Research Article ISSN: 2393 – 9540

International Journal of Nutrition and Agriculture Research

Journal home page: www.ijnar.com

MICRO-FARMING OF GREENS: A VIABLE ENTERPRISE FOR ENHANCING ECONOMIC, FOOD AND NUTRITIONAL SECURITY OF FARMERS

Manjula Devi Ghoora*[1] and Nagarajan Srividya[1]

[1*]Department of Food and Nutritional Sciences, Sri Sathya Sai Institute of Higher Learning (Deemed to be University), Anantapur, Andhra Pradesh, India.

ABSTRACT

The micro-farming of greens is currently gaining interest due to the potential it offers for enhancing economic, food and nutritional security of farmers. Yield quality assessment parameters for ten microgreens were standardised in a soil-less medium. These include average germination and harvest time, shoot population density, total fresh yield, shoot fresh weight, shoot height, and dry matter. The economics of microgreens were worked out in terms of the production cost and expected market price per tray. The standardised growth parameters favoured increased shoot population density, good yield, and early harvest within a period of 6 to 10 days. The organoleptic acceptability of the microgreens ranged from very good to excellent. The expected market value was found to be five to eleven-fold greater than the production cost of the microgreens. Thus, micro-farming of greens represents a viable enterprise which can aid in the economic stability of the rural and urban poor.

KEYWORDS

Microgreens, Cultivation, Food security, Yield parameters and Economics.

Author for Correspondence:

Manjula Devi Ghoora,
Department of Food and Nutritional Sciences,
Sri Sathya Sai Institute of Higher Learning (Deemed to be University),
Anantapur, Andhra Pradesh, India.

Email: manjuladevighoora@sssihl.edu.in

INTRODUCTION

Tropical countries like India, have a diversity of fresh produce which play an important role in nutrition and health. One of the fresh produce which have gained commercial importance as a new culinary trend during the past few years is the microgreens. Microgreens are seedlings of 1-3 inches in height with unique characteristics such as vivid colours, rich flavours, and tender textures, having a quick production cycle of 7-14 days[1]. There exists a large variety of microgreens which can broadly be categorised as culinary greens, or herbal greens based on the flavours and applications. In a study by the USDA team on 25 varieties of commercial microgreens, these tiny greens were found to be more nutrient-dense than their mature counterpart[2].

Though there are increasing literature on the cultivation, nutritional and postharvest quality of this novel produce in the temperate countries[3-5], very limited studies have reported on microgreens grown in the tropics. Thus, the present study has standardized the growth of ten culinary and herbal microgreens under the tropical climate and presented the associated organoleptic acceptability and economic considerations to enable the farmer community to adopt this high selling produce, which can provide food security for many low-income people.

MATERIAL AND METHODS

Microgreens Cultivation

Seeds used for the cultivation of the culinary and herbal microgreens were purchased from local agricultural shops except French basil which was procured from CIMAP, Bengaluru, India. The seeds were of good quality (70-99 % germination). Plastic trays (L 24.0cm x W 17.0cm x D 4.0 cm) were filled to a depth of 3 cm with cocopeat (soil-less) medium, pre-mixed with water to obtain the right moisture level. Initially, a paper board template with equally spaced rows was placed onto the medium and rows of equal depth were made for broadcasting the seeds. Seeds were soaked in potable water at a seed to water ratio of 1:4 for 8 hours except basil and fennel. The soaked seeds were then rinsed 1-2 times with potable water prior to seeding at the optimized seed density. The seeds were topped with a thin layer of cocopeat and the seeded trays were stacked. The trays were watered with a mist sprayer thrice a day and covered to maintain high humidity (RH: 95 ± 5 %) and darkness to initiate germination. The trays were exposed to sunlight after three to four days to ensure maximum germination. The seedlings were watered thrice daily to ensure adequate moistness of the cocopeat. During the growth period, daily air temperature ranged between 25 to 30 ºC and relative humidity was 65 ± 10 %.

Microgreens Harvest

Microgreens were harvested after the cotyledonary leaves have fully expanded and the emergence of the first true-leaf was visible at an approximate height of 2-3 inches tall. A sharp, sterile scissor (wiped with ethanol) was used to cut the stem with leaves just above the level of the medium leaving behind the roots. Microgreens were harvested into a clean colander, washed with potable water to remove any dirt particles or husk and fan-dried for 5-10 minutes without allowing the greens to wilt.

