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Effect of different liquid organic manures on nutrient content, uptake and quality parameters of Radish (*Raphanus sativus* L.) Cv. Arka Nishanth

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Abstract
In view of the cost effectiveness and eco-friendly characteristics of the organic manures, a field experiment was conducted at organic farming block of Zonal Agricultural Research Station, V. C. Farm, Mandya during late Kharif 2020 to study the effect of liquid organic manures on nutrient content, uptake and quality parameters of radish. The experiment was laid out in Randomized Complete Block Design with nine treatments and replicated thrice. The treatments comprised of soil application of Panchagavya and Jeevamrutha at the time of sowing and 30 DAS along with the application of 50% and 75% RDN through FYM and 100% RDN through FYM only as standard check. The result of present investigation indicated that significantly higher total N (98.96 kg ha^{-1}), P (9.08 kg ha^{-1}), K (105.12 kg ha^{-1}), secondary nutrient uptake, quality parameters of radish both in root and shoot *viz*., protein (0.72 and 2.06 g $100g^{-1}$), ash (1.74 and 0.76%), total phenols (53.12 and 88.67 mg GAE g^{-1}), total acidity (0.71 and 1.83%), TSS (5.52 and 6.87 ^{o}Brix), ascorbic acid (21.52 and 33.02 mg $100g^{-1}$) and glucosinolate content (60.57 and 20.88 µmol g^{-1}) were found higher in T_9 (75% RDN through FYM +two times application of Panchagavya) and was on par with application of 75% RDN through FYM +two times application of Jeevamrutha (T_5), whereas Nitrate-N content was found to be nonsignificant. Thus, organic manures play a major role in improving quality of radish.

Keywords: Panchagavya, jeevamrutha, nutrient content and uptake, glucosinolate content, total phenols

Introduction
Radish (*Raphanus sativus* L.) is one of the most popular root vegetable crop and is widely acclaimed for its excellent nutritive and medicinal values (Rawat and Pant., 2021) [31]. It is a good source of vitamin C, carbohydrate, protein, fat, fiber and minerals like calcium, potassium and phosphorous. It also contains glucose as the major sugar and smaller quantities of fructose and sucrose (Singh and Bhandari, 2015) [38]. The characteristic pungent flavour of radish is due to the presence of volatile isothiocynates (trans-4-methyl thio-3-butenyl isothiocynate) (Kushwah, 2016) [23].

Radish composition was found to be highly medicinal and nutritional value. Thus, it was suggested as an alternative treatment for various ailments including hyperlipidemia, coronary heart diseases and cancer and has refreshing and depurative properties. Radish preparations are useful in liver and gall bladder troubles. Roots, leaves, flowers and pods are active against gram-positive bacteria. Roots are said to be useful in the treatment of urinary complaints, piles and gastrodynia. A salt extracted from roots, dried and burnt to white ash is said to be used in curing stomach troubles. Seeds are said to be peptic, expectorant, carminative and potential source of nondrying fatty oil suitable for soap making illuminating and edible purpose.

Organic farming is an age-old traditional practice evolved by our fore fathers where in only organic manures or natural inputs like weeds, leaf litter and crop residues *etc*., available on the farm are used. It provides balanced nutrition thereby taking care of soil health by improving physical, chemical and biological properties of the soil (Anon., 2008) [5]. Apart from using conventional farm-based products there is an increasing demand for improvised materials like

