	0.248 grams	1.490 grams

The nitrogen was applied as before in 50 c.c. of water and the pots were afterward brought up to 16% moisture with additional water. The final application of sodium nitrate was made on the 21st of October.

On the 11th of October the plants in the pots were thinned to 6 plants per pot. 300 grams of a fine gravel mulch were added to the surface of the pots.

On the 4th of November, 1951, aeration of the soil in the pots was commenced with the gas mixtures contained in the cylinders. The flow rate was adjusted to give approximately 60 bubbles per minute through the glass jar. Some of the glass jars were roughly calibrated and this flow rate was found to be approximately equal to 5 liters of gas per pot per day. Calculations from the value for water holding capacity and moisture content of the soil suggest that the pore space occupied by air was 1.4 liters. The flow rate was checked daily and adjusted as necessary.

The cylinders had been obtained from a commercial source and the composition of the contained gas was known only approximately. The gas in the cylinders was analyzed using the Hemple gas analyzer. The method utilizes a 60% potassium hydroxide solution to remove CO_2. The amount of CO_2 lost by the sample is measured from the change in volume. After removal and measurement of the carbon dioxide the amount of oxygen is measured by the change in volume of the sample after absorption of the oxygen in strong potassium pyro gallate solution (2 parts of 30% pyrogallic acid plus 7 parts 36% potassium hydroxide). The gas which remained was assumed to be nitrogen. The results of this analysis for the gas contained in the cylinders was:

	% CO_2	% O_2	% N_2
A1	0	7.6	92.4
A2	24.5	5.8	69.7
A3	0	19.5	80.5
A4	28.8	15.7	55.5

The figures quoted are the means of 3 analyses and are given in per cent by volume.

The composition of the soil air one inch above the bottom of the pot was also measured approximately. A glass tube of approximately 0.54 cu. cm. volume was fitted snugly inside with a wire rod. The tube and rod were inserted into the soil in the pot to within 1 inch of the bottom and the rod was withdrawn. A 50 c.c. gas sampling tube filled with saturated sodium chloride solution was quickly fitted to the upper end of the glass tube by means of rubber tubing. The saturated salt solution was then allowed to drain out of the sampling tube and to be replaced by soil atmosphere. Except for the small amount in the glass tube which was inserted into the soil, care was taken to prevent entry of outside air into the sampling tube. The total pore space in the soil occupied by soil atmosphere was about 28 times the volume of the sample.

The sample of soil atmosphere so obtained was analyzed in the Hemple apparatus as described above. Two pots chosen at random were sampled from each of the four soil atmosphere treatments. The mean values so obtained for the composition (% volume) of the soil atmosphere were:

	CO_2	O_2	N_2
A1	0.8	14.0	85.2
A2	7.6	16.4	76.0
A3	0.7	19.7	79.6
A4	6.1	19.1	74.8

The experiment was harvested on the 1st of February, 1952, 148 days after planting. The harvesting technique was the same as that described for experiment no. P191 b. The data for the dry weight of plant parts are presented in tables 39, 40 and 41.

Table 39
Experiment No. P191 c - Pot Culture
Yield of onion weed after growth under several conditions of soil atmosphere and nutrient nitrogen--grams per pot of 6 plants
Roots only

Treatment	A	B	C	Mean
		low O_2 low CO_2		
N1	12.39	11.26	11.48	11.71
N3	11.70	11.99	10.75	11.48
N5	9.96	9.57	9.06	9.53
mean				10.91
		low O_2 high CO_2		
N1	11.71	11.99	10.93	11.54
N3	13.03	13.56	11.24	12.61
N5	10.95	14.16	10.73	11.95
mean				12.03
		high O_2 low CO_2		
N1	10.11	14.47	14.41	13.00
N3	8.29	9.45	11.96	9.90
N5	8.93	8.24	9.08	8.75
mean				10.55
		high O_2 high CO_2		
N1	10.92	12.86	11.56	11.78
N3	13.34	11.73	14.35	13.14
N5	9.38	9.10	11.16	9.88
mean				11.60

Analysis of variance

Variation due to:	Variance ratio:
Treatments	3.54**
nutrient nitrogen	8.16**
soil oxygen	less than 1 n.s.
soil carbon dioxide	6.16*
nutrient N x O_2	2.09 n.s.
nutrient N x CO_2	4.19*
O_2 x CO_2	less than 1 n.s.
nutrient N x O_2 x CO_2	1.56 n.s.
Blocks	less than 1 n.s.

Difference for significance
means of 3

5% = 2.22
1% = 3.03

Table 40
Experiment No. P191 C - Pot Culture
Yield of onion weed after growth under several conditions of soil atmosphere and nutrient nitrogen--grams per pot of 6 plants
Leaves only

Treatment	A	B	C	Mean
	low O_2 low CO_2			
N1	5.62	5.40	6.08	5.70
N3	6.35	6.27	5.99	6.20
N5	6.44	6.64	6.91	6.66
mean				6.19
	low O_2 high CO_2			
N1	6.08	6.72	6.93	6.57
N2	7.18	6.72	6.35	6.75
N5	7.13	8.09	7.49	7.57
mean				6.97
	high O_2 low CO_2			
N1	5.21	5.90	5.85	5.65
N2	5.48	6.01	6.29	5.93
N3	6.35	6.28	6.57	6.40
mean				5.99
	high O_2 high CO_2			
N1	5.97	5.73	6.76	6.15
N3	7.04	7.09	8.00	7.38
N5	7.23	7.06	8.11	7.47
mean				7.00

Table 41
Experiment No. P191 c - Pot Culture
Yield of onion weed after growth under several conditions of soil atmosphere and nutrient nitrogen--grams per pot of 6 plants
Total plant

Treatment	A	B	C	Mean
		low O_2 low CO_2		
N1	18.02	16.66	17.56	17.41
N3	18.06	18.26	16.74	17.69
N5	16.39	16.21	15.97	16.19
mean				17.10
		low O_2 high CO_2		
N1	17.79	18.71	17.86	18.12
N3	20.22	20.29	17.60	19.37
N5	18.08	22.25	18.22	19.52
mean				19.00
		high O_2 low CO_2		
N1	15.32	20.37	20.26	18.65
N3	13.77	15.45	18.26	15.83
N5	15.27	14.52	15.65	15.15
mean				16.54
		high O_2 high CO_2		
N1	16.90	18.59	18.32	17.94
N3	20.37	18.82	22.35	20.51
N5	16.61	16.15	19.28	17.35
mean				18.60

F. The comparative assimilation of nitrogen.

This experiment is based upon the following postulate: That a plant's competitive ability and therefore its community status is a function of its capacity to absorb nutrients from the environment and its capability in metabolizing them. Nutrient nitrogen has been utilized for this experiment because this element is thought to be critical over most of the country occupied by onion weed. Wimmera rye grass has been chosen as a standard for comparison because it is a highly successful pasture plant already in general use on onion weed country.

Aim: To compare the uptake and utilization of nutrient nitrogen by onion weed with the uptake and utilization of nutrient nitrogen by wimmera rye grass.

Experimental design: The experiment was carried out in pot culture. There were 9 nitrogen and harvest treatments:

1. No added nitrogen--harvest at time of adding nitrogen to other pots.
2. " " " " 2 days after " " " " "
3. " " " " 4 " " " " " " " "

4. 0.050 grams of nitrogen added per pot as $NaNO_3$--harvest 2 days after.
5. 0.050 " " " " " " " " " 4 " "

6. 0.200 " " " " " " " " " 2 " "
7. 0.200 " " " " " " " " " 4 " "

8. 0.200 " " " " " " " $(NH_4)_2SO_4$ " 2 " "
9. 0.200 " " " " " " " " " 4 " "

Each of these nine treatments received 2 sowing treatments:

1. Onion weed only.
2. Wimmera rye grass only.

Each of these 18 treatments was replicated once making 36 pots in all. The replicates were randomized in 2 blocks.

Procedure: The growth medium was a fine sand from the heath country near Keith, South Australia. The sand was washed with tap water to carry off any soluble nutrients and fine soil particles. 36 glazed earthenware pots were tared to 2.800 kilograms with coarse gravel. The sand was thoroughly mixed and 3.700 kilograms were placed in each pot. Samples for moisture determination were taken after filling every 8th pot. These were dried to constant weight at 105° C. The mean weight of oven dry sand was calculated to be 3.3995 kilograms per pot.

The water holding capacity of the sand as determined by the Keen-Raczkowski method (Piper, 1947a) was 21.0% of its oven dry weight. During the course of the experiment the pots were watered daily with tap water to bring the moisture content of the sand up to 60% of the water holding capacity. The water content of the sand was determined by weighing the pots on a beam balance.

The plants were grown in an unheated glasshouse. The seed source was the same as for experiment no. P191 b. The seeds were germinated on moist filter paper in petrie dishes in the dark at the temperature of the laboratory for 2 days before planting. On the 9th of April, 1952, 12 germinating onion weed seeds were planted in 18 of the pots and 12 germinating wimmera rye grass seeds were planted in the other 18 pots. The pots were arranged in numerical order on a glasshouse bench.

On the 30th of April and the 1st of May the seedlings were thinned to 4 plants per pot and the following nutrients were applied to each pot:

KH_2PO_4	0.134 grams per pot or	0.0023 molar in the pot.
$MgSO_4 \cdot 7H_2O$	0.243 " " " "	0.0023 " " " "
$CaSO_4$	0.233 " " " "	0.0040 " " " "

The molar concentration of the nutrient solution in the pot was calculated on the basis of 428 grams of water per pot at 60% water holding capacity. Micronutrients were added as 0.428 ml. per pot of Arnon's A4 solution. Arnon's (1938) A4 solution contains:

H_3BO_3	2.860 grams per liter			
$MnCl_2 \cdot 4H_2O$	1.810	"	"	"
$ZnSO_4 \cdot 7H_2O$	0.222	"	"	"
$CuSO_4 \cdot 5H_2O$	0.079	"	"	"

0.3 cc. of a solution containing 0.5% ferric sulphate + 0.4% tartaric acid was added to each pot weekly.

The nitrogen supply was kept low. On the 1st of May each pot was given 0.0121 grams of sodium nitrate (0.0020 grams of nitrogen). Further applications of sodium nitrate were given when symptoms of nitrogen deficiency were incipient. The dates of these supplementary applications and the amounts added to each pot were:

6th June	0.0121 grams $NaNO_3$		
20th June	0.1000	"	"
21st July	0.1000	"	"

The plants grew well and maintained a healthy appearance throughout the course of the experiment. On the 16th of May the wimmera rye grass plants were thinned to 3 plants per pot.

On the 6th of September (150 days after planting) the pots were transferred to a constant environment chamber. Only a few inflorescences had appeared and these were cut away. The plants were given a continuous light exposure by means of tungsten filament bulbs and fluorescent tubes. The temperature was controlled between 24° C. and 25° C. The plants remained inside the chamber for 2 1/4 days before any treatments were applied.

The treatments were randomized against the pot numbers in conformity with the experimental design.

On the 8th of September the first (Day 0) plants were harvested. The sand was dumped out of the pots and the roots were washed free of sand under a strong stream of water. The roots were cut away from each plant. The roots from each pot were bulked and kept separated from all other roots. The leaves (including crown stems of onion weed) from each pot were bulked and kept separated from all other leaves. These plant parts were labelled with the appropriate pot number, weighed and dried rapidly under forced draught at 90° C. to constant weight. The dried samples were cooled in a desiccator, weighed and stored in paper envelopes.

On the 8th of September after harvesting the Day 0 pots the sodium nitrate and ammonium sulphate were applied to conform to the experimental design. The nitrogen containing salt was applied in 50 c.c. of water and the pots were brought up to 60% of the water holding capacity immediately afterward by adding water.

On the 10th of September (47 hours after applying the nitrogen salts) the Day 2 pots were removed from the constant environment chamber and the plants were harvested. They were handled and dried in the same way as the Day 0 plants.

On the 12th of September there was a breakdown in the refrigeration unit of the constant environment chamber. Three hours later the temperature had risen to 28° C. and all of the Day 4 pots were removed and harvested. This was 89 hours after applying the nitrogen salts. The same harvesting technique was used as for the day 0 plants.

The roots were distributed throughout the culture medium.

The dried plant samples were ground in a C and N mill to pass through a sieve with round holes 0.5 mm. in diameter. The ground plant material was subjected to chemical analysis for protein nitrogen, non-protein nitrogen and ammonia nitrogen.

