EFFECTS OF SOME COLORED PLASTIC GREENHOUSE SUBDIVISIONS ON VEGETATIVE GROWTH AND TUBER SET OF SOLANUM TUBEROSUM

by

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INTRODUCTION

The effects of light sources on plant growth have been investigated for centuries. It was established many years ago that light is necessary for photosynthesis. This is the process by which plants convert carbon dioxide and water into carbohydrates in the presence of sun-light. Carbohydrates serve as a source of energy for many plant processes. In recent years plastic materials have become increasingly important in the construction of propagating structures. Much experimental work has been conducted on different type plastic materials for greenhouse construction. The materials used for this purpose previously have been clear and transparent. These studies were initiated to determine the effects of clear, yellow, red and green plastics on plant growth. The potato (Solanum tuberosum) was used as the test plant. As light was the primary factor to be evaluated in this study, no supplementary light sources were used. Therefore, only natural illumination was considered. The objectives of these experiments were: (1) to study the effects of these previously mentioned plastics and glass on vegetative growth of an early and late maturing potato variety, (2) to determine any beneficial effects of these treatments on tuber formation and development, (3) to determine any detrimental effects of these treatments on tuber formation and development, and (4) to evaluate the effects of treatments on flower production.

REVIEW OF LITERATURE

Priestly, according to Veen and Meyer (10), is generally considered to be the first who had some idea about photosynthesis. He observed that some plants tended to improve when placed in an atmosphere vitiated by breathing or by products of combustion. Pringle, the then chairman of the Royal Society, presented Priestly with a medal in 1773 in recognition of far reaching implication of this discovery. Priestly performed his experiment in an illuminated room at any rate in front of a window. He did not at that time realize the part played by light. Scheele, the chemist, endeavoured to confirm Priestly's results, but he obtained opposite results. His experiments were carried out in the dark. Neither Priestly nor Scheele had any idea that light had anything to do with the results obtained.

Jan Ingen Housz in 1779, as reported by Veen and Meyer (10), was the first scientist to state that light was the important factor in photosynthesis. He conducted several experiments and published them under the title of "Experiments upon Vegetables, Discovering their Great Power of Purifying the Common Air in Sunshine and of Injuring it in the Shade and at Night." He established that light is definitely essential to enable plants to purify the air, and that only green plants could accomplish this.

Van Barnerveld, according to Veen and Meyer (10), arrived at the same conclusion at about the same time, but independently of Ingen Housz. He noticed that the house leek, when placed out of the sunshine did not purify the air in a matter of days, but in the sun, plants could do so in a few hours. The effects of light quality on plant life are manifold; studies on this subject by plant physiologists are numerous and extend over more than 150 years. Senelier, according to Wassink and Stolwijk (11), investigated the effects on plants of different colored filters. He used double walled glass covers over plants as spectral filters in which the space between the double walls was filled with colored fluids.

In 1864 Sachs (7) used such spectral filters. The plants of common flax (Linum usitatissimum) and white mustard (Sinapis alba) when germinated, were treated with orange and blue lights. In case of orange lights, the plant development on the whole was good and the cotyledons were two to three times larger than the ones in the blue light. The effects could be related to light on one hand and to darkness on the other. These colors could be fitted in the given range. The plants in white light grew the best while in orange light they were not as good. Similarly, in blue light they were not as good as in orange light. As long as the food reserve lasted the plants lived. After the supply of food reserve was depleted, the plants died. There was no assimilation and no new substance formed by plants placed in blue light, but these processes occurred in some degree for plants placed under orange light. A definite statement about the increase and decrease of organic matter or any other substance was not made because the plants were not harvested and weighed.

Hunt's observation, as reported by Sachs (7), with garden cress and pepper weed concerned the percentage of dry matter. He called it wood fibre. The wood fibre was less in plants grown under blue light as compared to yellow, orange or white lights. Sachs did not recognize Hunt's observation as scientific evidence on the subject. The etiolated sprouts had an abnormal extension. Supposedly, this extension was not an effect of these colored lights, but it was due to lack of some of the rays which were not available to these etiolated sprouts. This phenomena could be possible in the dark. Sachs (7) concluded that the difference or similarities among the works of Hunt and others could not be taken as a discussion subject because the treatments of these colored lights differed from each other.

The visible spectrum has been shown to exert marked effects upon growth through carbohydrate synthesis and through a special formative action not fully understood. The infra-red region appears to be active mainly through its temperature effects. The great bulk of literature dealing with effects of ultra-violet radiation upon plants has been reviewed by Popp and Brown, as reported by Burkholder (1). It seems clear that the short wave ultra-violet from 289 - 200 millimicrons is distinctly harmful. The degree of injury depending upon the intensity, the wave length and the amount absorbed by the vital tissues. This lethal radiation given off by the sun is filtered out by the ozone in the outer layers of the atmosphere, therefore it never reaches the earth. Artificially produced wave lengths shorter than ordinary sun-light cause unusual effects upon organisms which have become adapted to the natural light environment of which lethal rays form no part. They also stated that even in very slight doses the short wave ultra violet has never been demonstrated to be beneficial, and evidence from the most accurately controlled experiments to date shows little, if any, beneficial effect of that region of the ultra violet present in the sun light.

The action of different portions of the visible spectrum upon size and form of plants has received attention from many investigators. Burkholder (1) reported that Popp in 1926 grew a number of different species in colored glass houses using filtered sun-light as the source of energy. Very little difference was noted between plants grown under full sun-light and those grown in the absence of ultra-violet radiation. When the blue end of the spectrum, including all wave lengths shorter than 529 millimicrons was excluded, growth was poor. The plants were also weak and a decrease occurred in fresh and dry weight. Also an increase in the moisture content resembling the symptoms associated with etiolation was evident. The intensities were not balanced in the different houses, but the data indicated that the blue violet end of the spectrum was indispensable for normal vigorous growth of plants. Somewhat similar experiments by Shirley (8) in 1929 have indicated that the blue violet part of the solar spectrum is more efficient in dry weight production than the red end. These results occurred when the intensities were 10 per cent of the outside sun-light. Pfeiffer (6) in 1926 reported better development, as expressed by greater stem thickness, height, leaf thickness, etc., in the full solar spectrum than in any fraction of it. Roodenburg, according to Burkholder (1), in 1931 found in his experiments with light from neon and mercury arcs, that the blue end of the spectrum tended to make plants grow stocky. Shirley (8) in 1929 grew plants in five different colored glass houses with three different intensities controlled by cloth shades in each house. The complete solar spectrum was considered more efficient for production of dry matter per unit of light intensity than any other portion of it. Investigations by Arthur and Steward, according to Burkholder (1), in 1935 suggested that a relatively high proportion of infra red in the incident radiation may bring about increased elongation of the stems, accompanied by decreased expansion and diminished chlorophyll content of the leaves of buckwheat plants.