Panchagavya, Jeevamrutha and other liquid organic manures which mainly enrich the soil with indigenous microorganisms.
Liquid organic manures are generally prepared from locally available materials. Nutrient rich materials are soaked in water for several days or weeks to undergo fermentation and frequent stirring encourages microbial activity. The resulting liquid can either be used as a foliar fertilizer or applied to the soil. Temporary nutrient deficiencies in plants can be overcome through using liquid organic manures. These also act as tonic or stimulant to plants and used as an insecticide or as a fungicide. Liquid organic manures may contain numerous plant growth-promoting bacteria (PGPB), which may enhance plant growth by nitrogen fixation, growth hormone production and control phytopathogens (Amalraj *et al*., 2013) [3]. Panchagavya is a fermented liquid made by blending five ingredients obtained from cow, such as dung, urine, milk, curd and ghee (Selvaraj *et al*., 2007) [33]. Jeevamrutha is a low-cost improvised preparation that is prepared by mixing cow dung, cow urine, jaggery, pulse flour and hand full of soil collected from farm (Gore *et al*., 2011) [16]. The greatest challenge to be faced by the nation in the coming years is to provide safe food for the growing population in the country. Therefore, it is very essential to develop sustainable and compatible good agriculture practices by using different organic nutrient sources *viz*., FYM, Jeevamrutha, Panchagavya *etc*. The main aim of this work is to 1) Study the effect of different liquid organic manures on nutrient content and uptake by radish 2) To know the effect of organic manures on quality parameters of radish.

2 Materials and Methods

2.1 Experimental location and details

A field experiment was conducted during late *Kharif* 2020 at organic farming block of Zonal Agricultural Research Station (ZARS) V. C. Farm, Mandya, University of Agricultural Sciences, Bangalore during 2020. The experiment was laid out in randomized block design with 09 treatments replicated thrice. The treatments involved were T_1-100% RDN through FYM, T_2-50% RDN through FYM + one time application of Jeevamrutha, T_3-50% RDN through FYM + two times application of Jeevamrutha, T_4-75% RDN through FYM + one time application of Jeevamrutha, T_5-75% RDN through FYM + two times application of Jeevamrutha, T_6-50% RDN through FYM + one time application of Panchagavya, T_7-50% RDN through FYM + two times application of Panchagavya, T_8-75% RDN through FYM + one time application of Panchagavya, T_9-75% RDN through FYM + two times application of Panchagavya. Panchagavya and Jeevamrutha were applied to soil one at the time of sowing and second application at 30 DAS at the rate of 500 L ha^{-1}. Panchagavya and Jeevamrutha were prepared were prepared as per the procedure given by Sutar *et al*. (2018). The variety under study was *Arka nishanth*.

Table 1: Physico-chemical and biological properties of experimental site

Particulars	Values
Soil textural class	Sandy loam
pH (1:2.5)	7.30
EC (1:2.5) (dS m^{-1})	0.29
Organic carbon (g kg^{-1})	5.24
Available N (kg ha^{-1})	302.24
Available P_2O_5 (kg ha^{-1})	43.3
Available K_2O (kg ha^{-1})	210.66
Exch. Ca [cmol (p+) kg^{-1}]	7.01
Exch. Mg [cmol (p+) kg^{-1}]	2.21
Available S (mg kg^{-1})	15.12
DTPA Fe (mg kg^{-1})	19.85
DTPA Mn (mg kg^{-1})	10.69
DTPA Zn (mg kg^{-1})	0.49
DTPA Cu (mg kg^{-1})	1.26

Plant analysis

Radish root and shoot were collected at the time of harvest and analyzed for total N by micro- Kjeldahl method, total P by vanadomolybdate yellow colour method and total K by flame photometer, Ca and Mg by complexometric titration (Piper, 1966) [30], sulphur by turbidometric method and micronutrients (Fe, Mn, Zn and Cu) (Page *et al*., 1982) [28].

2.2.8 Uptake of nutrients

The uptake of plant nutrients by root and shoot was calculated separately and the sum of nutrients in root and shoot was considered as the total uptake by the crop and expressed in kg ha^{-1}.

$$\text{Nutrient uptake (kg ha}^{-1}) = \frac{\text{Nutrient concentration (\%)}}{100} \times \text{yield (kg ha}^{-1})$$

Randomly five plants from each treatment were selected to record the data on moisture content (%) (AOAC, 1965) [7], Ash content (%) (Thimmaiah, 2016) [39], Crude fibre (%) (Sadasivam, 1992) [32], Protein (Bradford, 1976) [12] (mg GAE g^{-1}), Chlorophyll (%) by SPAD (Soil Plant Analytical Development), ascorbic acid (%) (Sadasivam, 1992) [32], total Acidity (AOAC 2000) [6] (g MA kg^{-1}), total soluble sugars (%) (Sadasivam, 1992) [32], total phenols (mg GAE g^{-1}) (Eugenio, 2017) [14], Glucosinolate content (Mawlong, 2017) [26] and Nitrate -N **(**Lastra, 2003) [24] (mg L^{-1}). The significance of variation among the treatments was observed by applying ANOVA and critical difference at 5% level was calculated to compare the mean values of treatments for all the characters.

