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Studies on effect of organic manures and biofertilizers on antioxidant activity of Turmeric (*Curcuma longa* L.) varieties

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Abstract
The present investigation on "Studies on effect of organic manures, biofertilizers on growth, yield and quality of Turmeric (*Curcuma longa* L.) Varieties" was conducted at College of Horticulture, Rajendranagar, SKLTSHU, Mulugu during 2018-19. The experiment was laid out in Factorial Randomized block design (FRBD) with 2 replications and 18 treatments. The results revealed that among all the organic manures, biofertilizers, varieties and their combinations, treatment M_1–FYM 45 t/ha + AMC (Arka microbial consortium) 1 lit per quintal manure recorded maximum antioxidant activity (12.01 µg mL^{-1}) followed by M_3–Vermicompost 14 t ha^{-1} + AMC (Arka microbial consortium) 1 l q^{-1} compost (12.53 µg mL^{-1}) and M_4 – Neem cake 4.5 t ha^{-1} + AMC (Arka microbial consortium) 1 l q^{-1} neem cake (12.90 µg mL^{-1}). Among the varieties, Salem recorded significantly the highest values for antioxidant activity (10.68 µg mL^{-1}) followed by followed by V_2 – First best treatment of first experiment (Vertical split of mother rhizome) of Rajendra Sonia variety (12.62 µg mL^{-1}). Among the interaction effects between organic manures, biofertlizers and varieties, the treatment M_1V_1 – FYM 45 t/ha + AMC (Arka microbial consortium) 1 lit per quintal manure + vertical split of mother rhizome of Salem variety recorded maximum antioxidant activity (10.18 µg mL^{-1}) followed by M_3V_1–Vermicompost 14 t ha^{-1} + AMC (Arka microbial consortium) 1 l q^{-1} manure + First best variety of first experiment (Vertical split of mother rhizome) of Salem variety (10.51 µg mL^{-1}).

Keywords: FYM, vermicompost, organic manures, biofertilizers, Arka microbial consortium, Salem, antioxidant activity

Introduction
Turmeric (*Curcuma longa* L.) is an important, sacred and ancient spice of India. It is a major rhizomatous spice produced and exported from India. Turmeric is an herbaceous perennial plant, native to Tropical South-East Asia, belonging to the family Zingiberaceae, under the order Scitaminae. It is cultivated for its underground rhizomes which is used as spice, condiment and dye stuff. It is used in cosmetic and drug industry, particularly in the preparation of anticancerous medicines. Globally, India is the world's largest producer and exporter of turmeric and produces nearly 50% of global turmeric production.

India is also the largest consumer of turmeric in the world accounting for nearly 90% of total production. Major producing states in India are Telangana, Andhra Pradesh, Tamil Nadu, Orissa, West Bengal, Karnataka and Kerala. In India tumeric is estimated to occupy an area of 295000 hectares with a production of 1102000 MT (Horticultural statistics Database: 2020-21). The area in Telangana under turmeric cultivation is 55443 hectares. With production of 307000 MT/ha and Productivity is 5.5 t/ha.

Turmeric being a long duration (8-9 months) exhaustive crop responds well to nutrition. Hence, optimum dose of nutrients is essential to get good yield. Use of chemical fertilizer, herbicide and pesticide in horticulture for increasing yield and controlling weeds and pests will contaminate the water, air, food, decrease soil fertility, inhibit growth of soil microorganisms and hazard human health. This negative effect of agricultural practices could be reversed by the correct utilization of manures and/or crop residues within cropping system either alone or in combination with organic fertilizer (Mandal *et al.* 2007) [5]. Beside these, utilization of organic manure is recommended for retaining productivity of problem soils, reducing the usages of chemical fertilizer, improving economy and minimizing environmental problems.

