Inheritance in Potatoes under Asexual Reproduction

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INHERITANCE IN POTATOES UNDER ASEXUAL REPRODUCTION.

In order to know what the nature of a hill grown from a certain tuber, or of a crop from a certain lot of seed potatoes will probably be, it is necessary to understand (a) degeneration, (b) the individual tuber, (c) the hill, and (d) the effect of environment. These are very important factors in the study of asexual inheritance in potatoes and they have not been given sufficient attention by other workers in the past. Certain studies and data concerning these factors will be presented in this thesis.

Degeneration in Yield of Potatoes.

That it is a common thing for potatoes to degenerate in yield is a fact well known to potato growers. A study of the column headed "Relative rank in yield on scale of 100" in the following table shows how strong this tendency has been at University Farm. Reference may be made, for example, to lot number 3593 on the first page of the table, which had a relative rank of 63.0 in 1908, 61.7 in 1909, 25.1 in 1910 and 11.1 in 1911.

Table I. - Yields from representative types of the more prominent commercial varieties grown at University Farm since 1900.

	Ac. No.	Years Grown	Mktble Bu. Per A	Total Bu. Per A	Rel. Rank in Yield of Mktble on scale of 100
Irish Cobbler Type					
Irish Cobbler	1626	1900	157.0	181.0	59.5
		1901	78.0	89.0	51.3
Tubers white; length,		1902	151.0	201.0	45.8
short to medium short;		1903	57.1	113.6	33.3
rather blocky; surface		1904	121.0	165.0	48.5
rather uneven to fair-		1905	166.2	190.4	59.7
ly even; eyes, medium		1906	133.6	162.5	44.4
to rather deep. Early.		1907	29.3	54.5	12.4
		1908	16.9	40.4	8.7
		1909	41.0	67.1	14.1
		1910	7.9	24.5	4.8
		1911	2.6	23.1	1.0
	3593	1908	122.0	133.7	63.0
		1909	179.6	200.3	61.7
		1910	41.5	54.9	25.1
		1911	29.4	47.8	11.1
	3758	1909	210.9	227.3	72.4
		1910	51.5	59.8	31.2
		1911	32.2	51.3	12.2
	3934	1911	72.6	86.2	27.5
	3946	1911	82.8	101.6	31.5

	Ac. No.	Years Grown	Mktble Bu. Per A	Total Bu. Per A	Rel.Rank in yield of mktble on scale of 100
Irish Cobbler Type(Cont.)					
Eureka Extra Early	2859	1905	246.3	272.2	88.4
		1906	220.6	251.2	73.3
Similar to Irish Cobbler		1907	109.4	126.7	46.1
		1908	22.5	29.3	11.6
		1909	75.6	98.6	26.0
		1910	52.9	62.8	32.0
		1911	17.3	28.8	6.5
	3759	1909	238.1	252.5	81.8
		1910	70.4	85.4	42.6
		1911	22.3	41.1	8.4
	3843	1910	107.3	114.6	65.0
		1911	27.9	45.0	10.6
Dreer's Early Standard	3064	1906	161.0	207.7	53.5
		1907	105.3	111.7	44.4
Similar to Irish Cobbler		1908	85.9	107.1	44.3
		1909	94.4	112.9	32.4
		1910	30.3	43.0	18.4
		1911	2.7	10.2	1.0
	3757	1909	157.1	166.7	53.9
		1910	66.6	77.8	40.3
		1911	57.0	79.0	21.6
Hamilton Early	3756	1909	198.5	214.8	68.2
		1910	29.0	36.7	17.6
Similar to Irish Cobbler					

	Ac. No.	Years Grown	Mktble Bu. Per A	Total Bu. Per A	Rel.Rank in yield of mktble on scale of 100
<u>Early Ohio Type</u>					
Early Ohio	2453	1900	202.0	210.0	76.5
		1901	111.0	131.0	73.0
Tubers pink to light pink;oval; fairly short to medium long; surface usually even; eyes usually shallow. Season early.		1902	177.0	203.0	53.6
		1903	49.7	52.8	29.0
	2365	1900	264.0	286.0	100.0
		1901	90.0	114.0	59.2
		1902	139.0	162.0	42.1
		1903	93.1	128.6	54.3
		1904	67.6	100.2	27.1
		1905	129.0	143.5	46.3
		1906	178.7	186.8	59.3
		1907	120.4	133.1	50.8
		1908	67.0	84.3	34.6
		1909	94.4	114.7	32.4
		1910	57.2	69.1	34.6
		1911	71.8	92.0	27.2
	3630	1908	92.8	104.6	47.9
		1909	182.2	202.2	62.6
		1910	73.1	81.8	44.3
		1911	57.8	77.5	21.9
	3787	1909	170.2	200.7	58.4
		1910	94.1	102.6	57.0
		1911	86.5	105.3	32.7

	Ac. No.	Years Grown	Mktble Bu. Per A	Total Bu. Per A	Rel.rank in yield of mktble on scale of 100
Early Ohio Type(Cont.)					
Early Ohio(Cont.)	3928	1911	134.1	152.1	50.8
	3931	1911	167.6	173.4	63.4
	3932	1911	172.6	176.6	65.3
	3951	1911	182.5	190.9	69.1
	3952	1911	146.5	155.8	55.5
Early Market	2050	1900	211.0	231.0	79.9
		1901	69.0	88.0	45.4
Similar to Early		1902	142.0	180.0	43.0
Ohio		1903	77.9	117.6	45.5
		1904	57.5	97.5	23.1
		1905	189.6	223.9	68.1
		1906	188.4	198.1	62.6
		1907	100.8	124.5	42.5
		1908	63.9	76.5	33.0
		1909	87.1	107.0	29.9
		1910	100.8	105.3	61.1
		1911	96.5	116.1	36.5
	3844	1910	90.8	97.3	55.0
		1911	141.5	153.1	53.6
Early Michigan Type					
Early Harvest	2847	1905	40.3	48.2	14.5
		1906	212.5	243.1	70.6
Tubers white;length,		1907	134.1	169.9	56.5
medium to fairly		1908	44.6	66.1	23.0
long, often fairly		1909	64.0	94.1	22.0

	Ac. No.	Years Grown	Mktble Bu. Per A	Total Bu. Per A	Rel.rank in yield of mktble on scale of 100
<u>Early Michigan Type</u>(Cont.)					
Early Harvest(Cont.)	2847	1910	38.9	57.6	23.6
		1911	13.1	33.6	5.0
short;surface fairly even;eyes shallow to medium in depth, some rather deep. Season medium early.	3859	1910	91.8	100.1	55.6
		1911	25.8	40.3	9.8
	3875	1910	53.0	71.5	32.1
		1911	14.6	52.2	5.5
	3927	1911	97.3	109.1	36.8
Early Michigan	2846	1905	19.8	25.0	7.1
		1906	180.3	231.7	59.9
Similar to Early Harvest		1907	134.0	154.7	56.5
		1908	132.2	157.9	68.2
		1909	127.5	164.2	43.8
		1910	58.6	75.5	35.5
		1911	24.8	45.4	9.4
	3860	1910	83.7	99.6	50.7
		1911	83.7	111.8	31.7
	3878	1910	86.3	98.2	52.3
		1911	54.0	99.1	20.4
Early Bird	3105	1906	238.1	265.3	79.1
		1907	167.5	214.3	70.6
Similar to Early Harvest		1908	112.2	139.9	57.9
		1909	69.6	94.4	23.9
		1910	50.1	65.4	30.3
		1911	4.4	15.7	1.7

	Ac. No.	Years Grown	Mktble Bu. Per A	Total Bu. Per A	Rel.rank in yield of mktble on scale of 100
<u>Early Michigan Type</u>(Cont.)					
Early Bird(Cont.)	3785	1909	237.5	283.2	81.6
		1910	69.4	88.1	42.0
		1911	67.5	98.4	25.5
	3863	1910	90.7	103.6	55.0
		1911	50.8	81.2	19.2
Early Puritan	3058	1906	235.1	312.4	78.1
		1907	138.2	165.3	58.3
Similar to Early		1908	135.1	159.1	69.7
Harvest		1909	115.1	144.8	39.5
		1910	25.5	48.7	15.4
		1911	11.7	27.9	4.4
	3879	1910	75.4	99.6	45.7
		1911	58.0	105.4	22.0
<u>Russet Type</u>					
California Russet	2850	1905	189.7	203.8	68.1
		1906	175.5	193.2	58.3
Tubers russet col-		1907	186.0	194.0	78.4
ored ;medium long;		1908	65.7	77.5	33.9
surface even;eyes		1909	59.8	73.8	20.5
shallow to very		1910	22.6	36.8	13.7
shallow. Late.		1911	17.3	35.9	6.5
	3778	1909	177.7	193.6	61.0
		1910	33.9	45.5	20.5
		1911	12.1	29.7	4.6
	3923	1911	72.4	92.0	27.4

	Ac. No.	Years Grown	Mktble Bu. Per A	Total Bu. Per A	Rel.rank in yield of mktble on scale of 100
Russet Type(Cont.)					
Golden Russet	2801	1905	161.3	170.7	57.9
		1906	Good yield; not weighed.		
Similar to		1907	104.4	113.6	44.0
Calif.Russet		1908	47.9	61.8	24.7
	3855	1910	63.4	81.2	38.4
		1911	95.2	118.3	36.0
Russet	3954	1911	87.4	109.6	33.1
Similar to California Russet	3955	1911	51.9	76.2	19.6
Green Mountain Type					
Carman No.1	1625	1905	235.6	310.3	84.6
		1906	216.9	241.1	72.0
Tubers white;		1907	93.9	152.0	39.6
blocky, short to		1908	42.7	53.7	22.0
medium in length;		1909	66.7	79.9	22.9
surface even to		1910	49.4	55.7	29.9
somewhat uneven;		1911	30.8	36.3	11.7
eyes usually shallow. Late.	3764	1909	290.2	303.6	99.7
		1910	53.1	59.3	32.2
		1911	25.9	34.9	9.8
	3881	1911	136.3	155.7	51.6
	3888	1911	183.7	195.5	69.5
	3889	1911	164.7	177.1	62.3
	3935	1911	102.9	116.1	38.9

	Ac. No.	Years Grown	Mktble Bu. Per A	Total Bu. Per A	Rel.rank in yield of mktble on scale of 100
<u>Green Mountain Type</u>(Cont.)					
Norcross	3095	1906	301.1	310.8	100.0
		1907	161.9	175.8	68.3
Similar to Carman No. 1.		1908	62.3	73.3	32.1
		1909	80.8	94.2	27.7
		1910	66.7	71.3	40.4
		1911	62.8	72.6	23.8
	3596	1908	90.3	103.0	46.6
		1909	130.9	141.5	45.0
		1910	44.1	55.6	26.7
		1911	38.2	45.4	14.5
	3761	1909	276.6	288.7	95.0
		1910	72.8	85.4	44.1
		1911	44.5	55.4	16.8
	3915	1911	142.5	161.9	53.9
Green Mountain	3057	1906	284.3	313.2	94.4
		1907	156.2	166.1	65.9
Similar to Carman No. 1		1908	68.7	85.2	35.4
		1909	116.7	135.1	40.1
		1910	45.7	56.4	27.7
		1911	53.5	60.8	20.2
	3595	1908	119.1	130.8	61.5
		1909	107.0	119.2	36.7
		1910	34.9	41.5	21.1
		1911	44.3	51.5	16.8
State of Maine Similar to Carman No. 1	3063	1906	225.4	273.7	74.9
		1907	144.1	159.1	60.8
		1908	79.3	93.3	40.9

	Ac. No.	Years Grown	Mktble Bu. Per A	Total Bu. Per A	Rel.rank in yield of mktble on scale of 100
<u>Green Mountain Type</u>(Cont.)					
State of Maine(Cont.)	3063	1909	102.7	121.2	35.3
		1910	42.6	53.7	25.8
		1911	47.8	57.9	18.1
	3590	1908	110.1	121.7	56.8
		1909	185.7	203.7	63.8
		1910	50.6	56.4	30.6
		1911	44.0	52.2	16.7
	3942	1911	120.2	141.4	45.5
Freeman	3616	1908	193.5	203.7	100.0
		1909	175.4	191.0	60.2
Similar to Carman		1910	74.5	78.9	45.1
No. 1		1911	46.6	58.2	17.6
Uncle Sam	3056	1906	198.0	244.7	65.8
		1907	148.0	197.5	62.4
Similar to Carman		1908	84.0	93.9	43.3
No. 1		1909	137.4	152.1	47.2
		1910	43.6	50.1	26.4
		1911	41.1	46.5	15.6
	3841	1910	82.7	89.4	50.1
		1911	89.2	102.4	33.8
Vermont Gold Coin	3099	1906	262.4	291.3	87.1
		1907	120.0	136.5	50.6
Similar to Carman No. 1		1908	25.1	32.3	13.0

	Ac. No.	Years Grown	Mktble Bu. Per A	Total Bu. Per A	Rel. rank in yield of mktble on scale of 100
Green Mountain Type(Cont.)					
Market Prize Similar to Carman No. 1.	3777	1909	291.2	307.1	100.0
		1910	58.6	64.7	35.5
		1911	42.3	50.1	16.0
The Lincoln Similar to Carman No. 1.	3867	1910	95.2	103.9	57.7
		1911	82.9	98.0	31.4
Rural New Yorker Type					
Rural New Yorker No. 2.	3631	1908	74.8	80.7	38.6
		1909	222.6	234.8	76.4
		1910	90.4	94.0	54.8
Tubers white; roundish, flattened, inclined to blocky; short to medium in length, sometimes long; surface even to very even; eyes shallow; late.		1911	110.1	117.2	41.7
	3762	1909	205.1	214.2	70.4
		1910	99.1	100.5	60.0
		1911	167.8	172.4	63.5
	3852	1910	139.8	140.9	84.7
		1911	115.7	127.4	43.8
	3857	1910	136.5	138.2	82.7
		1911	229.5	234.2	86.9
	3941	1911	264.2	265.0	100.0
Sir Walter Raleigh	2454	1900	181.0	203.0	68.6
		1901	105.0	118.0	69.1
Similar to Rural New Yorker No.2.		1902	179.0	198.0	54.2
	2733	1903		78.6	

	Ac. No.	Years Grown	Mktble Bu. Per A	Total Bu. Per A	Rel.rank in yield of mktble on scale of 100
Rural New Yorker Type(Cont.)					
Sir Walter Raleigh (Cont.)	2733	1904	249.3	259.3	100.0
		1905	109.2	130.4	39.2
		1906	251.0	269.1	83.4
		1907	215.5	225.3	90.9
		1908	77.9	84.6	40.2
		1909	142.5	164.1	48.9
		1910	101.8	106.9	61.7
		1911	123.6	125.3	46.8
	3763	1909	281.7	293.8	96.7
		1910	63.1	65.7	38.2
		1911	119.7	123.2	45.3
	3851	1910	129.3	131.7	78.3
		1911	192.7	195.4	72.9
	3939	1911	237.0	238.6	89.7
Carman No. 3	3765	1909	197.1	210.4	67.8
		1910	109.4	112.2	66.3
Similar to Rural New Yorker.		1911	151.5	159.0	57.3
	3848	1910	146.1	147.1	88.5
		1911	250.8	253.1	94.9
	3861	1910	137.6	139.9	83.3
		1911	223.1	226.5	84.4
	3944	1911	260.6	263.1	98.6
Ohio Wonder Similar to Rural New Yorker No.2.	3775	1909	230.9	245.1	79.3
		1910	100.1	103.7	60.6

	Ac. No.	Years Grown	Mktble Bu. Per A	Total Bu. Per A	Rel.rank in yield of mktble on scale of 100
<u>Rural New Yorker Type</u>(Cont.)					
Algonquin	3094	1906	247.2		82.1
		1907	169.9	183.6	71.6
Similar to Rural		1908	103.9	115.0	53.6
New Yorker No.2.		1909	211.4	223.1	72.6
		1910	94.5	97.9	57.2
White Beauty	2452	1900	173.0	183.0	65.5
		1901	47.0	58.0	30.9
Similar to Rural		1902	211.0	219.0	63.9
New Yorker No.2		1903	159.8	195.0	93.3
		1904	221.0	291.0	88.6
		1905	228.0	251.1	81.8
		1906	233.1	247.5	77.4
		1907	237.2	265.1	100.0
		1908	123.9	136.4	63.9
		1909	173.7	192.2	59.6
		1910	83.7	86.2	50.7
		1911	97.7	103.7	37.0
World's Wonder	3842	1910	120.5	123.1	73.0
Similar to Rural		1911	161.6	172.2	61.2
New Yorker No.2.					
Dusty Rural	3052	1906	173.9	194.8	57.8
Similar to Rural		1907	146.3	163.0	61.7
New Yorker No.2.		1908	92.1	104.0	47.5
		1909	176.8	202.1	60.7
		1910	96.5	98.1	58.4
		1911	127.1	131.3	48.1

Other facts which a study of the column on "Relative rank in yield" brings out are that the amount of degeneration varies (a) with different groups, (b) for different years and (c) that the different groups vary in their relative amount of degeneration from year to year.

One year's yield cannot be compared with some preceding year's yield of the same seed stock in determining the amount degeneration because there is no way of determining a factor by means of which to eliminate variation in yield, due to variation in soils and seasons. In the column of relative rank in yield, in Table I, this variation is largely eliminated, but there is still sufficient undeterminable variation to make it difficult to use the column for anything more than a general survey.

Another method of determining degeneration in yield is by comparing the yield from new seed stock with that from the old seed stock. This has been done in the following tables, which were prepared for the purpose of determining the increase in yield from new seed stock, but which may be studied in addition to

Fig. 1. Shows how the plants of degenerate potatoes look. Degenerate Irish Cobbler (1626) on right and new stock of Irish Cobbler (3593) on left. In many of the rows planted in 1911 from degenerate and well formed tubers selected from the same lot of seed stock the difference in the plants was as great as here shown.

Table I for what they indicate in the way of degeneration.

New seed stocksof many varieties have been obtained at frequent intervals. The gains in yield from the new stock as compared with the old stock were strikingly large and appear to have much commercial significance. The results are presented in Table II.

In preparing this table all varieties which were very much alike were assembled and treated as though they were but one variety; also all lots of a given type which were purchased in the same year were averaged before comparing them with lots purchased in other years for computing the gains.

The figures for each type of the table were compiled from the yields given for different lots of the corresponding type in Table I.

Table II. - Gains in yield from new seed stock of potatoes in bushels per acre.

Difference in age of old & new stock	Average gain for new stock over old stock the first six years.					
	First Year	Second Year	Third Year	Fourth Year	Fifth Year	Sixth Year
Irish Cobbler Type						
1 Yr.	16.2	-0.2	35.6	18.8	-22.6	14.6
2 Yrs.	47.5	41.9	11.2	26.7		
3 "	84.9	64.1	11.6	12.1		
4 "	101.3	13.4	19.9			
5 "	64.7	10.6				
6 "	60.4					
8 "	80.1	87.0	80.1	5.6	34.6	45.0
9 "	27.4	76.0	69.0	53.4	22.4	0.1
11 "	105.1	138.6	33.6	26.8		
12 "	160.2	46.5	34.6			
13 "	99.4	25.3				
14 "	75.1					
Aver.	76.9	50.3	37.0	23.9	11.5	10.2
Early Ohio Type						
1 Yr.	-14.5	37.5	29.2	-23.2	15.2	10.1
2 Yrs.	27.6	62.9	35.0	-28.2		
3 "	102.9					
9 "	25.8	87.8	15.9	-14.0		
10 "	52.4	66.0	-6.5	-38.7		
11 "	58.4	31.5	-10.0			
12 "	39.5	45.0				
13 "	64.2					
Aver.	44.5	65.1	12.7	-26.0	15.2	10.1

Difference in age of old & new stock	Average gain for new stock over old stock the first six years.					
	First Year	Second Year	Third Year	Fourth Year	Fifth Year	Sixth Year
Early Michigan Type						
1 Yr.	33.5	-0.5	35.3	-3.4	-11.0	-10.9
2 Yrs.	29.8					
3 "	145.1	31.6	59.4			
4 "	92.1	30.2	48.5			
5 "	60.3	28.8				
6 "	78.3					
Aver.	73.2	22.3	47.7	-3.4	-11.0	-10.9
Russet Type						
1 Yr.	2.5	83.1				
2 Yrs.	58.5					
4 "	117.9	11.3	-5.2			
5 "	40.8	77.9				
6 "	53.3					
Aver.	54.6	57.4				
Carman No. 1 Type						
1 Yr.	64.9	37.0	7.8	42.7	0.3	20.5
2 Yrs.	69.8	41.6	1.3	-8.0		
3 "	121.2	47.5	-6.1	12.5		
4 "	129.3	23.5	6.8			
5 "	66.5	55.3				
6 "	113.8					
Aver.	94.3	41.0	2.5	15.7	0.3	20.5

Difference in age of old & new stock	Average gain for new stock over old stock the first six years.					
	First Year	Second Year	Third Year	Fourth Year	Fifth Year	Sixth Year
Rural New Yorker Type						
1 Yr.	35.5	25.9	36.2			
2 Yrs.	43.0	57.0	-5.1	-17.0		
3 "	46.0	-10.6	-26.5	34.8	-14.0	-21.3
4 "	39.5	68.5				
5 "	61.9	80.1	-11.4	-13.5		
6 "	31.9	-44.0	-1.6	20.4	11.8	29.4
7 "	33.2	72.0				
8 "	40.6	48.9	6.7	12.4		
9 "	55.0	9.2	48.6			
10 "	51.3	97.9				
11 "	156.2					
Aver.	54.0	40.5	6.7	7.4	-1.1	4.1
Average of Averages of above sections of this table.	66.3	44.4	16.9	3.5	3.0	6.8

Considering the general average at the end of the preceding table, it is apparent that, when all types of potatoes are considered as a whole and all differences in age between old and new stock are considered together, the largest gains from new seed stock over the old stock are obtained the first year the new stock is planted. Two-thirds as large a gain is obtained the second year the new stock is planted as in the first year, and about one-fourth as large a gain the third year. After the third year the difference is not great enough to be of much importance. The same general principle holds true for nearly all the separate types, except that the proportions vary a great deal. In the Ohio and Russet types the average gain for the new stock was larger the second year the new stock was grown than in the first, and in the Early Michigan type, the average gain was larger the third year than in the second. These variations would, in all probability, be eliminated if a large enough amount of material were at hand to average from. The writer believes it can safely be said that, as a general rule, the gain from new stock over old stock will be largest the first year and will diminish fairly rapidly with each succeeding year that the new stock is planted.