Yield and Quality Assessment

The shoot population density (shoot m^{-2}), total fresh yield per unit area (g m^{-2}) and shoot fresh weight (mg shoot $^{-1}$) was determined as per the procedure given by Di Gioia *et al.*[6] with minor modifications. The shoot population density was calculated by counting the number of shoots in a random sub-sample of 100 cm^2 in a tray. Harvested microgreens were weighed immediately prior to washing to determine the fresh yield and results were expressed in grams per unit area (g m^{-2}). Individual shoots were weighed to determine the shoot fresh weight (mg shoot^{-1}). Shoot height of microgreens (mm) was determined by measuring the heights of the microgreens prior to harvest at the level of the growing medium. The dry matter was determined using the AOACmethod[7]. Briefly, samples were dried to a constant weight in a dry-air oven at 100 ºC and weighed to determine the percent dry matter. Microgreens were also evaluated for the organoleptic acceptability by a sensory panel based on a nine-point hedonic scale.

Economics of Microgreens

The production cost of microgreens was worked out based on the costs of tray, seeds and peat used for the cultivation. The commercial price of microgreens as given by ‘Growing Greens’ farm in Bangalore, India was considered for this study.

Statistical Analysis

Shoot population density, total fresh yield and percent dry matter were expressed as means of triplicate values. Shoot fresh weight and shoot height were mean of ten replicates. Analysis of variance

(ANOVA) followed by Tukey test were carried out to determine significant differences at P=0.05 in the yield quality assessment parameters. Correlation analysis were carried out using Pearson's correlation coefficient. Statistical analyses were carried out using MS-Excel Data Analysis Toolpak 2016 and IBM SPSS Statistics 21 software.

RESULTS AND DISCUSSION

The details of the cultivated microgreens are given in Table No.1.

They have been broadly categorized into culinary and herbal microgreens based on the flavour profile and the intensity of the flavours. Carrot, fenugreek, onions, red roselle, spinach and sunflower microgreens have milder flavours while mustard and radish microgreens have spicy and pungent flavours, respectively. Thus, they have been placed in the culinary group. French basil and fennel microgreens have strong herbal flavours and hence placed under the herbal category.

Table No.2 summarises the standardised growth parameters (seed density, seed soaking, germination time and harvest time) of the cultivated microgreens.

The optimised seed density for microgreens cultivation ranged from 188 gm^{-2} per tray for carrot microgreens to 500 gm^{-2} per tray for fennel microgreens. Spinach, onion, and French basil microgreens were planted at a seed density of 250 g m^{-2} while roselle, fenugreek and sunflower microgreens at 375 gm^{-2} and radish at 313 gm^{-2}. A seed density of 10,000 to 40,000 seeds/m^2 was reported to be ideal for microgreens cultivation[8] and many of the microgreens cultivated in this study had similar seed densities. Seed density was optimised through preliminary trials and was based on the seed size, weight, and germination percentage of the seed lot. Generally, in the cultivation of microgreens, it is recommended that seeds are planted at high density, blanketing the growth substrate to maximise nutrient uptake and yield[9] and to compensate for the limited biomass of single shoots, which is due to early harvesting[8]. Most of the seeds used in this study were soaked for 8 hours prior to seeding. Seed soaking helps speed up the germination process by advancing the seed metabolism[10]. Hence, most of the soaked seeds germinated within one to two days. Basil seeds on soaking form a gelatinous layer leading to difficulty in germination and in fennel seeds, it promoted fungal growth which was undesirable. The harvest time ranged from 6 to 9 days for fast-growing microgreens such as red roselle, fenugreek, radish, sunflower, and spinach. The slow-growing microgreens, mustard, carrot, onion, fennel, and basil, were harvested between 10 to 14 days.

The shoot population density ranged from 9,233 $shootsm^{-2}$ for sunflower microgreens to 51, 291 $shootsm^{-2}$ for carrot microgreens (Table No.3). Sunflower microgreens, being the bulkiest with the highest shoot fresh weight of 705 mg per shoot and an average shoot height of 79 mm require adequate space for growth and hence had the least shoot population density. On the other hand, carrot microgreens, with the least shoot weight and height of 24 mg/shoot and 40 mm, respectively, resulted in maximum shoot population density. Di Gioia *et al.* reported a shoot population density ranging 29, 831 to 31, 276 shoot/m^2 for *Brassica rapa* L. (rapini) microgreens across various growth media[6] while Murphy and Pill reported a shoot density ranging from 6,882 to 29,073 $shootsm^{-2}$ for arugula microgreens[3]. Most of the studied microgreens had shoot population densities within reported range.

