Volumen 40, Nº 3. Páginas 127-133
IDESIA (Chile) Septiembre, 2022

Use of sawdust and bark of *Pinus radiata* as substrates for Belgian Chrysanthemums grown for summer production

Uso de aserrín y corteza de Pinus radiata *como sustratos para crisantemos belgas cultivados para producción de verano*

F. Schiappacasse[1], *G. Carrasco*[1], *M.C. Espinoza*[1], *Moons, W.*[2]

ABSTRACT

In search for alternative substrates for containerized ornamentals, potted *Dendranthema grandiflora* (chrysanthemum) plants were grown in Maule Region for summer flowering, using pure fresh sawdust and sawdust plus pine bark (both from *Pinus radiata*) in mixes as growing media, with soluble fertilizer in fertigation. Rooted cuttings of cv. 'Marina' (Belgian type) were planted individually in 17 cm (diameter) x 14 cm (height) pots filled with different media. For 75 days, plants were kept in an unheated greenhouse under artificial long days and were fertilized weekly with a soluble fertilizer. After pinching, plants were taken outside the greenhouse to full sun conditions, and artificial short days were applied for 8 weeks. In a split plot design, 8 treatments were carried out: 4 media mixes (pure sawdust and sawdust: bark in ratios 1:1, 2:1 or 3:1 by volume), and 2 frequencies of watering with soluble fertilizer; daily and every 2 days (applying a solution of 200 ppm N, based on a soluble NPK fertilizer, with 3 replica per treatment. Plants showed a reduced growth in pure sawdust (25.5 cm height) as compared with sawdust: bark (30 to 35 cm). Media mixes and fertilization frequency affected diameter; plants in pure sawdust had a smaller diameter (34 cm) than plants cultivated in sawdust: bark (40 cm). Plants fertilized every 2 days had a smaller diameter (36 cm) than those fertilized daily (41 cm). Plants grown in pure sawdust had yellowish-green leaves, while the leaves of plants grown in sawdust plus bark showed colors close to dark green. Flowers showed different color as when grown in autumn (yellow vs. orange). Plants of all treatments bloomed on the same date. The pH of all media mixes in all measurements during cultivation time was close to 6.0. It is concluded that it is possible to grow potted chrysanthemum in all the tested media mixes, but in the case of pure sawdust, to avoid problems due to its low retention of irrigation solution, it is advisable to mix it with pine bark in a 3:1 ratio.

Keywords: soilless mix, mum, pot plant, *Dendranthema grandiflora*, summer chrysanthemum cultivation.

RESUMEN

En busca de sustratos alternativos para plantas ornamentales en contenedores, se cultivaron plantas de Dendranthema grandiflora *(crisantemo) en macetas en la Región del Maule para la floración de verano, utilizando aserrín fresco puro y aserrín más corteza de pino (ambos de Pinus radiata) en mezclas como medio de cultivo, con fertilizante soluble en fertirrigación, Esquejes enraizados del cv. 'Marina' (tipo belga) se plantaron individualmente en macetas de 17 cm (diámetro) x 14 cm (altura) llenas con los diferentes medios. Durante 75 días, las plantas se mantuvieron en un invernadero sin calefacción durante largos días artificiales y se fertilizaron semanalmente con un fertilizante soluble. Después de despuntar los ápices, las plantas se sacaron del invernadero a pleno sol y se aplicaron días cortos artificiales durante 8 semanas. En un diseño de parcelas divididas se realizaron 8 tratamientos: 4 mezclas de medios (aserrín puro y aserrín: corteza en proporciones 1:1, 2:1 o 3:1 por volumen), y 2 frecuencias de riego con fertilizante soluble; diariamente y cada 2 días (aplicando una solución de 200 ppm N, a base de un fertilizante NPK soluble, con 3 réplicas por tratamiento). Las plantas mostraron un crecimiento reducido en aserrín puro (25,5 cm de altura) en comparación con aserrín: corteza (30 a 35 cm). Las mezclas de medios y la frecuencia de fertilización afectaron el diámetro; las plantas en aserrín puro tuvieron un diámetro menor (34 cm) que las plantas cultivadas en aserrín: corteza (40 cm). Las plantas fertilizadas cada 2 días tuvieron un diámetro menor (36 cm) que las fertilizadas diariamente (41 cm). Las plantas cultivadas en aserrín puro tenían hojas de color verde amarillento, mientras que las hojas de las plantas cultivadas en aserrín más corteza mostraban colores cercanos al verde oscuro. Las flores mostraban un color diferente a las cultivadas en otoño (amarillo vs naranja). Las plantas de todos los tratamientos florecieron en la misma fecha. El pH de todas las mezclas de medios en todas las mediciones durante el tiempo de cultivo fue cercano a 6.0. Se concluye que es posible cultivar crisantemos en macetas en todas las mezclas de medios probadas, pero en el caso de aserrín puro, para evitar problemas debido a su baja retención de la solución de riego, se recomienda mezclarlo con corteza de pino en proporción 3:1.*