The gain in yield for new seed stock of the different types represented in the preceding table is largest in the Cobbler, Early Michigan and Carman No. I types, very large in the Russet* type, less in the Ohio type, and least in the Rural type.

The average total gain per acre for the first three years the new stock was planted is as follows(not including the Russet): Irish Cobbler type 164.2 bu., Early Michigan type 143.2 bu., Carman No. I type 137.8 bu., Early Ohio type 112.3 bu. and Rural New Yorker type 101.2.bu. These results are in all probability an

* The figures for the Russet type in the preceding table would undoubtedly have been larger than they were if more lots had been available for comparison.

approximate indication of the relative amount of degeneration for the various types.

The results of the preceding table have been assembled according to difference in age of old and new stock in the following table:

Table III. Averages from the different parts of Table II, according to differences in years between old and new stock, in bushels per acre.

Difference in age of old & new stock	Average gain for new stock over old stock the first six years.					
	First Year	Second Year	Third Year	Fourth Year	Fifth Year	Sixth Year
1 Yr.	23.0	30.5	28.8	8.7	-4.5	1.3
2 Yrs.	46.0	50.9	10.6	-6.6		
3 "	100.0	33.2	9.6	19.8	*	*
4 "	96.0	29.4	17.5			
5 "	58.8	50.5	*	*		
6 "	67.5	*				

*Figures for these spaces not considered because only one group was represented. There were no figures for the other blank spaces.

It will be noted in the preceding table that in the first year's results from the new stock the gain in yield increases very rapidly with the increase in years of difference between old and new stock up to three years, and then decreases with additional age. Such an apparent result is, of course, incompatible. If sufficient material were available, covering a large variety of seasons, the rise would undoubtedly have been more gradual and would have increased with each added year's difference in age until a balance had been struck between stock and conditions, if at some point the decline in yield discontinued. The first year's results were probably too high for lots differing three and four years in age, and not high enough for lots differing five and six years in age.

It appears from the above table that where there is only one or two year's difference in age between old and new stock the gain in favor of the new stock will be greater the second year it is planted than the first. This seems to indicate that, on the average, degeneration is more rapid in the second year than the first, a generalization which cannot safely be made until more extensive results become available.

While there are indications that degeneration may, to a certain extent, be overcome when such causes as can be remedied are understood, the increases in yield obtained from the new seed stock at University Farm are such as to warrant a most careful systematic trial of new seed stock by the growers of the state.

Two methods of procedure may be followed in renewing seed potatoes. One is to get enough new seed potatoes to plant the entire acreage at frequent intervals. It would probably pay to do this every two years with most varieties, and possibly every year with some. This plan has the disadvantage of requiring considerable ~~of a~~ cash outlay each year the stock is renewed. The other plan is to get enough new seed stock to plant a large enough area to produce all of the seed potatoes that will be needed to plant the following year's crop. Getting new seed stock every year would be best under this plan for practically all varieties. One acre of the new stock should be planted for about every ten acres to be planted from it the next year.

The advantages of this system of renewing the seod stock are that only a moderate cash outlay is required, and the risk of the new stock being inferior is less. If the new seed stock should proved to be mixed, inferior in yielding power, of the wrong variety, or for any other reason not desired, the old stock could be planted another year instead.

These recommendations can, of course, only hold for conditions where there is considerable degeneration. They would apply, however, to probably three-fourths of the potato ~~growers~~ acreage of the state and are worthy of most careful trial by all, whether the soil be rich, average or poor. The more unfavorable the conditions are for large yields the more likely frequent introduction of new stock is to pay, while with favorable conditions for large yields the opposite is likely to be true. However, even under favorable conditions for large yields this matter is worthy of careful trial for a period of years before it is given up as unprofitable.

The results given were obtained under conditions somewhat above the average so far as the average yield obtained is concerned.

Growers who wish to produce the Irish Cobbler for the southern seed trade, but who find that it does not pay to grow it, as compared with the Early Ohio, because it degenerates so badly, could undoubtedly grow it successfully if they would follow either of the plans of renewal of seed stock above suggested.

Where to Buy New Seed Stock.

The new seed stock which has been used for this work has largely come from outside of the state, having been obtained mostly from Wisconsin, Michigan, Ohio, New York, Pennsylvania and Maine. It has not been observed that the stock from any one of these states has been any better than from others. In the cases where comparisons were possible between Minnesota and other states the indications were that seed potatoes from Minnesota were in general the best. At any rate, whatever section may be best to buy seed stock from, it is clear that increases in yield were obtained from seed stock from our own state and from all the other states referred to. In many cases a high grade of seed stock can be secured in one's own neighborhood. For new stock of Irish Cobbler it is probably best to go east of Lake Michigan, but not to Maine on account of disease.

It would be preferable to go north rather than south for new seed potatoes. In going south, it would probably be preferable not to go south more than fifty or one hundred miles.

The question of change of soil is not clearly settled, but if equally good seed potatoes could be obtained from a different type of soil, it might probably be preferable to take that from some different type of soil.

A factor that is, in the writer's mind, far more important than the type of soil on which the seed stock was grown is the fertility or newness of the soil on which it was grown. Seed potatoes from a strong, rich soil are more likely to yield well than those from a more or less run down soil, and those grown on soil which has been under cultivation only a few years and still has most of the productive vigor of a new soil are probably the best of all. That this is true is supported by numerous strong indications along that line observed by growers as well as by the writer. Some growers in this state base their selection of new seed stock for renewal purposes on this point. Further experimental work leading to definite results along this line will be developed as rapidly as possible.

There are other points in regard to the selection of seed stock to be kept in mind when buying new stock which will be brought out later.

The best time to get new seed stock is in the fall. Potatoes are usually cheapest in the fall, and there is a much larger supply available then from which to select.

Relation of Form of Tubers to Degeneration.

General observations indicate very strongly that certain characteristics of the tubers of potatoes are associated with degeneration. Some of these characteristics are elongation in varieties which are typically roundish, oval or medium in length, slenderness in long varieties, roundness in long varieties, tapering ends, increase in number and depth of eyes, and reduction in average size of potatoes. All of these characters have been observed to be associated in varying degree with the degeneration of varieties at University Farm. It is probably safe to say that of two different lots of seed potatoes of the same variety the one which has the smallest aggregate amount of the above indications in its tubers is the least degenerated of the two. That being true, it would necessarily follow that the lot which had the least indications of degeneration would also have the greatest yielding power.

Another question which arises in this connection is whether tubers of the same lot having strong indications of degeneration are actually more degenerate than other tubers of the same lot which have slight or no indications of degeneration. Results bearing on this point were obtained by testing the yielding power of short, long, and small tubers of the Early Ohio and Sit Walter Raleigh varieties, and also by sorting out degenerate tubers of quite a number of the varieties in the variety plots.

The soil ~~of~~ and the cultural conditions for these tests were the same as in the variety test. The small tubers were such as went through the 1-3/4 inch screen and over a one-half inch screen (square mesh), and were not sorted out for shape. In the other plots the tubers were mostly from five to ten ounces in size. The relative size of the degenerate and better formed tubers was approximately the same for each variety. The pieces cut for planting were approximately one ounce in size for all plots. The plots consisted of three rows four rods long. The Early Ohio stock used in this experiment has been grown at this Station since 1908, and the

Sir Walter Raleigh stock for six years at least, and probably more. The results are given in the following Table IV. The word "size" in parenthesis after "% over 1-3/4 inch screen" calls attention to the fact that the per cent which went over that screen represents the approximate relative average size of the tubers on a scale of 100.

Table IV. Yields from elongated and small tubers as compared with well formed tubers, in bushels per acre.

	Form of Tubers planted	Bu. per A over 1-3/4 in. screen	Total Bu. per A	% over 1-3/4 in. screen (Size)
Part I. Variety: Early Ohio				
Plot 1 Check	Short-oval	104.3	131.6	79
Plot 2*	Long	69.1		
Check plots		103.9	128.9	81
Gain		-34.8		
Plot 3	Small	99.3	136.1	73
Check plots		103.9	128.9	81
Gain		-4.6	7.2	
Plot 4 Check	Short-oval	103.5	126.3	82
Part II. Variety: Sir Walter Raleigh				
Plot 1 Check	Round	173.8	185.3	94
Plot 2	Long	164.6	175.1	94
Check plots		182.1	193.9	94
Gain		-17.5	-18.8	
Plot 3	Small	182.1	200.1	91
Check plots		182.1	193.9	94
Gain		.0	6.2	
Plot 4 Check	Round	190.4	202.6	94

*The potatoes which went through the 1-3/4 inch screen from this plot became mixed with those which went through the same screen from Plot 2 in Part I of

Table XIX. The weight of the potatoes which went over the screen had, fortunately, been kept separate for the two plots, and in order to straighten matters out,it remained to be determined from which of two sacks the larger quantity came. This was accomplished without any reason being left to doubt the solution. As further evidence the records show that the seed pieces in the plot involved in this table were two days slower in coming up than those from the check plots, a phenomenon which was invariably accompanied by a lower yield in 1911,when the seed potatoes selected for planting the different plots came from the same lot of seed stock.

Fig. 2. Short-oval tubers of Early Ohio. Yielded at rate of 103.9 bu. per acre over 1-3/4 in. screen. (Table IV)

Fig. 3. Elongated tubers of Early Ohio. Yielded at rate of 69.1 bu. per acre over 1-3/4 in. screen. (Table IV)

Fig. 4. Small tubers of Early Ohio. Yielded at rate of 99.3 bu. per acre over 1-3/4 in. screen. (Table IV)

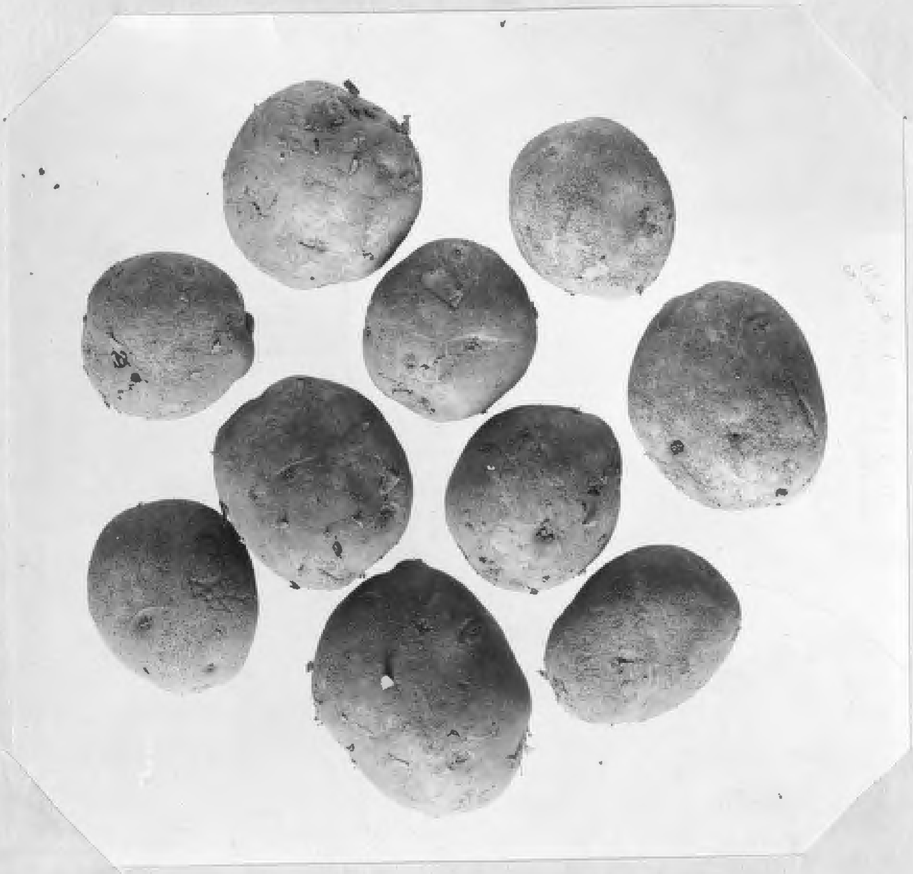


Fig. 5. Round tubers of Sir Walter Raleigh. Yielded at rate of 182.1 bu. per acre over 1-3/4 in. screen. (Table IV)

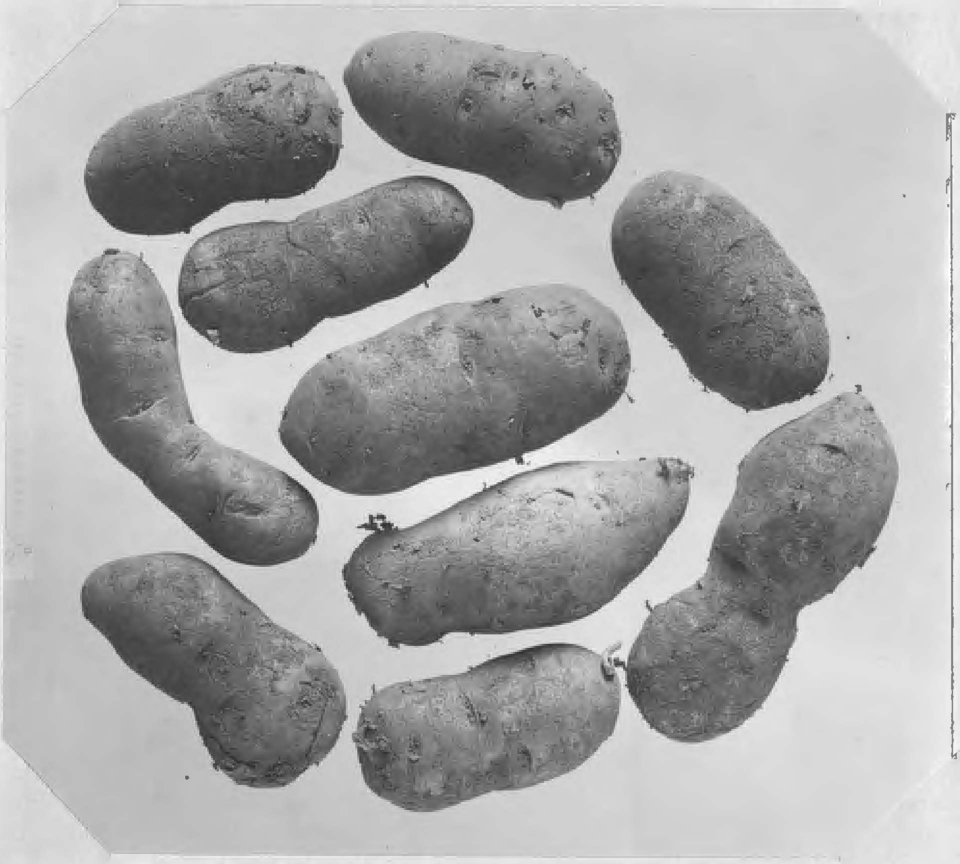


Fig. 6. Elongated tubers of Sir Walter Raleigh. Yielded at rate of 164.6 bu.per acre over 1-3/4 in. screen. (Table IV)

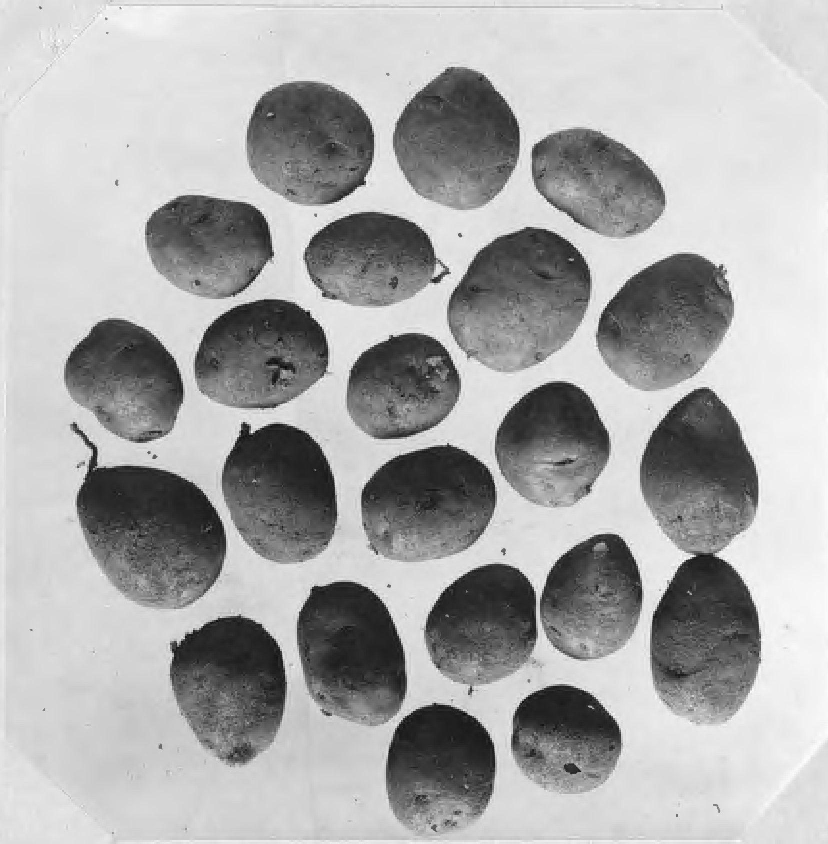


Fig. 7. Small tubers of Sir Walter Raleigh. Yielded at rate of 182.1 bu. per acre over 1-3/4 in. screen. (Table IV)

Additional results were secured by selecting degenerate tubers from quite a number of varieties in the variety of plots and planting them alongside of the selected tubers of the same varieties. The better seed stock sorted out for comparison was often limited in quality, owing to the fact that there was a very limited quantity of potatoes to select from. The size of the two kinds of each variety was nearly always about the same, and the size of the seed piece cut from each kind was usually about the same. One row four rods long was planted of the selected and degenerate tubers of each variety used in this test except in the degenerate rows of Eureka Extra Early, Early Ohio (3630), Acme, White Ohio, Early Michigan, Early Rose and Norcross (3095 and 3596) which were only two rods long. The selected and degenerate rows of each kind were planted side by side in nearly all cases. Nearly all the lots used in this test have been grown at this Station from two to six years. The general cultural conditions were, of course, the same as in the variety tests.

In preparing Table V, in which the results of this work are contained, the varieties were assembled into groups according to the system of classification in Table I.

Table V. Gains in yield from the better formed tubers as compared with the degenerate tubers from the same lot of potatoes, in bushels per acre.

