Tjia, B. and M N Rogers 1984 Growing gerberas, learn to solve problems of bent neck, stem break *Greenhouse Manager* 3 (2) 67, 70-76

Tjia, B 1980 Unpublished data

Tjia, B and T N Joiner 1984 Mineral deficiency symptoms on gerberas *Greenhouse Manager* (in press).

Van Meeteren, U 1978. Water relations and keeping quality of cut gerbera flowers I The cause of stem break *Scientia Hort* 8 65-74

PLUGS: USE AND FUTURE IN NEW ZEALAND

T.E. WELSH

Department of Horticulture and Plant Health
Massey University
Palmerston North

Climate and lifestyle in New Zealand are very conducive to bedding plant growing. This is evident in the extensive use of flowering annuals in both public and private gardens. The production of bedding plants, until recent years, has involved a very traditional approach. Because bedding plants can be grown year-round in New Zealand there is a tendency to produce small seedlings in an open-pack to be sold at the green stage. Difficult economic times and high inflation have created an awareness amongst growers of the need to increase production efficiency instead of simply increasing prices to counter rising costs.

A need for increased productivity is shared amongst bedding plant growers worldwide. Over the past decade, some new approaches to production techniques have arisen.

Direct seeding mechanically into the final container is one such approach. This eliminates the necessity for hand sowing and alleviates the need for pricking out. Interest in this system has seen the development of several types of automatic and manually operated equipment (3,10,11,13). A manually operated vacuum type seeder has been developed and marketed in New Zealand and direct seeding with this has been extensively used. However, the one major disadvantage growers have found with the system is the extra space required at the germination stage. Because of this some have used less than adequate environmental conditions for germinating trays. Often this has led to poor germination and consequent frustration with the system.

Pre-germinated seedlings are now offered by some seed companies as a means of reducing crop time and the risk involved with germination. These pre-germinated seedlings are usually sown in a lightweight polystyrene tray with separated rows for the seedlings. This "pre-finished" concept is not currently being used in New Zealand for bedding plant production. However, the idea of specialized propagators selling "liners" to other growers is a common practice here in the woody ornamental plant industry.

Containerised transplants have become widely accepted as a means of obtaining a high quality transplant. Cell-packs have been developed for the retail trade and cell trays to produce commercial vegetable transplants are being used universally. Speedling, Inc. of Florida has developed a system that combines cell culture with direct seeding to provide a highly automated technique for producing quality transplants (12). Although the true Speedling system is not being used in New Zealand, some vegetable transplant producers are growing in cell containers of some form. Some bedding plant growers are trying to introduce cell-packs for the retail trade but to date their use is limited.

The plug system of growing seedlings seems to be an evolution of the three previously mentioned production systems. Plug growing combines direct seeding and cell culture to produce a pre-finished seedling with its own containerised root system. Labour is saved by direct seeding, while space is economised by using a tray with numerous small cells. Transplanting into the final container is still necessary but because of the nature of the plug it is much quicker to transplant. The success of the plug system has been well publicized in recent years (4).

The plug system can be used by growers as a means of efficiently germinating seedlings for their own production or, a grower may choose to buy-in plugs from a specialist grower for finishing off. Listed are some of the advantages and disadvantages of plug growing that New Zealand growers should consider.

Advantages from germinating in plug trays

— plants hold longer, giving more flexibility in management

— exact amounts of seed are sown, resulting in less wastage

— spread of damping-off diseases is checked by plant compartmentalization.

Advantages from growing-on from plugs.

— transplanting time is cut by at least fifty percent

— seedling transplant shock is avoided

— the need for patching blanks is eliminated
— valuable heated greenhouse space can be saved
— production can be increased using existing resources.

Problems facing New Zealand growers.

— high capital cost of imported equipment
— unavailability of plug trays
— greater skill required for production
— high risk involved with new techniques

Despite the obstacles involved many New Zealand growers are interested in the plug system. This is especially true of those growers who have been able to use direct seeding successfully. To understand how this system can be adapted for New Zealand use, it is necessary to look at the components used in the system and the means by which they can be applied.

EQUIPMENT

The correct seeder is usually the first item of concern for a grower contemplating plug production. If growers are presently using satisfactory equipment for this purpose the seeding mechanism could be adjusted for a plug tray. There currently appears to be three suitable seeders being used in the country.

Fluid Drill, manufactured and imported from the U.K. This is the most expensive seeder available and there are only two machines currently in the country. The advantage of this model is its ability to sow pregerminated seed suspended in water.

Hamilton Natural Seeder, designed in the U.K. and imported from either the U.K. or U.S.A. This is a medium-priced seeder and two have recently been imported for plug sowing. It places seed using a modified manifold/ vacuum system. It can singulate seed down to the size of begonias.