Palabras clave: *mezcla sin suelo, crisantemo, planta de maceta,* Dendranthema grandiflora*, cultivo de crisantemo de verano.*

[1] Departamento de Horticultura, Facultad de Ciencias Agrarias, Universidad de Talca, Chile.
[2] Agrícola Alejandra Herrera, San Clemente, Chile.
* Corresponding author: F. Schiappacasse, fschiap@gmail.com

Fecha de recepción: 29 de Julio, 2021.
Fecha de aceptación: 17 de Septiembre, 2021.

Introduction

Naturally composted organic matter extracted from woodland soils had been traditionally used by Chilean nurseries, but due to the unsustainability of this practice, this substrate has been replaced by others. Sawdust and pine bark are subproducts of the forestry industry, cheap and widely available in the center-south of Chile. According to the Chilean statistical yearbook of forestry (2018), there are 1,308,770 ha planted with *Pinus radiata*. Pine bark is widely used in horticulture, but fresh sawdust, containing a high content of phenols, tannins and terpenes, is thought to be phytotoxic. Its high C/N ratio could also be limiting, but it is known that it can be avoided by applying fertilizers, especially through fertigation. Sawdust is made of carbohydrates (cellulose and hemi cellulose) and lignin. Its pH to the acid side, possible presence of toxic components, low CEC (similar to bark) and a C/ N relationship of 1000:1 (Nelson, 1991) or 400:1 (Dole and Wilkins, 1999) limit its use. Composted sawdust as potting media is a more accepted product than fresh sawdust (Worral, 1981; Nelson, 1991). Another drawback of fresh sawdust is the lack of aeration even if its total porosity is higher than perlite; aeration can be improved by mixing (i.e. up to 25% of sawdust in a mix) with other substrates containing bigger particles (Christoulaki *et al*., 2014). Prasad (1979) considers that air space of sawdust is adequate for container grown crops. Goh and Haynes (1977) used coarse grade sawdust and noted that the easily available water and the water buffering capacity were extremely low, causing the loss of water available for the plant soon after a watering.

Pine bark has been used as substitute for peat. Its limiting factor is the phytotoxicity due to tannins, which can be eliminated through leaching with water. This practice is carried out before it is being composted, a necessary process to be done before it becomes a horticultural substrate (Burés, 1997; Kaushal and Kumari, 2020), and the physical properties of pine bark depend on the particle size. Among its characteristics are high porosity (around 80%), low retention of readily available water and high retention capacity of hardly available water, and also a high aeration capacity. Low water retention of bark can be corrected by mixing it with other substrates or by maintaining an adequate moisture regime. It has a cation exchange capacity of the order of 40-180 meq L^{-1}, due to the presence of cellulose and lignin. Kaushal and Kumari (2020) point out that it is biologically active and suppresses some diseases, while a disadvantage is that it takes nitrogen from the growing medium as it decomposes, although this would affect crops with longer growing periods than chrysanthemums.