The ground plant material was prepared for analysis in the manner described by Hanson, Barrien and Wood (1941): approximately 0.1 gram of ground plant material was dried for one hour at 90° C., cooled in a desiccator and weighed. 20 c.c. of water was added and the plant material was extracted at 40° C. for 15 minutes. It was then boiled for one minute. After cooling the proteins which remained soluble were precipitated by adjusting the pH of the extract to 4.5 using the glass electrode and 8% trichloracetic acid. The extract was allowed to stand overnight in the refrigerator. The remaining operations were carried out in a single day. The extract was filtered under vacuum on a buchner funnel using a no. 42 Watman filter paper. The precipitate was washed twice with 10 c.c. of 1% trichloracetic acid. The precipitate which contained the insoluble or protein nitrogen was analyzed for total nitrogen. The filtrate which contained the soluble or non-protein nitrogen was made up to 50 c.c. in a volumetric flask. 25 c.c. of this was analyzed for total nitrogen and 5 c.c. aliquots of the remainder were used for determinations of ammonia nitrogen.

Determination of total nitrogen: The protein residue or the 25 c.c. aliquot from the soluble nitrogen fraction was transferred to a 300 c.c. Kjeldahl flask together with 15 c.c. of concentrated sulphuric acid and one knife-point of powdered selenium. Digestion was carried out over heat in a fume cupboard until the hydrolysate appeared colorless. The ammonia so formed was liberated in a Parnas-Wagner steam distillation unit by the addition of 30% sodium hydroxide. It was trapped in 5 c.c. of 2% boric acid containing 4 drops of indicator after the manner of Ma and Zuazaga (1942). The indicator was prepared by adding 10 c.c. of 0.1% bromcresol green in 95% alcohol to 2 c.c. of 0.1% methyl red in 95% alcohol. The boric acid was titrated with 0.01 N hydrochloric acid to match a boric acid blank. The value so obtained was corrected for a blank digestion run concurrently and the quantity of protein nitrogen or non-protein nitrogen was calculated. The total nitrogen was obtained by adding the appropriate values for protein nitrogen and non-protein nitrogen.

Determination of ammonia nitrogen: An initial attempt was made to displace ammonia from the plant extract with 0.29% NaOH (5 c.c. neutralized plant extract plus 0.15 c.c. of 10% NaOH) in a Van-Slyke aeration train. Under the prevailing conditions this technique yielded only 78% recovery of added ammonia nitrogen but 20% recovery of added glutamine nitrogen during a 4 1/2 hour aspiration. Spencer (1952) found that a number of common buffers over a range of concentrations all displayed the ability to liberate the highly labile glutamine nitrogen from solutions containing glutamine. From these beginnings an attempt was made to adapt a method described by Johansen (1951).

An apparatus of original design was assembled to enable the distillation of ammonia from plant extracts using Na_2HPO_4 at 40° C. under reduced pressure. The apparatus is illustrated in figure II-26. 5.00 c.c. of the non-protein plant extract was placed in a 1" x 8" test tube together with one drop of bromcresol green-methyl red indicator. The extract was neutralized with 1% NaOH delivered from a dropper with a fine capillary. One drop of caprylic alcohol solution was added to reduce frothing. 2.00 c.c. of 0.5 molar Na_2HPO_4 were added. The tube was connected to the distillation apparatus and placed in a water bath at 40° C. Aspiration was carried out for 20 minutes at a pressure of 40 mm. of mercury. The air intake was restricted by means of a screw clamp on ordinary pressure tubing as illustrated. The incoming air stream was passed through a dilute solution of sulphuric acid to remove alkaline vapors. The ammonia which distilled off was trapped in 2 c.c. of 2% boric acid plus one drop of indicator and was subsequently back-titrated with 0.01% hydrochloric acid in the manner described for total nitrogen. Similar distillations were carried out on blank aliquots and appropriate corrections were made. Under the conditions described there was a negligible recovery of added glutamine nitrogen and the recovery of added ammonia nitrogen approached

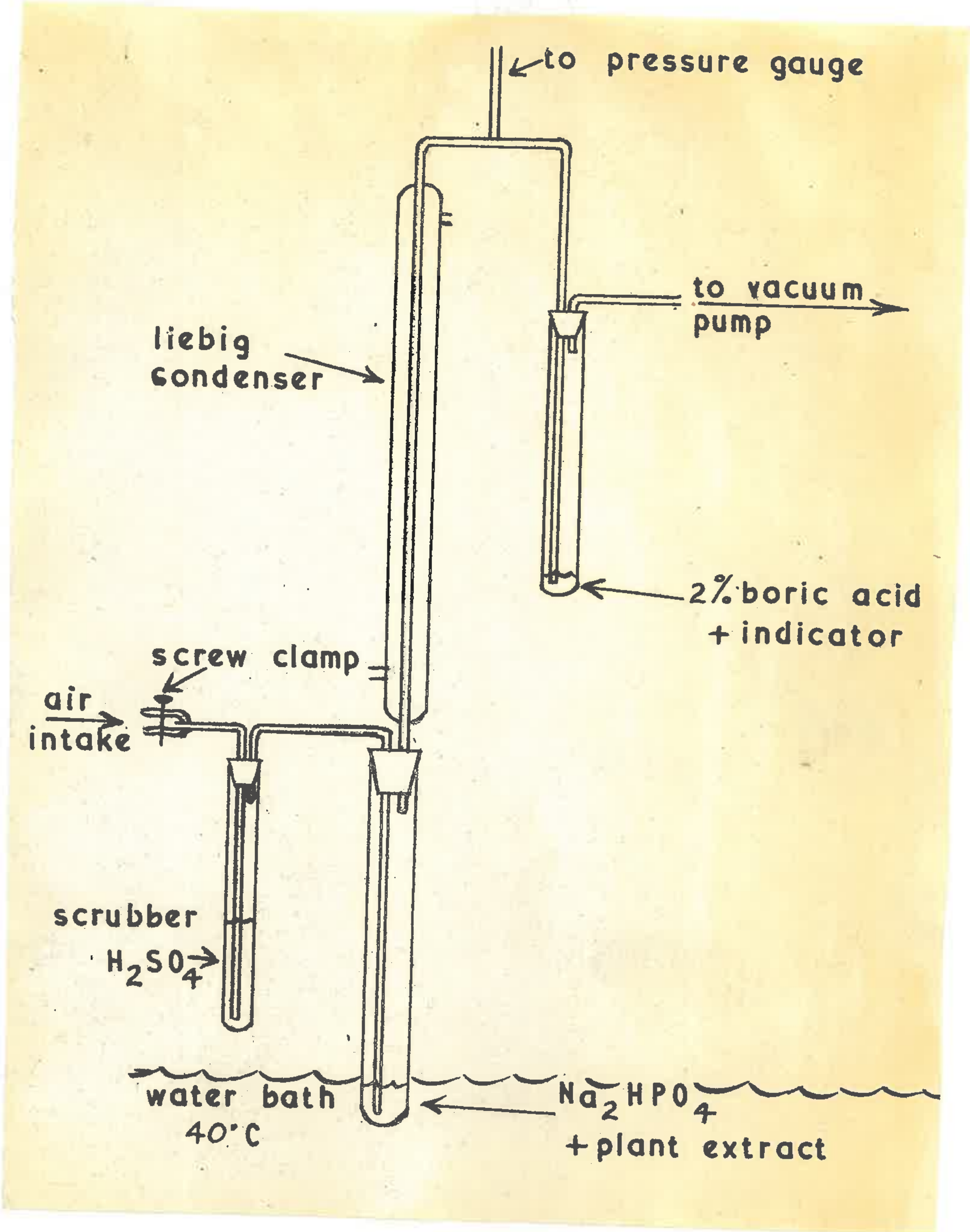

Figure II-26.

Apparatus for the micro-analysis of ammonia. (See text.)

100%.

The data for total nitrogen, protein nitrogen, non-protein nitrogen, ammonia nitrogen, and dry weight of roots, leaves and total plant are presented for each species in tables 42 to 47.

Table 42

Utilization of 2 forms of nutrient nitrogen by onion weed plants 5 months old.
Total plant = Roots and leaves

Harvest date	Protein nitrogen mgms/plant	Non-protein nitrogen mgms/plant	Total nitrogen mgms/plant	Ammonia nitrogen mgms/plant	Dry weight grams/plant
		no added nitrogen			
Day 0	4.10	1.80	5.90	0.13	0.56
Day 2	4.30	2.05	6.35	0.09	0.65
Day 4	4.50	2.20	6.70	0.11	0.54
	0.050 gms. nitrate nitrogen added on Day 0				
Day 2	5.00	1.85	6.85	0.12	0.66
Day 4	5.35	1.90	7.25	0.15	0.62
	0.200 gms. nitrate nitrogen added on Day 0				
Day 2	5.15	2.10	7.25	0.13	0.62
Day 4	5.70	3.05	8.75	0.14	0.59
	0.200 gms. ammonium nitrogen added on Day 0				
Day 2	5.20	2.50	7.70	0.10	0.62
Day 4	5.70	4.40	10.10	0.16	0.69
Variance ratio:					
Blocks	4.58 n.s.	2.04 n.s.	4.25 n.s.	0.94 n.s.	0.084 n.s.
Treatments	3.17 n.s.	28.50 ***	8.48 **	0.45 n.s.	0.756 n.s.
Diff. for signif. means of 2					
5%	--	0.51	1.45	--	--
1%	--	0.74	2.11	--	--
0.1%	--	1.12	--	--	--

Table 43

Utilization of 2 forms of nutrient nitrogen by wimmera
rye grass plants 5 months old
Total plant = Roots and leaves

Harvest date	Protein nitrogen mgms/plant	Non-protein nitrogen mgms/plant	Total nitrogen mgms/plant	Ammonia nitrogen mgms/plant	Dry weight grams/plant
		no added nitrogen			
Day 0	11.00	2.25	13.25	0.26	1.55
Day 2	11.40	2.25	13.65	0.39	1.63
Day 4	12.05	3.10	15.15	0.33	1.68
		0.050 gms. nitrate nitrogen added on day 0			
Day 2	17.00	4.75	21.75	0.32	1.90
Day 4	19.80	4.95	24.75	0.36	1.59
		0.200 gms. nitrate nitrogen added on day 0			
Day 2	16.35	7.10	23.45	0.35	1.63
Day 4	21.30	6.95	28.25	0.47	1.68
		0.200 gms. ammonium nitrogen added on day 0			
Day 2	18.95	19.30	28.25	0.37	1.76
Day 4	24.80	17.40	42.20	0.52	1.74
Variance ratio:					
Blocks	9.05*	1.066n.s.	4.70n.s.	2.37n.s.	2.098n.s.
Treatments	47.77***	33.40***	45.8 ***	2.34n.s.	0.89n.s.
Diff. for signif. means of 2					
5%	2.26	2.68	4.42	--	--
1%	3.29	3.90	6.43	--	--
0.1%	4.94	5.86	9.65	--	--

Table 44

Utilization of 2 forms of nutrient nitrogen by onion weed plants 5 months old
Roots only

Harvest date	Protein nitrogen mgms/plant	Non-protein nitrogen mgms/plant	Total nitrogen mgms/plant	Ammonia nitrogen mgms/plant	Dry weight grams/plant
	no added nitrogen				
Day 0	1.25	0.80	2.05	0.08	0.35
Day 2	1.35	0.75	2.10	0.05	0.41
Day 4	0.90	0.65	1.55	0.06	0.28
	0.050 gms. nitrate nitrogen added on day 0				
Day 2	1.30	0.55	1.85	0.08	0.40
Day 4	0.95	0.40	1.35	0.09	0.32
	0.200 gms. nitrate nitrogen added on day 0				
Day 2	1.25	0.90	2.15	0.07	0.38
Day 4	1.25	1.30	2.55	0.09	0.30
	0.200 gms. ammonium nitrogen added on day 0				
Day 2	1.35	0.85	2.20	0.06	0.38
Day 4	1.15	1.90	3.05	0.10	0.37
Variance ratio:					
Blocks	2.73 n.s.	0.080 n.s.	0.68 n.s.	1.438	0.0037 n.s.
Treatments	1.67 n.s.	16.32 ***	4.98 *	0.444	1.65 n.s.
Diff. for signif. means of 2					
5%	--	0.365	0.74	--	--
1%	--	0.532	--	--	--
0.1%	--	0.797	--	--	--

Table 45

Utilization of 2 forms of nutrient nitrogen by wimmera rye grass plants 5 months old
Roots only

Harvest date	Protein nitrogen mgms/plant	Non-protein nitrogen mgms/plant	Total nitrogen mgms/plant	Ammonia nitrogen mgms/plant	Dry weight grams/plant
		no added nitrogen			
Day 0	4.35	0.50	4.85	0.18	0.87
Day 2	4.00	0.30	4.30	0.21	0.84
Day 4	3.55	0.80	4.35	0.24	0.76
	0.050 gms. nitrate nitrogen added on day 0				
Day 2	5.55	1.10	6.65	0.16	1.10
Day 4	4.60	1.20	5.80	0.24	0.78
	0.200 gms. nitrate nitrogen added on day 0				
Day 2	5.00	2.75	7.75	0.18	0.86
Day 4	5.45	2.60	8.05	0.39	0.82
	0.200 gms. ammonium nitrogen added on day 0				
Day 2	5.15	2.50	7.65	0.22	0.92
Day 4	5.30	6.20	11.50	0.27	0.78
Variance ratio:					
Blocks	0.067 n.s.	0.402 n.s.	0.189 n.s.	0.032 n.s.	0.00034 n.s.
Treatments	3.200 n.s.	38.57***	14.325***	1.22 n.s.	1.855 n.s.
Diff. for signif. means of 2					
5%	—	0.96	1.99	—	—
1%	—	1.40	2.89	—	—
0.1%	—	2.10	4.34	—	—

