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Influence of Spacing and Nutrient Management on Nutrient Content of Okra

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A B S T R A C T

A Field experiment was conducted at College of Agriculture, V. C. Farm, Mandya, Southern Dry Zone of Karnataka to study the effect of different fertilizer levels and different spacings on nutrient content of okra. The experiment was laid out in split plot design with 3 replications. The variety used for the experiment was Arka Anamika. Main plot treatments consisted of three fertilizer levels like 125% RDF, 100 RDF and STCR approach with combination of different spacings, 60 cm × 30 cm, 60 cm × 22.5 cm, 60 cm × 22.5 cm, 60 cm × 15 cm, 60 cm × line sowing and 60 cm / 20 cm / 20 cm. Nutrient content in fruit was differed significantly due to varying levels of nutrients. Application of 125% RDF (M1) recorded significantly higher nitrogen, phosphorus and potassium content in fruit (2.69, 0.34 and 2.23% respectively), while, lower nitrogen, phosphorus and potassium content was observed in STCR approach (2.35, 0.26 and 2.04% respectively). Significantly higher content of nitrogen, phosphorus and potassium in fruit (2.95, 0.37and 2.04% respectively) was observed with the spacing 60 × 30 cm, whereas lower nitrogen, phosphorus and potassium content (2.21, 0.24 and 1.86% respectively) in fruit was observed in spacing 60 cm × line sowing. Similar trend was observed in secondary and micronutrients.

Introduction

India is the largest producer of Okra (*Abelmoschus esculentus* (L) Moench.) in the world. It is one of the foreign exchange earning crop and accounts for about 60 per cent of the exported fresh vegetable (Anon., 2014). In India, okra is cultivated in an area of about 5.07 lakh hectares with a production and productivity of 58.53 lakh tonnes and 11.5 tonnes per hectare respectively. In Karnataka, it is being cultivated in an area of about 10,191 hectares with a production of 85,582 tonnes and productivity 8 t ha^{-1} (Anon., 2015).

Okra is an annual vegetable crop grown in tropical and sub-tropical regions. It is said to be a native to South Africa or Asia and belongs to family Malvaceae. The green, tender fruits of okra are rich sources of vitamins, calcium, potassium and other minerals. Due to high iodine content, fruits help to control goiter disease while leaves are used in inflammation and dysentery. The fruits also help in renal colic, leucorrhoea and general weakness. Hundred grams of consumable unripe bendi contains 10.4 g dry matter, 3100 calories of energy, 1.8 g of protein, 90 mg of calcium, 110 mg of iron, 0.1 g of carotene, 0.01 mg of thiamine, 0.08 mg of riboflavin, 0.08 mg of niacin and 18 mg of vitamin C (Thamburaj and Narendra, 2001).

Appropriate plant spacing can lead to optimum fruit yield whereas too high or low plant spacing could result in relatively low yield and quality. Overcrowding of seedlings or plants in a particular area or spot may lead to competition among the plants for essential growth resources like sunlight, space, water and nutrients; this may affect plant performance and yield. With increasing plant population, yield per unit area increases up to a certain limit, beyond which it decreases as resources for plant growth become limited. Further, it was reported that optimum plant population is the key element for higher yields, as plant growth and yield are affected by intra and inter row spacing (Muhammad *et al.,* 2002).

The growth, yield and quality of crop are largely influenced by the fertility status of soil apart from genetic potential of the variety. Altering the soil nutrients and fertility status by providing balanced and adequate major nutrients like nitrogen, phosphorus and potassium as per the crop requirement is one of the easiest way to boost up crop productivity (Rajaraman *et al.,* 2013)

In Karnataka most soils, especially in Southern Dry Zone area are low in available plant nutrients which are necessary for plant growth and high yield. It is therefore, necessary to supplement the amount of nutrients present in the soil to meet crop requirement. If the yield of okra is to be increased, the low fertility soils would require additional nutrients. Several experiments on crops have generally indicated yield increased due to fertilizer application. Most of the small and marginal okra farmers produce it at low standard of crop husbandry and rarely care about the spacing and the application of fertilizers to the crop, which resulted, to low yield and much labour. In view of the uses and the economic importance and high demand of this crop, this study was carried out to examine the effect of nutrient management and spacing on nutrient content of okra.