3 Results and Discussion

Table 1: Effect of liquid organic manures on primary nutrient content of radish crop

Treatment	N content (%)		P content (%)		K content (%)	
	Root	Shoot	Root	Shoot	Root	Shoot
T_1:100% RDN through FYM	4.26	2.40	0.32	0.26	4.08	2.60
T_2: 50% RDN through FYM + one time application of Jeevamrutha	3.62	2.38	0.31	0.25	4.13	2.72
T_3: 50% RDN through FYM+ two times application of Jeevamrutha	4.03	2.56	0.35	0.28	4.53	3.03
T_4: 75% RDN through FYM+ one time application of Jeevamrutha	4.10	2.65	0.33	0.29	4.21	2.80
T_5: 75% RDN through FYM+ two times application of Jeevamrutha	4.37	2.80	0.37	0.33	4.66	3.23
T_6: 50% RDN through FYM + one time application of Panchagavya	3.88	2.58	0.34	0.27	4.31	2.76
T_7: 50% RDN through FYM + two times application of Panchagavya	4.22	2.79	0.36	0.30	4.58	3.10
T_8: 75% RDN through FYM + one time application of Panchagavya	3.95	2.61	0.35	0.32	4.27	2.93
T_9: 75% RDN through FYM + two times application of Panchagavya	4.69	3.08	0.39	0.34	4.87	3.43
S.Em±	0.18	0.12	0.01	0.02	0.16	0.15
CD@ 5%	0.55	0.35	0.04	0.05	0.49	0.46

The results showed that all treatments of significantly increased the N, P and K content (Table 1). Among the treatments data in Table 1 showed that, application of 75% RDN through FYM + two times application of Panchagavya recorded significantly highest N content (4.69 and 3.08%, respectively), P content (0.39 and 0.34%) and K content (4.87 and 3.43%). Lower N content of root (3.62%) and shoot (2.38%), P content of root (0.31%) and shoot (0.25%) and K content of root (4.13%) and shoot (2.72%) was recorded with application of 50% RDN through FYM + one time application of Jeevamrutha.

Table 2: Primary nutrients uptake by radish as influenced by application of different liquid organic manures

Treatment	N uptake (kg ha^{-1})		P uptake (kg ha^{-1})		K uptake (kg ha^{-1})	
	Root	Shoot	Root	Shoot	Root	Shoot
T_1:100% RDN through FYM	49.23	18.25	3.70	1.98	47.15	19.77
T_2: 50% RDN through FYM + one time application of Jeevamrutha	40.92	16.12	3.50	1.69	46.68	18.42
T_3: 50% RDN through FYM+ two times application of Jeevamrutha	48.88	21.05	4.25	2.30	54.95	24.92
T_4: 75% RDN through FYM+ one time application of Jeevamrutha	48.08	19.50	3.87	2.13	49.37	20.61
T_5: 75% RDN through FYM+ two times application of Jeevamrutha	60.84	26.59	5.15	3.13	64.88	30.67
T_6: 50% RDN through FYM + one time application of Panchagavya	44.24	19.12	3.88	2.00	49.15	20.45
T_7: 50% RDN through FYM + two times application of Panchagavya	52.71	24.37	4.50	2.62	57.20	27.07
T_8: 75% RDN through FYM + one time application of Panchagavya	47.19	20.64	4.18	2.53	51.01	23.18
T_9: 75% RDN through FYM + two times application of Panchagavya	67.66	31.30	5.63	3.46	70.26	34.86
S.Em±	2.23	0.93	0.18	0.10	2.34	1.04
CD@ 5%	6.69	2.80	0.55	0.31	7.02	3.11