Table 46
Utilization of 2 forms of nutrient nitrogen by onion weed plants 5 months old
Leaves only

Harvest date	Protein nitrogen mgms/plant	Non-protein nitrogen mgms/plant	Total nitrogen mgms/plant	Ammonia nitrogen mgms/plant	Dry weight grams/plant
		no added nitrogen			
Day 0	2.85	1.00	3.85	0.05	0.21
Day 2	2.95	1.30	4.25	0.05	0.24
Day 4	3.60	1.55	5.15	0.06	0.26
		0.050 gms. nitrate nitrogen added on day 0			
Day 2	3.70	1.30	5.00	0.04	0.26
Day 4	4.40	1.50	5.90	0.06	0.30
		0.200 gms. nitrate nitrogen added on day 0			
Day 2	3.90	1.20	5.10	0.06	0.24
Day 4	4.45	1.75	6.20	0.05	0.29
		0.200 gms. ammonium nitrogen added on day 0			
Day 2	3.85	1.65	5.50	0.05	0.24
Day 4	4.55	2.50	7.05	0.06	0.32
Variance ratio:					
Blocks	2.83 n.s.	2.60 n.s.	3.38 n.s.	0.09 n.s.	0.368 n.s.
Treatments	4.57*	7.52**	5.95*	0.552n.s.	2.266 n.s.
Diff. for signif. means of 2					
5%	0.94	0.52	1.32	--	--
1%	--	0.75	--	--	--
0.1%	--	--	--	--	--

Table 47

Utilization of 2 forms of nutrient nitrogen by wimmera rye grass plants 5 months old
Leaves only

Harvest date	Protein nitrogen mgms/plant	Non-protein nitrogen mgms/plant	Total nitrogen mgms/plant	Ammonia nitrogen mgms/plant	Dry weight grams/plant
		no added nitrogen			
Day 0	6.65	1.75	8.40	0.08	0.69
Day 2	7.40	1.95	9.35	0.07	0.79
Day 4	8.50	2.30	10.80	0.10	0.92
	0.050 gms. nitrate nitrogen added on day 0				
Day 2	11.45	3.65	15.10	0.16	0.80
Day 4	15.20	3.75	18.95	0.12	0.81
	0.200 gms. nitrate nitrogen added on day 0				
Day 2	11.35	4.35	15.70	0.19	0.78
Day 4	15.85	4.35	20.20	0.08	0.86
	0.200 gms. ammonium nitrogen added on day 0				
Day 2	13.80	6.80	20.60	0.16	0.84
Day 4	19.50	11.20	30.70	0.25	0.97
Variance ratio:					
Blocks	10.39*	1.86 n.s.	6.87*	0.0508n.s.	6.72*
Treatments	40.65***	15.37***	32.71***	1.44 n.s.	1.821 n.s.
Diff. for signif. means of 2					
5%	2.19	2.47	3.98	--	--
1%	3.19	3.59	5.79	--	--
0.1%	4.79	5.39	8.70	--	--

G. A preliminary experiment on intra-specific variation.

A preliminary experiment was carried out to investigate the variations which occur in onion weed. The extent of this variation has an important bearing on the general applicability of other experimental findings.

Seed was collected from several sites in South Australia and Victoria. Subsequently plants from this seed were grown side by side in the field at the Waite Institute. The design of the experiment was such as to enable geographically distinct groups of biotypes to be distinguished.

Aim: To discover whether variations of ecotypic magnitude exist in onion weed.

Experimental design: The seed was collected during May of 1950 from the following localities:

Locality	Approx. mean annual rainfall
1. Kooloonong, Victoria	9"
2. Bolton, Victoria	9"
3. Peterborough, S. A. (seed harvested from inflorescences)	13"
4. Peterborough, S. A. (seed sieved from soil)	13"
5. Tailem Bend, S. A.	15"
6. Halbury, S. A.	20"

In general the seed was that which had ripened during the spring of 1950 but which had not been shaken free of the capsules by the following May. The two lots of seed from Peterborough came from the same paddock but one was harvested in the usual manner from the capsules and the other was sieved from the soil at the base of the parent plants. This latter lot of seed was representative of the seed shattered in December. The close agreement between the two Peterborough samples in the tables which follow suggest that they were drawn from the same population.

The seed was planted in flats on the 10th of July, 1950. 15 plants from each of the above collections were transplanted into the field on the 23rd of July in 3 randomized blocks with 5 plants in each block. The plants were grown in rows and spaced 5 links apart each way. Competition from weed growth was kept low through frequent use of the hoe. The experiment was maintained for one year.

The plants were inspected and compared frequently but no morphological differences were readily apparent. Ecotypic differentiation is not necessarily accompanied by morphological differentiation (Turesson, 1922).

On the 11th of October the leaves on each plant were counted and the length of the 5 longest leaves on each plant was measured. The date of the first appearance of the flower stalk on each plant was recorded and also the date of opening of the first flower on each plant. These data are presented in table 48.

Seeds were harvested from the experimental plants. These were uniformly stored in open tins on the laboratory bench and subsequently germinated on moist blotting paper in an incubator for 6 days at 19° C. There were 3 replicates of seed from each locality. Each replicate contained 100 seeds. The replicates were arranged in randomized blocks on the incubator trays. Seeds from Morphett Vale, South Australia (approximate mean annual rainfall = 23 inches) having a similar history were included. The results are presented in table 49.

Table 48

Variation in onion weed plants from different localities
but sown and grown in a uniform environment
Each figure is the sum for 5 plants
Means of 3 replicates of 5 plants each.

Locality	Length in cm. of 5 longest leaves	Total number of leaves	Days to first appearance of in-florescence	Days to first flower
Kooloonong, Vict.	476	61	523	582
Bolton, Vict.	455	55	525	581
Peterborough, S.A.	399	72	544	602
Peterborough (ex soil)	407	69	545	601
Tailem Bend, S. A.	429	71	533	599
Halbury, S. A.	455	79	529	591
Mean	437	68	533	593
Variance ratio:				
Blocks	0.42 n.s.	0.30 n.s.	0.10 n.s.	0.22 n.s.
Treatments	2.23 n.s.	2.67 n.s.	2.99 n.s.	5.58*
Diff. for signif. means of 3 5%				12.8

Table 49
Germination of seed from parents from different localities
but grown and stored under uniform conditions
% germination after 6 days at 19° C.

Locality	Replicate A	B	C	Mean
Kooloonong, Vict.	46	55	52	51
Bolton, Vict.	67	68	64	66
Peterborough, S. A.	46	53	54	51
Peterborough (ex soil)	49	54	45	49
Tailem Bend, S. A.	62	65	55	61
Halbury, S. A.	50	40	42	44
Morphett Vale, S. A.	46	43	53	47
Mean	52	54	52	53

Analysis of variance:

Variation due to:	Variance ratio:
Blocks	0.326 n.s.
Treatments	8.06 **

Difference for significance

5%	8.53
1%	10.50

H. An experiment on seed dormancy.

During the preparation of the foregoing experiments erratic germination was noted to occur with certain batches of onion weed seed. A few germination experiments were undertaken to establish the extent of the dormancy.

Aim: To study the effect of post-harvest time on seed dormancy.

Experimental design: Seed was harvested from natural infestations at four localities in South Australia.

Locality	Approx. mean annual rainfall
1. Taylorville, S.A.	9"
2. Auburn, S. A.	24"
3. Bowmans, S. A.	14"
4. Moonta, S. A.	15"

The seed from each locality was stored for 3 time intervals and subjected to a germination test at the end of each time interval. The incubation dates were the same for each locality and were as indicated:

1st incubation -- 20th November, 1950
2nd incubation -- 7th December, 1950
3rd incubation -- 18th April, 1951

There were four replicates of each locality at each time interval. The replicates were randomized on an incubator tray in a 4 x 4 latin square. Each replicate contained 100 seeds.

Procedure: Seed of onion weed was harvested just after it had begun to shatter naturally in the field. The harvest dates were as indicated:

Taylorville	-- 19th October, 1950
Auburn	-- 13th November, 1950
Bowmans	-- 14th November, 1950
Moonta	-- 15th November, 1950

The inflorescences containing the seeds were cut from the plants and transported to the laboratory in canvas bags. They were placed in a covered container and shaken to dislodge the seed. A few whole capsules were also dislodged and seed was removed from these by gentle rubbing. The seed was cleaned by screening and hand-picking and stored in 4 open-topped metal containers on the laboratory bench.

Samples were drawn from the containers on each incubation date. Germination was carried out on moist blotting paper in an incubator ranging between 17° C. and 23° C. The optimum germination temperature for onion weed seed is about 18.9° C. (Carter, 1950). These trials had to be carried out during the hottest months. Difficulty was experienced in maintaining control of temperature within the incubator which was not equipped with a cooling device.

The seeds were examined daily and those which had germinated were counted and removed. The results are presented in table 50.

The seeds which failed to germinate after the first incubation were dried and stored for 3 months in an oven at 46° C. This seed was replaced in the incubator on moist blotting paper at 21° C. The mean germination at this time was found to be 99% and each of the seeds which did not germinate was found upon examination to be either hollow or very much undersized.

The low % germination found in these trials was not the result of a hard or impervious seed coat since all seeds invariably imbibed water, swelled in a normal manner and were quite soft to handle.

Table 50

% Germination of seed collected from 4 centres in South Australia at various time intervals after harvest. Means of four replicates of 100 seeds each.

Incubation date		Locality and date harvested				Mean
		Taylorville 19th October	Auburn 13th November	Bowmans 14th November	Moonta 15th November	
20th November		11	5	16	24	14
7th December		42	24	53	62	45
18th April		91	89	97	92	92
Mean						50
Diff. for significance	5%	15.3	8.37	14.6	14.3	
	1%	23.0	12.7	22.2	21.7	
	0.1%	37.0	20.4	35.6	34.8	

Analysis of variance

Variation due to:	Variance ratio:	
Treatments	96.	***
Locality	3.978	n.s.
Incubation date	109.202	***
Locality x date	4.47	**
Replicates	1.098	n.s.

I. Effect of germination temperature on seed dormancy.

A modified repetition of the foregoing experiment was carried out in 1952.

Aim: To study the effect of germination temperature on the dormancy of freshly harvested onion weed seed.

Experimental design: Seed from one locality only. There were 7 germination temperature treatments. There were 4 replicates of 100 seeds each for each treatment.

Procedure: Seed of onion weed was collected from a natural infestation at Avon, South Australia in the manner described for the foregoing experiment. Germination was carried out in a multiple temperature incubator so designed as to be able to maintain simultaneously a range of temperatures in different compartments of a single apparatus. The seeds were germinated on moist blotting paper. The germinated seeds were counted and removed daily. The experimental results are presented in table 51.

At 38.7° C. it was difficult to maintain the blotting paper in a moist condition and some drying out of the seed occurred. Frequent handling to maintain moisture provided opportunity for contamination with microorganisms. After 2 weeks mould began to develop in this compartment of the incubator and the part of the trial at this temperature was discontinued. No mould was visible in the other 5 compartments during the whole of the 31 days.

The viability of this sample of seed was tested some months later and at this time germination was 95%.

Table 51

% Germination of onion weed seeds collected at Avon, S. A. on 1st December and placed in a multiple temperature incubator on 12th December for 31 days

Replicates of	Mean germination temperature °C.						Alternate‡
100 seeds each	38.7‡	28.6	20.7	17.3	15.3	5.2	5.2 - 38.7
A	2	0	1	0	1	0	0
B	5	1	0	0	1	0	0
C	1	0	0	0	2	0	0
D	3	1	0	2	0	2	0

‡ Seeds at 38.7° C. and at alternating temperatures were germinated for 14 days only.

J. Effect of storage temperature on seed dormancy.

Aim: To study the effect of storage temperature on the dormancy of freshly harvested onion weed seed.

Experimental design: Seed came from four localities. Seed from each locality was stored prior to germination at each of 3 temperatures. Three replicates of 100 seeds each were germinated from each of these 12 treatments. The replicates were arranged in 3 randomized blocks in the incubator.

Procedure: 3 subsamples of seed were drawn from each of the four samples of seed described in section H. Each subsample of this seed was placed in a screw top glass jar and the top was sealed with wax to prevent exchange of moisture between the jar and the atmosphere. One subsample from each locality was placed at each of the following storage temperatures: 6° C., 20° C., and 45° C.

After storage for 16 days 3 subsamples of 100 seeds each were removed from each jar and placed on moist blotting paper in a germination incubator at 17° C. for 14 days to conform with the experimental design. The seeds were examined daily and seeds which had germinated were counted and removed.