Chrysanthemum (*Dendranthema* x *grandiflora* (Ramat.) Kitam.) is a perennial herbaceous plant that belongs to the Asteraceae family, and it is grown as an annual plant. It has a capitulum inflorescence with central disk tubular florets, and other outer ray ligulate florets (provided with ligule or false petals). Chrysanthemum flowering is controlled by photoperiod; short days promote flower initiation and development. Commercial uses are different; garden plants, cut flowers and pot plants, with the latter being among the most widespread in homes in the United States (Dole and Wilkins, 1999), and they are also very popular in other countries. Belgian chrysanthemums are a special product, characterized by rather big plants with round shape, usually grown for plants sale in the autumn. During cultivation, which lasts from 3 to 4 months, long days are provided initially, and after the plants reach a given size, short days are provided (i.e. during 8 to 12 weeks, depending on cv.) until flowering (Crater, 1980; Dole and Wilkins, 1999).

Fertilization of chrysanthemum grown in a soilless mix without nutrients should be carried out along with the irrigation (fertigation), applying 200 mg L^{-1} N and 200 mg L^{-1} K_2O every time plants are watered (Crater, 1980; Ball and Higgins, 1998), until the flower buds show color (Dole and Wilkins, 1999).

The aim of this study was to assess the effects on growth of Belgian chrysanthemum 'Marina' using fresh sawdust from *Pinus radiata* and bark from the same species in different proportions as media for plants grown in spring-summer period, aiming for Christmas sale (Southern hemisphere), along with two fertigation frequencies.

Materials and methods

Vegetative cuttings of Belgian 'Marina' chrysanthemum were taken on August 2 and stuck to root in a hot propagation bed with perlite, under intermittent mist in a polyethylene greenhouse belonging to growers of chrysanthemum potted plants near San Clemente, Maule Region (35º34' SL with 71º19' WL). Once the roots were approximately 5 cm

long, plants were individually transplanted into pots 14 cm high and 17 cm in diameter at the top (13.2 cm at the bottom) filled with substrates in different proportions. The apex was removed on September 11, with the aim of promoting lateral branching.

To provide long days during rooting and in the greenhouse phase after planting in pots, 150 W incandescent lamps were installed at a height of 2 m and spaced every 3 m between them. Cyclical lighting was applied to save electricity, with 15 minutes - lighting followed by 15 minutes darkness cycles during the lighting time in the middle of the night.

Pots were filled with different media mixes: pure fresh sawdust and three mixes of fresh sawdust with composted pine bark in ratios 1:1 (used as the control), 2:1 and 3:1 by volume. Fresh sawdust was from *Pinus radiata* D. Don, with a particle size smaller than 2 mm, and an initial pH of 5.5. Pine bark, complement to the media mixes, was also from *Pinus radiata*, composted for 5 months and with a particle size of 15 mm. Sawdust was moistened for 3 days before filling the pots. 12.5 g of a granular fertilizer (8N-21P_2O_5-14K_2O) were added to each pot. During the long-day period a nutrient solution of 82.5 mg L^{-1} N, based on a 25N-10P_2O_5-10K_2O-1MgO fertilizer was applied weekly, from September 6 to October 25.

When plants averaged 9.2 cm in height and 13.2 cm in diameter (November 6), pots were transferred to the field in full sun and short days were initiated. Wires were arranged to hold a 13 µm thick black polyethylene, covering the plants completely from 7:00 p.m. to 9:00 a.m. of the next day for 8 weeks, until plant commercial stage for sale (when one third or more of the flowers were open).

A nutrient solution was applied via drip irrigation, initially with 536 mg L^{-1} N (until 26 November) and afterwards 200 mg L^{-1} N, based on a 16N-6P_2O_5-18K_2O-2MgO + micronutrients fertilizer, every day or every other day, according to the treatment.

