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Smart Hydroponic System Using IOT

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Abstract: Hydro agriculture (Hydroponics), aqua agriculture (Aquaponics), and aerobic agriculture (Aeroponics), in addition to substrate culture, are examples of soilless farming. One of these hydroponics systems is gaining popularity due to its effective management of resources and food output. This project used The Nutrient Film Technique (NFT). NFT is a kind of hydroponic system in which nutrient solutions flow continuously through the plant roots. This project's objectives are to produce high-quality Brassica Rapa (Pak Choi) hydroponic plants using NFT, to monitor temperature, acidity, water level, and Total Dissolve Solids (TDS) readings on hydroponic drainage, and to reduce labour costs and time spent caring for hydroponic crops. Various kinds of sensors, including pH, humidity, TDS, and water level sensors, were employed to build a smart hydroponic system using IoT in order to meet the goals. Experiment 1 aims to identify suitable parameters such as temperature, AB fertiliser concentration, electrical conductivity (PPM), and acidity (pH) of the water solution that will be used in the hydroponic system for growing white mustard plants in experiments 2 and 3. This information was obtained on the harvest date, which is 35 days following the date of the nursery. The average weight for sale in the supermarket for the white mustard is 160g. The comparative results of the experiment, experiment 2 needed almost 28 days to reach the average weight to be sold while experiment 3 only needed 25 days. However, on the 35th day, the weight of mustard in experiment 2 was heavier than in experiment 3. Users can determine whether they want to produce a faster result using the parameters in experiment 3 or a heavier crop yield using the parameters found in experiment 2. This project will also be able to help small farmers as well as large industrial farmers.

Keywords: Hydroponic, Nutrient Film Technique, System, Experiment.

1. Introduction

Hydroponics is the cultivation of plants in nutrient solutions with or without the use of an inert medium to provide mechanical support, such as gravel, vermiculite, rockwool, peat moss, saw dust, coir dust, coconut fibre, etc. Hydroponics is derived from the Greek words hydro's, meaning water, and

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ponos, meaning labour, and literally means "water labor." Not only is cultivable land disappearing because of expanding urbanization and industrialization, but so are traditional agricultural practices, resulting in an array of severe environmental effects. To sustainably feed the world's growing population, methods for producing sufficient food must advance. For long-term production and the preservation of increasingly depleting land and water resources, the modification of the growth medium is a possible solution. Soilless agriculture might be initiated and regarded as an alternative method for cultivating nutrient-rich food plants, crops, and vegetables in the present circumstance.

White Mustard (Brassica Rapa L. cv group Pak Choi) is a species of mustard from the Cruciferae family that is cultivated in Malaysia for the local and export markets. White Mustard is one of several mustard varieties cultivated in Malaysia, including Bitter Mustard, Green Mustard, Curly Mustard, and Japanese Mustard. In 2010, the mustard plantations in Malaysia covered 2,300 hectares and produced 24 million metric tons. In the Districts of Johor Bahru, Kota Tinggi, Kulai Jaya, Kluang, and Muar, 28% of the total mustard growing area in Malaysia is in the State of Johor. Now that Pak Choi mustard is in great demand, the price per kilogram has also grown; in the year 2020, Pak Choi mustard will cost around RM10 per kilogram, and in the year 2021, the price per kilogram will be RM15 [1]. This is because Pak Choi mustard is in great demand on the market and is one of the most popular veggies in Malaysia.

NFT, or the Nutrient Film Technique, is a kind of hydroponic system in which nutrient solutions flow continuously through the roots of plants. The channel pipe is slightly slanted to allow the nutritional solution to flow under the influence of gravity. The plant roots receive more oxygen from the surrounding air than from the fertilizer solution [2]. Because just the root tips are exposed to nutritional solutions, these plants can get more oxygen, resulting in a quicker development rate. The requirements and procedures for hydroponic agriculture are considerably distinct from those of traditional agriculture [3]. This is a result of the various planting media, which needs particular care, including the maintenance of temperature and nutrition, as well as the pH of the growth medium, which also has a specific standard [4]. Therefore, a monitoring and scheduling system is required for the system to operate more efficiently.

