A STUDY OF THE ERADICATION AND ECOLOGY OF THE DANDELION

Taraxacum officinale -Weber

A Thesis

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by

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(*Taraxacum officinale. Weber.*)

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1. STATEMENT OF THE PROBLEM

The dandelion has long been a source of annoyance in the lawns of the urban dweller, and has also become a weed in pastures and waste land. Two methods of controlling the dandelion in lawns are in use. The first method is to treat the lawn and the dandelion with a differential herbicide, which eradicates the dandelion and does not appreciably damage the grass. The second method of control is to treat the individual plants with a chemical.

The dandelion eradication experiments carried on at the University of Manitoba were done with a view of finding a cheap and effective differential spray which could be used with ordinary spraying apparatus and which need be applied once or twice during the growing season. It was hoped that a spray could be found which had none of the disadvantages of iron sulphate namely the discoloration of sidewalks and clothes, and the necessity of numerous applications throughout the growing season. The experiments on the treatment of individual dandelion plants were carried on for the purpose of finding a method of eradicating the occasional plant, where the infestation was not heavy enough to warrant the treatment of the whole lawn. The common method used in the eradication of the individual dandelion plants is to "spud" them during the growing season. It was hoped that a chemical could be found which would eradicate the dandelion in a single treatment, without injury to the grass.

2. REVIEW OF LITERATURE

Dandelion eradication experiments carried on at research institutions have met with varying degrees of success. The chemical that has been used to the greatest extent for a differential spray is iron sulphate.

Thornton and Durrel (32) of Colorado have suggested the use of iron sulphate, 1¼ lbs., dissolved in 1 gallon of water and applied in the form of a fine mist on a cloudy day when there is no possibility of immediate rain. Three to five applications were found necessary, these applied at intervals of two weeks, throughout the growing season. Adams (1) of Rhode Island, recommended the use of a 20% solution of iron sulphate, sprayed on the plants just before the buds open. This worker found that four or five sprayings were necessary to destroy the dandelions. The percentage of plants killed was as high as 95. He recommended that the spraying be done on a warm sunny day, and at intervals of four to six weeks. Moore and Stone (18) of Wisconsin, also recommended the use of a 20% solution of iron sulphate and suggested that the sprayings be done on a warm afternoon when there is a promise of fair weather. The tests carried on by these workers showed that when large areas were treated, the results were not as satisfactory as when the spray was applied to the small lawn. This fact is ascribed to the length of the grass in the large areas which prevented the spray from reaching the leaves of all the dandelions. Olive (22) of South Dakota, applied a 20% solution of iron sulphate to lawns and did not find the results as satisfactory as those of other workers. This worker found that the young dandelions were killed with a single application, but that the larger plants persisted in reappearing, even when the infested area was treated three and four times. It was found that the clover in the lawn was damaged by the use of iron sulphate. Discoloration of anything with which the spray came into contact was also noted. Irritation of the skin and eyes, when using the iron sulphate spray was reported by this author.

French (7) of New York, stated that the universal use of iron sulphate as a dandelion eradicant is unlikely, judging from his experience that after twelve applications of the spray, the dandelions came up in profusion. The experiments of this worker had to be stopped in the second year, owing to the severe damage to the grass. After each application of the spray the lawn turned black and was unsightly for some days. Another point of view is obtained in the publication of Munn (21) also pf the New York Experimental Station. In a summary of eight years results it is stated that the use of iron sulphate is to be highly recommended in the eradication of the dandelion in lawns.

Some of the results of Munn (21) may be briefly summarized as follows. Four or five applications of the iron sulphate spray are needed:no material damage to the grass was found; the first spray should be applied before flowering; the later sprayings at intervals of four weeks. It is also suggested that the spraying be discontinued during the hot weather, in order to avoid material damage to the grass. Munn (21) also agrees with Olive (22) that the white clover in the lawn is damaged when using the iron sulphate spray. Bolley (3,4) states that iron sulphate successfully eradicated the dandelion, no injury to the grass being noted. It was found that the cost of spraying, when applied to large areas, was cheaper than cutting the lawn.

Pammel and King (23) working in Iowa, found that two sprayings of a 20% solution of iron sulphate killed the dandelions without damaging the grass permanently. Selby (27) in Iowa found that it was necessary to spray four times with a 20% iron sulphate solution before the treatment was effective. The first treatment according to this worker should be applied before the plant comes into bloom. Fyles (8) of Ottawa found that, after the third application of a 20% iron sulphate spray, the grass was so badly damaged that the experiment had to be discontinued. Howitt (14) of the Ontario Agricultural College found that after six sprayings using a 20% iron sulphate solution, the dandelions were reduced over 90%. No permanent damage to the grass was noticed. Longyear (16) of Colorado found that there was no easy method for the control of the dandelion. The reason was that reseeding occurred after all precautions had been taken. This worker suggests however, that the best and cheapest method of control is to be found in the use of iron sulphate sprays.

Loomis and Noecker (15) found that by the use of a petroleum distillate, with the addition of furfural, as high as 95% eradication was obtained with a single treatment. It was recommended by these workers that the spraying be done in warm weather and that the applications be made in early June or at the beginning of the fall growing period. Sturkie (30) of Alabama found that calcium cyanamide, when applied in the granular or powder form, at the rate of 1000 to 2000 lbs. to the acre, either in one application or two, reduced the number of weeds in lawns and greatly fertilized the grass. One applkcation of this chemical was found necessary to kill the dandelion. It should be applied between December and March. It is suggested, however, that the treatment be limited to Burmuda grass lawns, as there is considerable damage when the chemical is applied to bluegrass. Reseeding of the areas that appear bare after treatment is recommended by nearly all of the above workers.

Bateman (2) found that the toxic effect of a chemical is related to its concentration. This relationship was found to hold true for plants as well as insects and bacteria. It is shown by this worker that the relationship between the percentage of retardation in growth and the concentration of the chemical may be expressed in logarithmic terms. A parabolic relationship apparently holds true. This worker found that the various chemicals used gave a variety of slants to the charted lines varying with the constitution of the chemical used. The basis of calculation used by Bateman (2) was the formula $R = DC^n$, which is the general parabolic formula. McCool (17) showed that similar relationships were found when showing the effect of various chemicals, used in cultural solutions in which plants were grown. Tattersfield, Grimington, and Morris (31) found that, in insecticides, there is a relationship between the concentration and the toxicity. The technique used by these workers was found most applicable to the analysis of the dandelion eradication results.

The eradication of individual dandelions has been referred to by a number of workers. French (7) and Georgia (10) suggested the constant digging of the plants until the food reserve was exhausted. Thornton and Durrel (32) recommended digging up the lawn if the dandelions were very numerous. French (7) found that large healthy dandelions had to be dug seven or eight times before the roots of the plants were finally starved. Longyear (16) found that by digging the roots he was able to kill 64.7% of the plants. Henderson (13) found that cutting off the crown was useless in eradicating the dandelion. The results of experiments in which the crown or root was cut off have been far from satisfactory.

A number of workers in the field of dandelion eradication have suggested the use of various chemicals, which can be applied to the rosette or the cut crown. Georgia (10) suggested a pinch of salt applied to the cut crown. This treatment was found only to retard the growth of the dandelion, not kill it. Longyear (16) used gasolene on the plant and found that 95% of the plants were killed. Henderson (13) found that the use of a salt solution poured on the plant was useless in killing the dandelion and had an injurious effect on the grass. The same results were found when the crown was cut off and the brine poured on the cut surface of the root. This author found that coal oil, poured on the well expanded dandelion, checked the growth of the plant but did not kill it. It was found that the coal oil injured the grass surrounding the dandelion plants. When coal oil was applied to the cut crown the results were inconclusive and the damage to the grass appreciable. This worker found that gasolene poured on the plant retarded the growth for at least a season and did not injure the grass. Similar results were found when gasolene was poured on the cut crown.

Moore and Stone (18) recommended the use of iron sulphate crystals applied to the rosette. Thornton and Durrel (32) recommended the use of small amounts of gasolene or kerosene applied to the rosette, or the use of an icepick dipped in concentrated sulphuric acid, and then stuck into the crown of the plant. These authors suggested that a pinch of ammonium sulphate applied to each crown aided in the control of the dandelion. The use of ammonium sulphate has been suggested by various workers on the premise that this fertilizer will increase the acidity of the soil to an extent that it will be deleterious to weed growth. The use of the fertilizer offers great appeal in so far as it acts as an easily available source of nitrogen, which is stimulating to the grass. The acidity, or possibly the increased quantity of active aluminium associated with the use of this fertilizer, is tolerated by the "bent" grasses according to Garner and Damon (9), but is somewhat harmful to the common lawn weeds. It might be stated here that applying ammonium sulphate to the soil commonly found in the Winnipeg area, had little effect in changing the acidity. This is due to the high buffering action of the soil.

Muenscher (20) recommended cutting off the crown well below the ground level and placing a few drops of sulphuric acid on the cut surface. This worker also suggested the use of a pinch of ammonium sulphate on the surface of the cut crown. Among the more recent reagents used in the eradication of individual dandelion plants are petroleum and furfural mixtures, applied to the rosette of the plant. Loomis and Noecker (15) suggested the use of a petroleum furfural mixture. Buckardt (5) found that approximately 70% of the dandelions were killed with a single treatment of 4 c.c. of a petroleum furfural mixture. The solution used consisted of 95% Stanolex fuel oil no.1, and 5% furfural. The method followed in the above experiment was to use a "cane" which delivered the desired amount of chemical to each of the plants treated.

This worker also observed that the mature plants required more of the mixture to kill them than did the smaller plants. Some of the plants that were killed to a depth of three inches below the crown produced new growth about forty-two days after treatment.

The results that have been reported by workers in the field of weed eradication show that there is little agreement as to the best method of controlling or eradicating the dandelion. The discrepancy that is found may be due to a number of factors. It has been pointed out by Godel (11) that in herbicidal work, numerous factors usually neglected should be taken into consideration, in estimating the results. Weather and temperature are reported in few instances. The time of day at which the treatments were made, the purity of the chemical used, the atmospheric pressure and air movement, rainfall and dew, soil conditions and soil moisture, and other important factors have been neglected, or have not been thought important enough to report. It may be that these neglected factors are among the chief reasons that there is such a discrepancy in the results found by the various workers in the field of dandelion eradication.

3- PRELIMINARY EXPERIMENTS- 1934

The preliminary work on differential herbicides was carried on at the University of Manitoba by Tildseley (33). The preliminary experiments on dandelion eradication in which a number of chemicals and various rates of application were used, showed copper nitrate was the most promising as a differential herbicide. None of the other chemicals used, alone or in combination gave an appreciable reduction in the number of dandelions present. One view of the preliminary treatments where copper nitrate was used, is seen in Fig. 1.

The chemicals used in the preliminary work were:

1.- Sulphuric acid- 5%, 6%, 7%, 8% solutions applied at 100 gallons per acre.

2.- Copper nitrate- 2%, 3%, 4%, 5% solutions applied at 100 gallons per acre.

3.- Copper sulphate- 2%, 3%, 4%, 5%, solutions applied at 455 gallons per acre.

4.- Ammonium sulphate- 261, 435, 600, 783 lbs. per acre.

4.- HERBICIDAL EXPERIMENTS-1935

Methods

The preliminary results were so promising that it was thought advisable to concentrate on copper nitrate, and find the optimum number of applications, time of application and optimum per cent of copper nitrate for dandelion eradication. For this purpose a section of the football field was used which consisted chiefly of bluegrass (*Poa pratensis L.* and *Poa compressa L.*) and dandelions. The plots laid out were twenty feet square and the treatments were randomized so that a check plot was used for each of the treated plots. The rates of application were 1%, 2%, 3%, 4% and 5% copper nitrate, each percentage applied at the rates of 100, 200, 300, 400 and 500 gallons per acre. The plan of the plots is seen in Fig. 2 and 3. Block A was treated twice in 1935, July 8th and August 28th., and the observations on the treatments made the following spring. A second set of plots was laid out on the same general scheme as block A. On this set of plots which received copper nitrate treatments, the percentage of chemical applied was ¾%, 1½%, 2½%, 3½% and 4½%. The rates of application were 100, 200, 300, 400 and 500 gallons per acre, for each of the above percentages. This block received a single treatment on July 24th. 1935. The single treatment when applied on this date appeared to have little effect in controlling the dandelion, and for that reason, this set of plots was discontinued. The plan of the plots that received a single treatment, and the method of numbering the plots is seen in Fig. 31.

The plots treated in 1935 and reported upon in the spring of 1936, resembled a large checkerboard. The treated plots were greener and the grass longer than the plots which received no treatment. The method used in determining the effectiveness of the treatment was to take square yard areas from the centre of the treated and untreated plots and count the plants present. Error was overcome in counting the dandelion plants in the treated and untreated areas by repeating all counts. If there was any discrepancy the counts were made a third time. A square wooden frame was made and strung with wire at foot intervals. This gave nine sections, each a square foot, which facilitated the counting of the plants. The actual position of the dandelions was recorded on graph paper. A comparison of the treated plots and their checks gave an indication of the effectiveness of the various treatments.

Results and Discussion

The actual position of the plants within the square yard areas of the treated and untreated plots is shown in Figs. 4 to 28. The figures at the side of the charts indicate the number of dandelions found in each of the square feet. Of the various rates of application and percentages of copper nitrate used, the most effective results were obtained in the plots receiving a spray of 2% copper nitrate at the rate of 300 gallons per acre and the plots receiving a 3% copper nitrate spray at the rate of 200 gallons per acre. Though other rates of application gave a high percentage of plants killed, the damage to the grass was too severe for their recommendation. In examining Figs. 4 to 28, it will be seen that there is often a discrepancy in the number of plants killed, between the various percentages of copper nitrate used and also between the groups of plots receiving the same percentage of copper nitrate, but at different rates of application. It might be expected that as the amount of copper nitrate per plot increased, the effectiveness of the chemical would increase. The inconsistency in some cases may be due to a number of factors, namely the age of the plants, plants missed in the spraying, and the degree of dandelion infestation at the time of treatment.

The results of the 5% group of treatments in Block A may appear surprising in that they do not seem as effective as the 1% set of plots. This may be due to the fact that the 5% treatments were applied a week later than the other treatments and a heavy rain followed the application of the spray. General results of the 1935 sprayings are seen in Fig. 30.

Counts on the plots that received a single treatment of copper nitrate in 1935 showed that there was an inappreciable difference between the number of plants in the treated and untreated areas. For this reason the collection of further data was discontinued. A summary of the results obtained on Block A in 1935 is seen in Table 1.

Table 1.

SUMMARY OF RESULTS OF DANDELION ERADICATION USING COPPER NITRATE

1935-1936 Results on Block A.

Concentration (Per cent)	Rate of Application (Gals. per Acre)	No. Plants per Sq. Yd (Check)	No. Plants per Sq. Yd (Treated)	Units Copper Nitrate	Per Cent Kill
1.	100	242	86	1	64
1	200	153	6	2	96
1	300	234	51	3	83
1	400	277	1	4	99
1	500	219	8	5	96
2	100	174	20	2	88
2	200	133	25	4	77
2	300	99	3	6	96
2	400	171	16	8	90
2	500	150	4	10	97
3	100	160	17	3	89
3	200	204	0	6	100
3	300	262	1	9	99
3	400	206	10	12	95
3	500	160	3	15	98
4	100	223	8	4	96
4	200	135	5	8	96
4	300	237	2	13	99
4	400	76	23	16	72
4	500	119	2	20	98

The Effect of Concentration on Toxicity when Dandelions were Treated with Copper Nitrate.

One per cent copper nitrate, applied at 100 gallons per acre was the lowest concentration reported in detail here, and was designated as a concentration of 1. Bateman (2) found that the toxicity was related to the concentration when chemicals were applied to living plants. A modified form of the formula $R = DC^n$, used by Bateman was applied to the dandelion eradication results. In the formula R corresponds to the percentage of plants killed, C, to the concentration of the toxic material and n, the slope of the line when the results were graphed on logarithmic paper. D is a constant. The slope of the line varied with the chemical used and in this report both D and n were disregarded as a single chemical was under consideration.

The results of the herbicidal experiments on the dandelion in 1935 on Block A were analyzed to determine if they fitted the hypothesis of Bateman, namely, that the toxicity was affected by the concentration of a chemical. In Table 2 the treatment, concentration of the chemical (in units) and the percentage of plants killed are tabulated. The percentage of plants killed required by the logarithmic curve and the variations from the curve are also given. The results show that within the concentration of copper nitrate used in these experiments there is a relationship with the logarithmic curve. The results are graphically shown in Fig.42.

Table 2.

THE EFFECT OF CONCENTRATION ON THE TOXICITY OF COPPER NITRATE USED IN THE DESTRUCTION OF THE DANDELION.

Concentration Per cent	Rate of Application Gals. per Ac	Concentration in units of Copper Nitrate	Per cent plants killed	Per cent killed req. by curve	Difference between req. and found
1	100	1	64.46	64.46	0
1	200	2)			
		) Av.	92.00	73.00	19.00
2	100	2)			
1	300	3)			
		) Av.	86.00	77.00	9.00
3	100	3)			
1	400	4)			
2	200	4) Av	90.00	79.00	11.00
4	100	4)			
1	500	5	96.24	80.00	16.34
2	300	6)			
		) Av.	98.00	82.00	16.00
3	200	6)			
2	400	8)			
		) Av.	93.00	85.00	8.00
4	200	8)			
3	300	9	99.16	86.00	13.61
2	500	10	97.33	87.00	10.33
3	400	12)			
		) Av.	97.00	88.00	9.00
4	300	12)			
3	500	15	98.12	92.00	6.12
4	400	16	72.60	95.00	22.40
4	500	20	98.13	100.00	1.60

5.- HERBICIDAL EXPERIMENTS-1936

In 1936 experiments comparable to those of the previous year were conducted. The appearance of the plots in 1937 showed that the treatments had effected partial control of the dandelions, but that, on the whole, they were considerably less effecient than the treatments of 1935. Due to lack of funds actual counts of dandelion plants were not made in 1937. It is planned to make counts of dandelion plants on both series of plots in the summer of 1938 to determine the long-time effect of the treatments and to prepare a report on the entire project.

6. EXPERIMENTS ON THE ERADICATION OF INDIVIDUAL DANDELION PLANTS WITH HERBICIDES-1935

Methods

The area chosen for the 1935 experiments on the treatment of individual dandelion plants was on the east side of the football field where the dandelions were present in large numbers. The sod was chiefly bluegrass and redtop and had been seeded for at least ten years. The chemicals that were applied were gasolene, fuel oil and solvent. The chemicals were applied with a pipette, so that an exact amount of chemical could be applied to each plant. The quantity of chemical applied to each of the plants was 5 cc. Where treatments were applied to the rosette, the chemical was applied to the centre of the rosette, when to the crown, the rosette was removed by cutting below the ground level, and then the chemical was placed on the freshly cut surface. The plants were treated on July 6th. and examined on Sept. 20th. 1935.

A composite sample of the plants receiving identical treatment was taken and typical specimens drawn. These illustrations are seen in Figs.43 to 49. The methods used in reporting the effects of the various chemicals applied to the individual dandelion is as follows.

1.- Plants healthy on the date of reporting, no apparent damage done by the chemical.

2.- Plants damaged when reported. The root or crown appeared to have been affected by the chemical. The plants were alive and able to produce leaves.

3.- Plants dead or in a severely damaged condition. There were no leaves present and the roots were usually rotting.

Results and Discussion

The variation of the results within any identical treatment may be due to one or both of the following reasons: (1) part of the chemical running off the plant or the treated root: (2) the age of the dandelion plant may have played a part in the results obtained as the older plants tended to have larger roots and these may have been able to withstand more of the chemical.

The results of the various chemicals used in the eradication of the individual dandelion plants in 1935 are seen in Table 3, on the following page. The results show that none of the chemicals killed more than 68.7% of the plants treated. None of the chemicals used in 1935 are recommended for the eradication of individual dandelion plants.

Table 3.

COMPARISON OF CHEMICAL TREATMENTS ON INDIVIDUAL DANDELION PLANTS.

1935

Treatment	Plants Healthy Per cent.	Plants damaged but growing Per cent.	Plants Dead Per cent.
Gasolene on the Rosette	17.60	70.58	11.60
Gasolene on the Crown	4.10	87.59	8.33
Fuel Oil on the Rosette	13.60	59.09	27.26
Fuel Oil on the Crown	20.00	55.00	25.00
Solvent on the Rosette	6.25	25.00	68.70
Solvent on the Crown	77.77	22.22	0.00

EXPERIMENTS ON THE ERADICATION OF INDIVIDUAL DANDELION PLANTS WITH HERBICIDES- 1936.

The experiments carried on in 1936 were more extensive than those of 1935. A larger number of chemicals was used. It was thought that the time of application might have an effect on the efficiency of the chemical treatment, and so applications were made at various times throughout the growing season. Other variable factors that were taken into consideration were: (1) the amount of chemical applied to the plant; (2) the part of the plant to which the chemical was applied, and (3) the effect of leaving the cut crown exposed or of covering it.

When the chemical was in the form of a powder or crystals it was applied at the rate of ½ and 1 teaspoonful both to the rosette and the crown. When it was applied to the crown, some of the roots were covered with soil and others left exposed. The treatments were made on July 15th. and on August 15th. When the chemical to be applied was in the form of a liquid, 5 and 10 cc. were used. Applications were made on the rosette and the crown. When applications were to the crown, some were covered and others left exposed. Of the chemicals used, Raphanite and arsenic tri-oxide gave the most satisfactory results. Both of these chemicals killed a high percentage of plants under all variations of application. Ten cubic centimeters of Raphanite applied either to the crown or the rosette in August gave the best results. This chemical in no way injured the grass.

In using arsenic trioxide, the time of application and the part of the plant treated did not effect the efficiency of the herbicide. It is suggested that one half a teaspoonful be applied to the rosette during the growing season, for the eradication of the individual dandelion plants. Sodium chlorate killed 100% of the plants but severely damaged the grass surrounding the plants and for this reason it is not recommended.

A summary of the results obtained by using various chemicals on dandelion plants is seen in Tables 4 and 5. Table 4 shows the percentage of plants dead, injured and normal. Table 5 shows the percentage of plants dead, the variations in the treatments applied and whether the treatments are recommended.

Table 4.

SUMMARY OF THE TREATMENTS APPLIED TO INDIVIDUAL DANDELION PLANTS DURING THE GROWING SEASON OF 1936.

No.	Treatment	% Dead	% Injured	% Normal
1	Triple Super Phosphate	30.35	12.50	57.14
2	Used Crank Case Oil	16.80	13.44	69.74
3	Sodium Chloride	64.16	10.00	25.83
4	Potassium Sulphate	25.75	10.60	63.63
5	Gasolene	86.02	3.22	10.75
6	Sodium Chlorate	100.00	0.00	0.00
7	Raphanite(copper nitrate)	96.93	0.00	3.06
8	Sulphuric Acid	47.89	18.48	33.61
9.	Copper Sulphate	65.17	8.30	26.70
10	Arsenic Trioxide	100.00	0.00	0.00
11	Check- No Treatment	000.00	20.00	80.00
12	Check- No Treatment	000.00	20.00	80.00

Table 5.- SUMMARY OF RESULTS OF TREATMENTS APPLIED TO INDIVIDUAL DANDELIONS

1936

- Chemical Recommended

Date of Application	Chemical applied to Crown or Rosette	Amount of Chemical per plant when liquid or powder		Crown covered or uncovered with soil	Per cent of plants killed by chemicals: Copper Sulphate	Arsenic Trioxide #	Sulphuric Acid (10%)	Raphanite Copper Nitrate #	Sodium Chlorate	Gasolene	Potassium Sulphate	Sodium Chloride	Triple Super Phosphate	Used Crank Case Oil
July 15	C	1T	10cc.	Unc.	---	100	80	100	100	80	40	70	30	30
"	C	1T	10cc.	Cov	100	100	30	100	100	100	17	100	11	0
"	C	½T	5cc.	Unc.	---	100	80	100	100	88	0	80	33	70
"	C	½T	5cc.	Cov.	100	100	30	100	100	44	10	92	36	30
"	R	1T	10cc.	----	75	100	20	82	100	90	22	70	10	10
"	R	½T	5 cc.	----	65	100	20	100	100	90	30	70	0	10
Aug. 15	C	1T	10cc.	Unc	30	100	70	100	---	100	60	70	11	10
"	C	1T	10cc.	Cov	100	100	44	100	---	100	50	90	55	10
"	C	½T	5cc.	Unc.	45	100	70	100	---	66	50	30	50	10
"	C	½T	5cc.	Cov.	60	100	30	100	---	100	50	60	100	10
"	R	1T	10 cc.	-----	30	100	20	66	---	90	0	20	17	10
"	R	½T	5 cc.	-----	0	100	80	100	---	100	0	20	20	10

7.- GREENHOUSE EXPERIMENTS

Methods

In conjunction with the work done in the field on the eradication of the dandelion, a greenhouse project was carried on in the fall of 1936 to see whether the dandelion plant would react to the copper nitrate spray in the same manner as under field conditions.

Healthy plants were collected in the fall of 1936 and planted in pots in the greenhouse. The plants grew well under these conditions. From the material planted five pots were taken which appeared comparable in size and condition. As in the field experiments, 1%, 2%, 3%, 4% and 5% solutions were made up using Raphanite, one concentration to each of the five pots. To each of the plants 5cc. of the solution was applied. This amount fully covered the leaves with a fine misty spray. The chemical was applied to the plants in the greenhouse with an atomizer set in a graduate. On some of the leaves, leaf hairs were not present, with the result the spray tended to run into the leaf axils.

When the 1% solution of copper nitrate was applied to pot no. 1, the leaves did not begin to curl until five hours after the treatment. The effect of the spray was by no means permanent. In the photograph showing the plant fourteen days after the treatment, it appeared quite healthy. Pot no. 2, which received the 2% copper nitrate solution, began to wilt two hours after the chemical was applied. Fourteen days after the treatment, the plants had made little recovery. In pot no. 3, receiving the 3% copper nitrate solution, the plant began to wilt two hours after the spray had been applied. Fourteen days after the treatment, the plant had apparently recovered. This may be due to the fact that this plant contained numerous secondary crowns. Pot no. 4, receiving the 4% copper nitrate solution wilted within one hour after spraying, and fourteen days later had made little recovery. Pot no. 5, receiving the 5% copper nitrate solution, showed the leaves beginning to droop within thirty minutes after the treatment. After fourteen days there were only four leaves present on this plant.

Results and Discussion

Though the action of the spray in the greenhouse was much slower than was found under field conditions, the net effect was much the same as was found after the first spraying in the field. It took the dandelion plants in the field a little less time to recuperate from the first spraying. The fact that the humidity was high and the light intensity low in the greenhouse may partially explain the slowness in the action of the herbicide. Photographs showing two views of the treated plants, taken at various intervals after treatment are shown in Figs. 32 to 41. The illustrations show the progressive collapse of the leaves.

SUMMARY

1.- In the past the use of herbicides for the eradication of the dandelion have been only partially successful. These herbicides were found to have damaged the grass in some cases and had to be applied several times before effective control of the dandelion was obtained.

2.- Experiments at the University of Manitoba in 1935, have shown that the use of copper nitrate sprays, applied in two treatments about a month apart, were effective in killing the dandelion without damaging the grass permanently.

3.- The success obtained appears to be due to the fact that copper nitrate spray can be used to kill the leaves at two different periods in the growth of the plant, and thus exhaust the food reserve, weakening the plant so that it cannot overwinter.

4.- The effect of the spray was apparent within thirty minutes, when applied on a warm day.

5.- The grass temporarily turned a yellowish green color. A year after the spraying, however, the grass in the treated areas appeared more healthy than in the untreated ones, due no doubt to the fertilizing effect of the nitrate in the herbicide

6.- In eradicating individual dandelion plants the chemical -s that have been found effective are Raphanite (copper nitrate) and arsenic trioxide. These chemicals did not injure the grass surrounding the dandelion plants treated. Sodium

chlorate is not recommended as the damage to the grass was too severe.

7.- Greenhouse experiments suggested that the speed of action of the herbicide is due to the concentration of the copper nitrate, light intensity and humidity.

RECOMMENDATIONS FOR THE USE OF COPPER NITRATE FOR THE ERADICATION OF THE DANDELION.

1.- The copper nitrate solution should be applied in the form of a fine mist, on a warm day.

2.- A 2% copper nitrate solution applied at the rate of 300 gallons per acre or a 3% copper nitrate solution applied at the rate of 200 gallons per acre, give the best results.

3.- Copper nitrate sprays should not be applied to lawns where there is any quantity of young grass.

4.- A pressure tank sprayer gives good results when a small areas is to be treated.

5.- Two treatments of the infested area are necessary, the first about July 15th. and the second about August 15.

6.- Watering the lawn forty-eight hours after the spray is applied reduces the amount of discoloration of the grass.