Several times in December, watering had to be done 2 or 3 times a day (with pure water) to prevent plant dehydration.

A Split Plot design was used for the experiment. The influence of two factors was studied; the main one was the mixture of substrates, with 4 levels (pure sawdust, sawdust plus pine bark 1:1, 2:1 or 3:1), while the secondary one was fertigation with 2 levels (daily or every 2 days). The experiment had 8 treatments with 3 replica per treatment; each experimental unit was composed by 10 plants.

To evaluate plant growth, stem length was measured from the basal part of the plant at the end of the experiment (3 January, date of commercial plant stage), diameter and final height (from the upper edge of the pot to the top of the plant). Color of leaves and flower ligules were recorded weekly during the short-day period, using the Royal Horticultural Society (RHS) color chart. In extra plants, 4 substrate samples (two taken during November, one in December and one in January, before a fertigation cycle) of 30 g approx. were used to determine pH with a pH meter in the Vegetables Laboratory of the University of Talca.

The data were subjected to analysis of variance (ANOVA), through the Statgraphics plus program. In the cases where significant differences were detected, means separation was performed using the Tukey HSD test ($p \leq 0.05$). The records for color of leaves and ligules, and the pH were not statistically analyzed.

Results

Final plant height and diameter

The only factor that intervened in plant height was the growing media (Table 1). Plants in pure sawdust had the lowest final height, while the plants in the 3:1 sawdust: bark mix were those that showed the highest final height.

As regards the diameter, there were significant differences between the media mix used, as well as in the fertilizing frequency (Table 1). Plants in pure sawdust had the smallest diameter, while the diameters of the 3 sawdust: bark mixes were similar between them. Plants that were fertilized every 2 days had a smaller diameter than those fertilized on a daily basis. The form of soluble fertilizer application, daily or every two days, only intervened in the diameter of the plants, with the plants fertilized daily having a greater diameter. However, this aspect did not affect the final price of the plants (data not reported).

Leaf color

During the evaluation weeks, color tones of leaves kept changing (Table 2). They began with greenish yellow, both dark and light colors (147 and 146, respectively), then color changed to intense light green tones (144) and finally tones became

Table 1. Plant height and diameter of final product of plants of potted chrysanthemum 'Marina' (January 3), under the influence of media mixes and fertigation frequency applied to potted chrysanthemum plants

Treatments	Plant characteristics	
	Height	Diameter
Mix		
Pure sawdust	28.6 c	34.3 b
Sawdust: bark 1:1	33.4 b	39.4 a
Sawdust: bark 2:1	33.5 b	39.8 a
Sawdust: bark 3:1	38.3 a	40.0 a
Significance	*	*
Fertigation frequency		
Daily	32.44	36.0733 b
Every two days	34.41	40.6642 a
Significance	n.s	*
Interaction		
Mix x Fertigation frequency	n.s	n.s

n.s. There are no significant differences between treatments.
* Same letters in a column indicate that means do not differ significantly ($p \leq 0.05$) according to Tukey HSD Test.

dark green (138 and 137, this last being darker green color in relation to the former). The colors that are expected and desired in chrysanthemum plants are dark green colors, which are obtained when they are grown by the grower in his commonly used substrates and with a good nutrient level.

Regards the treatments, on November 8 the leaves of the 3:1 mixture plus daily fertilization, and the 1:1 and 2:1 media mixtures plus fertilization every two days presented a 146-A color, which is a yellowish green color. The other treatments presented a yellowish green but darker color (147-A). On the other hand, the plants treated with the 1:1 treatment with daily fertilization presented a leaf color that according to the RHS table was in the pure green tones, that is, color 137-A, a dark green. The mentioned condition was repeated in the week of November 15. The last weeks (December 13 to January 3), the leaves remained in fixed color tones, without further changes.