Experiments dealing with the influence of near infra-red radiation on plant growth and coloration were described by Johnston (4) in 1932. He emphasized the necessity for considering the presence of infra-red energy in order to properly evaluate the effects of the visible region, on Marglobe tomato plants grown under two different wavelength ranges of equal visual intensity. One intensity was limited entirely to visible radiation, but the other included a large amount of near infra-red energy. After two weeks, the plants exposed to visible plus infra-red radiation were characterized by longer internodes, larger leaves and decreased chlorophyll. According to Burkholder (1) these results were in accord with those reported by Stephan in 1928 who found that Marchantia species grew abnormally in a light environment with a very high proportion of infra-red rays. However, Foerster, as reported by Burkholder (1), in 1927 reported no influence of infra-red rays upon the development of Marchantia species.

Veen and Meyer (10) reported that many physiological phenomena are dependent on light in the plant world. One is likely to conclude that light is responsible for two distinct biochemical processes. The first one is dominated by the antagonism between red and infra-red, with antagonism by any other color. Caution should be exercised in any interpretation of the observations, since irradiation with pure blue or green light is invariably "contaminated" by the red in infra-red fluorescence produced by chlorophyll. Results obtained from irradiation with blue or green light might actually be the outcome of red or infra-red fluorescence.

They also reported that flowering of a short day plant such as Salvia occidentalis cannot be suppressed by green light given in a long day period. However, in long days of pure blue light, the lowest intensities capable of maintaining growth are sufficient to suppress any tendency to flower. The flourescence in intense green light is much stronger than in a weak blue light, but infra-red must be added to the strong green light if flowering is to be suppressed by long days. Obviously then, this is a long day effect that can be induced by blue light, but not by green. Blue light is definitely essential for a good spread of leaves; infra-red has no effect, whether it is given simultaneously with the red or subsequently. Green light has no effect either, so this must be a typical response to blue. It may be assumed that the two reactions are active at the same time. This greatly complicates any analysis of the reactions of plants to light. In case of the red and infra-red response there are some plants for which a major response occurs more towards the red, and others for which it lies more in the direction of infra-red. This response results in varying behavior under otherwise similar lighting conditions. If in addition, however, the response to the blue light is linked with this behavior, it becomes very difficult to interpret the ultimate observations according to Veen and Meyer (10).

The background of these varying responses to light has yet to be filled in. So far, it has not been possible to identify the pigments responsible.

MATERIALS AND METHODS

This work was divided into two experiments according to daylengths. The long day experiment and the short day experiment. These experiments were designated the spring experiment and the fall experiment respectively. The spring experiment was started on April 30, 1960 and was terminated 73 days later. The fall experiment was started in August; however, the rest period of seed pieces was not broken and the seed either failed to sprout or decayed. This experiment was replanted on October 5, 1960. The maturity of the crops was determined by appearance of the plants and tuber formation. Galvanized No. 10 cans were used as the plant containers in both experiments. Each can had four holes at the bottom for drainage. The cans were filled to 1½ inches of the top with a soil medium consisting of three parts silt loam, one part well rotted manure and one part sand. The cans were then placed on benches in the colored plastic greenhouses and the glass house which was used as a control. Corrugated fiberglass acrylic resin plastics were used in construction of the plastic houses. The plastic colors were clear, jonquil yellow, ivy green and tropical coral (red). The plastics were obtained from Butler Manufacturing Company, Kansas City, Missouri.

The treatments consisted of growing the plants in a subdivided plastic house. The subdivisions were green, red, yellow and clear corrugated plastic on the top and sides. Partitions of black plastic subdivided the houses. The vertical illumination was recorded as shown in Table 1 on January 5, 1961, in these houses by a Weston Model 756 sunlight Illumination Meter. It had a range of 0-12000 foot candles. This data was obtained on a clear day.

Table 1. Vertical illumination reading in foot candles

Place	9a.m.	10a.m.	11a.m.	12:00	1p.m.	2p.m.	3p.m.	4p.m.	Total for 8 hours
Outside	600	1800	3100	3700	4000	2800	2200	800	19,000
Glass	300	1200	2400	2800	3250	2400	1800	400	14,550
Clear	500	1100	1700	1850	1900	1300	950	400	9,700
Yellow	450	1000	1300	1550	1550	1300	1000	600	8,750
Red	300	800	1200	1450	1550	1150	750	300	7,500
Green	200	600	900	1350	1500	1000	800	350	6,750

The unpublished data which has been recorded in Table 1 was supplied by Dr. W. J. Carpenter, Department of Horticulture, Kansas State University.

Two varieties of potatoes, Irish Cobbler and Red Pontiac, were used in both experiments. The size of the seed piece used was approximately 1½ ounces. Seed was planted 3 inches deep for both varieties. A complete fertilizer solution was applied to the soil at intervals of 10 to 12 days after the plants were 8 to 10 inches tall. Aluminum stakes ¼ inch in diameter were used to support the plants in both experiments.

Observations were recorded for internode length, stem length, dry weight of the above ground parts, number and weight of tubers in both experiments. Each variety was replicated three times in a randomized block design. Each replication consisted of three plants except in a very few cases where there were only two. The data reported was based on an average of the plants in each replication.

Spring Experiment

The seed used for the spring experiment was certified northern grown seed. The seed was planted on March 31, 1960. The cans were watered immediately after planting. The plants began to emerge in about ten days. The speed of germination was comparatively faster for Red Pontiac than for Irish Cobbler in all treatments. As the plants did not emerge uniformly, the entire experiment was replanted on April 30, 1960.

Mealy bugs and red spider mites attacked the plants in the clear plastic subdivision. They were first observed 23 days after replanting. These insects were controlled by subsequent sprays of malathion.