Part 2- AN ECOLOGICAL STUDY OF THE DANDELION

Introduction and Review of Literature

There are few references in the literature on the ecology of the dandelion. Among the workers that have contributed to the knowledge of the dandelion on this continent, Sheriff (28) has attacked the problem from the taxonomic viewpoint. In his "North American Species of Taraxacum", the distribution and characteristics of five species found on this continent are described. The number of synonyms given for each of the species is large and the line of demarcation between the species often slight. Sears (26) describes the life-history of the dandelion in some detail. This worker has attacked the problem from the viewpoint of taxonomy and ecology combined. He points out the multiplicity of names used in the early nomenclature for the species of Taraxacum . This was due to the fact that many taxonomists used the leaf as a distinguishing character. The use of the leaf in determining the species has been shown by this worker to be unreliable. Other characters used in distinguishing species of Taraxacum were the seed, flower color, bract shape and bract color. Most of these characters are inconsistent within one species and for this reason difficulty in naming the species has arisen. Rydberg (25) recognizes only two species of Taraxacum.

Little has been written on the life cycle of the dandelion, or the variations in the plant during the growing season. It is a common experience to find dandelions with heavily indented leaves and some with entire leaves. Both of these types of leaves may be found on the same plant. Various opinions concerning the segmentation of the leaf have been presented in the literature. Goebel (12) classes the dandelion with those plants that form two kinds of leaves, first the entire leaf, and later in the growing season, the segmented form. De Varegny quoted by Morgan (19) attributes the dissection of the leaf to dry soil conditions. Frank (6) states that the leaf development is basipetal and that the top segment develops first. Stork (29) found that the seedlings grown from seed from the same head under identical conditions seemed to have the same general leaf shape, no matter what the leaf shape of the parent.

The determination of the age of dandelion plants has been attempted by a number of workers. Sears (26) adopted the method of digging up the plant and determining the condition of the root, the number of secondary crowns and the type of leaf produced by the plant. The method described by this worker is indefinite and the results are only an approximation. It is well known that the dandelion forms rings in the roots similar to those found in woody perennials. Roberts (24) has used the method of counting the number of rings on the primary root and recording them as the age of the plant, assuming that one ring is laid down every year.

The rapid decline in the number of leaves of the dandelion throughout the growing season has been reported by Longyear (16) and Sears (26). These workers found that a number of leaves on the dandelion are rapidly produced and just as rapidly die to make room for those that follow.

It was hoped that the examination of the life-cycle of the dandelion and the variations in the plant during the growing season would aid in determining the optimum time for the eradication of the plant.

Present Work - 1935 Observations

During the summer of 1935, a few dandelions were examined. These were dug from a section of land that had lain waste for a number of years. The growth in the spring began from numerous secondary crowns, each of which contained a number of buds. One of the largest plants examined showed fifteen secondary crowns. Each of these secondary crowns contained an average of 15.5 buds. A number of plants from a lawn were collected during May 1935. The heads were separated and the number of florets per head counted. The results of these counts are seen in Table 6.

Table 6.

NUMBER OF FLORETS PER HEAD, FOUND IN DANDELION PLANTS-1935.

Head No.	May 5	May 15	May 19	May 20	May 20	May 27
	FLORETS PER HEAD					
1	243	329	258	127	165	130
2	197	302	144	98	250	132
3	208	147	183	156	180	157
4	215	245	222	108	235	135
5	200	200	284	153	220	233
6	166	162	150	144	201	154
7	205	122	232	109	166	215
8	158	268	179	99	162	
9	214	191	187	128	234	
10	158	256	182	123	190	
11		261				
12		241				
13		261				
14		221				
Average	196.4	202.3	202.0	124.5	200.6	115.6

Present Work-1936 Observations

A collection of dandelion plants was made at weekly intervals during the growing season of 1936. The plants were examined and the following data recorded.

1.- Age (assuming the rings in the root are laid down one per year.)

2.- Flower Number

3.- Leaf Number

4.- Bud Number

5.- Crown Number

6.- Root Size (diameter), 2 and 4 inches below ground level.

7.- Leaf Length (maximum)

8.- Leaf Length (mean)

9.- Number of Side Roots, 0-2 inches below the ground level.

10.-Number of Side Roots, 0-4 inches below the ground level.

11.-Number of Side Roots, 2-4 inches below the ground level.

Determinations were made on 20 plants, taken at random, from four ecological situations at weekly intervals where possible. The ecological situations are as follows.

1.- Lawn (short grass, football field) chiefly a mixture of Kentucky bluegrass and redtop.

2.- Long Grass area- chiefly brome, crested wheat grass and western rye grass.

3.- Waste area- This area situated immediately north of the Dominion Rust Laboratory, contained weeds of all kinds.

4.- Windbreak area- The windbreak consisted of spruce and crabapple trees and was about twenty-five feet wide.

The history of these ecological areas is helpful in explaining the results found in this study. The windbreak had been planted over ten years. The long grass area had been seeded for at least five years . Previous to this time potatoes had been on the land. The waste area had been untouched for at least five years. The lawn, namely the football field, has been under grass for at least ten years.

In the lawn the dandelions had to compete with a heavy turf of bluegrass and redtop. It was found generally that the plants taken from this area were small. The dandelion plants in the long grass area had to compete both for light and space. The dandelions in the waste area had to compete with themselves and also a variety of other weeds, perennial sow thistle (Sonchus arvensis L.), red root pigweed (Amaranthus retroflexus L.), American dragonhead (Dracocephalum parviflorum Nutt.), annual spurge (Euphorbia maculata L.) and wild cranesbill (Geranium maculatum L.). The dandelion plants in the windbreak had to compete chiefly for light, especially when the trees came into leaf.

The plants were dug with a spade and as much of the root as possible taken with the plant. The plants were brought into the laboratory, where they were cleaned and the measurements made. In all cases the plants were collected and measured the same day. The method of recording the data is as follows:

<u>Leaves</u>:- All of the leaves over one inch were counted, and all the dead leaves on the plant discarded. Leaves were cut from the plant at ground level and their length determined.

<u>Flowers</u>:-The flowers were counted as such when there were any florets showing through the bracts, and until the seed had begun to disperse.

<u>Buds</u>:- All buds that could be seen were counted. The buds varied in maturity from those with no scape, to those where the florets were about to break through the bracts.

<u>Root</u>:- The samples of the root taken to determine the age of the plants were bagged and after the other measurements were completed the roots were examined and the number of rings counted. In determining the root size, the root was sectioned at two inch intervals, below the crown, and the diameter of the cut surface measured. The average root size that is reported is the average between the size at the two inch level and the four inch level.

<u>Side Roots</u>:- There were numerous fine roots on the main tap root of the dandelions, but these were disregarded and only those side roots over 1/8 inch in diameter counted.

The weather during the growing season is seen in Fig. 29. A summary of each of the factors concerned, determined from the plants from the four ecological positions, was made for ease of comparison. These are seen in Figs. 50 to 62. In Figs. 63 to 75 the measurements taken at weekly intervals are shown, each figure an average of twenty measured plants.

RESULTS AND DISCUSSION

AGE

In determining the age of the dandelion plants examined, sections of the root were taken from the main tap root and examined under the microscope. In all of the samples the sections were taken from about 2 inches below the ground level. Figs. 50 and 65 show the variations in the number of rings, found in the plants from the four ecological situations. The decayed cortex on the outside of the dandelion roots was disregarded in determining the number of rings present. It may well be that the apparent variations found in the plant ages between July 1st. and July 15th., from all ecological positions, were largely due to the shrinking of the outer cortex layer of the root. From July 1st. to the 15th. the greatest amount of reserve food was being used for leaf production. As the root released its stored food the root shrank and rotted. The data obtained may be the result of taking a predominance of young plants, which would lower the average age of the samples. These facts may partially explain the extreme variations found in the ages of the plants within one growing season.

Waste area- Plants from this area were on an average 13.9 years old.

Long Grass- Plants from this area averaged 14.2 years of age.

Lawn-(short grass) Plants from this area averaged 9.57 years of age.

Windbreak- Plants from this area averaged 10.2 years of age.

FLOWER NUMBER

The variations in the number of flowers present on any day of collection are seen in Figs. 51 and 64. It will be noticed that there are great variations in the flower number within the various situations and between the ecological positions.

Waste- Plants from this area produced the largest number of flowers per plant. The seasonal average was 10.18.

Long Grass- Plants from the long grass area produced the second greatest number of flowers per plant. The seasonal average being 6.70.

Windbreak- Plants from the windbreak averaged 1.80 flowers per plant for the summer. In this situation the flowering period extended from June 15th. to July 15th.

Lawn (short grass)- The dandelions in the lawn produced the smallest number of flowers per plant. The seasonal average being 1.59. The peak of flower production was reached about June 1st. and then gradually fell. The difference in the number of flowers produced in the lawn and the waste area may be due to the fact that the plants in the lawn had smaller roots and fewer crowns. This fact would reflect the amount of food stored in the root, and it seems logical to suppose that the greater the amount of stored food the larger the flower production will be.

LEAF NUMBER

The variations in the leaf number per plant in the various ecological positions throughout the growing season are seen in Figs. 52 and 63.

Waste- Plants from this area averaged 80.4 leaves per plant throughout the summer months. In this case we find a distinct rise in the leaf number per plant from May 15th. to June 1st. This may be due to an increase in the temperature or to the fact that the plants from this area have a large number of secondary crowns. The decline in the leaf number after June 1st. may be due to the fact that the food supply had been temporarily exhausted. Then, too, the leaves on the outside of the rosette may have had insufficient light to carry on photosynthesis. The decline in the number of leaves per plant may be a question of transpiration. It is possible that the moisture given off by the leaves exceeded that taken in by the root, causing the leaves to wilt. On May 9th., the average leaf number per plant was 176.45. There was then a distinct rise until a peak was reached on June 1st. with an average of 267.05 leaves per plant. A rapid fall in the average number of leaves was found between June 1st. and June 17th. There was a general decline in the number of leaves per plant during the fall.

Long Grass- Plants from this area possessed the largest average number of leaves per plant. Specimens from this area were not collected throughout the entire growing season. The average number of leaves per plant over the period of collection was 133.71. In the samples collected we find a distinct drop from 228.30 leaves per plant on May 11th. to 53.20 leaves per plant on June 23rd. when the observations on this area were stopped.

Windbreak- Plants from this area showed very little variations in the leaf number throughout the growing season. As there were fewer crowns on the plants from this area there were fewer leaves produced. The peak of leaf production occured about June 1st. Though the leaves from this situation were small in number, they were large in size. Heliotropism caused some of the leaves from this situation to reach a length of fifteen inches.

Lawn (short grass)- The number of leaves per plant collected from this area varied only slightly throughout the growing season. The number of crowns per plant was small. This is a limiting factor in the number of leaves produced. The average number of leaves per plant during the growing season was 11.65.

BUD NUMBER

The data presented in Figs. 53 and 71 show the relative number of buds on the plants from the four ecological positions. It is seen by a comparison with the flower number that there is little difference in the type of graph obtained. Not all of the buds present formed flowers. Some of the buds were found rotting in the axils of the leaves. This was true of the plants from the waste and the long grass areas only.

Waste- The average number of buds for the growing season was 10.05. The peak of bud production appeared to be about June 1st. after which there was a rapid decline. After June 15th. the number of buds produced was exceedingly low.

Long Grass- Plants from this area averaged 30.03 buds per plant, for the limited length of time that the collections were made. The peak of bud production was about May 20th. after which there was a rapid decline. After June 15th. the average was less than five buds per plant.

Windbreak- In this case the number of buds produced was very small, averaging only .51 per plant throughout the growing season. The peak of bud production was about June 1st. after which there was a rapid decline.

Lawn (short grass)- The seasonal average was only .13 buds per plant. There was no definite peak of bud production noticed.

The differences in the yearly average between the various ecological situations is likely due to the difference in the number of secondary crowns. The larger the number of crowns the greater the number of buds produced.

CROWN NUMBER

Figures 54 and 66 show the variations in the number of crowns that were found in the plants examined from the various ecological situations. The variations found in the waste and long grass areas can only be explained by assuming that in sampling, plants of different ages were collected together. The large variations in the plants from the waste area may have been due to the previous treatment of the land. If this area had not all received the same treatment, it would be expected that those plants that had been damaged more by cultivation implements would have the largest number of crowns.

Waste- The yearly average crown number of the plants from this area was 6.61.

Long Grass- The plants from this area had the highest number of crowns per plant for the limited length of time that the observations were made. The average number of crowns was 7.18.

Windbreak- Plants from this area showed little variation in the number of crowns over the growing season. The yearly average was 2.00 crowns per plant.

Lawn (short grass)- Plants from this area had the lowest yearly average of crowns of any of the ecological situations examined. The yearly average was 1.60 crowns per plant.

From the results it would seem that the less the competition and the more disturbed the surface of the soil, since the establishment of the dandelions, the greater is the number of secondary crowns produced.

ROOT SIZE

The root diameter was measured in two places, two inches below the ground level and four inches below the ground level. A third determination is also reported, which is an average of the two previous determinations.

The size of the roots (diameter) varied greatly within the areas from which they were collected. This was expected as there was a considerable number of young plants as well as old plants present. The older the root the larger was found the root size. In the six Figs. 55, 56, 57, 73, 74 and 75 there is a great similarity in the shape of the curves from any of the four ecological situations.

Waste- In this case the average diameter of the root from the 0-4 inch level below the ground was .50 inches. The variations during the growing season may be due to the fact that in the sampling more young plants were taken than old ones.

Long Grass- Plants within this area had an average root diameter for the first four inches below the ground of .64 inches. This determination is for the limited time that the collections were made.

Windbreak- Plants from the windbreak were considerably smaller in root size than the plants in the waste or long grass areas. The yearly average size of the roots was .25 inches. This determination is for the first four inches below the ground level.

Lawn (short grass)- The roots of the plants in this area were small, averaging only .22 inches in diameter. This may have been due to the extreme competition of the grass sod.

LEAF LENGTH

In the collection of the data, not only the leaf number was recorded, but the average leaf length of the leaves from the various situations and also the maximum leaf length. The results are illustrated graphically in Figs. 61, 62, 67, and 72.

Waste- The average leaf length of the plants from this area was 5.15 inches for the growing season of 1935. The leaf length reached a peak about July 15th. and then gradually fell until the autumn. The longest leaves averaged 9.40 inches and these were found about July 1st.

Long Grass- The average mean leaf length of the plants from this ecological situation was 5.59 inches. A peak of leaf length was reached about June 15th. and then there was a general falling off, until the sampling from this field was discontinued. It was found that the longest leaves were produced about June 1st.

Windbreak- The leaves from this area were the longest of any of the situations examined. The average mean leaf length was 6.07 inches. About July 15th. the leaves present averaged over ten inches. As there was considerable shading, resulting from the leaves of the trees, heliotropism was doubtless the reason for this fact.

Lawn (short grass)- The average mean leaf length from this area was 2.80 inches. The longest leaves were produced about July 10th.

SIDE ROOT NUMBER

In determining the number of side roots, all over 1/8 inch in diameter were counted. All roots beside the main tap root were classified as side roots. The side roots were counted within the top two inches of the soil, then from the two to four inch level and then a third determination was made which was an average of the results of the previous two determinations.

A glance at Figs. 58, 59, 60, 68, 69, and 70 will show that the number of side roots varied widely within any ecological situation and greatly between ecological positions. It is seen in an examination of the figures above that the greater number of side roots lie within the 2-4 inch level.

Waste- The plants in this area had a yearly average of 6.29 side roots per plant within the top 4 inches of soil. The average number of side roots on any date of collection varied greatly, indicating that there were other contributing factors beside age.

Long Grass - Plants from this area had a yearly average of 10.04 side roots within the top four inches of soil. Here again there is a large variation in the number of side roots between the dates of collection.

Windbreak- The number of side roots in the plants from the windbreak averaged only 2.33 for all of the plants examined throughout the growing season. This average is for all the roots within the top 4 inches of soil.

<u>Lawn (short grass)</u>- The number of side roots in this case was greatly reduced probably due to the thickness of the grass sod. The yearly average number of roots per plant was .72. This determination is for the top 4 inches of soil.

The number of side roots that was found in the samples from the various ecological situations seems to depend on the previous treatment of the soil. Where there has been little disturbance, the number of side roots seems to be smaller. The older the plant the greater seems to be the number of side roots. This fact is well exemplified in the case of the plants from the waste area.

SUMMARY OF INVESTIGATIONS ON THE ECOLOGY OF THE DANDELION

1.- Assuming that the age of the dandelion can be determined by the number of rings on the root. great variation in the age of the plants from the various ecological situations was found. The average ages in years of the plants from the long grass area, waste area, windbreak and short grass area were 14.2, 13.3, 10.2 and 9.5 respectively.

2.- The flower number in all of the plants examined reached a peak between June 1st. and June 15th. The average number of flowers per plant at this time varied between 65 in the case of the plants from the waste area and 5 in the case of the plants from the windbreak.

3.- The number of buds present in any of the ecological situations varied as did the flower number. In some cases, especially in the waste and the long grass areas, buds were found that were rotting.

4.- The number of crowns that the dandelion possessed depended on the competition present, the previous treatment of the soil and the age of the plants. The greatest number of crowns per plant was found in the waste and the long grass areas.

.. 5.- The root size as measured by the diameter of the root at the two inch level and the four inch level and then averaging them, showed that the plants from the windbreak and the short grass areas were much smaller than the roots of the plants in the waste and the long grass areas. The root size varied with the age of the dandelion plants.

6.- The greatest leaf length of the dandelion plants was reached between June 1st. and June 15th. The longest leaves were found in the windbreak.

7.- The number of side roots in the plants from the various locations was in every case larger in the 2-4 inch level, than in the top two inches of the soil. The number of side roots was largest in those areas having the oldest plants, and the roots with the greatest diameter within the top four inches.

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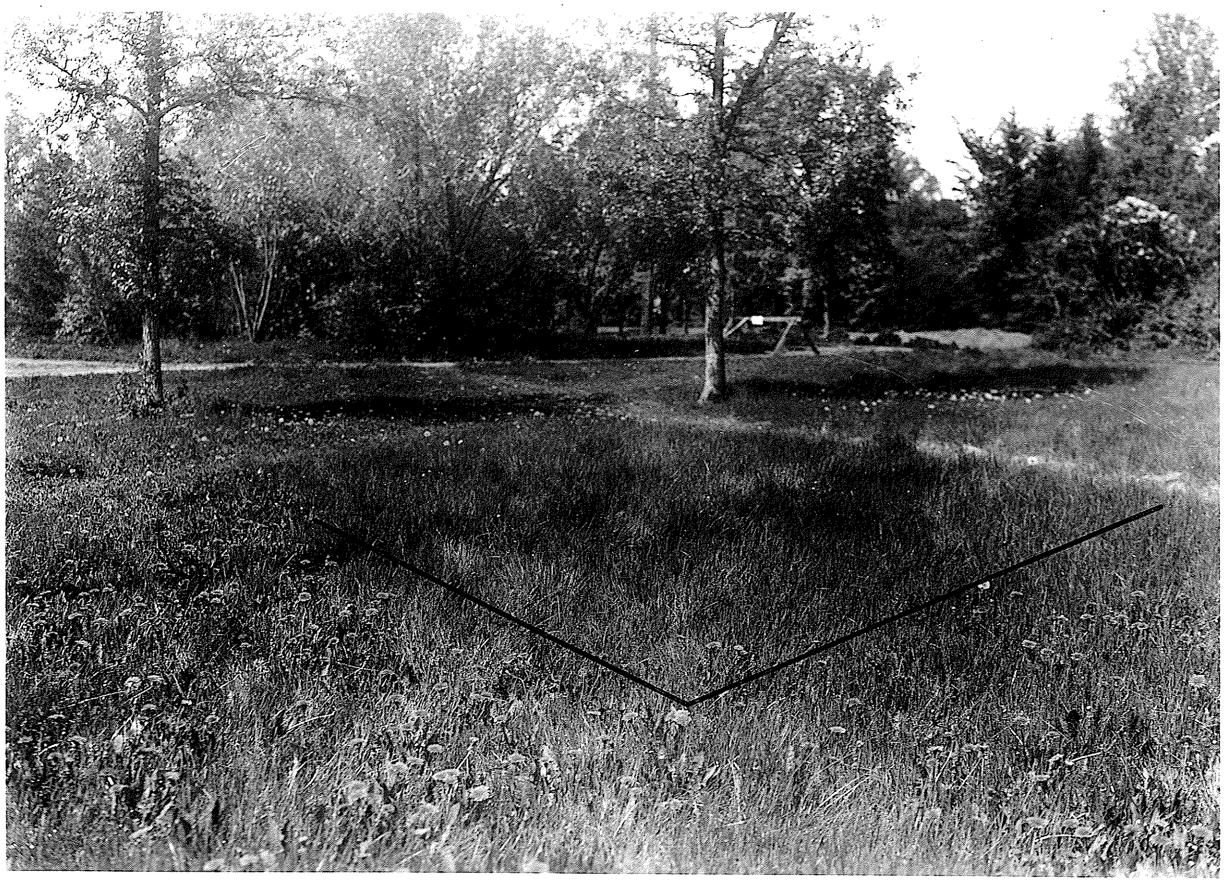


Figure I.- Area behind the Horticulture Building at the University of Manitoba. Area sprayed in 1934, with Copper Nitrate, picture taken in 1936.

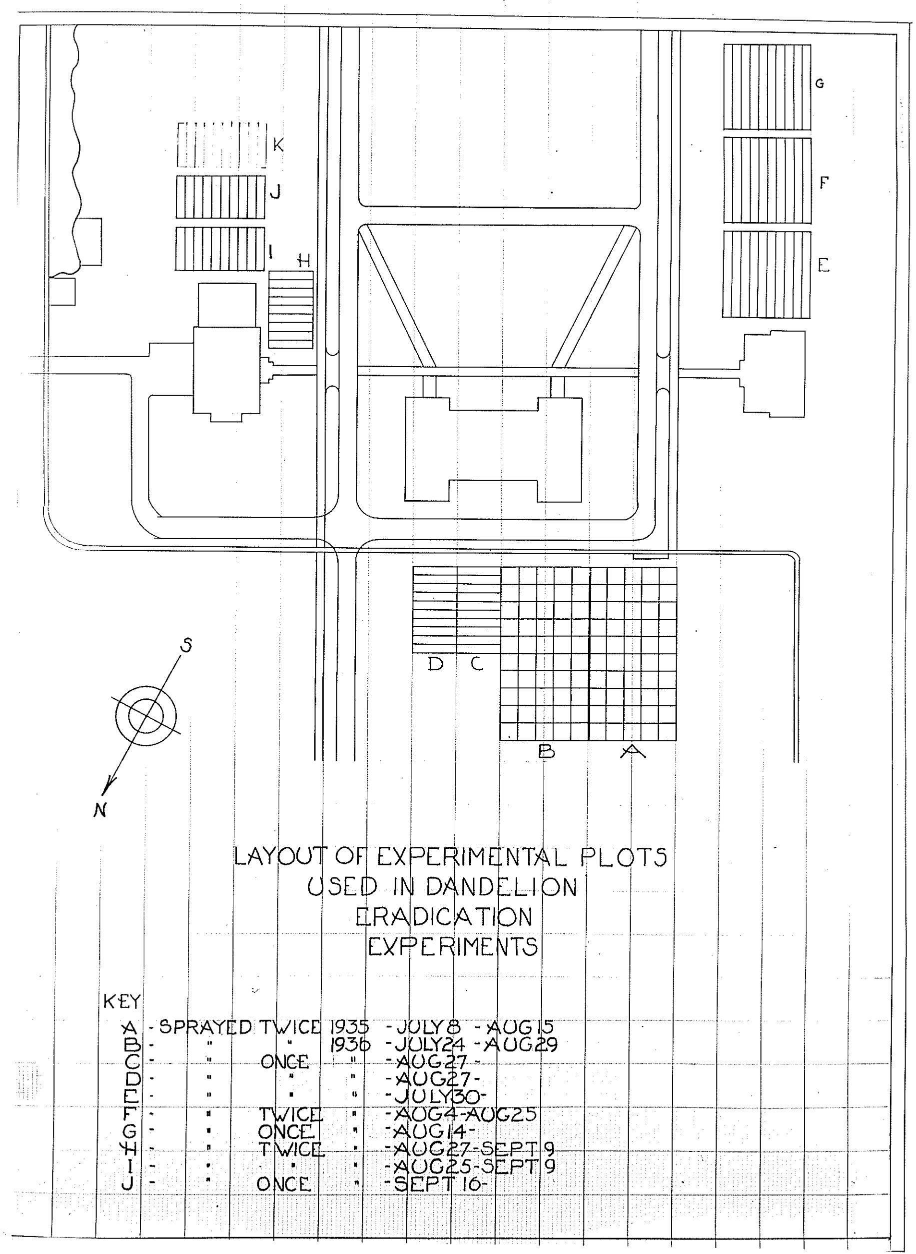


Figure 2.- Layout of the Blocks of plots used in the Dandelion eradication programme, 1935-6.

PLOT 'A'

North

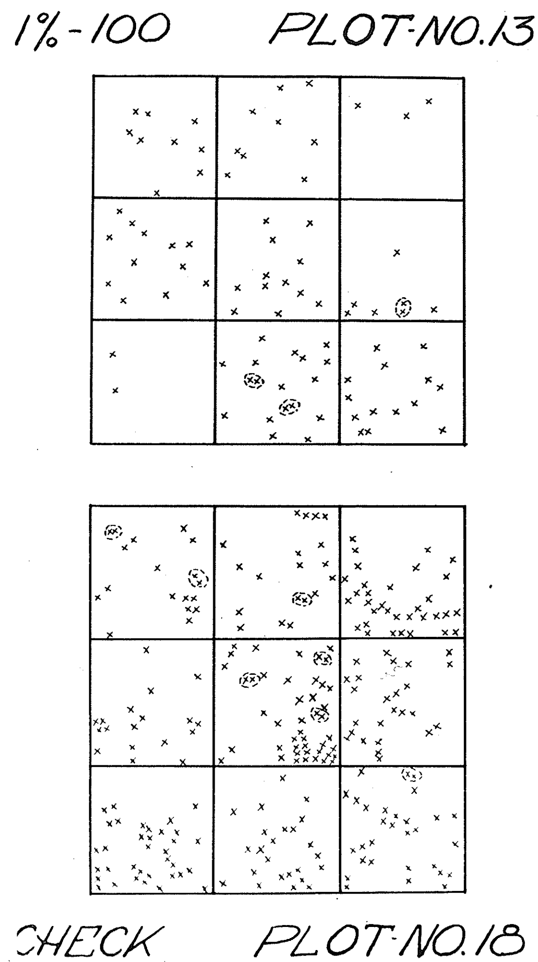
CHECK 46	3% 300 47	CHECK 48	1% 400 49	CHECK 50
3% 400 41	CHECK 42	5% 500 43	CHECK 44	1% 500 45
CHECK 36	3% 100 37	CHECK 38	2% 200 39	CHECK 40
4% 200 31	CHECK 32	4% 300 33	CHECK 34	5% 100 35
CHECK 26	5% 400 27	CHECK 28	1% 300 29	CHECK 30
4% 100 21	CHECK 22	5% 300 23	CHECK 24	4% 400 25
CHECK 16	3% 200 17	CHECK 18	2% 400 19	CHECK 20
4% 500 11	CHECK 12	1% 100 13	CHECK 14	2% 100 15
CHECK 6	2% 500 7	CHECK 8	5% 200 9	CHECK 10
2% 300 1	CHECK 2	1% 200 3	CHECK 4	3% 500 5

PLOT 'B'

North

CHECK 46	3% 300 47	CHECK 48	1% 400 49	CHECK 50
3% 400 41	CHECK 42	5% 500 43	CHECK 44	1% 500 45
CHECK 36	3% 100 37	CHECK 38	2% 200 39	CHECK 40
4% 200 31	CHECK 32	4% 300 33	CHECK 34	5% 100 35
CHECK 26	5% 400 27	CHECK 28	1% 300 29	CHECK 30
4% 100 21	CHECK 22	5% 300 23	CHECK 24	4% 400 25
CHECK 16	3% 200 17	CHECK 18	2% 400 19	CHECK 20
4% 500 11	CHECK 12	1% 100 13	CHECK 14	2% 100 15
CHECK 6	2% 500 7	CHECK 8	5% 200 9	CHECK 10
2% 300 1	CHECK 2	1% 200 3	CHECK 4	3% 500 5

Figure 3.- Layout of Blocks A and B, showing the placement of the individual treatments.