Material and Methods

The present investigation was conducted at College of Horticulture, Rajendranagar during 2018-19. The experiment was laid out in Factorial randomized block design (FRBD) with 18 treatments and 2 replications. The treatments used in this experiment are as follows:

Factor-I: Organic manures and biofertilizers

M_1: FYM 45 t ha^{-1} + AMC (Arka microbial consortium) 1 l q^{-1} manure

M_2: Poultry manure 7 t ha^{-1} + AMC (Arka microbial consortium) 1 l q^{-1} manure

M_3: Vermicompost 14 t ha^{-1} + AMC (Arka microbial consortium) 1 l q^{-1} compost

M_4: Neem cake 4.5 t ha^{-1} + AMC (Arka microbial consortium) 1 l q^{-1} Neem cake

M_5: Control (RDF-150: 60: 108 NPK kg ha^{-1}) + AMC (Arka microbial consortium) 1 l q^{-1}

M_6: Control (RDF-150: 60: 108 NPK kg ha^{-1})

Factor–II: Varieties (V)

V_1: First best treatment of first experiment (Vertical split of mother rhizome) Salem (Long duration)

V_2: First best treatment of first experiment (Vertical split of mother rhizome) Rajendra Sonia (Medium duration)

V_3: First best treatment of first experiment (Vertical split of mother rhizome) ACC–79 (Short duration).

Treatment Combinations

M_1V_1: FYM 45 t ha^{-1} + AMC (Arka microbial consortium) 1 l q^{-1} manure + First best treatment of first experiment (Vertical split of mother rhizome of Salem)

M_1V_2: FYM 45 t ha^{-1} + AMC (Arka microbial consortium) 1 l q^{-1} manure + First best treatment of first experiment (Vertical split of mother rhizome of Rajendra Soina)

M_1V_3: FYM 45 t ha^{-1} + AMC (Arka microbial consortium) 1 l q^{-1} manure + First best treatment of first experiment (Vertical split of mother rhizomeof ACC–79)

M_2V_1: Poultry manure 7 t ha^{-1} + AMC (Arka microbial consortium) 1 l q^{-1} manure + First best treatment of first experiment (Vertical split of mother rhizome of Salem)

M_2V_2: Poultry manure 7 t ha^{-1} + AMC (Arka microbial consortium) 1 l q^{-1} manure + First best treatment of first experiment (Vertical split of mother rhizome of Rajendra Sonia)

M_2V_3: Poultry manure 7 t ha^{-1} + AMC (Arka microbial consortium) 1 l q^{-1} manure + First best treatment of first experiment (Vertical split of mother rhizome of ACC–79)

M_3V_1: Vermicompost 14 t ha^{-1} + AMC (Arka microbial consortium) 1 l q^{-1} compost + First best treatment of first experiment (Vertical split of mother rhizome of Salem)

M_3V_2: Vermicompost 14 t ha^{-1} + AMC (Arka microbial consortium) 1 l q^{-1} compost + First best treatment of first experiment (Vertical split of mother rhizome of Rajendra Sonia)

M_3V_3: Vermicompost 14 t ha^{-1} + AMC (Arka microbial consortium) 1 l q^{-1} compost + First best treatment of first experiment (Vertical split of mother rhizome of ACC–79)

M_4V_1: Neemcake 4.5 t ha^{-1} + AMC (Arka microbial consortium) 1 l q^{-1} Neem cake + First best treatment of first experiment (Vertical split of mother rhizome of Salem)

M_4V_2: Neemcake 4.5 t ha^{-1} + AMC (Arka microbial consortium) 1 l q^{-1} Neem cake + First best treatment of first experiment (Vertical split of mother rhizome of Rajendra Sonia)

M_4V_3: Neemcake 4.5 t ha^{-1} + AMC (Arka microbial consortium) 1 l q^{-1} Neem cake + First best treatment of first experiment (Vertical split of mother rhizome of ACC–79)

M_5V_1: Control (RDF-150: 60: 108 NPK kg ha^{-1}) + AMC (Arka microbial consortium) 1 l ha-1 + First best treatment of first experiment (Vertical split of mother rhizome of Salem)