The first stem length and internode readings were recorded 35 days after planting, or on June 4, 1960. The second stem length records were taken 22 days later. The third stem length records were taken 17 days later. The vegetative growth was harvested on July 16, 1960. The plant material was air dried to a constant weight in a glass greenhouse. The tubers were also harvested the same day.

Fall Experiment

The seed used for fall experiment was grown in variety plots at the Horticultural farm from certified northern grown seed. The seed pieces were planted on August 28, 1960. Germination in this experiment was poor and not uniform.

Replanting of the entire experiment was done on October 5, 1960. This replanted seed took about 10 to 13 days to germinate. The germination of the replanted seed was not one hundred percent, but it approached this level. The first records were taken 32 days after planting for internode length and the first stem length measurement. The second and third determinations of stem length were recorded on December 24, 1960 and January 4, 1961 respectively. Red spider mites became a problem in the clear plastic subdivision during the latter part of the experiment. The plants were sprayed with malathion, but this did not prevent damage to these plants. The crop was harvested on January 4, 1961. The vegetative portions were oven dried at a temperature of 160°F. for twenty-four hours. Individual plants were dried separately. Then the three plants per replicate were combined prior to weighing. The weight was recorded in grams per plant. The tubers were washed prior to weighing. Fresh tuber weight per plant and number of tubers per plant was obtained.

EXPERIMENTAL RESULTS

Spring Experiment

Irish Cobbler and Red Pontiac potato varieties were grown under four different colored plastics and a conventional glass house. Plant determinations were recorded for the following characteristics: internode length, stem length at various periods, dry weight of vegetation, number of tubers, and fresh weight of tubers. The data was analyzed by the analysis of variance procedure. L.S.D. values were then computed by extracting the square root of the following

$\frac{2 \text{ X error of variance}}{\text{number of replications}}$ X t value for 5 percent level from table of t according to Cochran and Cox (2). The internode length records in millimeters were taken 34 days after planting. The fifth internode was measured on all plants. There was no significant difference in internode length between colored plastics for the Red Pontiac variety. However, there were significant differences in internode lengths for Irish Cobbler plants.

Table 2. Mean internode length per plant in millimeters on June 4, 1960.

Varieties	Treatments: Green	Yellow	Clear	Red	Glass	5 percent L.S.D. Values
Irish Cobbler	3.6	3.3	3.0	2.6	2.6	0.6
Red Pontiac	3.3	3.3	4.0	3.0	2.6	n.s.

The green plastic treatment showed a significant increase in internode length when compared to the clear, red, or glass treatment. Similarly, plants from the yellow plastic treatment showed a significant increase in internode length when compared to the red plastic and glass treatments. From the data in Table 2 it was obvious that the potato varieties reacted differently to light for internode length. Plants of the Red Pontiac variety were not statistically affected by light but there were significant differences due to treatment for the Irish Cobbler variety. It was interesting to observe that both varieties had the same internode length when grown under glass and yellow plastic, but that there were differences between varieties for the other treatments.

Stem lengths of Irish Cobbler plants grown under the different treatments were significantly different. Stem lengths of plants grown under the yellow, red and green plastics were significantly longer than plants grown under glass. There was no significant difference in stem lengths for plants grown under clear plastic and glass.

Table 3. Mean stem length per plant in inches on June 4, 1960.

Varieties	Treatments					L.S.D. Values
	Yellow	Red	Green	Clear	Glass	
Irish Cobbler	21.16	20.96	18.96	15.46	14.10	3.0
Red Pontiac	21.85	25.11	23.20	19.83	19.43	2.5

The Red Pontiac variety also showed significant increases in stem length for the red and green treatments when compared with the glass treatment as shown in Plate I. These same two treatments were also significantly different from the clear plastic treatment. These results are shown in Table 3.

Table 4. Mean stem length per plant in inches June 26, 1960.

Varieties	Treatments: Yellow	Red	Green	Clear	Glass	L.S.D. Values
Irish Cobbler	33.20	33.13	31.60	25.8	23.83	5.6
Red Pontiac	38.33	41.90	37.86	32.46	35.43	5.5

Irish Cobbler plants grown under the yellow, red, and green plastic treatments showed significant increases in stem length over the clear plastic and glass treatments. Plants of the Red Pontiac variety showed the same results with the exception that the red plastic treatment showed a slightly greater increase in the stem length over the yellow, although the difference was not significant.

Table 5. Mean stem length per plant in inches July 13, 1960.

Varieties	Treatments: Red	Green	Yellow	Clear	Glass	L.S.D. Values
Irish Cobbler	40.80	40.43	40.04	30.2	29.0	7.7
Red Pontiac	52.83	48.36	49.06	43.23	40.56	8.0

Plants of the Irish Cobbler variety grown under the red, green and yellow treatments were significantly longer in stem length than plants grown under the clear plastic or glass treatments, see Plate I. There was no significant difference in stem length between the clear plastic and glass treatments. Plants

EXPLANATION OF PLATE I

Spring Experiment

Fig. 1 Close up of typical Red Pontiac plants showing relative stem length for different treatments in the spring treatment.

Fig. 2 Close up of typical Cobbler plants showing relative stem length for different treatments in the spring experiment.

PLATE I

Fig. 1

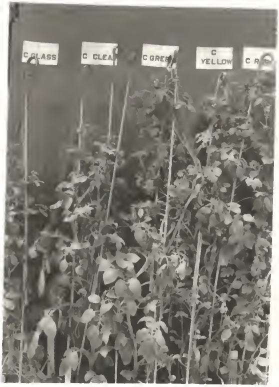


Fig. 2

of the Red Pontiac variety had the same general response for stem length. However, plants grown under the green plastic treatment were not different statistically for stem length, from plants grown under the clear plastic and glass treatments. Again there was no significant difference in stem length for the plants grown under the clear plastic and glass treatments.

Table 6. Mean dry weight for vegetative growth in grams per plant.

Varieties	Treatments: Glass	Yellow	Red	Green	Clear	L.S.D.Values
Irish Cobbler	37.76	35.86	32.43	31.43	31.03	n.s.
Red Pontiac	50.20	34.60	41.06	33.76	40.13	8.6

It was evident from Table 6 that there was no significant difference in dry weight of stem and leaf material for the Irish Cobbler variety due to treatment. Plants of the Red Pontiac variety grown under the glass treatment had a significantly greater dry weight than plants grown under any other treatment. No other significant differences for dry weight of vegetation occured due to treatment.