The experimental results are presented in table 52.

Table 52

% Germination of seed collected from 4 centres in South Australia and stored for 16 days at several different temperatures
Means of 3 replicates of 100 seeds each

Storage temperature	Locality				Mean
	Taylorville	Auburn	Bowmans	Moonta	
6° C.	20	4	30	14	17
20° C.	30	3	25	24	21
45° C.	70	29	75	86	65

K. Statistical.

A large mass of experimental data has been accumulated and much time has been spent in its preparation for presentation in a coherent manner. Many of the tables lend themselves to more complicated forms of mathematical analysis than those attempted. In some cases (notably table 51) the trends of the experiment are so obvious as to make further analysis superfluous. In other cases the additional information to be anticipated does not warrant further expenditure of time in analysis. In still other cases a number of transformations were tested but basic assumptions of homogeniety and normality could not be upheld. The analyses presented with a number of the tables is thus preliminary in nature and the complete data has been given in order to make further statistical work possible if required. This may be permissable since this thesis is also intended to comprise a report of the work carried out.

The method of presenting the analytical results by means of the variance ratios and least significant differences is considered to provide adequate information to assess the trends of the experiments. The following symbols have been employed.

*	means	significant	at	the	5%	level	of	probability
**	"	"	"	"	1%	"	"	"
***	"	"	"	"	0.1%	"	"	"
n.s.	"	not significant.						

Whenever a set of data has been subjected to mathematical analysis no positive conclusions have been drawn from treatment differences unless they attain a probability of chance occurrence of 5% or less.

III. Discussion and Conclusions

Field experiments were carried out at Avon, South Australia, and at the Waite Institute but the Avon experiments are of greater significance to the onion weed problem because they were laid down on a class of land on which onion weed occurs extensively. Onion weed occurs infrequently and with less severity on heavy soils in the higher rainfall districts including those of the Waite Institute and is more readily controlled through tillage on such land.

A. Pasture production on *A. fistulosus* infestations.

The grazing value is usually reduced when land becomes infested with onion weed. In severe cases of infestation palatable herbage may be entirely absent (Fig. I-10 and Fig. I-11). It may be that onion weed is destined to become a permanent feature of agriculture in certain areas in southern Australia so that it is in order to consider here the yields of palatable herbage which can be obtained from the several pastures on onion weed infested land. Tables 53 and 54 attempt to summarize the yield data of the field experiments over the three experimental years. They give the mean yields of palatable herbage obtained at Avon and at the Waite Institute. Palatable herbage is considered to be the entire non-onion weed fraction of the harvests. The mean yields of the pastures which received 112 lbs. per acre or less of sulphate of ammonia (N1, N2, N3 and N4 pastures in 1951 and N1, N2 and N3 pastures in 1952 and 1953) are designated the low fertility group. They may be considered in relation to the mean yields of the pastures which received 224 or 448 lbs. per acre of sulphate of ammonia (N5 pastures in 1951 and the N4 and N5 pastures in 1952 and 1953) which are designated the high fertility group. This division is arbitrary but the low

Table 53

Experiment no. P190 a

Mean yields of palatable herbage at Avon
in lbs. (oven dry weight) per acre

		1951	1952	1953	Means
Volunteer pasture	N1	2255	2778	1678	
	N2	1940	2947	2035	
	N3	1555	2088	2009	
	N4	1482	1954	2473	
	N5	1813	1691	2328	
Mean of low fertility group					2077
Mean of high fertility group					2052
Wimmera rye grass pasture	N1	2425	3887	1420	
	N2	1906	2910	1429	
	N3	2801	3669	2220	
	N4	2367	3307	2679	
	N5	4183	5547	3402	
Mean of low fertility group					2503
Mean of high fertility group					3824
Perennial veldt grass pasture	N1	1532	2206	1239	
	N2	1838	4113	1426	
	N3	1412	2354	1812	
	N4	1821	3002	1817	
	N5	1288	3230	1644	
Mean of low fertility group					1975
Mean of high fertility group					2196
Lucerne pasture	N1	1710	1508	851	
	N2	1542	2029	970	
	N3	2058	2575	1184	
	N4	1899	2245	1247	
	N5	1465	2094	1073	
Mean of low fertility group					1632
Mean of high fertility group					1625
Mixed pasture	N1	2236	2562	1358	
	N2	2850	3034	1579	
	N3	1919	2774	1433	
	N4	2084	2708	1550	
	N5	2288	4352	1899	
Mean of low fertility group					2183
Mean of high fertility group					2559

Table 54

Experiment no. F190 b

Mean yields of palatable herbage at the Waite Institute in lbs. (oven dry weight) per acre

		1951	1952	1953	Means
Volunteer pasture	N1	1552	1046	611	
	N2	2118	1288	1203	
	N3	1858	2112	1136	
	N4	3117	3093	2277	
	N5	3034	4851	3881	
Mean of low fertility group					1604
Mean of high fertility group					3427
Wimmera rye grass pasture	N1	2565	2128	834	
	N2	3840	1901	679	
	N3	4366	2344	1815	
	N4	4355	3547	2312	
	N5	6012	5603	4458	
Mean of low fertility group					2483
Mean of high fertility group					4386
Perennial rye grass pasture	N1	1814	1285	853	
	N2	2177	1763	1394	
	N3	2440	1874	1400	
	N4	2585	3046	3065	
	N5	4455	4973	4234	
Mean of low fertility group					1759
Mean of high fertility group					3955
<u>Phalaris</u> <u>tuberosa</u> pasture	N1	2394	1334	1377	
	N2	1713	1666	1155	
	N3	2346	1939	3037	
	N4	2093	2641	3642	
	N5	3528	4598	5033	
Mean of low fertility group					1905
Mean of high fertility group					3686
Mixed pasture	N1	4996	4906	3478	
	N2	5422	4590	3656	
	N3	5144	4872	4106	
	N4	5796	4871	4729	
	N5	6533	4919	5400	
Mean of low fertility group					4697
Mean of high fertility group					5290

nitrogen group is considered to represent fertility levels already existing or readily obtainable through the application of nitrogenous fertilizers at customary rates per acre or through the employment of sound management practices. The high nitrogen group then represents levels of fertility less common, more expensive to obtain with commercial fertilizers or more difficult to attain through sound management practices.

Table 53 shows that at Avon the highest yields of palatable herbage were obtained from the wimmera rye grass pasture at both low and high levels of nitrogen nutrition. Nearly all of this feed was wimmera rye grass (tables 4, 7, 9 and 15).

The commonest type of pasture on wheat and sheep farms on solonized brown soils is the volunteer pasture. It is shown in table 53 that the volunteer pasture contained smaller quantities of palatable herbage than the wimmera rye grass pasture especially in the group receiving high nitrogen nutrition. However, at the very lowest levels of nitrogen nutrition when ammonium sulphate was not applied (N1 pastures) there was little difference in total yield between wimmera rye grass pasture and volunteer pasture at Avon (tables 3, 8 and 14) although there was considerable difference in botanical composition between the two pastures (tables 4, 7, 9 and 15). A significant difference was not demonstrated in any year between the total yield of N1 wimmera rye grass pasture and the total yield of N1 volunteer pasture. Nitrogenous fertilizers are not commonly used on solonized brown soils and experiences of this kind may be sufficiently common to justify the reluctance of some farmers to sow wimmera rye grass.

The best assessment of the growth made by the perennial veldt grass pasture was obtained in the 1952 harvest. In 1952 the harvest at Avon was 40 days later than in 1951 and 48 days later than in 1953. Perennial veldt grass grows more slowly during the winter than does wimmera rye grass but its growth rate increases considerably in the spring and early summer. In the later harvest of 1952 the mean yield (means of 10) of the perennial veldt grass pasture including all levels of nitrogen fertility did not differ significantly from the mean yield of wimmera rye grass pasture at all levels of nitrogen fertility (table 8). The mean yield of wimmera rye grass pasture was significantly greater than the mean yield of perennial veldt grass pasture only at the N5 level of nitrogen fertility. In 1951 and 1953 the wimmera rye grass pasture gave significantly higher yields than the perennial veldt grass pasture (tables 3 and 13). Table 9 shows that the perennial veldt grass pasture contained more onion weed in 1952 than the wimmera rye grass pasture so that even when the mean yields of palatable herbage for the two pastures are compared for 1952 the wimmera rye grass pasture is still found to have produced more palatable herbage than the perennial veldt grass pasture. In the low nitrogen group for 1952 the perennial veldt grass pasture produced 2891 lbs. per acre of palatable herbage and the wimmera rye grass pasture 3489 lbs. per acre. In the high nitrogen group for 1952 the perennial veldt grass pasture produced 3116 lbs. per acre and the wimmera rye grass pasture produced 4427 lbs. per acre of palatable herbage.

In no instance did the lucerne pasture appear to match the wimmera rye grass pasture in the production of palatable herbage. Actual measurements of the summer growth of the lucerne pasture were not made but it was evident from inspection of the plots that the post-harvest growth of the lucerne pasture was slight compared to its pre-harvest growth.

The harvest data given in tables 4, 9 and 15 and the point quadrat data in table 7 suggest that the mixed pasture plots at Avon were dominated by lucerne and wimmera rye grass. The yields of palatable herbage given in table 53 for both the low nitrogen fertility group and the high nitrogen fertility group of the mixed pasture are intermediate between the yields of palatable herbage produced by the relatively pure stands of wimmera rye grass and lucerne in the same group.

Table 54 shows that at the Waite Institute the highly adapted mixed pasture produced more palatable herbage in both the high and the low nitrogen fertility groups than any of the other pastures included in the experiment. Unlike the volunteer pasture and the lucerne pasture at Avon all of the pastures at the Waite Institute yielded considerably more palatable herbage at the high level of nutrient nitrogen than at the low level of nutrient nitrogen.

The experimental pastures were harvested only once in each season. Had they been grazed or frequently harvested then lower annual yields may have been obtained. Davies and Sim (1931) found that maximum production was obtained from a natural pasture at the Waite Institute when it was cut once each season. When the pasture was cut three times in one season there was no serious reduction in total production but when it was cut more frequently there was a serious reduction in total production. The exact amount of grazing or cutting which can be applied to pastures on onion weed land without increasing the onion weed or greatly decreasing the yield of palatable herbage is likely to vary with the degree of infestation and with the season and class of land and still remains to be determined.

B. The Control of *A. fistulosus* by Plant Competition.

The experimental pastures were quite different from one another in their competitive effects upon onion weed. At Avon, onion weed made the most growth on volunteer pasture. The approximate botanical composition of the plots at Avon is indicated in tables 4, 7, 9 and 15. The mean yields of each pasture at each level of nutrient nitrogen and the yields of onion weed in each pasture are illustrated in figures III-1, III-2 and III-3. The figures are derived from the harvest data of tables 4, 9 and 15. Very little onion weed appeared in any of the plots up to the time of the first harvest. At Avon onion weed made the most growth in the volunteer pasture and the degree of control afforded by the other pastures has been expressed as the ratio of onion weed in the particular pasture to onion weed in comparable volunteer pasture. The pastures are discussed in order of decreasing control of onion weed.

In the 10 lucerne pasture plots the onion weed was reduced to 8.1% of the 10 volunteer pasture plots at the end of the first year (point quadrat data of table 5) or to 9.1% at the end of the second year (ranking method of table 11) or to 7.6% (ranking method of table 12) or to 1.05% (Third harvest table 14 and fig. III-3) near the end of the third growing season. The amount of onion weed in lucerne pasture was about the same at all levels of nutrient nitrogen. Lucerne itself was the dominant plant in the lucerne pasture.