Highest total fresh yield was recorded in radish microgreens while lowest one in spinach. No significant differences were recorded in the yield of carrot, fenugreek, onion, roselle, sunflower and French basil. The fresh yield data of these microgreens was within the range reported in literature[3,6,11]. The least shoot fresh weight (mg $shoot^{-1}$) was found in carrot microgreens while the highest in sunflower microgreens. The shortest shoot height was also found in carrot microgreens while highest was roselle, followed by sunflower microgreens. Microgreens shoot height was found to have a strong positive correlation with shoot weight ($r = 0.679$; $P < 0.01$) and both shoot height and shoot weight were negatively correlated with shoot population density ($r_{shoot\ height}= -0.533$, $r_{shoot\ weight} = -0.423$; $P < 0.05$).

The maximum percent dry matter was recorded in fennel (10.6 %) and least in onion (5.3 %) microgreens. Similar dry matter content in was reported in 25 temperate microgreens[2], indicating the high moisture content of these produce. From the quality aspect, it can be deduced that a high percent dry matter accumulation may be associated with higher shelf life[12].

The organoleptic acceptability of the microgreens was found to be very good to excellent with scores ranging from 7.25 to 8.00 on a 9-point hedonic scale (Figure No.1). Fennel microgreens were most accepted in terms of its organoleptic characteristics, followed by French basil, spinach and red roselle.

The production cost of microgreens ranged from INR 275m^{-2} in the case of mustard to INR 750m^{-2} for basil microgreens (Figure No.2). Variations in production cost can be mostly attributed to the cost of the seeds. The expected profit margin per m^{-2} of 6 out of 10 microgreens was found to be 10 to 11-fold greater than the production cost and for the remaining microgreens, it was 4 to 7-fold higher. Other expenditure includes initial setup cost such as racks to hold the seeding trays and gardening tools. However, these could be easily made up for during the first few months to maximum first year of marketing of the produce. It should also be noted that the trays could be re-used for a minimum of a 5-crop cycle or even more. This makes the cultivation and marketing of microgreens a highly profitable enterprise, especially for the farmers/entrepreneurs.

Table No.1: detalis of microgeens (culinary and herbal) cultivated in the study

S.No	Common name	Genus and species	Family	Cultivated microgreens
Culinary microgreens				
1	Carrot	*Daucus carota* L.	Apiaceae	
2	Fenugreek	*Trigonella foenum-graecum* L.	Fabaceae	
3	Mustard	*Brassica juncea* L.	Brassicaceae	
4	Onion	*Allium cepa* L.	Amaryllidaceae	
5	Radish	*Raphanus sativus* L.	Brassicaceae	
6	Red roselle	*Hibiscus sabdariffa* L.	Malvaceae	
7	Spinach	*Spinacia oleraceae*	Amaranthaceae	
8	Sunflower	*Helianthus annus* L.	Asteraceae	
Herbal microgreens				
9	Fennel	*Foeniculum vulgare* Mill.	Apiaceae	
10	French basil	*Ocimum basilicum* L.	Lamiaceae	

Table No.2: Standardised growth parameters of microgreens

S.No	Microgreens	Optimized seed density(g m^{-2})	Seed soaking	Germination time (Days)	Harvest time (Days)
1	Red roselle	375	✓	2-3	6-8
2	Fenugreek	375	✓	2-3	7-9
3	Radish	313	✓	2-3	7-9
4	Sunflower	375	✓	2-3	6-8
5	Spinach	250	✓	2-3	8-9
6	Mustard	313	✓	2-4	10-11
7	Carrot	188	✓	4-5	10-12
8	Onion	250	✓	4-5	10-12
9	Fennel	500	x	5-7	12-14
10	French basil	250	x	3-4	12-14

Table No.3: Shoot population density, total fresh yield, shoot fresh weight and dry matter accumulation in the microgreens

