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Quality evaluation, pesticide residual analysis and post-harvest characters of organic curry leaf (*Murraya koenigii* Spreng.)

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Abstract
Curry leaf (*Murraya koenigii* Spreng.) is a perennial nutritious herbal spice crop grown for its aromatic leaves. Besides, being a spice crop, curry leaf plays a major role in the Ayurveda and Unani systems of medicine due to its wide range of medicinal properties. This research study was performed to explore the quality, pesticide residue and post-harvest characters of curry leaves that was grown in the environment of applying different organic manures and bio-stimulants. Application of 50% N as Vermicompost + 50% N as Neem cake + Panchagavya (3%) as foliar spray was recorded the highest leaf iron content (3.62%), leaf calcium content (950.37 mg/100 g), essential oil content (0.186%), shelf life (15 days) and leaf to powder ratio (1.06). Results of pesticide residue analysis showed that T_3 of curry leaf contained pesticide named Endosulfan, Malathion, Chlorpyriphos, Quinalphos and the residual level of these pesticides are less than 0.1 mg/kg. These pesticide limit is BLQ as mentioned by the Pesticide residue analysis report. Hence, Curry leaf fed with 50% N as Vermicompost + 50% N as Neem cake + Panchagavya (3%) as foliar spray yielded high quality and more shelf life leaves without pesticide residue.

Keywords: Organic, curry leaf, shelf life, nutritional quality, pesticide residue etc.

1. Introduction
Curry leaf (*Murraya koenigii* Spreng.) plays an important role as a condiment in the culinary preparation of South Indian dishes. It is a perennial nutritious herbal spice crop grown for its aromatic leaves. Being a rich source of protein, carbohydrate, vitamin A and vitamin C, these are said to be used in many Ayurvedic and Unani medicines. Fresh leaves, dried leaf powder, and essential oil are widely used for flavoring soups, curries, fish and meat dishes, eggs dishes, traditional curry powder blends, seasoning and ready to use other food preparations (Gupta and Nigam, 1971) [7]. It is called as 'Magical plant of Indian spice'. It is not only used as food enhancing purpose but also shows medication for many diseases (Surbsighal and Meenakshi, 2016) [27]. Curry leaf trees are naturalised in forests and waste land throughout the Indian subcontinent except in the higher parts of the Himalayas. Curry leaf plant is commonly found in tropical and subtropical forests throughout India and Andaman Islands up to an altitude of 1500 m MSL. It occurs in wild form from Garhwall hills in Uttranchal to Sikkim, West Bengal and Assam. It is also found growing in Bengal, Madhya Pradesh, Kerala, Karnataka, Tamil Nadu and Andhra Pradesh. In Andhra Pradesh, it is cultivated in more than 800 acres in Gundur and Krishna districts. In Karnataka, it is cultivated under considerable area on commercial scale. In Tamil Nadu, curry leaf is cultivated in around 500 acres in Coimbatore, Erode, Madurai, Salem and Trichirappalli districts (Jagadeeshkanth *et al*., 2018) [10]. Curry leaf has a huge demand in India and abroad which has made the commodity of immense trade value. The fresh leaves of curry leaf are exported to Gulf, European and African countries etc.
Among the Horticulture crops, most of the spices and plantation crops are majorly cultivated by the application of organic manures for maintaining its quality. Since, curryleaf is cultivated for it's green leaf, nitrogen plays a major role on growth, yield and keeping quality. Moreover nitrogen availability from the applied sources to throughout the crop growth period is also of considerable importance. As, curry leaf is indispensably used in our culinary preparations of south India, there is a need to improve the herbage yield, quality and to optimize the usage of organic manures and bio-stimulants for the leaf production. Curry leaves have been reported to contain tocopherol, b-carotene, lutein and alkaloids (Khanum *et al*., 2000) [12]. But it is observed that curry leaves have received red alert message from the European Union, who are the major importers, where the pesticide residue limits were found much beyond the permissible levels. This created a panic among the mass as curry leaves constitute a major spice exported from India.

Pesticide exposure may produce biochemical alterations in the body long before adverse clinical health effects are manifested (Khan *et al*., 2008) [11]. Therefore, taking above facts into consideration, the present investigation has been undertaken to evaluate the effect of different organic manures and bio-stimulants on nutritional quality and post-harvest characters of curry leaf.