In the 10 mixed pasture plots at Avon onion weed was reduced to 8.9% of the comparable volunteer pasture plots at the end of the first year, or to 11.2% at the end of the second year, or to 13.2% (ranking method) or to 2.7% (harvest) near the end of the third growing season. The amount of onion weed in mixed pasture was about the same at all levels of nutrient nitrogen. The dominant plants were lucerne and wimmera rye grass. Perennial veldt grass was not an

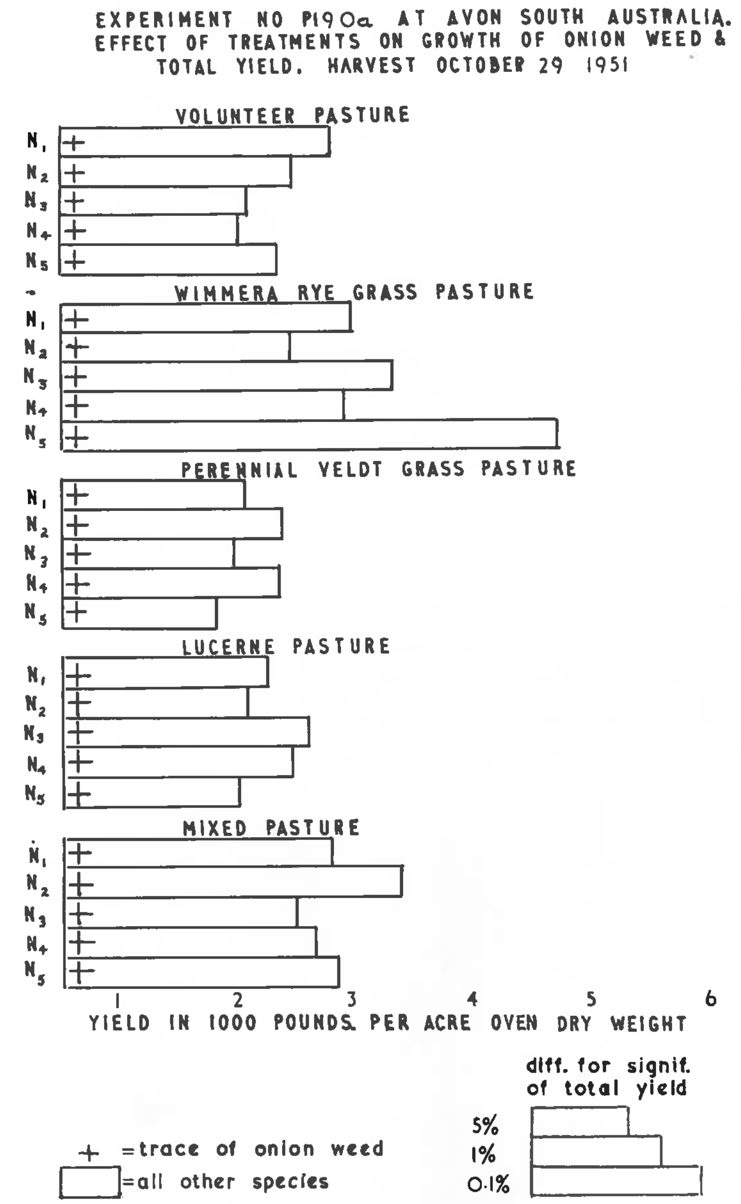
EXPERIMENT NO P190a AT AVON SOUTH AUSTRALIA.
EFFECT OF TREATMENTS ON GROWTH OF ONION WEED &
TOTAL YIELD. HARVEST OCTOBER 29 1951
VOLUNTEER PASTURE
N1
N2
N3
N4
N5
WIMMERA RYE GRASS PASTURE
N1
N2
N3
N4
N5
PERENNIAL VELDT GRASS PASTURE
N1
N2
N3
N4
N5
LUCERNE PASTURE
N1
N2
N3
N4
N5
MIXED PASTURE
N1
N2
N3
N4
N5
1
2
3
4
5
6
YIELD IN 1000 POUNDS PER ACRE OVEN DRY WEIGHT
diff. for signif. of total yield
5%
1%
0.1%
+ =trace of onion weed
=all other species

Figure III-1

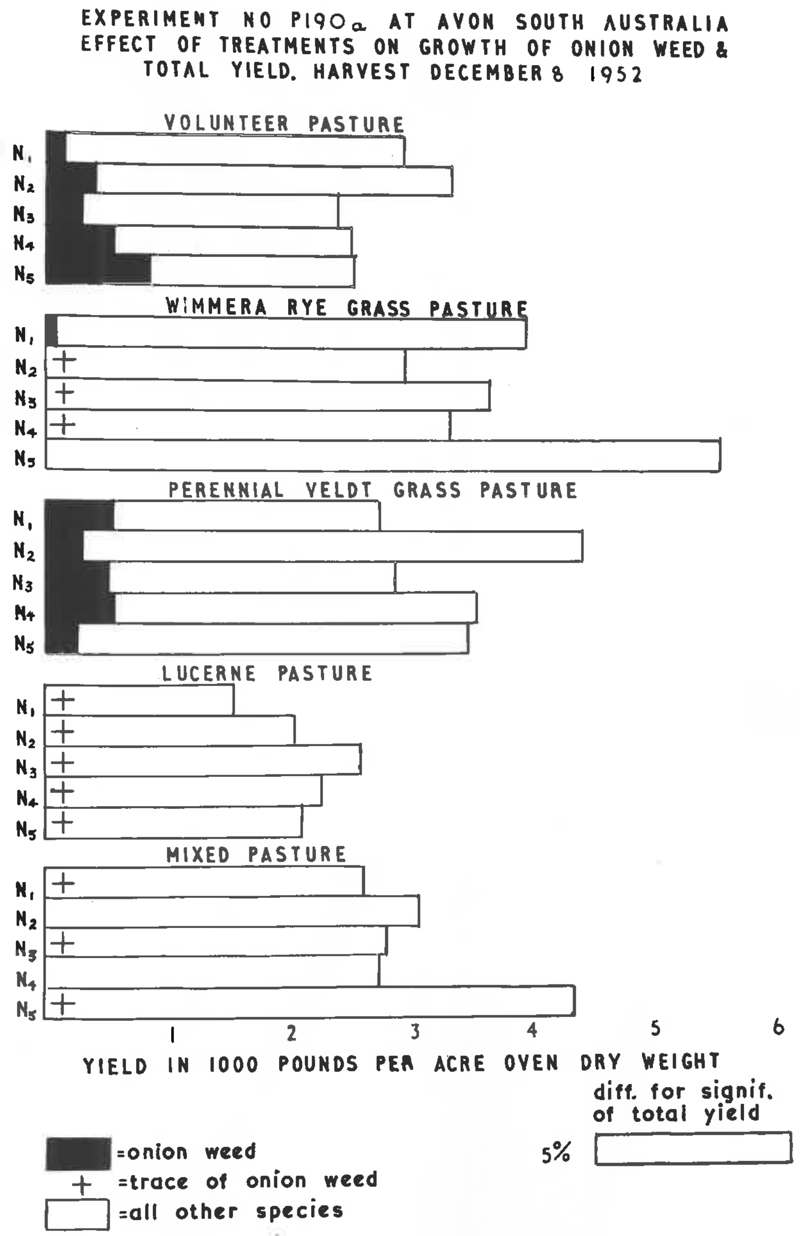
EXPERIMENT NO P190a AT AVON SOUTH AUSTRALIA
EFFECT OF TREATMENTS ON GROWTH OF ONION WEED & TOTAL YIELD. HARVEST DECEMBER 8 1952
VOLUNTEER PASTURE
N1
N2
N3
N4
N5
WIMMERA RYE GRASS PASTURE
PERENNIAL VELDT GRASS PASTURE
LUCERNE PASTURE
MIXED PASTURE
1
2
3
4
5
6
YIELD IN 1000 POUNDS PER ACRE OVEN DRY WEIGHT
diff. for signif. of total yield
5%
=onion weed
=trace of onion weed
=all other species

Figure III-2

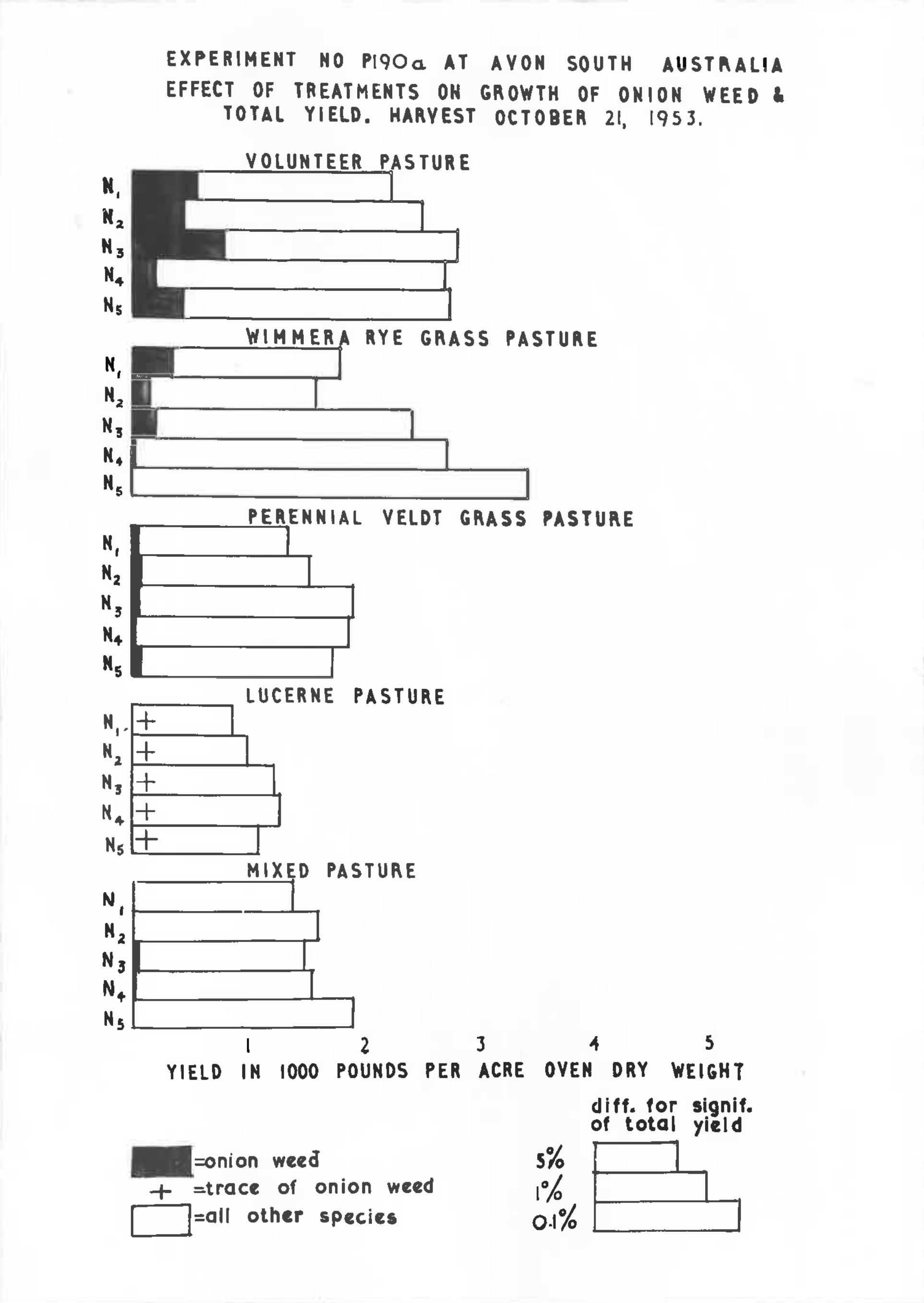
EXPERIMENT NO P190a AT AVON SOUTH AUSTRALIA
EFFECT OF TREATMENTS ON GROWTH OF ONION WEED & TOTAL YIELD. HARVEST OCTOBER 21, 1953.
VOLUNTEER PASTURE
WIMMERA RYE GRASS PASTURE
PERENNIAL VELDT GRASS PASTURE
LUCERNE PASTURE
MIXED PASTURE
N1
N2
N3
N4
N5
1
2
3
4
5
YIELD IN 1000 POUNDS PER ACRE OVEN DRY WEIGHT
diff. for signif. of total yield
=onion weed
+ =trace of onion weed
=all other species
5%
1%
0.1%

Figure III-3

important component of the mixed pasture and barrel medic did not persist after the first year. The mixed pasture at Avon was seeded to lucerne at the rate of 1 lb. of seed per acre and in 1951 contained about 25%, in 1952 about 38% and 1953 about 92% as much lucerne as the pasture seeded to lucerne only at 3 lbs. of seed per acre. The mixed pasture and the lucerne pasture tended to approach the same mean botanical composition although the mixed pasture did contain more wimmera rye grass and less lucerne than the lucerne pasture. Individual plots of the lucerne pasture which contained very little wimmera rye grass appeared to afford excellent control of onion weed. This and the fact that the wimmera rye grass pastures did not always provide good control of onion weed suggests that lucerne was the main species reducing the amount of onion weed in lucerne and mixed pastures at Avon.

The exact value of perennial veldt grass as a competitor of onion weed is more obscure. Near the end of the third growing season it had reduced the incidence of onion weed to 59% of the volunteer pasture when assessed by means of the ranking method (table 12) or to 16.5% of the volunteer pasture when the oven dry weights (table 14) are used for comparison. The initial development and growth of perennial veldt grass was slow and onion weed may have been able to become firmly established in the perennial veldt grass pasture before the grass offered effective competition. Tables 10, 11 and 12 (means of 10) show that there was no great change in the value for onion weed in the perennial veldt grass pasture from December 1952 to October 1953. This suggests that the veldt grass--onion weed community had reached some degree of stability. The difference for the amount of onion weed on veldt grass pastures at the several levels of nutrient nitrogen were not significant. It appears from this experiment that perennial veldt grass should not be recommended where control of onion weed is an important consideration.