Among the eight treatments, only three of them presented at the end of the experiment (January 3) a dark green color tone (137-A), these were the 1:1 and 2:1 mixes plus daily fertilization and the 1:1 mixture plus fertilization every 2 days. On the other hand, plants in pure sawdust plus daily fertilization or every 2 days, ended up in intense light green (144) and yellowish (146) colors, respectively. In plants in pure sawdust, the color change always varied from dark to light yellowish green colors, whereas the foliage in the other mixes, their coloration varied from green with yellowish tones to light or dark green. The color changes of leaves from plants in the sawdust: bark mixes (1:1, 2:1, and 3:1) that occurred 20 days after the start of the short days was attributed to the change in the fertilizer dose that was performed on that date, since in these mixes the color change was noticeable.

The color of the ligules of the floral heads was also recorded (data not reported), noting that when the inflorescences expanded, the color was yellow (tone 21 in the RHS table) in all treatments, very different from the usual bronze color of the variety cultivated in autumn - winter in the company,

Table 2. Color of potted chrysanthemum 'Marina' leaves grown in different substrates (RHS table values) from 8 November to 3 January

Treatments		Color evolution of potted chrysanthemum leaves							
Substrate*	Fertigation frequency	08-nov	15-nov	22-nov	29-nov	06-dec	13-dec	20-dec	03-jan
1:0	Every day	147-A	147-A	147-A	146-A	146-A	144-A	144-A	144-A
1:0	Every 2 days	147-D	147-B	144-A	144-A	144-A	146-A	146-A	146-A
1:1	Every day	137-C	137-C	137-B	137-B	137-B	137-A	137-A	137-A
1:1	Every 2 days	146-A	147-B	137-B	137-A	137-A	137-A	137-A	137-A
2:1	Every day	147-A	147-A	147-B	144-A	146-A	144-A	144-A	137-A
2:1	Every 2 days	146-A	146-A	146-A	144-A	138-A	138-A	138-A	138-A
3:1	Every day	146-A	146-A	146-A	144-A	144-A	138-A	138-A	138-A
3:1	Every 2 days	146-B	144-A	146-A	144-A	144-A	144-A	138-A	138-A

* Ratio expressed as sawdust: bark.
** Numbers indicate different green color types; letters indicate color intensity.

and that corresponds to the color indicated by the grower's Plant variety catalog (Segers, Belgium. 2005. Vroegbloeiende troscrysanten (in Belgian)).

Media pH

The media pH values varied along the evaluation dates between 5 and 7 (Table 3), and in most measurements it was around 6. These values are well adjusted to the recommended pH values for soilless cultivation in potted chrysanthemum (Gloeckner, 1988).

Discussion

It was possible to use pure fresh sawdust (being the most economic substrate) in containers, agreeing with Prasad (1979), however, there were problems caused by its low retention of the solution, which was improved when mixing it with pine bark.

Plants traditionally cultivated by the grower (for autumn season sales, and pots filled with naturally composted organic matter plus sand), have a rounded canopy, that is, a plant diameter similar to plant height. The maximum plant diameter usually reached by the grower is 70 cm, and the lower part of the plant covers up to half the height of the pot. In this experiment, all plants were smaller than 70 cm, and plants that were in pure sawdust presented a different development than the rest of the plants; height was lower than the diameter. Hicklenton (1983) observed that chrysanthemum plants grown in sawdust were somewhat smaller than in another tested growing media (vermiculite plus sphagnum peat and sand), and this is in agreement with what was found in this study. In the case of the sawdust: bark mixes (1:1, 2:1, and 3:1), plants had a rounded shape. The entire pots were covered with flowering stems, having the plants a height similar to their diameter. The different shape of plants grown in pure sawdust vs. plants grown in sawdust mixed with bark, is attributed to the fact already described for sawdust, being the low retention of water or fertilizer solution, also pointed out by Goh and Haynes (1977), although Salinger (1991) considers that fresh sawdust exhibits free drainage and moderate moisture retention. This fact, in addition to the high temperatures of the season (average maximums of around 28ºC during December, field records), could have caused temporary water stress especially to the plants grown in pure sawdust. The plants were placed in full sun with no shading net, then the temperatures at which they were exposed were higher than the ones recorded in the shade, and all plants needed to be watered (with pure water) twice and even three times some days in December. One possible effect of these frequent waterings could have been the leaching of nutrients, evidenced by the leaf colors. Plants in pure sawdust, due to the low retention capacity of the solution causing the inability of the roots to obtain the necessary nutrients, were not able to obtain enough nutrients to change to a darker green color. The difference in coloration presented by the plants in pure sawdust was drastic, since when observing them in the field, it was clearly noticeable in which part of the experimentation sector they were located, contrasting with the rest of the treatments.

