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Influence of Flowering and Fruiting Upon Vegetative Growth and Tuber Yield in the Potato

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THE COMMONLY cultivated varieties of the potato, *S. tuberosum* L., are highly nonfruitful in contrast to the species as a whole which Krantz et al (6) have found to be highly fruitful. These investigators have suggested that the possible influence of fruit development upon tuber yield might explain why the less fruitful types have proven superior for cultivation. This view is in accord with the findings of other investigators (1, 2, 4, 7, 8, 9, 10), who have established a rather definite association between fruiting and vegetative plant development with many of the crop plants. In general this association, or probable antagonism, has been explained on the basis of a competition for synthates between the developing fruit and growth of the vegetative structures of the plant. If a similar competition exists in the potato between fruit formation and tuber development then nonfruitfulness would be a desirable character to retain in the breeding of improved varieties. The studies presented here were made to determine a possible influence of flowering and fruiting upon vegetative growth and yield of tubers.

REVIEW OF LITERATURE

Relatively little work dealing with the interrelationship of tuber yield, vegetative and reproductive phases has been done with the potato. Knight (5) believed that the failure of early potatoes to produce seed was due to tuber formation, assuming that the early growth of tubers removed food materials necessary for floral and fruit development. Thus by preventing the formation of tubers, Knight states, "numerous blossoms will soon ap-

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pear, and almost every blossom will afford fruit and seeds." In a similar experiment, by removing the tubers East (3) obtained a more vigorous growth on some varieties but observed no influence on the production of viable pollen, flowers, and fruits.

The investigations of Wollny as reported by Snell (13) showed increased yields of tubers through the removal of flowers. Snell (13) in his own work reported that defloration of all profusely blooming types resulted in slightly reduced yields as compared to the flowering plants, while in the instance of the varieties producing only a few flowers the data submitted indicate that slightly higher yields were obtained with the deflorated plants.

As a result of their observations of plants with the variety Lookout Mountain, Newman and Leonian (11) concluded that, "In most cases the heaviest tuber production, the richest vegetative growth, and the largest seed production go hand in hand." More recently Young (14) reported that, "In the fall crop of Lookout Mountain a high degree of correlation was found between vegetative growth and seed production, and vegetative growth and yield of tubers, while a somewhat less degree of correlation was found between seed production and yield of tubers." The conclusion of Young that "there is no mutual antagonism between the several characters" hardly seems warranted. The fruiting and nonfruiting plants he studied were clearly the result of external conditions. The correlated response he observed to these conditions supplies little information on the direct influence of flowering and fruiting, either alone or in combination, on yield of tubers.

EXPERIMENTAL MATERIALS AND METHODS

Preliminary studies were conducted at Castle Danger during the summer of 1938.[2] In 1939 the experiments were enlarged and more detailed studies were carried on at Castle Danger and at University Farm, St. Paul.

In selecting material for the present studies an effort was made to include varieties differing in flowering and fruiting behavior but alike in the respect that all were of indeterminate growth habit with flowering and fruiting continuous with the

[2] Located on the north shore of Lake Superior with plots bordering the lake.

vegetative growth of the plant. Thus varieties chosen for all experiments represented different degrees of vegetative vigor, production of flowers and fruits, and tuber yield. To obtain this range two numbered selections, 5-10-1-42 and 5-2-4-2, characterized as vigorously growing, highly self-fruitful types, of late and intermediate maturity, respectively, and two standard commercial varieties, Russet Rural and Irish Cobbler, were grown. Both standard varieties flower moderately under average growing conditions and are normally nonself-fruitful. However, under some growing conditions, Irish Cobbler has produced a certain amount of seed. Some previous pollination work at University Farm gave a somewhat larger seed set from crosses on Irish Cobbler than on Russet Rural. For this reason Irish Cobbler was chosen for studies at this location.

The present experiments were designed to produce the following three types of plants: (1) Type I, plants allowed to set fruit (fruiting plants); (2) Type II, plants permitted to flower but not set fruit, all flowers being removed approximately three days after opening (flowering, nonfruiting plants); and (3) Type III, plants treated by the removal of all flower clusters in the bud stage (nonflowering, nonfruiting plants). Cross pollination was practiced daily to insure the maximum fruit set possible on the Type I plants of the commercial varieties employed. All flowers and bud clusters were removed regularly at three-day intervals on the Type II and Type III plants, respectively. All bud clusters were removed at a time when they were well enough developed so that no injury to the plant would result.