A very dynamic relationship existed between wimmera rye grass and onion weed at Avon from December 1952 to October 1953. During this time onion weed increased considerably in low nitrogen wimmera rye grass pasture and remained relatively sparse on high nitrogen wimmera rye grass pasture. Figure III-4 illustrates this relationship. In October 1953 the amount of onion weed in N1 wimmera rye grass pasture did not differ significantly by the ranking method from the amount of onion weed in N1 volunteer pasture but the amount of onion weed in N5 wimmera rye grass pasture was very significantly lower than the amount of onion weed in N5 volunteer pasture (onion weed ratio = 9.8%). In October 1953 no onion weed at all was obtained from the harvested samples of wimmera rye grass pasture at the N5 level of nutrition (table 14). The relationship which existed in October 1953 between the mean yield of wimmera rye grass, the mean yield of onion weed and the level of nutrient nitrogen is illustrated in figure III-5. During the winter growing season the wimmera rye grass pastures were strongly dominated by the wimmera rye grass. During the summer months few species other than onion weed were present.

The final extent of onion weed development in the several pastures at the Waite Institute did not become apparent until near the end of the experimental period. This may have been partly due to the slow initial development of some of the sown pasture species but it is probably due as well to peculiarities of certain transient species which volunteered in the pasture swards. Wireweed (Polygonum aviculare) was dominant on certain plots during the year of pasture establishment but was totally absent during subsequent years. For these reasons the persistence of onion weed in the several types of pastures at the Waite Institute is best assessed from tables 26, 27a, 27b and 29 because the data in these tables were obtained after the botanical composition of the pastures

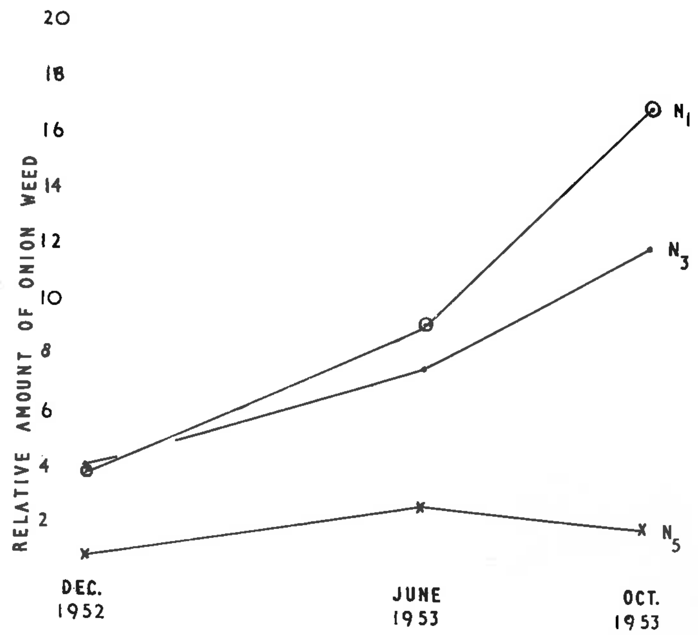

Figure III-4

The development of onion weed at Avon, South Australia in Wimmera rye grass pastures which received different amounts of sulphate of ammonia. N1 = Wimmera rye grass pasture without sulphate of ammonia. N3 = Wimmera rye grass pasture which received 280 lbs. per acre of sulphate of ammonia in 3 years. N5 = Wimmera rye grass pasture which received 1120 lbs. per acre of sulphate of ammonia in 3 years.

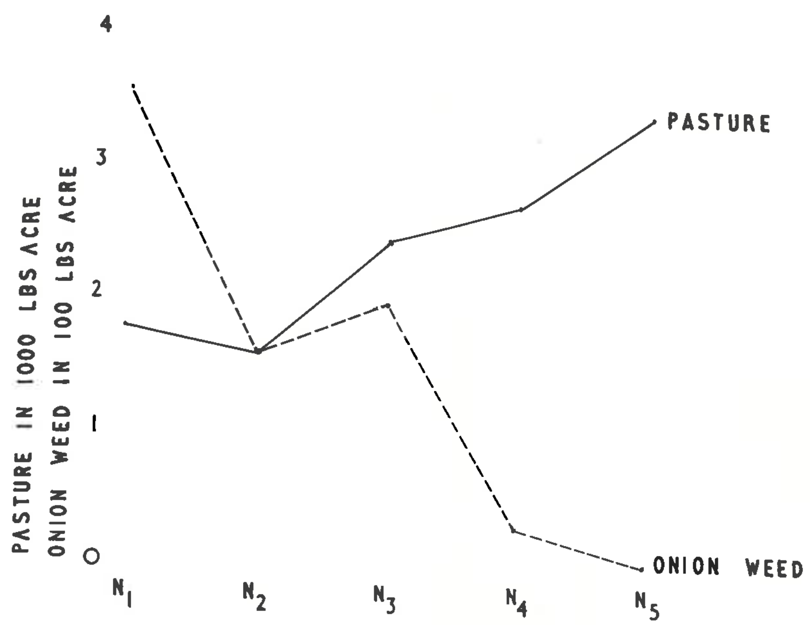

Figure III-5

The development of onion weed in a Wimmera rye grass pasture at Avon, South Australia when sulphate of ammonia was applied at different rates. N1 to N5 represent increasing amounts of sulphate of ammonia.

reached approximate stability. These tables are in near agreement. They are difficult to analyze statistically due to the heterogeneous distribution of the values for x and the analysis of table 27b should be regarded with caution since it is scarcely valid for this reason.

Table 27b shows that there was no significant difference between the values for onion weed in volunteer pasture at the various levels of nutrient nitrogen. Botanically the volunteer pasture was mainly composed of wimmera rye grass and other annual grasses and miscellaneous species during the year of establishment (table 21) and of these plus increasing amounts of onion weed in subsequent years.

Tables 27a and 27b show that onion weed was significantly reduced in the N1 mixed pasture to 40.8% of the onion weed in the N1 volunteer pasture. Onion weed was progressively reduced in the mixed pasture through the N2, N3 and N4 levels of nutrient nitrogen to 0.6% of the N1 volunteer pasture or to 0.9% of the N5 volunteer pasture in the N5 mixed pasture. The mixed pasture was dominated by wimmera rye grass, subterranean clover and miscellaneous species during the year of establishment (table 21) with increasing amounts of Phalaris tuberosa and decreasing amounts of subterranean clover and miscellaneous species during subsequent years so that by September 1953 wimmera rye grass and P. tuberosa were co-dominant at all levels of nutrient nitrogen (tables 23, 25 and 30).

The amount of onion weed in the P. tuberosa pasture did not differ significantly in table 27b from the amount of onion weed in the mixed pasture for any one level of nutrient nitrogen. Onion weed was significantly reduced in the N1 P. tuberosa pasture to 26.2% of the onion weed in the N1 volunteer pasture. It was progressively reduced in the P. tuberosa pasture through the N2, N3 and N4 levels of nutrient nitrogen to 2.8% of the N1 volunteer pasture or to 4.3% of the N5 volunteer pasture in the N5 P. tuberosa pasture. The P. tuberosa pasture was dominated by wimmera rye grass and other annual grasses and miscellaneous species during the year of pasture establishment with increasing P. tuberosa and decreasing miscellaneous species during subsequent years so that by September 1953 P. tuberosa and wimmera rye grass were dominant.

The amount of onion weed in the N1 perennial rye grass pasture was just significantly lower at the 5% level of probability in table 27b from the amount of onion weed in the N1 volunteer pasture. The N2 perennial rye grass pasture did not differ significantly in onion weed content from the N1 or the N2 volunteer pastures. At higher levels of nitrogen fertility the differences between the amount of onion weed in perennial rye grass pasture and in comparable volunteer pasture became increasingly significant. At the N5 level of nitrogen nutrition the amount of onion weed in the perennial rye grass pasture was reduced to 10.1% of the amount in the N1 volunteer pasture or to 15.5% of the amount in the N5 volunteer pasture and these differences were significant beyond the 0.1% level of probability. In all three experimental years the perennial rye grass pasture was dominated by annual and perennial rye grasses and by miscellaneous species.

Although onion weed may have been reduced in wimmera rye grass pasture as compared with volunteer pasture during the early stages of the field experiment at the Waite Institute (tables 19, 21 and 22) by September 1953 there were no significant differences between any wimmera rye grass pasture and any volunteer pasture (table 27b). The N1 wimmera rye grass pasture contained 131.1% as much onion weed as the N1 volunteer pasture and the N5 wimmera rye grass pasture contained 92.2% as much onion weed as the N1 volunteer pasture and 142.3% as much onion weed as the N5 volunteer pasture. The N5 wimmera rye grass pasture was slightly but significantly (5% level) lower in onion weed content than the N2 wimmera rye grass pasture. The ratio of onion weed in N5 wimmera rye grass pasture to onion weed in N2 wimmera rye grass pasture was 56.6%. This may indicate a trend toward decreasing amounts of onion weed in wimmera rye grass pasture with increasing nitrogen fertility as was found to be the case at Avon. The wimmera rye grass pasture was dominated by wimmera rye grass in the year of establishment and by wimmera rye grass and onion weed in September 1953.

The results of the field experiments suggest that certain well adapted pastures give high yields of palatable herbage on onion weed infested land and provide effective control of the onion weed itself. Certain grass dominated pastures controlled onion weed most effectively when the available nutrient nitrogen was raised to a high level. Pastures at Avon which were dominated by lucerne also gave an effective control of onion weed but this species is partially independent of external supplies of mineral nitrogen. For maximum yields combined with maximum control of onion weed the most effective pasture at Avon was a pasture of wimmera rye grass supplied with a high level of available nutrient nitrogen. At a low level of nutrient nitrogen wimmera rye grass did not give higher yields than volunteer pasture and did not control onion weed. At the Waite Institute the most effective combination of high yields plus good control of onion weed was obtained from a pasture of subterranean clover, wimmera rye grass and Phalaris tuberosa.

The success of these experiments at Avon makes it reasonable to suppose that the same principles and methods can be applied in certain other areas also subject to severe onion weed infestation. Control of onion weed and reasonable yields of palatable herbage from onion weed infested land may be expected on solonized brown soils primarily devoted to wheat and sheep farming even though they receive less rainfall than occurs at Avon. Lucerne is well adapted to solonized brown soils and provided the soil is rich in lime lucerne can be grown under South Australian conditions in areas with a mean annual rainfall of 10 inches (Anonymous, 1952). Wimmera rye grass "gives satisfactory results in districts with a rainfall as low as 12 inches per annum" (Cook, 1951).

It is premature to anticipate the applicability of these principles in the pastoral areas north of the solonized brown soils but the outlook is encouraging. Here onion weed invades the valuable watercourse community first. "This plant community is an ephemeral one with well marked seasonal aspects. . . It presents few problems of regeneration since the plants are annuals and the soil contains such a high percentage of silt and clay that it has no tendency to drift" (Wood, 1936). Provided that appropriate plant species can be identified and encouraged by reseeding where necessary and that conservative stocking is practiced, the outlook for reducing the spread of onion weed in watercourse communities, for providing high yields of palatable herbage on areas already infested and for reducing the amount of onion weed in the watercourse appears promising. Saltbush communities on higher ground are also invaded by onion weed during "good" seasons. Investigations by the Botany School of the University of Adelaide at Koonamore Station have shown that the saltbush communities are nicely balanced with their environment and that overstocking is the primary cause of degeneration. "Provided the equilibrium between the plants and their environment is not upset by overstocking, saltbush will withstand prolonged drought and regenerate readily" (Wood, 1936). This suggests that the unpalatability of onion weed may give it advantages in saltbush country which can be eliminated if grazing is withheld or carefully limited for adequate periods of time. Further experimental work is necessary on onion weed infested areas in the pastoral districts to fully assess the nature of the onion weed communities there and to study the establishment of successful palatable competitors in the watercourse communities.

C. The Nature of Competition between *A. fistulosus* and Wimmera Rye Grass.

Certain pastures were observed in the field to reduce the quantity of associated onion weed. Examination of the data in the tables and inspection of the pastures in the field indicate that both the size and the number of the onion weed plants were reduced. When onion weed plants were grown with one of these pasture plants under the more readily controlled conditions provided by pot cultures a reduction in their size was noted just as was observed to occur in the field. A feature of this reduction was its unequal distribution between the species. Pot culture experiments no. P191 a and P191 b show that when the roots and top growth of onion weed plants and wimmera rye grass plants occupy the same general areas then the wimmera rye grass plants more successfully maintain their dry weight than do the onion weed plants. When onion weed and wimmera rye grass plants were grown over a wide range of available soil nitrogen in experiment no. P191b the total plant weight (table 31) of onion weed grown in association with wimmera rye grass was reduced to 18% to 31% of that of onion weed grown separately from wimmera rye grass while the wimmera rye grass was reduced (table 32) as a result of its association with onion weed only to 60% to 84% of its total weight when grown alone. A similar relationship exists when onion weed and wimmera rye grass are grown in association at high, medium and low soil moisture levels (tables 35 and 36) and the same type of relationship holds for leaves and roots (tables 33 and 37) as for total plant. Although these effects of one species on the other are well established by the experiments the mechanisms by which they occur are by no means so obvious.