Robinson Seeder, designed for and available from Robinson Nursery, Masterson is a manually operated vacuum type seeder in the lower price range. Several original models are in use and the manufacturer has recently introduced a new lightweight model that sells for half the price of the original. The seeder plate is not capable of delivery of very small seed such as petunia. However pelleted seed can be used for small seeded plants

Plug trays come in a variety of sizes and shapes (8). Trays with larger cells are generally easier to grow in but less efficient in terms of space utilisation. Small celled trays are economical on space but harder to grow in. The size of the cells will effect the buffer capacity of the medium. Current regulations only allow the importation of small quantities of plug trays and, so far, the market size has been insufficient to attract plastic manufacturers. This has forced one grower, who is committed to growing plugs, into making his own trays with a small vacuum forming plant. A resultant positive effect may be a standardisation of products based upon the "273" tray.

POST-GERMINATION HANDLING

Seed Germination can be achieved in various ways. Existing facilities within a greenhouse can be used for germination (6,9,13), or space in the greenhouse may be conserved by germinating in a specially created environment in a shed. One method is to construct a frame covered with polythene film in which racks of moistened trays are placed until emergence commences. Another method is to use a specially equipped room or chamber with precise control of light, moisture, and temperature. With either of these last two techniques very careful monitoring is necessary as trays must be shifted to the greenhouse as soon as seed germination is completed.

The medium should be fine enough in particle size to evenly fill cells and hold moisture in the finer pores, yet it should at the same time, drain freely to avoid water-logging. One solution to the drainage problem is to grow on capillary mats using the mat to draw off excess water from the cell. Standard soil-less media based germination mixes already in use seem to give adequate results if the particle size is correct (1). Liquid fertiliser application of NPK nutrients seems to be the only safe and accurate method of feeding (5). A general purpose formulation can be used effectively as a constant feed with every irrigation. Application rates start at 50 ppm N. and graduate up to 200 ppm N. for finishing (6). Exact formulations and application rates must be determined to suit individual needs. Liquid feeding may be foreign to some New Zealand growers who normally rely on incorporated nutrients in the medium. Commercial preparations of liquid feed and suitable proportioning equipment are now available in New Zealand. When a constant feeding programme is used for liquid fertilisers, irrigation and fertilisation become inseparable.

Irrigation of plug trays, because of the small size of individual cells, must be both frequent and accurate in distribution. Hand watering can be effective but is very time consuming and requires a skilled applicator. Although automated circular pattern irrigation is acceptable, problems may occur in distribution and, therefore, evenness of water levels for each cell. A solution to this problem is to construct an overhead boom system that can be automated (12). This type of application is incorporated in the Speedling system in the U.S.A. and is being investigated by at least one seedling producer in New Zealand.

Environmental control of greenhouses, especially in the North Island of New Zealand, is based upon natural radiant heat and natural air circulation via side vents for cooling. This system is possible because of a relatively mild climate and lack of extreme winter or summer temperatures. Maximisation of plug production benefits will require many seedling growers to provide a more carefully regulated greenhouse environment. The main requirements for plug growing will be adequate heating for early development of the plugs and sufficient cooling to keep mature plug plants from "stretching". Other environmental controls make use of light, moisture, and nutrients (7).

Chemical control of growth is sometimes necessary when all other possible environmental controls have been used. Two chemicals used to retard growth are available and already used in New Zealand. They are Alar® and Cycocel®. Growers should carefully check recommendations on crop effectiveness and application rates before these chemicals are used (2). The main purpose in controlling the growth of maturing plug plants is to overcome "stretching" so they can be held longer.

Application of plugs in New Zealand will be for individual grower's own finishing production until the system is mastered and someone is equipped well enough to enter this new market. One of the largest obstacles for the sale of pre-finished plug seedlings will be distribution in a country with a small, scattered population such as New Zealand. Because our growers traditionally rely on natural heating, some of the warm temperature crops, i.e. geranium, vinca, and celosia, would be excellent candiates for selling as plugs.

Transplanting of plug seedlings also has its different approaches. Once finishing trays are filled, plugs are extracted and planted in various ways. One simple method is to pull well-rooted plugs from the tray with one hand and punch them into place with the other free hand. This method is particularly suitable when planting into larger containers. Seedlings that are not well root-bound or weak in nature can be damaged by this technique. Equipment is available for predibbling holes and extracting plugs which leaves the transplanter the simple job of placing the plugs into the holes. The choice of techniques will be influenced by the scale of operation at the nursery concerned.

OTHER APPLICATIONS

The perfection of this type of culture will open up opportunities for other areas of horticulture in New Zealand — some obvious ones to consider include: seedling production of vegetables; cut flowers; indoor plants; woody ornamentals; forestry. Some areas of vegetative propagation could also benefit from similar cultural techniques used in the plug system. Perhaps the re-establishment of tissue-culture plantlets could be improved by making use of this mini-cell culture. Possibilities also exist for propagation of mini cuttings of such plants as ericas, boronias, and grevilleas, using plug trays for economy of space and easy handling.