M_5V_2: Control (RDF-150: 60: 108 NPK kg ha^{-1}) + AMC (Arka microbial consortium) 1 l ha^{-1}+ First best treatment of first experiment (Vertical split of mother rhizome of Rajendra Sonia)

M_5V_3: Control (RDF-150: 60: 108 NPK kg ha^{-1}) + AMC (Arka microbial consortium) 1 l ha^{-1}+ First best treatment of first experiment (Vertical split of mother rhizome of ACC–79)

M_6V_1: Control (RDF-150: 60: 108 NPK kg ha^{-1}) + First best treatment of first experiment (Vertical split of mother rhizome of Salem)

M_6V_2: Control (RDF-150: 60: 108 NPK kg ha^{-1}) + First best treatment of first experiment (Vertical split of mother rhizome of Rajendra Sonia)

M_6V_3: Control (RDF-150: 60: 108 NPK kg ha^{-1}) + First best treatment of first experiment (Vertical split of mother rhizome of ACC–79)

Results and Discussion

The results of the present investigation regarding the response of organic manures, biofertilizers, varieties and their combinations on antioxidant activity of Turmeric have been discussed and interpreted in light of previous research work in India. The results of the experiment are summarized below and also presented in table 1.

Antioxidant activity (IC_{50}-µg mL^{-1})

IC_{50} Value is inversely proportional to DPPH scavenging activity.

At harvest, antioxidant activity was significantly Effected by organic manures and biofertilizers. Among all the organic manures and biofertilizers, the treatment M_1–FYM 45 t ha^{-1} + AMC (Arka microbial consortium) 1 l q^{-1} manure recorded significantly highest antioxidant activity (12.01 µg mL^{-1}) followed by M_3–Vermicompost 14 t ha^{-1} + AMC (Arka microbial consortium) 1 l q^{-1} compost (12.53 µg mL^{-1}) and M_4–Neem cake 4.5 t ha^{-1} + AMC (Arka microbial consortium) 1 l q^{-1} neem cake (12.90 µg mL^{-1}). The treatment M_6–Control (RDF–150: 60: 108 NPK kg ha^{-1}) reported significantly lowest antioxidant activity (15.04 µg mL^{-1}).

Among varieties, antioxidant activity was significantly effected at harvest. The variety V_1- First best treatment of first experiment (Vertical split of mother rhizome) of Salem variety recorded significantly highest antioxidants activity (10.68 µg mL^{-1}) followed by V_2–First best treatment of first experiment (Vertical split of mother rhizome) of Rajendra Sonia variety (12.62 µg mL^{-1}). Whereas lowest antioxidant activity was recorded by variety V_3- First best treatment of first experiment (Vertical split of mother rhizome) of ACC-79 (16.58 µg mL^{-1}).

Interaction between organic treatments and spacing had significant effect on antioxidant activity at harvest. Among all interactions, M_1V_1–FYM 45 t ha^{-1} + AMC (Arka microbial consortium) 1 l q^{-1} manure + First best treatment of first experiment (Vertical split of mother rhizome) of Salem variety recorded significantly highest antioxidant activity (10.18 µg mL^{-1}) followed by M_3V_1–Vermicompost 14 t ha^{-1} + AMC (Arka microbial consortium) 1 l q^{-1} manure + First best variety of first experiment (Vertical split of mother rhizome) of Salem variety (10.51 µg mL^{-1}) and M_4V_1 – Neem cake 4.5 t ha^{-1} + AMC (Arka microbial consortium) 1 l q^{-1} neem cake + First best treatment of first experiment (Vertical split of mother rhizome) of Salem variety (10.65 µg mL^{-1}), M_2V_1 (10.74 µg mL-$^{-1}$), M_5V_1(10.78 µg mL^{-1}) and M_6V_1 (11.23 µg mL^{-1}) which were remained on par. The treatment M_6V_3 – Control (RDF–150: 60: 108 NPK kg ha^{-1}) + First best treatment of first experiment (Vertical split of mother rhizome) of ACC-79 variety (20.32 µg mL^{-1}) reported significantly lowest antioxidant activity.