Table 7. Mean number of tubers per plant.

Varieties	Clear	Red	Green	Yellow	Glass	L.S.D. Values
	Treatments					
Irish Cobbler	21.5	19.6	8.9	7.9	6.8	n.s.
Red Pontiac	11.5	6.11	0.0	0.4	0.0	1.84

Significant differences in the number of tubers per treatment for the Irish Cobbler variety did not occur; however, it was interesting to observe that plants under the glass treatment produced the smallest number of tubers. Tuber number for the Red Pontiac variety varied considerably from treatment to treatment, see Plate II. Plants under the green plastic and glass treatments did not set tubers. Plants under the clear plastic treatment had significantly more tubers than plants under any other treatment. Plants under the red plastic treatment set significantly more tubers than plants in any other treatment except the clear plastic treatment. Table 7 indicated that there is a distinct varietal difference in tuber set under the different treatments used.

Table 8. Mean fresh weight of tubers in grams per plant.

Varieties	Clear	Red	Yellow	Glass	Green	5 percent L.S.D. Values
	Treatments					
Irish Cobbler	199.2	64.3	17.7	15.7	11.8	80.5
Red Pontiac	155.3	16.3	4.4	0.0	0.0	12.8

EXPLANATION OF PLATE II

Fig. 1. Close up of tubers per replicate of the Irish Cobbler variety in spring experiment for respective treatments: 1, clear plastic; 2, red plastic; 3, green plastic; 4, yellow plastic; and 5, glass.

Fig. 2. Close up of tubers per replicate of the Red Pontiac variety in spring experiment for respective treatments: 1, clear plastic; 2, glass; 3, red plastic; 4, green plastic; and 5, yellow plastic.

PLATE II

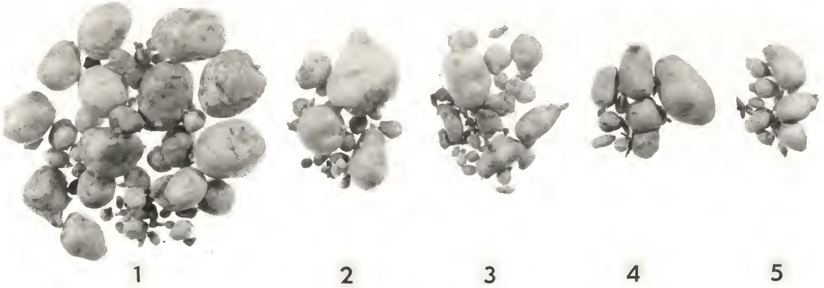


Fig. 1

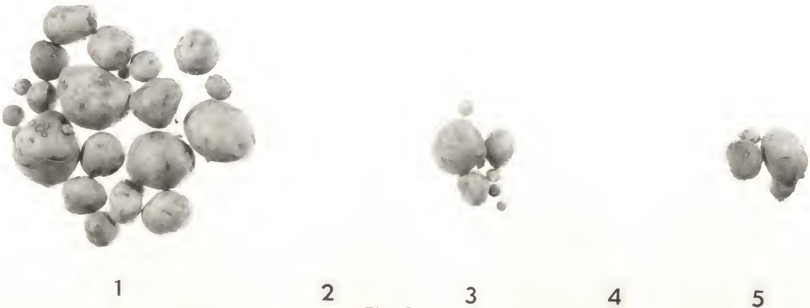


Fig. 2

Fresh tuber weight from plants grown under the clear plastic treatment was significantly greater than tuber weight from any other treatment for the Irish Cobbler variety. There were no other significant differences due to treatments for fresh tuber weight. Fresh tuber weight for the Red Pontiac variety was significantly larger from plants grown under the clear plastic treatment than the tuber weight for any other treatment. Weight of tubers from plants grown under the red plastic treatment was significantly greater than tuber weight from plants grown under the glass and green treatments.

Only one flower opened on an Irish Cobbler plant under clear plastic. Failure of flower buds to open and their abscission probably was affected by unfavorable conditions. Hardenburg (3) observed that some varieties blossom more than others and the amount of bloom varies with the season. Cool, humid weather favors the development of blossoms. Dry hot weather at blooming time usually causes the flower buds to absciss before opening.

Fall Experiment

Plants grown under yellow plastic had a significant increase in internode length when compared to the glass treatment for the Irish Cobbler variety. In contrast, plants of the Red Pontiac variety grown under glass had significantly longer internodes than plants grown under the colored plastic treatments. Plants grown under the clear treatment had significantly longer internodes than plants grown under the green treatment for the Red Pontiac variety as shown in Table 9.

Table 9. Mean internode length in millimeters per plant on December 2, 1960.

Varieties	Treatments: Yellow	Red	Green	Clear	Glass	L.S.D. Values
Irish Cobbler	4.0	3.0	3.0	2.6	2	1.8
Red Pontiac	3.0	3.0	2.6	3.3	4.0	0.6

Table 10. Mean stem length in inches per plant on December 2, 1960.

Varieties	Treatments: Red	Yellow	Green	Glass	Clear	L.S.D. Values
Irish Cobbler	15.6	11.6	10.6	10.3	9.0	n.s.
Red Pontiac	23.0	17.6	25.3	19.6	17.6	2.76

It appears from the data in Table 10 that there was no significant difference in stem length for the Irish Cobbler variety. Red Pontiac plants grown under the green and red plastic treatments had significantly longer stems than plants from the other three treatments.

Table 11. Mean stem length in inches per plant on December 25, 1960.

Varieties	Treatments: Red	Yellow	Green	Clear	Glass	L.S.D. Values
Irish Cobbler	23.0	19.6	18.3	18.0	16.3	3.45
Red Pontiac	27.6	24.6	29.0	20.6	30.6	4.61

Plants of the Irish Cobbler variety grown under the red plastic treatment showed a significant increase in stem length, when they were compared with plants grown under the green, clear and glass treatments as shown in Table 11. For the Red Pontiac variety, plants grown under glass had significantly longer stems than plants grown under yellow and clear plastic. Plants grown under the red and green plastics had significantly longer stems than plants grown under the clear plastic.