Ac. No.	Variety	Over 1-3/4 in. Screen	Total	% over 1-3/4 in. Screen (Size)	Days for Rows to appear	Size of Plants on Scale of 10
Part I. Cobbler Group.						
3593	Irish Cobbler, Selected.	22.8	47.8	48	20	5
	Degenerate	.0	19.9	0	19	4
	Gain over degenerate	22.8	27.9			
3843	Eureka Extra, Early. Selected.	17.4	45.0	39	18	3
	Degenerate	31.8	53.5	59	19	5
	Gain over degenerate	-14.4	-8.5			
	Average gain for group	4.2	9.7			
Part II. Ohio Group.						
3630	Early Ohio, Selected.	34.8	77.5	45	20	6
	Degenerate	47.8	87.1	55	21	5
	Gain over degenerate	-13.0	-9.6			

Ac. No.	Variety	Over 1-3/4 in. Screen	Total	% over 1-3/4 in. Screen (Size)	Days for Rows to appear	Size of Plants on Scale of 10
3787	Early Ohio, Selected.	58.2	105.3	55	19	7
	Degenerate	77.9	118.7	66	19	7
	Gain over degenerate	-19.7	-13.4			
3786	Acme, Selected.	72.3	109.4	66	20	8
	Degenerate	69.1	92.3	75	20	8
	Gain over degenerate	3.2	17.1			
3866	Early Six Weeks	64.2	105.0	61	21	8
	Degenerate	41.4	65.1	64	22	7
	Gain over degenerate	22.8	39.9			
3854	White Ohio	24.2	72.9	33	20	6
	Degenerate	50.0	81.0	62	22	6
	Gain over degenerate	-25.8	-8.1			
	Average gain for group	-6.5	5.2			

Ac. No.	Variety	Over 1-3/4 in. Screen	Total	% over 1-3/4 in. Screen (Size)	Days for Rows to appear	Size of Plants on Scale of 10
Part III. Michigan Group						
2846	Early Michigan	9.9	45.4	22	20	4
	Degenerate	17.6	45.7	39	21	4
	Gain over degenerate	-7.7	- 0.3			
3858	Early Rose	44.4	109.4	41	18	8
	Degenerate	13.2	57.9	23	17	5
	Gain over degenerate	31.2	51.5			
3754	Burbank	53.7	101.1	53	18	6
	Degenerate	3.6	36.7	10	19	3
	Gain over degenerate	50.1	64.4			
3755	Pingree	73.9	121.8	61	18	8
	Degenerate	29.2	48.1	61	21	4
	Gain over degenerate	44.7	73.7			
	Average gain for group	39.6	47.3			

Ac. No.	Variety	Over 1-3/4 in. Screen	Total	% over 1-3/4 in. Screen (Size)	Days for Rows to appear	Size of Plants on Scale of 10
Part IV.	Green Mountain Group					
3057	Green Mountain	45.9	60.8	75	21	4
	Degenerate	3.7	18.8	19	24	1
	Gain over degenerate	42.2	42.0			
3063	State of Maine	38.5	57.9	66	21	3
	Degenerate	9.8	21.2	41	24	1
	Gain over degenerate	28.7	36.7			
3590	State of Maine	32.9	52.2	63	21	3
	Degenerate	10.1	26.8	38	22	2
	Gain over degenerate	22.8	25.4			
1625	Carman No.1	21.2	36.3	58	23	3
	Degenerate	6.0	12.0	50	28	1
	Gain over degenerate	15.2	24.3			
3764	Carman No. 1	18.1	34.9	52	22	3
	Degenerate	14.5	31.8	46	22	1
	Gain over degenerate	3.6	3.1			

Ac. No.	Variety	Over 1-3/4 in. Screen	Total	% over 1-3/4 in. Screen (Size)	Days for Rows to appear	Size of Plants on Scale of 10
Part IV (Cont.)						
3095	Norcross	53.8	72.6	74	23	4
	Degenerate	29.2	42.4	69	24	3
	Gain over degenerate	24.6	30.2			
3596	Norcross	30.0	45.4	66	24	3
	Degenerate	4.2	13.2	32	29	1
	Gain over degenerate	25.8	32.2			
3616	Freeman	41.1	58.2	71	21	4
	Degenerate	39.4	55.3	61	22	4
	Gain over degenerate	1.7	2.9			
	Average gain for group	20.6	24.6			
Part V. Rural Group						
3631	Rural New Yorker No. 2.	103.8	117.2	89	24	3
	Degenerate	57.7	70.0	82	26	2
	Gain over degenerate	46.1	47.2			

Ac. No.	Variety	Over 1-3/4 in. Screen	Total	% over 1-3/4 in. Screen (Size)	Days for Rows to appear	Size of Plants on Scale of 10
Part V. Rural Group(Cont.						
3762	Rural New Yorker No. 2.	156.4	172.4	91	21	7
	Degenerate	64.8	76.7	84	27	2
	Gain over degenerate	91.6	95.7			
2733	Sir Walter Raleigh	114.7	125.3	92	22	4½
	Degenerate	89.0	99.9	89	26	3
	Gain over degenerate	25.7	25.4			
3763	Sir Walter Raleigh	116.5	123.2	95	22	4½
	Degenerate	83.3	88.6	94	27	2½
	Gain over degenerate	33.2	34.6			
3765	Carman No. 3	141.4	159.0	88	21	7
	Degenerate	50.1	57.5	87	28	2
	Gain over degenerate	91.3	101.5			

Ac. No.	Variety	Over 1-3/4 in. Screen	Total	% over 1-3/4 in. Screen (Size)	Days for Rows to appear	Size of Plants on Scale of 10
Part V. Rural Group(Cont.)						
3589	Late Petoskey	149.0	154.1	97	24	5
	Degenerate	101.8	112.5	90	27	4½
	Gain over degenerate	47.2	41.6			
	Average gain for group	55.9	57.7			
Part VI. Factor Group						
3587	Factor	54.0	68.1	79	22	6
	Degenerate	19.0	32.1	59	24	2
	Gain over degenerate	35.0	36.0			

<u>Note</u>. A minus sign before a number means a loss instead of a gain.

In addition to the experiments of the two preceding tables, selected and more or less degenerate seed stock of the Early Ohio variety was secured from each of three different potato growers of this state. Lots 3928 and 3929 were from C. E. Brown of Elk River, lots 3930 and 3931 were from Henry Schroeder of Sabin, and lots 3932 and 3933 were from Sam G. Wallace of Perham. The selected stock from all three was good. The poorer of the two lots from Mr. Schroeder was not badly degenerated, but the degenerate lots from the other two men were quite degenerate. The degenerate lots from Mr. Brown* and Mr. Wallace were from the same lot of seed stock and had been grown on the same land. The partly degenerate lot from Mr. Schroeder was obtained from a neighbor's stock of Early Ohio, but had been grown on the same kind of land as Mr. Schroeder's. Two four-rod rows were planted of each of lots 3928 to 3931, and one four-rod row from lots 3932 and 3933. The cultural conditions were the same as for the plots in the two preceding tables. The results are contained in Table VI, which follows.

* According to a letter of May 2, 1911 from Mr. Brown, which had been overlooked, lots 3828 and 3829 were not selected from the same lot as had been supposed. A. R. K. 3/31/13

Table VI. Gains in yield from selected tubers of Early Ohio from different farmers as compared with more or less degenerate tubers of the same variety, in bushels per acre.

Ac. No.	Variety	Over 1-3/4 in. Screen	Total	% over 1-3/4 in. Screen (Size)	Days for Rows to appear	Size of Plants on Scale of 10
3928	Selected stock	102.6	152.1	67	18	7
3929	Degenerate "	111.1	162.5	68	19	7
	Gain over degenerate stock	-8.5	-10.4			
3931	Selected stock	154.3	173.4	89	20	8
3930	Medium stock	127.8	159.1	80	20	8
	Gain over Medium stock	26.5	14.3			
3932	Selected stock	165.9	176.6	94	20	9
3933	Degenerate "	142.0	168.9	84	19	9
	Gain over degenerate stock	23.9	7.7			
	Average gain for the better stock	14.0	3.9			

It will be observed in Table IV that the plots planted from small potatoes (about 1-1/2 to 3 ounce tubers) yielded a little more with both the Early Ohio and the Sir Walter Raleigh varieties than the average of the check plots which were planted from the best formed tubers that could be selected from the material available. This result is contradictory to the usual recommendation in regard to the use of small potatoes for planting and corresponds with results sometimes mentioned byfarmers, who on account of being short of seed potatoes of good size had planted small ones and thought they got just as good results from them as they did from the larger tubers. It must be said in this connection, however, that these same farmers,who have used small seed potatoes for one year in an emergency condemn it as a general practice, and claim that where done more than one year it leads to very rapid degeneration, a belief that is held by most Experiment Station workers as well. It is very important, therefore, that potato growers should not conclude, because the results were favorable for one year, that small seed potatoes can be planted continuously without unfavorable results. The results indicate only that small seed, or what is better known as "second size", can be used for one season in case of shortage of the better seed. Another year's test at the experiment station might show unfavorable results even the first year with the smaller seed. It is much more dangerous to buy small seed potatoes to plant than to use one's own in case of a shortage. The value of small seed potatoes probably depends altogether on the crop from which they were taken. If the general crop from which they were taken was of a degenerate character, the smaller tubers may have a great deal degeneration in them that does not show in their form. If it is necessary to buy second size potatoes for planting, it is important to know that the crop they were sorted out of was a good well grown crop with a minimum of degeneration.

The smaller size of the tubers from the plots planted from small tubers, as shown inthe last column of Table IV, should be noted. This difference probably resulted from the fact that the eyes were more numerous on the pieces cut from the smaller tubers and used on those plots than on the pieces cut from the larger ones used on the other plots.

The fact that elongated tubers from varieties which are short to medium in length and slender tubers from long varieties have a weaker yielding power than tubers of the opposite character is clearly demonstrated in the preceding tables. The results in the Michigan Group, especially with the Burbank type(Burbank and Pingree) and in the Green Mountain and Rural Groups, seem to demonstrate the smaller yielding power of tubers having degenerate form very conclusively. The very poor yield in the Cobbler Group and the few tests in it make the results from that group of little value until additional results can be obtained. In the Ohio Group the results are disconcerting in that in Table V three cases out of five show a higher yield than the degenerate stock. In the first and third comparisons of Table VI the conditions as to source of seed stock are parallel to those in the Ohio Group of Table V, the selected and degenerate seed tubers in each of the two cases having been obtained from the same stock. The results are also parallel, one lot resulting in favor of the selected seed stock and the other in a higher yield for the degenerate stock. This makes four instances where the degenerate stock yielded most to three where the selected yielded most. The average results from the seven comparisons, 0.3 bushels per acre of marketable (over 1½ inch screen) and 3.3 bushels per acre, total, in favor of the selected seed stock, are so small as to be almost insignificant. Contrasted with this is the large gain of 34.8 bushels per acre of large tubers in favor of the plot planted with the selected short-oval tubers over the plot planted with the long tubers from the Early Ohio variety in Part I, Table IV. (See note at the end of Table IV). A study of the photographs of the seed stock planted explains some of the apparent inconsistencies in the results from this group. Everything considered the general indications are that the principal ~~thing considered~~ is the same for the Ohio Group as in the other groups.

Another point worthy of attention in connection with this work is that the weakness of the degenerate seed stock was almost universally shown in the greater amount of time required for the plants to come through the ground. The long tubers of the Early Ohio variety of Table IV were two days behind the short tubers in coming through the ground. In the Sir Walter Raleigh variety of the same table the long tubers came up about as fast as the others, but by referring to the Rural Group of Table V it will be found that the long tubers averaged four and one-half days slower than the round tubers. In the Green Mountain Group of Table V the degenerate seed tubers average two and one-half days slower in coming up. In the other groups the difference was less.

The plants from the degenerate tubers were also smaller during the summer than those from the better formed tubers, as reference to the preceding tables will show. (See Fig. 1, p 16)

In 1909 tubers of five different shapes were se-

Fig. 8. Selected and degenerate tubers of Irish Cobbler (3593). Yielded total of 47.8 and 19.9 bu. per acre respectively. (Table V)

Fig. 9. Selected and degenerate tubers of Eureka Extra Early (3843). Yielded totals of 45.0 and 53.5 bu. per acre respectively. (Table V)

Fig. 10. Selected and degenerate tubers of Early Ohio (3630). Yielded total of 77.5 and 87.1 bu. per acre respectively. (Table V)

Fig. 11. Selected and degenerate tubers of Early Ohio (3787). Yielded total of 105.3 and 118.7 bu. per acre respectively. (Table V)

Fig. 12. Selected and degenerate tubers of Acme (3786). Yielded total of 109.4 and 92.3 bu. per acre respectively. (Table V)

Fig. 13. Selected and degenerate tubers of Early Six Weeks, Yielded total of 105.0 and 65.1 per acre respectively. (Table V)

Fig. 14. Selected and degenerate tubers of White Ohio. Yielded total of 72.9 and 81.0 respectively. (Table V)

Fig. 15. Selected (3928) and degenerate, so-called 3929 Early Ohio from C. E. Brown. Yielded total of 152.1 and 162.5 bu. per acre respectively. (Table VI)

Fig. 16. Selected (3932) and degenerate (3933) Early Ohio from Sam. G. Wallace. Total yielded 176.6 and 168.9 bu. per acre respectively. (Table VI)

Fig. 17. Selected and degenerate tubers of Early Michigan (2846). Yielded total of 45.4 and 45.7 bu. per acre respectively. (Table V)

Fig. 18. Selected and degenerate tubers of Early Rose (3858). Yielded total of 109.4 and 57.9 bu. per acre respectively. (Table V)

Fig. 19. Selected and degenerate tubers of Burbank (3754). Yielded total of 101.1 and 36.7 respectively. (Table V)

Fig. 20. Selected and degenerate tubers of Pingree (3755). Yielded total of 121.8 and 48.1 respectively. (Table V)

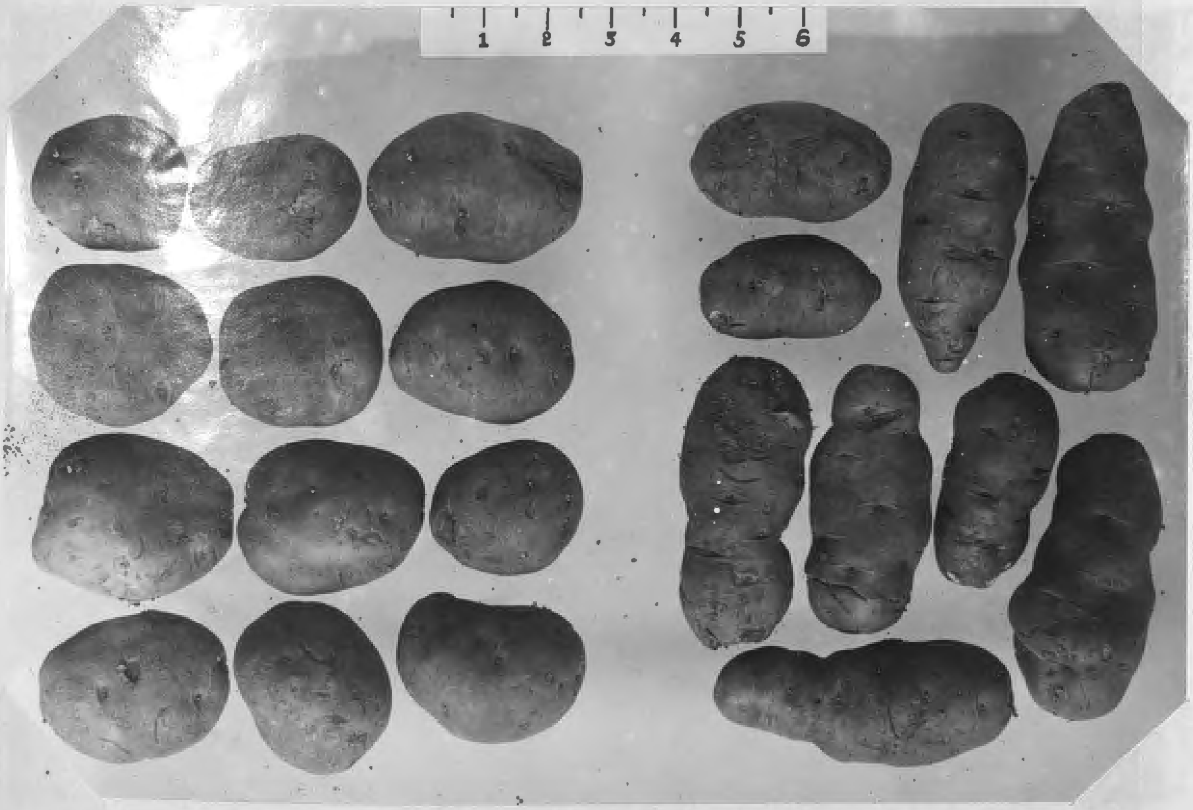


Fig. 21. Selected and degenerate tubers of Green Mountain (3057). Yielded total of 60.8 and 18.8 bu. per acre respectively. (Table V)

Fig. 22. Selected and degenerate tubers of State of Maine (3063). Yielded total of 57.9 and 21.2 bu. per acre respectively. (Table V)

Fig. 23. Selected and degenerate tubers of State of Maine (3590). Yielded total of 52.2 and 26.8 bu. per acre respectively. (Table V)

Fig. 24. Selected and degenerate tubers of Carman No. 1 (1625). Yielded total of 36.3 and 12.0 bu. per acre respectively. (Table V)

Fig. 25. Selected and degenerate tubers of Carman No. 1 (3764). Yielded total of 34.9 and 31.8 bu. per acre respectively. (Table V)

Fig. 26. Selected and degenerate tubers of Norcross (3095). Yielded total of 72.6 and 42.4 bu. per acre respectively. (Table V)

Fig. 27. Selected and degenerate tubers of Norcross (3596).. Yielded total of 45.4 and 13.2 bu. per acre respectively. (Table V)

Fig. 28. Selected and degenerate tubers of Freeman (3616). Yielded total of 58.2 and 55.3 bu. per acre respectively. (Table V)

Fig. 29. Selected and degenerate tubers of Rural New Yorker (3631). Yielded total of 117.2 and 70.0 bu. per acre respectively. (Table V)

Fig. 30. Selected and degenerate tubers of Rural New Yorker (3762). Yielded total of 172.4 and 76.7 bu. per acre respectively. (Table V)

Fig. 31. Selected and degenerate tubers of Sir Walter Raleigh (2733). Yielded total of 125.3 and 99.9 bu per acre respectively. (Table V)

Fig. 32. Selected and degenerate tubers of Sir Walter Raleigh (3763). Yielded total of 123.2 and 88.6 bu. per acre respectively. (Table V)

Fig. 33. Selected and degenerate tubers of Carman No. 3 (3765). Yielded total of 159.0 and 57.5 bu. per acre respectively. (Table V)

Fig. 34. Selected and degenerate tubers of Late Petosky (3589). Yielded totals of 154.1 and 112.5 bu. per acre respectively. (Table V)

Fig. 35. Selected and degenerate tubers of Factor (3587). Yielded totals of 68.1 and 32.1 bu. per acre respectively. (Table V)

lected from the White Beauty (2452), a variety of the Rural Group, for the purpose of determining the heredity of form. One row about 80 feet long was planted of each form. The results in yield are given in Table VII, which follows.

Table VII. Yields from different shaped tubers of the White Beauty Variety (Rural Group) in 1909. Given in bushels per acre.

Plot No.	Form of Tubers Planted	Over 1-3/4 in. Screen	Total
1	Short,round,flattened	166.4	216.7
2	Short,round,thick	171.1	230.7
3	Long,oblong	154.7	210.3
4	Tapering toward stem end	196.6	234.0
5	Tapering toward "seed" end	167.0	229.0

Fig. 36. Round, flattened seed potatoes of White Beauty. (Table VII)

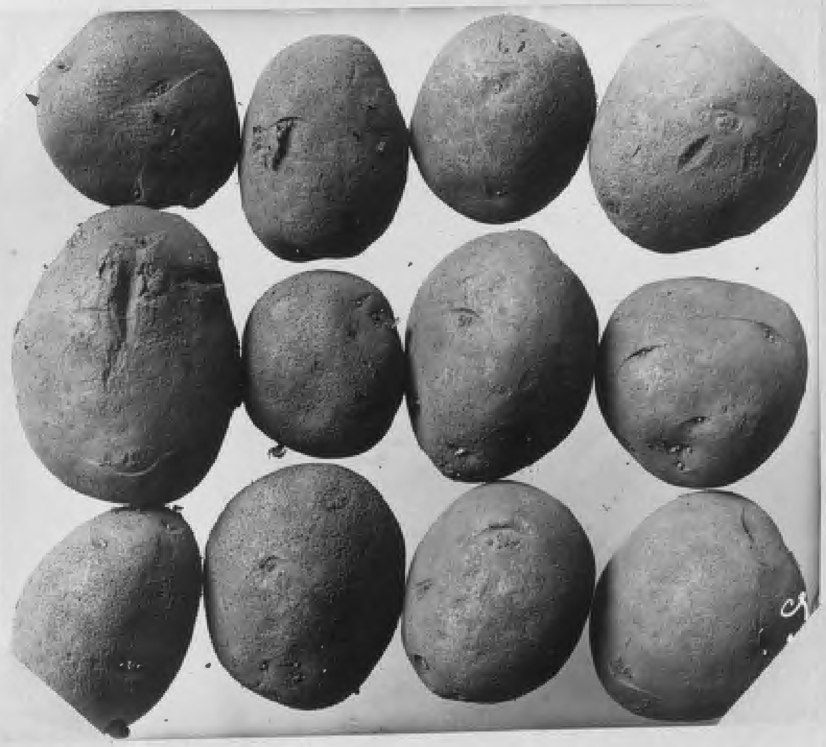


Fig. 37. Round, thick seed potatoes of White Beauty. (Table VII)

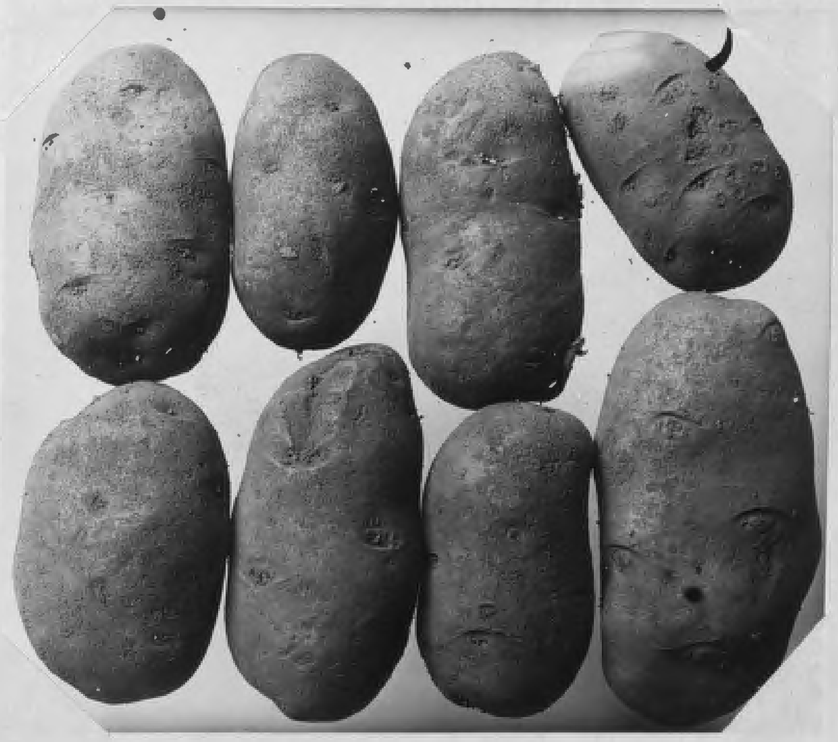


Fig. 38. Long seed potatoes of White Beauty.