S.No	Microgreens	Shoot population density	Total fresh yield	Shoot fresh weight	Shoot height	Dry matter
		(shoot m^{-2})	(g m^{-2})	(mg $shoot^{-1}$)	(mm)	(%)
1	Carrot	51,291^{e}	2194.5^{bcd}	23.8^{a}	40.1^{a}	7.3^{abc}
2	Fenugreek	11,500^{ab}	3464.9^{de}	207.5^{b}	59.1^{b}	5.5^{a}
3	Mustard	18,066^{c}	4334.6^{ef}	31.5^{a}	40.5^{a}	6.6^{abc}
4	Onion	18,386^{c}	1099.8^{ab}	32.2^{a}	65.7^{b}	5.3^{a}
5	Radish	16,866^{c}	5267.4^{f}	268.7^{b}	64.2^{b}	6.6^{abc}
6	Red roselle	11,566^{ab}	2934.6^{d}	235.0^{b}	80.2^{c}	8.9^{cd}
7	Spinach	12,366^{b}	758.3^{a}	44.5^{a}	44.7^{a}	7.0^{abc}
8	Sunflower	9,233^{a}	2463.3^{cd}	705.1^{c}	78.5^{c}	8.4^{bcd}
9	Fennel	18,597^{c}	797.6^{a}	24.6^{a}	44.3^{a}	10.6^{d}
10	French basil	22,695^{d}	1142.6^{abc}	25.0^{a}	37.9^{a}	5.7^{ab}

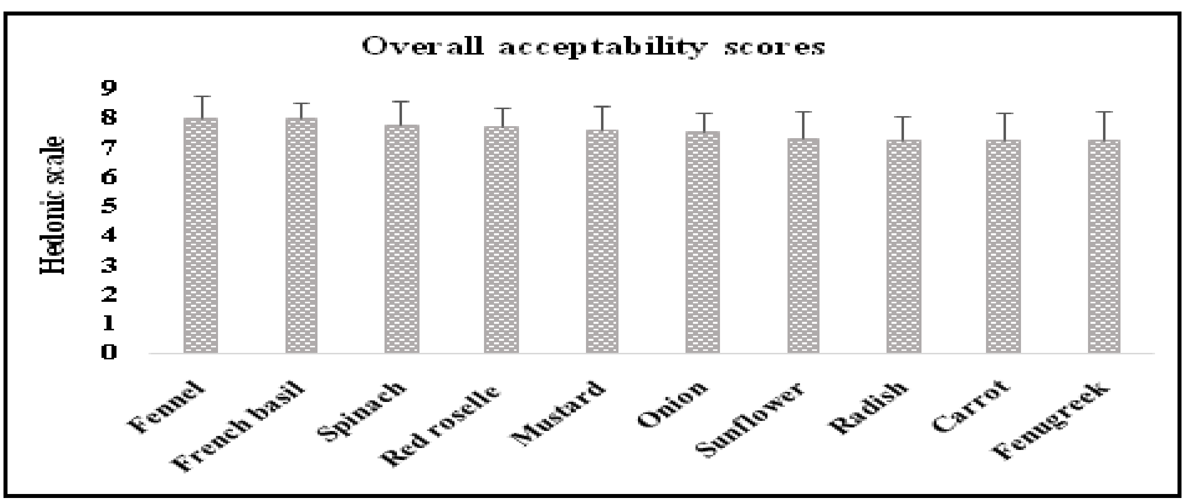

Figure No.1: Overall acceptability scores of microgreens

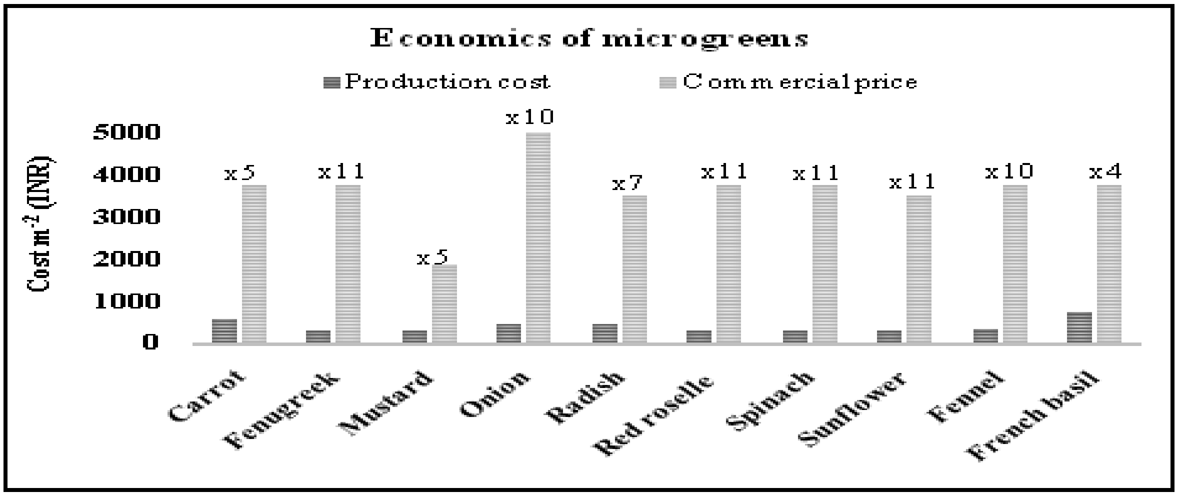

Figure No.2: Estimated production cost, commercial price, and profit (indicated by numbers above bars) of microgreens cultivation in India