Hafiza *et al*. 2017 [2] reported that a lower IC_{50} value represents a stronger DPPH scavenging capacity. Tanvir *et al*. 2017 [7] reported that the ethanolic extract of Khulna's mura showed a higher DPPH radical-scavenging activity with the lowest 50% inhibitory concentration (IC_{50}-1.08 µg mL^{-1}). Jesmin *et al*. 2019 [4] reported that the highest scavenging activity with the lowest (IC_{50}-26.5 µg mL^{-1}), which was not significantly different with the IC_{50} value of the standard antioxidant Trolox (IC_{50}:23.2 µg mL^{-1}). On the other hand, Okinawa ukon showed the highest IC_{50} value (291.3 µg mL^{-1}). These results are in conformity with Alafiatayo *et al*. 2014 [1] that compared the antioxidant activity of several turmeric species and reported that *C. longa* showed the highest scavenging activity followed by *C. xanthorrhiza* and *C. amada*. These results are also partially consistent with Nahak and Sahu, 2011 [6].

Table 1: Effect of organic manures, biofertilizers and varieties on antioxidants (IC_{50}) at harvest

	Antioxidants (IC_{50})			
Treatments	**Varieties (V)**			
Organic manures and Biofertilizers (M)	**At Harvest**			
	V_1 (210 DAT)	**V_2 (180 DAT)**	**V_3 (150 DAT)**	**Mean**
M_1	10.18	11.43	14..44	12.01
M_2	10.74	13.30	16.60	13.55
M_3	10.51	11.60	15.48	12.53
M_4	10.65	12.30	15.76	12.90
M_5	10.78	13.51	16.87	13.72
M_6	11.23	13.58	20.32	15.04
Mean	10.68	12.62	16.58	
	M		V	M x V
S.Em±	0.08		0.05	0.14
C.D (p = 0.05)	0.24		0.17	0.42

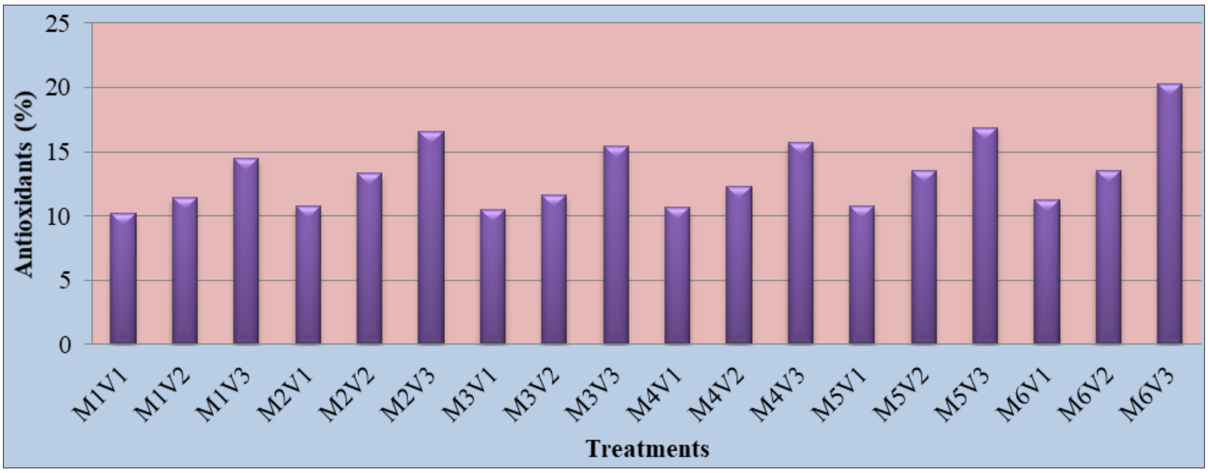

Fig 1: Effect of organic manures, biofertilizers and varieties on antioxidants (%) of turmeric at harvest

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