In 1938 all plants were harvested at one date. In 1939 plots were laid out similarly to the initial studies. In addition, plots were included on which successive harvests were made. These plots were harvested at the completion of the following four growth stages: (1) at the start of flowering; (2) at the termination of a period of active flowering, fruit set, and vegetative growth, which was midway between the first and third harvest dates; (3) when the vines were still green but had practically ceased growth, and after the greatest tuber production had occurred; and (4) after the vines were dead. The harvest date of 1938 corresponded to that of the third digging date in the 1939 studies.

EXPERIMENTAL RESULTS

Effect of Floral and Fruit Development on Vine Growth

Both flowering and fruiting resulted in significant decreases in growth of vines during both years of the experiments. Table 1 shows the effect of flowering and fruiting upon fresh weight of vines at Castle Danger and University Farm. It will be noted that the vine growth of Type I (fruiting) plants was consistently lower than on the Type III (nonflowering, nonfruiting) plants with the exception of 5-2-4-2 at Castle Danger in 1938. The amounts of vine growth on the fruiting plants at Castle Danger in 1938 and 1939 and at University Farm in 1939 were, respectively, 9.62, 24.03, and 17.81 per cent less than on the plants which were not allowed to produce flowers and fruit. The average reduction obtained for the three tests was 18.01 per cent. Approximately one half of this loss appears to have been due to flowering. It is evident from these data that permitting the plants to flower but not set fruit (Type II plants) resulted in appreciable reductions in vine growth as compared to plants from which the flower clusters were removed in the bud stage (Type III plants). Thus the decrease in vine growth amounted to 1.94 and 14.25 per cent at Castle Danger in 1938 and 1939, respectively. At University Farm this decrease amounted to 8.86 per cent, while the average decrease in vine growth for all tests amounted to 102 grams, or 9.05 per cent.

Table 1. Effect of Floral and Fruit Development on Fresh Weight of Vines

Location and year	Variety	Fresh weight of vines			Decrease in vine growth on	
		Type I Fruiting	Type II Flowering-Nonfruiting	Type III Nonflowering-Nonfruiting	Type I plants	Type II plants
		Grams	Grams	Grams	Per cent	Per cent
1938						
Castle Danger	5-10-1-42	1109	1115	1408		
	5-2-4-2	864	976	803		
	Russet Rural	536	630	564		
	Mean(1)*	836	907	925	9.62	1.94
1939						
Castle Danger	5-10-1-42	1034	1401	1671		
	5-2-4-2	1246	1256	1557		
	Russet Rural	773	790	792		
	Mean(2)*	1018	1149	1340	24.03	14.25
University Farm	5-10-1-42	1118	1144	1299		
	5-2-4-2	1157	1317	1335		
	Irish Cobbler	479	593	718		
	Mean(3)*	918	1018	1117	17.81	8.86
General Mean		924	1025	1127	18.01	9.05

* Least difference necessary for significance between means of plant types: (1) Not significant with respect to residual error; (2) 255 grams; (3) 125 grams.

Table 2. Effect of Floral and Fruit Development on Fresh Weight of Vines to the Completion of Three Growth Stages at Castle Danger in 1939

Variety	Harvest period	Type I Fruiting		Type II Flowering-Nonfruiting		Type III Nonflowering-Nonfruiting
		Fruits	Vines	Flowers	Vines	Vines
		Grams	Grams	Number	Grams	Grams
5-10-1-42	First	*	338	0.5	324	311
	Second	172	1343	246	1940	2232
	Third	1105	1422	513	1939	2470
	Fourth	1232	.....	365	.....	.....
5-2-4-2	First	*	433	0.2	470	611
	Second	112	1644	66	1648	1722
	Third	450	1662	79	1651	2338
	Fourth	356	.....	91	.....	.....
Russet Rural	First	*	173	0.1	240	296
	Second	19	810	35	1020	911
	Third	204	1335	66	1110	1168
	Fourth	168	.....	43	.....	.....

* No fruits set prior to the termination of the first harvest. Plants harvested before plant types had differentiated.