Hydroponic plantings of mustard (Pak Choi) need extreme accuracy in order to produce healthy mustard of a high quality. The primary obstacle in generating high-quality hydroponic mustard crops is nutrient leakage that does not conform to hypothesis [5]. Hydroponic mustard needs a fertilizer combination of not less than 1050 PPM (Parts per million) and not more than 1400 PPM. The pH level in hydroponic water drainage must be between 6.5 and 7, and the ideal temperature for Mustard (Pak Choi) hydroponic plants is 25C to 30C [6].

2. Materials and Methods

2.1 Materials

In this project the hardware and software show in table 1 has been used to build the hydroponic system. This project has using AC-DC converter to generate power to EPS32 and DC motor and use various type of sensor as shown in Table 1.

Table 1: List of hardware and software

Hardware	Software
ESP 32, pH sensor, EC sensor, DHT 22, Water level sensor, DC pump motor, LCD IC2 Screen, Relay	Arduino IDE, Fritzing, Blynk

2.2 Methods

In this process the data that has been taken from all sensors will be analysed whether it has met the parameters that have been set or not. The ideal data for the PH sensor is between 6.5 to 7, if the data obtained does not meet the parameters dc pump that brings the solution PH down and PH up will be activated. Data from the water level sensor must also pass the value of Low or 1, otherwise the dc pump that brings the water supply to the NFT system tank will be activated. The temperature reading should be below 30°c, if the temperature has exceeded the water spray will be active. For data readings from the EC sensor, it should be less than 1050ppm and more than 1400ppm. If the reading exceeds these parameters, water will be channelled to the NFT system tank, whereas if the EC sensor reading is less, the fertilizer solution will be channelled to increase the water ppm reading to the NFT system tank. All data and readings will be displayed using a 20×4 IC2 display and will also be displayed on a mobile phone display using the blynk application.

