Table 3. *Dioscorea* species and cultivars tested, their recent geographical sources, and crude protein content (dry wt basis).

Species	Cultivars	Geographical source	% crude protein
D. alata	Cuello Largo	India	11.22
	Espada	India	10.82
	Florido	Puerto Rico	10.47
	Vino B	Puerto Rico	10.47
	Prolific	India	9.44
	Pyramid	India	9.41
	Hunte	Barbados	9.22
	De Palo	Puerto Rico	8.88
	Gordito	India	8.47
	Hawaii Branched	Puerto Rico	8.28
	Farm Lisbon	Trinidad	8.25
	Corazon	India	8.16
	Feo	Puerto Rico	8.16
	Barbados	Barbados	8.12
	Vino A	Puerto Rico	8.06
	Morado	Puerto Rico	8.04
	Yellow Lisbon	Philippines	7.91
	Seal Top	Puerto Rico	7.84
	Oriental	Trinidad	7.72
	Macoris	Puerto Rico	7.68
	Purple Lisbon	Philippines	7.66
	Vino C	Puerto Rico	7.47
	Bottleneck Lisbon	Trinidad	7.25
	Forastero	Puerto Rico	7.25
	Ashmore	Puerto Rico	7.21
	Sweet	Trinidad	6.84
	Smooth Statia	Puerto Rico	6.56
	Brazo Fuerte	India	6.28
	Mean of 28 cultivars		*8.33*
D. esculenta	Fasciculata	India	13.41
	Pana	Puerto Rico	9.31
	Trinulenta	Trinidad	8.94
	Spindle	India	8.82
	Papa	Puerto Rico	8.19
	Assam	India	7.84
	Mean of 6 cultivars		*9.42*
D. rotundata	Guinea Blanco	Puerto Rico	8.06
	Akandou	Ivory Coast	7.28
	Mean of 2 cultivars		*7.67*
D. bulbifera	Angled Gunda	Puerto Rico	11.06
	Sativa	India	10.94
	Round Gunda	Puerto Rico	9.90
	Mean of 3 cultivars		*10.63*
D. trifida	Mapuey Largo	Puerto Rico	7.38

are being considered further. It is now evident that variability in protein content is not as broad as that of other important characteristics such as yield, disease and insect resistances, cooking qualities, and storeability. Protein content, while important, may thus not merit a high ranking in a selection index.

Our crude protein determinations are slightly higher than those of Winton and Winton (7) but comparable to those reported by Oyenuga (5). Yam protein contents are much higher than those reported for cassava, sweetpotato, and aroids (4) and thus should be able to play a significant role in the diet, especially in areas where yams are accepted as staple foods. The quality of yam proteins both in terms of amino acid contents and biological utilization are now being determined.

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Some Plant Growth Effects under Infra-Red Heating in Greenhouses

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Abstract. **Infra-red light induced stem elongation of several species of plants. Tomato plants also had reduced fruit yield. Geraniums had wider leaves and longer internodes and flower stalks, but the no. of flower stalks was unaffected by infra-red treatment. These effects should be taken into consideration if infra-red heating is to be used in greenhouse operations.**

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[2] Financial assistance from Manitoba Hydro is gratefully acknowledged. Heating equipment was provided by American Electric Supply Company Limited, Winnipeg.

Heating costs are a major concern to greenhouse operators in severe-winter climates. Infra-red heat has the particular advantage of supplying heat to solid objects without great loss to the surrounding air and thus plants growing under infra-red could be maintained from 5-10°F higher than the ambient air temperature. The lower air temperature requirement may result in a substantial saving in heating costs.

Stinson et al. (1) reported that chrysanthemum, geranium and Easter lily could be produced satisfactorily under infra-red. They found no adverse photoperiodic response in chrysanthemum and no color fading even in a susceptible cultivar. In a later study Stinson and Buelow (2) found that infra-red delayed maturity in potted rose and delayed maturity and lowered quality in Easter lily. Out of 18 kinds of bedding plants, 6 showed reduced growth.

Our purpose in this study was to determine plants performance in an infra-red heated greenhouse.

Two identical greenhouse sections each 10 sq ft were constructed using 4 inch laminated rafters with an outer covering of "Mylar" plastic and an inner layer of polyethylene film. A 5000 watt convection heater equipped with thermostatic controls was located in each section. In addition, one section was supplied with two 1000 watt, reflector type, electric infra-red heaters mounted to achieve a min variation in intensity over the growing area. The convection and infra-red heaters with control panel are shown in Fig. 1.