(Table VII)

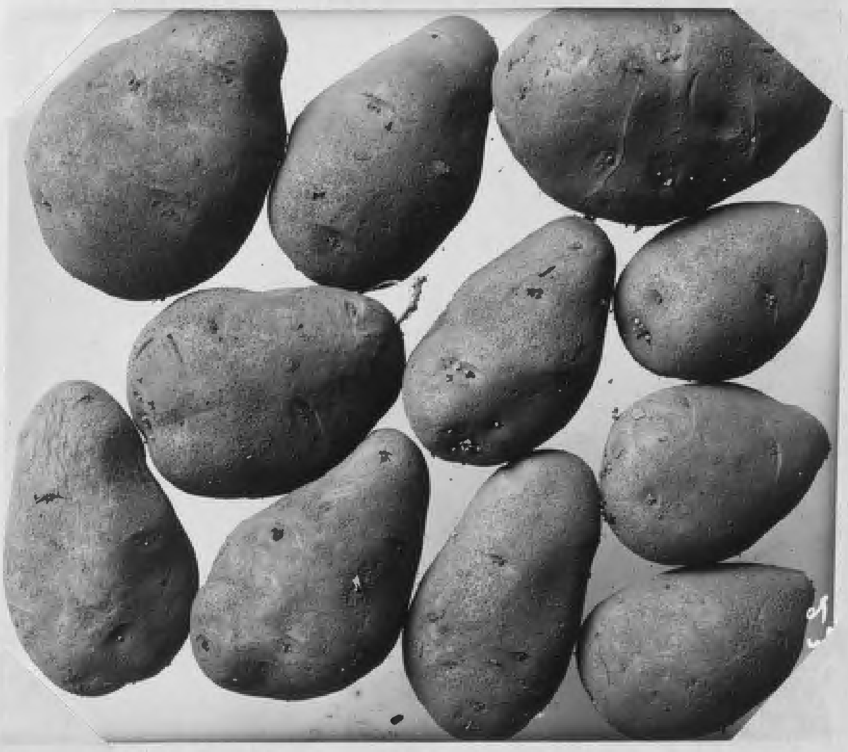


Fig. 39. Seed potatoes tapering at stem end, of White Beauty. Table VII)

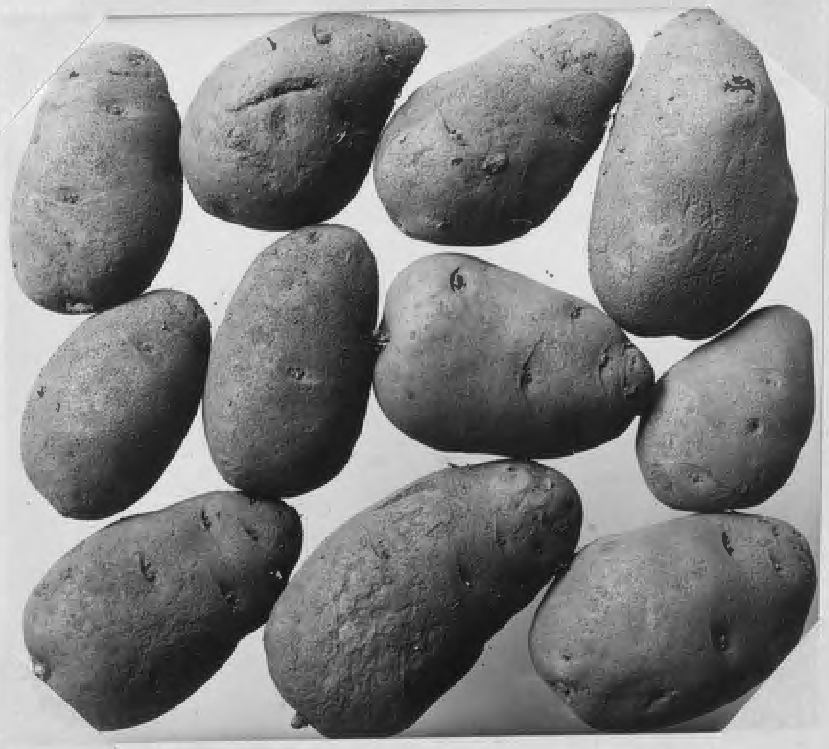


Fig. 40. Seed potatoes tapering at "seed" end, of White Beauty (Table VII)

The long tubers used for planting in the above test were not as degenerate in character as the large tubers of the Rural Group selected for planting in 1911. They differed in being less slender for their width.

The results from the long tubers as compared with the round ones correspond with those shown in Tables V and VI. Apparently thick, round tubers are just as good as flattened, round tubers (better inthis instance), but more trials are necessary before any conclusions can be drawn. More tests are also needed with tapering tubers before the results can be given much weight.

The principal reason for giving these results was to show that long tubers had yielded less than round tubers in 1909 as well as in 1911.

The results in the Michigan Group, especially with the Burbank and its similar variety, the Pingree, and in the Green Mountain and Rural Groups, are so large and so generally in favor of the better formed tubers that there can be no question of the importance of avoiding degenerate tubers in selecting seed potatoes from varieties of those types. The same thing that was true of the

Michigan Group would, in all probability, hold true in the Russet Group. While the results are indefinite as yet for the Cobbler Group and not wholly conclusive for the Ohio Group, it would undoubtedly be wise for growers to assume the same principles to be true for these groups also and select seed potatoes accordingly.

Lots No. 3931 and 3930 of Early Ohio in Table VI were not selected from the same lots of seed stock, No. 3930 having been selected from a crop which yielded appreciably less from that from which No. 3931 was selected. The gain in favor of the better stock may have been due in part to less degeneration in the stock from which the tubers were selected, as well as to the difference in vitality, as indicated by the individual tubers of each lot. Lots 3828 and 3829 were also not selected from the same lot

In order to show that the possible smaller size of hills in which the long tubers grow was not the cause of the smaller yield, some of the results of a hill study experiment will be presented at this point. Forty-seven Sir Walter Raleigh hills were saved separately in 1910 and planted separately in 1911. Eleven of the hills selected were composed of only distinctly long tubers. These hills weighed an average of 20.6 ounces per hill. Their product averaged 14.1 ounces per hill. Contrasted with these the eleven smallest hills of the lot containing only round tubers weighed an average of 16.9 ounces per hill and their product weighed an average of 21.3 ounces per hill, which was 51% more than the product from the hills consisting of long tubers.

The results from a few hills containing both round and long tubers showed less difference in favor of the round tubers than above, but on account of incompleteness of data, the small number of the hills of this class and the ~~varieties~~ variation in the results among individual hills it is necessary to wait for further results before making any statement on this phase of the problem. The average yield from the round tubers of these seven hills was 22.7 ounces per hill and from the long tubers was 20.5 ounces per hill, which was in this case 10.7% in favor of the round seed tubers.

In the spring of 1911 a selection of fairly short and rather blocky tubers was made from three lots of Early Michigan and one lot of Early Harvest potatoes and planted separately to see whether they were different strains of those varieties. Comparison of the two selections of each lot during the growing season and of the tubers at the end of the season seemed to warrant the conclusion that the short tubers were not of a different strain. The results are therefore available for a study of the yielding power of short tubers from varieties which are normally long. The tubers of the shorter form were somewhat smaller than the others, but not enough so to account for the results obtained. The cultural conditions were the same as for the variety test. The results are given in table VIII, which follows.

Table VIII. Yield from short tubers as compared with long tubers in varieties which are normally long, in bushels per acre.

Ac. No.	Variety	Over 1-3/4 in. Screen	Total	% over 1-3/4 in. Screen (Size)	Days for Rows to appear	Size of Plants on Scale of 10
2846	Early Michigan, Typical form.	9.9	45.4	22	20	4
	Short blocky tubers	2.1	35.3	6	21	3
	Gain	7.8	10.1			
3860	Early Michigan, Typical form	58.2	111.8	52	19	8
	Short blocky tubers	21.6	58.9	37	21	6
	Gain	36.6	52.9			
3878	Early Michigan, Typical form.	32.4	99.1	33	18	7
	Shorter blocky tubers	6.5	42.8	15	20	3
	Gain	25.9	56.3			
3927	Early Harvest, Typical form.	74.1	109.1	68	18	8
	Short blocky tubers	45.4	87.1	52	20	7
	Gain	28.7	22.0			

The results in Table VIII show that short tubers inclined to blockiness of form are considerably inferior in yielding power to the longer, more normally formed tubers of the varieties tested. At first thought these results seem contradictory to those obtained in such groups as the Green Mountain and Rural, in which short tubers yield more than long ones. They are, however, not necessarily so. They simply show that short tubers will not yield more than long tubers regardless of variety, and that in determining which are the degenerate tubers of a variety (degeneration being regarded as parallel to reduced yielding power) it is necessary to take into consideration the normal form of the variety when grown under the best of conditions.

A knowledge of the relation of form of tubers to degeneration and yielding power is of value, not only in the selection of seed potatoes from one's own stock, but in judging the probable state of degeneration of seed stock under consideration for purchase. The larger the per cent of badly degenerated tubers and the greater the degree of degeneration of the general run of the stock the more ~~is~~ the probable yielding power is reduced. Moreover it is probably true that even the better formed tubers of a crop showing considerable degeneration do not have as high a yielding power as similarly formed tubers of a crop showing little degeneration. There is, at any rate, a great difference in the yield produced by different lots of seed stock when one is apparently no better formed than the other. This has been noticed most in the Rural Group.

The better forms of tubers can largely be determined from the illustrations given in connection with this work. In may cases, however, the best formed tubers that could be selected from the stock available were far from ideal.

It must be understood in all cases that the tubers ought not to be too small when judging their probable merits according to form. They ought not to be less than four or five ounces in weight and six to ten ounces is better.

If a large proportion of the tubers average rather small in size, that fact is in itself likely to be a strong indication of degeneration. When the soil is unusually rich and the tubers are small on account of a very deficient rainfall this may not hold true, but such exceptions would rarely apply to Minnesota.

The best form of tuber for varieties of the Cobbler and Green Mountain Groups is one which is short, preferably no longer than wide, and blocky, having rather square ends. They may be more or less flattened according to the nature of the variety. In the Rural Group the requirements are much the same, differing in that the form is not quite so blocky, tending more toward roundish and usually quite flattened. In the Factor, and other similar varieties, the form is also quite flattened, but still more roundish than in the Rural Group. In the Ohio Group the form is what is known as oval. The shorter this oval form, as compared with the width of the tuber, the better it is. The ends of the tubers should be well rounded and plump, rather than tapering. In long varieties of the Michigan and Russet Group extreme shortness of form is not particularly desirable; in fact tubers of these varieties which approach a round form do not yield as well as those of normal length for the variety. Thickness of tuber as compared with length, the tuber being plump for practically its full length, is, in general, the most desirable form for varieties of these two groups.

A strong tendency to taper toward the ends is also a sign of degeneration. In long varieties a natural decrease in size toward the ends must not be confused with the tapering above referred to. Plump ends as contrasted with narrow ends inclined toward pointedness is the thing to look for in long varieties.

Badly degenerated tubers usually have in addition to the other indications mentioned an increased number of eyes, which are apt to be deeper and smaller than usual.

The causes of degeneration are probably malnutrition of some sort, which may be insufficient, unbalanced, irregular or other improper feeding due to soil, season, climate, disease, management of the crop and other causes.

Heredity of Form of Tubers.

The tubers produced in 1909 on each of one of the plots in Table VII were sorted into the five shapes first selected to see what the proportion of each shape for each plot would be. Only those tubers which went over the 1-3/4 inch screen were used for this purpose. The quantity of tubers used ranged from 51 to 65 pounds per plot. The results are contained in the following table:

Table IX. Per cent of tubers of different shapes from plots planted with different shaped seed tubers.

Plot No.	Form of tubers planted	% Round, Flat	% Round, Thick	Sum of Two Prec. Col.	% Long Oblg	% Tapg twd Stem End	% Tapg twd Seed End	% Un Classified
1	Round, flattened.	34.8	26.5	61.3	19.8	9.2	3.9	5.8
2	Round, thick	39.4	25.3	64.7	17.9	12.7	0.5	4.2
3	Long, oblong	26.9	26.1	53.0	23.0	15.7	1.0	7.3
4	Tapering toward stem end	32.5	30.9	63.4	20.3	11.4	0.8	4.1
5	Tapering toward seed end	25.1	31.4	56.5	24.2	10.6	1.0	7.8

It is apparent in the above table that the tendency of the crop to conform in shape to some selected form of seed potatoes was almost negligible, but that instead the form of the product conformed to the natural tendencies of the variety regardless of form of tuber selected for planting. In plot 3, which was planted with the long oblong tubers, there is a somewhat larger percent of long tubers than in the other plots, but this could easily be ascribed to the influence of the degeneracy of the tubers planted, as was indicated in the yield of this plot as shown in Table VII. Approximately the same per cent of long tubers was obtained from plot 5, which was planted from tubers tapering toward the seed end, and which, if the yield shown in Table VII is considered, may with plot 3 also be regarded as having been more degenerate than the seed potatoes used for the other plots.

In Part II of Table IV (p35) it will be noted that Plot 1 was planted with round seed tubers of the Sir Walter Raleigh variety (Rural Group) and Plot 2 with long seed tubers of the same variety. Samples of the seed potatoes used will be found illustrated in Figs. 5 and 6. In order to determine the relation of the form of the product to the form of the seed tubers the length and width of each of the tubers of Plots 1 and 2 were measured. Only those which went over the 1-3/4 inch screen were used, those which went through having already been discarded. The length of each tuber was then divided by its width in order to get the relation of length to width of each. The tubers were then classified into groups according to relation of length to width. Tubers which were of the same length and width were in the "1.0" class, those one and one-half times as long as wide in the "1.5" class and others in proportion. In placing tubers in their respective classes the plan followed may be illustrated by referring to the 1.5 class. This class included all tubers from 1,445 to 1.544 in relation of length to width. The number of tubers measured were 302 from the plot planted with round seed and 274 from the plot planted with long seed. The results are given in Table X, which follows:

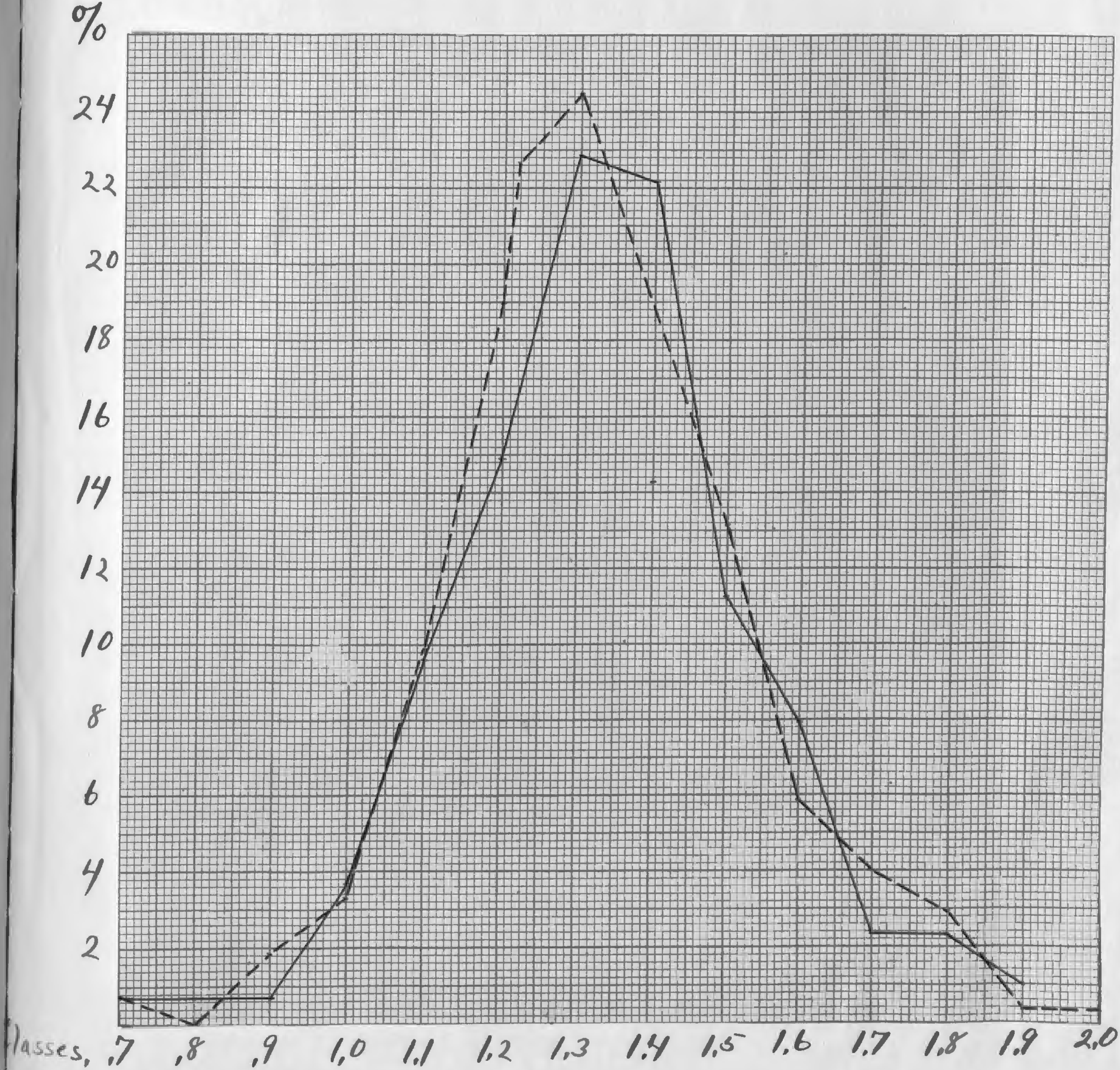
Table X. Number and per cent of different shaped tubers obtained from short and long seed potatoes selected from the same lot of Sir Walter Raleigh Stock.

Relation of Length to Width	Plot 1. Product from round seed tubers		Plot 2. Product from long seed tubers	
	No. of Tubers	Per Cent	No. of Tubers	Per Cent
0.7 to 1	2	0.67	2	0.73
0.8 " 1	2	0.67		
0.9 " 1	2	0.67	5	1.82
1.0 " 1	11	3.64	9	3.28
1.1 " 1	29	9.60	27	9.85
1.2 " 1	45	14.90	52	18.98
1.3 " 1	69	22.84	67	24.45
1.4 " 1	67	22.18	39	14.23
1.5 " 1	34	11.25	36	13.15
1.6 " 1	24	7.94	16	5.84
1.7 " 1	7	2.32	11	4.01
1.8 " 1	7	2.32	8	2.92
1.9 " 1	3	1.0	1	0.37
2.0 " 1			1	0.37
	302		274	

In order to illustrate these results graphically they were plotted on a curve as shown in Fig. 41. The figures at the bottom of the chart are the classes according to the relation of length to width of tubers, with the shortest tubers to the left and the longest ones at the right, and the vertical distance represents the per cent of tubers of each class.

One glance at the curves on Fig. 41 is sufficient to show that the long seed tubers yielded a product which was no longer than that from the round seed tubers. The slight increase of those 1.7 and 1.8 longer than wide was probably due to the weaker yielding power of the long seed tubers.

The product of many of the varieties shown in Table VI where selected and degenerate tubers had been planted to study their relative yielding power were also measured and classified according to relation of length to width as in the preceding table. The method of procedure was the same. Unfortunately there was a comparatively small quantity of each lot, making the results too irregular for a good comparison . On this account



——— Percentages of each class from round seed tuber

- - - - Percentages of each class from long seed tubers,

Fig. 41, Results from round and long seed tubers of Sir Walter Raleigh. Table X.

all varieties of one group were assembled and treated as one variety, although there were some objections to its being done. The counts for the different lots are given in Table XI, which follows:

Table XI. Number and per cent of different shaped tubers obtained from short and long seed potatoes which had been selected from the same lots.

Part I. Ohio Group.