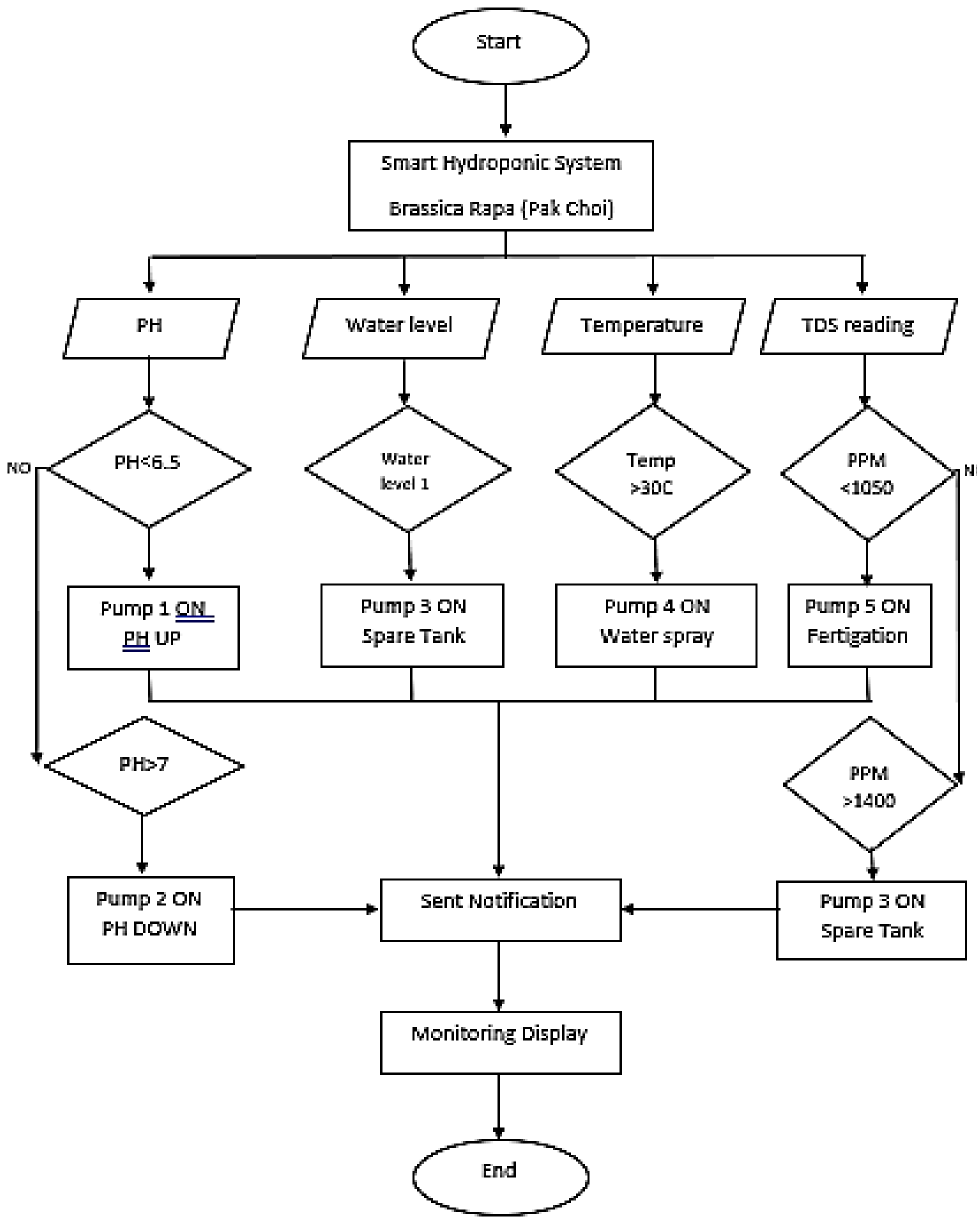

Figure 1: The flowchart of the system

3. Results and Discussion

3.1 pH and EC Sensor Calibration

Sensor calibration is an adjustment or set of adjustments performed on a sensor or instrument to make that instrument function as accurately, or error free, as possible. For the hydroponic system, collect accurate data from sensor are so important to maintain the actual parameter form pH sensor, EC sensor and temperature sensor that the plant needs. Figure 2 shows pH sensor calibration.

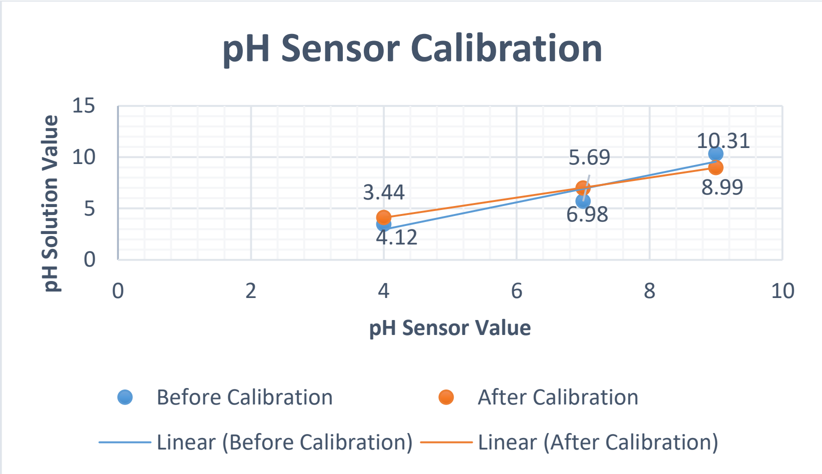

Figure 2: pH sensor Calibration

A series of reference standards, or so-called pH buffers, with known and precise pH values at various temperatures are measured to calibrate a pH metre. Determine which buffered standards will best frame the anticipated values at the sampling sites. Three standards—one near seven, one at least two pH units below seven, and the other at least two pH units above seven—are required for calibration if the pH of the water body is unknown. If the sample's pH is outside the initial calibration range, instruments that won't accept three standards need to be recalibrated. Calibration can be done by setting the resistance value on the pH sensor board. Figure 3 shows EC sensor calibration.