Thermocouple measurements in the greenhouse section supplied with

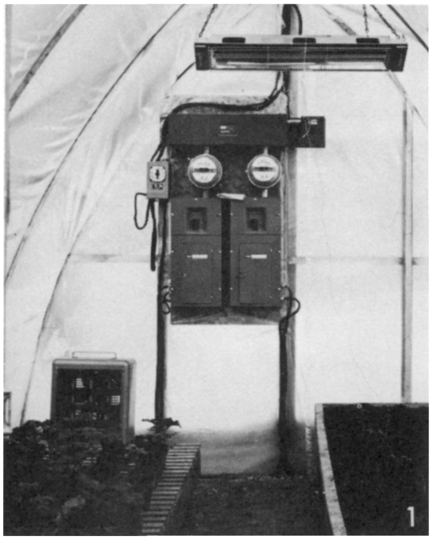

Fig. 1. End view of infra-red greenhouse showing convection and infra-red heaters with control panel.

Table 1. The effect of infra-red heating on tomato (cv. Michigan State Forcing x Ohio WR-3 F_1). 1967.

Variable[z]	Infra-Red	Control
Plant ht (cm)		
Jan. 24	13.5*	10.7
Feb. 21	19.6	17.1
Mar. 7	148.3*	129.0
No. of fruit	148*	198
Yield (kg)	13.7*	18.1

[z]Means of 10 plants per treatment.
*Difference significant from control at 5% level.

Table 2. Effect of infra-red heating on geranium (cv. Red Meteor) 1968.

Variable[y]	Infra-Red	Control
Plant ht (cm)	20.6**	12.7
No. of flower stalks	0.87	0.93
Length of flower stalks (cm)	17.0**	11.9
Length of internodes (cm)	3.6**	1.5
Width of matured leaves (sq cm)	13.2**	12.2

[y]Means of 15 plants.
**Difference significant from control at 1% level.

Fig. 2. Typical plants of chrysanthemum grown with and without infra-red.

Fig. 3. Potted Colorado spruce grown with and without infra-red.

infra-red indicated that leaf temperatures were approx 5°F above the air temperatures whereas in the control house leaf and air temperatures were essentially the same.

Throughout the term of the experiment the thermostat was set at 70°F within the control house and 60°F in the infra-red section.

In 1967 tomatoes were grown in beds and geraniums in pots and in 1968 potted chrysanthemums, daffodils, hydrangeas, tulips, Colorado spruce, geraniums and Easter Lilies were grown. During 1967, the infra-red operation was continuous while in 1968 the units were controlled to provide 30% of capacity between 8:00 AM and 5:00 PM and 100% capacity overnight.

Tomato plants grown in benches during winter 1967 were taller under infra-red but fruit no. and total yield were less than on plants grown in the control greenhouse (Table 1).

Infra-red tended to promote excessive elongation in potted geranium cuttings which was expressed in increased internode and flower stem length. The no. of flower clusters was approx the same for both treatments (Table 2).

Increased ht was the most striking feature of chrysanthemums (Fig. 2), daffolils, hydrangeas, tulips, Easter lilies and Colorado spruce grafting stock (Fig. 3) grown under infra-red heaters.

The most striking difference between plants grown under infra-red and those under the control conditions was the consistent increase in plant ht. The reasons for this are not clear. According to the manufacturers specifications (3) less than 0.5% of the total energy emitted by the infra-red units used is below 800 mμ. The authors are unaware of any plant growth responses induced by such long wavelengths. Certainly Stinson et al. (1, 2) did not report any elongation effects.

It is possible that higher heat levels in the infra-red section during the sunny days of March and April may have been responsible. During this period the air temperatures sometimes rose as much as 15°F above the thermostat setting. However, increases in tomato ht were continuous from the beginning of treatment (Table 1); plants under infra-red were 26% taller 2 weeks after being transplanted and approx 15% after 5 weeks. During this early period there was no difficulty in controlling the 10°F differential between the 2 sections.

While increases in stem length in greenhouse crops may not be undesirable in itself, and under some circumstances may be an advantage, this etiolating factor must be considered. Increases in plant ht at the expense of other growth characteristics, as was the case with most of the plants tested, could nullify any advantage gained in heating costs.

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