Table 12. Mean stem length in inches per plant on January 4,1961.

Varieties	Treatments: Red	Green	Yellow	Clear	Glass	L.S.D.Values
Irish Cobbler	25.6	21.6	21.6	18.3	18.0	4.15
Red Pontiac	28.0	28.6	26.6	21.3	31.3	4.38

Table 12 shows the effects of treatments on stem length at the termination of this experiment. Irish Cobbler plants grown under red plastic had significantly longer stems than plants under clear plastic and glass. There were no other significant differences in stem length for this variety on this date. Red Pontiac plants grown under the glass treatment were significantly longer than plants grown under the yellow or clear plastic treatments. Plants grown under the clear plastic treatment were significantly shorter than plants from any other treatment for the Red Pontiac variety.

Table 13. Mean dry weight of vegetative growth in grams per plant.

Varieties	Glass	Red	Yellow	Green	Clear	L.S.D.Values
	Treatments					
Irish Cobbler	11.0	9.0	7.0	7.0	6.0	0.64
Red Pontiac	14.0	8.0	8.0	7.0	6.0	2.7

Dry weight of vegetative growth of the Irish Cobbler variety grown under glass was significantly greater than the dry weight of vegetative growth from any other treatments, see Table 13. Vegetative growth of plants from the red treatment was significantly more than the vegetative growth from the yellow, green and clear plastic treatments. Dry weight of vegetative growth from the yellow and green plastic treatments were similar; however, they produced significantly more vegetative growth on a dry weight basis than plants from the clear plastic treatment. Dry weight of vegetative growth for the Red Pontiac variety grown under glass was significantly more than the dry weight from among other treatments. There were no other significant differences in dry weight of vegetative growth for the Red Pontiac variety.

Table 14. Mean number of tubers per plant.

Varieties	Glass	Red	Yellow	Clear	Green	L.S.D.Values
	Treatments					
Irish Cobbler	6.6	4.6	3.0	3.0	2.3	3.4
Red Pontiac	9.3	3.6	3.6	3.3	2.6	2.3

The number of tubers per plant for the Irish Cobbler variety varied considerably from treatment to treatment. Significantly more tubers were produced under the glass treatment than under any other treatments except the red plastic treatment, see Table 14. There were no significant differences in tuber number between the colored plastic treatments. Tuber number for plants grown under glass was significantly more than for plants grown under any other treatment for the Red Pontiac variety as shown in Plate III. Differences in tuber number between the plastic treatments were not significant.

Table 15. Mean fresh weight of tubers in grams per plant.

Varieties	Treatments: Glass	Red	Yellow	Clear	Green	L.S.D. Values
Irish Cobbler	78.0	25.0	22.0	21.0	9.0	30.0
Red Pontiac	116.0	47.0	45.0	54.0	33.0	32.0

It appears from Table 15 that the glass treatment was much superior for both varieties for tuber weight. There was no significant difference in fresh weight for either variety between the different colored plastic treatments.

DISCUSSION OF EXPERIMENTAL RESULTS

Seed potatoes used for the spring experiment were northern grown, and certified. A few seed pieces did not germinate in the spring experiment. A number of factors contribute to

EXPLANATION OF PLATE III

Fig. 1. Close up of tubers per replicate of the Red Pontiac variety in the fall experiment for respective treatments: 1, glass; 2, clear plastic; 3, red plastic; 4, green plastic; and 5, yellow plastic.

Fig. 2. Close up of tubers per replicate of the Irish Cobbler variety in the fall experiment for respective treatments: 1, glass; 2, clear plastic; 3, red plastic; 4, green plastic and 5, yellow plastic.

PLATE III

Fig. 1

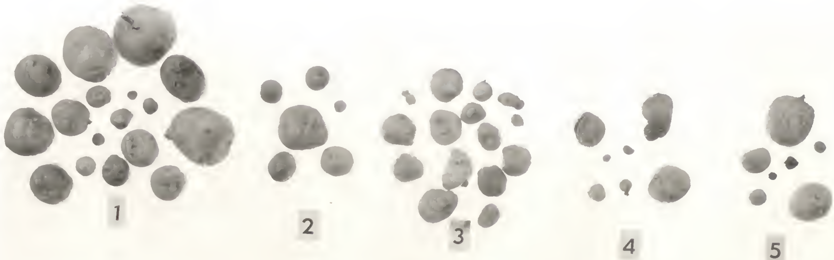


Fig. 2

germination of potato seed pieces, any of which could prevent germination. Performance of potato seed pieces can be hindered by one of the following factors, such as rest period, apical dominance, decay and multiple sprouting. Seed pieces of the fall experiment did not germinate uniformly. In fact, many seed pieces did not germinate for several weeks. Then occasionally plants began to emerge. This experiment was replanted due to non uniform and poor germination of the seed. The rest period had not been broken prior to planting this experiment. Hardenburg (3) found that potato seed pieces would not germinate immediately after harvest because they have a rest period. Another factor which could have necessitated replanting was temperature. The seed was planted August 28, at a period when average greenhouse temperatures were around 75° F. This temperature was considerably higher than 60 to 65° F. which is ideal for potato seed piece suberization.

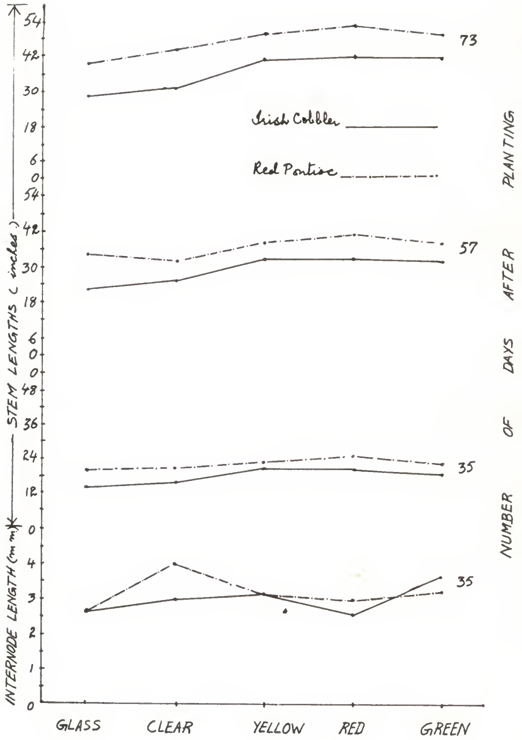
The first objective of these experiments was to study the effects of previously mentioned treatments on the vegetative growth of an early and late maturing potato variety.