The data presented in table 2 for successive harvest periods at Castle Danger suggest that the retardation of vine growth for both flowering and fruiting plants occurred between the first and second harvest. Figure 1 illustrates the plants of 5-10-1-42 at this growth stage. The plant types had not differentiated at the time the plants were harvested at the termination of the first growth period. Consequently, differences between plant types in general were small. Significant differences became apparent when plants

FIG. 1. SHOWING VARIATION IN PLANT HEIGHT AND VEGETATIVE VIGOR OF VARIETY 5-10-1-42
Left, Fruiting plant (Type I); Center, Flowering, Nonfruiting plant (Type II); Right, Nonflowering, Nonfruiting plant (Type III).
Castle Danger, August 20, 1939

were harvested after the completion of the second period of growth and after a period of most active vine growth and flowering and fruit set. A study of the data in table 2 further indicates that flowers and fruits continued to be formed to the completion of the third developmental stage. However, the large number of flowers initiated and fruits set following the second harvest period apparently had little effect on the fresh weights of tops. Presumably this was due to the relatively small amount of vegetative growth on all plant types after this time. Nevertheless the Type I (fruiting) plants tended to cease growth at an earlier date and were marked by an observable stunted growth and fewer leaves. Also the Type III (nonflowering, nonfruiting) plants retained their deeper green color and continued to differentiate new lateral growth and leaves to the end of the third growth stage.

Depression in Vine Growth in Relation to Number of Flowers and Fruits Formed

As was stated previously, to obtain a range of from light to heavy fruit set and from comparatively lightly to profusely blooming types, varieties were selected to represent different degrees of floral and fruit development. Thus the severity of treatments on any of the plant types for the individual varieties was dependent upon the extent of its flowering and fruiting. Table 3 compares the extent of floral and fruit development of all varieties with the depression in vine growth per flower and fruit formed.

It will be noted from the data presented in table 3 that the length of the flowering period varied only slightly for the three varieties at Castle Danger in 1938 and 1939. At University Farm this period was somewhat reduced with 5-2-4-2 and Irish Cobbler. The largest number and weight of fruits set occurred with 5-10-1-42 grown at Castle Danger. This was directly followed by 5-2-4-2 at this same location. At University Farm the number of flowers initiated per plant on 5-10-1-42 and 5-2-4-2 were comparable to the number produced at Castle Danger, but in neither case did fruit production compare with the number or weight of seed balls set at Castle Danger. However, the number and weight of fruits set per plant in the instance of the hand pollinated Irish Cobbler compared favorably with the extent of floral and fruit

Table 3. Comparative Depression in Vine Growth in Relation to the Number of Flowers and Fruits Formed on the Individual Varieties of the Experiments

Location and year	Variety	Type I Fruiting		Type II Flowering-Nonfruiting		Depression in vine growth per	
		Fruits set per plant	Weight of fruits set per plant	Length of flowering period	Flowers formed per plant	One flower formed	One gram of fruit set
		Number	Grams	Days	Number	Grams	Grams
1938							
Castle Danger	5-10-1-42	69	278	49	230	1.27	1.07
	5-2-4-2	33	135	43	57	*	*
	Russet Rural	14	38	45	31	*	0.73
1939							
Castle Danger	5-10-1-42	168	836	50	281	0.96	0.76
	5-2-4-2	52	306	43	59	5.10	1.01
	Russet Rural	26	130	47	36	0.05	0.14
University Farm	5-10-1-42	5	15	46	231	0.67	12.06
	5-2-4-2	6	14	32	75	0.24	12.71
	Irish Cobbler	21	61	25	24	5.20	3.91

* Plants of Type III class produced less vine growth than Type I or Type II plants. See Table 1.

development of Russet Rural. This may be due, in part at least, to the fact that climatic conditions encountered at both locations differed with respect to environment favorable for floral and fruit development. At Castle Danger all varieties flowered profusely and set a large amount of fruit. At University Farm both numbered selections failed to set an appreciable amount of fruit regardless of continued hand pollinations.