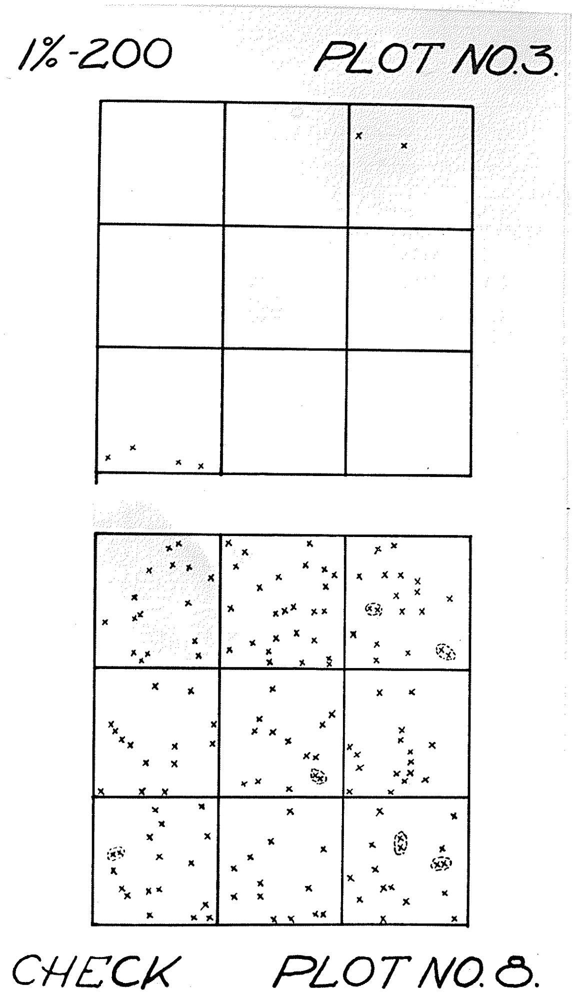
Infestation Count

I-9
2-9
3-3
4-I2
5-I2
6-7
7-2
8-I8
9-I4
Total-86

Infestation Count

I-I8
2-I9
3-33
4-I8
5-44
6-24
7-33
8-24
9-29
Total-242

Figure 4.- Diagram showing the comparative infestation of treated and untreated plots- Treatment-I% Copper Nitrate, applied at the rate of I00 Gallons per acre.



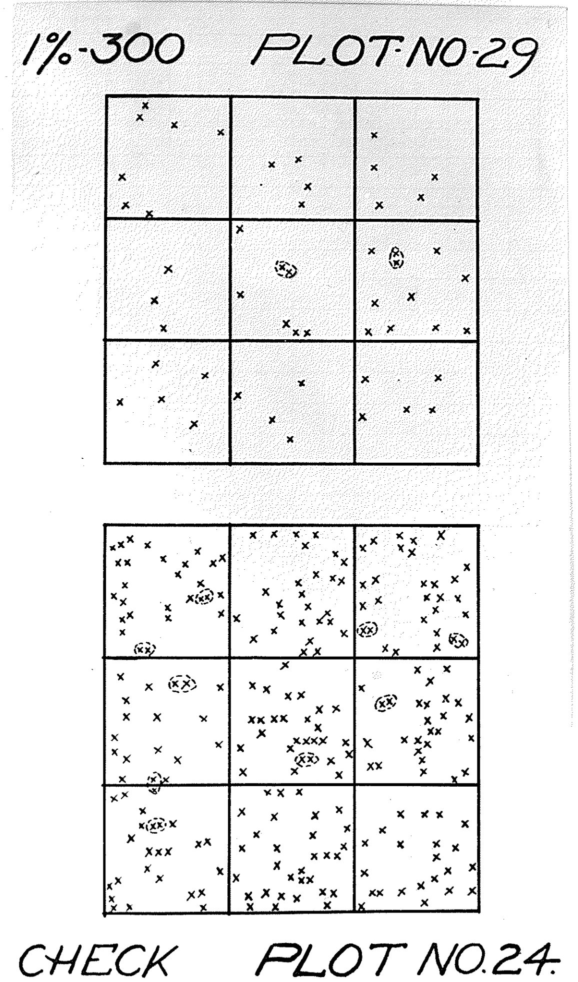
Infestation Count

I-0
2-0
3-2
4-0
5-0
6-0
7-4
8-0
9-0
Total-6

Infestation Count

I-I6
2-26
3-I9
4-I4
5-I4
6-I6
7-I8
8-I3
9-I7
Total-I53

Figure 5.- Diagram showing the comparative infestation of treated and untreated plots- Treatment-I% Copper Nitrate, applied at the rate of 200 Gallons per acre.



Infestation Counts

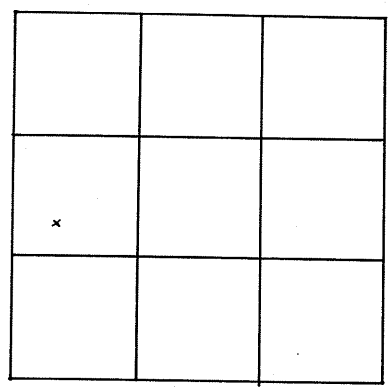
I-7
2-4
3-5
4-3
5-7
6-II
7-5
8-4
9-5
Total-5I

Infestation Counts

I-28
2-27
3-29
4-I8
5-28
6-27
7-25
8-3I
9-2I
Total-234

Figure 6.- Diagram showing the comparative infestation of treated and untreated plots-Treatment-I% Copper Nitrate, applied at the rate of 300 Gallons per acre.

1%-400 PLOT-NO.49

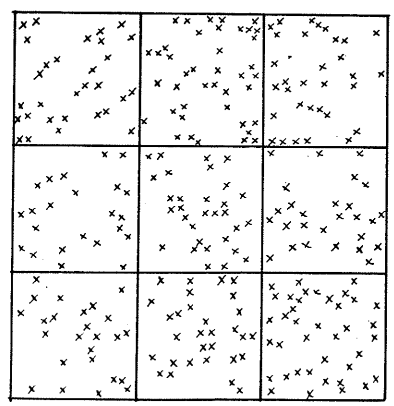


Infestation Count

I-0
2-0
3-0
4-I
5-0
6-0
7-0
8-0
9-0
Total-I

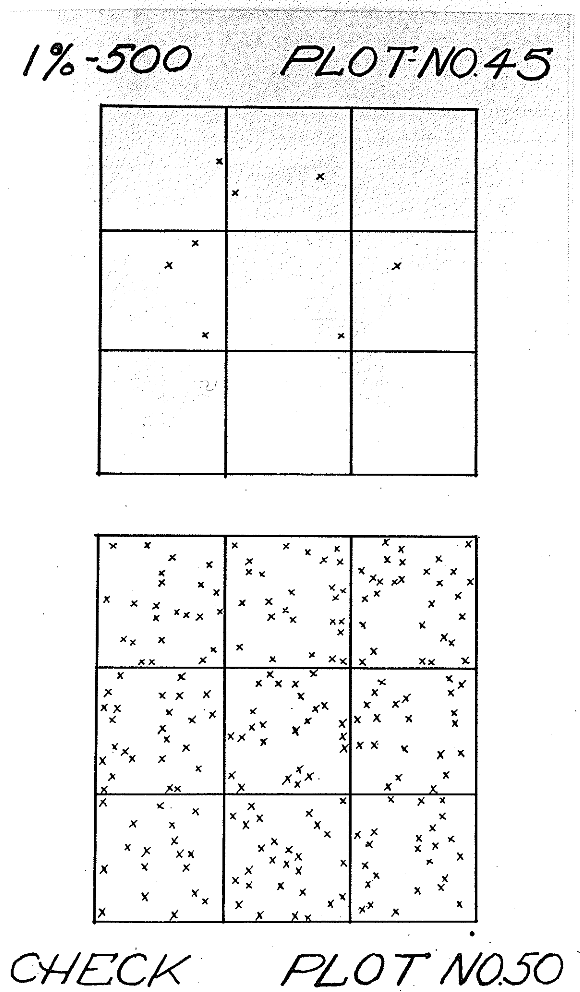
Infestation Count

I-30
2-4I
3-32
4-23
5-3I
6-27
7-25
8-30
9-38
Total-277



CHECK PLOT-NO.44

Figure 7.- Diagram showing the comparative infestation of treated and untreated plots-Treatment-I% Copper Nitrate, applied at the rate of 400 Gallons per acre.



Infestation Count

I-I
2-2
3-0
4-3
5-I
6-I
7-0
8-0
9-0
Total-8

Infestation count

I-23
2-26
3-29
4-25
5-25
6-22
7-I8
8-27
9-24
Total-219

Figure 8.- Diagram showing the comparative infestation of treated and untreated plots- Treatment-I% Copper Nitrate, applied at the rate of 500 Gallons per acre.

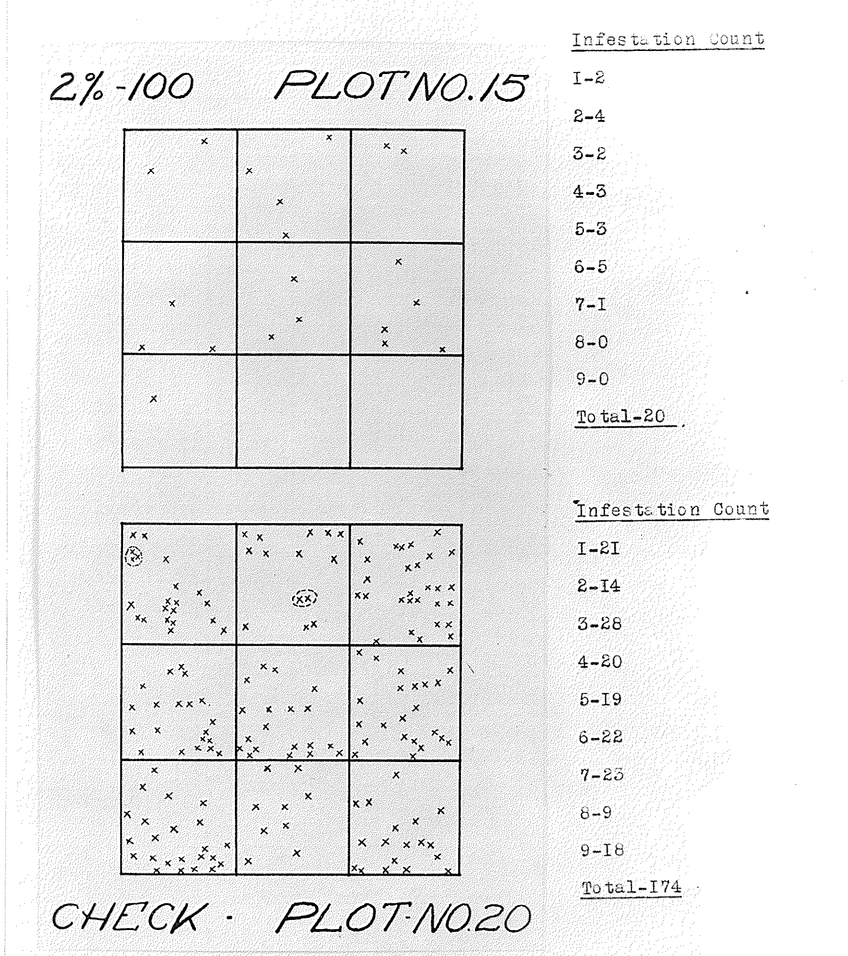
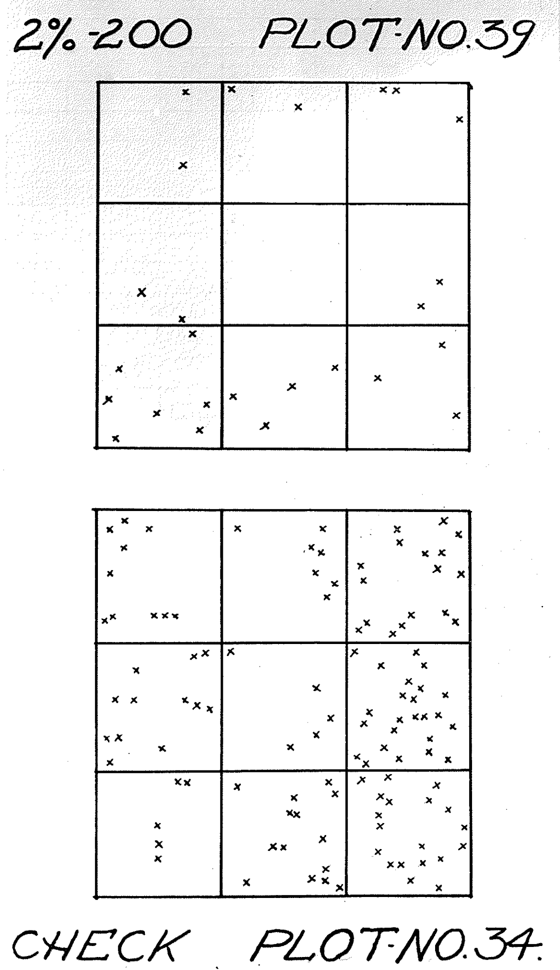


Figure 9.- Diagram showing the comparative infestation of treated and untreated plots- Treatment 1% Copper Nitrate, applied at the rate of 100 Gallons per acre.



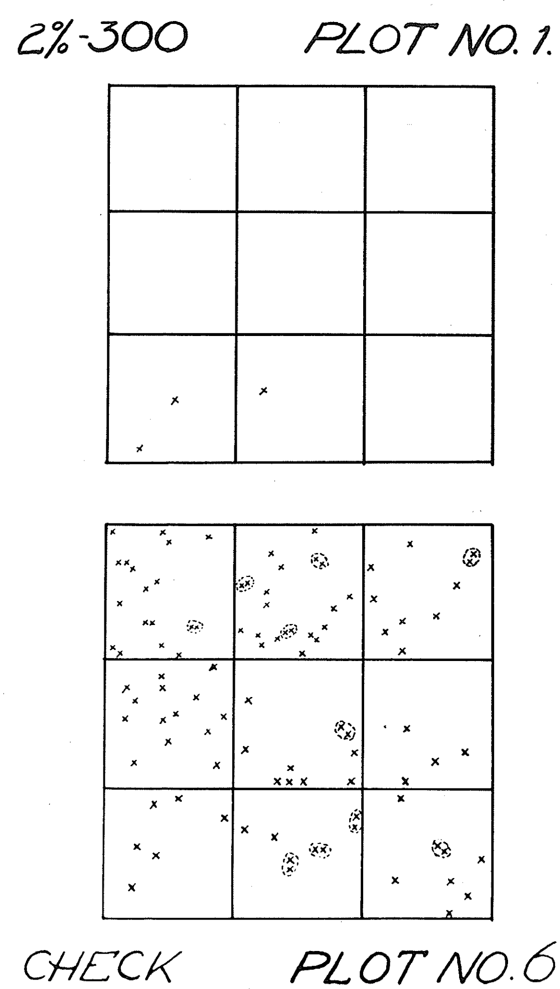
Infestation Count

I-2
2-2
3-3
4-2
5-0
6-2
7-7
8-4
9-3
Total-25

Infestation Count

I-I0
2-7
3-I7
4-I2
5-5
6-24
7-5
8-I4
9-I9
Total-II3

Figure IO.- Diagram showing the comparative infestation of treated and untreated plots- Treatment-2% Copper Nitrate, applied at the rate of 200 Gallons per acre.



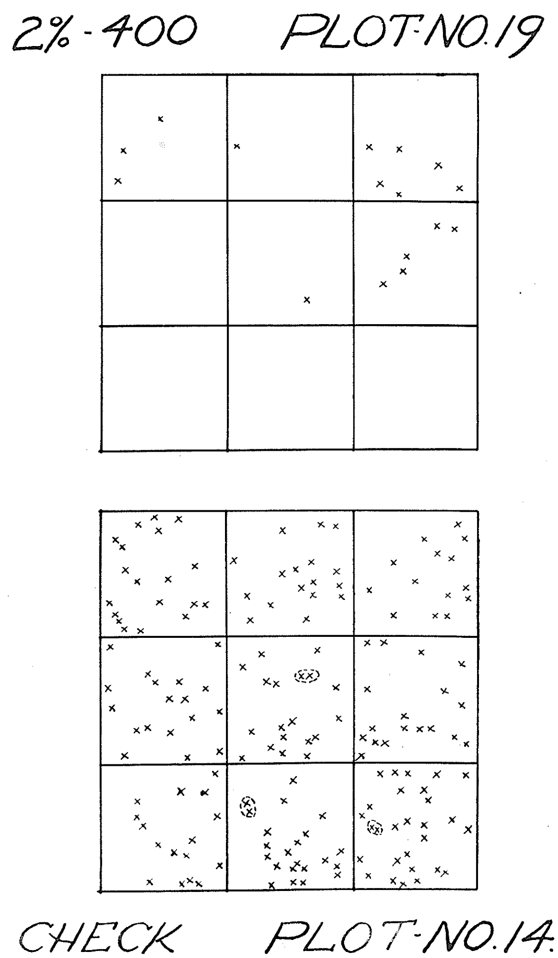
Infestation Count (Plot No. 1)

I-0
2-0
3-0
4-0
5-0
6-0
7-2
8-I
9-0
Total-3

Infestation Count (Plot No. 6)

I-I8
2-2I
3-I0
4-I4
5-I0
6-4
7-6
8-8
9-8
Total-99

Figure II.- Diagram showing the comparative infestation of treated and untreated plots- Treatment-2% Copper Nitrate, applied at the rate of 300 Gallons per acre.



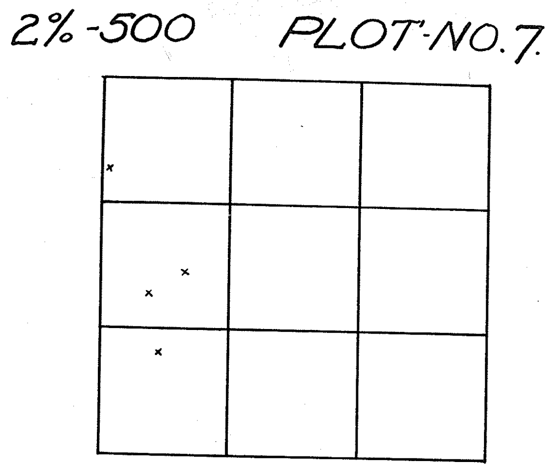
Infestation Count

I-3
2-I
3-6
4-0
5-I
6-5
7-0
8-0
9-0
Total-I6

Infestation Count

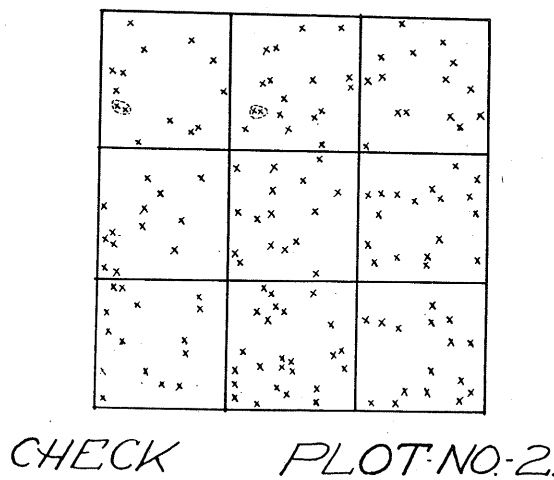
I-I9
2-I7
3-I4
4-I8
5-I9
6-I8
7-I6
8-22
9-28
Total-I7I

Figure I2.- Diagram showing the comparative infestation of treated and untreated plots- Treatment-2% Copper Nitrate applied at the rate of 400 Gallons per acre.



Infestation Counts

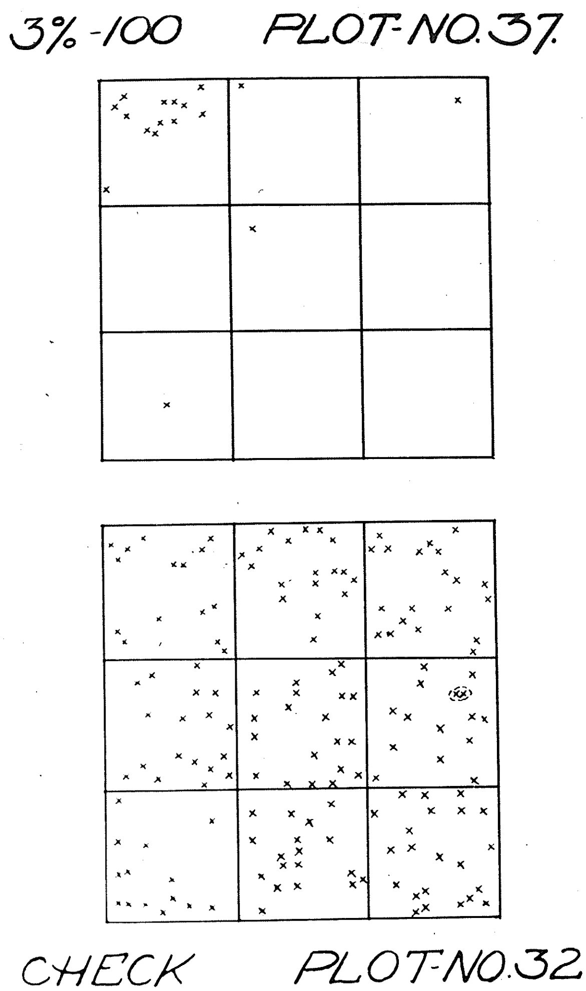
I-I
2-0
3-0
4-2
5-0
6-0
7-I
8-0
9-0
Total-4



Infestation Count

I-I4
2-I8
3-I5
4-I3
5-I6
6-I8
7-I5
8-25
9-I6
Total-I50

Figure I3.- Diagram showing the comparative infestation of treated and untreated plots- Treatment-2% Copper Nitrate, applied at the rate of 500 Gallons per acre.



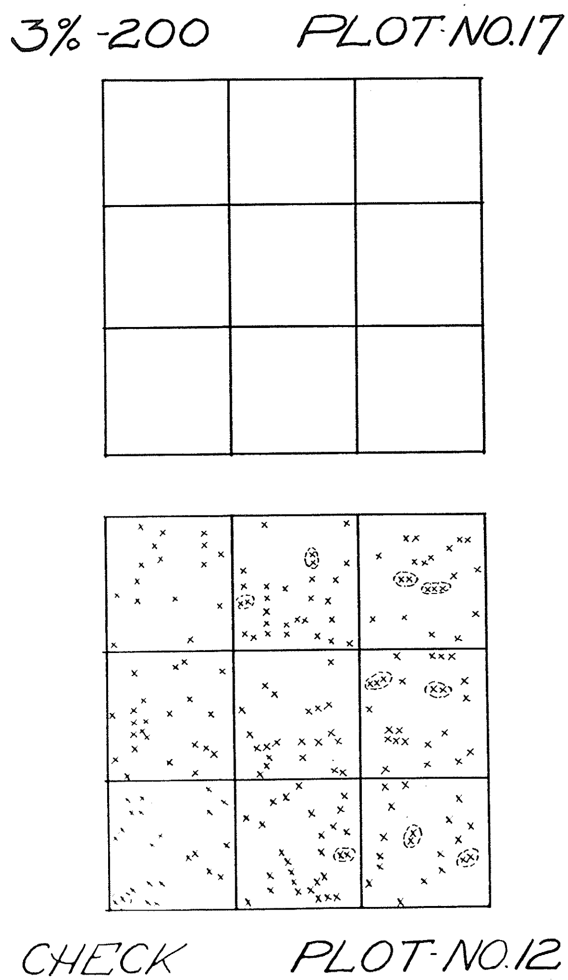
Infestation Count

I-I3
2-I
3-I
4-0
5-I
6-0
7-I
8-0
9-0
Total-I7

Infestation Count

I-I5
2-I8
3-20
4-I8
5-20
6-I5
7-I4
8-I8
9-22
Total-I60

Figure I4.- Diagram showing the comparative infestation of treated and untreated plots- Treatment-3% Copper Nitrate, applied at the rate of I00 Gallons per acre.



Infestation Count

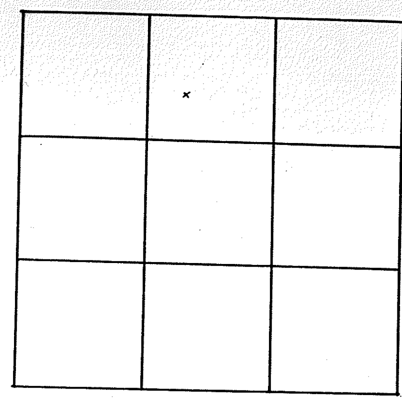
I-0
2-0
3-0
4-0
5-0
6-0
7-0
8-0
9-0
Total-0

Infestation Count

I-I6
2-29
3-2I
4-23
5-2I
6-24
7-23
8-28
9-I9
Total 204

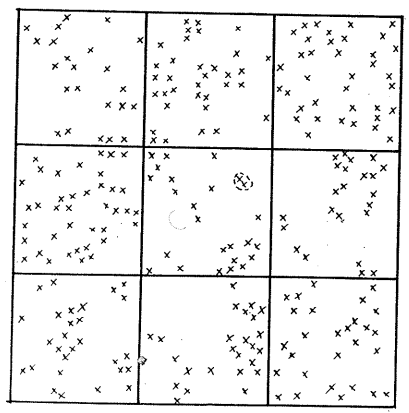
Figure I5.- Diagram showing the comparative infestatión of treated and untreated plots- Treatment-3% Copper Nitrate, applied at the rate of 200 Gallons per acre.

3%-300 PLOT-NO.47



Infestation Count

I-0
2-I
3-0
4-0
5-0
6-0
7-0
8-0
9-0
Total-I



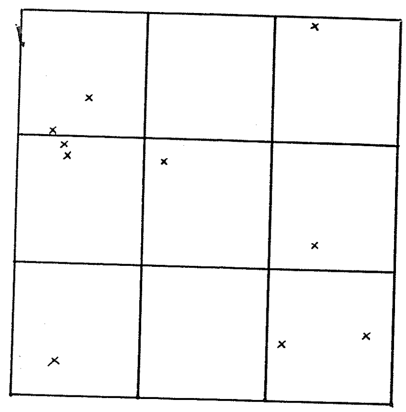
Infestation Count

I-23
2-34
3-37
4-39
5-25
6-23
7-28
8-25
9-28
Total-262

CHECK PLOT-NO42

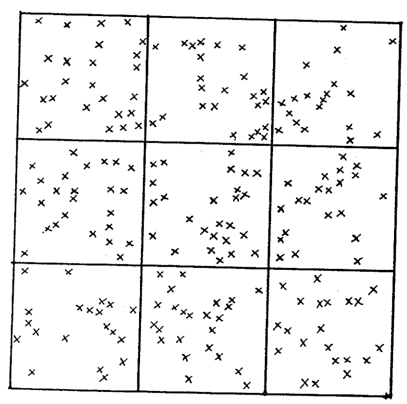
Figure 16.- Diagram showing the comparative infestation of treated and untreated plots- Treatment-3% Copper Nitrate, applied at the rate of 300 Gallons per acre.

3% -400 PLOT-NO.41.



Infestation Count

I-2
2-0
3-I
4-2
5-I
6-I
7-I
8-0
9-2
Total-I0

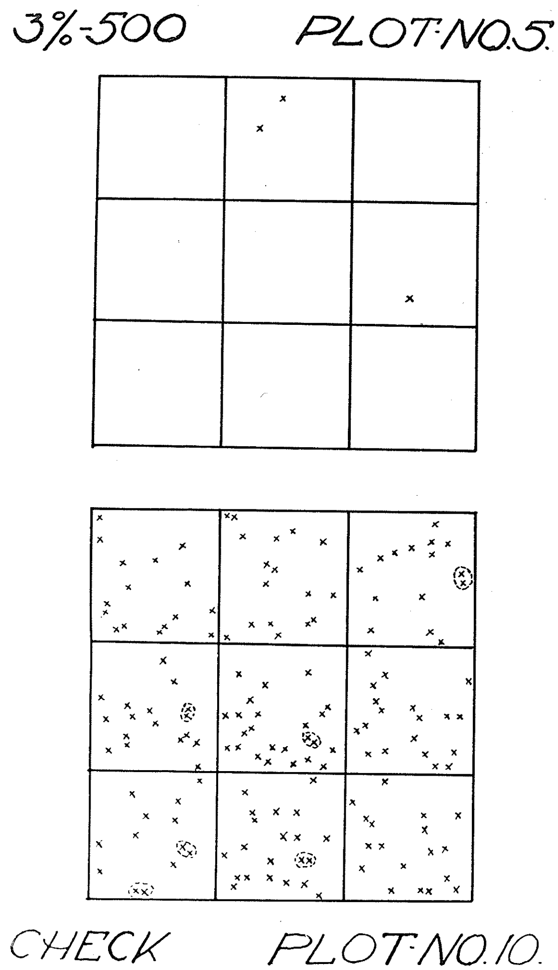


CHECK PLOT NO.46.

Infestation Count

I-26
2-24
3-I9
4-25
5-26
6-2I
7-20
8-24
9-2I
Total-206

Figure 17.- Diagram showing the comparative infestation of treated and untreated plots- Treatment-3% Copper Nitrate, applied at the rate of 400 Gallons per acre.