Plants of the Irish Cobbler variety grown under green plastic had longer internodes in the spring experiment than in the fall experiment, see Plates IV and V. This difference in plant development between seasons could be related to Hardenburg's findings (3). He found that temperature increased internode lengths of potato plants. The next longest internode lengths were of plants grown under yellow, clear, glass and red

EXPLANATION OF PLATE IV

Effect of treatments on both varieties for internode lengths per plant and relative stem lengths at three intervals of growth in the spring experiment.

PLATE IV



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30
18
6
0
0
48
36
24
12
0
4
3
2
1
0
STEM LENGTHS (inches)
INTERNODE LENGTH (m m)
Irish Cobbler
Red Pontiac
73
57
35
35
NUMBER OF DAYS AFTER PLANTING
GLASS
CLEAR
YELLOW
RED
GREEN

plastics respectively in the spring experiment. Red plastic could depress the internode length according to Veen (10) under certain conditions. Plants of the Red Pontiac variety showed different results for internode lengths. This was probably due to variety characteristics. Plants grown under yellow, green and red plastics had intermediate internode lengths. Plants grown under clear plastic had the longest internodes and those grown under glass had the shortest internodes. Red plastic also depressed internode length of the Red Pontiac variety more than the other plastic treatments. The difference in internode lengths between the plants of the spring experiment and the fall experiment and among treatments was probably due to temperature, light intensity and daylength differences. In the fall experiment plants of Irish Cobbler variety grown under yellow plastic had the longest and those grown under glass had the shortest internodes, as shown in Plate V. Plants grown under green, red and clear plastic had intermediate internode lengths. Plants of the Red Pontiac variety grown under glass had the longest internodes. This difference was probably due to higher temperature in the glass house as compared to the plastic subdivisions. Plants of this variety had intermediate length of internodes when grown under clear, yellow and red plastics. Plants grown under green plastic had the shortest internodes.

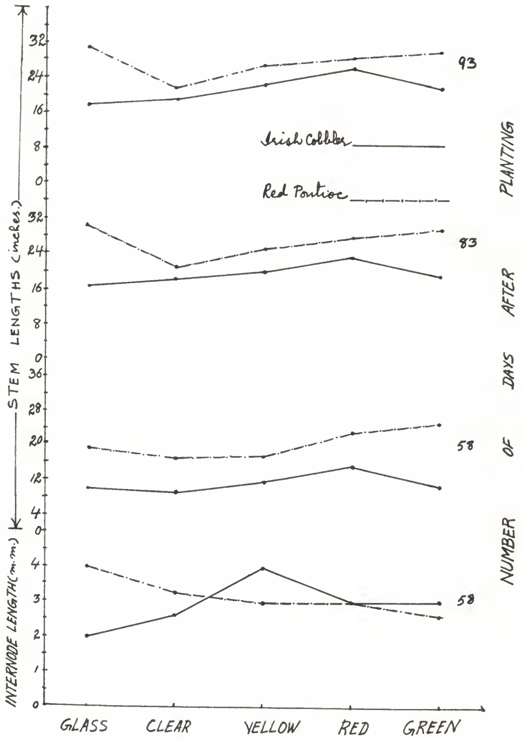
Stem lengths of plants grown during the spring and fall experiments differed from each other under certain colored plastics and glass. In the spring experiment plants of both varieties elongated similarly under the different treatments as shown in Plate IV. However, stem length of the Red Pontiac variety was much greater than for Irish Cobbler. The presence of red spidermites on plants in the clear plastic subdivision and the effects of more light probably resulted in shorter stem lengths under the clear plastic treatment. Plants of both varieties grown under red plastic had the longest stem lengths. Plants grown under the yellow, green and clear plastics and glass had the next longest stem lengths respectively. Stem lengths of plants of both these varieties responded differently to the treatments in the fall experiment. Irish Cobbler plants had the longest stems when grown under red plastic. There was very little difference in stem lengths for plants grown under the yellow and green plastic treatments. Plants grown under glass had the shortest stems, see Plate V. Plants grown under clear plastic exceeded in stem length the plants grown under glass, but stem length was less than that obtained under any other treatments. Stem length of the Red Pontiac variety was greatest under the glass treatment. This increased stem length was probably due to higher temperature. Plants of this variety grown under the green plastic treatment had the second longest stems. Plants grown under the red, yellow and clear plastic treatments had respectively decreasing stem lengths.

Vegetative growth on a dry weight basis was greatest for both varieties grown under glass for both experiments, see Plates VI and VII. The reduction in weight of vegetative growth

EXPLANATION OF PLATE V

Effect of treatments on both varieties for internode lengths per plant and relative stem lengths at three intervals of growth per plant in the fall experiment.

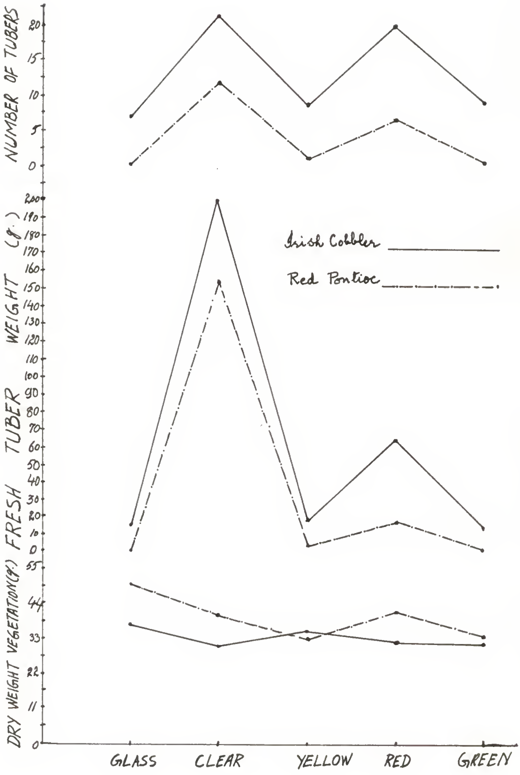
PLATE V


93
83
58
58
Irish Cobbler
Red Pontiac
STEM LENGTHS (inches.)
INTERNODE LENGTH (m.m.)
NUMBER OF DAYS AFTER PLANTING
GLASS
CLEAR
YELLOW
RED
GREEN

EXPLANATION OF PLATE VI

Effect of treatments on both varieties for relative dry weight of vegetation per plant, relative number of tubers per plant, and relative fresh weight of tubers per plant in the spring experiment.