It has been shown in tables 1 and 2 that most marked reductions in vine growth occurred in the more profusely blooming, highly self-fruitful varieties. With this in mind it is noteworthy that within the limits of experimental error the reduction in fresh weight of vines was closely associated with the number of flowers initiated and weight of fruits set. The greatest reduction was obtained on 5-10-1-42 at Castle Danger in 1939, which corresponded to the largest number of flowers and weight of fruits set. However, it is apparent that when interpreting the original data on the basis of a reduction in vine growth per flower formed or per one gram of fruit set the greatest resultant decrease in the extent of vine growth occurred at University Farm. In this respect vine growth was most markedly reduced per one flower formed on the normally scant-flowering Irish Cobbler, which showed a reduction of 5.20 grams. The average decrease per one gram of fruit set shows that the most pronounced reduction occurred with 5-10-1-42 and 5-2-4-2 at University Farm. Marked

FIG. 2. VARIETY 5-10-1-42. NOTE CLUSTERS OF FRUIT SET. CASTLE DANGER, AUGUST 20, 1939

decreases in vine growth were noted regardless of the fact that relatively few fruits were set. In this relation it is particularly important to note that vine growth was more noticeably reduced on the lesser flowering and fruiting Irish Cobbler at University Farm, on a per flower and fruit basis, than on the more profusely blooming, highly self-fruitful 5-10-1-42 when grown under conditions favorable for flowering and maximum seed set at Castle Danger. These data permit the assumption that reproductive processes even on the comparatively lightly flowering and fruiting varieties seriously reduced the ultimate growth of vines.

Development of fruits set on 5-10-1-42 at Castle Danger in 1939 is illustrated in figure 2.

Effect of Floral and Fruit Development on Growth of Underground Parts

The term "underground parts" refers to stolons plus roots, plus all portions of the stems remaining underground after the plant had been severed at soil level. In table 4 a comparison is given of the fresh weight of underground parts on each of the three plant types grown at Castle Danger. These data show that

root and stolon growth were significantly influenced through fruiting (Type I) only in 5-10-1-42, although there was an indicated tendency for these parts to be reduced on the fruiting plants of the other two varieties. This tendency is also apparent in the instance of the flowering (Type II) plants.

A further examination of the results secured on successive harvest dates, given in table 4, shows that growth of these parts paralleled closely that of vine growth. In general, differences among plant types became noticeable when harvested at the termination of the first growth period. With the later maturing 5-10-1-42 these differences became more widespread at the completion of the third growth stage. Apparently the period of maximum vegetative growth of vines was concurrent with that of underground parts and it was during this period that flowering and fruiting had the most effect on the growth of these parts. Furthermore the increased weights through the season with all plants, irrespective of plant type, suggest that a downward transport and accumulation of food materials in roots and stolons had occurred after vine growth had practically ceased.

Effect of Floral and Fruit Development on Tuber Yields

The data presented in table 5 and in figure 3 show a decided decrease in yield on the Type I (fruiting) plants as compared to the Type III (nonflowering, nonfruiting) plants in each of the

Table 4. Effect of Floral and Fruit Development on Fresh Weight of Underground Parts at Castle Danger in 1939

Variety	Harvest period	Fresh weight of underground parts		
		Type I Fruiting	Type II Flowering-Nonfruiting	Type III Nonflowering-Nonfruiting
		Grams	Grams	Grams
5-10-1-42	First	38	42	51
	Second	107	162	153
	Third	129	171	190
	Mean*	91	125	131
5-2-4-2	First	60	53	66
	Second	103	91	91
	Third	116	103	128
	Mean*	93	82	95
Russet Rural	First	30	30	35
	Second	53	78	68
	Third	107	94	101
	Mean*	63	67	68

* Least difference necessary for significance between means of plant types = 21 grams.