Materials and Methods

Field experiment was conducted at the College of Agriculture, V. C. Farm, Mandya, Southern Dry Zone of Karnataka. Geographically the experimental site was located at 12º 45' and 30º 57' north latitude and 76º 45' and 78º 24' east longitude of 695 metre above mean sea level. Soil samples were collected from 0-15 cm from experimental area using screw auger before initiation of the experiment and analyzed for physical and chemical properties as per standard procedures. The soil at experimental site was red sandy loam in texture with an average particle content of sand (79.00%), silt (15.50%) and clay (5.50%). The soil was neutral in reaction (pH 7.6), organic carbon (5.55 g kg^{-1}) content was low with an electrical conductivity of 0.19 dS m^{-1}. The soil was low in available nitrogen (225.79 kg ha^{-1}), medium in available phosphorus (56.21 kg ha^{-1}) and available potassium (176.40 kg ha^{-1}).

The experiment was laid out in split plot design with 3 replications. The variety used for the experiment was Arka Anamika. Main plot treatments consisted of three fertilizer levels like 125% RDF, 100 RDF and STCR approach with combination of different spacings, 60 cm × 30 cm, 60 cm × 22.5 cm, 60 cm × 22.5 cm, 60 cm × 15 cm, 60 cm × line sowing and 60 cm / 20 cm / 20 cm (paired row) and the recommended dose of fertilizer is125: 75: 62.5 NPK kg ha^{-1} and farmyard manure is 25 t ha^{-1}.

The recommended dose of phosphorus and potassium and 50 per cent of nitrogen were applied at the time of sowing for respective treatments. The remaining 50 per cent of nitrogen was applied after 28 days after sowing. Nitrogen, phosphorus and potassium in the form of urea, single super phosphate and potassium respectively were applied. Five plants were randomly selected from the net plot leaving the border row and were tagged fruits and leaves were used for nutrient analysis using standard procedures.

Results and Discussion

Efficient use of fertilizers in any crop plant was necessary for optimum growth and yield. So knowledge about the availability of nutrients in the soil is very essential. A clear understanding of specific nutrient requirement of the crop during various stages of growth will substantially reduce the possible wastage of applied nutrients and improve both potentiality of the plant and nutrient use efficiency. During vegetative stage, the plant vigorously absorbs nutrients to build up the plant frame. Plant analysis serves as an elegant tool for understanding the growth and physiology of the plant at various growth stages.

Nitrogen, phosphorus and potassium nutrient content

Significantly higher nitrogen content in stalk (2.01%) was recorded with the application of 125% RDF (M_1) over the other nutrient levels and this was followed by the application of 100% RDF (M_2) was 1.84% and significantly lower concentration of nitrogen content in stalk (1.78%) was recorded with the application of nutrient through STCR approach (M_3). Significantly higher nitrogen content in stalk (2.11%) was observed with the spacing 60 × 30 cm (S_1) and this was on par with the spacing S_2. While, lower content of nitrogen in stalk (1.61 %) was recorded in spacing 60 cm × line sowing (S_4) (Table 1.).

Nitrogen content in fruit was differed significantly due to varying levels of nutrients. Application of 125% RDF (M_1) recorded significantly higher nitrogen content in fruit (2.69%) and it was on par with the nutrient level 100% RDF (M_2) was 2.54%. While, lower nitrogen content in fruit (2.35%) was observed in STCR approach. Significantly higher content of nitrogen in fruit (2.95%) was observed with the spacing 60 × 30 cm (S_1) followed by the spacing S_2 (2.62%). While, lower nitrogen content (2.46%) in fruit was observed in spacing 60 cm × line sowing (S_4).

Phosphorus plays key role in the plants energy transfer system. Phosphorus content in stalk differed significantly due to varying levels of nutrients at harvest. Significantly higher phosphorus content in stalk (0.28%) was recorded in 125% RDF (M_1).