Relation of Length to Width	Product from short-oval seed tubers: No. of tubers from each lot 3630	3787	3866	3786	Total No.	Per Cent	Product from long seed tubers: No. of tubers from each lot 3630	3787	3866	3786	Total No.	Per Cent
0.7 to 1										1	1	0.62
0.8 " 1	1			1	2	0.87						
0.9 " 1			1	2	3	1.31			2	0	2	1.23
1.0 " 1	2	2	2	3	9	3.93		7	1	2	10	6.17
1.1 " 1	4	7	9	12	32	13.97	1	4	1	5	11	6.79
1.2 " 1	5	12	14	11	42	18.34	6	14	2	6	28	17.28
1.3 " 1	4	19	8	18	49	21.40	4	20	2	5	31	19.14
1.4 " 1	9	13	14	10	46	20.09	5	20	6	3	34	20.99
1.5 " 1	5	9	8	4	26	11.35	3	8	3	7	21	12.96
1.6 " 1	1	2	7	2	12	5.24		3	8		11	6.79
1.7 " 1	1	2		2	5	2.18		1	4	1	6	3.70
1.8 " 1				2	2	0.87	2		3		5	3.09
1.9 " 1							1		1		2	1.23
2.0 " 1	1				1	0.44						
	33	66	67	63	229		22	77	30	33	162	

See p 118 concerning 3866

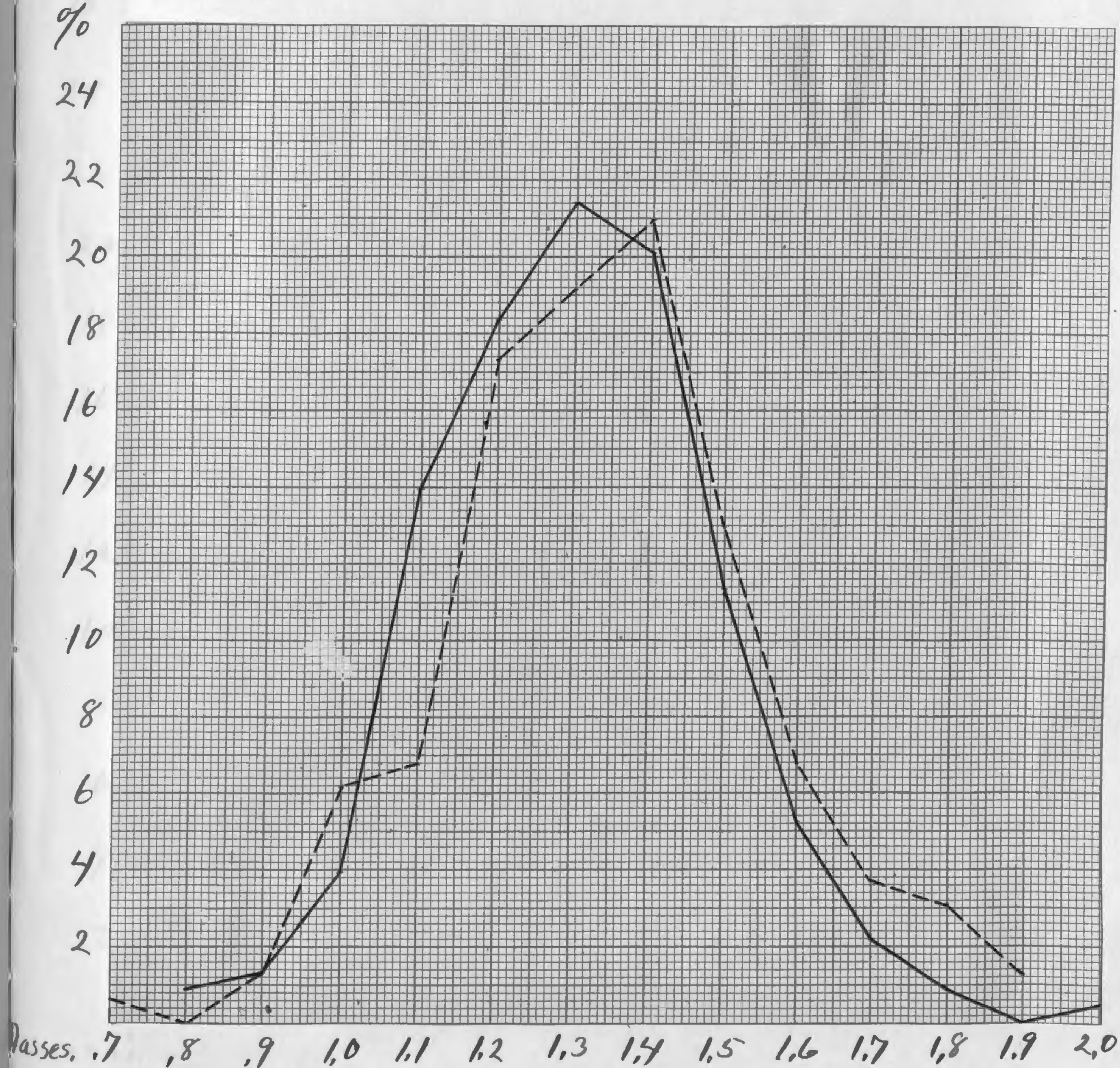
Part II. Green Mountain Group

Relation of Length to Width	Product from short-oval seed tubers: No. of tubers from each lot 3095	3616	Total No.	Per Cent	Product from long seed tubers: No. of tubers from each lot 3095	3616	Total No.	Per Cent
0.7 to 1		1	1	1.03				
0.8 " 1	2	2	4	4.12				
0.9 " 1		2	2	2.06	2	1	3	5.0
1.0 " 1	7	5	12	12.37	1	5	6	10.0
1.1 " 1	10	8	18	18.56	5	10	15	25.0
1.2 " 1	13	6	19	19.59	6	5	11	18.33
1.3 " 1	9	2	11	11.34	2	5	7	11.67
1.4 " 1	3	7	10	10.31	2	4	6	10.0
1.5 " 1	7	4	11	11.34	2	5	7	11.67
1.6 " 1	4	4	8	8.25		3	3	5.0
1.7 " 1								
1.8 " 1	1		1	1.03		2	2	3.33
1.9 " 1								
2.0 " 1								
	41	56	97		40	20	60	

Part III. Rural Group

Relation of Length to Width	Product from short-oval seed tubers: Number of tubers from each lot 3631	3762	2733	3763	3765	3589	Total No.	Per Cent	Product from long seed tubers: Number of tubers from each lot 3631	3762	2733	3763	3765	3589	Total No.	Per Cent
0.7 to 1					1		1	0.22								
0.8 " 1	1				2		3	0.66			1				1	0.36
0.9 " 1			1		1		2	0.44			1	2	1	1	5	1.81
1.0 " 1	6	8	1	6	4	4	29	6.42	4	2	4	2	6	5	23	8.30
1.1 " 1	8	16	16	10	15	12	77	17.04	6	10	5	6	3	7	37	13.35
1.2 " 1	14	23	20	17	13	4	91	20.13	4	9	13	11	4	16	57	20.58
1.3 " 1	9	29	23	16	14	9	100	22.12	7	9	15	8	8	10	57	20.58
1.4 " 1	8	12	7	10	14	9	60	13.27	6	5	9	9	3	7	39	14.08
1.5 " 1	9	1	6	6	13	6	41	9.07	5	3	4	8	6		26	9.39
1.6 " 1	1	4	3	3	3	7	21	4.65	1	2	4	4	1	3	15	5.42
1.7 " 1	2	1	1	3	4	7	18	3.98	1		3	1	1	2	8	2.89
1.8 " 1				2	1	2	5	1.11	2	1		3			6	2.17
1.9 " 1						3	3	0.66					1		1	0.36
2.0 " 1	1						1	0.22	1				1		2	0.72
	59	94	78	73	85	63	452		37	41	59	54	35	51	277	

In order to present the results graphically, each part of Table XI was plotted on a separate chart. The method was the same as for Fig. 41. In Fig. 42, showing the results from the Ohio Group, the broken line, representing the product from the long seed tubers, shows that the tubers were a little longer than those produced by the short seed tubers, indicating that there is somewhat of a tendency for the length of the seed tubers to be hereditary. By referring to Lot No. 3866 on both sides of Table XI, Part 1, a probable reason for this result is suggested. By examining the distribution of the tubers it will be noted that the product from the long seed tubers of 3866 was longer than the product of the short seed tubers of the same lot. A probable reason for this anomalous result, as compared with all of the others, is that the lot from which the selections were made may have been mixed. The variety was Early Six Weeks. This variety normally has longer tubers than the Early Ohio. If it was mixed with Early Ohio tubers, then the short seed tubers selected from this lot would contain more or less of the Early Ohio variety, and the

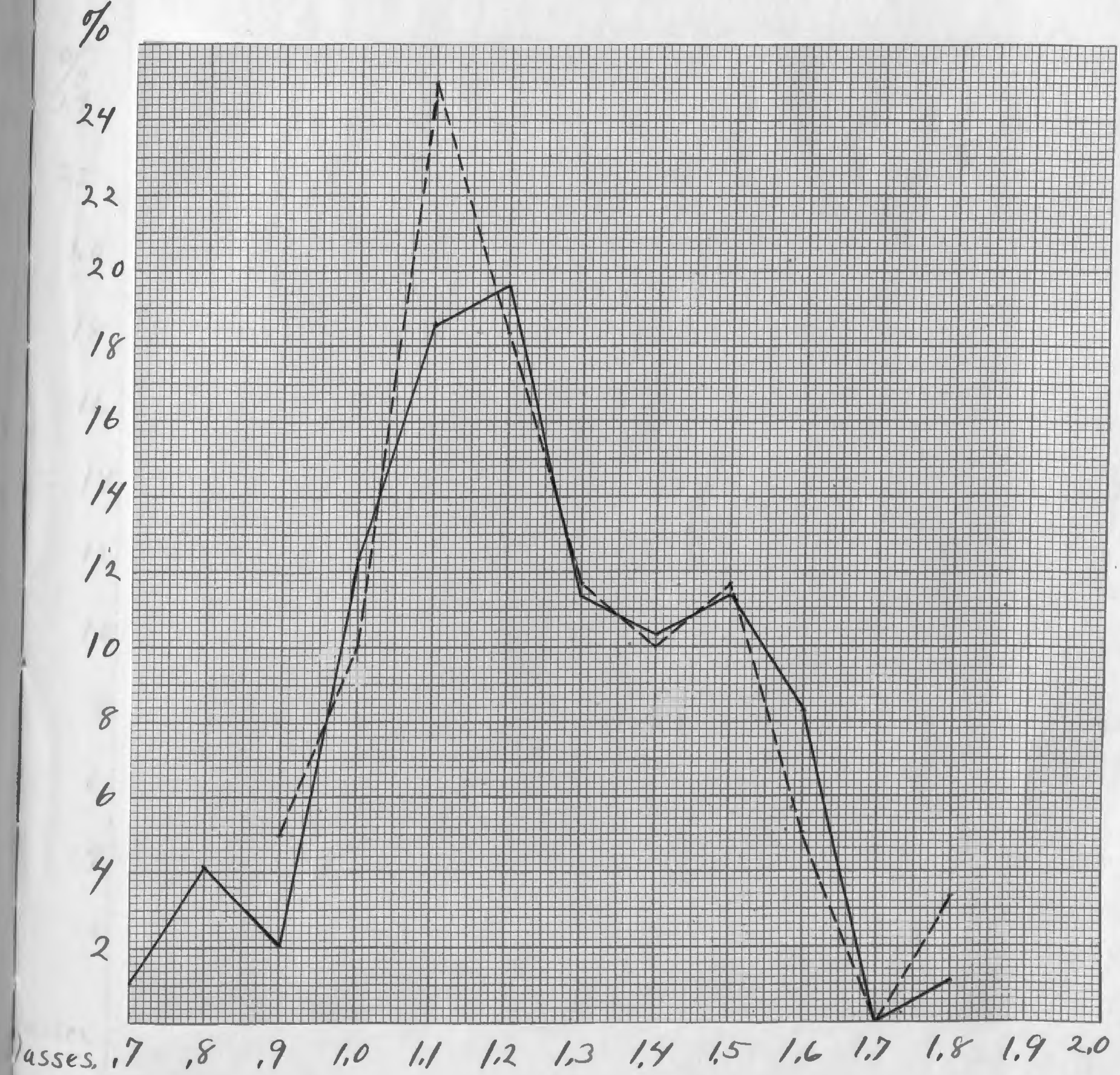


——— Percentages of each class from short seed tubers.

– – – Percentages of each class from long seed tubers.

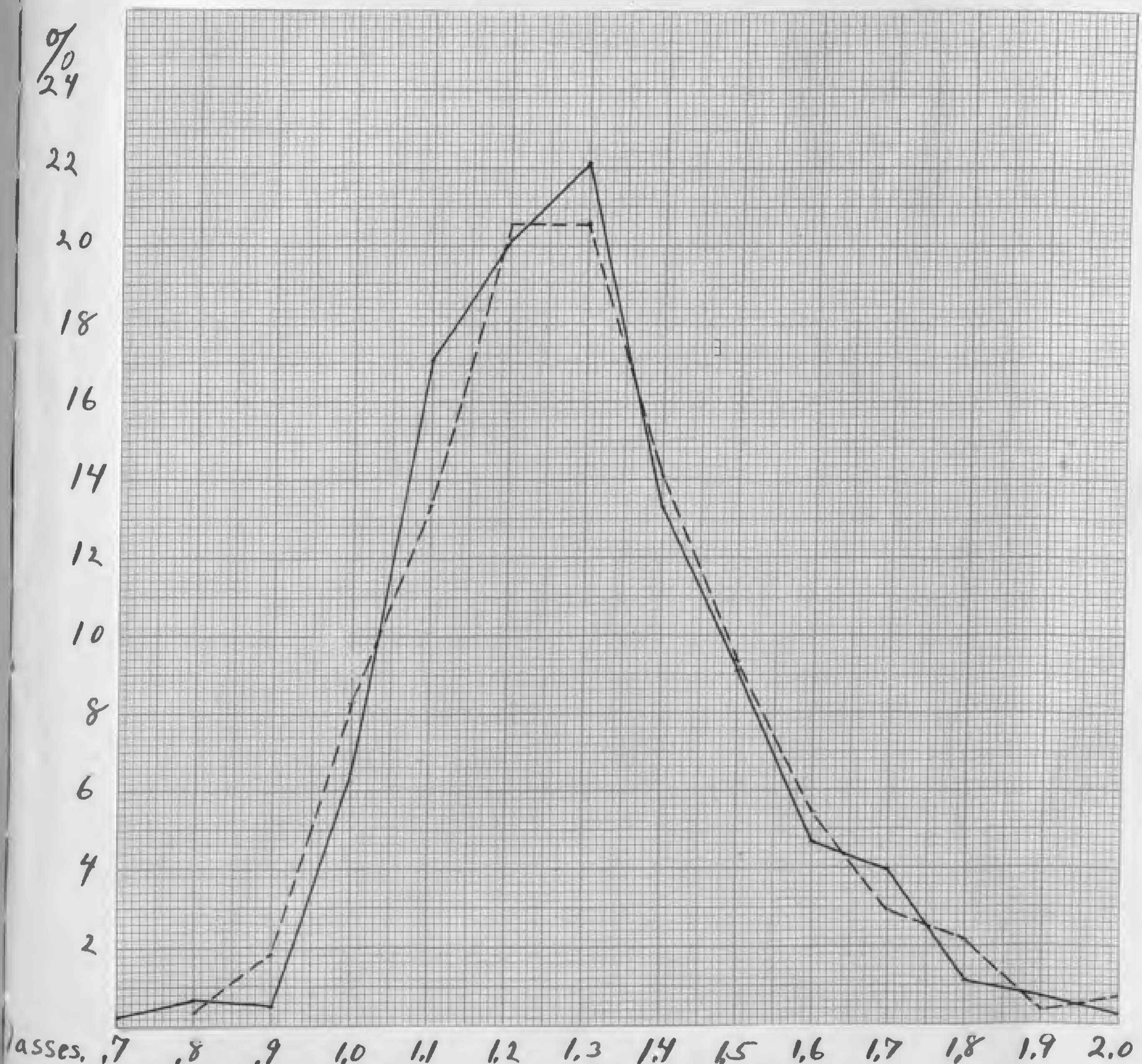
Fig. 42. Ohio Group.

See P 118.



——— Percentages of each class from short seed tubers.
- - - Percentages of each class from long seed tubers.

Fig. 43. Green Mountain Group.



——— Percentages of each class from round seed tubers.

- - - Percentages of each class from long seed tubers.

Fig. 44. Rural Group.

long seed tubers would be apt to consist mainly of the Early Six Weeks variety. If such was actually the case, as seems probable, this variety would need to be eliminated before making a comparison.*

Fig. 43 for the Green Mountain Group (see Part 2, of Table XI) and Fig. 44 for the Rural Group (see Part 3, Table XI) show that the product from the long seed tubers was practically no longer than the product from the short seed tubers of those two groups.

The question might be raised as to whether hills which consisted entirely of long tubers - the normal type for the variety being short tubers - would be more likely to produce long tubers than other hills of the same variety. As was previously mentioned in connection with a group of 47 hills of Sir Walter Raleigh potatoes which had been saved separately in 1910, eleven of those hills consisted of distinctly long tubers. Unfortunately no measurements were taken, but a general observation of the product when it was dug in the fall of 1911 failed to reveal any more tendency on the part of the eleven hills which consisted of long tubers to produce long tubers

*Subsequent examination for general appearance showed that the product from the degenerate seed of 3866 had quite a few more degenerate tubers than the product from the selected seed potatoes, there being a case of degenerate to form carried over rather than inherited form.

than could be seen in the potatoes produced by the hills which consisted of round tubers.

Other work which has been done along this line at University Farm was to select the shortest tubers of the Early Ohio and Sir Walter Raleigh varieties each year for the seed potatoes for the next year. The crop from two consecutive seasons' selection of the Early Ohio and from three consecutive seasons' selection of the Sir Walter Raleigh has been available for observation, and while no statistics were kept, so that it cannot be determined whether any progress has been made in changing the average shape to a shorter formed tuber, it can at least be said that the progress, if any, has been very slow, and there seems to be little hope of getting strains by this method that will produce only, or even largely, ideal tubers.

These results, and more especially the statistical results presented, indicate very plainly that it is practically hopeless to attempt to change the form of a variety of potatoes by selecting for planting tubers of a certain form or type. Of course, if two varieties should happen to be mixed, and one of them produced a largerper cent of tubers of the form desired than the other, then selection ~~from~~ for a certain form would bring results by means of the gradual reduction of the proportion of tubers of the variety or strain producing the smaller proportionof the form or type desired. In that case a better way would be to select a number of hills known to be of the more desired type and then keep the product from each hill separate, treating it as one would a variety until it could be determined which was the best strain, should any difference be found. If this would be done, selection for a given form would afterwards be unnecessary, because all that could be done toward getting a certain form would have been accomplished when the hill ultimately chosen was first selected.

The fact that the form of a variety cannot be changed by selecting tubers of the form desired should not be construed as meaning that the selection of seed potatoes is without value, for by referring to the preceding section of this thesis ~~bulletin~~ it will be seen that it pays to select the best formed tubers for planting because they yield considerably more per acre than the degenerate forms.

Heredity of Yield from Individual Hills.

It is a common practice to recommend the selection of the best yielding hills, made up of the best formed tubers for seed potatoes. The results presented in the preceding section of this ~~bulletin~~ thesis show that the form of seed potato planted apparently has no influence on the form of the tubers in the resulting crop aside from the possible effect of weakness due to the degeneration of certain forms.

As has already been mentioned forty-seven hills of Sir Walter Raleigh potatoes were saved separately in 1910. Each hill was weighed in ounces, and the number of tubers and the shape of all but the small ones in each hill recorded. Three hills were planted from each tuber, except the small ones, in the spring of 1911. Notes were taken on the size of the plants during the growing season. The results are given for each tuber planted in Table XII, which follows;

Table XII

Yields produced by Individual Hills of
Sir Walter Raleigh Potatoes,
Classified by Tubers.

Data on Parent Hills				Data on Product from Parent Hills						
No. of hill	Weight of hill	No. of small tubers	Large tubers by form	Plants: Size of plants on scale of 10.	Plants: Uniformity of size on scale of 10.	Yield of each hill in ozs.: Ist hill	Yield of each hill in ozs.: 2nd hill	Yield of each hill in ozs.: 3rd hill	Aver. Wt of hills grown from each tuber in ounces	Aver. w of all hills grown from each original hill in ounces.
1	8 oz	0	R	3	10	1	10	10	7.0	7.0
2	12 oz	0	L	3½	7	9	3	14	8.7	8.7
3	11 oz	0	L	4	10	*	10	12	11.0	11.0
4	11 oz	0	L	3		9	*	*	9.0	9.0
5	20 oz	0	R	7	9	33	21	16	23.3	
			R	7		23	*	*	23.0	23.2
6	13 oz	0	R	6	10	33	34	17	28.0	
			R	6	10	30	16	20	22.0	25.0
7	24 oz	0	R	7	10	20	34	36	30.0	
			R	7	10	24	19	27	23.3	26.7
8	16 oz	0	R	6	7	21	28	16	21.7	
			R	5	9	17	22	21	20.0	20.9
9	21 oz	0	R	6	10	31	30	24	28.3	
			R	7	8	38	38	11	29.0	28.7
10	16 oz	0	R	4½	8	19	26	28	24.3	
			R	5	8	14	18	31	21.0	22.7
11	12 oz	0	R	6	10	20	22	30	24.0	
			R	6	10	21	18	25	21.3	22.7
12	17 oz	0	R	6½	9	34	18	23	25.0	
			R	6	9	22	22	18	20.7	22.9
13	20 oz	0	L	5½	10	17	18	22	19.0	
			L	5½	10	16	23	22	20.3	19.7

No. of hill	Weight of hill	No. of small tubers	Large tubers by form	Plants: Size of plants on scale of 10	Plants: Uniformity of size on scale of 10	Yield of each hill in oz.: 1st hill	Yield of each hill in oz.: 2nd hill	Yield of each hill in oz.: 3rd hill	Average weight of hills grown from each tuber in ounces	Averag weight all hill grown from ea origina hill in ounces
14	23 oz	2	L	2½	10	7	7	10	8.0	
			L	2½	10	7	7	10	8.0	
			L	2½	10	7	5	7	6.3	7.4
15	21 oz	0	L	4	7	7	14	8	9.7	
			L	5	7	22	6	22	16.7	
			L	6	8	21	18	16	18.3	14.9
16	30 oz	0	L	5	8	21	20	8	16.3	
			L	6	9	20	30	41	30.3	
			L	7	9	19	27	23	23.0	23.2
17	22 oz	1	L	7	10	35	27	26	29.3	
			L	6	10	26	28	20	24.7	
			L	7	10	23	26	*	24.5	26.2
18	25 oz	1	L	2½	10	8	7	6	7.0	
			L	6	10	28	26	29	27.7	
			L	7	10	32	25	32	29.7	21.5
19	24 oz	1	L	2	10	6	6	9	7.0	
			L	2	10	9	8	*	8.5	
			L	2	10	8	7	8	7.7	7.7
20-	26 oz	0	L	2	10	4	4	9	5.7	
			L	2	10	4	7	9	6.7	
			L·	2	10	6	5	5	5.3	5.9
21	23 oz	2	R	6	6	16	38	9	21.0	
			L	7	5	38	25	8	23.7	
			L	6	9	17	24	31	24.0	22.9
22	25 oz	1	R	6	10	24	18	36	26.0	
			R	5	7	20	23	6	16.3	
			L	2½	7	10	4	7	7.0	16.4
23	27 oz	0	R	5	7	21	22	6	16.3	
			R	5½	10	20	22	19	20.3	
			R	6	10	21	16	26	21.0	
			R	6	5	16	27	4	15.7	18.3