Significant variation in N, P and K uptake was noticed due to application of liquid organic manures (Table 2). Significantly highest (67.66 and 31.30 kg ha^{-1} of N respectively) N uptake, (5.63 and 3.46 kg ha^{-1} of P respectively) and (70.26 and 34.86 kg ha^{-1} of K respectively) was observed in T_9 (75% RDN through FYM + two times application of Panchagavya) and was followed by treatment T_5 (75% RDN through FYM + two times application of Jeevamrutha). Similar trend of result was noticed with total uptake of N, P and K by radish root and shoot due to application of liquid organic manures (Fig. 1).

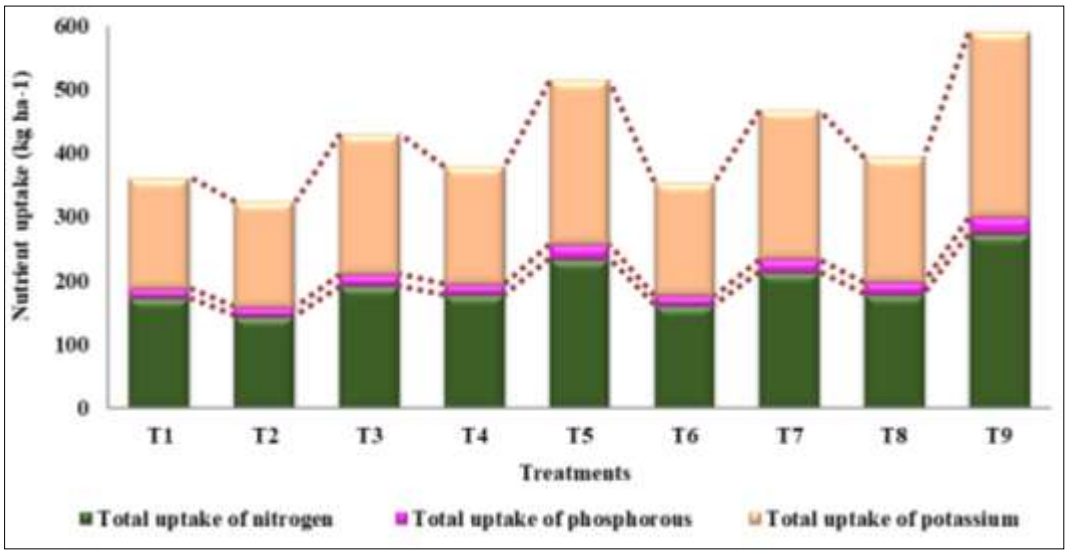

Fig 1: Total primary nutrients uptake by radish as influenced by application of different liquid organic manures

Content and uptake of NPK were found to be significant with the application of liquid organic manures this might be attributed to increased availability of nutrients due to buildup of soil micro flora resulting in increased bacteria, fungi, actinomycetes, P-solubilizers and N fixers in the soil. The additional NPK present in Panchagavya might be one of the reasons for improving the uptake of NPK by the radish. Similar results have been reported by Zeid (2015) [41] wherein application of organic manures resulted in higher N, P and K per cent in the radish root and shoot that might be due to quick buildup of soil micro flora and fauna which has consequently increased the enzymatic activity and helped in mineralization, solubilization of native and applied nutrients and made them available for plant uptake or the increase in uptake of nutrients in Panchagavya treated plots might be due to increased availability of nutrients due to buildup of soil microflora resulting in increased biological efficiency of crops for creating greater source and sink in the plant system (Boomathi *et al*., 2005) [11] that might have helped in absorption of the nutrients. The increased content and uptake of N, P and K due to application of organic manures are in line with the results obtained by Bodkhe and Mahorkar (2010) [10], Naveen Yadav *et al*. (2018) [27], Adekiya *et al*. (2019) [1] and Yousaf *et al.* (2021) [40] in radish.