This was followed by nutrient level M_2 and M_3 (0.26% and 0.24%, respectively) and the differences among them were significant. Significantly higher of phosphorus content in stalk (0.32%) was observed with the spacing 60 × 30 cm (S_1). While, less phosphorus content (0.22%) in stalk was observed in spacing 60 cm × line sowing (S_4).

Application of 125% RDF recorded significantly higher phosphorus content in fruit (0.34%), this was followed by nutrient level at 100% RDF (M_2) and STCR (M_3) was (0.30 and 0.26, respectively). Significantly 60 × 30 cm spacing (S_1) recorded the higher phosphorus content in fruit (0.37%). While, lower phosphorus content (0.27%) of phosphorus was recorded in 60 cm × line sowing (S_4).

Potassium being a protoplasmic factor is an essential plant nutrient. Many enzymes are activated by potassium and potassium is also involved in photo and oxidative phosphorylation thus augmenting the energy required for pod growth (Ghanta and Mitra, 1993). The results showed that both spacing and nutrient management had significant variation on stalk and fruit potassium. Accumulation of potassium content in stalk varied significantly due to varying levels of nutrients at harvest. Significantly higher potassium content in stalk (1.57%) was recorded with the application of 125% RDF (M_1). This was followed by application of nutrient level M_2 and through STCR approach (1.41% and 1.38% respectively) and there was a significant difference among the nutrient levels. Significantly higher potassium content in stalk (1.67%) was observed with the spacing 60 × 30 cm (S_1) followed by the spacing 60 × 22.5 cm (S_2) was 1.52%. While, lower potassium content (1.21%) in fruit was observed in spacing 60 cm × line sowing S_4.

Potassium content in fruit was differed significantly due to varying levels of nutrients. Significantly higher potassium content in fruit (2.23%) was recorded with the application of 125% RDF (M_1) and it was on par with the application of 100% RDF (2.13%). While, lower potassium content in fruit (2.04%) was observed in STCR approach. Significantly higher potassium content in fruit (2.38%) was observed with the spacing 60 × 30 cm (S_1) followed by the spacing 60 × 22.5 cm (2.22%). While, the lower potassium content (1.86%) in fruit was observed in 60 cm × line sowing (S_4).

Increased nitrogen content in different plant parts are due to the higher availability in the root zone, uptake and accumulation of nitrogen, which may take place gradually with the advancement of crop growth phase (Rajaraman and Pugalendhi, 2013). The higher nutrient contnet in stalk is increased as the increasing in application of nutrient, this indicates that the nutrient uptake was directly proportional to soil application of nutrients as well as fruit yield of the crop reported by Majeeduddin Solangi *et al.,* (2015). Bhat and Singh (1996) and Venkadeswaran and Sundaram (2016) the increased uptake may also be attributed to cumulative effect of increased nutrient content and highest dry matter production. Pallavi *et al.,* (2016) also reported that N, P and K content in plant found higher with combined application of organic and inorganic fertilizers. It is due to increased nutrient availability and higher meristematic activities of leaves and root of the plant which ultimately resulted in the higher absorption of nutrients.

Calcium, magnesium and sulphur nutrient

Application of 125% RDF (M_1) recorded significantly higher calcium content in stalk (0.52%) and it was on par with nutrient level 100% RDF was (0.46%). While, lower calcium content (0.39%) in stalk was observed in STCR approach (Table 2). Spacing 60 × 30 cm recorded the higher calcium content in stalk (0.55%). While, lower calcium content in stalk (0.37%) was recorded in 60 cm × line sowing.

Application of 125% RDF recorded the significantly higher calcium content in fruit (1.05%). While, less calcium content in plant (0.90%) was recorded in STCR approach. Spacing 60 × 30 cm recorded the higher calcium content in fruit (1.24%) and it is on par with the spacing 60 × 22.5 cm (1.11%). While, lower calcium content in fruit (0.72%) was recorded in 60 cm × line sowing (S_4). Magnesium content in stalk differed significantly due to varying levels of nutrients at harvest. Significantly higher magnesium content in stalk (0.27%) was recorded in 125% RDF (M_1).