No. of hill	Weight of hill	No. of small tubers	Large tubers by form	Plants: Size of plants on scale of 10.	Plants: Uniformity of size on scale of 10	Yield of each hill in oz.: 1st hill	Yield of each hill in oz.: 2nd hill	Yield of each hill in oz.: 3rd hill	Average weight of hills grown from each tuber in ounces.	Average weight of all hills grown from each original hill in ounces
24	25 oz	2	R	6	9	30	24	31	28.3	
			R	6½	10	16	24	17	19.0	
			R	6½	10	27	24	22	24.3	
			R	5	10	15	14	24	17.7	22.3
25	30 oz	3	R	7	10.	24	26	24	24.7	
			R	6	8	27	15	23	21.7	
			R	5	8	20	25	9	18.0	
			R	5	10	18	19	26	21.0	21.4
26	24 oz	0	R	7½	10	28	36	30	31.3	
			R	7	9	23	32	19	24.7	
			R	6	10	17	20	27	21.3	
			R	6½	10	18	17	29	21.3	24.7
27	20 oz	2	R	2	10	*	7	8	7.5	
			R	6	9	28	30	20	26.0	
			R	2	10	6	6	7	6.3	
			R	2	10	5	4	5	4.7	11.1
28	32 oz	0	R	7	9	27	38	19	28.0	
			R	7	10	*	33	31	32.0	
			R	7	10	35	26	26	29.0	
			R	7	9	28	19	*	23.5	28.1
29	24 oz	1	R	7	8	37	11	30	26.0	
			R	7	10	34	30	27	30.3	
			R	6	5	26	24	3	17.7	
			R	6	10	26	22	21	23.0	24.3
30	34 oz	0	R	2	10	7	7	5	6.3	
			R	2	10	7	8	7	7.3	
			R	2	10	9	*	8	8.5	
			R	2	10	10	8	5	7.7	7.5
31	20 oz	0	R	6	10	26	20	9	18.3	
			R	7	9	27	29	26	27.3	
			R	7	9	34	25	24	27.7	
			R	7	9	29	27	23	26.3	24.9

No. of hill	Weight of hill	No. of small tubers	Large tubers by form	Plants: Size of plants on scale of 10.	Plants: Uniformity of size on scale of 10	Yield of each hill in oz: 1st hill	2nd hill	3rd hill	Average weight of hills grown from each tuber in ounces	Average weight of all hills grown from each original hill in ounces
32	33 oz	0	R	7	8	9	22	20	17.0	
			R	8	9	32	24	7	21.0	
			R	7	9	38	26	28	30.7	
			R	7	8	15	10	51	25.3	23.5
33	23 oz	0	R	6	8	6	24	18	16.0	
			R	7	10	28	28	24	26.7	
			R	8	10	25	38	26	29.7	
			R	7½	10	29	27	32	29.3	25.4
34	25 oz	1	R	7	10	21	27	*	24.0	
			R	7½	8	40	23	26	29.7	
			R	7	5	4	39	8	17.0	
			R	7	9	32	28	42	34.0	26.2
35	25 oz	0	R	5		*	*	18	18.0	
			R	7½	10	38	35	31	34.7	
			R	7	10	13	29	23	21.7	
			R	7	10	22	42	50	38.0	28.1
36	25 oz	0	R	7	6	10	28	26	21.3	
			R	6	6	6	27	11	14.7	
			R	7	8	19	31	19	23.0	
			R	8	9	30	29	33	30.7	22.4
37	32 oz	2	R	2	10	5	6	4	5.0	
			R	2	10	5	5	5	5.0	
			R	2	10	4	8	5	5.7	
			R	3	8	9	6	4	6.3	5.5
38	24 oz	0	R	3	6	7	2	9	6.0	
			R	3	9	11	5	*	8.0	
			R	8	9	36	23	35	31.3	
			L	7	8	35	28	21	28.0	18.4
39	33 oz	0	R	8	9	12	36	35	27.7	
			R	8	10	13	26	28	22.3	
			R	8	9	15	29	17	20.3	
			L	8	9	35	34	31	33.3	25.9
40	37 oz	0	R	7½	5	9	44	29	27.3	
			R	7	9	37	22	43	34.0	
			R	7½	9	*	53	30	41.5	
			L	7½	7	19	47	5	23.7	31.6

No. of hill	Weight of hill	No. of small tubers	Large tubers by form	Plants: Size of plants on scale of 10.	Plants: Uniformity of size on scale of 10	Yield of each hill in oz.: 1st hill	Yield of each hill in oz.: 2nd hill	Yield of each hill in oz.: 3rd hill	Average weight of hills grown from each tuber in ounces	Average weight of all hills grown from each original hill in ounces
41	29 oz	0	R	7½	8	44	13	26	27.7	
			R	7½	9	28	28	*	28.0	
			R	6	10	29	26	21	25.1	
			R	7½	9	36	29	25	30.0	
			R	6	10	15	24	25	21.3	26.4
42	33 oz	0	R	7½	9	28	23	22	24.1	
			R	7	8	24	33	42	33.0	
			R	7½	9	31	*	61	46.0	
			R	7	10	17	37	23	25.7	
			R	7½	10	28	27	44	33.0	32.4
43	23 oz	0	R	2		*	*	4	4.0	
			R	6	5	35	30	1	22.0	
			R	3	7	11	6	3	6.7	
			R	6	9	37	15	16	22.7	
			R	6	9	21	10	22	17.7	14.6
44	27 oz	0	R	8	9	39	27	24	30.0	
			R	8	10	33	27	36	32.0	
			R	8	10	34	26	33	31.0	
			R	7	10	18	27	19	21.3	
			R	7	10	16	20	27	21.0	27.1
45	35 oz	1	R	3	10	3	7	5	5.0	
			R	7	6	7	33	28	22.7	
			R	3	10	5	4	7	5.3	
			R	7½	8	30	19	37	28.7	
			R	2	10	7	3	5	5.0	13.3
46	30 oz	0	R	7	9	16	21	25	20.7	
			R	7	10	28	24	34	28.7	
			R	7	9	*	26	24	25.0	
			L	7	8	27	18	40	28.3	
			L	3	5	7		1	4.0	21.3
47	33 oz	1	R	3	10	9	7	8	8.0	
			R	6	10	25	23	16	21.3	
			R	7	8	36	20	14	23.3	
			L	7	9	24	30	30	28.0	
			L	2	10	5	6	5	5.3	17.2

* Hill missing.

The average results from each of the forty-seven hills selected are presented graphically in Fig. 45. The original hills were divided into three classes - those composed of short tubers, those which contained both short and long tubers, and those composed of long tubers. The solid lines on the chart represent the hills of each group arranged on an ascending scale according to weight in ounces. The average weight of the hills from each parent hill was located on the same vertical line with the weight of the parent hill, and a dotted line was then drawn connecting these points. An examination of the part of the chart representing the results from the hills with round tubers shows that the average yield from the largest hills was no better than the average yield from the smaller hills and that the medium sized hills produced the best average yield. The seven hills which contained both short and long tubers are so few that little can be determined from them. The last part of the chart, representing the hills with long tubers, shows how much smaller the yield was from them as compared with the yield from the round tubers, and here also the largest

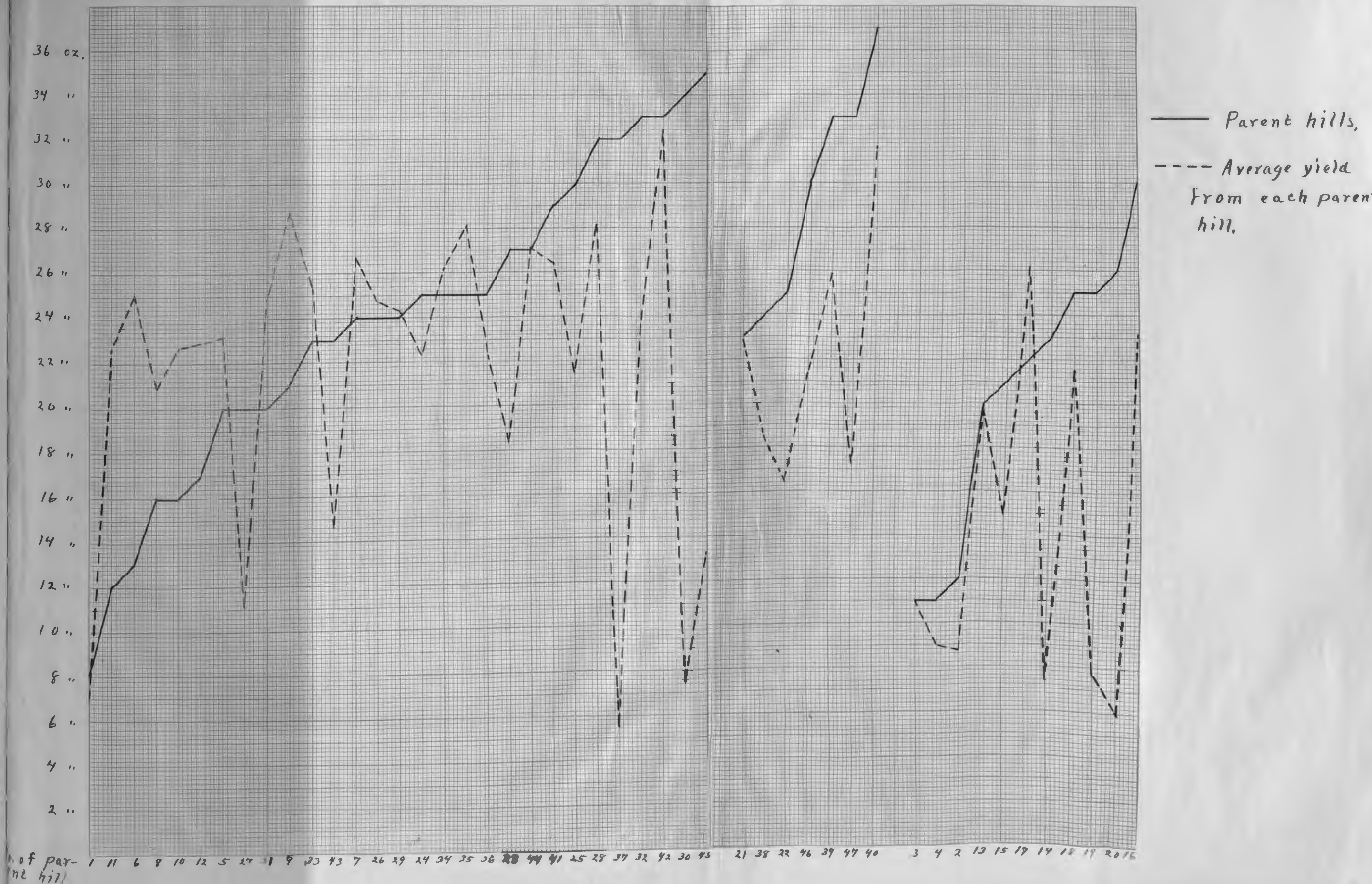

36 oz.
34 "
32 "
30 "
28 "
26 "
24 "
22 "
20 "
18 "
16 "
14 "
12 "
10 "
8 "
6 "
4 "
2 "
of par-
nt hill
1 11 6 8 10 12 5 27 31 9 33 43 7 26 29 24 34 35 36 44 41 25 28 37 32 42 30 45
21 38 22 46 39 47 40
3 4 2 13 15 17 14 18 19 20 16
Parent hills.
Average yield from each parent hill.

Fig. 4

hills yielded no better than the small ones, and the medium ones averaged the best.

The hills were then grouped according to the number of large tubers and their shape. The results are given in Table XIII, which follows:

Table XIII. Results from hills arranged according to number and shape of tubers.

	Average Wt. of Seed Hills in oz.	Average Wt. of Yield in oz.	
Avg. of hills No. 1	8.0	7.0	1 round tuber
" " " " 2-4	11.3	9.6	1 long tuber
" " " " 5-12	17.4	24.1	2 round tubers
" " " " 13	20.0	19.7	2 long tubers
" " " " 14-20	24.6	15.3	3 long tubers
" " " " 21	23.0	22.9	1 round and 2 long tubers
" " " " 22	25.0	16.4	2 round and 1 long tuber
" " " " 23-37	26.6	20.9	4 round tubers
" " " " 38-40	31.3	25.3	3 round and 1 long tuber
" " " " 41-45	29.4	22.8	5 round tubers
" " " " 46 & 47	31.5	19.3	3 round and 2 long tubers

The following comparison, taken in part from the preceding table, is interesting.

No. of large tubers (round)	No. of Parent Hills in Ave.	Av. Wt. of Parent Hills in oz.	Av. Wt. of Hills Produced in oz.
2	8	17.4	24.1
4	15	26.6	20.9
5	5	29.4	22.8

Table XIV. Distribution of hills of different sizes with reference to the size of the parent hills. *

Weight of parent hills in ounces.	8	12	13	16	16	17	20	20	20	21	23	23	24	24	24	25	25	25	25	27	27	29	30	32	32	33	33	34	35
Parent hill No.	1	11	6	8	10	12	5	27	31	9	33	43	7	26	29	24	34	35	36	23	44	41	25	28	37	32	42	30	45
No. of tubers in parent hills.	1	2	2	2	2	2	2	4	4	2	4	5	2	4	4	4	4	4	4	4	5	5	4	4	4	4	5	4	5
Average Weight of hills produced, in oz.	7.0	22.7	25.0	20.9	22.7	22.9	23.2	11.1	24.9	28.7	25.4	14.6	26.7	24.7	24.3	22.3	26.2	28.1	22.4	18.3	27.1	26.4	21.4	28.1	5.5	23.5	32.4	7.5	13.3
0 oz.							2	1				2					1	2				1		2			1	1	
1 oz.	1											1																	
2 oz.																													
3 oz.												1			1														2
4 oz.								1				1					1			1					3				1
5 oz.								2																	5			2	3
6 oz.								2			1	1							1	1					2				
7 oz.								2																		1		4	4
8 oz.								1									1								1			3	
9 oz.									1														1		1	1		1	
10 oz.	2											1							1							1		1	
11 oz.										1		1			1				1										
12 oz.																													
13 oz.																		1				1							
14 oz.					1											1													
15 oz.												1				1						1	1			1			
16 oz.			1	1			1					1				1				2	1						1		
17 oz.			1	1										2		1													
18 oz.		1			1	2				1				1				1			1		1						
19 oz.					1								1	1					2	1	1		1	2					1
20 oz.		1						1	1				1	1						1	1		1			1			
21 oz.		1		2			1					1			1		1			2		1					1		
22 oz.		1		1		2						1			1	1		1		2						1	2		
23 oz.						1	1		1					1			1	1					1				1		
24 oz.									1	1	2		1		1	4					1	1	2			1			
25 oz.		1							1		1											2	1						
26 oz.					1				2		1				2		1		1	1	1	2	2	2		1			
27 oz.									2		1		1	1	1	1	1		1	1	4		1	1			2		
28 oz.				1	1			1			1			1			1		1			2		1		1			
29 oz.									2		1			1				1	1			2							1
30 oz.		1	1					1		1		1		1	2	1			1								1		
31 oz.					1					1						1		1	1					1		1			
32 oz.											1			1			1										1		1
33 oz.			1				1												1		2			1					
34 oz.			1			1			1				1		1						1								
35 oz.												1						1						1					
36 oz.													1	1							1	1					1		1
37 oz.												1			1									1		1			
38 oz.										2	1							1											
39 oz.																	1				1								
40 oz.																	1												
41 oz.																											1		
42 oz.																	1	1											
43 oz.																											1		
44 oz.																						1							
50 oz.																		1								1			
51 oz.																											1		
61 oz.																													

* Includes only parent hills composed of round tubers.

An examination of the table will show that if the twenty-nine largest hills produced in 1911 had been selected for planting in 1912 they would have included twenty-eight hills over thirty-five ounces in weight, having parent hills all the way down to twenty-one ounces in weight, and that the twenty-ninth hill might have been secured from a parent hill weighing as little as thirteen ounces. In actual selection the results would have been a little different. In field practice the largest hills would have been selected by eye, and some of the hills taken would probably have weighed little over thirty ounces. This would bring the selection within ~~the~~ an inheritance range of all but the smallest parent hill.

It would not be safe to conclude from this experment that hill selection is useless, but the results are at least unfavorable to promiscuous selection of the largest hills without regard to the average yield of all of the hills produced by the same parent hill. On the average, the largest hills selected did not bring the largest returns, but the largest average returns from any one hill came from one of the largest hills, while on the hand the second largest average yield came from a parent hill which weighed only twentyone ounces. The latter case, however, corresponds to the results that might be expected from the smallest of the hills which composed the largest average - the product of Hill No. 42 - which weighed seventeen ounces. If it may be assumed that all of the hills from any given hill have ~~assumed~~ the same hereditary yielding power, the 17 ounce hill from Hill No. 42 could be expected to produce as large a yield as the other much larger hills which came from the same parent.

One conclusion that it seems safe to make from this experiment is that, if hill selection is to be carried on, the best method to follow is to plant each hill separately and treat it as a separate variety. In this way the poor strains could be eliminated promptly, leaving only the best ones for working with in the future tests, from which the one best strain could ultimately be selected. Whether this best strain when once eliminated could be further improved by continuing the selection of the best hills would still have to be determined.

The fact that the largest hills were produced by hills above medium size, as may be seen by referring to the lower part of Table XIV, seems to indicate that there is at least a tendency for the size of the hill to be hereditary. This, however, does not necessarily follow. It seems entirely possible for growing conditions which cause a hill to become larger than the average size to sometimes also give that hill greater vitality, in which case the tubers of that hill would have an advantage over the others when planted the next year. The continuance of such an advantage to another generation would probably be entirely dependent upon a repetition of the favorable circumstances which gave the hill its advantage. Under such conditions a higher yield would not be hereditary at all. It would merely be the result of temporary conditions, and would disappear soon afterthe hills fell back into average growing conditions again.

It is highly probable that in some of the cases where a gain in yield from the selection of the best hills has been obtained it has been due to the impure character of the seed stock with which the experiments began. For instance, should two similar varieties with different yielding power be mixed, the selection of the largest hills would merely result in an increase of the percentage of the better yielding variety. It is also improper to compare the poorest hills with the best ones in determining whether hill selection pays. Medium to good hills should be used for comparing with the best ones, because the smallest hills are more likely to be diseased or in the more advanced stages of degeneration.

To make a practical test of hill selection so as to determine whether it is better than the ordinary farm method, it should be compared with taking potatoes just about as they come from the bin. Judging from the results presented in this thesis ~~in the selection of this bulletin~~ on the yielding power of tubers of different shapes, it would be reasonable to expect some increase in yield as a result of hill selection on the basis above mentioned. The selected hills would be composed of the best formed tubers while the seed potatoes taken indiscriminately from the bin would contain more or less degenerate tubers. The degenerate tubers would cause the latter to yield less than the selected hills regardless of what the yield of the individual hills might have been.

The writer's work in hill selection at University Farm began in the fall of 1907. The best hills were selected from quite a number of varieties, ~~a~~ which was continued for three years. The object was to compare hill selection with the selection of the best formed tubers from the bins. The results are given in Table XV.

Table XV. Results from hill selected seed potatoes versus seed potatoes selected from the bin, in bushels per acre.