Table 3: Effect of liquid organic manures on secondary nutrient content of radish crop

Treatment	Ca content (%)		Mg content (%)		S content (%)	
	Root	Shoot	Root	Shoot	Root	Shoot
T_1:100% RDN through FYM	4.27	0.73	1.78	0.33	1.55	1.12
T_2: 50% RDN through FYM + one time application of Jeevamrutha	4.03	0.72	1.68	0.34	1.57	1.21
T_3: 50% RDN through FYM+ two times application of Jeevamrutha	4.55	0.72	1.90	0.36	1.67	1.39
T_4: 75% RDN through FYM+ one time application of Jeevamrutha	4.32	0.77	1.80	0.37	1.69	1.47
T_5: 75% RDN through FYM+ two times application of Jeevamrutha	4.62	0.86	1.93	0.43	1.83	1.65
T_6: 50% RDN through FYM + one time application of Panchagavya	4.29	0.71	1.79	0.34	1.73	1.57
T_7: 50% RDN through FYM + two times application of Panchagavya	4.29	0.72	1.79	0.36	1.77	1.58
T_8: 75% RDN through FYM + one time application of Panchagavya	4.57	0.76	1.90	0.36	1.78	1.43
T_9: 75% RDN through FYM + two times application of Panchagavya	4.69	0.89	1.95	0.42	1.94	1.82
S.Em±	0.22	0.08	0.08	0.02	0.07	0.13
CD@ 5%	NS	NS	NS	NS	0.22	0.39

Non significant differences were recorded with respect to Ca and Mg content but S content was found to be significant (Table 3). Highest Ca (root - 4.69, shoot - 0.89%) content, Mg (root - 1.95, shoot - 0.42%) content and S (root - 1.94 and shoot - 1.82%) content was recorded in T_9 (75% RDN through FYM + two times application of Panchagavya) and lowest was recorded in T_2.

Uptake of Ca, Mg and S by root and shoot varied significantly among treatments due to different times of application. Highest uptake was recorded in T_9 (Ca - 4.69 and 0.89, Mg - 1.95 and 0.42 and S - 1.94 and 1.82 kg ha^{-1} in root and shoot, respectively) and lowest was observed in T_2. Similar trend was noticed with Ca, Mg and S total uptake by radish root and shoot due to application of liquid organic manures (Fig. 2).

Table 4: Effect of liquid organic manures on secondary nutrient uptake of radish crop

Treatment	Ca uptake (kg ha^{-1})		Mg uptake (kg ha^{-1})		S uptake (kg ha^{-1})	
	Root	Shoot	Root	Shoot	Root	Shoot
T_1:100% RDN through FYM	49.35	5.55	20.56	2.64	17.91	8.52
T_2: 50% RDN through FYM + one time application of Jeevamrutha	45.55	4.88	18.98	2.32	17.75	8.20
T_3: 50% RDN through FYM+ two times application of Jeevamrutha	55.19	5.92	23.00	2.82	20.26	11.43
T_4: 75% RDN through FYM+ one time application of Jeevamrutha	50.66	5.67	21.11	2.70	19.82	10.82
T_5: 75% RDN through FYM+ two times application of Jeevamrutha	64.33	8.17	26.80	3.89	25.48	15.67
T_6: 50% RDN through FYM + one time application of Panchagavya	48.92	5.26	20.38	2.51	19.73	11.63
T_7: 50% RDN through FYM + two times application of Panchagavya	53.58	6.29	22.33	2.99	22.11	13.80
T_8: 75% RDN through FYM + one time application of Panchagavya	54.60	6.01	22.75	2.86	21.26	11.31
T_9: 75% RDN through FYM + two times application of Panchagavya	67.66	9.05	28.19	4.31	27.99	18.50
S.Em±	2.35	0.27	0.98	0.13	0.91	0.50
CD@ 5%	7.03	0.80	2.93	0.38	2.72	1.51