Two types of mechanisms have been evoked to explain the reduced growth of one plant in the presence of another. These are: (1) the secretion of toxic substances by the plant roots and (2) competition for factors of the environment.

Few plant scientists, if any, deny that competition for factors of the environment are important in community dynamics but the role of toxic substances is neither well established nor universally accepted. In 1937 Loehwing made an analysis of the literature pertaining to root interactions and concluded that there is no evidence of plant excretions conferring toxic properties on the soil where aeration is normal and calcium carbonate adequate. More recently, Bonner (1950), Russell (1950b) and Salisbury (1952) among others have credited toxic secretions with an important role in plant communities. Bonner refers to the researches of Bonner and Galston (1944) and of Bonner (1944) which demonstrated the presence of the phytotoxic substance trans-cinnamic acid in guayule and of Gray and Bonner (1948) which demonstrated the presence in Encelia farinosa of 3-acetyl 6-methoxybenzadehyde, a phytotoxic substance not previously known. However, these substances were not shown to operate under field conditions. Russell cites field observations such as the reduced interpenetration of neighboring root systems and the fact that very small weeds interfere with a germinating crop more than can be expected from their power to compete for light and nutrients as evidence for the importance he attaches to root excretions. Salisbury's views are of especial interest because to him the greater aggressiveness of weeds introduced from South Africa and the Mediterranean into Australia as compared to the aggressiveness of native plant species suggests that antibiotic substances are involved. Onion weed is exotic in Australia and is of Mediterranean origin. It has successfully invaded large areas in southern Australia. It occurs most often on solonized brown soils which are characteristically well aerated and well supplied with calcium carbonate.

The experiments undertaken in this study do not furnish any evidence at all in respect to toxic root secretions. However, certain evidence was obtained to suggest that competition between the species for factors of the environment was adequate to produce the effects which were observed in the field in wimmera rye grass pasture and in pot cultures containing wimmera rye grass and onion weed.

It should be noted that pot culture experiments similar to experiment no. P191 a and P191b are of limited use in evaluating the effects of the several factors for which plants ordinarily compete. Firstly, the complex relationships between the factors make it impossible to vary just one factor at a time. Changing the amount of soil moisture may also change the amount of available soil nutrients, their rate of uptake, the amount and composition of the soil atmosphere and the nature and degree of activity by microorganisms as well as other factors. Secondly, only the mean soil moisture or the mean amount of nutrients are known with any accuracy but the conditions prevailing in the rhizosphere are not necessarily the same as the mean conditions prevailing in the soil or pot. Thirdly, correlations between two observations do not necessarily imply that a causal relationship exists when they are obtained from complex systems. In view of these considerations, caution should be the major keynote in the interpretation of pot culture experiments carried out under so-called "controlled" conditions of the type used in experiment no. P191 a and P191 b.

The sand culture experiment (tables 42 through 47) suggests that onion weed does not take up nitrogen from the soil nor convert it to protein nearly so rapidly as does wimmera rye grass. Four days after wimmera rye grass plants were supplied with 200 mgms. of nitrate nitrogen per pot their total nitrogen content increased to 186% (a mean increase of 52.4 mgms. per pot) of comparable plants which did not receive nutrient nitrogen. Four days after onion weed plants were similarly supplied with 200 mgms. of nitrate nitrogen per pot their total nitrogen content increased to only 131% (a mean increase of 8.20 mgms. per pot) of comparable plants which did not receive nutrient nitrogen. Four days after wimmera rye grass plants were supplied with 200 mgms. of ammonia nitrogen per pot their total nitrogen content increased to 278% (mean increase 81.15 mgms. per pot) of comparable plants which did not receive nutrient nitrogen while four days after onion weed plants were supplied with 200 mgms. of ammonia nitrogen per pot their total nitrogen content increased only to 151% (mean increase 13.60 mgms. per pot) of comparable onion weed plants which did not receive nutrient nitrogen. The relative ability of wimmera rye grass plants and onion weed plants to take up available soil nitrogen was even more strikingly contrasted when smaller amounts of nutrient nitrogen were applied and shorter periods of time allowed for its uptake. Two days after wimmera rye grass plants were supplied with 50 mgms. of nitrate nitrogen per pot their total nitrogen content increased to 164% (a mean increase of 24.30 mgms. per pot) of comparable plants which did not receive nutrient nitrogen and this increase was significant at the 1% level of probability. The increase in protein nitrogen of these wimmera rye grass plants was 69% of the increase in total nitrogen and the increase in protein nitrogen was significant at the 0.1% level of probability. Two days after onion weed plants were supplied with 50 mgms. of nitrate nitrogen per pot their total nitrogen content increased to only 108% (mean increase 2.00 mgms. per pot) of comparable plants which did not receive nutrient nitrogen and this increase was not significant.

The ability displayed by wimmera rye grass to rapidly take up small amounts of nutrient nitrogen and to utilize them quickly may be an important characteristic contributing to its success especially in a system of nitrogen economy such as has been postulated in the next section for solonized brown soils where the bulk of soil nitrogen is bound in unavailable forms and where nitrogen becomes available only sparingly through the process of ammonification. This idea is consistent with the observation that onion weed in wimmera rye grass pastures on solonized brown soils was progressively reduced as the supply of nutrient nitrogen was increased. Each increase in available nitrogen would tend to increase the growth of wimmera rye grass relative to the growth of onion weed and result in the acquisition by the wimmera rye grass of proportionately larger amounts of other factors such as carbon dioxide and light. On the basis of experiments by Lundegardth and others, Waksman (1952a) considers that plants depend a great deal upon CO_2 liberated from the soil humus for their nutrition to supplement the CO_2 present in the atmosphere above the plants and that normally microorganisms act as regulators of the CO_2 tension in the atmosphere. CO_2 contributes to the carbohydrate level of the plant through the process of photosynthesis. It has been demonstrated by Hamner (1936) and other workers that the utilization of nutrient nitrogen is dependent upon available supplies of carbohydrate in the plant and this has been specifically shown for wimmera rye grass by Amos and Wood (1939). Light also may regulate the carbohydrate supply of the plant through the mechanisms of photosynthesis and possibly plays some more direct role in nitrogen assimilation (Burström, 1943). Pritchett and Nelson (1951) have shown that the growth response of brome grass seedlings to nitrogen fertilizers decreased under reduced light intensities and stopped entirely below 422 foot candles. There are thus good reasons for believing that at certain concentrations of the factors involved the increased supplies of CO_2 and light available to the wimmera rye grass as a result of high nitrogen nutrition can further increase its uptake of nutrient nitrogen relative to onion weed and result in still further suppression of the latter.

The amount of cover on the lucerne pasture was very sparse and competition for light in this case was almost certainly of minor importance.

The arid nature of solonized brown soils suggests that the observed reduction of onion weed in certain pastures may have resulted from competition for soil water. In June 1952 there was ample moisture under all of the plots tested at Avon (table 17). In April 1953 after a long dry summer the soil under the lucerne pasture and the mixed pasture was below the mean permanent wilting point from 15 to 21 inches below the surface (table 18). Competition for soil water during the dry summer months may therefore have contributed to the decline of onion weed in lucerne pasture and in mixed pasture at Avon. Competition for soil moisture is less likely to have been important in wimmera rye grass pasture. Table 18 shows that in April 1953 both the volunteer pasture and the wimmera rye grass pasture were above the mean permanent wilting point between 15 inches and 21 inches below the surface. Moreover, onion weed appears able to carry out vital functions for a limited time in the complete absence of external supplies of water. The flower stalk of specimens of onion weed in a plant press have been observed to elongate, turn upward, flower and set seed while the roots and leaves were encased in dry newspaper. Reports have been received of plants which flowered and set seed after having been uprooted and hung on a fence wire in the sun. These experiences suggest that severe water stress must be maintained for several weeks in order to kill onion weed and that the available moisture under the wimmera rye grass pasture was adequate to support the onion weed plants over the dry summer period. The wimmera rye grass pasture was particularly free of summer growing miscellaneous species which might otherwise have competed with the onion weed for the reserve of soil moisture. Moreover, the main fluctuations in onion weed content of wimmera rye grass pasture occurred between June 1953 and October 1953 (Fig. III-4) during a time and in a manner which renders it unlikely that soil moisture was limiting growth. Certain pot culture experiments suggest that wimmera rye grass continues to limit the growth of onion weed even though the mean soil moisture is adequate. Table 35 shows that onion weed plants grown alone under mean soil moisture conditions never in excess of 12% (29% W.H.C.) were higher in dry weight than onion weed plants grown under competition in pots where the mean soil moisture did not fall below 14% (34% W.H.C.) or 20% (48% W.H.C.). For these reasons it seems that competition for soil water was not a major factor in the decline of onion weed on N5 wimmera rye grass pasture at Avon.

The picture of onion weed presented here is not one of a vigorous competitor in mixed pasture communities. This suggests that some other quality accounts for its successful infestation of extensive areas in southern Australia. The almost universal prevalence of large numbers of sheep and rabbits in areas heavily infested by onion weed seem to provide the required explanation. Under severe grazing the palatable herbage is eaten down and more light, atmospheric CO_2, soil moisture, and nutrients are made available to the onion weed which is thus able to persist and regenerate more readily. These considerations support the conviction that the grazing animal is an important factor in the spread of onion weed and therefore the first step in the management of onion weed infested land is to gain control of grazing by livestock and rodents.

D. The Fate of Nitrogenous Fertilizers on Solonized Brown Soil.

The wide range in application rates, the number of species involved and its duration over three years combine to make experiment no. P190 a at Avon one of the most comprehensive trials ever carried out with sulphate of ammonia on solonized brown soils. The nature of the response to sulphate of ammonia in this experiment has important implications. Callahan and Breakwell (1937) reviewed the work dealing with the use of sulphate of ammonia on solonized brown (mallee) soils. They quote numerous cases where responses were not obtained following the application of 1/2 to 1 1/2 cwt. of sulphate of ammonia or where negative responses were obtained following the use of 1/2 to 1 1/2 cwt. of this fertilizer on low rainfall (below 20 inches per annum) alkaline wheat soils in Victoria and South Australia. These trials were concerned with the yield of grain and forage from wheat, barley and oats. Callahan and Breakwell attribute this failure to obtain economic increases through the use of sulphate of ammonia to climatic conditions particularly low rainfall, to the beneficial effects of bare fallowing and to the encouragement of nitrogen fixing legumes following the use of superphosphate. The implication appears to be that responses were not obtained because there was already as much nitrogen available in the soil as the plants could utilize under the environmental conditions peculiar to solonized brown soils. Their conclusion that sulphate of ammonia is unlikely to give payable returns on alkaline soils in low rainfall districts except on new, overcropped, badly managed or unusual soils is strongly discouraging to the use of sulphate of ammonia on mallee soils and to further experimental work in this field.

Just as in the majority of cases quoted by Callahan and Breakwell the majority of the treatments in experiment no. P190 a did not produce a response to sulphate of ammonia. In 1951 (table 3) the volunteer pasture did not show any yield response following the use of 28, 56, 112 or 224 lbs. per acre of sulphate of ammonia. The perennial veldt grass pasture, the lucerne pasture and the mixed pasture also did not respond to the use of sulphate of ammonia. The wimmera rye grass pasture did not show a yield response to applications of 28, 56 or 112 lbs. per acre of sulphate of ammonia. The one exception in 1951 was the wimmera rye grass pasture which received 224 lbs. per acre of sulphate of ammonia. This amount of sulphate of ammonia is greater than that used in any experiment quoted by Callahan and Breakwell. The mean increase over 0 lbs. per acre obtained in 1951 through the use of 224 lbs. per acre of sulphate of ammonia on wimmera rye grass pasture was 1758 lbs. of oven dry herbage. This increase was significant at the 0.1% level of probability.

In 1952 the rates of application of sulphate of ammonia were doubled for all treatments. In this year only the wimmera rye grass pasture which had received 448 lbs. per acre of sulphate of ammonia, the mixed pasture which received 448 lbs. per acre of sulphate of ammonia and the perennial veldt grass pasture which had received 56 lbs. per acre of sulphate of ammonia gave significant responses. The M5 mixed pasture contained 92% of wimmera rye grass and presumably the response of this in mixture was similar to the response of wimmera rye grass in the pure stand.

In spite of the low rainfall in 1953, wimmera rye grass pasture responded by significant yield increases to applications of 224 and 448 lbs. per acre of sulphate of ammonia but no other pastures responded to sulphate of ammonia.