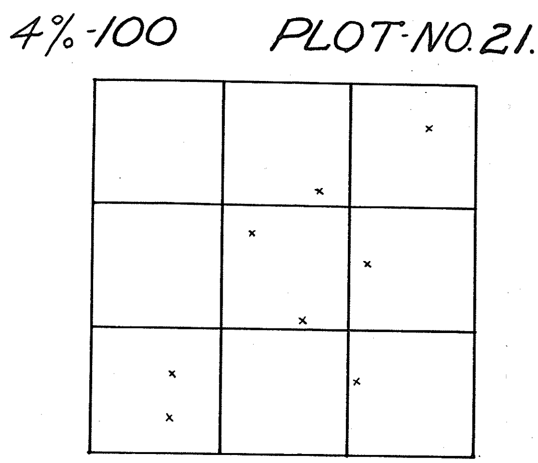
Infestation Count

I-0
2-2
3-0
4-0
5-0
6-I
7-0
8-0
9-0
Total-3

Infestation Count

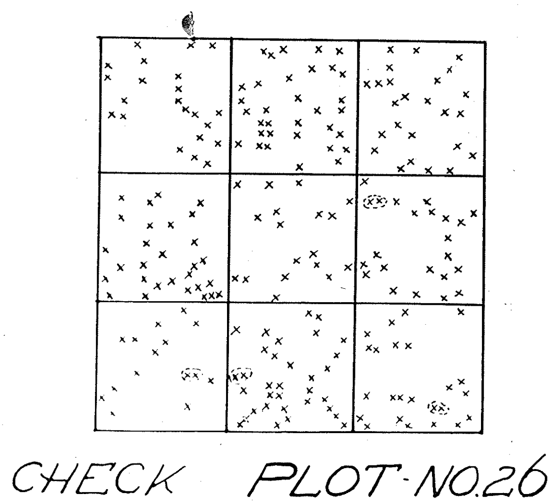
I-I6
2-I7
3-I5
4-I7
5-24
6-I9
7-I3
8-2I
9-I8
Total-I60

Figure 18.- Diagram showing the comparative infestation of treated and untreated plots- Treatment-3% Copper Nitrate, applied at the rate of 500 Gallons per acre.



Infestation Count

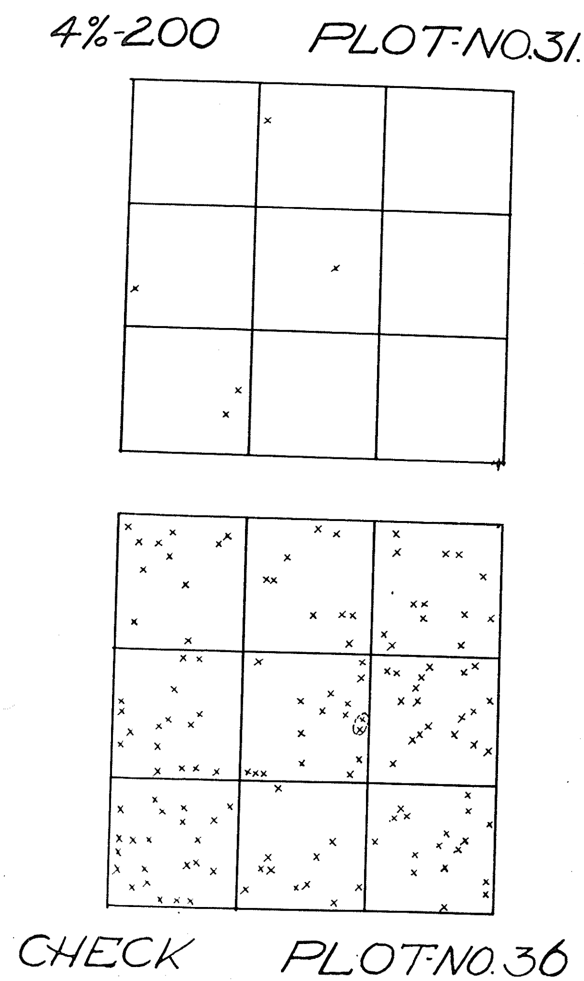
I-0
2-I
3-I
4-0
5-2
6-I
7-2
8-0
9-I
Total-8



Infestation Count

I-22
2-33
3-25
4-30
5-I8
6-23
7-I5
8-33
9-24
Total-223

Figure 19.- Diagram showing the comparative infestations of treated and untreated plots- Treatment-4% Copper Nitrate, applied at the rate of I00 Gallons per acre.



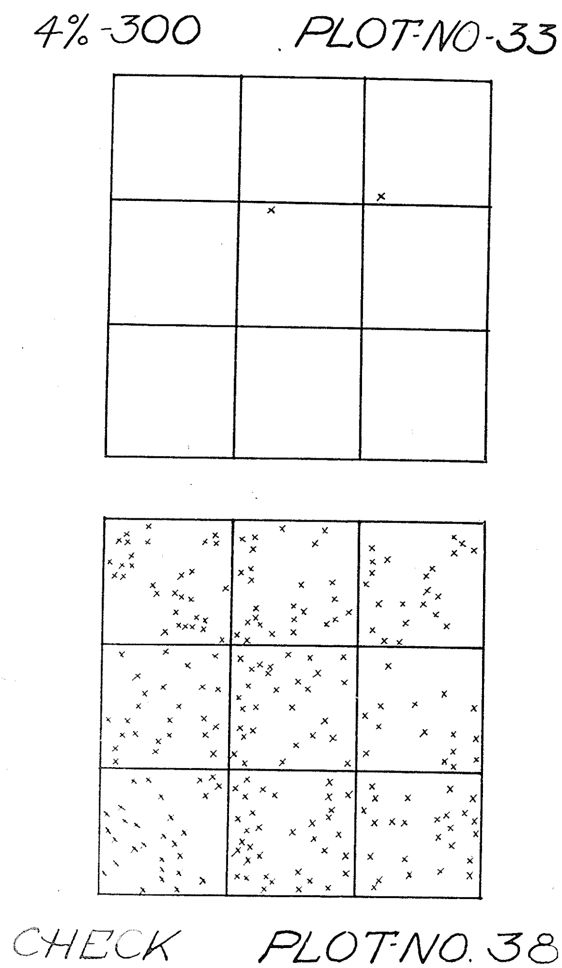
Infestation Count

I-0
2-I
3-0
4-I
5-I
6-0
7-2
8-0
9-0
Total-5

Infestation Count

I-II
2-9
3-I3
4-I6
5-I7
6-I9
7-22
8-II
9-I7
Total-I35

Figure 20.- Diagram showing the comparative infestation of treated and untreated plots- Treatment-4% Copper Nitrate, applied at the rate of 200 Gallons per acre.



Infestation Count

I-0
2-0
3-I
4-0
5-I
6-0
7-0
8-0
9-0
Total-2

Infestation Count

I-3I
2-26
3-22
4-25
5-29
6-I5
7-29
8-35
9-25
Total-237

Figure 21.- Diagram showing the comparative infestation of treated and untreated plots-, Treatment-4% Copper Nitrate, applied at the rate of 300 Gallons per acre.

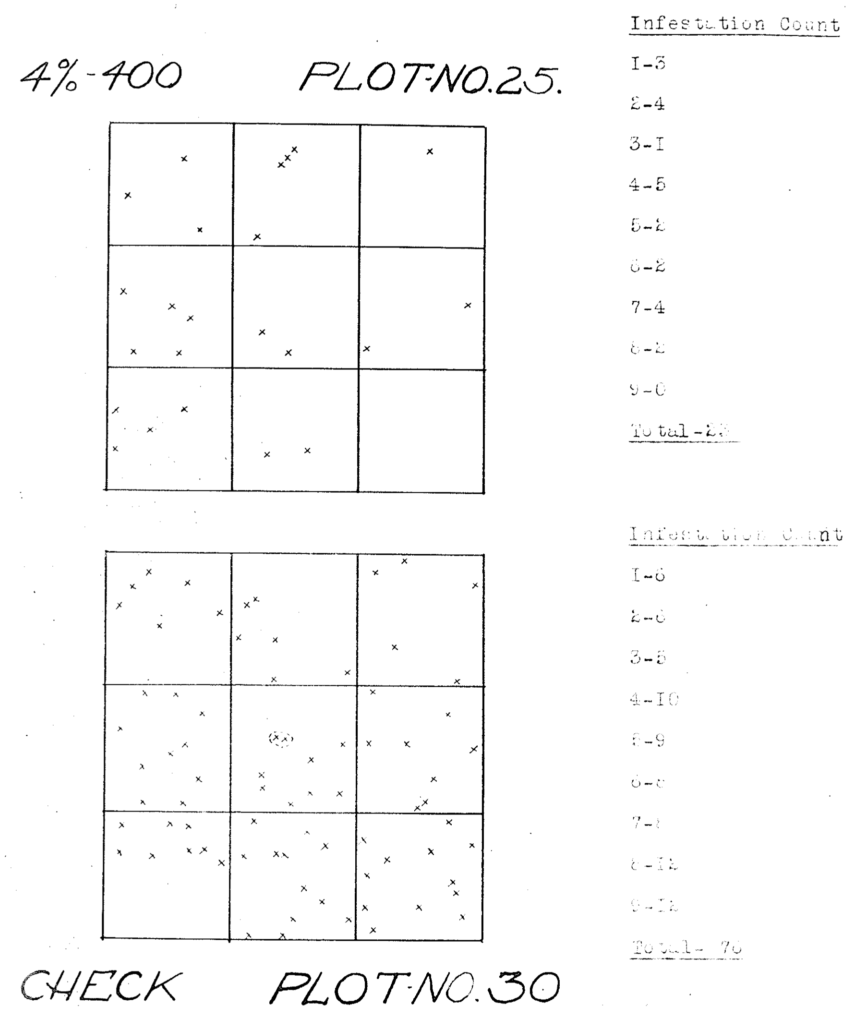
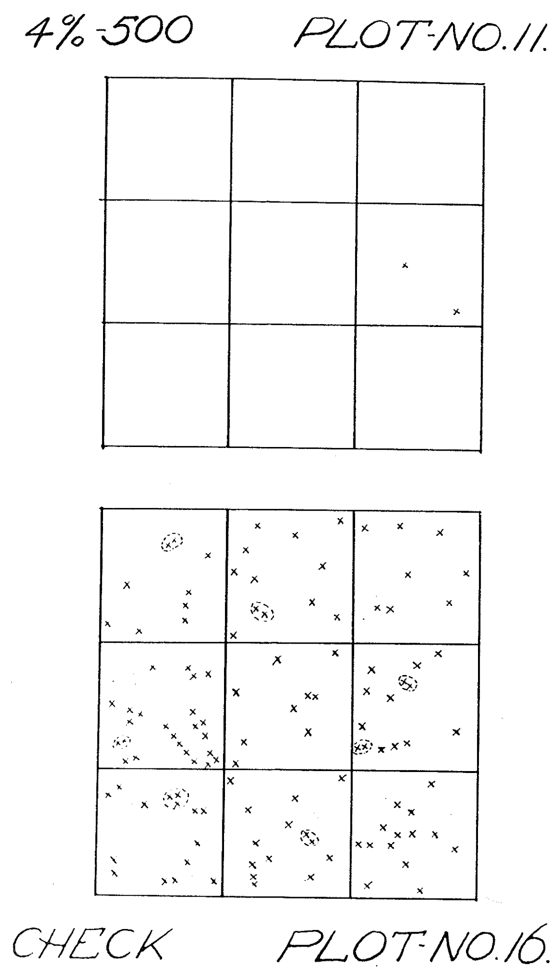


Figure 22.- Diagram showing the comparative infestation of treated and untreated plots- Treatment-4% Copper Nitrate applied at the rate of 400 Gallons per acre.



Infestation Count

I-0

2-0

3-0

4-0

5-0

6-2

7-0

8-0

9-0

Total-2

Infestation Count

I-9

2-II

3-8

4-I4

5-9

6-I4

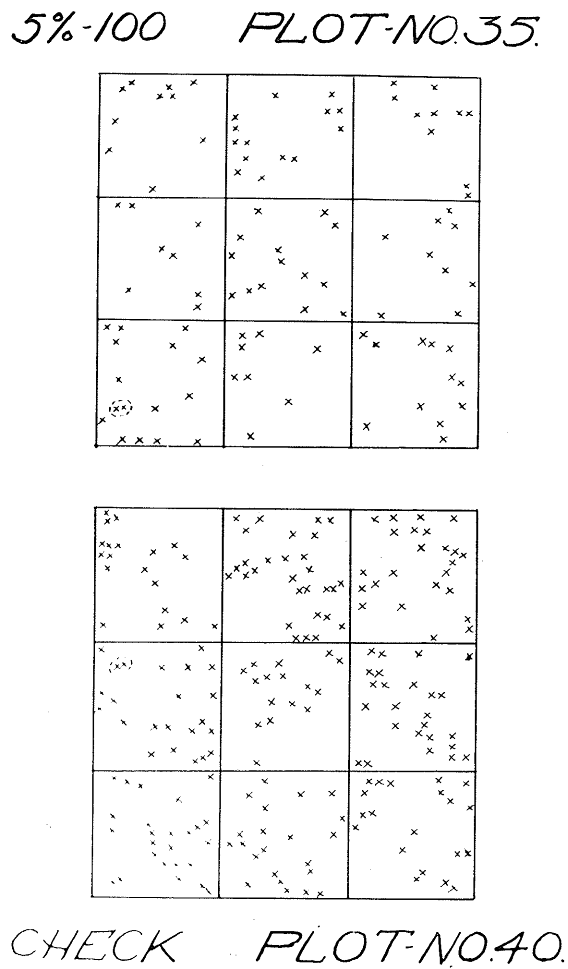
7-I5

8-I4

9-I4

Total-II9

Figure 23.- Diagram showing the comparative infestation of treated and untreated plots- Treatment-4% Copper Nitrate, applied at the rate of 500 Gallons per acre.



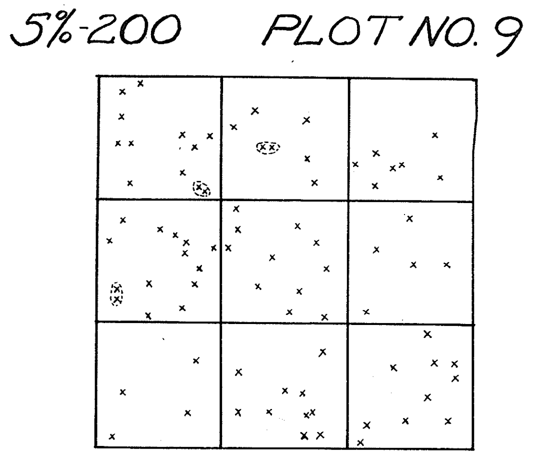
Infestation Count

1-10
2-14
3-10
4-8
5-14
6-9
7-16
8-8
9-12
Total- 101

Infestation Count

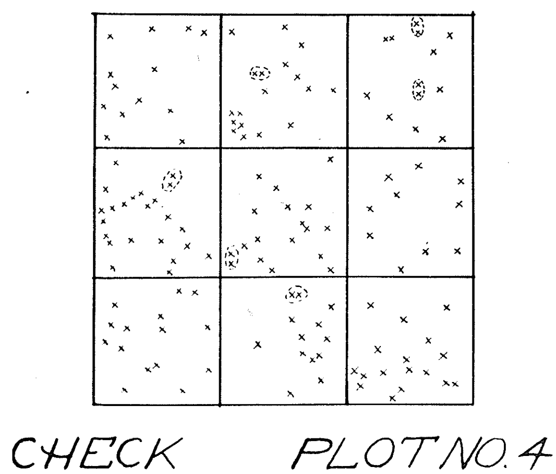
1-19
2-29
3-24
4-23
5-16
6-26
7-26
8-22
9-20
Total-205

Figure 24.- Diagram showing the comparative infestation of treated and untreated plots- Treatment-5% Copper Nitrate, applied at the rate of 100 Gallons per acre.



Infestation Count

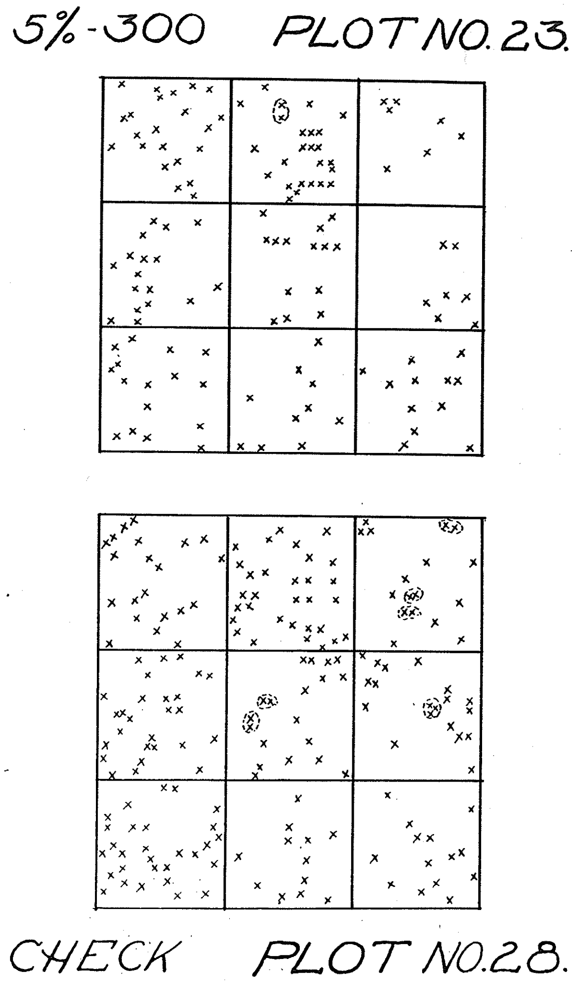
1-12
2-7
3-7
4-14
5-11
6-5
7-4
8-10
9-10
Total-80



Infestation Count

1-13
2-16
3-13
4-23
5-18
6-10
7-15
8-13
9-17
Total-14[illegible]

Figure 25.- Diagram showing the comparative infestation of treated and untreated plots- Treatment-5% Copper Nitrate, applied at the rate of 200 Gallons per acre.



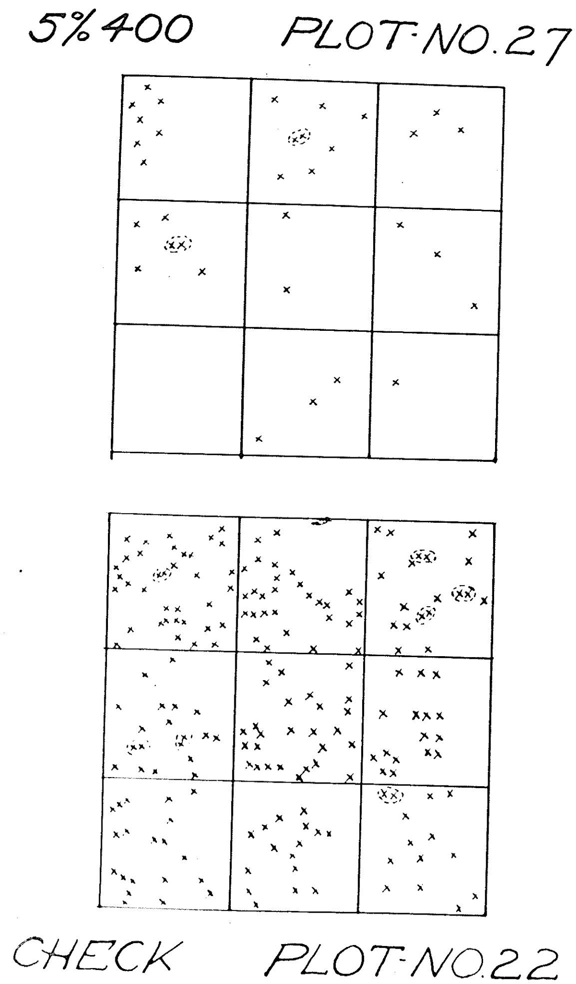
Infestation Count

I-22
2-25
3-7
4-I7
5-I4
6-7
7-I6
8-I0
9-I2
Total-I30

Infestation Count

I-2I
2-3I
3-I7
4-27
5-I9
6-I9
7-29
8-I2
9-I4
Total-I89

Figure 26.- Diagram showing the comparative infestation of treated and untreated plots- Treatment-5% Copper Nitrate, applied at the rate of 300 Gallons per acre.



Infestation Count

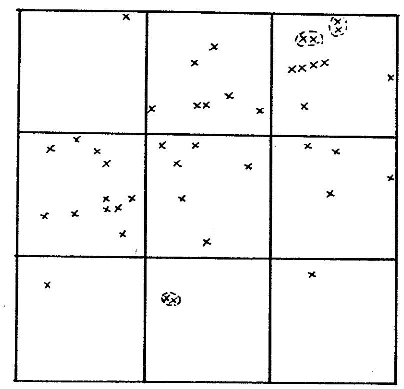
I-7
2-8
3-3
4-6
5-2
6-3
7-0
8-3
9-I
Total-33

Infestation Count

I-36
2-29
3-I9
4-I9
5-27
6-I6
7-20
8-I6
9-I4
Total-I96

Figure 27.- Diagram showing the comparative infestation of treated and untreated plots- Treatment-5% Copper Nitrate, applied at the rate of 400 Gallons per acre.

5%-500 PLOT NO. 43.



Infestation Counts

I-I

2-7

3-I0

4-II

5-6

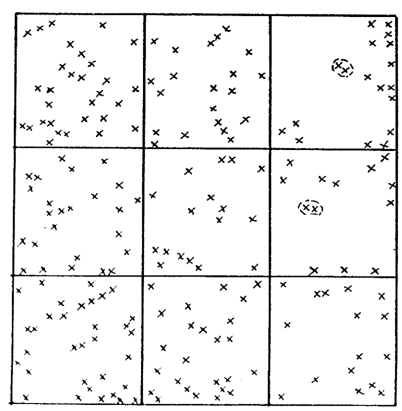
6-4

7-I

8-2

9-I

Total-43



Infestation Count

I-30

2-2I

3-I8

4-25

5-I7

6-I3

7-33

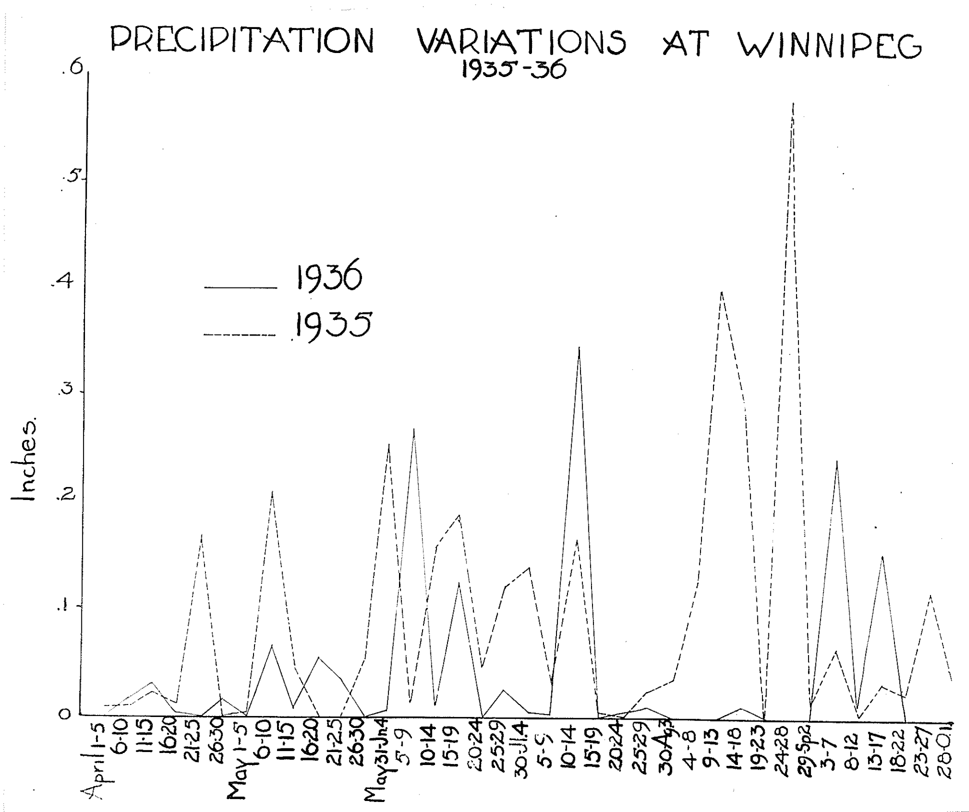
8-25

9-I6

Total-I98

CHECK PLOT NO. 48.

Figure 28.- Diagram showing the comparative infestation of treated and untreated plots-Treatment-5% Copper Nitrate, applied at the rate of 500 Gallons per acre.



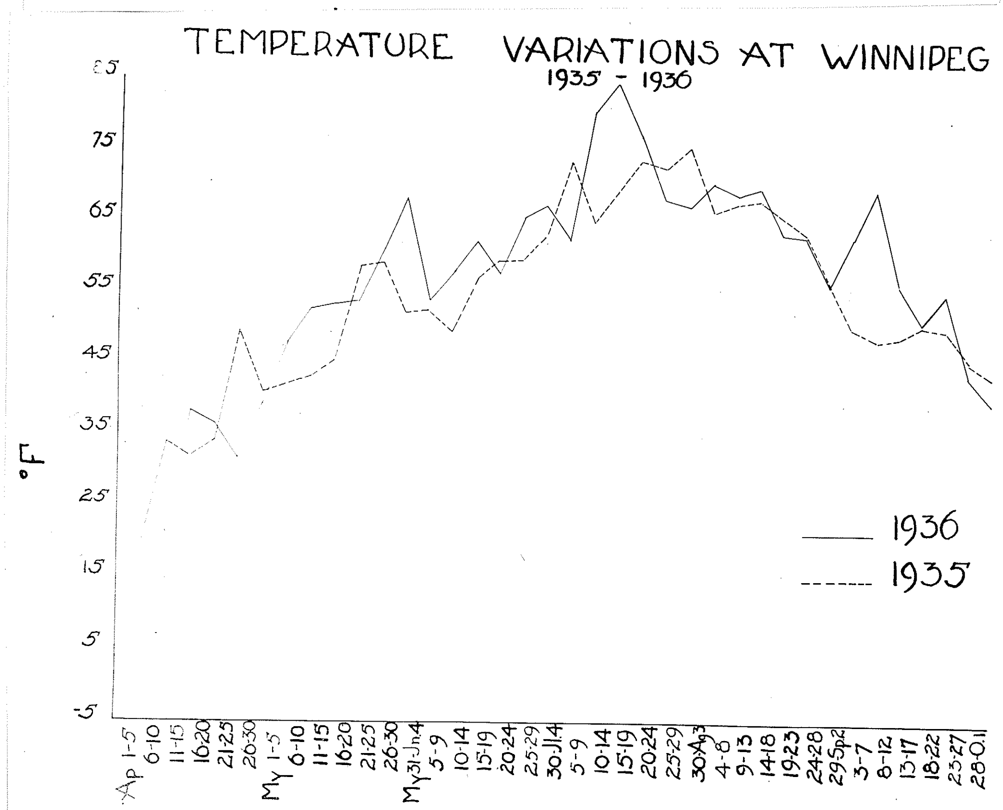


Figure 29.- Charts showing the Precipitation and Temperature variations at the University of Manitoba, for the growing seasons I935-6, at five day intervals.

Figure 30.- Photographs showing treated and untreated areas of the football field. Plots treated in 1935, pictures taken in 1936.

Ck.	4½% 500	Ck.	4½% 300	Ck.
3½% 200	Ck.	1½% 300	Ck.	¾% 100
Ck.	1½% 500	Ck.	2½% 500	Ck.
2½% 400	Ck.	2½% 300	Ck.	2½% 200
Ck.	¾% 300	Ck.	½% 100	Ck.
¾% 200	Ck.	4½% 200	Ck.	¾% 400
Ck.	1½% 200	Ck.	3½% 100	Ck.
4½% 400	Ck.	3½% 300	Ck.	3½% 400
Ck.	3½% 500	Ck.	¾% 500	Ck.
1½% 400	Ck.	2½% 100	Ck.	4½% 100

46	47	48	49	50
41	42	43	44	45
36	37	38	39	40
31	32	33	34	35
26	27	28	29	30
21	22	23	24	25
16	17	18	19	20
11	12	13	14	15
6	7	8	9	10
1	2	3	4	5

Figure 31.- Diagram of plots used in supplementary experiment in Dandelion eradication in 1935.

Figure 32.- Greenhouse Experiment- Showing the effect of a I% Copper Nitrate solution, on Dandelion plant.

Figure 33.- Greenhouse Experiment- Showing the effect of a 1% Copper Nitrate solution, on Dandelion plant.

Figure 34.- Greenhouse Experiment- Showing the effect of a 2% Copper Nitrate solution, on Dandelion plant.

Figure 35.- Greenhouse Experiment- Showing the effect of a 2% Copper Nitrate solution, on Dandelion plant.

Figure 36.- Greenhouse Experiment- Showing the effect of a 3% Copper Nitrate solution, on Dandelion plant.

Figure 37.- Greenhouse Experiment- Showing the effect of a 3% Copper Nitrate solution, on Dandelion plant.

Figure 38.- Greenhouse Experiment- Showing the effect of a 4% Copper Nitrate solution, on Dandelion plant.

Figure 39.- Greenhouse Experiment- Showing the effect of a 4% Copper Nitrate solution, on Dandelion plant.

Figure 40.- Greenhouse Experiment- Showing the effect of a 5% Copper Nitrate solution, on Dandelion plant.