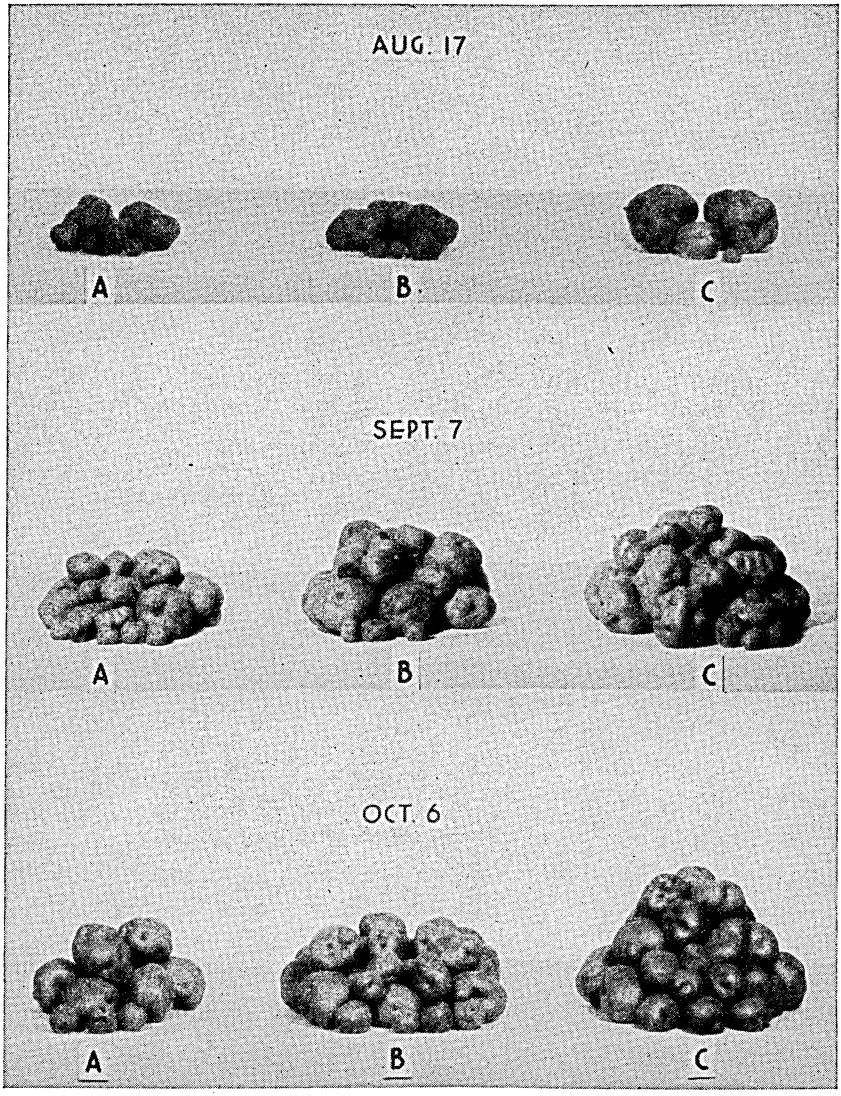

FIG. 3. SHOWING MEAN YIELDS OF TUBERS ON VARIETY 5-10-1-42 WHEN HARVESTED ON AUGUST 17, SEPTEMBER 7, AND OCTOBER 6
A = Fruiting plants (Type I); B = Flowering, Nonfruiting plants (Type II);
C = Nonflowering, Nonfruiting plants (Type III).
Castle Danger, 1939

separate studies. In all cases a comparison of the means for each location shows this decrease to be highly significant. The greatest reduction obtained amounted to 511 grams per plant. An average for all tests amounted to 172 grams per plant, or a decrease of

22.96 per cent. If the mean yields for each of the individual locations of the studies are compared, these data show that this decrease in total yield reduction ranged from 12.77 per cent to 27.24 per cent, with the greatest reduction noted at Castle Danger. As with fresh weight of vines, it is assumed that part of this yield reduction was due to flowering.

Data presented in table 5 further illustrate that yields of Type II (flowering, nonfruiting) plants were significantly lower than yields obtained on the Type III (nonflowering, nonfruiting) plants. With the exception of 5-2-4-2 grown at Castle Danger, this yield reduction was evident with all varieties during both years of the studies. For the individual locations yields were more markedly reduced at Castle Danger than at University Farm where differences noted amounted to decreases of 7.37 per cent and 12.90 per cent in 1938 and 1939, respectively. Taking into consideration the data obtained for all studies the average decrease was 75 grams, or a decrease in yield amounting to approximately 10 per cent. These results suggest that about one half of the total reduction noted on the Type I (fruiting) plants occurred as a result of flowering.

The weights of tubers as displayed in table 6 indicate that the production of fruit decreases the potential rate of tuber development from the time the tubers are set until the vines are dead.