2. Materials and Methods

The field experiment was conducted at the College Orchard, Department of Spices and Plantation Crops, Horticultural College and Research Institute, Tamil Nadu Agricultural University, Periyakulam during 2017-18 to 2018-19. The trial was taken to study the effect of organic manures (FYM, neem cake, vermicompost, biocompost – Sugar mill pressmud) and biostimulants (Panchagavya, humic acid and liquid biofertilizer - *Azospirillum*) on growth and yield of curryleaf. The field is located at 10˚12' North latitude and 77˚58' East longitude and at an altitude of 356 m above Mean Sea Level. The soil of the experimental field was red sandy loam in texture. The present study was conducted on ten years old curry leaf local ecotype Senkambu. The plot size was 6 m × 1.2 m with a plant spacing of 60 cm × 60 cm having 20 plants per plot. The initial nutrient status of the soil was 182:14.9:354 kg NPK /ha. Before the study, curry leaf plants are purely grown under organic manure using farm yard manure and neem cake. Regular cultural operations were followed for the curry leaf as prescribed in Horticultural Crop Production Manual (Anon., 2018) [(2)]. In general, three crops are harvested in a year with 3 - 4 months interval. *Rabi* (October - December) and summer (March – May) are the two main seasons for leaf production. The experiment was laid out in randomized block design with ten treatment combinations of organic manure and bio-stimulants replicated thrice. The treatment details are as follows,

T_1 25% N as FYM + 25% N as Vermicompost + 25% N as Neem cake + 25% N as Biocompost + Panchagavya (3%)
T_2 50% N as Vermicompost + 25% N as Neem cake + 25% N as FYM + Panchagavya (3%)
T_3 50% N as Vermicompost + 50% N as Neem cake + Panchagavya (3%)
T_4 25% N as FYM + 25% N as Vermicompost + 25% N as Neem cake + 25% N as Biocompost + Humic acid (0.5%)
T_5 50% N as Vermicompost + 25% N as Neem cake + 25% N as FYM + Humic acid (0.5%)
T_6 50% N as Vermicompost + 50% N as Neem cake + Humic acid (0.5%)
T_7 25% N as FYM + 25% N as Vermicompost + 25% N as Neem cake + 25% N as Biocompost + Liquid biofertilizer
T_8 50% N as Vermicompost + 25% N as Neem cake + 25% N as FYM + Liquid biofertilizer
T_9 50% N as Vermicompost + 50% N as Neem cake + Liquid biofertilizer
T_{10}Control (without organic manures and biostimulants)

Organic manures like farm yard manure, neem cake, vermicompost and biocompost were applied in four splits at three months intervals after each clipping as per the treatment schedule. The fertilizers were applied as straight fertilizers to the control plot in the form of urea, superphosphate and muriate of potash @ 150:25:50 g of NPK/plant/year (Kumar *et al*., 2006) [14]. The foliar spray of bio-stimulants *viz*., Panchagavya (3%) and Liquid biofertilizer (1%) was given three times using hand sprayer at 21 days interval. Humic acid (0.5%) was applied through soil application. Irrigation was given once in ten days through drip. After harvesting, quality parameters such as leaf iron content, leaf calcium content and essential oil were estimated. For shelf life assessment, 5 healthy leaflets were collected from each treatment and packed in a polythene sheet with 5% vent. It was kept for 3 weeks and the leaves were observed at frequent intervals for the leaf freshness and the changes in leaf colour. The leaves were shade dried for a day and was kept in the hot air oven for drying at a temperature of 105ºC. Then the dried leaves were grinded to a fine powder. The weight of the powder was taken and leaf to powder ratio was calculated. Pesticide residue was estimated using Gas Chromatographic method (Anastassiades 2003) [1]. The mean values were subjected to statistical scrutiny as suggested by Panse and Sukhatme (1985) [18].