Figure **41**.- Greenhouse Experiment- Showing the effect of a 5% Copper Nitrate solution, on Dandelion plant.

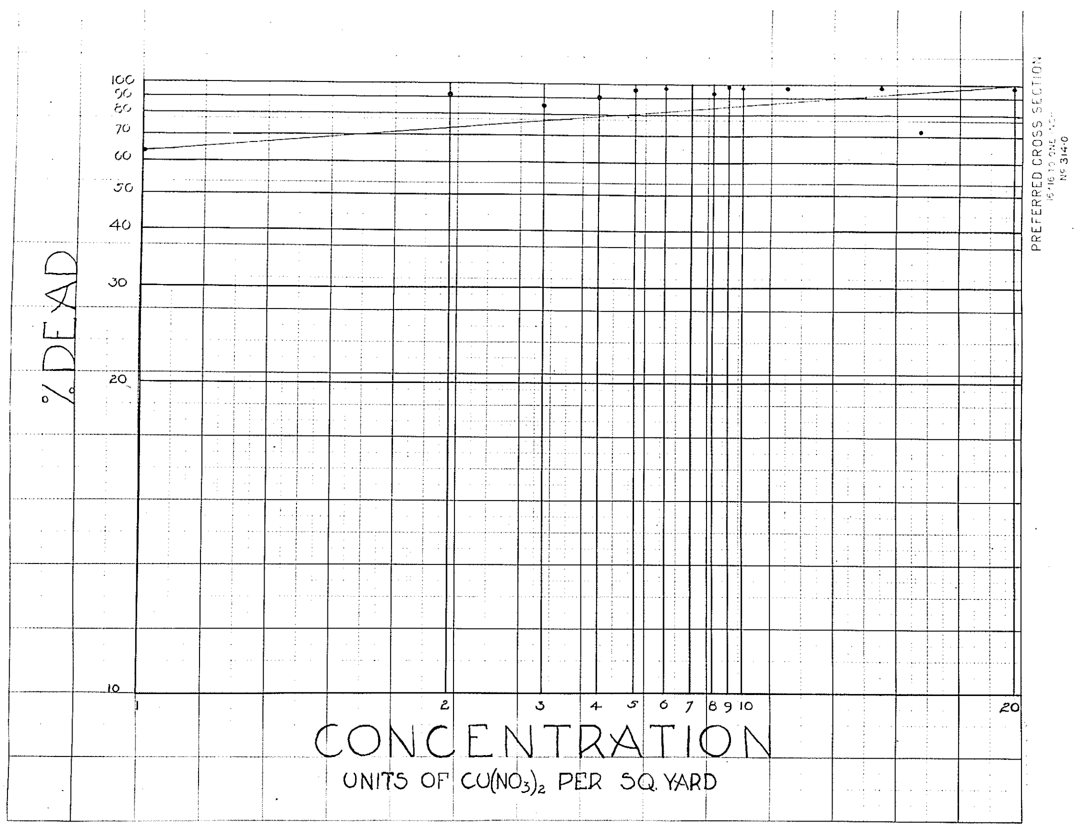


Figure 42.- Diagram showing the effect of concentration of Copper Nitrate on Toxicity, when used in the destruction of the Dandelion.

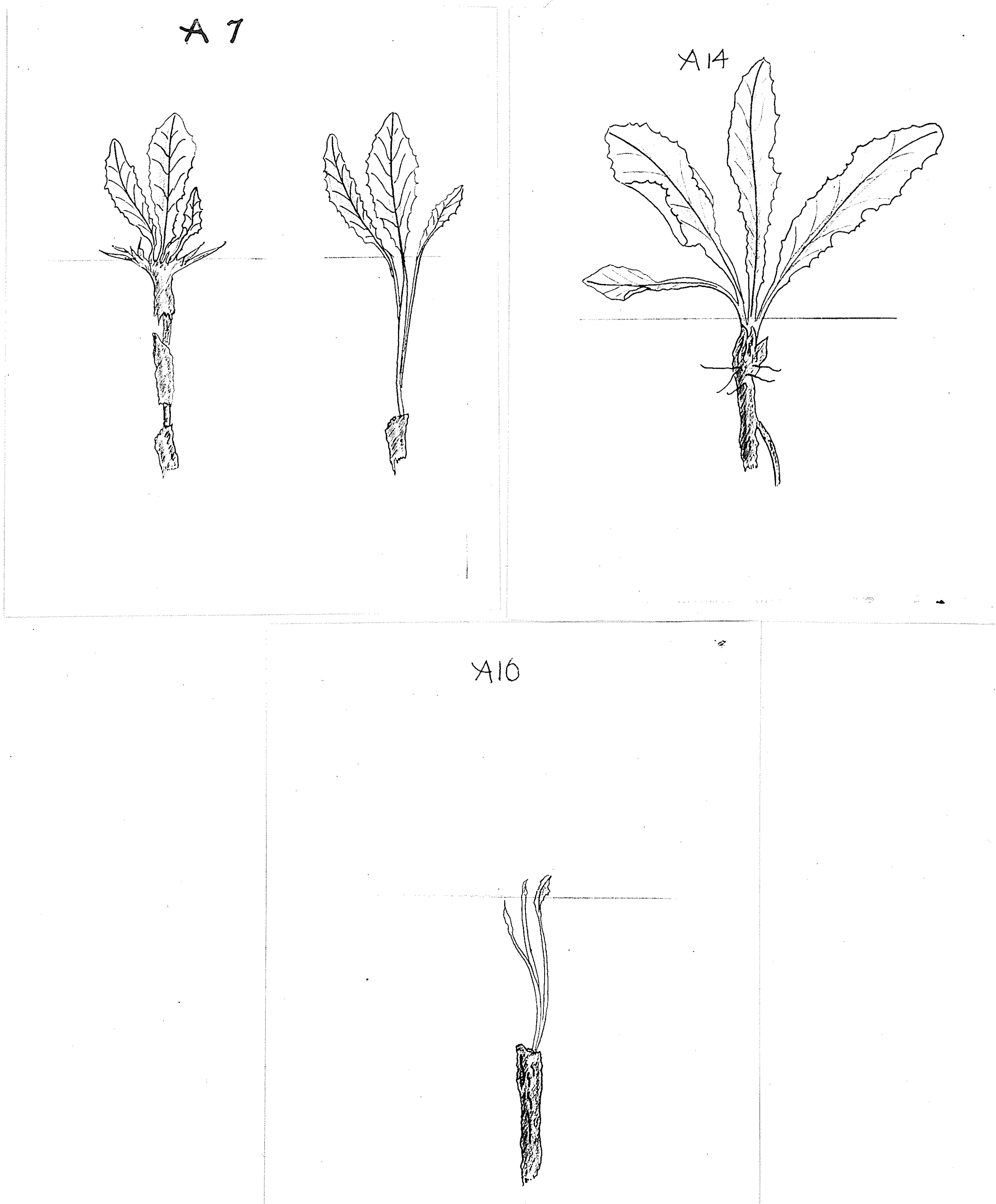


Figure 43.- Diagram of Dandelion plants treated with Gasolene on the rosette.

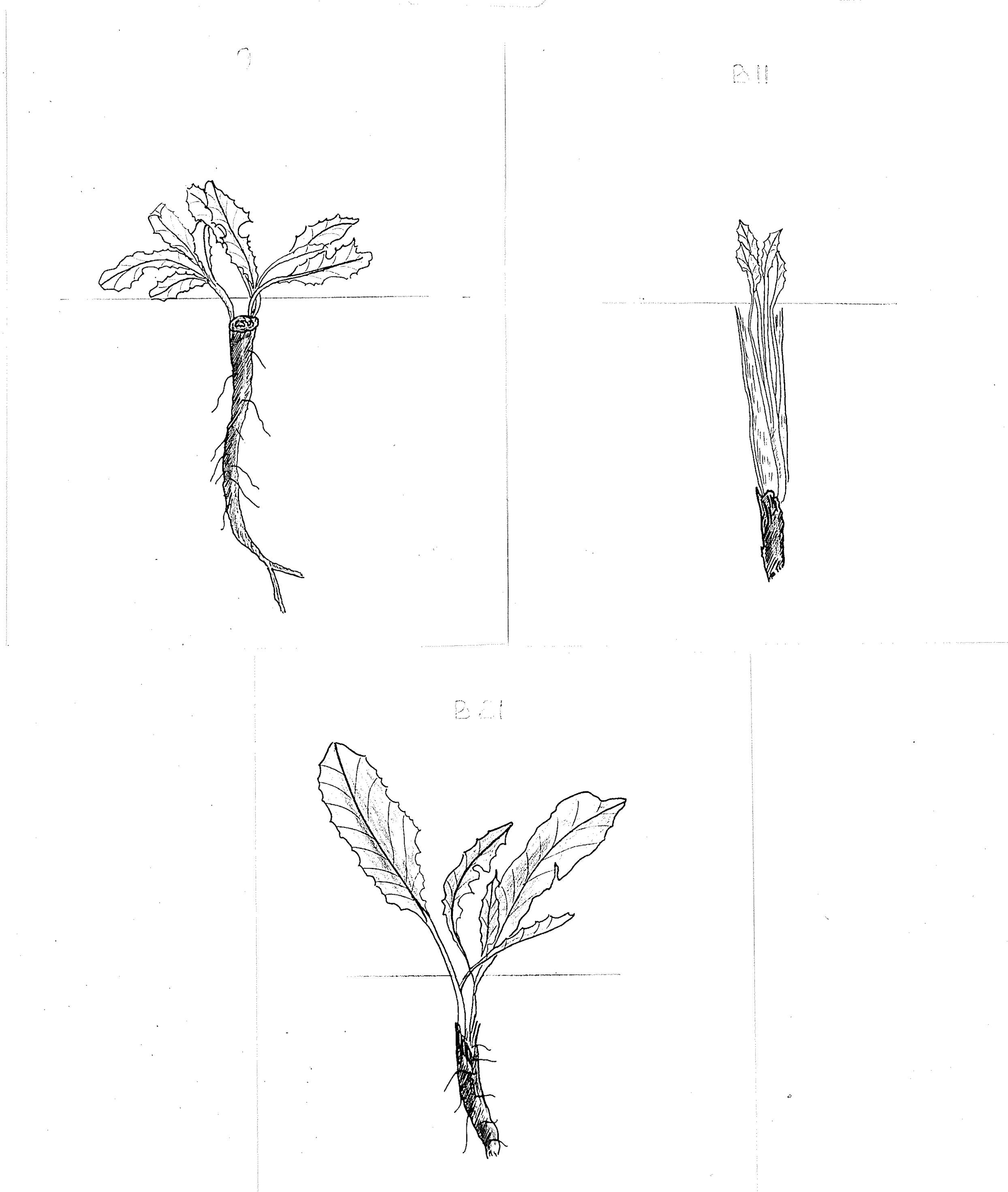


Figure 44.- Diagram of Dandelion plants treated with Gasolene on the crown.

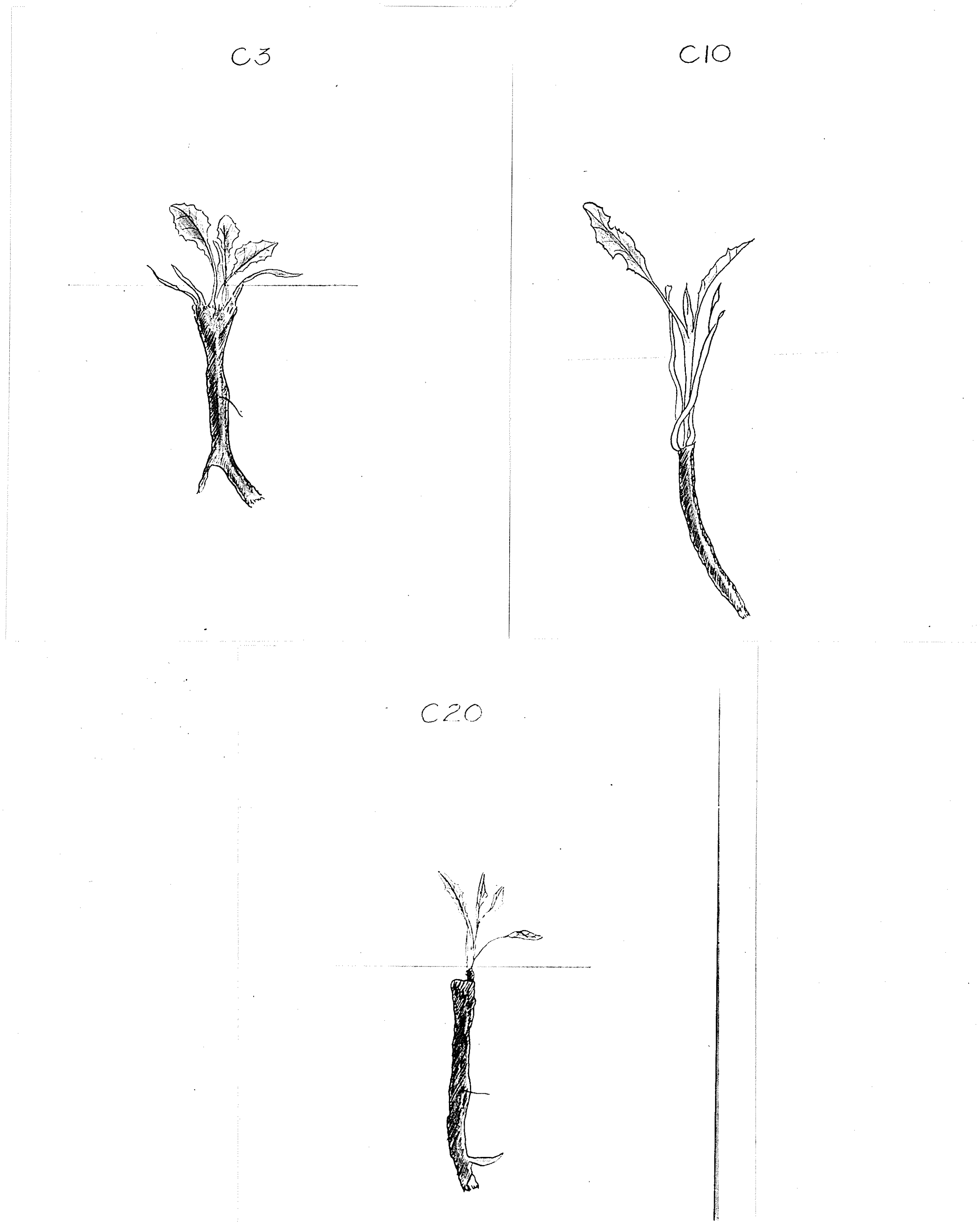


Figure 45.- Diagram of Dandelion plants treated with Fuel Oil on the rosette.

Figure 46.- Diagram of Dandelion plants treated with Fuel Oil on the crown.

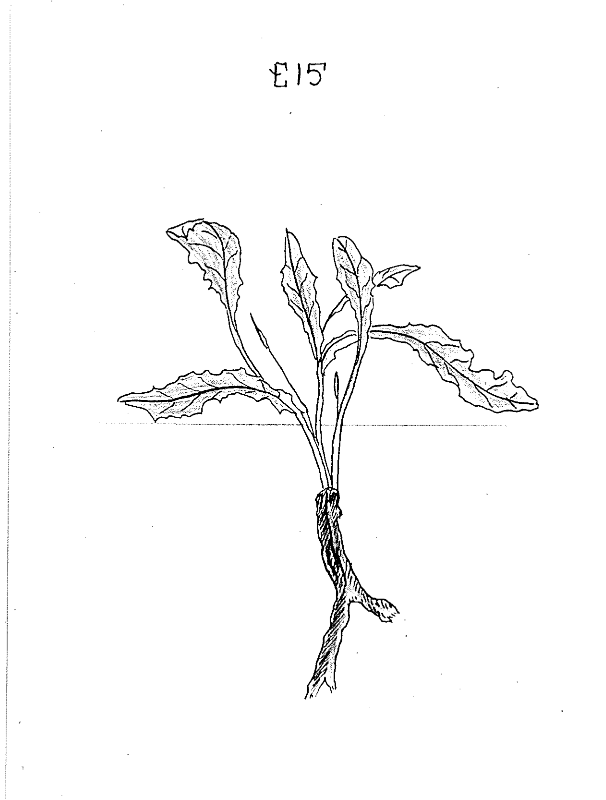


Figure 47.- Diagram of Dandelion plants treated with Solvent on the rosette.

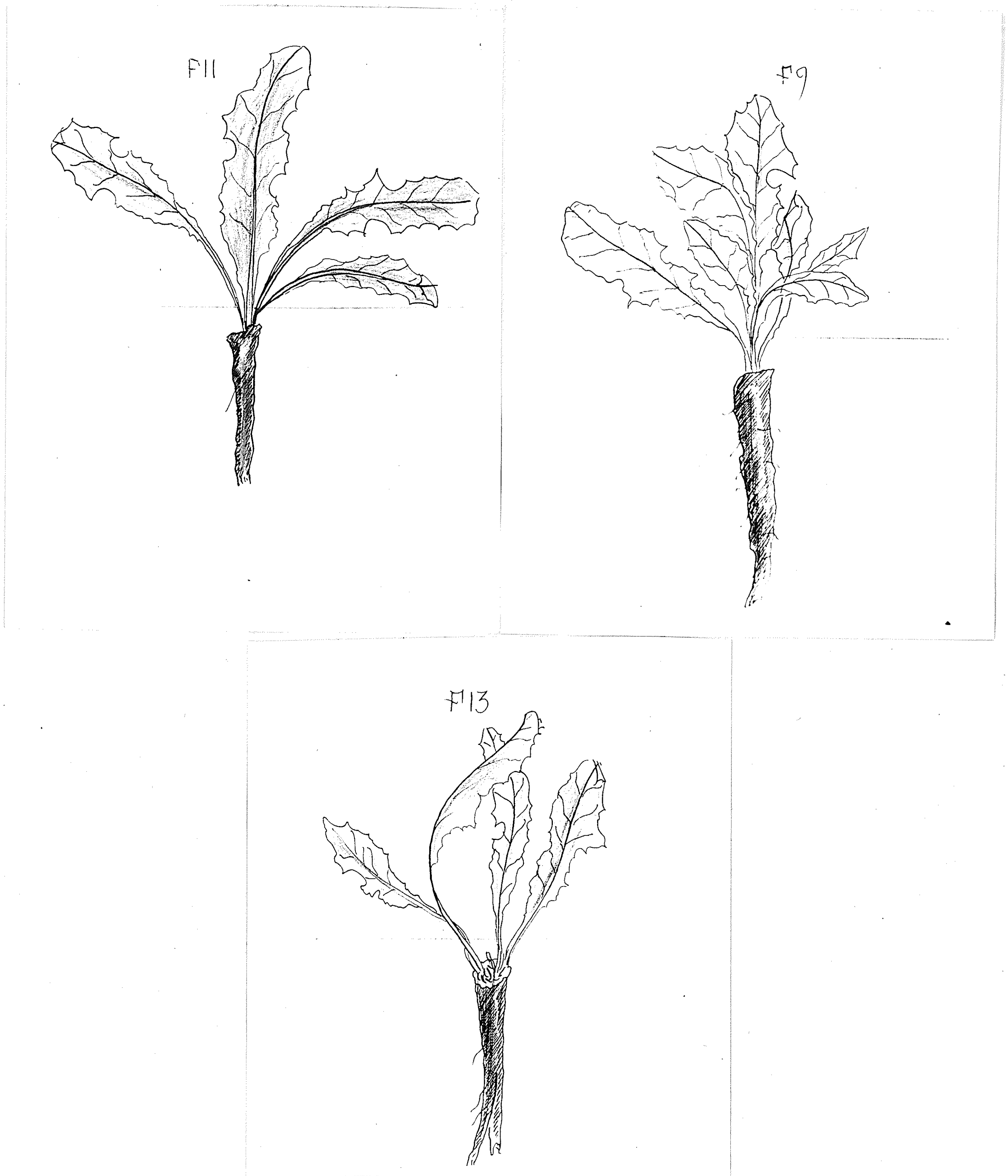


Figure 48.- Diagram of Dandelion plants treated with Solvent on the crown.

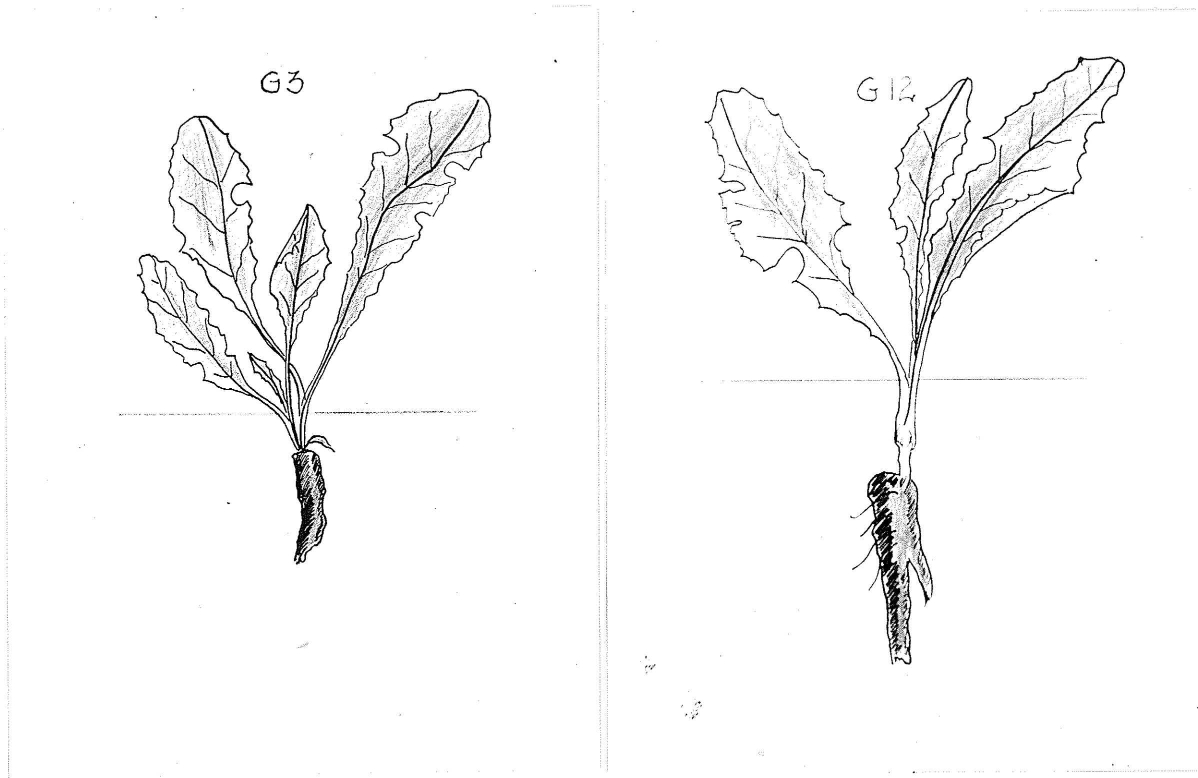


Figure 49.- Diagram of Dandelion plants receiving no chemical treatment- Plants cut off at the crown.

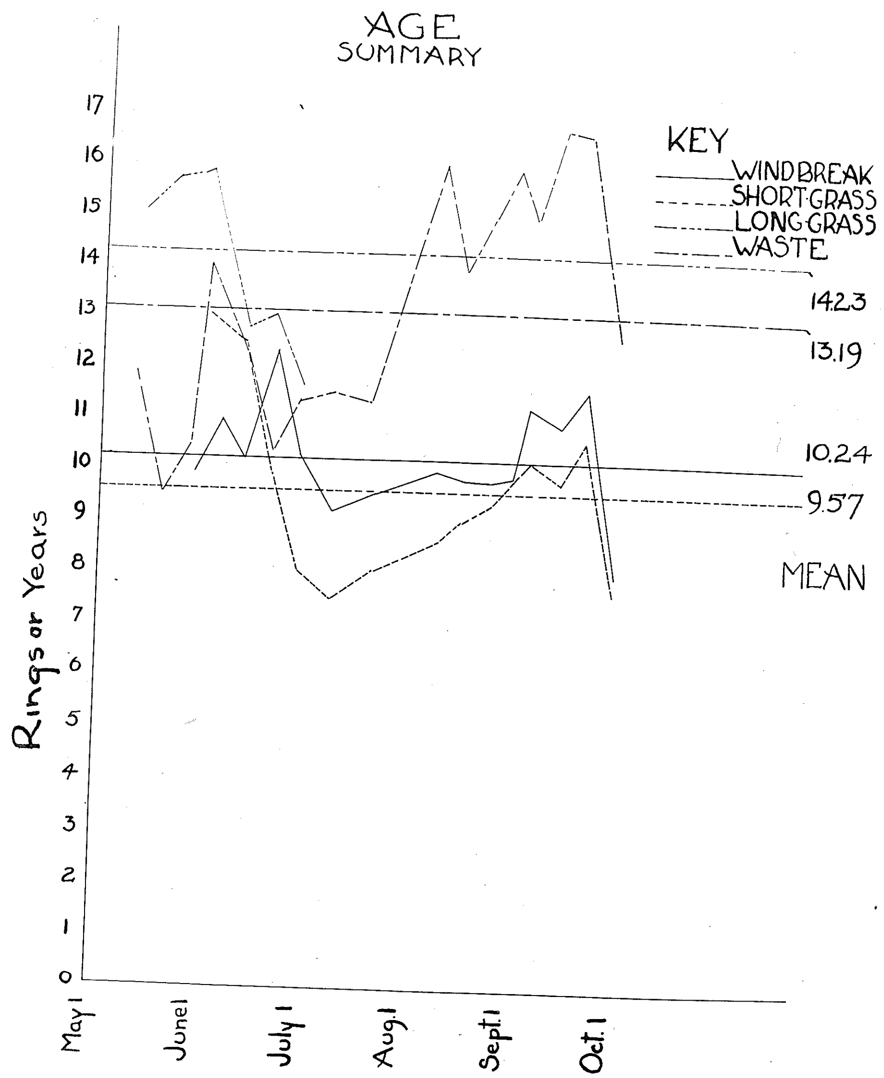


Figure 50.- Summary of variations in the Ages of Dandelion plants.

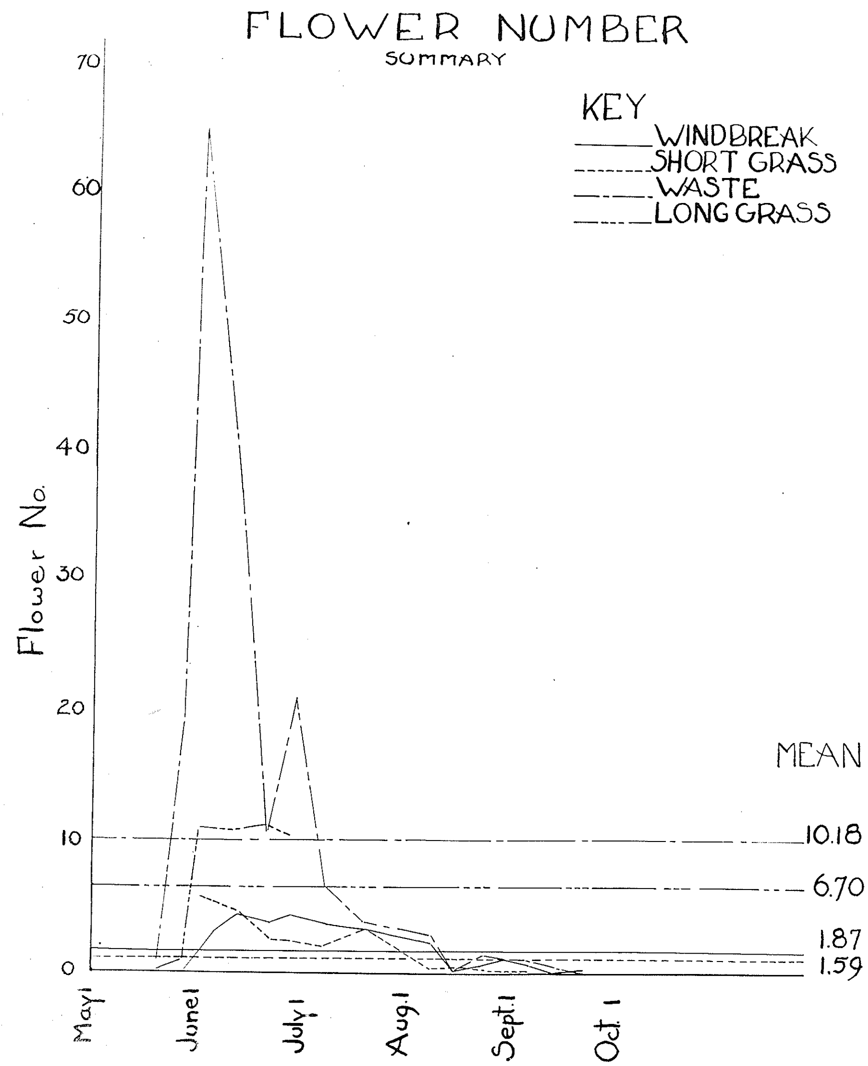


Figure 51.- Summary of variations in the Flower Number of Dandelion plants.