Table 5. Effect of Floral and Fruit Development on Total Yield of Tubers

Location and year	Variety	Yield of tubers			Decrease in tuber yields on	
		Type I Fruiting	Type II Flowering-Nonfruiting	Type III Nonflowering-Nonfruiting	Type I plants	Type II plants
		Grams	Grams	Grams	Per cent	Per cent
1938						
Castle Danger	5-10-1-42	287	389	538		
	5-2-4-2	577	751	732		
	Russet Rural	603	631	640		
	Mean(1)*	489	590	637	23.23	7.37
1939						
Castle Danger	5-10-1-42	375	709	886		
	5-2-4-2	1080	1219	1294		
	Russet Rural	981	987	1167		
	Mean(2)*	812	972	1116	27.24	12.90
University Farm	5-10-1-42	19	12	68		
	5-2-4-2	486	525	546		
	Irish Cobbler	785	843	866		
	Mean(3)*	430	460	493	12.77	6.69
General Mean		577	674	749	22.96	10.01

* Least difference necessary for significance between means of plant types: (1) 106 grams; (2) 110 grams; (3) 51 grams.

The data show only small differences between plant types at the termination of the first growth period. No tubers were set on 5-10-1-42 prior to the first harvest. However, it is evident that up to this point the yields of the Type I and Type II plants of 5-2-4-2 and Russet Rural are nearly identical. The indicated tendency for these two types to show a lower weight of tubers than on the Type III plants may be ascribed to the effect of flowering. At the second harvest, after a period of active fruit set and development, these differences have greatly increased and their significance begins to be apparent. The data show further that the yield differences continue to increase, as is indicated by the weights obtained at the third harvest, and presumably reached their maximum at the fourth harvest. In general the data suggest that fruit and tuber development were concurrent processes except that the time of initiation varied slightly according to environmental conditions. It is possible that the reduced tuber yield of the Type I (fruiting) plants was due to the direct withdrawal of synthates by the developing fruits. The close association between the increase in weight of fruits between the second and fourth harvests and the apparent lack of further tuber enlargement or development of the fruiting plants from the third to the fourth harvest tends to support this view.

Table 6. Effect of Floral and Fruit Development on Total Yield of Tubers to the Completion of Four Growth Stages at Castle Danger in 1939

Variety	Harvest period	Yield of tubers				
		Type I Fruiting		Type II Flowering-Nonfruiting		Type III Nonflowering-Nonfruiting
		Fruits	Tubers	Flowers	Tubers	Tubers
		Grams	Grams	Number	Grams	Grams
5-10-1-42	First	*	†	0.5	†	†
	Second	172	160	246	191	276
	Third	1105	685	513	1245	1529
	Fourth	1232	655	365	1401	1740
5-2-4-2	First	*	27	0.2	32	52
	Second	112	818	66	931	936
	Third	450	1891	79	1893	2235
	Fourth	356	1584	91	2020	1954
Russet Rural	First	*	14	0.1	15	39
	Second	19	447	35	782	728
	Third	204	1860	66	1753	1922
	Fourth	168	1604	43	1399	1980

* No fruits set prior to the termination of the first harvest. Plants harvested before plant types had differentiated.

† No tubers set prior to the termination of the first harvest.

Table 7. Depression in Tuber Yield in Relation to the Number of Flowers and Fruits Formed on the Individual Varieties of the Experiments

Location and year	Variety	Type I Fruiting		Type II Flowering-Nonfruiting		Depression in tuber yield per	
		Fruits set per plant	Weight of fruits set per plant	Length of flowering period	Flowers formed per plant	One flower formed	One gram of fruit set
		Number	Grams	Days	Number	Grams	Grams
1938							
Castle Danger	5-10-1-42	69	278	49	230	0.64	0.90
	5-2-4-2	33	135	43	57	*	1.15
	Russet Rural	14	38	45	31	0.30	0.97
1939							
Castle Danger	5-10-1-42	168	836	50	281	0.63	0.61
	5-2-4-2	52	306	43	59	1.27	0.70
	Russet Rural	26	130	47	36	5.00	1.43
University Farm	5-10-1-42	5	15	46	231	0.24	3.26
	5-2-4-2	6	14	32	75	0.28	4.28
	Irish Cobbler	21	61	25	24	0.96	1.33

* Plants of Type III class produced lower total yield of tubers than Type II plants. See table 5.

Seasonal trends given in table 6 show a slight but continued increase in yields of the Type II (flowering, nonfruiting) plants following the third harvest. Small differences in favor of the Type III plants became noticeable at the termination of the first growth stage. In general, these discrepancies became more pronounced through successive harvests.