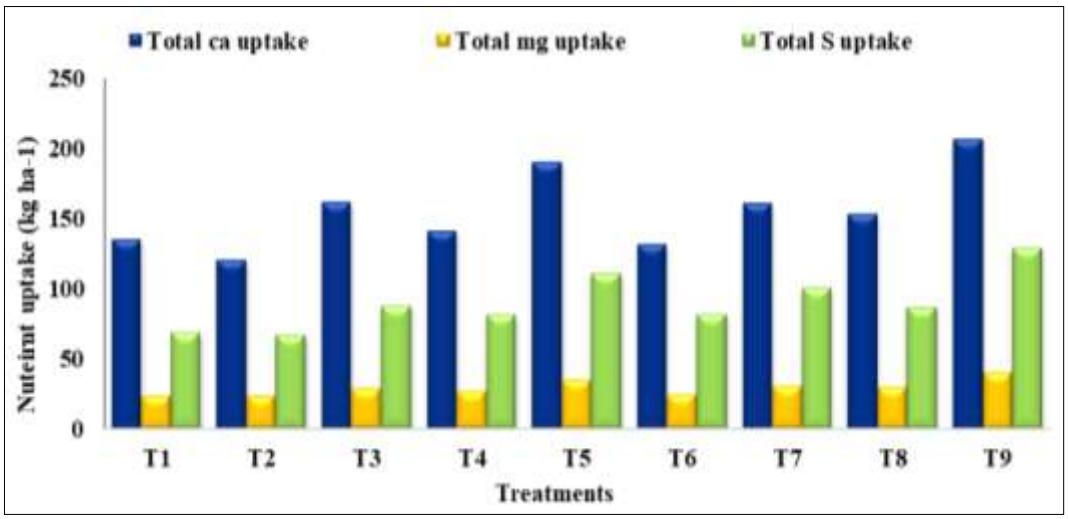

Fig. 2: Total secondary nutrients uptake by radish as influenced by application different liquid organic manures

Secondary nutrients uptake in treatment T_9 (75% RDN through FYM + two times application of Panchagavya) was found to be the highest. The superiority of Panchagavya for supplying calcium, magnesium and sulphur to the crop was due to the presence of high content of Ca, Mg and S in Panchagavya. The response of nutrient concentrations of radish to application of liquid organic manures was consistent with the values of soil chemical properties recorded for these treatments. There was increased nutrient availability in the soil as a result of application of liquid organic manures leading to increased uptake by radish plants. The increased uptake of Ca, Mg, S and Na due to application of organic manures are in line with the results obtained by Kopta and Pokluda (2013) [21], Jurica and Petrikova (2014) [19] and Goyeneche *et al*. (2015) [17] in radish.

Table 5: Effect of liquid organic manures on micronutrient content of radish crop

Treatment	Fe content (%)		Mn content (%)		Cu content (%)		Zn content (%)	
	Root	Shoot	Root	Shoot	Root	Shoot	Root	Shoot
T_1:100% RDN through FYM	3.43	4.63	0.63	0.77	0.35	0.15	0.66	0.44
T_2: 50% RDN through FYM + one time application of Jeevamrutha	3.59	4.90	0.66	0.79	0.39	0.17	0.69	0.47
T_3: 50% RDN through FYM+ two times application of Jeevamrutha	3.86	5.24	0.71	0.86	0.43	0.20	0.73	0.51
T_4: 75% RDN through FYM+ one time application of Jeevamrutha	3.67	5.09	0.69	0.85	0.41	0.19	0.71	0.49
T_5: 75% RDN through FYM+ two times application of Jeevamrutha	4.39	5.89	0.78	0.93	0.46	0.23	0.78	0.55
T_6: 50% RDN through FYM + one time application of Panchagavya	3.51	4.72	0.65	0.78	0.37	0.16	0.67	0.46
T_7: 50% RDN through FYM + two times application of Panchagavya	3.74	5.13	0.70	0.84	0.42	0.19	0.72	0.50
T_8: 75% RDN through FYM + one time application of Panchagavya	3.54	4.79	0.67	0.83	0.40	0.18	0.70	0.48
T_9: 75% RDN through FYM + two times application of Panchagavya	4.01	5.82	0.74	0.89	0.44	0.21	0.75	0.53
S.Em±	0.20	0.28	0.03	0.04	1.25	0.01	0.03	0.02
CD @ 5%	NS	NS	NS	NS	NS	NS	NS	NS