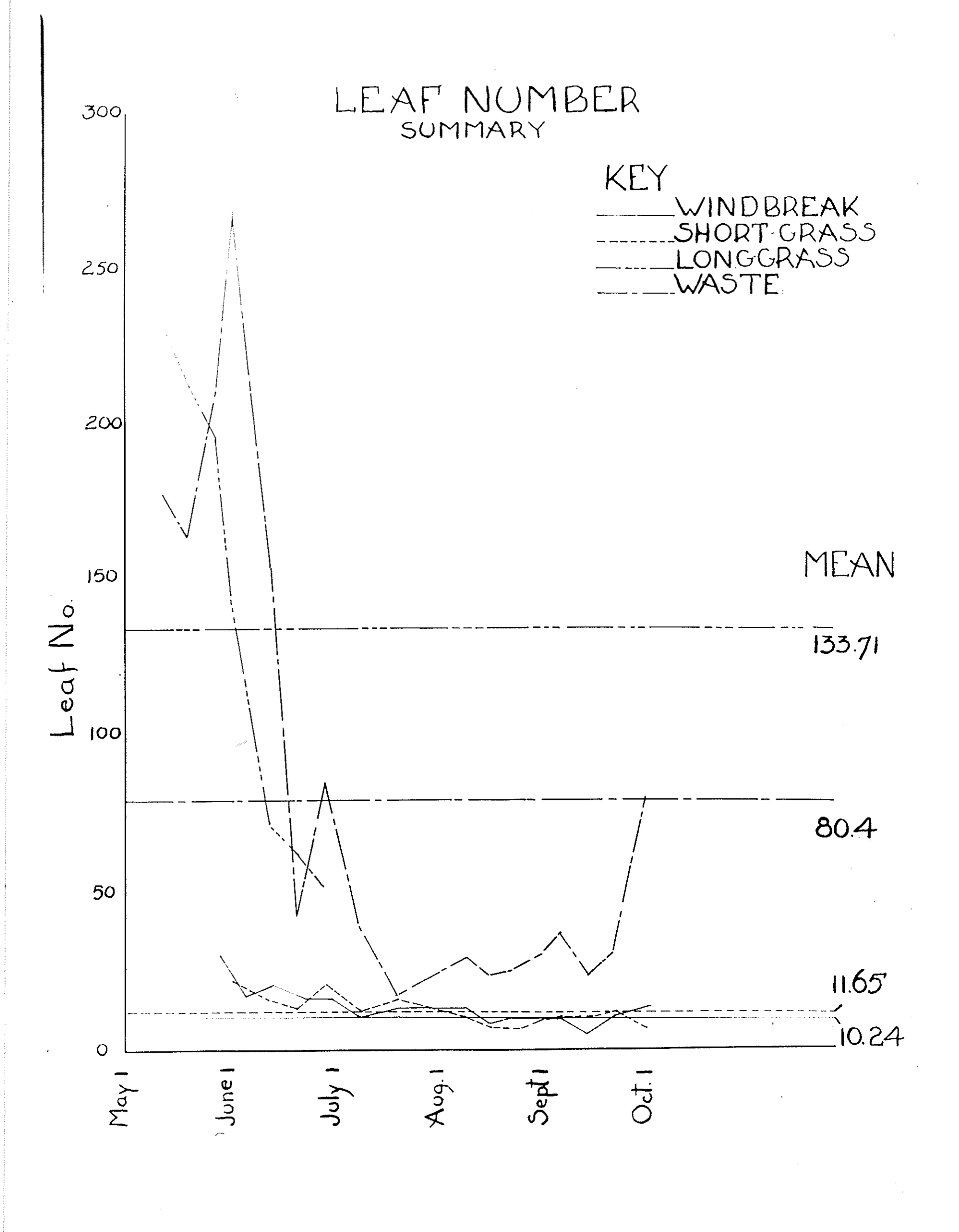


Figure 52.- Summary of variations in the Leaf Number of Dandelion plants.

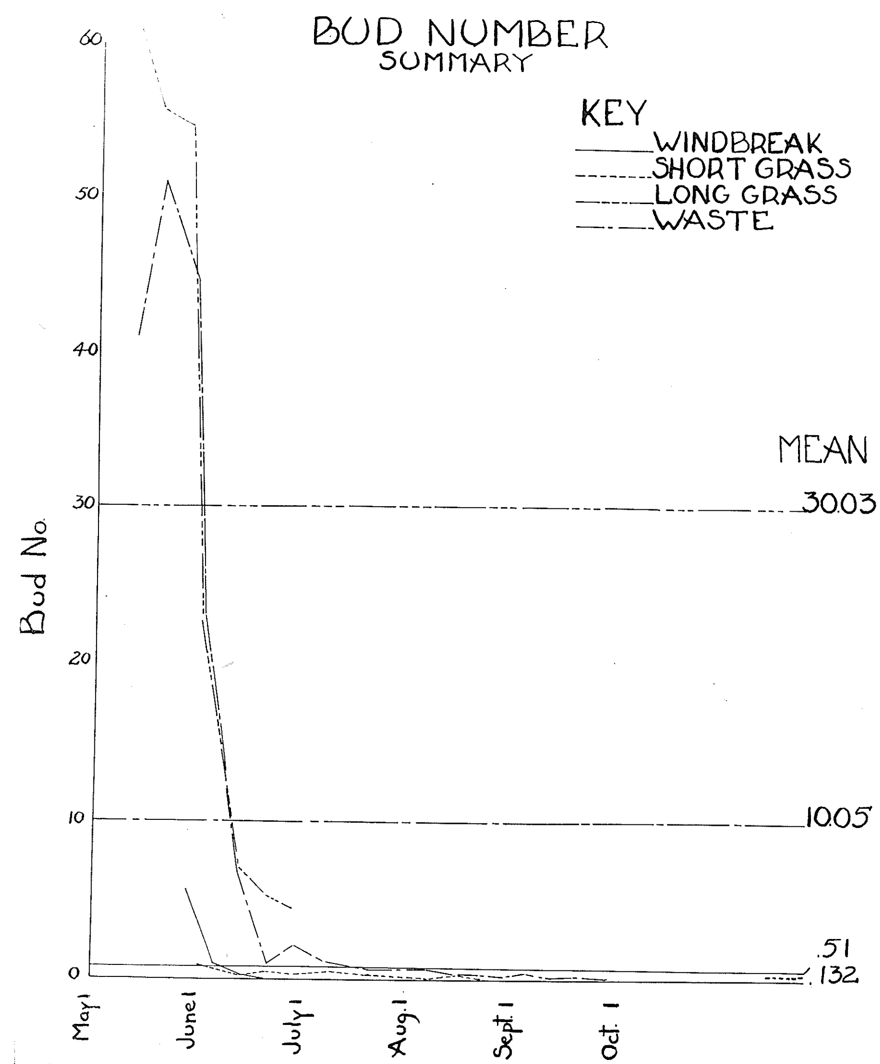


Figure 53.- Summary of variations in Bud Number of Dandelion plants.

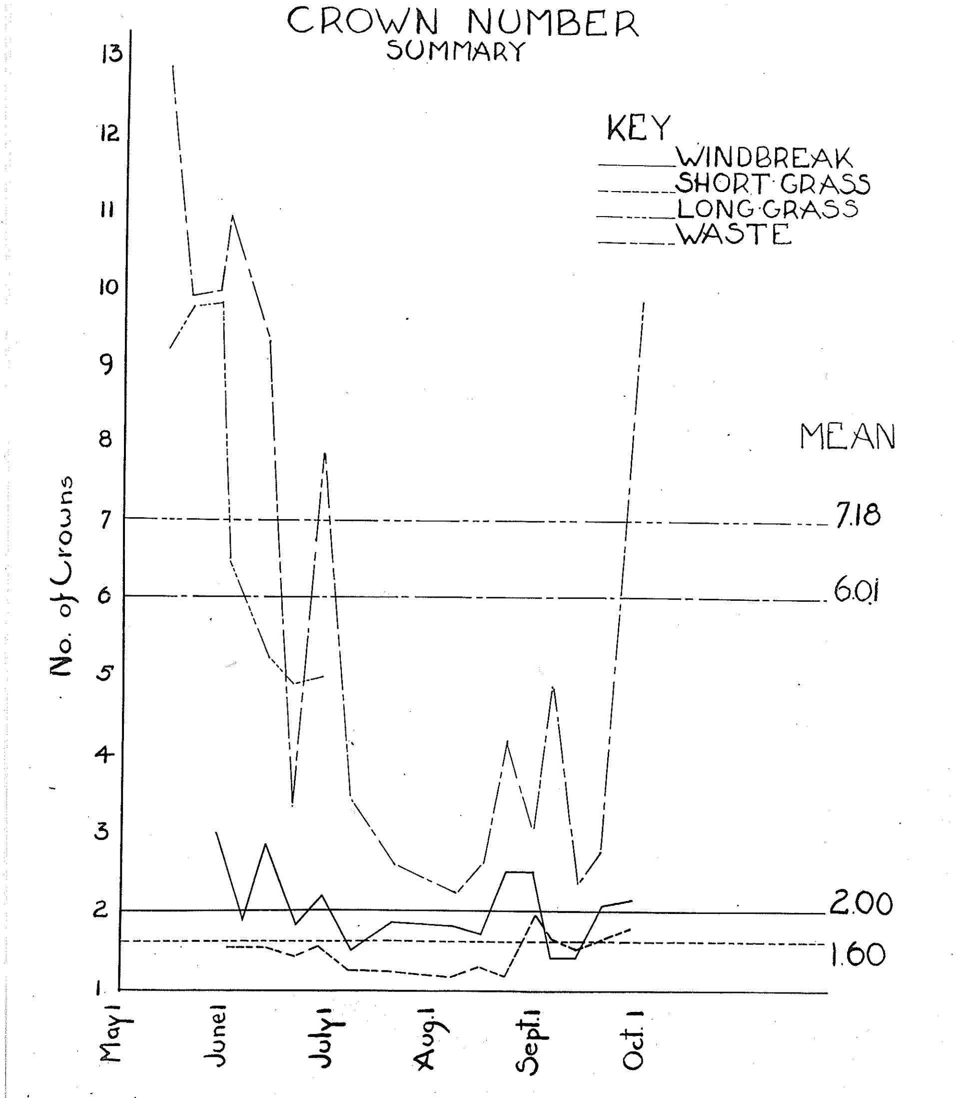


Figure 54.- Summary of variations in Crown Number of Dandelion plants.

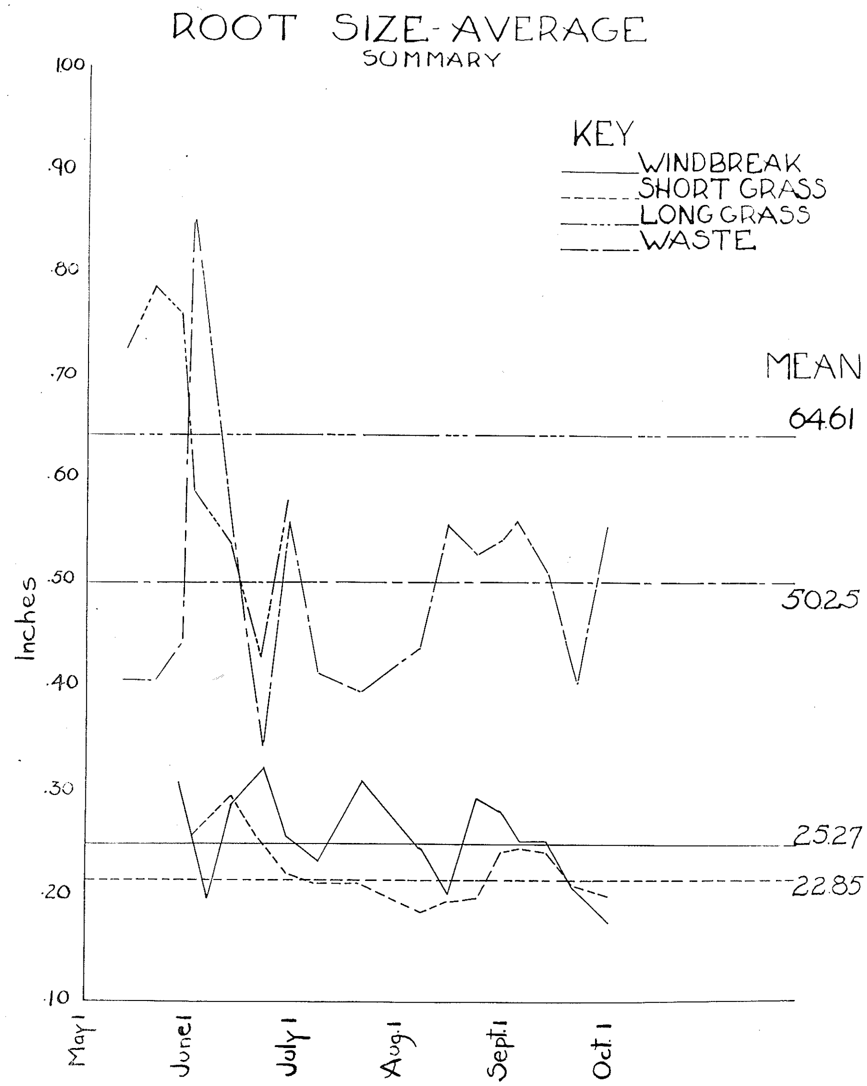


Figure 55.- Summary of variations in Average Root Size (Diameter) of Dandelion plants.

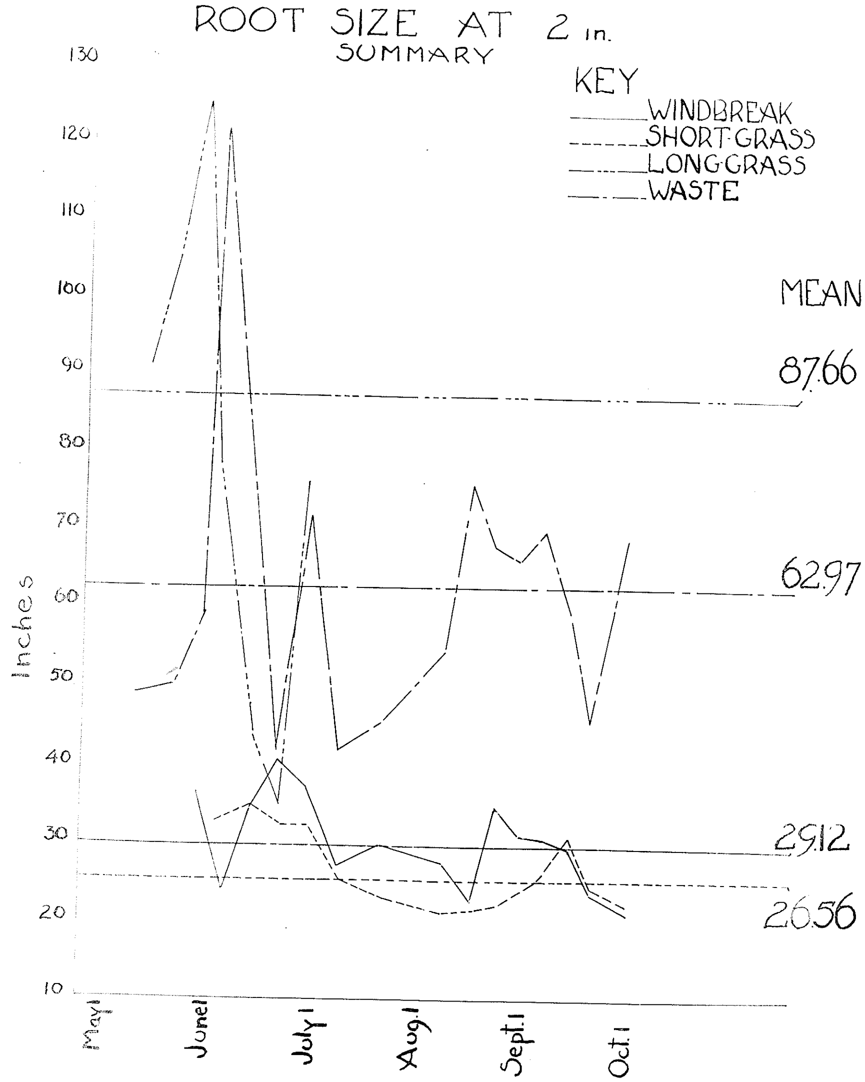


Figure 56.- Summary of variations in Root Size(Diameter at 2 inches below ground level) of Dandelion plants.

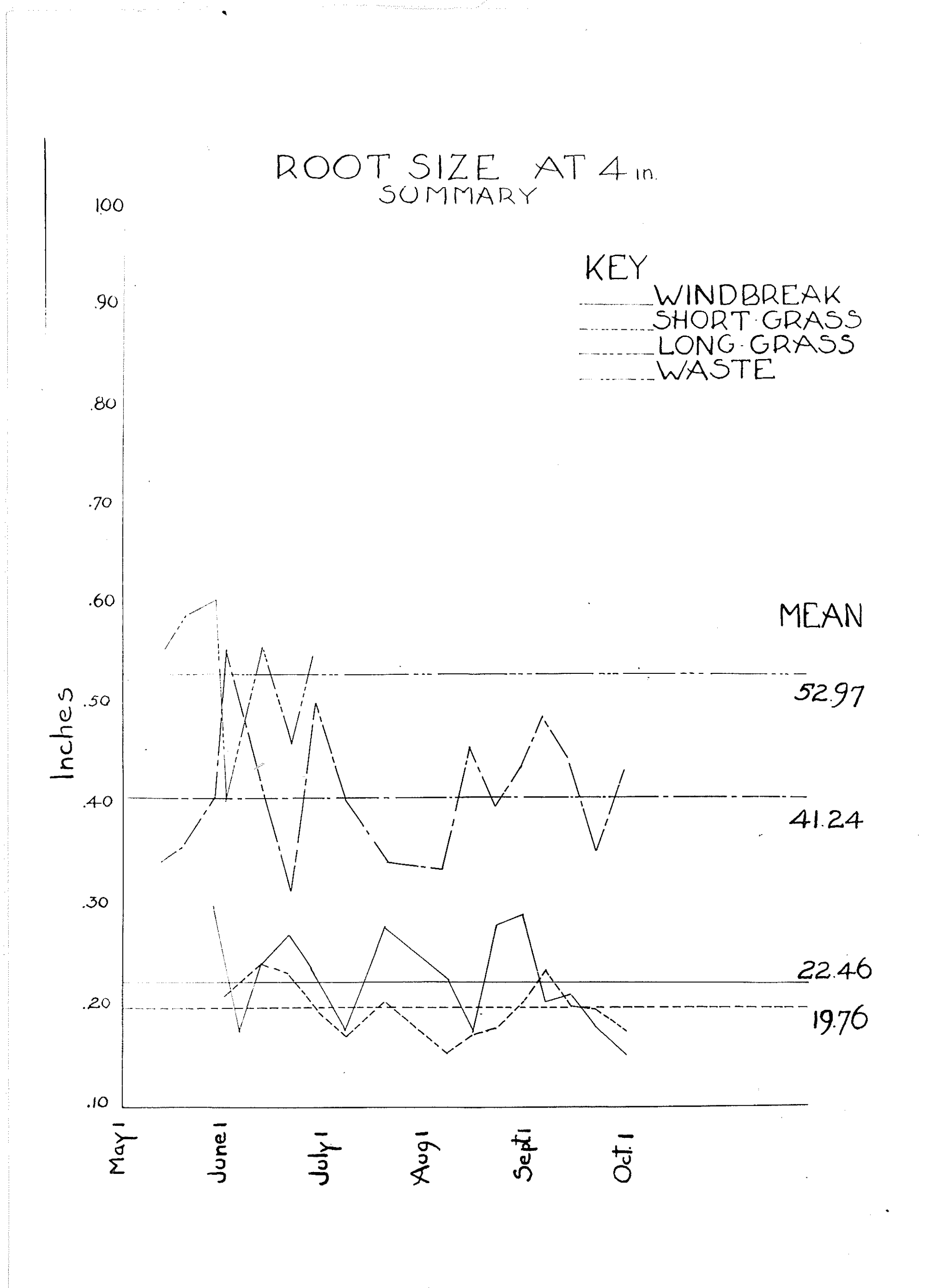


Figure 57.- Summary of variations in Root Size (Diameter at 4 inches below ground level) of Dandelion plants.

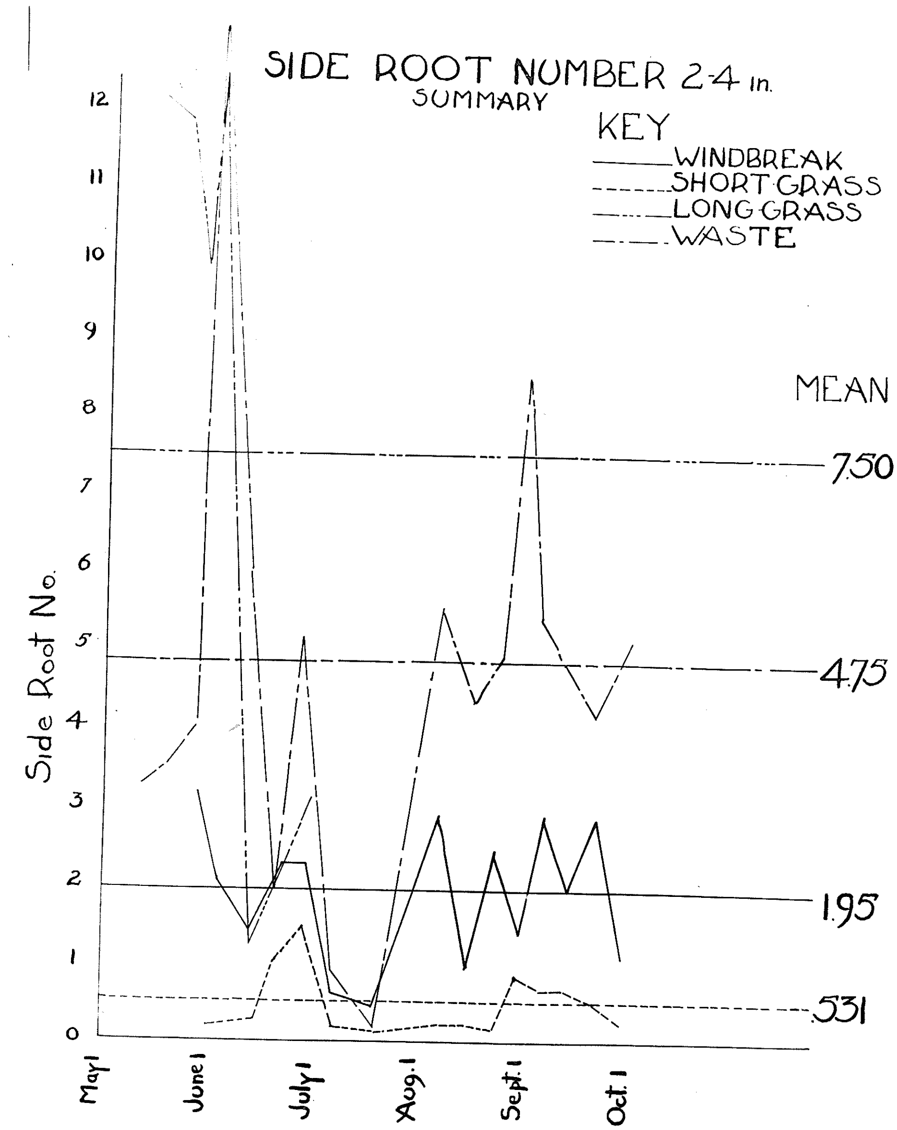


Figure 58.- Summary of variations in Side Root Number (2-4 inches below ground level) of Dandelion plants.

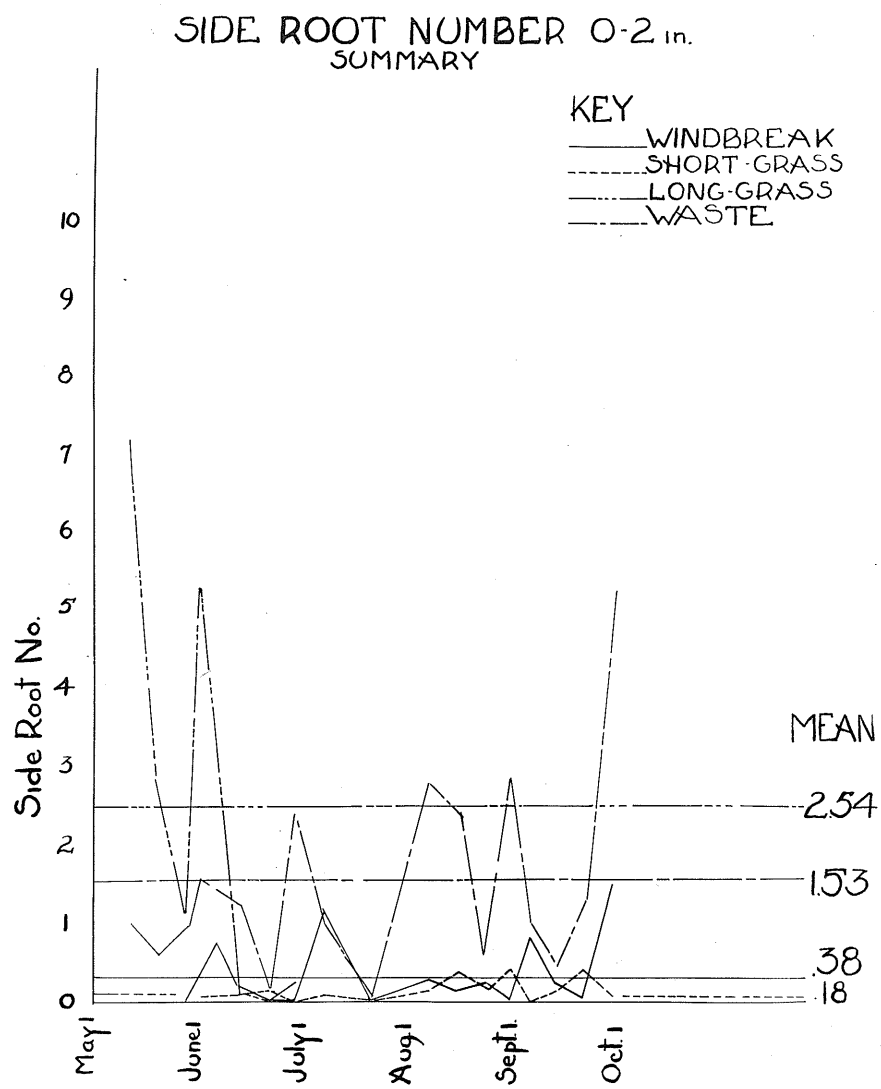


Figure 59.- Summary of variations in Side Root Number (0-2 inches below ground level) of Dandelion plants.

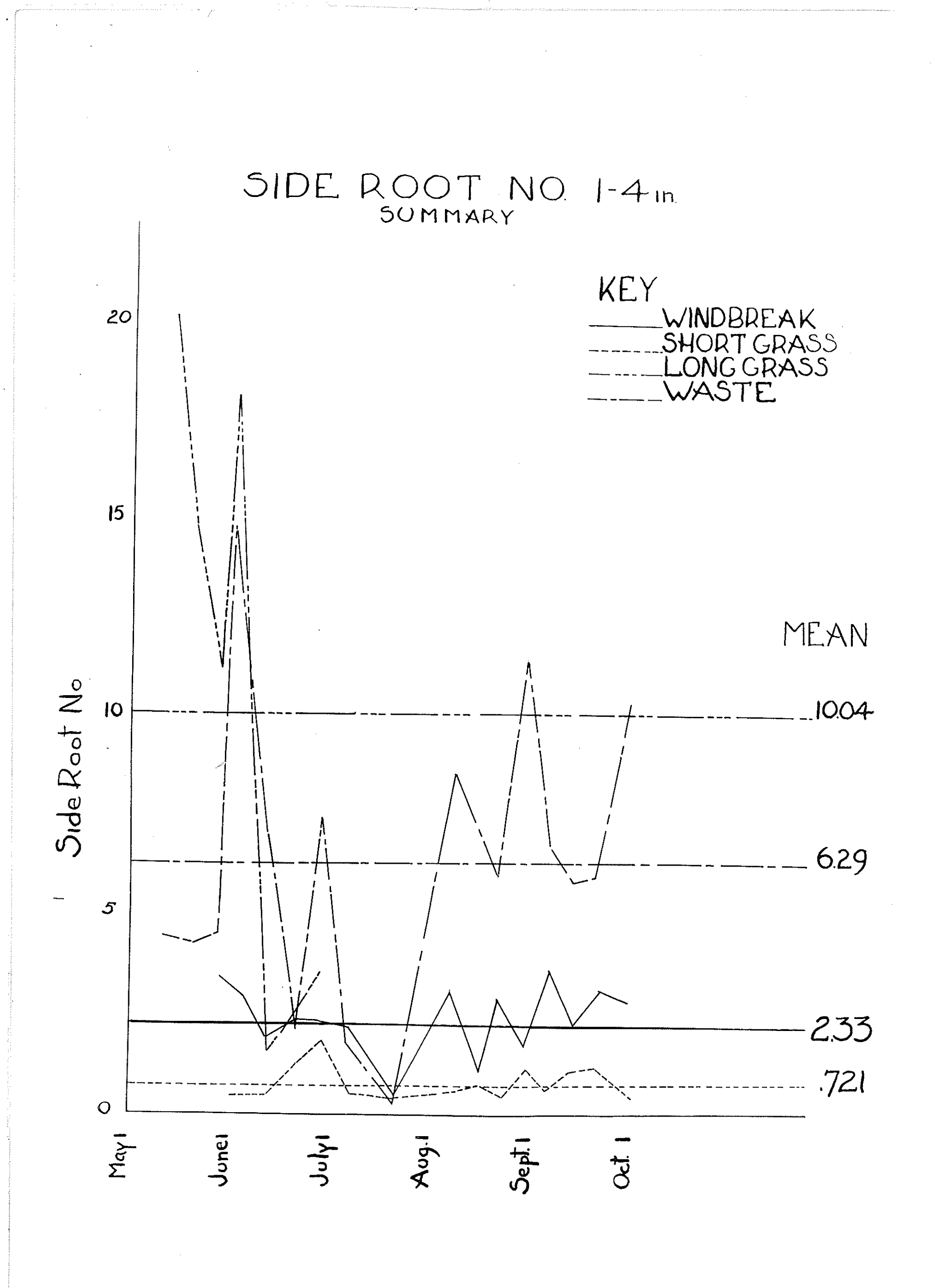


Figure 60.- Summary of variations in Side Root Number (0-4 inches below ground level) of Dandelion plants.