Table 3. pH of different media mixes of potted chrysanthemum 'Marina' plants on 4 different monitoring dates.

		pH**			
Substrate mix*	Fertigation frequency	14-nov	20-nov	17-dec	04-jan
1:0	Every day	6.52	5.64	6.27	6.73
1:0	Every 2 days	6.45	5.49	6.57	6.8
1:1	Every day	5.99	5.41	6.48	6.71
1:1	Every 2 days	6.12	6.05	6.44	6.68
2:1	Every day	6.04	4.99	6.38	6.42
2:1	Every 2 days	5.64	5.17	6.19	6.69
3:1	Every day	6.17	5.41	6.35	6.45
3:1	Every 2 days	6.16	5.2	6.58	6.75

* Ratio expressed in sawdust: pine bark.

** pH average of 3 replica per treatment, measurements recorded in the mornings.

Flower petals of different species mainly have carotenoids and anthocyanins, pigments formed by metabolic routes. Carotenoids (tetraterpenes) have a yellow, orange color, whereas anthocyanins (flavonoids) are responsible for red, blue and purple colors. The main pigments in chrysanthemum ray flowers or ligules are carotenoids, these are derived from α-carotene, specifically from lutein and lutein-5,6-epoxide (Kishimoto *et al*., 2007). However, despite the fact that these pigments are found in greater quantities in the plant, the combination of these with anthocyanins, generate the wide range of colors present in the flower heads. The difference in color of the ligules between the plants that flowered in the summer season, in relation to the usual ones in autumn - winter of the same cultivar, produced by the grower in the months of March - April, may be attributed to several factors of stress, as the high temperatures present during December, possible nutrition temporary deficiencies, possible stress caused by wind, media pH (which could affect the pH of the vacuole), and temporary lack of water. The combination of these factors probably caused the color change of the flower ligules by altering the metabolic pathways of these secondary metabolites.

In the bark mixes, the pore space decreased notably as more sawdust was added, generating a reduction in the size of the pore. This helped the retention of the added solution within the media, thus preventing the fertilizer or applied water from draining excessively, and in this way, the roots of the plants could capture the available nutrients, allowing them to grow properly. The presence of small quantities of nutrients such as N, P, K and Ca in the bark may have also influenced the higher development of plants as compared with plants in pure sawdust, whose input is practically null (Nelson, 1991).

The problem attributed to the use of fresh sawdust is the high C/N ratio, and the eventual phytotoxicity. During the course of the experiment, the only fact that was observed was during the long day phase, in which the plants in pure sawdust developed reddish coloration in the leaves, which led to their loss. For this reason, all plants of the different treatments were fertilized with soluble fertilizer, in addition to the granular fertilizer applied at transplanting. Water of fertilizer solution applied in all the pots drained, but more easily in pure sawdust. Its retention was minimal, that is, the retained water did not last all day and could be noticed by the weight of the pots. This became more noticeable when the plants were taken outside to the field. A shade house would have been very helpful, rather than exposing the plants to full sun. Under this condition, plants had to be watered 2 to 3 times a day (with pure water), because the plants that were in the sawdust: bark mixes (1:1, 2:1, and 3:1) and more critically in pure sawdust, dehydrated, manifesting leaf wilting. As a consequence of the low moisture retention, pots in pure sawdust were lighter as compared with the rest of the pots, and product of the morning wind that the sector presented, many times plants fell to the ground, which led to damaged stems.