Table.1 Effect of nutrient levels and spacing on N, P and K content (%) in stalk and fruit of okra

Treatments	Nitrogen		Phosphorus		Potassium	
	Stalk	Fruit	Stalk	Fruit	Stalk	Fruit
Nutrients levels						
M_1	2.01	2.69	0.28	0.34	1.57	2.23
M_2	1.84	2.54	0.26	0.30	1.41	2.13
M_3	1.78	2.35	0.24	0.26	1.38	2.04
S.Em±	0.044	0.057	0.0067	0.0041	0.023	0.03
CD at 5%	0.17	0.22	0.026	0.016	0.092	0.11
Spacing						
S_1	2.11	2.95	0.32	0.37	1.67	2.38
S_2	1.99	2.62	0.28	0.29	1.52	2.22
S_3	1.79	2.38	0.24	0.26	1.41	2.05
S_4	1.61	2.21	0.22	0.24	1.21	1.86
S_5	1.89	2.46	0.26	0.27	1.47	2.14
S.Em±	0.048	0.054	0.0084	0.0073	0.045	0.050
CD at 5%	0.14	0.15	0.024	0.021	0.13	0.14
Interactions						
M_1S_1	2.31	3.19	0.36	0.37	1.75	2.58
M_1S_2	2.15	2.81	0.31	0.33	1.62	2.30
M_1S_3	1.86	2.54	0.24	0.27	1.47	2.12
M_1S_4	1.69	2.27	0.23	0.25	1.41	1.98
M_1S_5	2.07	2.62	0.26	0.29	1.58	2.17
M_2S_1	2.10	2.90	0.30	0.33	1.72	2.37
M_2S_2	1.98	2.64	0.28	0.29	1.52	2.20
M_2S_3	1.83	2.36	0.25	0.25	1.37	2.06
M_2S_4	1.46	2.25	0.22	0.24	1.07	1.85
M_2S_5	1.83	2.53	0.27	0.26	1.40	2.15
M_3S_1	1.92	2.77	0.28	0.30	1.54	2.20
M_3S_2	1.84	2.41	0.24	0.27	1.42	2.15
M_3S_3	1.69	2.24	0.22	0.24	1.38	1.98
M_3S_4	1.68	2.12	0.21	0.23	1.14	1.77
M_3S_5	1.78	2.23	0.24	0.26	1.43	2.10
S.Em±	0.084	0.093	0.014	0.0127	0.078	0.086
CD at 5%	NS	NS	NS	NS	NS	NS

M_1: 125% RDF, M_2: 100% RDF, M_3: STCR approach, S_1:60×30 cm, S_2: 60× 22.5 cm, S_3: 60 × 15 cm, S_4: 60 cm × line sowing, S_5: 60cm / 20 cm / 20 cm (Paired row) and NS: non-significant

Table.2 Effect of nutrient levels and spacing on Ca, Mg and S content (%) in stalk and fruit of okra

Treatments	Calcium		Magnesium		Sulphur	
	Stalk	Fruit	Stalk	Fruit	Stalk	Fruit
Nutrients levels						
M_1	0.52	1.05	0.27	0.90	0.28	0.22
M_2	0.46	0.96	0.24	0.86	0.27	0.19
M_3	0.39	0.90	0.23	0.80	0.23	0.18
S.Em±	0.017	0.020	0.007	0.019	0.008	0.0062
CD at 5%	0.070	0.078	0.028	0.075	0.032	0.024
Spacing						
S_1	0.55	1.24	0.28	0.96	0.31	0.24
S_2	0.49	1.11	0.26	0.89	0.27	0.21
S_3	0.45	0.86	0.23	0.85	0.25	0.19
S_4	0.37	0.72	0.22	0.73	0.21	0.15
S_5	0.44	0.91	0.24	0.85	0.25	0.20
S.Em±	0.010	0.044	0.0079	0.016	0.016	0.0052
CD at 5%	0.031	0.13	0.023	0.048	0.048	0.015
Interactions						
M_1S_1	0.62	1.37	0.31	1.012	0.35	0.26
M_1S_2	0.59	1.21	0.27	0.95	0.34	0.23
M_1S_3	0.52	0.93	0.26	0.91	0.26	0.20
M_1S_4	0.40	0.77	0.25	0.75	0.21	0.17
M_1S_5	0.48	0.97	0.26	0.91	0.24	0.22
M_2S_1	0.55	1.22	0.28	0.98	0.32	0.24
M_2S_2	0.50	1.13	0.25	0.89	0.31	0.20
M_2S_3	0.45	0.81	0.23	0.85	0.23	0.18
M_2S_4	0.35	0.74	0.21	0.71	0.22	0.16
M_2S_5	0.46	0.89	0.23	0.85	0.25	0.19
M_3S_1	0.47	1.14	0.25	0.88	0.25	0.22
M_3S_2	0.39	0.99	0.25	0.82	0.17	0.19
M_3S_3	0.37	0.85	0.22	0.79	0.26	0.17
M_3S_4	0.34	0.65	0.19	0.72	0.20	0.14
M_3S_5	0.38	0.88	0.24	0.80	0.27	0.18
S.Em±	0.0184	0.077	0.013	0.0285	0.0285	0.0090
CD at 5%	NS	NS	NS	NS	NS	NS