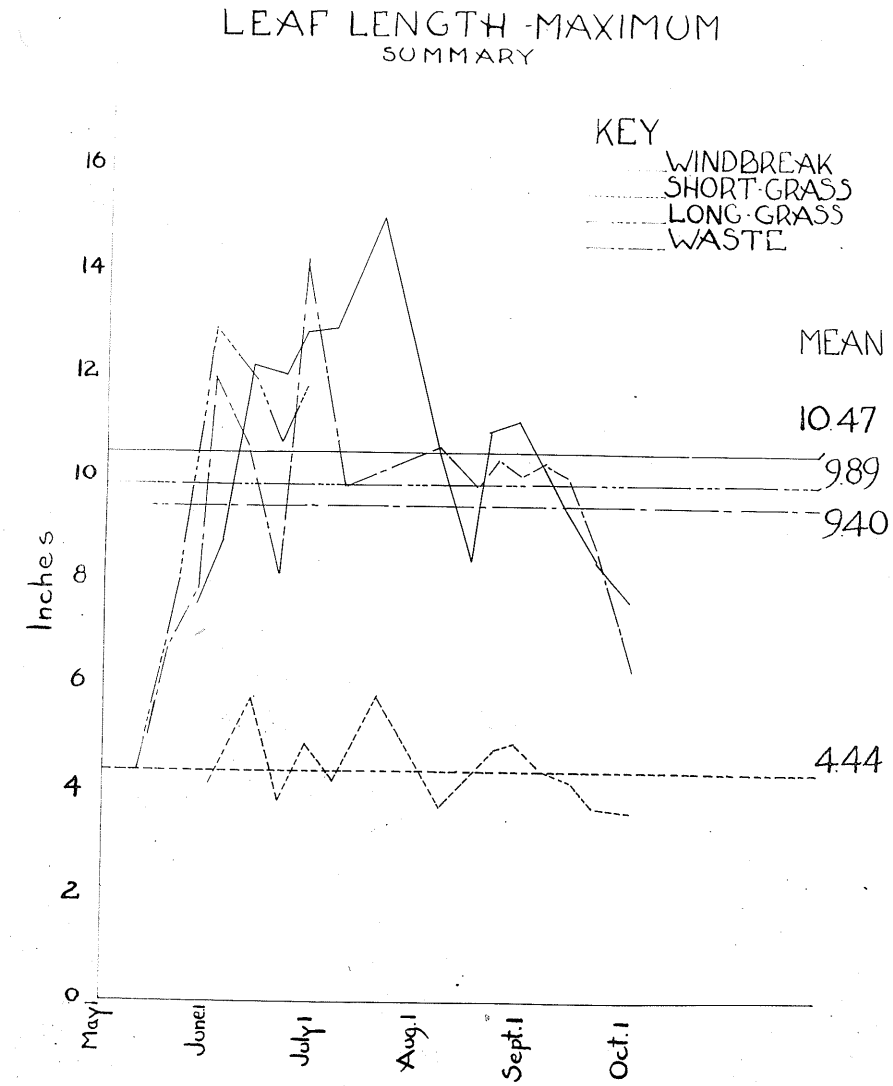


Figure 61.- Summary of variations of Maximum Leaf Length of Dandelion plants.

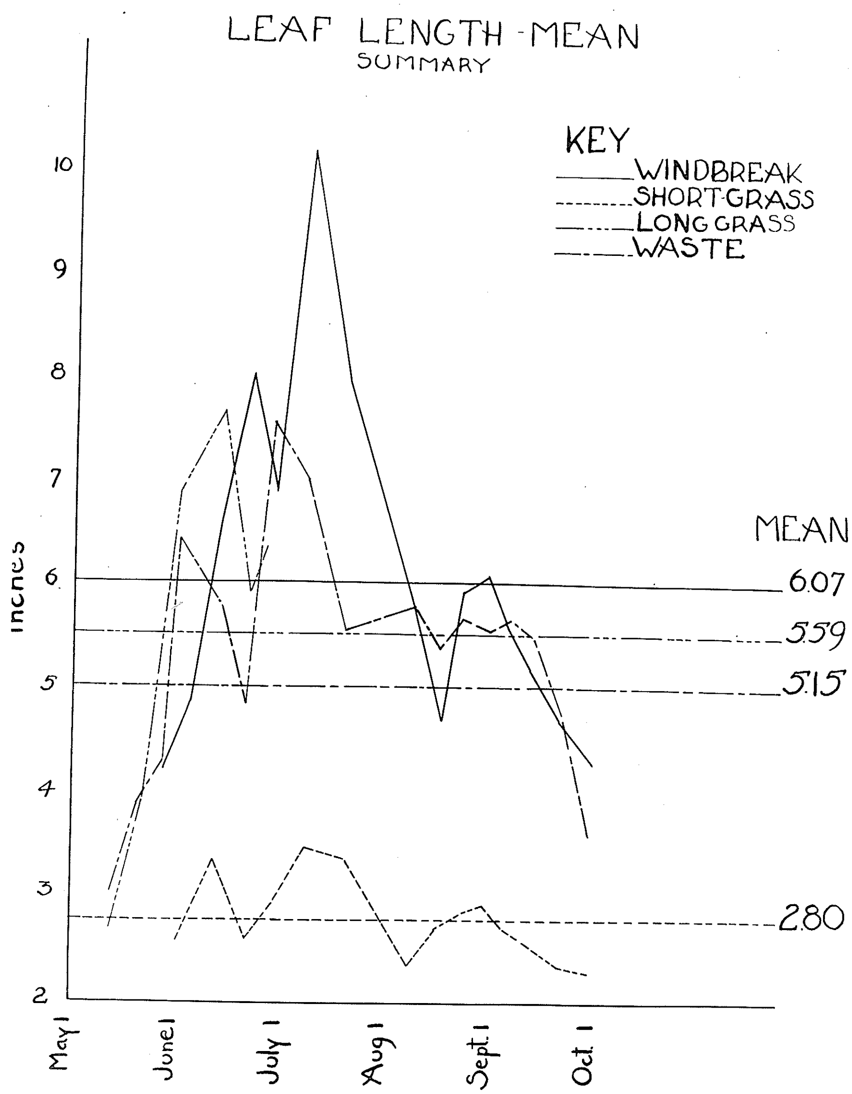


Figure 62.- Summary of variations in Mean Leaf Length of Dandelion plants.

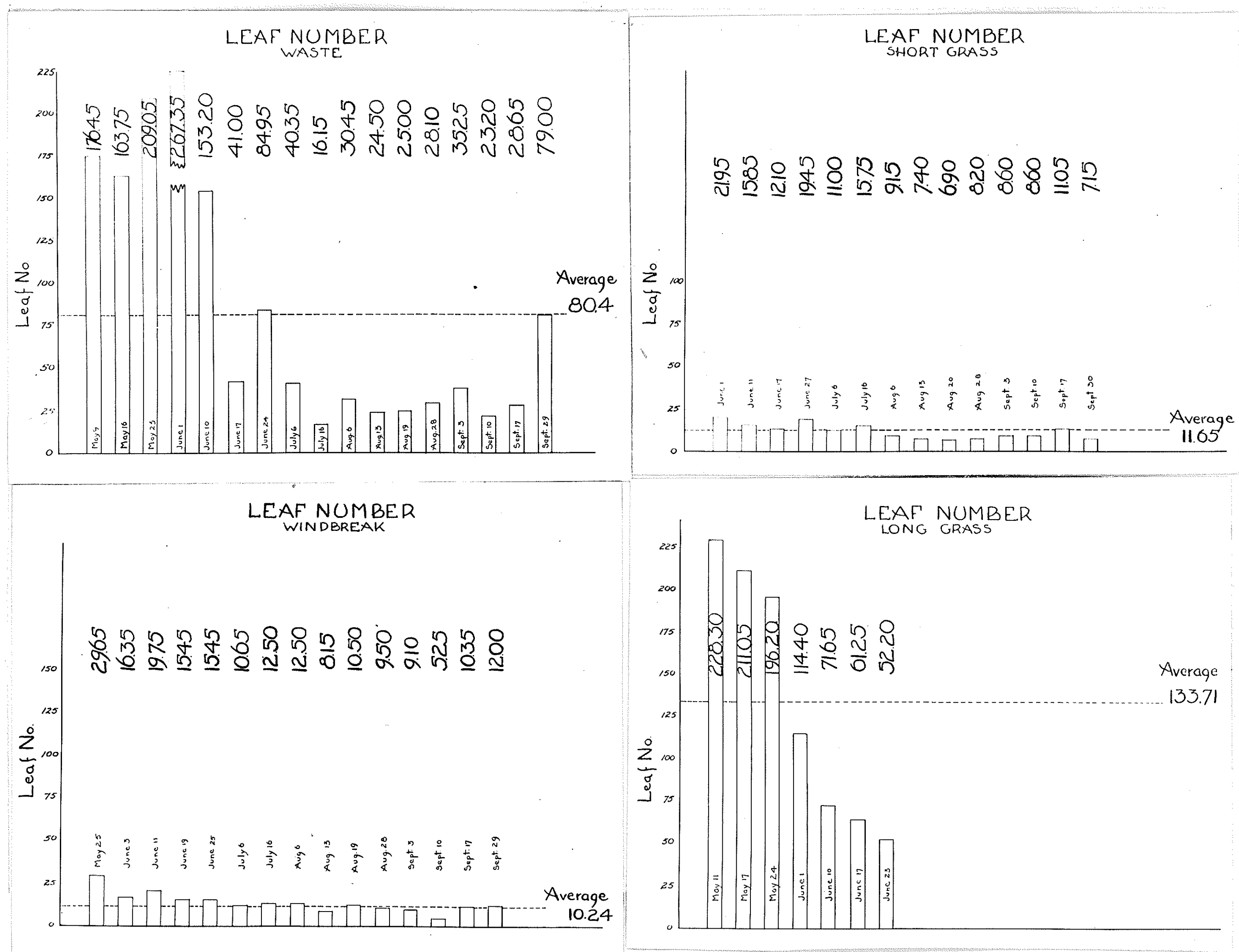


Figure 63.- Weekly variations in the Leaf Number of Dandelion plants.

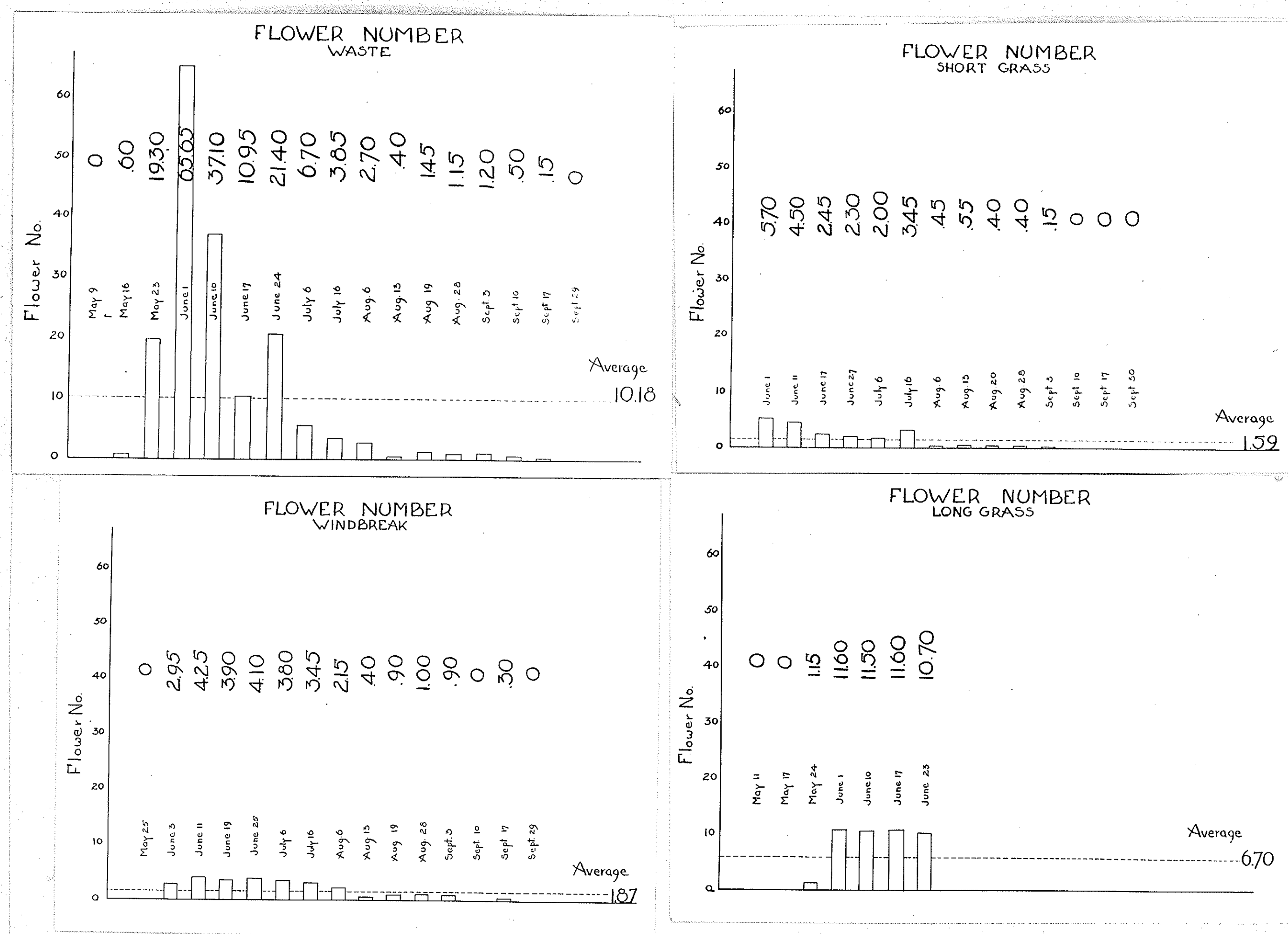


Figure 64.- Weekly variations in Flower Number of Dandelion plants.

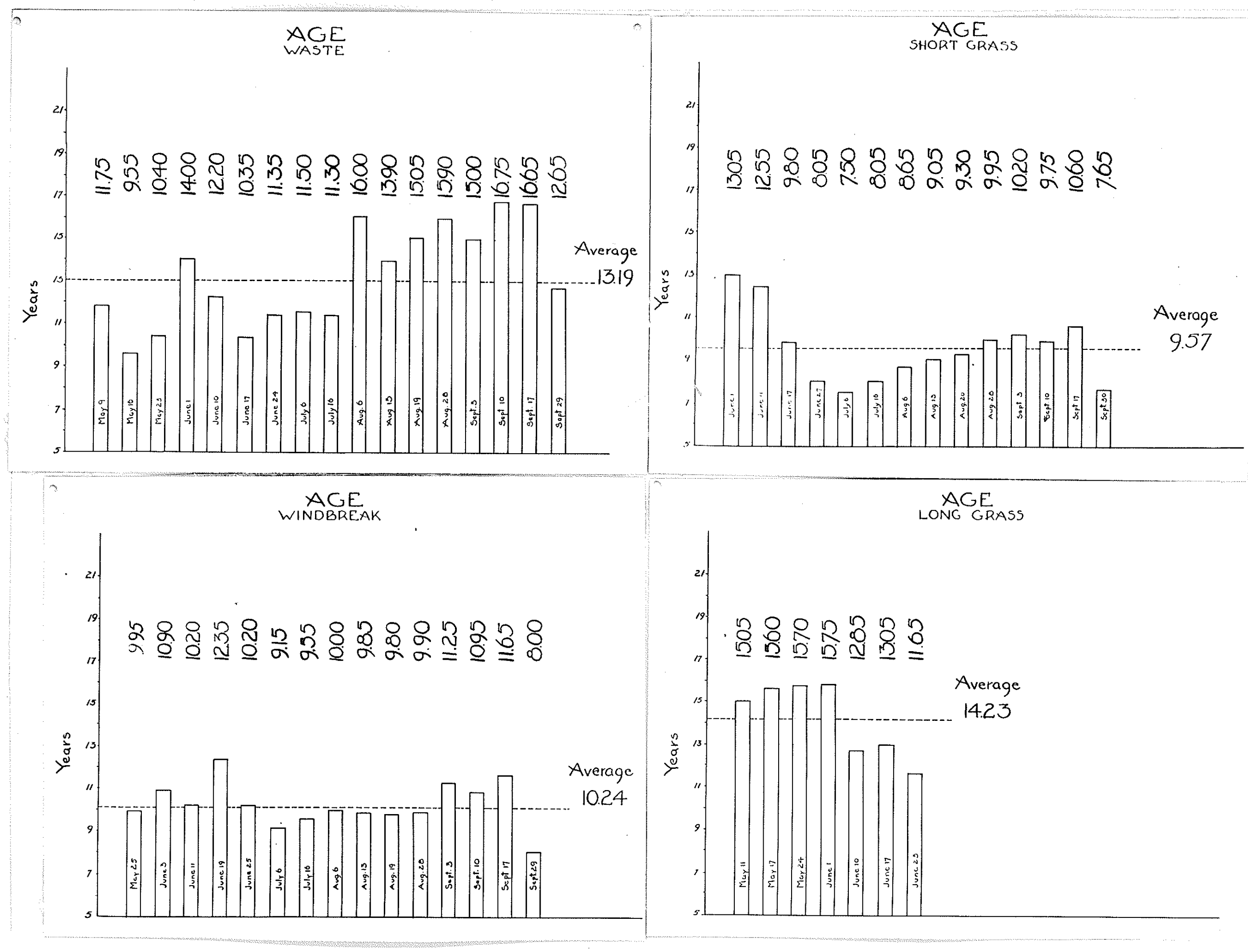


Figure 65.- Weekly variations in the Age of Dandelion plants. Measured by rings on the root.

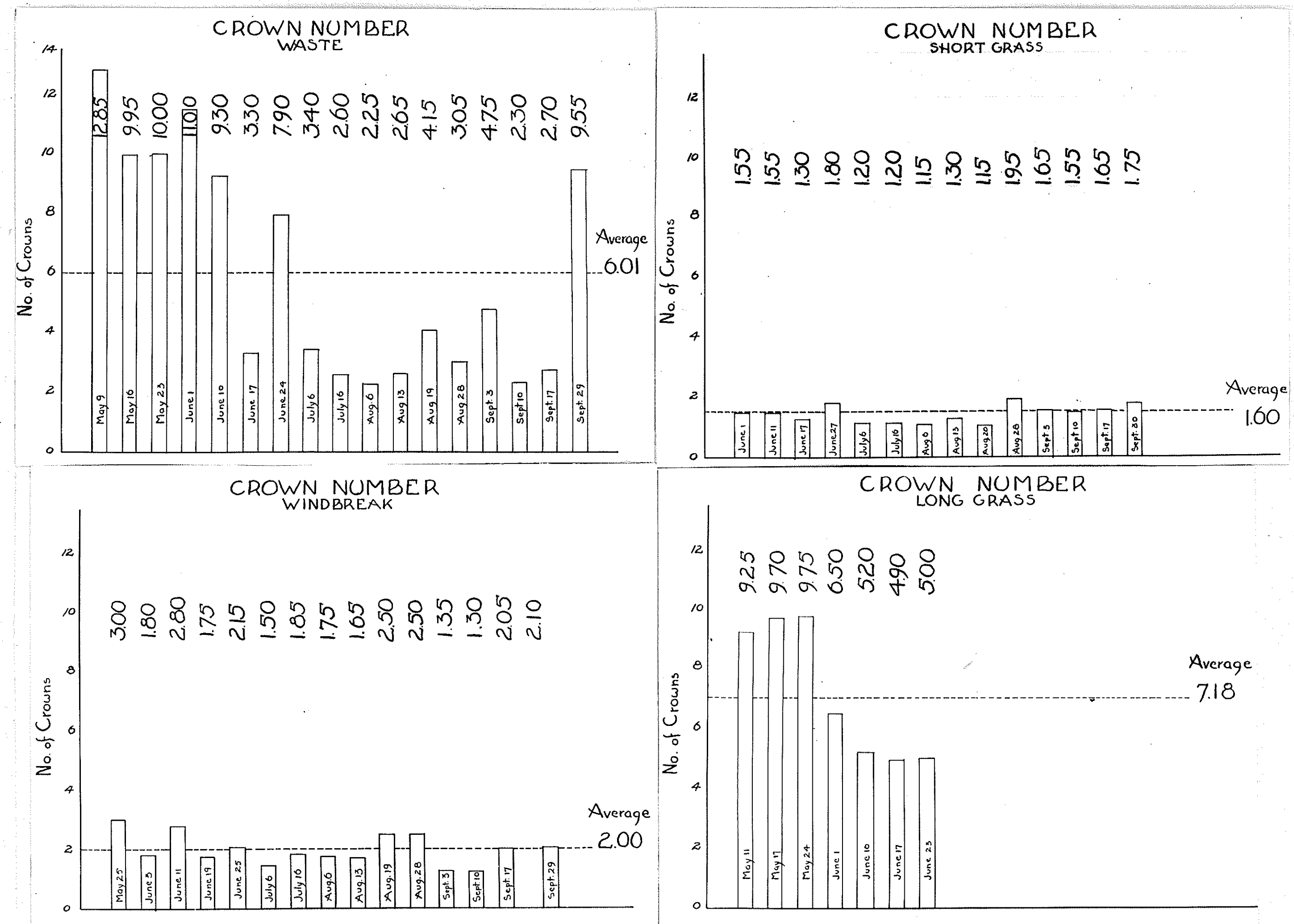


Figure 66.- Weekly variations in the Crown Number of Dandelion plants.

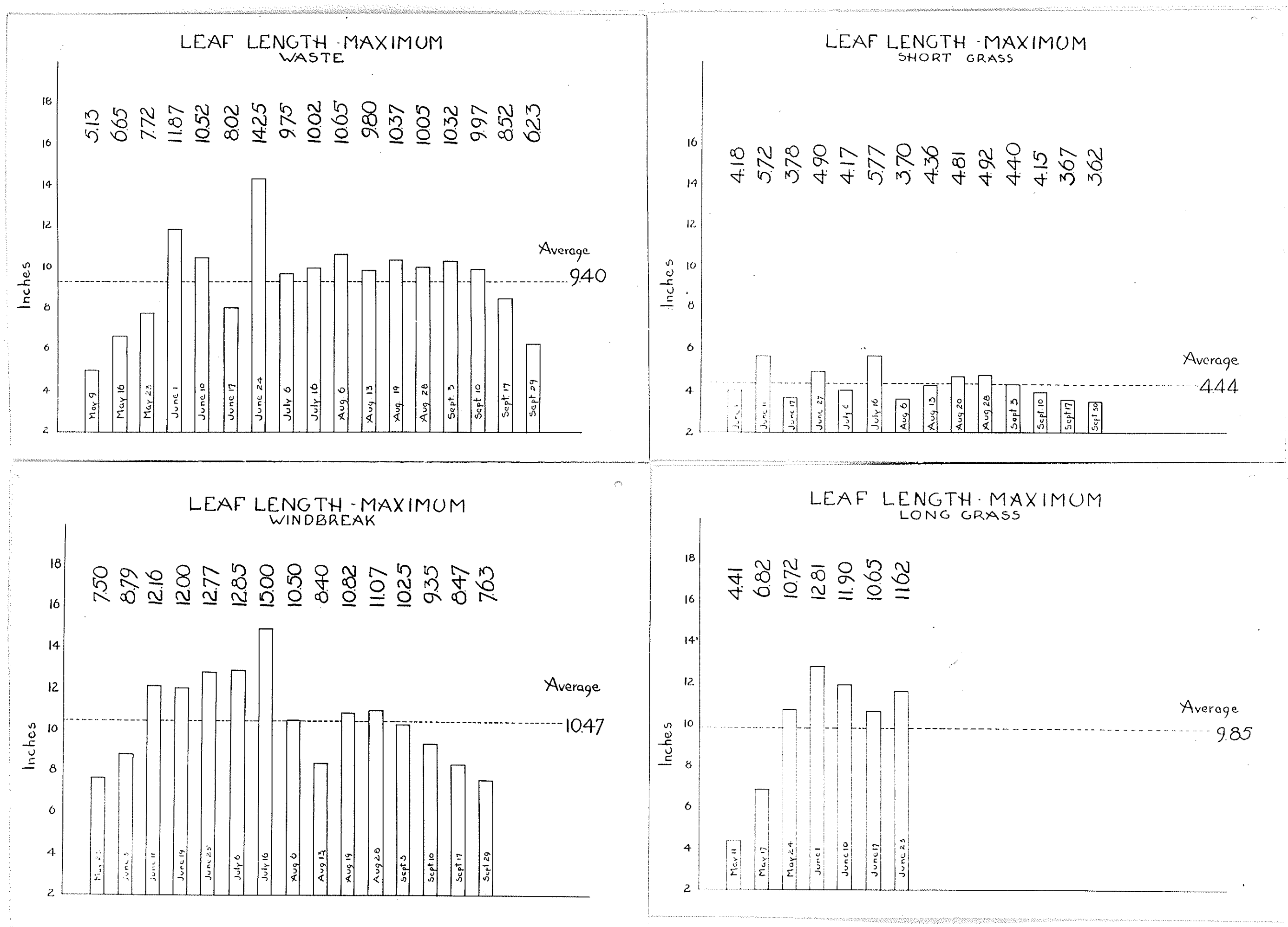


Figure 67.- Weekly variations in the Maximum Leaf Length of Dandelion Plants.

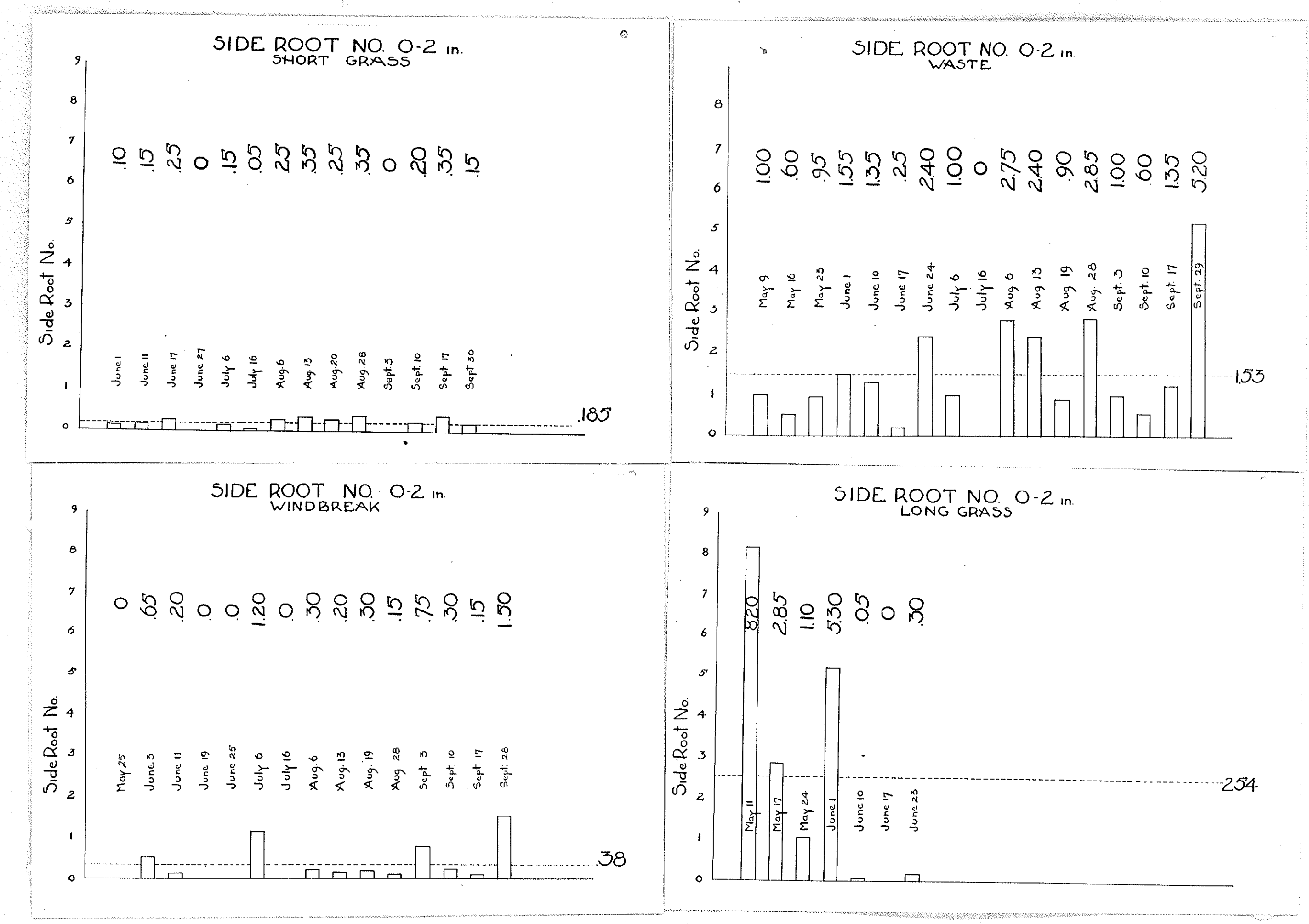


Figure 68.- Weekly variations in Side Root Number (0-2 inches below ground level) of Dandelion plants.