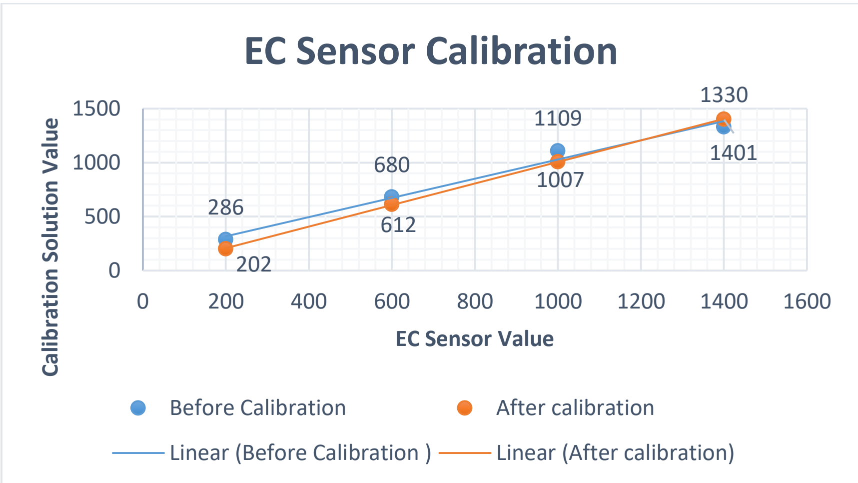

Figure 3: EC sensor Calibration

To ensure accuracy, the probe needs to be calibrated for its first use and after not being used for an extended period of time. This tutorial uses four-point calibration and therefore requires standard buffer solutions of 200ppm – 1400ppm.

3.2 Experiment 1

This experiment aims to identify suitable parameters such as temperature, AB fertilizer concentration electrical conductivity (PPM) and acidity (pH) of the water solution that will be used in the hydroponic system for white mustard plants that will be done in experiment 2 and 3. All this data has been collected on the day of harvest which is 32 days after the day of the nursery as shown in Table 2.

Table 2: Experiment 1

Plant	**pH**	**ppm**	**Temp**	**Leaf Width (cm)**	**Leaf Length (cm)**	**Weight (g)**
1	6.5	950	26	6.4	13.2	122
2			30	6.8	12.7	138
3		1250	26	7.9	15.8	167
4			30	8.2	15.4	172
5		1450	26	7.0	14.1	154
6			30	7.1	13.9	153
7	7	950	26	6.3	12.1	129
8			30	6.5	13.8	132
9		1250	26	8.6	18.8	162
10			30	8.8	19.0	178
11		1450	26	6.2	16.4	144
12			30	6.6	16.9	151
13	7.8	950	26	5.1	11.0	102
14			30	5.0	11.8	90
15		1250	26	6.3	13.5	126
16			30	5.9	14.1	111
17		1450	26	5.2	11.9	115
18			30	4.8	10.4	102

3.3 Experiment 2

The parameters in this experiment have been taken from plant no 4 in experiment 1. This aims to use those parameters in the real smart hydroponic system to get the best results by using the pH 6.5 and 1250ppm. This experiment has been conducted for 35 days after nursery day. All data was taken at 5-day intervals by collecting data in terms of width, leaf length and tree weight as show in Table 3. Figure 4 show the graph of weight. Figure 4 shows the graph of the rate of increase in the weight of the tree at intervals of 5 days up to 35 days. The data is taken using gram units.

Table 3: Experiment 2

Day	**Leaf Width (cm)**	**Leaf Length (cm)**	**Weight (g)**
5	2.8	8.6	53
10	3.9	10.7	74
15	5.1	13.7	108
20	6.7	15.5	137
25	7.2	17.3	165
30	8.5	18.3	172
35	8.8	18.5	176