Depression in Tuber Yield in Relation to Number of Flowers and Weight of Fruit

The depression in tuber yield was within the limits of the experimental error proportionate to the number of flowers and weight of fruits produced on the three varieties at the three locations tested. The data are presented in table 7. The smaller proportionate decrease in tuber yield per flower and per gram of fruit on 5-10-1-42 than that obtained on the other two varieties at Castle Danger in 1938 and 1939 suggests that there might be a decreasing rate of loss with increasing number of flowers and weight of fruit. The higher proportionate loss of tubers per gram of fruit at University Farm compared to that obtained at Castle Danger in 1938 and 1939 also suggests that there might not be a direct quantitative relationship between the number of flowers and weight of fruit and the depression in tuber yield. While these variances from a direct quantitative relationship are suggestive,

Table 8. Effect of Floral and Fruit Development on Total Number of Tubers Formed

Location and year	Variety	Mean number of tubers per plant		
		Type I Fruiting	Type II Flowering-Nonfruiting	Type III Nonflowering-Nonfruiting
		Number	Number	Number
1938				
Castle Danger	5-10-1-42	28.5	32.1	22.2
	5-2-4-2	17.7	18.0	17.7
	Russet Rural	10.1	7.6	8.7
	Mean(1)*	18.7	19.2	16.2
1939				
Castle Danger	5-10-1-42	14.8	25.1	29.8
	5-2-4-2	35.4	34.5	41.7
	Russet Rural	15.5	12.9	16.8
	Mean(2)*	21.9	24.1	29.4
University Farm	5-10-1-42	2.3	1.1	3.2
	5-2-4-2	25.8	29.2	32.9
	Irish Cobbler	17.8	21.8	24.5
	Mean(3)*	15.3	17.3	20.2

* Least difference necessary for significance between means of plant types: (1) Not significant with respect to residual error; (2) 3.8 tubers; (3) 2.7 tubers.

the data presented indicate a high association between the number of flowers and weight of fruit, and the depression in tuber yield.

Number of Tubers

The effect of floral and fruit development on the total number of tubers formed per plant is given in table 8. In recording the number of tubers, all tubers developed regardless of size were considered. With 5-10-1-42 and 5-2-4-2 numerous tubers were developed from lateral buds as well as from the terminal buds of the stolons. Tuber formation with both standard varieties was confined almost entirely to the enlargement of terminal buds. Table 8 shows that significant reductions occurred in the number of tubers formed on Type I (fruiting) plants and the Type II (flowering, nonfruiting) plants as compared to the Type III (nonflowering, nonfruiting) plants. Results obtained at Castle Danger were not consistent during both seasons. However, highly significant differences are indicated in the results obtained at Castle Danger in 1939. A comparison of the number of tubers formed at University Farm shows also marked significant reductions on both the Type I and Type II plants.

In general, tuber formation on all varieties was not restricted to the early stages in the development of the plant, but continued to set on all plant types until the harvest at the completion of the third growth period.

A study of the data presented in tables 5 and 8 suggests that the reduction noted in tuber yields in the initial experiments on the Type I and Type II plants was due chiefly to the increase in tuber size and not to the increase in the number of tubers formed. In contrast, the data obtained in 1939 at Castle Danger and University Farm suggest that the increased number of tubers on the Type III plants also entered in as a factor in increasing the total weight of tubers produced. Observations made at the completion of each harvest period indicated that the number of tubers recorded at the termination of the fourth harvest was noticeably less than at the end of the third growth stage for all varieties and plant types. Possibly certain of the tubers set prior to the third harvest were reabsorbed or had dried up. Yields were apparently determined largely by a few of the earlier formed tubers, while the later formed tubers had no appreciable influence on the total weight set. Furthermore the results secured relative to the number of marketable tubers formed indicate that the total yield was determined chiefly by a relatively few of the large number of tubers formed. These data are presented in table 9.

Number of Marketable Tubers

The data summarized in table 9 show clearly that the number and weight of tubers reaching marketable size (exceeding 85 grams) were decreased significantly on both the Type I and Type II plants. The data further indicate only small differences between plant types in the number of tubers reaching marketable

Table 9. Effect of Floral and Fruit Development on the Number and Weight of Tubers Reaching Marketable Size at Castle Danger in 1939