PLATE VI


NUMBER OF TUBERS
20
15
10
5
0
FRESH TUBER WEIGHT (g.)
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
DRY WEIGHT VEGETATION (g.)
55
44
33
22
11
0
Irish Cobbler
Red Pontiac
GLASS
CLEAR
YELLOW
RED
GREEN

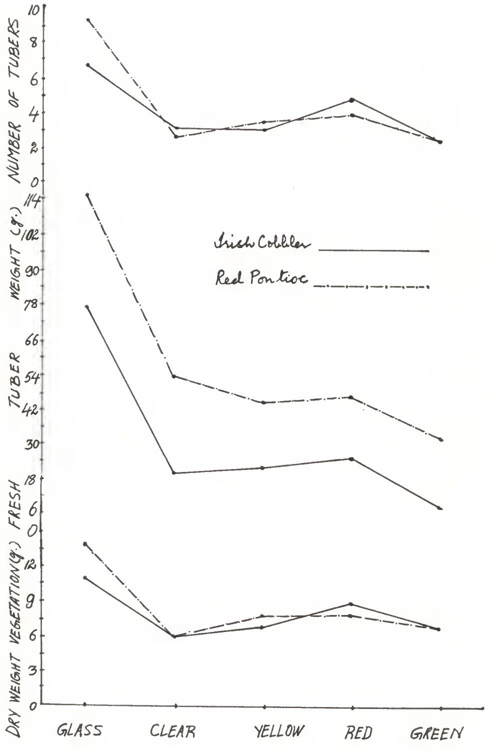
under the plastic treatments was probably due to less light, and to lower temperature. Table 1 shows the vertical illumination under the different treatments for one date. Temperature was also lower for the plastic treatments than for glass particularly during the conclusion of the spring experiment. The big difference between the two varieties was in the total vegetative growth under the yellow and red plastics. The Irish Cobbler variety had comparatively more vegetative growth than the Red Pontiac, when grown under yellow plastic and still less vegetative growth when grown under red plastic. Furthermore, plants grown under glass had the shortest stems, but produced the greatest dry weight of vegetation. Plants of the Red Pontiac variety grown under the red plastic subdivision had longer stems than plants grown under glass in the spring experiment. However, the weight of plant material was greatest for the plants grown under glass. In the fall experiment, plants of Red Pontiac variety grown under glass had the longest stems and also the greatest dry weight of vegetation, as shown in Plate VII. Irish Cobbler plants under the red plastic treatment were the longest for the fall experiment; however, on a weight basis, the plants grown under glass were superior to plants grown under any other treatment.

The second objective of this work was to determine any beneficial effects of these treatments on tuber formation. In the spring experiment tuber number was the largest for plants of both varieties when grown under clear plastic. Tuber number was

EXPLANATION OF PLATE VII

Effect of treatments on both varieties for relative dry weight of vegetation per plant, relative number of tubers per plant, and relative fresh weight of tubers per plant in the fall experiment.

PLATE VII


NUMBER OF TUBERS
10
8
6
4
2
0
TUBER FRESH WEIGHT (g.)
114
102
90
78
66
54
42
30
18
6
0
DRY WEIGHT VEGETATION (g.)
12
9
6
3
0
Irish Cobbler
Red Pontiac
GLASS
CLEAR
YELLOW
RED
GREEN

the lowest for plants of both varieties when grown under glass, see Plates VI and VII. Tuber number for the Red Pontiac plants grown under red plastic was superior to tuber number of plants grown under green or yellow plastic and glass.

Tuber weight for the spring experiment was greatest for both varieties grown under the clear plastic. Red Pontiac plants grown under the red plastic had a decidedly larger tuber weight than plants grown under the green plastic or glass.

These differences in tuber number and weight between the plastic treatments are probably due to illumination, see Table 1. However, the differences between the plastic treatments and the glass treatment was probably due to temperature, because it was impossible to keep the temperature in the glass house as low as the temperature in the plastic houses. Evidently, enough light penetrated the plastic house for photosynthesis to take place and the temperature was low enough so that storage of carbohydrates was possible. No doubt, more photosynthesis took place in the glass house; but, the temperature was so high that respiration took place at a higher rate. Therefore, reserve carbohydrates were not available for storage in the tubers. Thompson (9) reported quite similar results. Werner (12) reported that tubers were produced at high temperatures only when the plant received a high rate of illumination. The higher the rate of light intensity during the growing season the higher the maximum temperature allowing tuber initiation and development. This was probably true under conditions of their experiment, but no doubt would not apply to June and July temperatures under a glass house.

Beneficial effects of plastic treatments did not occur for tuber number or tuber weight in the fall experiment.

The third objective of this work was to determine any detrimental effects of these treatments on tuber formation.

In the fall experiment the glass treatment was probably superior to any plastic treatment for tuber number. Tuber number was significantly decreased for both varieties when plants were grown under yellow, clear and green plastic. For the Red Pontiac variety the glass treatment also produced significantly more tubers than the red plastic treatment, as shown in Plate VII.

Tuber weight from both varieties was significantly larger for plants grown under glass than tuber weight from any other treatment. Clear plastic produced the next largest tuber weight for the Red Pontiac variety. The green plastic treatment produced the smallest tuber weight for both varieties. These results on tuber number and weight indicated that light was the single factor which produced these results. Table 1 shows these differences. The results of these studies indicate that detrimental effects for tuber number and weight occurred for both varieties when grown under red, yellow and green plastics. In general, tuber number and weight decreased when plants were grown under red, yellow and green plastics respectively. Increased tuber number and yields for the red and yellow treatments was probably due to the nature of the rays absorbed by plants under these treatments. Red and yellow rays probably were absorbed more readily by the chlorophyll than under the green rays. Red and yellow rays were more effective in promoting carbohydrate manufacture according to LeCrone (5).