Accession No.	Variety	Year of 1908				Year of 1909				Year of 1910				No. of times selected hills yielded more		No. of times selected tubers yielded more	
		Hill selected seed		Bin selected seed		Hill selected seed		Bin selected seed		Hill selected seed		Bin selected seed					
		Over 1-3/4" screen	Total	Over 1-3/4" screen	Total	Over 1-3/4" screen	Total	Over 1-3/4 screen	Total	Over 1-3/4" screen	Total	Over 1-3/4" screen	Total	Over 1-3/4" screen	Total	Over 1-3/4" screen	Total
Part I.	Cobbler Group:																
3593	Irish Cobbler					139.9	181.7	175.5	219.	15.4	43.8	43.8	61.7			2	2
2859	Eureka Extra Early	20.6	47.7	4.7	10.9	46.9	80.0	68.8	117.2	41.0	61.8	49.5	63.7	1	1	2	2
3759	" " "									57.7	86.5	64.1	84.3		1	1	
3064	Dreer's New Early Standard	71.3	126.2	38.4	88.0	32.5	60.9	119.3	164.7	25.9	51.0	13.6	34.8	2	2	1	1
3757	"									36.3	59.8	82.3	95.8			1	1
2857	Noroton Beauty	66.4	116.5	31.2	64.9	83.0	104.1	77.7	111.0	26.1	42.6	31.3	46.2	2	1	1	2
3760	" "									29.8	47.1	25.7	48.5	1			1
2845	Red Bliss Triumph					44.6	78.4	29.1	59.9	32.0	56.9	33.3	50.4	1	2	1	
	Total	158.3	290.4	74.3	163.8	346.9	505.1	470.4	671.8	264.2	449.5	343.6	485.4	7	7	9	9.
	Per cent gain	113.07	77.3					35.60	33.00			30.05	7.99				
Part II.	Ohio Group:																
3630	Early Ohio					168.6	212.1	152.7	192.2	28.9	62.1	87.0	101.4	1	1	1	1
3787	" "									92.8	106.9	77.3	98.2	1	1		
2365	Extra Early Pioneer	38.8	81.0	33.0	87.6	81.7	119.4	71.5	109.9	47.9	77.9	34.8	60.0	3	2		1
2849	Acme	61.2	92.8	110.7	146.4	56.3	91.7	63.1	90.0	20.2	46.0	27.0	55.1		1	3	2
3786	"									79.0	102.0	108.2	127.9			1	1
	Total	100.0	173.8	143.7	234.0	306.6	423.2	287.3	392.1	268.8	394.9	334.3	442.6	5	5	5	5
	Per cent gain			43.70	34.56	6.72	10.23					24.37	12.08				

Accession No.	Variety	Year of 1908 Hill selected seed Over 1-3/4" screen	Year of 1908 Hill selected seed Total	Year of 1908 Bin selected seed Over 1-3/4" screen	Year of 1908 Bin selected seed Total	Year of 1909 Hill selected seed Over 1-3/4" screen	Year of 1909 Hill selected seed Total	Year of 1909 Bin selected seed Over 1-3/4" screen	Year of 1909 Bin selected seed Total	Year of 1910 Hill selected seed Over 1-3/4" screen	Year of 1910 Hill selected seed Total	Year of 1910 Bin selected seed Over 1-3/4" screen	Year of 1910 Bin selected seed Total	No. times selected hills yielded most. Over 1-3/4" screen	No. times selected hills yielded most. Total	No. times selected tubers yielded most. Over 1-3/4" screen	No. times selected tubers yielded most. Total
Part III. Michigan Group:																	
2846	Early Michigan	74.7	173.4	81.1	142.4	69.0	138.2	109.1	190.1	43.9	83.1	33.0	67.7	1	2	2	1
2847	Early Harvest	3.5	51.1	30.0	81.1	35.5	87.4	40.8	100.8	29.8	62.8	24.2	52.3	1	1	2	2
3105	Early Bird	55.6	126.1	97.4	153.7	60.9	112.4	44.6	76.4	37.0	77.2	19.2	53.5	2	2	1	1
3785	" "									23.1	57.8	78.3	118.3			1	1
3058	Early Puritan	94.8	175.8	86.2	142.4	56.5	100.0	115.9	189.7	8.5	35.1	26.6	62.1	1	1	2	2
3591	" "					79.8	113.5	70.0	104.3	11.0	35.2	28.1	44.5	1	1	1	1
3599	Early Michigan					74.7	115.7	50.3	88.2	2.8	42.9	17.2	39.7	1	2	1	
3594	Early Harvest					48.0	80.9	38.6	76.8	5.4	32.3	18.2	43.6	1	1	1	1
3092	Early Coos	79.1	136.4	56.1	116.7	46.1	76.7	27.2	52.0					2	2		
3602	World's Wonder					133.3	196.3	119.5	179.6	29.8	71.2	41.1	69.9	1	2	1	
3050	Milwaukee	63.0	103.8	58.9	119.1	40.5	77.8	40.5	73.8					1	1		1.
3106	New Queen	115.7	162.5	100.6	162.7	77.3	121.4	45.9	84.3	33.7	76.1	50.0	64.7	2	2	1	1
3067	Early Norwood	51.9	113.3	70.2	111.9	43.3	77.9	76.6	129.1	13.4	56.3	24.2	53.1		2	3	1
3769	" "									42.2	81.3	48.9	83.7			1	1
3774	Maxima									90.2	119.1	98.5	133.1			1	1
3754	Burbank									53.7	80.8	64.6	96.9			1	1
3755	Pingree									40.4	76.3	77.8	120.7			1	1
	Total	538.3	1042.4	580.5	1030.0	764.9	1298.2	779.0	1345.1	464.9	987.5	649.9	1103.8	14	19	20	16
	Per cent gain	7.84	1.20					1.84	3.61			39.79	11.78				

Accession No.	Variety	Year of 1908 Hill selected seed Over 1-3/4" screen	Total	Bin selected seed Over 1-3/4" screen	Total	Year of 1909 Hill selected seed Over 1-3/4" screen	Total	Bin selected seed Over 1-3/4" screen	Total	Year of 1910 Hill selected seed Over 1-3/4" screen	Total	Bin selected seed Over 1-3/4" screen	Total	No. of times selected hills yielded most. Over 1-3/4" screen	Total	No. of times selected ~~hills~~ tubers yielded most. Over 1-3/4" screen	Total
Part IV. Russet Group:																	
2850	California Russet	40.9	77.2	32.1	77.7	50.5	78.1	42.5	69.5	7.9	36.3	13.9	37.2	2	1	1	2
3778	" "									21.2	46.9	18.6	44.0	1	1		
2801	Golden Russet	39.3	79.2	14.4	44.4									1	1		
	Total	80.2	156.4	46.5	122.1	50.5	78.1	42.5	69.5	29.1	83.2	32.5	81.2	4	3	1.	2
	Per cent gain	72.47	28.09			18.82	12.21				2.46	11.68					
Part V. Green Mountain Group:																	
1625	Carman No. 1	22.7	62.2	17.0	45.1									1	1		
2652	" "	41.3	68.9	52.2	80.5	95.3	130.1	111.6	140.6							2	2
3764	" "									46.6	61.2	49.6	57.3		1	1	
3095	Norcross	45.8	70.0	41.7	76.6	95.5	123.0	43.1	65.2	68.7	81.8	46.5	60.7	3	2		1
3596	"					121.2	143.7	106.8	139.2	38.6	55.7	27.9	55.3	2	2		
3616	Freeman					159.2	185.5	153.3	196.4	73.6	90.9	56.7	66.8	2	1		1
3057	Green Mountain	55.5	96.0	26.5	74.4	101.0	149.0	89.6	121.1	36.7	56.5	37.0	56.1	2	3	1	
3595	" "					92.5	113.5	91.2	125.0	28.0	39.6	27.8	43.2	2		2	
3063	State of Maine	50.8	83.2	65.3	103.4	43.9	80.4	129.3	162.0	23.6	48.2	42.8	59.0			3	3

Accession No.	Variety	Year of 1908				Year of 1909				Year of 1910				No. times selected hills yielded most.		No. times selected tubers ~~hills~~ yielded most.	
		Hill selected seed		Bin selected seed		Hill selected seed		Bin selected seed		Hill selected seed		Bin selected seed					
		Over 1-3/4" screen	Total	Over 1-3/4" screen	Total	Over 1-3/4" screen	Total	Over 1-3/4" screen	Total	Over 1-3/4" screen	Total	Over 1-3/4" screen	Total	Over 1-3/4" screen	Total	Over 1-3/4" screen	Total
3590	State of Maine					170.9	211.3	161.8	195.9	45.8	60.	37.0	52.7	2	2		
3056	Uncle Sam	66.4	98.1	55.5	89.7	111.2	140.1	125.2	164.1	30.3	44.1	39.6	55.9	1	1	2	2
3099	Vermont Gold Coin5	10.1	28.2	18.9	36.3											1	1
3093	Million Dollar	11.5	28.5	40.7	79.9	43.5	60.5	59.4	84.0	41.4	60.1	39.4	52.0	1	1	2	2
3103	McGregor	71.7	102.6	43.8	77.7	126.9	162.1	122.1	152.9	39.2	55.4	37.9	52.7	3	3		
3047	Merrill	65.6	120.6	62.0	107.5	39.5	80.9	49.2	88.3					1	1	1	1
3770	"									41.9	63.3	39.9	53.9	1	1		
3597	Twentieth Century					120.6	141.9	165.6	201.9	43.3	57.8	43.2	58.3	1		1	2
	Total	441.4	758.3	423.6	771.1	1321.2	1722.0	1408.2	1836.6	557.7	774.6	525.3	723.9	22	19	14	17
	Per cent gain	4.20			1.69			6.59	6.66	6.17	7.0						
Part VI.	Rural Group:																
3631	Rural New Yorker #2					192.5	225.9	219.6	243.8	84.3	97.9	85.7	89.9		1	2	1
3762	" " " "									93.7	99.8	97.2	101.0			1	1
2733	Sir Walter Raleigh	45.7	80.4	64.2	88.8	114.4	168.7	122.0	159.5	114.6	128.5	76.8	85.2	1	2	2	1
3763	" " "									34.5	37.3	83.8	93.9			1	1
3765	Carman No. 3									108.4	114.4	99.2	110.0	1	1		
3094	Algonquin	76.8	128.5	66.3	101.4	217.0	251.8	166.2	194.2	72.4	82.5	97.9	113.1	2	2	1	1
	Banner	39.6	72.1	70.8	103.6	198.7	236.2	172.4	215.3					1	1	1	1
3052	Dusty Rural	66.9	112.3	68.1	95.6	162.3	219.5	142.4	184.4	77.9	86.0	101.0	110.0	1	2	2	1
3601	Enormous					213.5	250.4	239.5	266.5	90.9	98.5	109.3	117.6			2	2
3589	Late Petoskey					197.9	235.2	227.5	264.0	95.0	100.1	117.0	126.1			2	2
	Number 37	76.4	118.4	64.5	97.5	166.4	209.7	153.9	193.8	68.0	82.4	92.0	101.1	2	2	1	1
3775	Ohio Wonder									96.1	105.2	91.5	102.2	1	1		
3452	White Beauty					140.9	182.2	161.8	202.3	76.5	82.9	80.0	89.3			2	2

Accession No.	Variety	Year of 1908: Hill selected seed: Over 1-3/4" screen	Total	Year of 1908: Bin selected seed: Over 1-3/4" screen	Total	Year of 1909: Hill selected seed: Over 1-3/4" screen	Total	Year of 1909: Bin selected seed: Over 1-3/4" screen	Total	Year of 1910: Hill selected seed: Over 1-3/4" screen	Total	Year of 1910: Bin selected seed: Over 1-3/4" screen	Total	No. times selected hills yielded most: Over 1-3/4" screen	Total	No. times selected tubers yielded most: Over 1-3/4" screen	Total
	Part VII. Rural Group con.:																
2653	White Mammoth	89.7	124.8	92.1	126.2	169.7	206.0	168.7	207.8	79.2	87.3	94.0	101.8	1		2	3
	Total	395.1	636.5	426.0	613.1	1773.3	2185.6	1769.0	2131.9	1091.5	1202.8	1225.4	1341.2	10	12	19	17
	Per cent gain		3.82	7.82		.25	2.52					12.27	11.50				

Accession No.	Variety	Year of 1908				Year of 1909				Year of 1910				No. times selected hills yielded most.		No. times selected tubers yielded most.	
		Hill selected seed		Bin selected seed		Hill selected seed		Bin selected seed		Hill selected seed		Bin selected seed					
		Over 1-3/4" screen	Total	Over 1-3/4" screen	Total	Over 1-3/4" screen	Total	Over 1-3/4" screen	Total	Over 1-3/4" screen	Total	Over 1-3/4" screen	Total	Over 1-3/4" screen	Total	Over 1-3/4" screen	Total
Part VII. Miscellaneous:																	
3309	Bundder Landwirth	6.5	32.0	1.8	33.9									1			1
3277	Charter	16.5	39.3	16.6	39.1	25.3	50.3	36.7	60.3						1	2	1
1495	Clay Rose	39.2	72.7	28.9	43.6	51.0	82.8	43.1	72.0					2	2		
3618	Commercial No.2					202.1	288.5	224.6	303.4	23.2	50.4	67.0	107.0			2	2
3104	Early Petoskey	14.1	36.4	21.0	68.4											1	1
3598	Endurance					83.0	104.6	73.0	90.6					1	1		
3587	Factor					116.5	167.0	153.1	200.9	42.6	72.9	42.2	64.2	1	1	1	1
3592	Invincible					106.1	125.6	53.5	72.2	30.3	46.4	29.4	51.0	2	1		1
2861	Ionia Seedling	29.1	58.4	.0	16.2	10.6	17.4	19.7	30.3					1	1	1	1
3073	King of Missouri	59.9	99.7	22.8	46.4	135.4	171.3	139.5	180.2					1	1	1	1
3066	Lady Finger	8.4	49.0	7.9	42.3									1	1		
3305	Leo	45.3	96.0	60.1	96.5	122.1	148.4	108.3	139.1					1	1	1	1
2681	Medium	58.7	119.3	26.9	70.7	29.7	47.9	32.3	66.1					1	1	1	1
3310	Minister von Miguel	44.0	123.6	47.4	109.5	125.4	216.3	48.2	120.2	13.9	40.4	10.1	45.8	2	2	1	1
3097	Montana Prize taker	31.5	62.3	17.1	41.2									1	1		
3071	Peachblow	106.0	144.6	100.7	137.0	118.9	159.4	118.0	158.1	57.9	71.3	58.8	79.0	2	2	1	1
3276	Phobus	16.2	108.8	15.8	59.2									1	1		
3045	Plucky Baltimore	45.2	96.8	78.5	142.8	56.7	147.4	40.8	86.0					1	1	1	1
2455	President McKinley					83.9	130.2	99.4	144.6							1	1
3259	Professor Maerker	34.8	84.6	51.3	85.9	69.8	105.5	83.9	122.1	7.6	47.1	10.9	35.3		1	3	2
3584	Provost					90.0	131.6	70.1	109.4	13.3	38.7	29.1	49.3	1	1	1	1

Accession No.	Variety	Year of 1908				Year of [redacted]				Year of 1910				No. times selected hills yielded most.		No. times selected tubers ~~hills~~ yielded most.	
		Hill selected seed		Bin selected seed		Hill selected seed		[redacted]elected seed		Hill selected seed		Bin selected seed					
		Over 1-3/4" Screen	Total	Over 1-3/4" screen	Total	Over 1-3/4" screen	Total	Over 1-3/4" [redacted]en	Total	Over 1-3/4" screen	Total	Over 1-3/4 screen	Total	Over 103/4" screen	Total	Over 1-3/4" screen	Total
3288	Radium	6.1				105.9	169.3	154.8	102.2	54.8	82.8	39.2	62.4	2	2		
3306	Sass	6.1	67.2	6.3	39.6										1	1	
3585	Scot					23.1	38.1	40.8	66.3							1	1
	Seedling B					11.3	55.9	10.6	64.3					1			1
3281	Sharp's Express					57.7	109.3	52.7	95.6	39.7	66.8	26.9	55.2	2	2		
3308	Siegfried	.0	17.7	.0	27.6												1
3280	Sir Thomas Lipton					2.6	35.7	12.5	28.2						1	1	
3053	Snowball	28.0	75.7	39.6	73.2										1	1	
3307	Topaz	60.2	135.8	49.1	122.5									1	2	2	1
3072	Up-to-Date	18.5	43.1	3.2	20.3	101.9	180.5	123.0	168.8	22.6	59.2	22.9	60.9	1	1		
3051	Valentine	3.8	27.5	1.8	13.0									1	1		
3278	Viol	4.2	88.0	4.5	108.2											1	1
2856	White Victor	4.0	22.1	12.9	28.5											1	1
3275	Woltman	5.1	62.5	24.8	92.7											1	1
	Total	685.3	1763.1	639.1	1558.3	1729.0	2682.9	1638.6	2480.9	305.5	576.0	336.5	610.1	28	31	27	25
	Per cent gain	7.23	13.14			5.52	8.14					10.15	5.92				
	Total for all varieties	2398.6	4820.9	2333.7	4492.4	6292.4	8895.1	6395.0	8927.9	2981.7	4468.5	3447.5	4778.3	90	96	95	91
	Ave. Per cent Gain for all varieties	2.78	7.31					1.63	.37			15.62	6.93				

The average per cent of gain for all varieties at the end of Table XV shows that the hill selected potatoes yielded the most the first year, and that the bin selected tubers yielded the most the second and third years. The average for the three years is in favor of the bin selected seed potatoes on those which went over the 1-3/4 inch screen, but on the total yield, which is a better scientific measure of the inherent yielding power of seed potatoes, the yield of the hill selected and bin selected tubers lacks but 0.01 of one per cent of being even. Comparing the number of times that the hill selected and bin selected seed potatoes yielded most it will be observed that they, too, are almost even. It is also significant that there is only one instance among the lots where hill selection was carried on for three years that the yield of those over the 1-3/4 inch screen and the total was continuously in favor of the hill selected tubers, and this is offset by one instance, which happens to be in the same group in which the opposite was true. The lots were Nos. 3063 and 3103 in the

Green Mountain Group of the preceding table. There were six instances among the lots with which hill selection had been carried on for two years in which the yield of those which went over the 1-3/4 inch screen and the total yield was continuously in favor of the hill selected seed potatoes, but these six are offset by six others in which the opposite was true.

There were some conditions that tended to offset the possible results of hill selection. One resulted from the method of planting. In 1907 and 1908 the potatoes were planted with an Iron Age potato planter. As the pieces drop out of the spout from this planter, they frequently roll one way or the other with the result that occasionally two pieces are left rather close together. No measurements were made, but from considerable observation, the writer's judgment is that they were very seldom closer than six inches. The result was that whenever two hills were close there was a tendency on the part of the diggers to get two together for one. If two hills, thus placed together as one, happened to be uniform and to have tubers of desirable shape, they would be very apt to be selected from one good hill. Such a mistake, however, was relatively rare because the diggers were cautioned against it and were as strictly supervised in regard to it as possible. It probably happened more often the first of the two years than in the second because the importance of this possibility was not so fully appreciated the first year as in the second year, and much of the digging and selecting was not done under the writer's personal supervision at that time. However the writer feels that he can safely say that it did not happen very often, and certainly not enough to offset the possibilities of hill selection to any great degree. The number of times the mistake might have been made would probably be not over four or five per cent. in 1907 and one or two per cent in 1908. It is significant that the gain for hill selection in 1908 results became a loss in 1909.

In the spring of 1909 the potatoes were planted by hand, and in order to be sure of getting the pieces the right distance apart a cord, marked at the place for each piece, was stretched along the row. In the hill selections made in the fall of that year there were probably no errors whatever of the kind mentioned in connection with the previous selections.

Another departure from the preconceived plan was in the second year's selection of the hills. In this selection the best hills were taken from rows planted with bin selected tubers, as well as from the rows planted with hill selected tubers. About as many of the best hills were found in one as in the other. In selecting the best hills in the fall of 1909 from the varieties which were already in the experiment, they were taken only from rows which had been planted with hill selected tubers.

The idea in making the hill selections was to take only hills which had six or more tubers of good uniform size and shape and no small ones. This did not always result in the selection of the most productive hills, but the hills selected were at least among the more productive ones. It was often necessary, in order to get the ~~amount~~ number of tubers needed, to accept hills which were somewhat off in shape, lacked somewhat in uniformity, had some small tubers or a less number of large ones than desired.

The season of 1910 was unfavorable to potatoes at University Farm. There were so few varieties which yielded anywhere near the required number of really desirable hills for the continuation of this work that, when the rather negative results of previous years and tha apparent negative results of that year (as afterwards proved to be the case), were considered, the work of hill selection was given up. An unfortunate circumstance in connection with the results of 1910 was that during the writer's absence the potato bugs were allowed to do considerable damage before they were brought under control. Parts of rows which had been seriously injured were discarded in determining the results. The injury reduced the yield in many instances, but it seems impossible that the average could have been affected more than slightly either way.

Another set of data bearing on the heredity of yield of individual hills is available from the work with seedlings at University Farm.

Of the seedlings which were saved from those started in 1908, there were planted two hills from each one in 1909. Some of the seedlings were discarded in 1909, but of those which were saved the two hills were kept separate, numbered, and three hills planted from each in 1910. It was thus possible to determine whether there was, on the average, any tendency for the largest hill to produce the largest average yield. The results are given in Table XVI.

Table XVI. Average Yield Produced in 1909 by Individual Hills from Potato Seedlings of 1908.

