Initial research on the production of water-grown wasabi in the Waikato

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Abstract

Wasabi or Japanese horseradish (*Wasabia japonica* (Miq.) Matsum.; Brassicaceae) is a native perennial from Japan used as a traditional condiment with Japanese food. It requires specific conditions of light and water to thrive. In Japan, highest quality fresh product is grown on tree-shaded, terraced gravel beds covered by a thin layer of cool, clean, running water from mountain streams or on artificially shaded mounded gravel ridges formed in river beds. High quality cold water conditions are limited in Japan, but are widespread in New Zealand, so there is an opportunity to grow this high priced crop in New Zealand for export to Japan.

Intensive research on wasabi has been carried out at Ruakura since 1986. Initial trials were established in large concrete troughs filled with rock and gravel similar to the tatami-ishi wasabi beds of Shizuoka, Japan. Spring water at 13-14°C was flowed over the beds at about 160 ℓ/min. From cutting grown plants, sequential harvests indicated that the crop takes at least 18 months to achieve reasonable production of stems >50 g. Wasabi plants grew poorly in full sunlight and artificial shading was required to keep the light levels below 700 μmols m^{-2} sec^{-1} otherwise plants were liable to wilt. Japanese recommendations of using 50% shade cloth were inadequate and a further 30% shade cloth was required over summer. Diseases had a significant effect on wasabi production, particularly those caused by *Erwinia carotovora* and *Phoma wasabiae*, and production systems need to be devised to limit these. Wasabi is attacked by all pests of brassicas and regular spray programmes are required for pest control. Crop yield within the initial trials were calculated to be 17 t/ha of stems with 3.1 t/ha of stems >50 g, but considerably higher yields would be possible with adequate disease control.

Test marketing in Japan showed that New Zealand grown wasabi was of acceptable quality. Ongoing research aims to modify Japanese production methods to better suit New Zealand conditions.

Additional key words: Wasabi japonica, Erwinia carotovora *subsp.* carotovora, Phoma wasabiae, *Japanese market, vegetable, Japanese horseradish.*

Introduction

Wasabi or Japanese horseradish (*Wasabia japonica* (Miq.) Matsum; Brassicaceae) grows in wet places alongside mountain streams in Japan (Ohwi, 1965). It is a glabrous perennial herb which produces simple stems as it matures, similar to condensed kale or brussel sprout stalks. Stems are grated to produce a pungent condiment which is considered essential by the Japanese for flavouring raw fish (sashimi) and noodle (Soba) dishes (Hodge, 1974). High quality wasabi stems are produced under shade in gravel beds either moulded out of stream beds or especially constructed to allow a thin layer of cold water to flow over the surface of a free draining profile (Hodge 1974; Follett 1986a,b; Chadwick *et al.*, 1992). Suitable conditions to produce water-grown wasabi are abundant in New Zealand. After initial plant introductions in 1982 research on this crop was intensified in the late 1980's. The research approach follows that described by Douglas (1991).

The market for wasabi

The unique environmental requirements to grow wasabi limit its production to about 800 ha in Japan and 400 ha in Taiwan. The increasing demand for wasabi and the inability to expand production has seen prices rise steadily since 1970 (Chadwick *et al.*, 1992). In 1991 these averaged about $100/kg in Tokyo (Fig. 1). High prices have stimulated research on artificial production methods, substitutes for wasabi and the investigation of production areas outside Japan (Chadwick *et al.*, 1992).

Production requirements of wasabi

Water Quality. Wasabi is best grown in clean running water at 10-13°C (Hodge, 1974). Our experience has shown that one of the key requirements for wasabi production is that the roots are well oxygenated; less than 5 ppm dissolved oxygen in the water caused leaves to rapidly wilt. Plants rapidly recovered when put into higher oxygen conditions. A dissolved oxygen level of 9 ppm is a

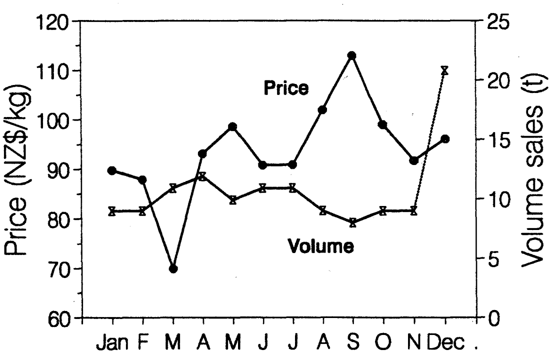

Figure 1. Wasabi auction prices and volume sold - Tokyo Market 1991 (1NZ$ = 69 yen).