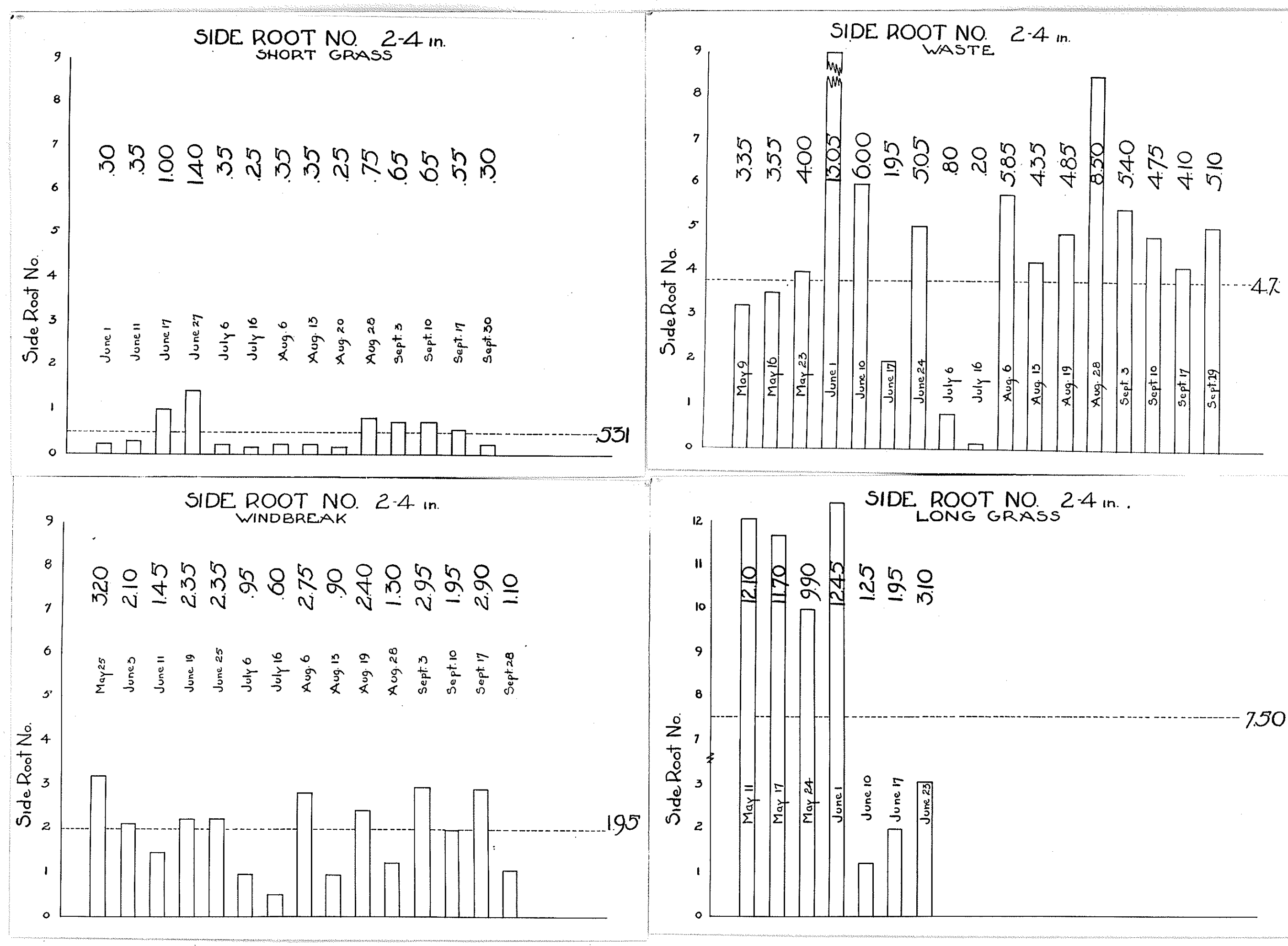


Figure 69.- Weekly variations in the Side Root Number (2-4 inches below the ground level) of Dandelion plants.

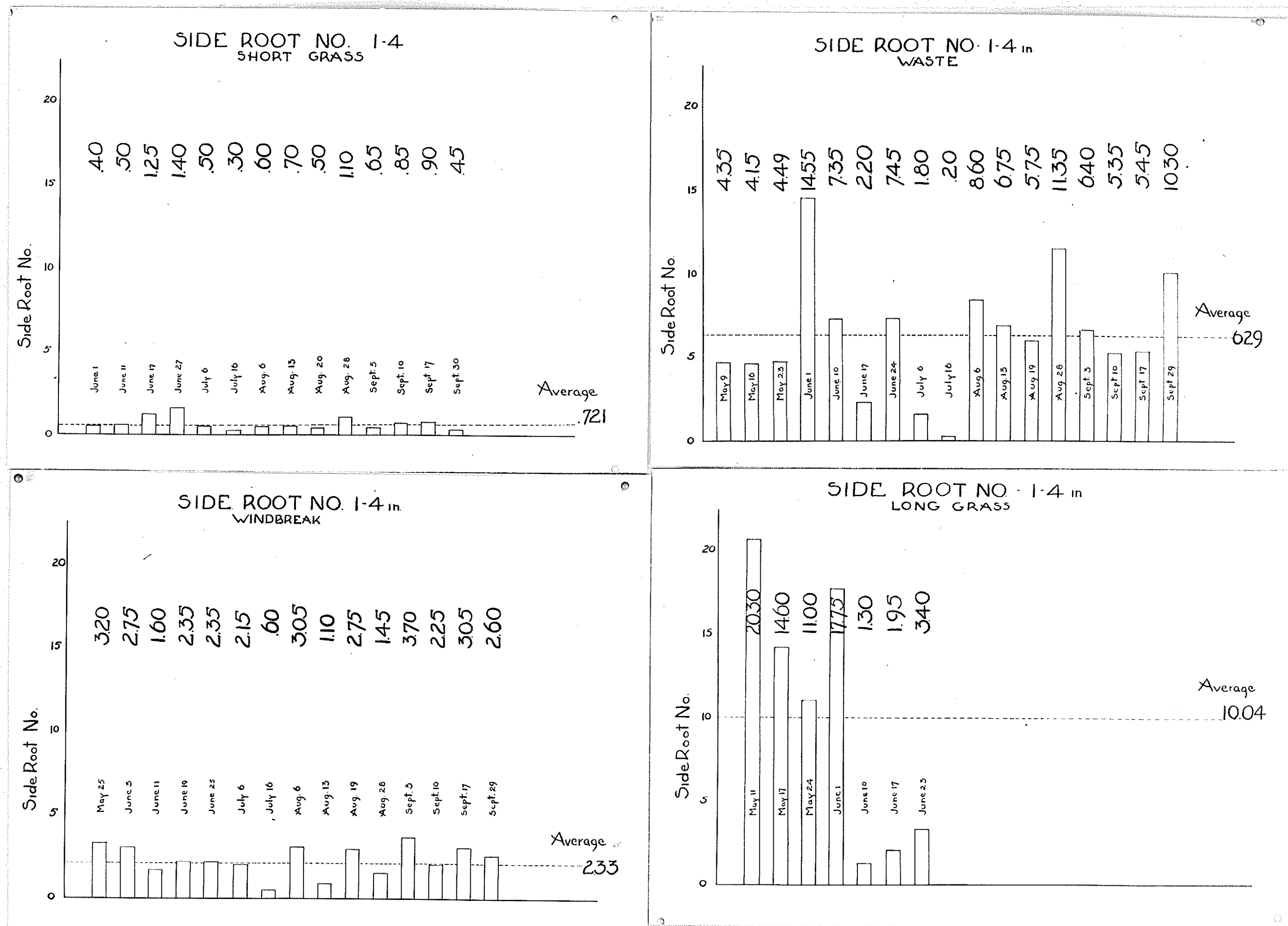


Figure 70.- Weekly variations in the Side Root Number (0-4 inches below ground level) of Dandelion plants.

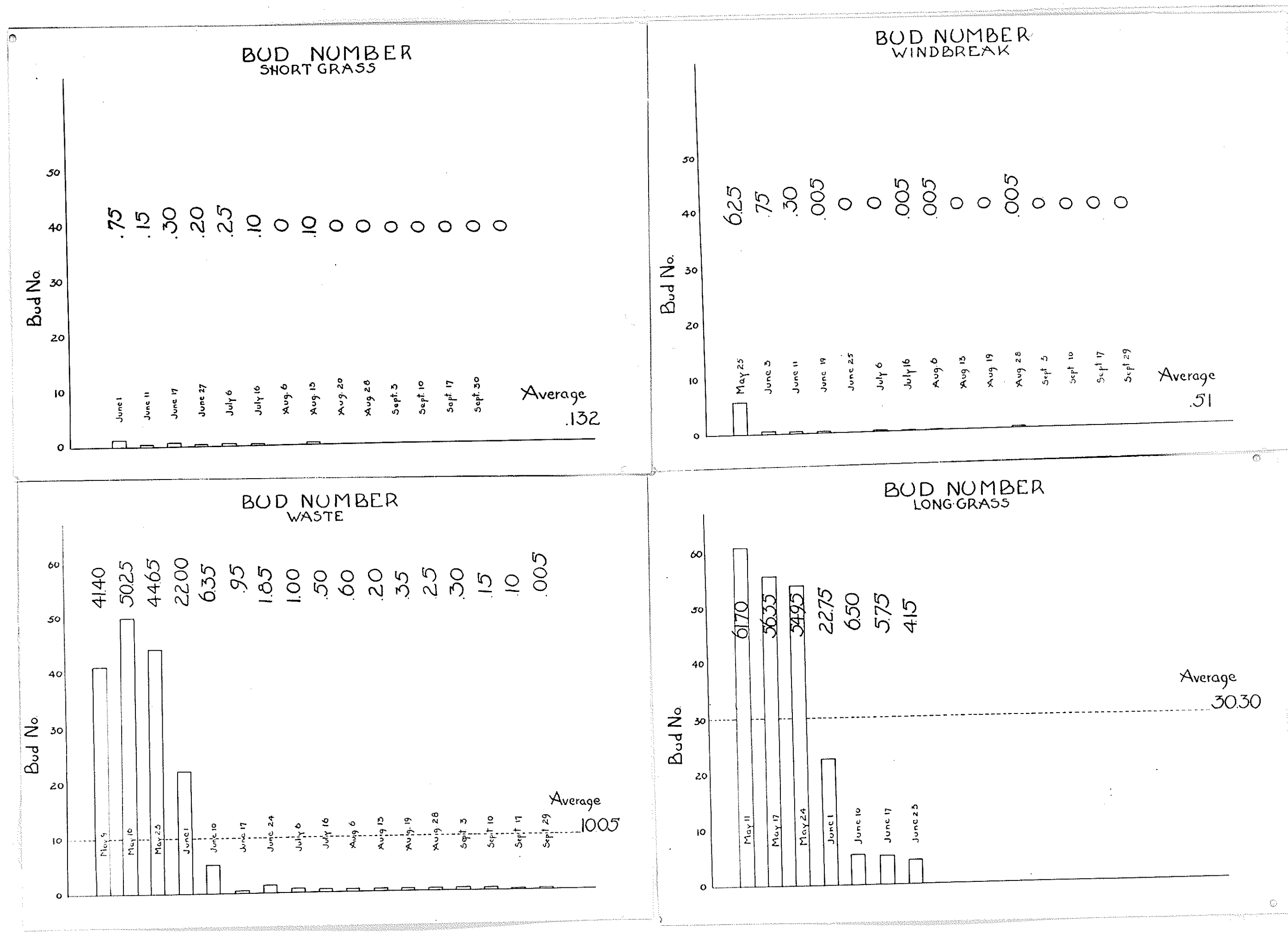


Figure 71.- Weekly variations in the Bud Number of Dandelion plants.

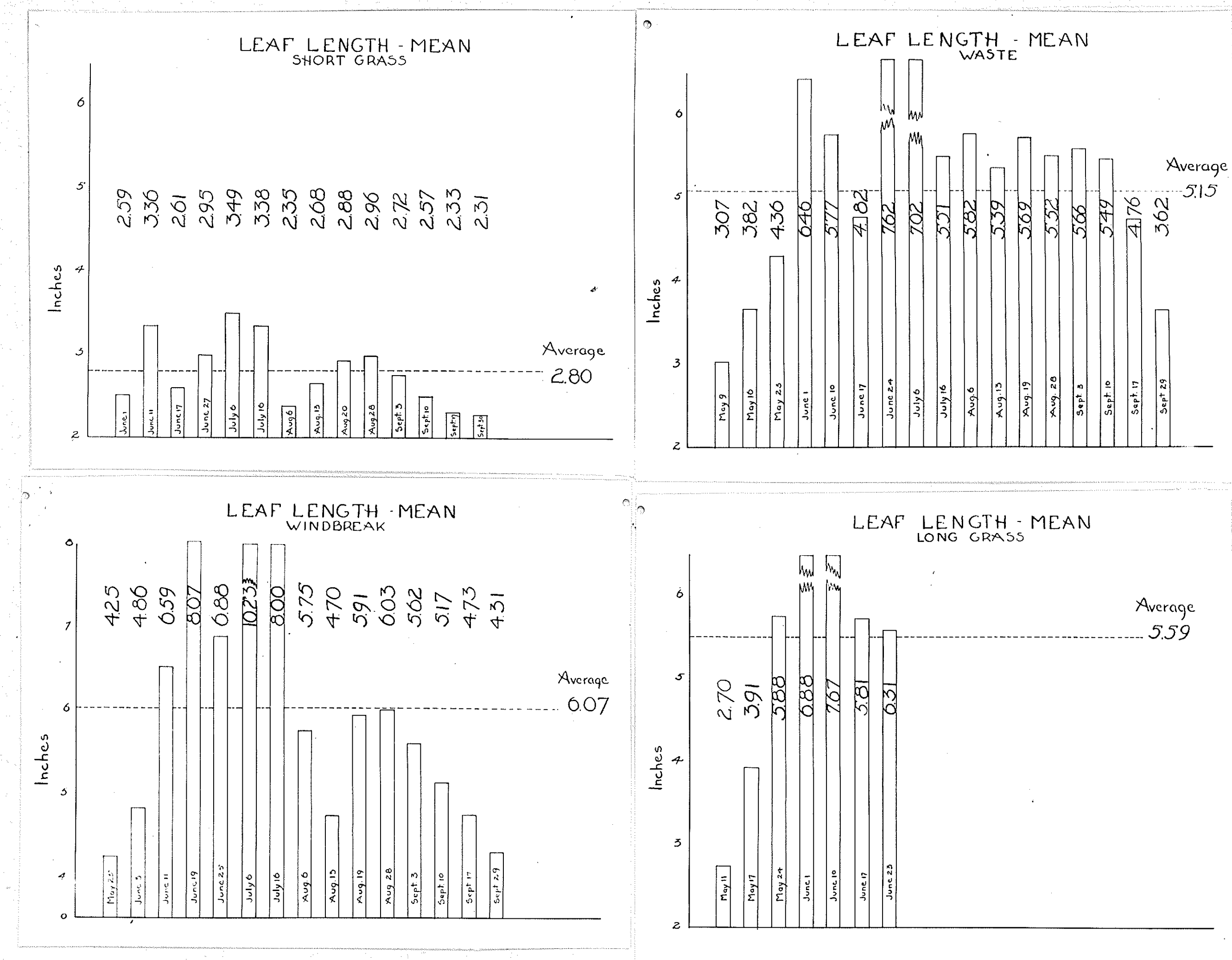


Figure 72.- Weekly variations in the Mean Leaf Length of Dandelion plants.

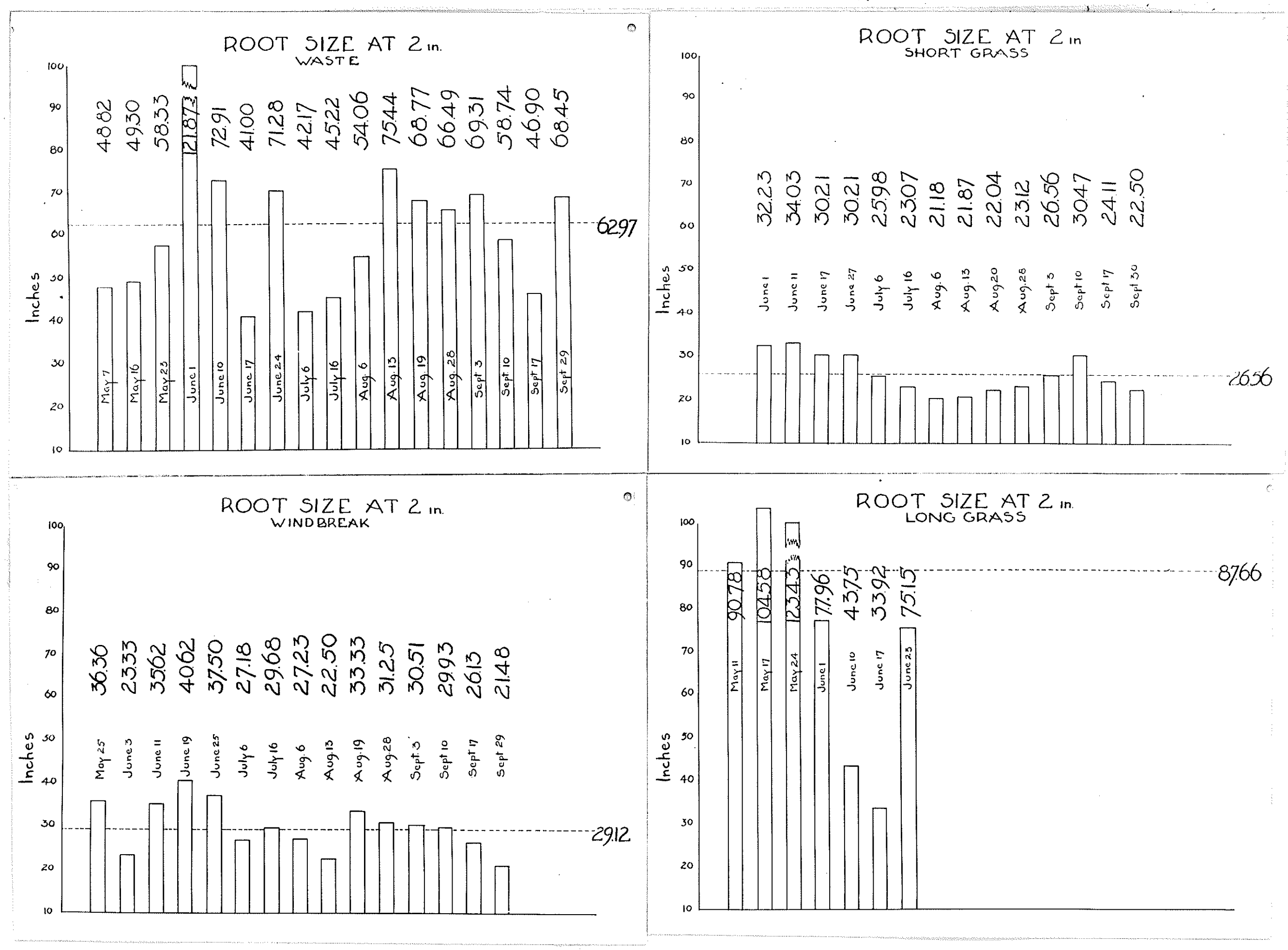


Figure 73.- Weekly variations in the Root Size (at 2 inches below the ground level) of Dandelion plants.

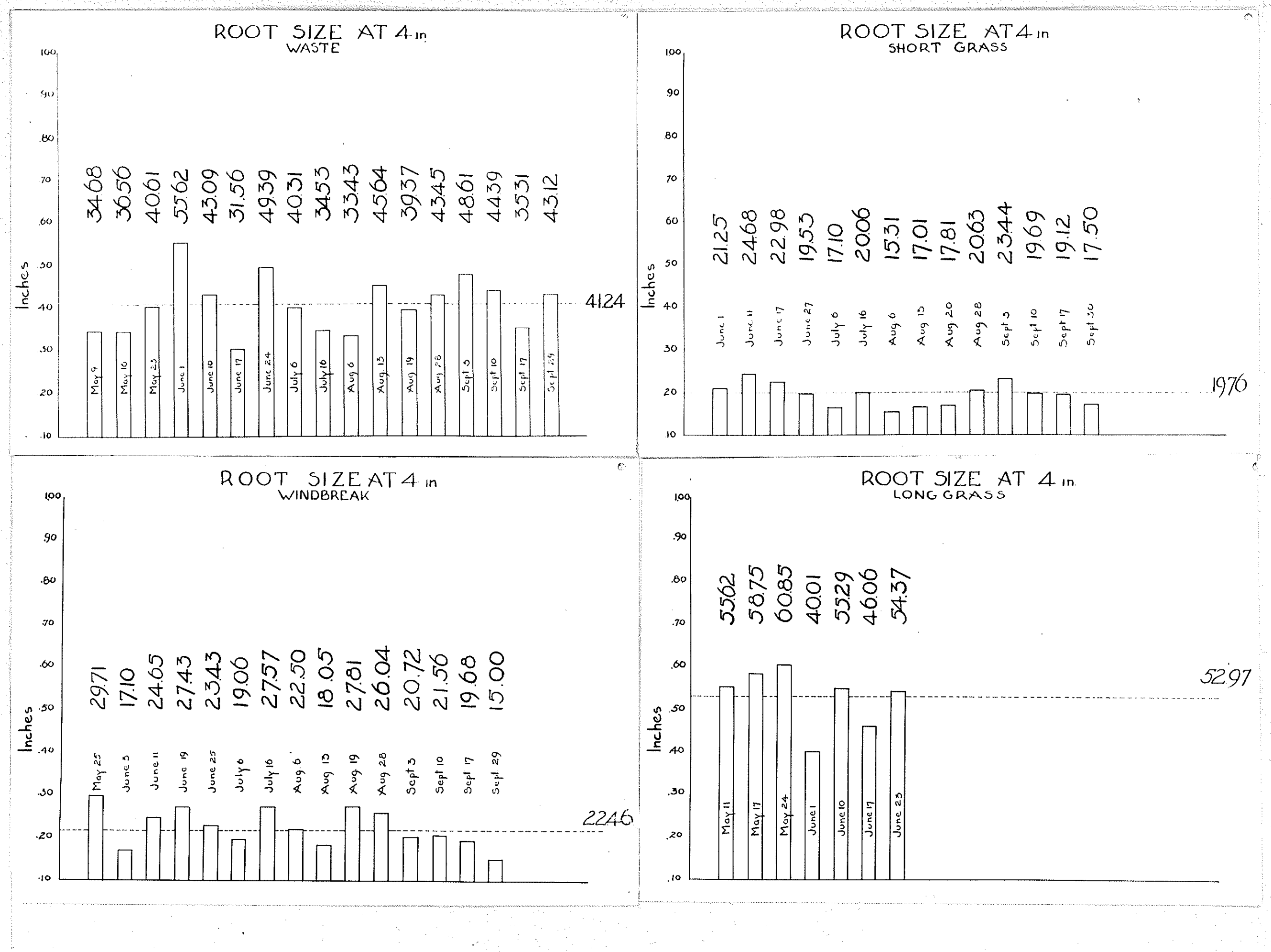


Figure 74.- Weekly variations in the Root Size (at 4 inches below the ground level) of Dandelion plants.

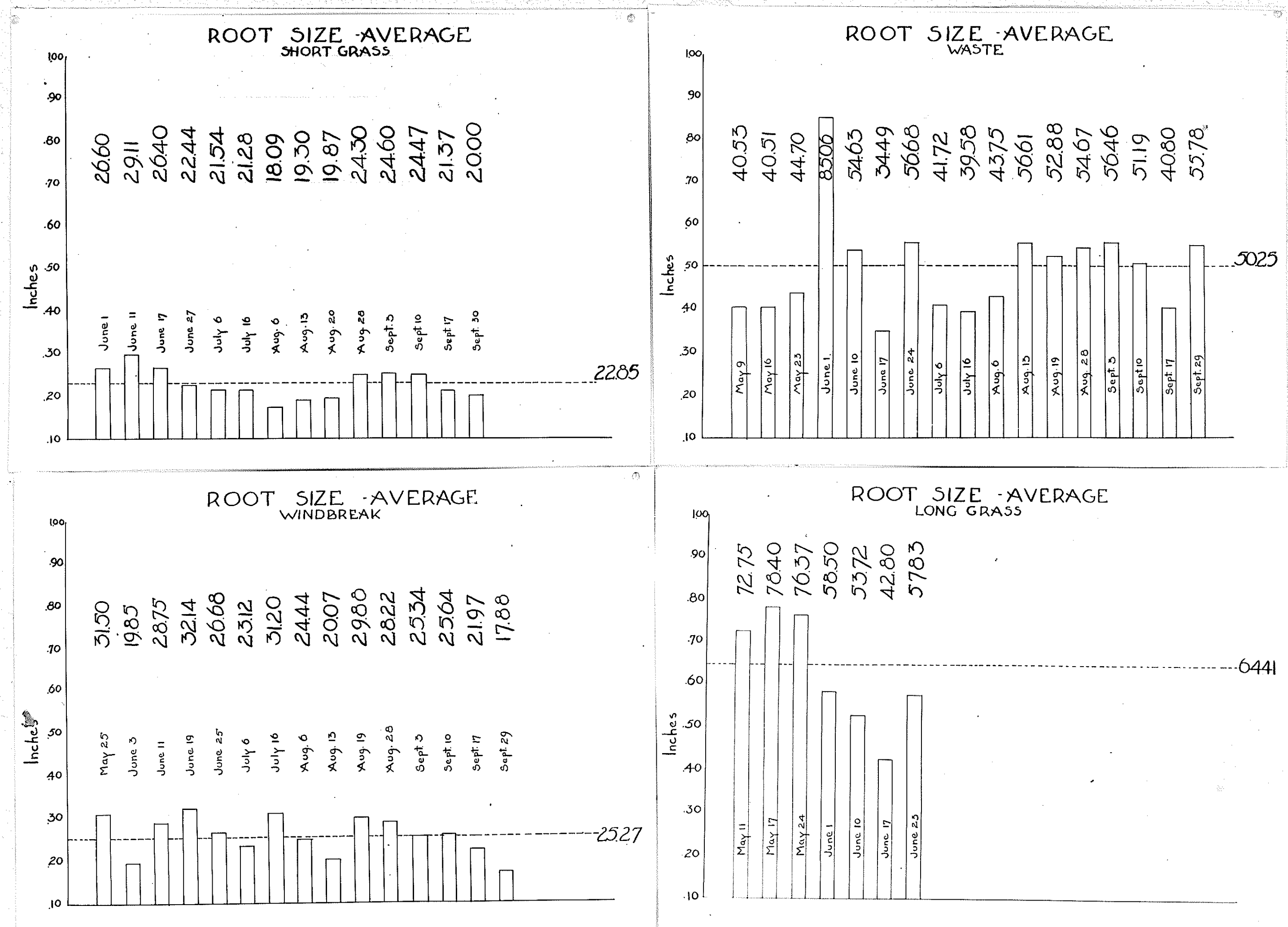


Figure 75.- Weekly variations in the Average Root Size (0-4 inches below ground level) of Dandelion plants.