CONCLUSION

Micro-farming of greens, an innovative cultivation technique using local seed varieties is a sustainable way of coping up with the challenges of food security. With its fast-growing cycle, limited space requirement, year-round growth possibility and limited nutrient management, microgreens can be cultivated in both open areas and within enclosures such as the balcony, on the windowsill and even inside the house. Cultivation of such a produce not only contribute to increase the availability and accessibility of food to the poorest sections of the population, but can also make important contributions to combat dietary deficiencies and be a source of food and nutritional security in the rural-urban continuum. Micro-farming can also double-up as an entrepreneurial activity, especially during the non-cropping season, ensuring economic security of the farmers.

ACKNOWLEDGEMENT

The authors are grateful to the Founder Chancellor and acknowledge the management, Sri Sathya Sai Institute of Higher Learning, Andhra Pradesh, India for the research amenities provided.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

BIBLIOGRAPHY

1. Xiao Z, Lester G E, Park E, Saftner R A, Luo Y, Wang Q. Evaluation and correlation of sensory attributes and chemical compositions of emerging fresh produce: Microgreens, *Postharvest Biology and Technology*, 110, 2015, 140-148.
2. Xiao Z, Lester G E, Luo Y, Wang Q. Assessment of vitamin and carotenoid concentrations of emerging food products: Edible microgreens, *Journal of Agricultural and Food Chemistry*, 60(31), 2012, 7644-7651.
3. Murphy C. Pill W. Cultural practices to speed the growth of microgreen arugula (roquette; *Eruca vesicaria* subsp. sativa), *The Journal of Horticultural Science and Biotechnology*, 85(3), 2010, 171-176.
4. Kou L, Luo Y, Yang T, Xiao Z, Turner E R, Lester G E, Wang Q, Camp M J. Postharvest biology, quality and shelf life of buckwheat microgreens, *LWT - Food Science and Technology*, 51(1), 2013, 73-78.
5. Pinto E, Almeida A A, Aguiar A A, Ferreira I M P L V O. Comparison between the mineral profile and nitrate content of microgreens and mature lettuces, *Journal of Food Composition and Analysis*, 37(3), 2015, 38-43.

6. Di Gioia F, De Bellis P, Mininni C, Santamaria P, Serio F. Physicochemical, agronomical and microbiological evaluation of alternative growing media for the production of rapini (*Brassica rapa* L.) microgreens, *Journal of the Science of Food and Agriculture*, 97(4), 2017, 1212-1219.
7. AOAC. Official methods of analysis of the association of analytical chemists, *AOAC Inc, Virginia, USA,* 1, 15th Edition, 1990.
8. Di Gioia F. Santamaria P. Microgreens: Nuovi alimenti freschi e funzionali per eploarre il valore della biodiversita, *Eco-logica Editore, Bari,* 2015.
9. Weber C F. Broccoli microgreens: A mineral-rich crop that can diversify food systems, *Frontiers in Nutrition,* 4(7), 2017, 1-9.
10. Ashraf M, Foolad M R. Pre-sowing seed treatment-A shotgun approach to improve germination, plant growth and crop yield under saline and non-saline conditions, *Advances in Agronomy*, 88, 2005, 223-271.
11. Lee J S, Pill W G, Cobb B B, Olszewski M. Seed treatments to advance greenhouse establishment of beet and chard microgreens, *The Journal of Horticultural Science and Biotechnology*, 79(4), 2004, 565-570.
12. Manzocco L, Foschia M, Tomasi N, Maifreni M, Dalla Costa L, Marino M, Cortella G, Cesco S. Influence of hydroponic and soil cultivation on quality and shelf life of ready-to-eat lamb's lettuce (*Valerianella locusta* L. Laterr), *Journal of the Science of Food and Agriculture*, 91(8), 2011, 1373-1380.

Please cite this article in press as: Manjula Devi Ghoora and Nagarajan Srividya. Micro-farming of greens: A viable enterprise for enhancing economic, food and nutritional security of farmers, *International Journal of Nutrition and Agriculture Research*, 5(1), 2018, 10-16.