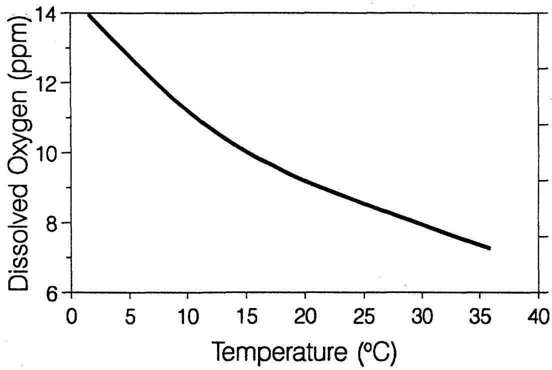

Figure 2. The saturation level of dissolved oxygen at various temperatures (after Wilcox, 1980).

satisfactory threshold to maintain wasabi in a good growing condition. This can only occur when the water temperature is les than 20°C (Fig. 2).

Water is the major source of plant nutrients for wasabi and this is one reason why high water flows are recommended. In Japan 180 ℓ sec^{-1} ha^{-1} is recommended (Chadwick *et al.*, 1992). We have grown excellent wasabi without any nutrient addition. A comparison of the nutrient content of Waikato water with that from Shizuoka shows that Waikato water has high natural nitrogen levels (Table 1). Shizuoka wasabi growers are known to make monthly applications of slow release 12:12:12 fertiliser into the head races of their wasabi fields. They also spray wasabi foliage with sulphur sprays to correct sulphur deficiency and enhance flavour (Chadwick *et al.*, 1992).

Shade. Wasabi is a native of the sub canopy vegetation in the montane regions of Japan and has evolved to grow under subdued light. Production systems in Japan use both natural shading from black alders (*Alnus japonica*) or poplars (*Populus* spp.) or artificial shade (Chadwick *et al.*, 1992). Chadwick *et al.* (1992) reported that Adachi (1987) considered that shading for wasabi in Shizuoka was site-dependent, with some sites requiring 70-80% shade, some 50-60% and some none at all.

In the Waikato, wasabi plants grown under ambient light levels rapidly wilted with new growth producing small, thick, chlorotic leaves. Shade levels of 40-50% in summer were found to be insufficient with leaves commonly wilting. In response a further 30% shade was added to the roof and north and west walls of the shade structure. A light response curve obtained using a climate controlled mini curvette system (Buwalda *et al.*, 1991) showed that light saturation had occurred when the light level (photosynthetic photon flux density) reached 500 μmols m^{-2} sec^{-1} (Fig. 3). Crop management should aim to maintain these light levels to achieve maximum photosynthesis without causing wilting and chlorosis.

Production in the Waikato

Site

Wasabi research in the Waikato has been carried out at a disused fish hatchery near Arapuni fed by spring water at a temperature of 13-14°C. Fifteen 7 x 1.2 x 1 m concrete troughs were converted for wasabi production using local rock and gravel substrates to imitate the tatami-ishi wasabi beds used in Japan. The beds were 1 m deep constructed with rocks for the bottom 50 to 60 cm, overlaid with coarse gravel with a 10-15 cm layer of sand or crusher dust.

Table 1. Nutrient content of Waikato spring water used in trials compared to average Japanese levels

	pH	NH_4-N	NO_3-N	K	P	Ca	S	Mg
Waikato	6.8	0.02	1.17	3.3	0.11	3.0	2.7	1.8
Shizuoka (good growers)*	6.4	.009	0.31	2.9	0.22	3.7	3.7	1.0
Shizuoka (poor growers)*	6.4	.003	0.11	1.5	0.10	3.3	3.6	1.3

* mean of 10 growers

Trial production:

The trial was established in May 1987 using unrooted wasabi (cv. Midori) cuttings. These cuttings were planted in off-set rows 25 cm apart into 12 cm diameter PVC rings. The rings were provided to prevent water eroding the sand around the cutting. The water flow rate was adjusted to maintain approximately 160 l min^{-1} through each trough.

Algae (*Melosira granulata and Spirogya* spp) was a problem especially during the establishment phase. The beds required regular cleaning to avoid new wasabi growth being smothered. This proved to be a problem until canopy closure when the lack of light restricted algal growth.

A routine spray programme containing Kocide and Orthene was sprayed once every 7 to 10 days.

The trial was established to investigate the growth and development of wasabi plants when planted on five different substrate mixtures of rock, pumice, sand and stone chips with plants harvested sequentially 15, 20 and 25 months after establishment. Plant growth was unaffected by substrate so the plots were used to measure the main effect of each harvest. Plant death and weak and dying plants affected the harvesting plan and to overcome this individual plant information rather than plot information was used. Thirty plants were dissected at each harvest from populations in which the lightest third of weak and spindly plants were discarded. The results therefore represent production from well grown wasabi plants at each harvest. For each plant, stems were separated, counted and weighed with the leaf petioles trimmed 5 cm from the top of the stem.