M_1: 125% RDF, M_2: 100% RDF, M_3: STCR approach, S_1:60×30 cm, S_2: 60× 22.5 cm, S_3: 60 × 15 cm, S_4: 60 cm × line sowing, S_5: 60cm / 20 cm / 20 cm (Paired row) and NS: non-significant.

Table.3 Effect of nutrient levels and spacing on iron, zinc, manganese and copper content (mg kg^{-1}) in stalk and fruit of okra

Treatments	Iron		Zinc		Manganese		Copper	
	Stalk	Fruit	Stalk	Fruit	Stalk	Fruit	Stalk	Fruit
Nutrient levels								
M_1	239.4	68.79	18.89	37.20	71.21	22.92	9.04	5.59
M_2	237.16	66.70	18.53	36.58	69.64	21.52	8.88	5.40
M_3	223.49	65.04	17.46	35.85	66.45	20.35	8.47	5.12
S.Em±	2.93	0.703	0.15	0.25	0.87	0.27	0.110	0.073
CD at 5%	11.54	2.76	0.60	1.00	3.42	1.06	0.43	0.28
Spacing								
S_1	262.00	69.51	20.49	39.55	78.47	24.45	9.35	6.07
S_2	242.22	68.92	18.98	37.60	73.28	22.00	9.10	5.55
S_3	221.82	66.05	17.39	35.84	65.08	21.13	8.60	5.18
S_4	212.66	63.10	16.75	33.34	58.84	18.86	8.21	4.79
S_5	226.05	66.64	17.85	36.38	69.83	21.54	8.71	5.27
S.Em±	5.31	0.92	0.37	0.84	1.20	0.53	0.13	0.11
CD at 5%	15.50	2.70	1.10	2.46	3.51	1.55	0.39	0.34
Interactions								
M_1S_1	273.00	70.78	21.88	40.44	81.37	26.30	9.62	6.31
M_1S_2	250.33	72.23	20.55	38.29	78.51	24.16	9.46	5.93
M_1S_3	228.66	68.83	18.00	36.65	64.86	21.56	8.78	5.35
M_1S_4	215.33	64.16	16.26	33.12	57.16	19.53	8.48	4.90
M_1S_5	229.66	67.96	17.77	37.51	74.16	23.06	8.84	5.47
M_2S_1	262.66	70.36	20.24	39.36	78.84	24.30	9.46	6.14
M_2S_2	254.00	67.55	18.99	37.64	74.70	21.83	9.21	5.56
M_2S_3	225.00	65.86	17.07	35.71	65.82	21.30	8.72	5.16
M_2S_4	213.33	63.00	17.86	34.16	58.67	19.00	8.32	4.89
M_2S_5	230.83	66.73	18.49	36.04	70.16	21.16	8.68	5.23
M_3S_1	256.33	67.41	19.35	38.85	75.20	22.76	8.99	5.75
M_3S_2	222.30	66.99	17.42	36.88	66.62	20.00	8.63	5.17
M_3S_3	211.80	63.45	17.11	35.16	64.57	20.53	8.29	5.02
M_3S_4	209.33	62.15	16.14	32.75	60.69	18.06	7.83	4.58
M_3S_5	217.66	65.22	17.29	35.60	65.18	20.40	8.62	5.10
S.Em±	9.20	1.60	0.65	1.462	2.08	0.92	0.23	0.201
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS

M_1: 125% RDF, M_2: 100% RDF, M_3: STCR approach, S_1:60×30 cm, S_2: 60× 22.5 cm, S_3: 60 × 15 cm, S_4: 60 cm × line sowing, S_5: 60cm / 20 cm / 20 cm (Paired row) and NS: non-significant

This was followed by nutrient level M_2 and in STCR approach (0.24% and 0.23% respectively). Significantly higher magnesium content in stalk (0.28%) was observed with the spacing 60 × 30 cm (S_1) and it was on par with the spacing 60 × 22.5 cm (S_2) was 0.26%.While, less magnesium content in fruit (0.22%) was observed in spacing 60 cm × line sowing (S_4). Magnesium content in fruit is differed significantly due to varying levels of nutrient. Significantly higher magnesium content in fruit (0.90%) was recorded with the application of 125% RDF (M_1) and it was on par with the application of 100% RDF (0.86%). While, lower magnesium content in fruit (0.80%) was observed in STCR approach. Significantly higher magnesium content in fruit (0.96%) was observed with the spacing S_1 (60 × 30 cm) followed by the spacing 60 × 22.5 cm (0.89%). While, lower concentration of magnesium in fruit (0.73%) was observed in spacing 60 cm× line sowing.

Significantly higher sulphur content in stalk (0.28%) was recorded due to the application of 125% RDF in nutrient level (M_1) and it was on par with the application of 100% RDF (M_2) was 0.27%. While, less sulphur content in stalk (0.23%) was observed in STCR approach. Spacing 60 × 30 cm recorded significantly higher sulphur content in stalk (0.31%) and it was on par with the spacing 60 × 22.5 cm (S_2) (0.27%). While, less sulphur content in stalk (0.21%) was recorded in 60 cm × line sowing.

Sulphur content in fruit was differed significantly due to varying levels of nutrients. Significantly higher sulphur content in fruit (0.22%) was recorded with the application of 125% RDF and it was on par with the application of 100% RDF (M_2) (0.19%). While, less sulphur content in fruit (0.18%) was observed in STCR approach (M_3). Significantly higher sulphur content in fruit (0.24%) was observed with the spacing 60 × 30 cm (S_1) followed by the spacing 60 ×22.5 cm (S_2) (0.21%). While, less sulphur content in fruit (0.15%) was observed in spacing 60 cm × line sowing (S_4).

Nutrient content of secondary nutrients increases with increase in fertilizer dose because increased level of fertilizers gives more biomass production and synergetic effect of P on Ca and Mg as reported by Prakash and Badrinath (1995). Prasad *et al.*, (1996) reported that FYM being a good source of Ca and Mg has contributed to substantial amount of Ca and Mg in the treatments. Yifter Nega (1999) reported that uptake of S was relatively higher under SSP and FYM treatments, which could be due to contribution of S from SSP and FYM to the available pool of the element in the soil.

Micronutrient content

Significantly higher iron content in stalk (239.4 mg kg^{-1}) at harvest was recorded in 125% RDF (M_1) and it was on par with the application of 100% RDF (237.16 mg kg^{-1}).While, lower accumulation of iron content in stalk (223.49 mg kg^{-1}) was observed in STCR approach (Table 3). Spacing 60 × 30 cm recorded significantly higher iron content in stalk (262 mg kg^{-1}).

Whereas, less iron content in stalk (212.66 mg kg^{-1}) was recorded in 60 cm × line sowing. Application of 125% RDF (M_1) recorded significantly higher iron content in fruit (68.79 mg kg^{-1}). While, less iron content in fruit (65.04 mg kg^{-1}) was recorded in STCR approach.

Spacing 60 × 30 cm recorded higher accumulation of iron content in fruit (69.51 mg kg^{-1}) and it was on par with the spacing 60 × 22.5 cm (68.92 mg kg^{-1}). While, less iron content in fruit (63.10 mg kg^{-1}) was recorded in 60 cm × line sowing (S_4).