Variety	Type I Fruiting			Type II Flowering-Nonfruiting			Type III Nonflowering-Nonfruiting		
	No. of tubers	Weight of tubers	No. of tubers reaching marketable size	No. of tubers	Weight of tubers	No. of tubers reaching marketable size	No. of tubers	Weight of tubers	No. of tubers reaching marketable size
	No.	Grams	Per cent	No.	Grams	Per cent	No.	Grams	Per cent
5-10-1-42	1.8	250	12.16	3.0	535	11.95	4.1	670	13.75
5-2-4-2	4.8	681	13.55	5.5	852	15.94	6.1	1049	14.62
Russet Rural	5.0	997	32.25	5.5	1069	42.63	6.6	1253	39.28
Mean(1)(2)*	3.9	643		4.7	819		5.6	991	

* Least difference necessary for significance between means of plant types: (1) 0.90 tubers; (2) 146 grams.

size when expressed on a percentage basis. Since an increased number of tubers formed were noted on the Type III plants such a relationship might be expected.

Fewer marketable tubers were produced by the Type I (fruiting) plants and the Type II (flowering, nonfruiting) plants previous to the second harvest. This same relationship existed among the plant types at the termination of the third and fourth harvests. However, the number of tubers reaching marketable size with the Type I and Type II plants tended to remain constant after the third harvest, while the Type III plants tended, on the whole, to show a definite gain in number.

DISCUSSION

A study of the effect of floral and fruit development upon certain growth responses of the potato has shown that both flowering and fruiting resulted in pronounced reductions in the vegetative growth and in the tuber yield. Significant decreases were noted on both the lightly blooming, normally self-sterile varieties and the more profusely blooming, highly self-fruitful varieties. The results suggest certain probable explanations.

It is possible that the inhibitory effects of floral and fruit development on vegetativeness and tuber development may be due to a simple direct competition for elaborated food materials between the vegetative organs and floral differentiation and fruit formation. The results presented substantiate this view. It is generally accepted that in the process of the initiation of floral primordia large quantities of nitrogen and carbohydrate materials are removed. That large quantities of nitrogen are required in the development of fruits and seeds has also been shown by numerous investigators. Moreover, it is logical to assume that large amounts of elaborated nitrogen and carbohydrates are necessary for the developing tuber. In this respect the potato is generally considered to be a modified vegetative part capable of assimilating large quantities of carbohydrates. In view of these facts it is therefore reasonable to suppose that flowering or fruiting tends to lessen the elaborated food materials available for tuber formation and enlargement and consequently results in a proportionate reduction in tuber yield. On this assumption, vegetative growth would also be retarded.

Roberts (12) observed an increased phloem development in nonflowering as compared to flowering plants. It may be that this increase in phloem development is part of the general increase in vegetative growth found to be associated with nonflowering (Type III) plants in the present studies. The heavier tuber production of these plants points to a greater production and translocation of synthates in the nonflowering than in the flowering plants. Whether this would tend to stimulate the development of a more highly differentiated phloem in the nonflowering than in the flowering plants as observed by Roberts is not known.

In the statement of the problem the importance of the present experiments has been stressed relative to breeding work. If tuber yields are reduced through flowering or fruiting this would be valuable information in the breeding of new varieties. To this effect it is felt that the results secured, although preliminary in nature, have added materially to certain aspects of the problem and have provided the groundwork for future studies.

SUMMARY

Studies conducted with four varieties of potato at two locations indicated that both flowering and fruiting caused significant reductions in vegetative growth and tuber yields. Fruiting plants, and to a lesser extent flowering plants, tended to produce a smaller weight of vines than did the nonflowering, nonfruiting plants. This influence was noted in the early developmental stages of growth following a period of most active flowering and fruit set. An association between the extent of flower and fruit production and vine growth was indicated, although marked decreases were observed with the lighter flowering, less fruitful individuals.

Growth of underground parts (stolons plus roots) closely paralleled that of vines. Similarly, flowering and fruiting exhibited a tendency to reduce the ultimate size of these portions.

To determine the influence of both flowering and fruiting, measurements were made on total yield of tubers and number of tubers reaching marketable size (exceeding 85 grams). Yields were significantly reduced on both fruiting and flowering plants

of all varieties as compared to nonflowering, nonfruiting plants. Fruit formation and tuber production were found to be concurrent processes. The decrease in yield appeared to be related to the number of flowers and fruits formed. Yield reductions per gram of fruit set and per flower formed tended to be greater on the lesser flowering and less fruitful plants. The study further indicated that flowering and fruiting reduced the total number of tubers set, and the number and weight of tubers reaching marketable size.

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