3. Results and Discussion

The application of organic manures and the biostimulants helps to increase the quality of the leaves and also the shelf life. Quality is yet another vital dimension of a produce, which is manifested by better nutritional value, flavour, taste, storability and others. Curry leaf is an important and widely used produce both as spicy green leaves and dry powder. The plants fed with 50% N as Vermicompost + 50% N as Neem cake + Panchagavya (3%) as foliar spray (T_3) recorded the highest leaf calcium, leaf iron and essential oil content (Table 1). Effect of panchagavya on improving the calcium content of *Solanum nigrum* observed by Sivakumar (2004) [25] also confirmed the results of the present study. All the applied organic inputs *viz.*, vermicompost, neem cake and panchagavya are rich in nitrogen, phosphorus, and potassium contents would have been readily available to the plants which directly influence the growth of plants. This is in corroboration with the findings of Krogdahl and Dahlsgard (1981) [13], Santhi (2003) [24] in palmarosa and Vimala (1991) [30] in coriander.

The increase in the macro (N, P, and K), secondary (Ca, and Mg) micro (Fe, Zn, Cu, Mn etc.,), nutrient contents of the plants due to the addition of organic inputs of poultry manure with panchagavya and humic acid might increase the Cation Exchange Capacity (CEC) of the soil, which might have been responsible for providing all nutrients from unavailable form to available form to the plants. According to Samson and Visser (1989) [22], humic substances in organic manures induce increased in the permeability of biomembranes for electrolytes accounting for increased uptake of nutrients.

Subhavasugi (2007) [26] also reported that contents of macro, secondary, micronutrients of leaves were superior under FYM @ 6.25t/ha + poultry manure 2t/ha + vermicompost 2t/ha and foliar application of panchagavya (2%) + vermiwash (20%) + humic acid (0.1%) treatments. Higher nutrient uptake and more nutrient use efficiency in senna were also observed which confirmed the present investigation in curry leaf. The possible reason for the improvement of essential oil content by organic manure application with foliar spray of panchagavya might be due to supply of sufficient quantity of nitrogen, which was essential compound in many amino acids and lipids associated with the production of more number of leaves, which consequently would have increased the number of oil glands resulting in higher oil content. Similar influences were also reported by Panduranga Shenoy (1980) [17] in davana (*Artemisia pallens* Wall.), Arularasu (1995) [3] in *Ocimum Sanctum*, Hazarika *et al.* (1978) [9] in palmarosa and Vadivel and Sampath (1981) [29] in bergamot mint and Sadasakthi (1986) [21] in marjoram.

As like that of other food products are perishable by nature, it requires protection from spoilage during their preparation,

storage and distribution to give them desired shelf-life. The main spoilage mechanisms affecting the shelf life of the fresh cut products are oxidation phenomena, due to the enzymatic activity of the cut leaves, moisture loss and proliferation of spoilage and pathogenic microorganisms (Gimenez *et al*., 2003) [6]. The greenness of leaves was significantly influenced by the different treatments. Among the various treatments, T_3 (50% N as Vermicompost + 50% N as Neem cake + Panchagavya (3%)) exhibited better greenness of leaves. Significant results were obtained with different treatments on the shelf life of fresh curry leaves both unpacked and packed condition. The plants treated with three per cent panchagavya as foliar spray (T_3) recorded the highest shelf life of 4.05 days in unpacked fresh curry leaves which was significantly superior over the other treatments. Possible reason for the improvement of shelf life of fresh curry leaves harvested from crop subjected to biostimulant spray (three per cent panchagavya) might have higher and continuous uptake of potassium nutrients from organic substances throughout the crop season. It would have led to long shelf life through increased dry matter content. Optimum level of potassium helped in greater translocation of metabolites to storage organs and enhanced thickening of leaves. Thus efficient metabolism and better source sink relationship might have contributed on improved storage life of curry leaves. These results were in accordance with findings of Fosket and Peterson (1950) [5] in onion and Madan and Sandhu (1983) [16] in white onion. Potassium nutrition imparts sturdiness to the leaf tissues by increasing thickness of cell wall and helped in getting healthy leaves. Further, the strong peel of leaf would have protected them against decay and the reduced rate of respiration during storage (Sankar, 2004) [23].