Seedling Number	Larger Hill 1909 in ounces.	Average Yield 1910 in ounces	Smaller Hill 1909 in ounces.	Average Yield 1910 in ounces.
1- 1-08	13	3-3/4	8	5
1- 5-08	22	2-1/4	20	2-1/4
1- 6-08	23	2	16	6
1- 9-08	23	4-3/4	19	4
1-10-08	44	5-1/4	41	4-3/4
1-11-08	15	1-3/4	9	3-3/4
1-13-08	20	3-1/4	18	5-1/4
1-14-08	35	10-3/4	29	5-3/5
1-17-08	27	6	24	4
1-18-08	55	11-3/4	50	5-1/4
1-19-08	13	4	6	3-3/4
2- 1-08	16	2-1/4	14	1-3/4
2- 2-08	15	3	4	1/20
2- 3-08	17	3	12	2-1/4
2- 4-08	26	2-1/4	18	1/2
3- 2-08	20	2-1/4	9	3
3- 4-08	18	1/20	16	7
3- 5-08	23	3-1/4	15	3-3/4
3- 6-08	16	1	2	1-3/4
3- 7-08	20	6-1/4	12	7-1/4
4- 1-08	29	3	14	6-3/4
4- 8-08	24	2	15	2
4- 3-08	20	1	14	2-1/4
4- 4-08	24	3	16	4
4- 5-08	15	3	11	5
4- 6-08	6	3/4	3	1
4- 7-08	19	1.	17	1
4- 8-08	27	1/20	20	1/20
4-11-08	6	1/10	2	1

Seedling Number	Larger Hill 1909 in ounces	Average Yield 1910 in ounces	Smaller Hill 1909 in ounces	Average Yield 1910 in ounces.
4-12-08	17	5-3/4	12	9
4-13-08	21	3-1/4	19	3-1/4
4-15-08	23	1/4	18	1/4
4-16-08	6	3/4	5	1
4-19-08	49	3-1/4	35	3
4-20-08	31	3-1/4	22	1-1/2
4-21-08	13	1/30	5	1/30
4-22-08	14	1	9	2-3/4
4-23-08	26	3-3/4	18-	3-1/4
4-24-08	52	2-1/4	27-	1
4-25-08	20	4-1/4	6	5
4-26-08	12	2-1/4	9	1-1/4
4-27-08	9	2-1/4	7	2
4-28-08	24	2	8	3/4
4-29-08	36	6	28	5
4-30-08	20	2	8	1
4-31-08	17	2-3/4	11	0
4-32-08	31	7-1/4	26	4-3/4
4-33-08	24	4-1/4	21	4
4-34-08	24	1	17	3/4
4-35-08	15	1	10	1/2
4-36-08	16	2	9	1-3/4
4-37-08	31	6-3/4	22	7-1/4
4-38-08	17	1-1/2	15	2
4-39-08	34	1/2	26	3
4-40-08	41	5-1/4	40	9
4-41-08	14	5-3/4	9	3-1/2
4-44-08	13	1-3/4	10	3
4-45-08	3	1	2	1-3/4
4-46-08	26	1/20	24	2-1/4
4-47-08	13	2	9	1-1/4
5- 1-08	24	1/2	19	1
11-1-08	37	6-3/4	30	7
11-3-08	45	2	39	3

Seedling Number	Larger Hill 1909 in ounces	Average Yield 1910 in ounces	Smaller Hill 1909 in ounces	Average Yield 1910 in ounces.
11-4-08	28	6	25	5-1/4
14-1-08	15	2-3/4	14	2
15-1-08	30	7-3/4	13	2-1/4
18-1-08	26	7	16	5-1/2
18-2-08	15	1-3/4	1	0
18-3-08	27	5	21	4
18-4-08	32	3/4	26	0
18-5-08	23	3/4	16	3-1/4
19-1-08	42	1	16	2-1/4
20-1-08	11	2	10	1
21-2-08	12	1	11	1-3/4
22-2-08	10	1-3/4	7	2
22-3-08	24	3/4	16	1/6
24-2-08	32	5	22	6-1/2
27-1-08	17	3	1/2	0
28-2-08	34	11	31	0
30-1-08	25	1-3/4	5	1-1/4
31-1-08	8	2-1/4	5	2-3/4
35-1-08	23	8	21	13-3/4
35-2-08	24	7-1/4	20	10-1/4
35-3-08	25	24-1/4	22	18
35-1-08	14	4	13	4
39-1-08	15	5-3/4	12	10-3/4
Total	1941	297-1/2	1372½	292½
Average	22.57	3.46	15.95	3.40

There were 86 seedlings in the above table. In 42 of them the larger of the two hills of 1909 produced the largest average yield in 1910; in 36 the smaller hill produced the largest average yield in 1910, and in eight the smaller hill produced an average yield equal to that of the larger hill. This makes a total of 42 seedlings, which the larger hill produced the larger average yield against 44 in which it did not produce a larger average yield. As may be observed at the end of the table, the larger hills in 1909 averaged 22.57 ounces against 15.95 ounces for the smaller hills, while the average weight for the hills produced by the larger ones was 3.46 ounces against 3.40 ounces for the product of the smaller hills. Such a difference is insignificant.

Comparisons for 1911 are possible for 17 of the above hills. In ten instances the progeny of the of the larger hill of 1909 produced the larger average yield in 1911, but in only seven of them had the larger yield been continuous through 1910. In seven instances out of the 17 the progeny of the smaller hill of 1909 had produced the larger yield in 1911, it having also been larger in 1910.

Comparing the 1910 yields with the 1911 yields, the larger average yield of 1911 came from hills which produced the larger average yield in 1910 in 14 instances against three in which the larger average of 1911 came from a smaller average yield in 1910. This comparison would seem to indicate that the two hills of 1909 from the original of 1908 had inherited different yielding power, the relative amount of which could not be determined until the average yield from hills which they produced was available for comparison, and that the one which had expressed the higher yield in that manner had the higher yielding power and could ordinarily be expected to again produce the higher yield the following year. This apparent result can, however, be very easily explained on the basis of degeneration. Degeneration was extremely rapid among these seedlings and present in greater or less degree in all of them. Where the yield was less for two generations in the progeny of one of the two original hills of 1909 the difference could easily have been due to unequal degeneration in the progeny of the two hills. There can be no question but that such was actually the case. The only alternative explanation is that the progeny of one of the hills developed a yielding power superior to the original power of the seedling. The greater amount of degeneration shown in all of the seedlings immediately removes any such possibility from consideration. It is possible that the Fusarium rot disease might have affected the results to some extent. Notes on it were not taken.

Similar results to those of Table XVI are available from seedlings which were started in 1909. There was a difference in that three hills were planted the second year instead of two as from the 1908 seedlings. In 1911 six hills were planted from each of the three hills saved in 1910. The results are given in Table XVII.

Table XVII. Average yield produced in 1910 by individual hills from potato seedlings of 1909.

No.of Sdlg	Wt.of Largest Hill in 1910 in oz.	Av.Wt. of Product in 1911 in oz.	Wt.of Intermediate Hill in 1910 in oz.	Av.Wt. of Product in 1911 in oz.	Wt.of Smallest Hill in 1910 in oz.	Av.Wt. of Product in 1911 in oz.
1-2-09	23	14-3/4	21	20-1/4	10	9-3/4
1-4-09	17	3-1/2	10	3-1/4	9	8
1-7-09	16	14-1/4	10	3-1/4	8	8-1/4
1-12-09	17	15	16	21-1/4	11	22-1/4
1-13-09	19	20-1/4	15	8-1/4	11	0
6-2-09	9	2-3/4	4	1-1/2	4	1-1/4
11-6-09	10	5-1/2	8	3-1/2	5	3/4
20-1-09	12	13-3/4	9	7-1/4	7	14-1/4
20-17-09	14	15-3/4	11	9-1/4	8	10-1/4
46-1-09	13	17-3/4	10	6-1/4	7	1-1/2
46-8-09	8	9-1/4	7	13-1/4	6	8-3/4
47-3-09	9	8	8	7-1/4	6	10-1/2
Total	167	140-1/2	129	104-1/2	92	96-1/2
Ave.	13.92	11.71	10.75	8.71	7.67	8.04

The results of Table XVII are the most favorable to hill selection so far secured. They can, however, easily be accounted for on the basis of unequal degeneration. Seedling No. 1-13-09, it will be observed, varied from an average of 20½ ounces from the product of the largest hill to 8¼ ounces for the product of the intermediate hill and 0.0 for the product of the smallest hill. In a similar manner, with seedling No. 46-1-09, the average weight of the product from the largest hill was 17-3/4 ounces per hill, with a drop to 6¼ ounces per hillfor the product from the intermediate hill, and only 1½ ounces per hill for the product from the smallest hill. The size of the plants corresponded to the yield. In seedling 1-13-09 it was 5½, 3 and 1 respectively on a scale of 10 for the product of the three hills and in seedling 46-1-09 it was 7½, 4 and 1 respectively for the product of the three hills. Moreover there was not only a difference in size, but the size of the six hills planted from each one of the three was generally very uniform. Many instances of this nature could be given from the records which have been made. If it were possible to eliminate the effects of degeneration the results of the preceding table would undoubtedly conform with the other results which have been secured. The largest average yield for 1911 in Table XVII came from the largest hill of 1910 in six instances, from the intermediate hill in two instances and from the smallest hill in four instances. These results are also somewhat in favor of hill selection, but the advantage would disappear if the cases of manifest unequal degeneration were removed from the table as previously pointed out.

The way all of the ~~tables~~ hills from some one hill will suddenly degenerate is in itself a problem to be worked out. The phenomenon was plainly evident in connection with the hill study work presented as well as in many of the seedlings, and the product of certain hills from them. By referring to Hills No. 14, 19, 20, 30 and 37, in Table XII, (p123) it will be observed that the plants are not only small, but that they were uniformly small, even though the parent hill was of good size.

Likewise it will be found that the hills produced by certain tubers were small, often uniformly so, when the hills produced by other tubers from the same hill were large, as may be observed by referring to Hills No. 18, 22, 27, 38, 43, 46 and 47 of the same table. The same phenomenon was observed in the seedlings, as already noted. A study of Table XII shows that hills composed partly or entirely of degenerately formed tubers - these having been the long tubers in that table - are more likely to develop this phenomenon than hills composed entirely of well formed tubers- the round tubers in that table.

Notes were not taken on the tubers for infection with Fusarium rot, a disease which might have had something to do with it. None of the tubers were seriously affected, however, and the growth of the plants during the summer was not such as to indicate that this disease was the cause. The plants were slow in coming up and remained dwarf the entire season. Their general behavior was the same as was common among the plants from the degenerate tubers in the studies along this line in the Rural Group, where it is not apparent how Fusarium could have had anything to do with it. Moreover, had Fusarium been the cause of this behavior in the case of the individual hills it could not have been so uniform in its action. It was shown in another experiment that the seed end half of tubers slightly affected with Fusarium rot did not show any material effects of the disease in the amount yielded from the rows planted from the seed end half of the tubers. According to these results some of the hills among those planted from the hills above referred to should have reached normal size had Fusarium been the cause of the small size, because many of them were planted from pieces cut far enpugh away from the stem end not to be affected.

While the indications, causes and methods of preventing degeneration of potatoes are gradually coming to light, it still seems impossible to say what degeneration actually is. If it should be found that it was a weakening of the protoplasm, as a result of the improper nutrition of some sort, and the fundamentals underlying it could be determined. the knowledge would be of great assistance in devising means of overcoming and preventing degeneration.

Relation of Fertility of Soil to Degeneration.

It has been observed that potatoes grown on new land have better shape than those grown on old land. This seemed to indicate that on new land there was less degeneration. It is a belief among quite a few potato growers that seed potatoes from new land will yield more than potatoes from old land. The same things should apply to different degrees of fertility in land which can no longer be regarded as new. The writer has observed unquestionable differences in the form of potatoes which have been grown on fertilized soil as compared with those grown on the same soil not fertilized when the seed stock used under both conditions was exactly the same. Measurements to determine the actual amount of difference in form were not made.

In the fall of 1910 seed potatoes of the Early Ohio and Sir Walter Raleigh varieties were saved from various plots of the manure and fertilizer series of that year and planted in 1911 to compare their yielding power. The different kinds of plots from which potatoes were saved were as follows: (a) without manure or commercial fertilizer, (b) with manure at the rate of ten tons per acre, (c) with commercial fertilizer containing 2% of nitrogen (only 1% for the Sir Walter Raleigh variety), 6% of available phosphoric acid and 9% of potassh at the rate of 800 lbs per acre and (d) with both the manure of "b" and the commercial fertilizer of "c".

The seed potatoes selected were in all cases as nearly alike as possible. Those from the unfertilized plots (a) were somewhat smaller, but otherwise there was comparatively little difference. Those from the plots with both manure and commercial fertilizer were used for check plots because there were more well formed tubers available from those plots than from any of the others. Each plot consisted of three rows four rods long. The results are given in Table XVIII, which follows:

Table XVIII. Yield produced by seed potatoes grown under different conditions as to fertility, in bushels per acre.

		Over 1-3/4 in. Screen	Total	% Over 1-3/4 in. Screen (Size)
Part I. Variety: Early Ohio				
Plot 1. Grown with manure at rate of 10 tons per acre and 2-6-9* commercial fertilizer at rate of 800 lbs. per acre.		100.0	133.5	75
Plot 2.#Grown without manure or commercial fertilizer.		102.8		
	Check	94.1	128.7	73
	Gain	8.7		
Plot 3. Grown with manure at rate of 10 tons per acre.		96.7	125.6	77
	Check	94.1	128.7	73
	Gain	2.6	-3.1	
Plot 4. Same as Plot 1.		79.0	112.0	71

		Over 1-3/4 in. Screen	Total	Per Cent Over 1-3/4 in. Screen (Size)
Part I.(Continued)				
Plot 5. Grown with 2-6-0*commercial fertilizer at rate of 800 lbs. per acre,		126.9	159.0	80
	Check	94.1	128.7	73
	Gain	32.8	30.3	
Plot 6. Same as Plot 1.		103.4	140.7	73
Part II. Variety: Sir Walter Raleigh				
Plot 1. Grown with manure at rate of 10 tons per acre and 1-6-0* commercial fertilizer at rate of 800 lbs. per acre.		181.9	193.7	94
Plot 2. Grown without manure or commercial fertilizer.		195.4	209.1	93
	Check	190.6	202.6	94
	Gain	4.8	6.5	
Plot 3. Grown with manure at rate of 10 tons per acre.		159.0	170.5	93
	Check	190.6	202.6	94
	Gain	-31.6	-32.1	

		Over 1-3/4 in. Screen	Total	Per Cent Over 1-3/4 in. Screen (Size)
Part II. (Continued)				
Plot 4. Same as Plot 1.		204.1	216.6	94
Plot 5. Grown with 1-6-9* commercial fertilizer at rate of 800 lbs. per acre.		216.7	227.2	95
	Check	190.6	202.6	94
	Gain	26.1	24.6	
Plot 6. Same as Plot 1.		185.8	197.4	94

*The three figures show the percentages of nitrogen (N), phosphoric acid(P_2O_5) and potash (K_2O) respectively, which was contained in the commercial fertilizer.

#See note under Table IV.

It will be noted in the above tables that the check plots were averaged for comparison with the other plots instead of following the usual custom of varying the value of the check plots according to the relative position of the plots compared. This was done because another series of check plots on the same land, but not connected with this experiment showed that the variation of the check plots of this experiment was not due to variation in the land. Why the check plots should have varied as they did is not clear.

Some of the results from this experiment, as shown in the preceding table, were very unexpected. They may be summarized as follows: (a) seed potatoes from land treated with manure produced a smaller yield than those from land not fertilized, (b) seed potatoes from land treated with both manure and commercial fertilizer yielded less than those from land not fertilized, (c) seed potatoes from land treated with manure alone yielded less, when the results from both varieties are averaged, than from those when land treated with both manure and commercial fertilizer, (d) seed potatoes from land treated with commercial fertilizer alone yielded considerably more than those from land treated with manure, or with manure and commercial fertilizer, or not fertilized at all.

Since the land on which the seed potatoes were grown was not in need of nitrogen for the production of potatoes, as has been demonstrated by three years of experimentation with commercial fertilizers on it, and since the use of commercial fertilizer which was relatively high in content of mineral elements and low in nitrogen gave the seed potatoes the greatest yielding power, it seems that what was lacking must have been one of both of the mineral elements when considered from the standpoint of relation to degeneration. The influence of the manure, which is rich in nitrogen, would seem to indicate that the addition of considerable quantities of nitrogen would offset the beneficial effects of the mineral elements, and that it was more important to have a relatively high proportion of the available mineral elements for the prevention of degeneration rather than merely a given quantity of available nitrogen present. In this respect the results seem to correspond with the situation in regard to new land, which is relatively richer in the quantity of available mineral elements than in the quantity of nitrogen. However much more work along this line will be needed before any conclusions can be drawn.

Hill Selection at Other Stations.

Work along the line of hill selection of potatoes has been carried on at a number of other stations. The reports were nearly always favorable to the selection of the best hills and it seems to have become a matter of general opinion among the majority of experiment station workers that potatoes could be improved in that manner.

It cannot be denied that results have been obtained from hill selections. The work has, however, been done on what seems to be an entirely erroneous basis. The underlying idea has been that by the selection of the best hills cumulative advantage was being taken of variation in the direction of increases in yields, and that such variation was hereditary. The factor of degeneration seems not to have been taken into consideration at all.

The fact that results have been obtained from hill selection does not necessarily prove that the hills selected have varied in the direction of larger yield than the ordinary hereditary yield of the variety. The work previously presented and numerous observations of the writer's have demonstrated conclusively the fact of unequal degeneration. Wherever results have been obtained from hill selections it is entirely possible that they were due simply to the isolation of the least degenerate strains, or the elimination of the most degenerate ones. The ordinary hereditary yield of the variety as it would be if there had been no degeneration was not necessarily affected at all. In order to prove that the better hills have greater yielding power than the inherent yielding power of the variety, affirmative results would have to be obtained with pure seed stock, undegenerate in character, and with the environment such that all factors tending to reduce the vitality of the plant so that it could not give a normal performance would be removed. That means pure seed stock with the original yielding power of the variety, conditions of soil, culture and climate which will in no way induce degeneration, and freedom from disease.

In many of the hill selection experiments the mistake has been made of comparing the yield from the best hills with the yield from poor hills. That the poor hills are likely to be the most affected by degeneration is self evident, and that favorable results should be obtained under such conditions is highly probable.

If all of these conditions above mentioned cannot be met and an experiment in hill selection is tried, nevertheless it is at least incumbant upon the experimenter to select the best formed tubers ~~either~~ regardless of hills or at least from good, average hills for comparison with his selected, most productive hills.

A mixture of the seed stock with which the experiment was begun has probably been a source of apparently favorable results at times. Similar varieties and strains are so hard to distinguish that different ones could easily be mixed without the experimenter knowing it. Should such be the case, results from hill selection would simply mean that the better variety or strain had been separated out from the rest.

The factor of disease, and especially the Fusarium rot of the tubers, should also be taken into account in carrying on hill selection experiments.

From the practical standpoint hill selection may be of value for the purpose of separating out the best strain. Once this is accomplished all that can be done is to eliminate degenerate strains as they appear. For this, hill selection is not necessary. The selection of the best formed tubers will accomplish it just as well and possibly better, as was shown in the writer's hill selection with varieties from 1907 to 1910.

Summary.

Degeneration in potatoes is very common. It is much worse in unfavorable years for potatoes than in good years. It is also much worse in some types of potatoes than in others. Varieties of the Rural Group degenerated least as a class, with varieties of the Ohio Group next. Varieties of the Cobbler Group degenerated most with those of the Green Mountain Group next; those from the Michigan and Russet Groups coming in between the two best and two poorest named.

Degeneration in potatoes is recognized primarily by a decrease in yield. Other signs of it are decrease in average size of the tubers, change in shape in a greater or less proportion of them, increase in the number of eyes, with increased depth and increased size of eyes.

The plants also show the degeneration. They become smaller with a tendency to become very small, single stemmed, upright plants in advanced cases.

There is a great difference in the rapidity of degeneration of individual hills or tubers. For reasons not understood some will degenerate much more rapidly than others.

Degeneration in individual hills is likely to be accompanied by decrease in the size of the tubers, but not necessarily so, except in extreme cases where they are quite certain to be small and few. Where degeneration has not progressed to an extreme stage and the tubers are of fair size, it can best be recognized in the individual hill by the shape of the tubers and the number and condition of the eyes.

Individual tubers within a hill are very likely not to be possessed of a uniform degree of degeneration. Size, when part of the tubers of the hill have reached good size, probably counts for little in determining the relative degree of degeneration of individual tubers of the hill. Form, when tubers are large enough to have developed their ultimate form, and the number and condition of the eyes, are the best guides in selecting or rejecting degenerate tubers. All tubers with good form are not necessarily free from degeneration, but are most likely to be so.

The best form of the tuber depends on the natural form of the variety when grown under good conditions. In round or oval varieties, or those of medium length which normally develop a larger proportion of short tubers the best form is one which is as short for the width as can be selected and free from any tapering at the ends. Varieties of the Cobbler, Ohio, Green Mountain, Rural and Factor Groups are in this class. In varieties which are normally medium to long the selection of the shortest forms is to be avoided. In such types thickness of tuber, well developed for its full length and free from tapering at the ends are the indications of a minimum of degeneration. The eyes should be normal for the variety. It appears thatshort tubers from long varieties are degenerate just as much as long ones from short varieties. The Michigan and Russet Groups belong in this class. While size of tuber is not a reliable indication of degeneration, with the individual tuber it seems as though it would be a good precaution to select those of good size notwithstanding.

The causes of degeneration may be natural decline of a variety, improper nutrition, excessive heat, and other unfavorable environmental ~~atmospheric~~ conditions.

The primary nutritional causes seem to be lack of sufficient moisture in the soil, lack of a sufficient quantity of mineral plant food elements and disease.

Unfavorable climatic or nutritional factors probably cause degeneration by weakening the vitality of the protoplasm.

Good culture and high fertility will prevent degeneration in varieties which are able to endure occasional lack of moisture and such other unfavorable conditions as cannot be brought under control.

No increase in the inherent yielding power of potatoes is accomplised by hill selection, even though results may be obtained thereby. This is proved by the fact that just as good results can be obtained by the selection of the best formed tubers regardless of hills. When results are obtained by hill selection, it must be due to the elimination of the more degenerate strains. If the factor of degeneration were eliminated in a hill selection experiment, it would undoubtedly be found that good, average hills would produce as large an average yield as the largest hills. In the one experiment which the writer tried with individual hills the average hills produced a considerably larger average yield than the largest hills.

Hill selection may be of value for the purpose of isolating the best strain where it is suspected that the seed stock in use consists of more than one strain. After the isolation of the best strain has been accomplished further hill selection is needless, if the isolation of the best tubers is employed to keep degenerate strains eliminated.

The form of a variety cannot be changed by selection toward any specific type, except as it may be affected by degeneration. If long tubers are selected from a round variety and planted alongside of the round tubers, the form of the product of both lots will be the same, except that the lot planted from the long tubers may have a few more degenerately formed ones than the other as a result of the greater amount degeneration originally presents.

In conclusion, it seems to the writer, from the work and observation which he has so far carried on, that apart from the factor of degeneration, a pure strain or variety of potatoes cannot be changed in any particular by selection from the normal response to a certain set of conditions which it first obtained from the seed from which it grew. Should bud variation occur, of which authentic records are few, hill selection would be of value for separating out the variate, but would be useless as soon as that was accomplished aside from its possible relation to the factor above mentioned.