The results just enumerated suggest that commonly current concepts relating to the use of sulphate of ammonia on low rainfall alkaline wheat soils need reconsideration. It is not reasonable to explain the response of wimmera rye grass at high rates of sulphate of ammonia and the lack of response at lower rates of sulphate of ammonia in terms of new overcropped, badly managed or "unusual" soils or in terms of climatic differences. The unfertilized soil could not have contained the maximum amount of available nutrient nitrogen capable of being used by the plants since a highly significant response was obtained following the application of sulphate of ammonia at exceptionally high rates although if sulphate of ammonia had been applied only at moderate rates such a conclusion would have been tempting. Although liberal amounts of superphosphate were used at Avon, the small size of the volunteer legume population does not justify the view that volunteer legumes made a major contribution to the yields (tables 5, 7, 9 and 15). The peculiar nature of this response appears more likely to be due to factors inherent in the solonized brown soils.

One noteworthy feature of solonized brown soils is the absence of leaching and the shallow penetration of moisture which results from a low rainfall per wet day (Prescott and Piper, 1932). Examination of the soil profile at Avon suggested that the available water did not exist deeper than about three feet below the surface. Biological activity is thus restricted to a fairly narrow vertical range. Mineral nutrients tend to become locked within this zone and seldom move outside the reach of plant roots. The complete lack of available phosphorus at a depth of 15 inches which was observed at Avon while determining the permanent wilting point suggests that some nutrients may be restricted to more shallow depths. Another feature of solonized brown soils is their universally low nitrogen content (Prescott and Piper, 1932). If this conception of solonized brown soils is valid the apparent disappearance of substantial amounts of nutrient nitrogen—as when normally adequate amounts of sulphate of ammonia are applied to the soil and appropriate plant response is not observed—suggests that the nitrogen is being rendered unavailable to the crop rather than oversupplied.

Prescott and Piper (1932) found a mean ratio of carbon to nitrogen of about 15 for solonised brown soils. A more usual C:N ratio for agricultural soils is 8 or 10. The C:N ratio of the experimental soil at Avon was not determined but in view of the consistently high C:N ratio found for solonized brown soils by Prescott and Piper it is likely that a similarly high ratio existed there as well as in many of the examples quoted by Callahan and Breakwell. A number of workers including Parberry and Swaby (1941) have shown that the C:N ratio affects the availability of nutrient nitrogen. These investigators kept the nitrogen content constant but used different sources of nitrogen in order to vary the C:N ratio. Only when the added material contained more than 2 1/2% of nitrogen was there a consistent increase in the nitrogen available to the test plant (Italian rye grass). The C:N ratio appears to be not related closely to the total nitrogen content since different forms of manuring and cropping at Rothamsted have had only a small influence on the C:N ratio although they have caused large differences in the carbon and nitrogen contents (Russell, 1950d).

Only a small part of the nitrogen in the soil is available for plant growth. The greater portion is bound up in the soil organic matter. The transformation from organic nitrogen to available nitrogen is mainly brought about by soil microorganisms which excrete into the soil amounts in excess of their requirements. The sole important nitrogenous excretion product of the soil microflora under aerobic conditions is ammonia. This process has been called ammonification. Soil animals probably excrete uric acid and urea (Russell, 1950c). In the presence of large quantities of carbohydrate relative to nitrogen (high C:N ratio) less ammonia is excreted and the ammonia which is excreted may be reassimilated by the microorganisms which utilize the carbohydrates as a source of energy. Then the microorganisms are competing with the higher plants for the available nitrogen compounds of the soil. "If the available energy material is equal to or in excess of the energy-nitrogen ratio required by the flora, the coefficient of ammonia formation tends to approach zero; it tends to approach a maximum if the available energy material is less than the energy-nitrogen ratio. Depending on the proportion of energy material to nitrogenous substances 'beneficial' bacteria may become 'harmful'." (Waksman, 1952b). Recent work by Morton and MacMillan (1954) suggests that soil fungi take up applied ammonia nitrogen more readily than nitrate nitrogen already present.

The foregoing suggests that when a high C:N ratio prevails in the soil, and ammonium sulphate is applied at seeding time, only the ammonium nitrogen which is applied in excess of the requirements of the microorganisms during the time between the application and the establishment of the higher plants will be available to the higher plants and only this amount can contribute to yield increases. Even after establishment of the higher plant competition for nitrogen between the higher plant and the microorganisms may still prevail and species such as wimmera rye grass which can readily take up small amounts of available nitrogen will respond to smaller amounts of applied sulphate of ammonia than species less capable in this respect. These considerations suggest why large amounts of sulphate of ammonia had to be applied at Avon to produce a yield response and why this response was most consistently displayed by wimmera rye grass. Further experimentation which includes the measurement of available soil nitrogen, including ammonia nitrogen which is liberated and reassimilated, and of microbiological activity over the growing season, should lend credence to the part of this explanation which applies particularly to the use of sulphate of ammonia on solonized brown soils.

The actual magnitude of the increase obtained from the use of sulphate of ammonia on solonized brown soils remains to be considered. The value of a pasture depends upon its quality as well as upon its quantity so that an evaluation of the increase obtained through the use of sulphate of ammonia on wimmera rye grass pasture should consider the increase in protein content of the herbage as well as the increase in dry weight. In 1953 (table 16) the wimmera rye grass pasture without sulphate of ammonia produced 1380 lbs. per acre of wimmera rye grass with a crude protein (N x 6.25) content of 5.65%. By comparison, the wimmera rye grass pasture which received 448 lbs. per acre of sulphate of ammonia produced 3402 lbs. per acre of wimmera rye grass having a crude protein content of 10.4%. With the meagre data available it is possible to translate this increase into probable cash returns only very approximately.

It can be calculated that the wimmera rye grass pasture which received 448 lbs. per acre of sulphate of ammonia contained 207 lbs. per acre more of digestible protein (Crude protein x 0.75) than the wimmera rye grass pasture which did not receive sulphate of ammonia. The protein requirement for maintenance and growth of a 50 lb. lamb is 0.17 lbs. of digestible protein daily (Maynard, 1951). From this it can be calculated that the increase in pasture protein obtained above is equal to 1217 lamb days per acre. Supposing this highly theoretical value were to result in practice in 2 extra export quality lambs per acre it can be shown that a profit would have been returned through the use of 448 lbs. per acre of sulphate of ammonia on wimmera rye grass at Avon:

2 export lamb carcasses	64 lbs. @ 25 1/2 pence	136-0
2 skins	@ 17 shillings	34-0
Total receipts per acre		170-0
4 cwt. (448 lbs.) sulphate of ammonia @	767 shillings per ton	153-4
Additional profit per acre from sulphate of ammonia		16-8

If the additional pasture produced three additional fat lambs per acre the profit from the use of sulphate of ammonia on wimmera rye grass pasture would have been 96 shillings and 7 pence per acre.

Jensen (1940) has suggested the use of legume-free pastures and nitrogenous fertilizers for replacing the nitrogen reserves of the soil in situations where leguminous plants do not succeed. At least a part of the fertility problem on solonized brown soils results from lowered reserves of soil nitrogen (Cornish, 1949; Woodroofe, 1949, Jensen, 1940) and one method of replacement which ought to receive consideration is through the direct addition of nitrogenous fertilizers. Only about 1/2 of the added nitrogen was recovered on N5 wimmera rye grass pasture in 1953. Due to the nature of solonized brown soils 45 lbs. of nitrogen per acre presumably remained in the soil and contributed to its total nitrogen content. The available nitrogen is proportional to the total nitrogen (Jensen, 1940) so that additional available nitrogen in subsequent years can be expected as a result of this increase in the nitrogen reserve of the soil and part of the cost of the fertilizer should be debited against several years rather than a single year. Further studies may reveal that nitrogenous fertilizers are especially suitable for use on solonized brown soils due to the fact that the nitrogen which is not recovered immediately is never the less not lost permanently from the system but remains in the soil to boost the mean yields of grain and pasture in subsequent years.

E. Intraspecific Variation.

The preliminary experiments on variation in onion weed were initiated because of the idea expressed by Turesson (1922) that "knowledge of the ecology of an ecospecies presupposes a knowledge of its most important ecotypes. . ." An ecotype is the ecological unit which results from the genotypical response of an ecospecies to a particular habitat.

Frequent inspection of the onion weed plants from several habitats which were grown side by side in the field at the Waite Institute suggested that the plants from any one habitat were not very different in respect to size and vigor from the plants from any other habitat. The measurements of leaf length and leaf number in table 48 confirm these observations. Slight differences in earliness were found between the plants according to habitat. Table 48 shows that plants from Peterborough and Tailem Bend, South Australia, flowered about 4 days later than plants from the two sites in Victoria. Table 49 shows that there were also differences in germination percentage after six days at 19° C. between the plants from the several habitats. The main value of these preliminary experiments on intraspecific variation lies in the demonstration that onion weed appears to have a number of ecotypes. In future experimental work and in recommendations of control measures it will be advisable to keep this fact in mind. However, the differences which were found in these initial experiments do not seem great enough to affect any recommendations likely to arise out of the present work.

F. Seed Dormancy.

Contrary to opinions expressed elsewhere (Carter, 1950, p. 153) the majority of onion weed seeds are dormant at the time of shattering. Tables 50 and 51 show that the percentage of dormant seeds decreases as the storage time increases. At a storage temperature of 45° C. the percentage of dormant seeds decreased more rapidly than at 20° C. or 6° C. (table 52). This type of after ripening has been found in cereals and other plants and is discussed by William Crocker (1948). The mechanism appears to be not thoroughly understood but it is suggested that volatile inhibitors may be involved which disappear on heating or on prolonged dry storage. The possibility of the existence of such an inhibitor may make this phenomenon worthy of further study.

The storage temperature of 45° C. which accelerated the release of the seeds from dormancy is close to the temperatures attained during summer in the upper layers of the soil. Records maintained at the Waite Institute show that the mean maximum soil temperature in January at a depth of one inch is 43.1° C. In the field dormancy of this type may effectively reduce the germination of onion weed seeds in the event that late seasonal rains occur. Late rains are not likely to result in sufficient moisture in the surface soil to prevent newly germinated seedlings from desiccation. After exposure to high temperatures near the surface of the soil during the dry summer months the majority of seeds are able to germinate when the autumn rains commence. Dormancy in this case is possibly an adaption to a mediterranean type of habitat which carries the plant over the dry summer in the seed stage and enables it to grow upon the onset of winter rains.

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While much of what is good in the present paper is the direct outcome of the stimulating contact with the author's supervisors and colleagues, only the author himself is responsible for any inaccuracies and misinterpretations.

The advice of Mrs. I. Mathieson, Statistician at the Waite Institute, was followed during the final statistical computations but since she was not present at the outset she is not responsible for the experimental designs nor for the sampling techniques. Mr. Norman Stenhouse of the C.S.I.R.O. Division of Mathematical Statistics in Perth also gave advice and assistance in checking some of the computations.

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Mr. P. J. Nichols of Avon, South Australia, generously made available land for the field experiment there and maintained rainfall records on the site of the experiment.

V. Summary

Onion weed (Asphodelus fistulosus, Linn) is an unpalatable exotic perennial pasture weed. Apparently first introduced into Australia as a garden plant it escaped and flourished unchecked for many years before its noxious habits were generally appreciated. The results of a survey to study its distribution and agronomic characteristics are presented. These suggest that the majority of serious onion weed infestations occur on solonized brown soils and on the closely related desert loams below the 15 inch annual isohyet on land which has been cultivated or grazed.

Results of field experiments designed to test the competitive ability of some common pasture plants are presented. The commonly used pasture of volunteer species was not very effective in controlling onion weed over a considerable range of experimental conditions. On a typical solonized brown soil wimmera rye grass pasture effectively reduced onion weed only at exceptionally high rates of applied sulphate of ammonia. Lucerne pasture reduced the onion weed to about 1% of its growth on volunteer pasture at all rates of applied sulphate of ammonia but the yield of palatable herbage from the lucerne pasture was much lower than the yield of palatable herbage from the wimmera rye grass pasture under all of the experimental conditions. Where high yields plus effective control of onion weed are required the use of wimmera rye grass pastures at high levels of soil fertility appeared promising. Evidence is presented which suggests that contrary to widely held opinion applications of sulphate of ammonia to wimmera rye grass pastures on solonized brown soils in order to achieve the necessary high levels of soil fertility may result in a financial gain.

On the heavier more acid soils at the Waite Institute which receive more winter rainfall than the solonized brown soils a pasture of *Phalaris tuberosa*, wimmera rye grass and subterranean clover provided the most effective control of onion weed and gave the highest yields over a wide range of experimental conditions.

The results of pot culture experiments and field studies suggest that the competitive ability of onion weed in vigorous adapted pasture is low.

A preliminary search for ecotypes of onion weed was carried out but plants from several habitats were only slightly different from plants of other habitats and it seems that the control of onion weed is not complicated by ecotypes giving widely different responses.

The presence of a dormant condition of the seeds of onion weed is reported for the first time. Dormancy is broken by dry storage and exposure to high temperatures.

The experimental evidence suggests that affective control of onion weed is possible in most areas if the present mechanical and chemical treatments are combined with the sowing of certain vigorous pasture plants and provided grazing by livestock and rabbits is limited.

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