CONCLUSION

Many growers are now considering whether plug growing will become a reality for growers in New Zealand and, as mentioned previously, already one bedding plant nursery has made a commitment to the system. For them, plug growing will become a reality if they can adapt techniques to suit their situation and innovate ways to maximise the benefits. If they are successful it is likely others will follow.

Acknowledgement. Examples of plug growing experiences in New Zealand have been cited from information gathered at Harraps Nursery Ltd , Main Road, Napier, New Zealand

LITERATURE CITED

1. Anon 1983 NZNRC standard growing mix fertilisers. *Ann Rept N Z Nursery Research Centre*, 1983. p123

2 Armitage, A M , 1982. Growth regulators tools for controlling plant growth *Fifteenth Inter Bedding Plant Proc.*. 190-194

3 Bakos, S , 1983. Plugging into seeders. *Florists' Rev* 172 (4469).22-29

4 Eastburn, D P , 1984. The plug potential. *Florists' Rev* 174 (4497):26-29

5. Freeman, R N , 1982 Nutrition and fertilization of bedding plants *Fifteenth Inter Bedding Plant Proc* .76-82.

6 Jeffery, J , 1983 How our plug system works *Sixteenth Inter. Bedding Plant Proc.* 142-145

7. Laffe, S R and Koranski, D S , 1984. Keeping plugs under control. *Florists' Rev.* 173 (4477) 39-42.

8. Kellen, V , 1983 Leaders of the packs. *Florists' Rev* 173 (4483).19-22

9 Koranski, D.S., 1983 Solving plug problems. *Florists' Rev* 173 (4477).39-42

10 Peterson, J.C , 1982 Overview of automatic seeding equipment *Fifteenth Inter. Bedding Plant Proc.* 173-176

11. Reed, D , 1983 Plugs, seeders, and auto-transplanters how it all started and where we are today *Sixteenth Inter. Bedding Plant Proc* 146-159.

12 Todd, G. Jr., 1981. The Speedling system. *Proc Inter. Plant Prop. Soc.*, 31 612-616

13 Wilhelm, R A 1983 Plugs, seeders and our procedure *Sixteenth Bedding Plant Proc.* 139-141

THE INFLUENCE OF NUTRITION ON PRODUCTION OF CONTAINER-GROWN ORNAMENTAL PEPPERS

MICHAEL B. THOMAS and ALFRED G.B. LEONG

Department of Horticulture, Landscape, and Parks
Lincoln College, Canterbury

Abstract: Three experiments were conducted to study the influence of nutrition on the production of container-grown *Capsicum annuum* 'Fips' the first was a central composite design which examined the influence of five rates of N, P, K and lime 0 to 600 g N m^{-3}, 0 to 400 g P m^{-3}, 0 to 332 g K m^{-3} and 0 to 12 kg lime m^{-3} The second experiment was a 4 × 2 × 2 factorial with 4 rates of Mg from 0 to 450 g m^{-3}, 2 rates of P at 50 and 400 gm^{-3} and 2 rates of K at 83 and 415 g m^{-3}. The third experiment was a simple randomised block design with 5 rates of K from 300 to 700 g m^{-3} Strong responses to N and K were noted while P had a moderate influence. Lime had no apparent effect at low N rates but influenced growth significantly at high N by raising the pH from 4.2 to 5 8. There was no response to added Mg Foliage growth, plant quality and fruiting were optimal at 600 g N, 300 g P and 500 g K m^{-3} Lime at 6 kg m^{-3} was recommended (optimum pH 5 8 - 6.1). Suggested tissue composition of good quality ornamental pepper 'Fips' are given as 3 4 to 3 8% N, 0 4% P, 4 6% K, 3 4% Ca, and 1 4% Mg

INTRODUCTION

Ornamental peppers (*Capsicum* spp.) are popular pot plants providing colour for the autumn and winter months. A bonus of ornamental peppers in the home is the potential use of the fruits for making pepper sauce and flavoring food (4). The increased production of a wide range of pot plants emphasises the need for research on cultural requirements (23).

Previous studies on the nutrition of peppers were confined to chilli and sweet pepper cultivars (17). Recommended fertilizer rates in the potting medium and liquid feeding for ornamental peppers were based on standard responses of a range of container-grown plants rather than the specific requirements of *Capsicum* spp. (3,21). Studies of chillies and sweet peppers revealed a strong N response (13,20). Responses to P and K were dependent on existing soil P and K levels (6). Calcium deficiency in peppers resulting in blossom-end rots was indirectly caused by high Mg application (11) while high liming was considered beneficial (22). Magnesium deficiency is common among Solanaceous species and is often a result of high