The fourth objective of this study was to evaluate the effects of these treatments on flower production. Flower production was very poor under all treatments; in fact, only one or two plants blossomed. Werner (13) has shown that under glass the most extensive bloom, fruit and seed production occurs when a light intensity of about 500 foot candles at the top of the plants is used for supplemental light during a full 24-hour photoperiod. None of these treatments used in this study was effective in any way to produce the above mentioned results by Werner, probably the daylengths were too short and in some cases light intensity was not great enough for blossom formation. This experimental work was designed to test the effects of the treatments under natural light conditions. Therefore, supplemental lights were not used.

SUMMARY

Irish Cobbler and Red Pontiac varieties of potatoes were grown in cans under four different colored plastic greenhouses and a glass house. The colors of the plastic were; clear, jonquil yellow, ivy green, and tropical coral (red). These plastics were of the corrugated fiberglass type and were made of acrylic resins. Experiments were conducted in the spring and again in the fall. The spring plants were grown under higher temperatures and longer daylengths than the fall experiment. The purposes of these experiments were to study the effects of different propagating structures on the vegetative growth and tuber setting characterics of two potato varieties. Maturity of these experiments was determined by the physiological condition of the foliage and tuber formation. The spring experiment crop was harvested in 73 days and the fall experiment crop in 93 days. The data for both foliage and tuber characters were analyzed statistically and the following conclusions were made. Internode length was not changed appreciably due to treatment. Although, yellow, green and clear plastics had a tendency to increase internode lengths of plants for both varieties.

Stem lengths of both varieties in the spring experiment were not distinctly different at an early physiological age. As the plants progressed in growth the results of treatments became more and more prominent. It was concluded from these studies that the red colored plastic produced the longest stem lengths

and glass the shortest for both the varieties during the spring experiment. The other treatments were intermediate between red plastic and glass as far as stem lengths were concerned. The plants grown for the fall experiment gave similar results in stem length for three treatments only. Among these three treatments, plants grown under red plastic had the longest stem length and those under the clear plastic the shortest stem lengths. Plants grown under yellow plastic had stem lengths between the two extremes of red and clear plastics. Plants of both varieties differed from each other under glass and green colored plastics. Irish Cobbler plants had the longest stem lengths under glass and shortest under green plastic. Red Pontiac plants had the shortest stem length under glass and the next to the longest under green plastic. Different response of both the varieties to the treatments mentioned above indicates that illumination was the factor affecting stem length. Both varieties produced the most vegetative growth on dry weight basis and set the fewest number of tubers in the spring experiment. This was probably due to high temperature. The Red Pontiac variety produced the least vegetative growth on dry weight basis and no tubers under the green plastic treatment. This was probably due to poor light intensity. This variety also did not set tubers under glass. This was probably due to high temperature. Plants of both varieties grown under clear plastic produced the maximum number of tubers and the largest fresh tuber weight irrespective of the amount of vegetative growth.

Fresh tuber weight was directly related to vegetative dry weight produced by plants grown under glass during the fall experimental conditions. Vegetative dry weight produced was further directly related to the illumination received in each treatment. The higher the illumination received the higher the vegetative growth, the larger the number of tubers and ultimately the higher yield of fresh tuber weight. Accordingly, the plants under the green plastic received the least illumination and produced the fewest number and weight of tubers.

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EFFECTS OF SOME COLORED PLASTIC GREENHOUSE SUBDIVISIONS ON VEGETATIVE GROWTH AND TUBER SET OF SOLANUM TUBEROSUM

by

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Plastic forcing structures have been a focus for research of horticulturists and other scientists during recent times. Most of the research has been done on different kinds of clear plastic materials. These studies were undertaken to compare colored plastics with glass as a propagating structure. Jonquil yellow, Ivy green, tropical coral (red) and clear plastics were used. The effects of these materials on the vegetative growth and tuber formation of Irish Cobbler and Red Pontiac potato (Solanum tuberosum) varieties were investigated. The specific objectives of these studies were to determine the effects of these colored plastic materials and glass on the following: (1) vegetative growth of an early and late maturing potato variety, (2) to determine any beneficial effects on tuberization, (3) to determine any detrimental effects on tuber development, and (4) to evaluate the effects of treatments on flower production. The results of these studies indicated that internode length was not changed appreciably due to treatments, although yellow, green and clear plastics tended to increase internode lengths of plants for both varieties. Stem lengths of both varieties in the spring experiment were not distinctively different at any early physiological age. However, at later intervals stem lengths varied according to treatment. Stem lengths determined at the termination of the spring experiment indicated that red plastic increased the stem length for both varieties. Plants with the shortest stem lengths were grown under glass. Differences occurred between experiments for stem lengths of plants grown under different treatments.

In the fall experiment stem lengths were longest under red colored plastic and shortest under glass for the Irish Cobbler variety. Plants of the Irish Cobbler and Red Pontiac varieties differed from each other in stem lengths when grown under glass and green colored plastics. Irish Cobbler plants had the longest stem length under red plastic and the shortest stem lengths under glass. Red Pontiac plants had the longest stem length under glass and next to the longest under green plastic. Different responses of both the varieties to the treatment mentioned above indicated that illumination was the factor effecting stem length, but that both the varieties probably differed in their light requirements.

Both the varieties under spring experimental conditions produced the maximum vegetative growth on dry weight basis and set the fewest number of tubers under glass. It should be emphasized that temperature in the glass house was considerably higher than temperature in the plastic houses.

The Red Pontiac variety produced the least vegetative growth on a dry weight basis and the fewest number of tubers under the green plastic treatment. This was probably directly related to intensity of illumination. Plants of both varieties grown under clear plastic produced the maximum number of tubers and the largest fresh tuber weight irrespective of amount of vegetative growth. In the fall experiment fresh tuber weight was directly related to vegetative dry weight produced by plants grown under glass. Dry weight of vegetation was related to the illumination received in each treatment. The higher the illumination received the higher the vegetative growth, the larger the number of tubers and ultimately the higher yield of fresh tuber weight. Accordingly, the plants under the green plastic received the least illumination and produced the fewest number and weight of tubers.