Significantly higher zinc content in stalk (18.89 mg kg^{-1}) was observed in nutrient level 125% RDF (M_1).While, less zinc content in stalk (17.46 mg kg^{-1}) was observed in STCR approach (M_3).Spacing 60 × 30 cm (S_1) recorded the higher zinc content in stalk (20.49 mg kg^{-1}). While, less zinc content in

stalk (16.75 mg kg^{-1}) was recorded in 60 cm× line sowing (S_4).
Application of 125% RDF recorded significantly higher zinc content in fruit (37.20 mg kg^{-1}) and it was on par with the application of 100% RDF (36.58 mg kg^{-1}).While, lower zinc content in fruit (35.85 mg kg^{-1}) was recorded in STCR approach. Among the all the spacing 60 × 30 cm (S_1) recorded significantly higher zinc content in fruit (39.55 mg kg^{-1}) and it was on par with the spacing 60 × 22.5 cm (S_2) (37.60 mg kg^{-1}). While, less of zinc content in fruit (33.34 mg kg^{-1}) was recorded in 60 cm × line sowing (S_4).

Significantly higher manganese content in stalk (71.13 mg kg^{-1}) was recorded with the application of 125% RDF (M_1) and it was on par with the application of 100% RDF (M_2) was 69.19 mg kg^{-1}. While, lower manganese content in stalk (66.21 mg kg^{-1}) was observed in STCR approach.

Spacing 60 × 30 cm (S_1) recorded significantly higher manganese content in stalk (81.16 mg kg^{-1}). While, lower manganese content in fruit (58.84 mg kg^{-1}) was recorded in 60 cm × line sowing (S_4).

Application of 125% RDF (M_1) recorded significantly higher manganese content in fruit (22.92 mg kg^{-1}). While, lower manganese content in fruit (20.35 mg kg^{-1}) was recorded in STCR approach (M_3).

Spacing 60 × 30 cm (S_1) recorded significantly higher manganese content in fruit (24.45 mg kg^{-1}). While, less manganese content in fruit (18.86 mg kg^{-1}) was recorded in 60 cm × line sowing (S_4).

Significantly higher copper content in stalk (9.04 mg kg^{-1}) at harvest was recorded in 125% RDF (M_1) it was on par with the application of 100% RDF (8.88 mg kg^{-1}). While, lower copper content in stalk (8.47 mg kg^{-1}) was observed in STCR approach (M_3).
Spacing 60 × 30 cm (S_1) recorded significantly higher copper content in stalk (9.35 mg kg^{-1}) it was on par with the spacing 60 × 22.5 cm (9.10 mg kg^{-1}).While, lower copper content in stalk (8.21 mg kg^{-1}) was recorded in 60 cm × line sowing (S_4).

Application of 125% RDF (M_1) recorded significantly higher copper content in fruit (5.59 mg kg^{-1}) and it was on par with application of 100% RDF (5.40 mg kg^{-1}).Whereas, lower copper content in fruit (5.12 mg kg^{-1}) was recorded in STCR approach (M_3).Spacing 60 × 30 cm (S_1) recorded significantly higher copper content in fruit (6.07 mg kg^{-1}). Whereas, less copper content (4.79 mg kg^{-1}) was recorded in 60 cm × line sowing (S_4).

Higher uptake of Fe, Zn, Mn, Cu in stalk (245, 19.13, 72.44 and 9.31 g ha^{-1}respectively) and in fruit (128.86, 68.85, 41.61 and 10.52 g ha^{-1}respectively) was recorded in the nutrient level M_1, whereas lower uptake of Fe, Zn, Mn, Cu in stalk (207, 16.36, 61.76 and 7.92 g ha^{-1} in stalk respectively) and in fruit 90.08, 54.77, 31.58 and 7.10 g ha^{-1} respectively. The results were similar to the findings of Gupta and Mehta (1993) reported that high fertility levels increased the uptake of Zn, Cu, Mn and Fe by 21, 10, 22 and 18 per cent, respectively. Ghosh *et al.*, (2001) reported that application of FYM along with recommended dose of NPK fertilizers considerably increased the uptake of Zn, Mn, Cu and Fe over absolute control and RDF treatments.

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