The use of sawdust as a medium for potted chrysanthemum was successful, as was also the case in the study conducted by Hicklenton (1983). However, considering future productions, the most appropriate media mix would be sawdust: bark 3:1, due to the low cost (data not reported) because of the smaller amount of bark (more expensive than sawdust) used, and also the adequate appearance of the plants. In turn, the most convenient fertilization was fertilization every 2 days, due to the lower cost of production and equally good results as with daily fertilization. Finally, it is highly advisable to shade the plants when grown in the summer period to reduce water stress.

Acknowledgment

The family business Agrícola Alejandra Herrera provided all the materials needed for this study, and labor to perform photoperiod control on chrysanthemums, among other activities.

Literature cited

Chilean statistical yearbook of forestry. 2018 Available online: https://wef.infor.cl/publicaciones/anuario/2018/Anuario2018.pdf Consulted: 1/feb/2021.

Ball, V.; Higgins, E. 1998. *Dendranthema* (chrysanthemum). In Ball, V. (Ed.). Ball RedBook. Ball Publishing, Batavia, Illinois, U.S.A. pp. 447-473.

Burés, S. 1997. Substrates (In Spanish). Ediciones Agrotécnicas S.L. Madrid, Spain. ISBN 84-874480-75-6. 342 p.

Crater, G. 1980. Pot Mums. In: Larson, R.A. (Ed.). Introduction to floriculture. California, U.S.A. Academic Press, INC. pp. 263-285.

Christoulaki, M.; Gouma, S.; Manios, T.
2014. Deployment of Sawdust as Substrate Medium in Hydroponically Grown Lettuce. *Journal of Plant Nutrition* 37(8): 1304-1315.
Dole, J.M.; Wilkins, H.F.
1999. Floriculture: principles and species. New Jersey. Prentice Hall. pp. 292-304.
Gloeckner, F.C.
1988. Chrysanthemums manual. New York, U.S.A. Edited by Gloeckner & Company Inc. 11 p.
Goh, K.M.; Haynes, R.J.
1977. Evaluation of potting media for commercial nursery production of container-grown plants. *New Zealand Journal of Agricultural Research* 20(3): 363-370.
Hicklenton, P.R.
1983. Flowering, vegetative growth and mineral nutrition of pot chrysanthemum in sawdust and peat-lite media. *Scientia Horticulturae* 21(2): pp. 189-197.
Kaushal, S.; Kumari, P.
2020. Growing media in floriculture crops. *Journal of Pharmacognosy and phytochemistry* 9(2): 1056-1061.
Kishimoto, S.; Sumitomo, K.; Yagi, M.; Nakayama, M.; Ohmiya, A.
2007. Three routes to orange petal color via carotenoid components in 9 Compositae species. *J. Japan. Soc. Hort. Sci.* 76(3): 250-257.
Nelson, P.V.
1991. Greenhouse Operation & Management. 6th ed. Prentice Hall. Upper Saddle River, N.J., U.S.A. pp. 183-185.
Prasad, M.
1979. Physical properties of media for container-grown crops. I. New Zealand peats and wood wastes. *Scientia Horticulturae* 10(4): 317-323.
Salinger, J.P.
1987. Commercial flower growing. Butterworths Horticultural Books. Wellington, New Zealand. pp. 52-58.
Worral, R.J.
1981. Comparison of composted hardwood and peat-based media for the production of seedlings, foliage and flowering plants. *Scientia Horticulturae* 15: 311-319.