The shelf life of curry leaves with five per cent ventilation, the treatment T_3 as application of 50% N as Vermicompost + 50% N as Neem cake + Panchagavya (3%) as foliar spray recorded in more number of days of shelf life of 15.00 days than over all the other treatments. Ryall and Lipton (1979) [20] reported that the use of plastic films for packaging the produce provides a high relative humidity around the commodity and results in lower water losses from it. The use of polythene films had been studied in asparagus and beneficial effects were obtained, especially, when small perforated areas were allowed for minimal ventilation as reported by Harden Berg *et al.*, (1986) [8] and Lill, (1980) [15]. Application of 50% N as Vermicompost + 50% N as Neem cake + Panchagavya (3%) recorded higher amount of leaf to powder percentage (1.06) in curry leaf which might be due to the influence of nitrogen in promoting the vegetative growth parameters *viz.*, plant height, number of leaves and leaf lets, leaf area, leaf weight leading to increased herbage and TDMA. This is in accordance with the results of Prabhu *et al.* (2010) [19] in Kalmegh.

Results of pesticide residue analysis showed that T_3 of curry leaf contained pesticide named Endosulfan, Malathion, Chlorpyriphos, Quinalphos and the residual level of these pesticides are less than 0.1 mg/kg. These pesticide limit is BLQ as mentioned by the Pesticide residue analysis report. Bourn *et al.* (2002) [4] found after an extensive survey on vegetables that 17 – 50 percent of conventional vegetables contained pesticide residues. In a similar study by Tasiopoulon *et al.* (2007) [28] concluded that 97.4% of organic farming products were devoid of detectable pesticide residues. This study concludes that organic cultivation improve the nutritional quality, shelf life and post- harvest characters, thus endearing it more among consumers. The plant grown in organic way does not having pesticide residue. In this era, where food safety is the prime concern of the universe at large, a pesticide free produce is a blessing for the health of mankind.

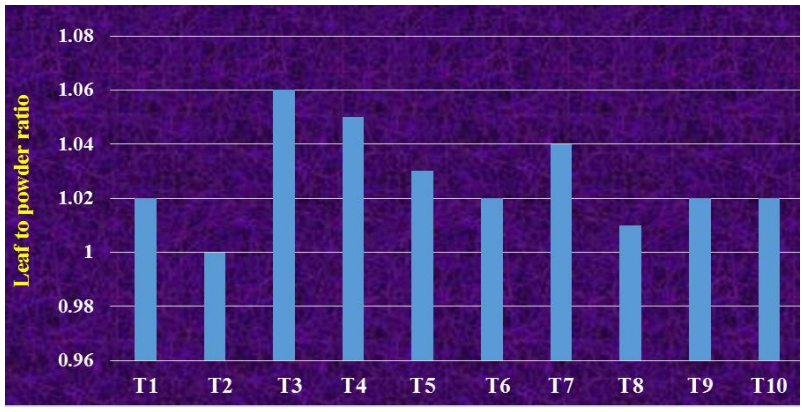

Fig 1: Effect of organic manure and bio-stimulant on leaf powder ratio of curry leaf

Table 1: Effect of Organic manures and Bio-stimulants on quality and post-harvest traits of Curry leaf

Treatments	Iron content (%)	Calcium content (mg/100g)	Essential oil content (percent)	Shelf life (days)	
				Unpacked condition	packed with 5% ventilation
T_1	3.16	815.54	0.135	3.00	11.50
T_2	3.15	810.78	0.129	2.70	9.55
T_3	3.62	950.37	0.186	4.05	15.00
T_4	3.11	810.43	0.128	2.50	10.55
T_5	3.48	880.87	0.159	3.20	13.00
T_6	3.22	820.12	0.136	3.00	11.00
T_7	3.09	800.67	0.122	2.65	8.00
T_8	3.61	905.32	0.161	3.60	13.50
T_9	3.29	840.23	0.142	3.20	12.65
T_{10}	3.04	778.43	0.117	2.00	6.00
Mean	3.28	841.28	0.140	2.99	11.07
S.Ed	0.16	41.72	0.006	0.16	0.02
CD (0.05)	0.34	87.04	0.014	0.35	0.06

Table 2: Pesticide residues detected in curry leaf

Name of the Pesticides	Residue (mg/kg)
Endosulfan-β	BLQ (<0.1)
Malathion	BLQ (<0.I)
Chlorpyrifos	BLQ (<0. I)
Quinalphos	BLQ (<0.1)
Imidacloprid	BLQ (<0.025)
Thiamelhoxam	BLQ (<0.025)
Thiacloprid	BLQ (<0.025)
C lothianidin	BLQ (<0.025)
Acetamiprid	B HQ (<0.025)

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