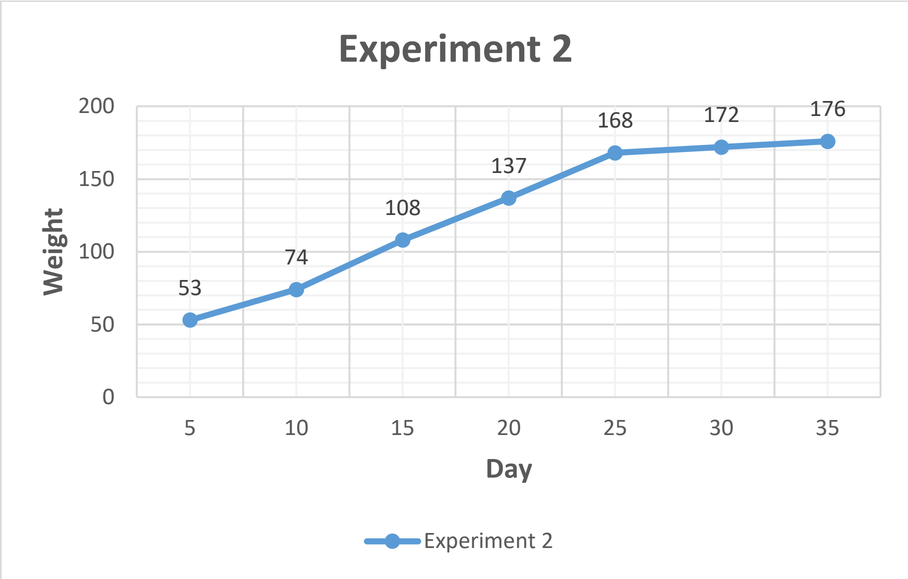

Figure 4: Graph of experiment 2

3.4 Experiment 3

The parameters in this experiment have been taken from plant no 7 in experiment 1. This aims to use those parameters in the real smart hydroponic system to get the best results to compare with experiment 2 by using the pH 7 and 1250ppm. This experiment has been conducted for 35 days after nursery day. All data was taken at 5-day intervals by collecting data in terms of width, leaf length and tree weight as show in Table 4. Figure 5 shows the graph of weight. Figure 4 shows the graph of the rate of increase in the weight of the tree at intervals of 5 days up to 35 days. The data is taken using gram units.

Table 4: Experiment 3

Day	Leaf Width (cm)	Leaf Length (cm)	Weight (g)
5	3.5	6.9	43
10	4.7	8.6	66
15	6.6	10.6	97
20	7.0	13.5	119
25	7.8	15.8	151
30	8.5	18.3	170
35	8.6	18.9	179

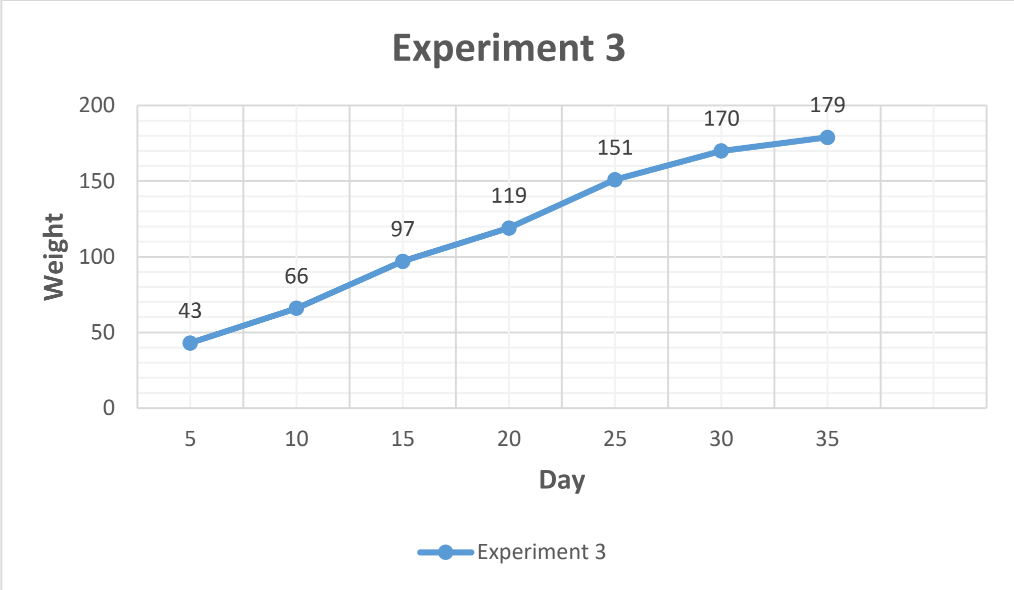

Figure 5: Graph of experiment 3

3.5 Data comparison

Figure 6 shows the graph comparison between data from the experiment 2 and 3. This comparison aims to identify the best experiment results to get a good and fast harvest. The average weight for sale in the supermarket for the white mustard is 160g. The comparative results of the experiment, experiment 2 needed almost 28 days to reach the average weight to be sold while experiment 3 only needed 25 days. However, on the 35th day, the weight of mustard in experiment 2 was heavier than in experiment 3. This shows that the fertilizer water solution and the acidity of the water affect the growth of mustard.