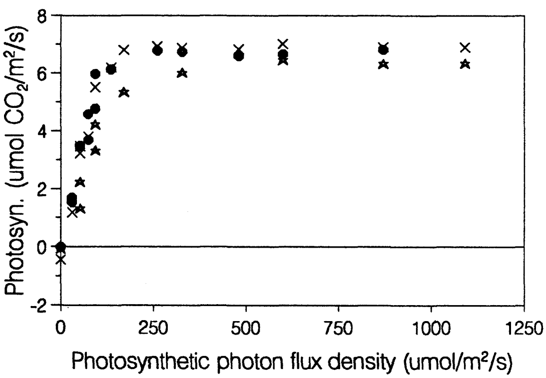

Figure 3. Effect of light levels on photosynthesis in wasabi. Data are presented for three plants.

Results and Discussion

Stem development

During the 10 month period from 15-25 months total stem production increased by 59% with individual stems increasing in size but with no change in stem numbers (Table 2). The percentage of larger stems increased as the plants aged. Taking a 50 g stem as a threshold size for export each plant produced over two marketable stems by 20 months (Table 3).

Disease

Disease had a significant effect on the wasabi production and stem quality. Wasabi suffers from most of the pests and diseases common to the cruciferae family. Although a number of diseases were identified on the crop during the growth cycle the two greatest problems were Erwinia (*Erwinia carotovora* subsp carotovora) and Phoma (*Phoma wasabiae*). Both are systemic diseases and difficult to control with therapeutants. They are also common problems in Japan (Follett, 1986). In the Waikato *Erwinia* was most noticeable affecting large well developed plants which initially wilted then quickly collapsed leaving rotten smelly stems. Although Phoma was more widespread the disease did not cause the death of the plant. This disease resulted in black lesions on the stem and necrosis within the conductive tissue downgrading the quality of the stem. Despite the widespread incidence of the disease on wasabi

Table 2. Stem production of 30 wasabi plants cv Midori at three sample times

Growth period	Total stem wt. (kg)	Total stem no.	Stem wt. per plant (g)	Average stem wt. (g)
15 months	8.35	447	278	18.7
20 months	11.61	466	387	24.9
25 months	13.28	446	443	29.7

Table 3. Percentage stem weight distribution and stems/plant over 50 g from 30 wasabi plants cv. Midori at three sample times

Growth period	Weight range (g)					Stems per plant >50 g
	0-19	20-39	40-59	60-89	80+	
15 months	71	22	5	2	-	0.3
20 months	56	23	11	7	3	2.1
25 months	44	29	15	7	5	2.7

in Japan, phoma on stems from New Zealand could possibly cause quarantine problems. Other diseases identified on the crop included *Albugo*, *Alternaria*, *Sclerotinia*, *Pithium*, *Botrytis*, Clubroot (*Plasmodiophora brassicae*) and *Pseudomonas*.

Plant mortality increased steadily throughout the trial. After 15 months survival was 48% with this continuing to decline to 34 and 24% after 20 and 25 months respectively. The deaths caused by disease were further compounded by weakened plants being smothered by more vigorous neighbours.

Pests

Pests were well controlled by the spray programme. Potentially the most serious pests if left unchecked were aphids because of their ability to transmit virus. Wasabi can be seriously affected by tobacco, turnip and cucumber mosaic viruses which causes stunting and distortion of plants and leads to low plant vigour in subsequent crops if vegetative propagation is used (Chadwick *et al.*, 1992). Root aphids (*Pemphigus bursarius*) have been found from time to time on wasabi roots above the water line. This pest was not widespread but it could be difficult to control.

Extrapolated crop yield

Calculations of crop yield at the final harvest were made taking into account the plant deaths. From the original population established at 0.25 x 0.25 m the final harvest population had a plant spacing of about 0.5 m and was only 24% of the original planting. The plant population was 38,760 plants/ha with a stem yield/plant of 443 g. The calculated yield was 17 t/ha with 3.1 t/ha of stems greater than 50 g. Once better disease control gives higher plant populations at harvest it is likely that crop yields will be markedly improved.

Test marketing

Wasabi stems from the Waikato trial have been test marketed in Japan on two occasions. Taste, texture, colour and appearance were evaluated. The response has been favourable with the only criticism being the Waikato wasabi was lighter in colour than most of the Japanese product. The reasons for this are not clear. However market research in Japan also indicates that Japanese product varies in colour from very pale to dark green. Possible reasons include excessive shading of the stem during development and cultivar variations. One evaluation found no difference between the Waikato and Shizuoka produced wasabi.

Conclusions

Using techniques similar to those used in Japan this research has shown that wasabi can be successfully produced in the Waikato. Test marketing in Japan has confirmed the quality of the New Zealand product is acceptable to the market. Generally production results in the two countries have been similar. For example in both countries the optimum time to crop harvest is eighteen months to two years while *erwinia* and *phoma* major problems.

The trial results indicate not only that wasabi grows very well in New Zealand but that there is considerable scope for improvement. Improved disease control and better plant performance through improved cultivars could greatly increase yields.

The results indicate that wasabi has the potential to become a significant new export crop in New Zealand. Research is still in its infancy to optimise production systems appropriate for New Zealand conditions but the initial results are very positive.

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