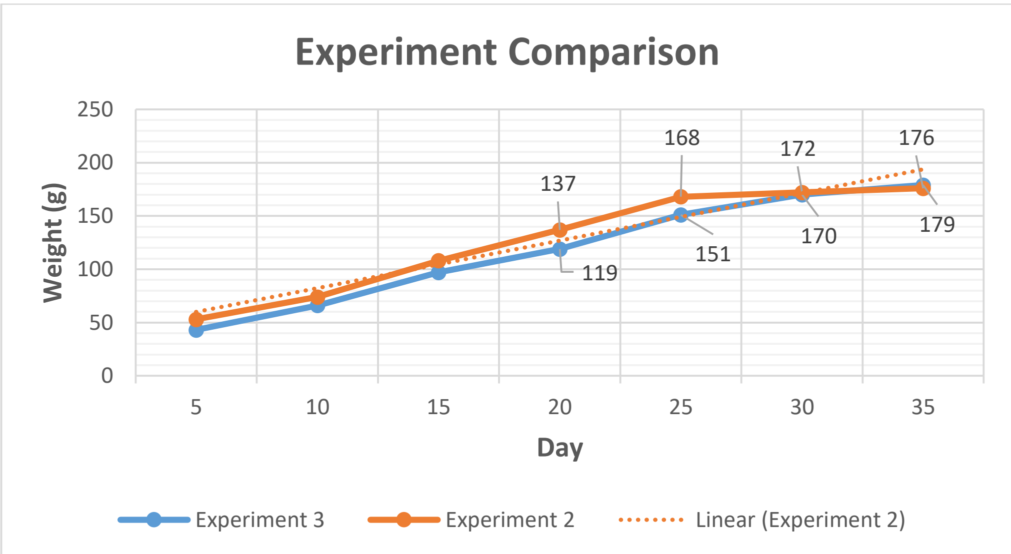

Figure 6: Graph of experiment comparison

4. Conclusion

The research results of this project show the effectiveness of the smart hydroponic system to produce high-quality white mustard that exceeds the weight standard set to be marketed. Users can also choose to use the parameters found in experiment 2 and 3 because both experiments have succeeded in showing the best results. Users can determine whether they want to produce a faster result using the parameters in experiment 3 or a heavier crop yield using the parameters found in experiment 2. This project will also be able to help small farmers as well as large industrial farmers.

For small-scale agriculture, they can continue to use the prototype that has been produced in this project because the prototype that has been built in this project only 20 plants at a time, but if converted to a larger dc motor pump, this prototype will accommodate up to 50 plants. For large-scale hydroponic farmers, hardware must be change on the prototype to ensure durability, but the parameters used can be taken from the results of this project because the effectiveness on white mustard trees has been shown through experiment 2 and experiment 3.

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References

[1] Noor Hasloza Nusi (14 April 2021) “Harga sawi Pak Choi dan bawang Naik mendadak” Utusan Malaysia https://www.utusan.com.my/berita/2021/04/harga-sawi-pak-choi-daun-bawang-naik-mendadak/

[2] Resh, H.M. 2004. Hydroponic food production: A definitive guidebook for the advanced home gardener and the commercial hydroponic grower.Newconcept Press, Inc. New Jersey.

[3] Nalwade, R., & Mote, T. (2017,May). Hydroponics farming. In Trends in Electronics and Informatics (ICEI), 2017 International Conference on (pp. 645-650).IEEE

[4] Nxawe, S., C.P. Laubscher, and P.A. Ndakidemi.2009. Effect of Regulated Irrigation Water Temperature On Hydroponics Production of Spinach (Spinacia Oleracea L.). African Journal Of Agriculture Research Vol. 4, No.12: 1442-1446.

[5] Singh, S. and Singh, B. S.. ―Hydroponics – A technique for cultivation of vegetables and medicinal plants‖. In. Proceedings of 4th Global conference on ―Horticulture for Food, Nutrition and Livelih,ood Options‖ Bhubaneshwar, Odisha, India. p.220. (2012)

[6] De Kreij C; Voogt W; Baas R (1999). Nutrient solutions and water quality for soilless cultures. Research Station for Floriculture and Glasshouse Vegetables (PBG), Naaldwijk, The Netherlands, Brochure 196