There was no significant variation of Fe, Mn, Cu and Zn content in root and shoot (Table 5). Relatively highest was observed with 75% RDN through FYM + two times application of Jeevamrutha (Fe- 4.39 and 5.89, Mn - 0.78 and 0.93, Cu - 0.46 and 0.23 and Zn - 0.78 and 0.55 mg kg^{-1} both in root and shoot, respectively).

Table 6: Effect of liquid organic manures on micronutrient uptake of radish crop

Treatment	Fe uptake (g ha^{-1})		Mn uptake (g ha^{-1})		Cu uptake (g ha^{-1})		Zn uptake (g ha^{-1})	
	Root	Shoot	Root	Shoot	Root	Shoot	Root	Shoot
T_1:100% RDN through FYM	3.96	3.52	0.73	0.59	0.40	0.11	0.76	0.33
T_2: 50% RDN through FYM + one time application of Jeevamrutha	4.06	3.32	0.75	0.54	0.44	0.12	0.78	0.32
T_3: 50% RDN through FYM+ two times application of Jeevamrutha	4.68	4.31	0.86	0.71	0.52	0.16	0.89	0.42
T_4: 75% RDN through FYM+ one time application of Jeevamrutha	4.30	3.75	0.81	0.63	0.48	0.14	0.83	0.36
T_5: 75% RDN through FYM+ two times application of Jeevamrutha	6.11	5.59	1.09	0.88	0.64	0.22	1.09	0.52
T_6: 50% RDN through FYM + one time application of Panchagavya	4.00	3.50	0.74	0.58	0.42	0.12	0.76	0.34
T_7: 50% RDN through FYM + two times application of Panchagavya	4.67	4.48	0.87	0.73	0.52	0.17	0.90	0.44
T_8: 75% RDN through FYM + one time application of Panchagavya	4.23	3.79	0.80	0.66	0.48	0.14	0.84	0.38
T_9: 75% RDN through FYM + two times application of Panchagavya	5.79	5.92	1.07	0.90	0.65	0.23	1.08	0.54
S.Em±	0.20	0.18	0.04	0.03	0.02	0.01	0.04	0.02
CD @ 5%	0.59	0.54	0.11	0.09	0.06	0.02	0.11	0.05

There was a significant variation of uptake of Fe, Mn, Cu and Zn (Table 6 and Fig.3). Application of 75% RDN through FYM + two times application of Jeevamrutha recorded highest total Fe uptake of 11.71 g ha^{-1} corresponding to 6.11 g ha^{-1} in root and 5.59 g ha^{-1} in shoot. The highest uptake of Mn by radish root (1.09 g ha^{-1}) was observed in T_5 (75% RDN through FYM + two times application of Jeevamrutha) followed by T_9 (1.07 g ha^{-1}) and in shoot (0.90 g ha^{-1}, respectively) was observed in T_9 followed by T_5 (0.88 g ha^{-1}) which was significantly higher than rest of the treatments. Zn uptake also showed similar trend where two times application of Panchagavya with 75% RDN through FYM recorded significantly highest total uptake of 1.62 g ha^{-1} (1.08 and 0.54 g ha^{-1} in root and shoot respectively) followed by two times application of Jeevamrutha with 75% RDN *i.e.*, 1.61 g ha^{-1} (1.09 and 0.52 g ha^{-1} in root and shoot respectively). Copper uptake by root and shoot due to application of Panchagavya and Jeevamrutha showed significant results. T_9 (0.65 and 0.23 g ha^{-1} in root and shoot respectively) and T_5 (0.64 and 0.22 g ha^{-1}, respectively) recorded significantly highest uptake than other treatments and lowest was observed in T_1 (0.40 and 0.11 g ha^{-1}, respectively).

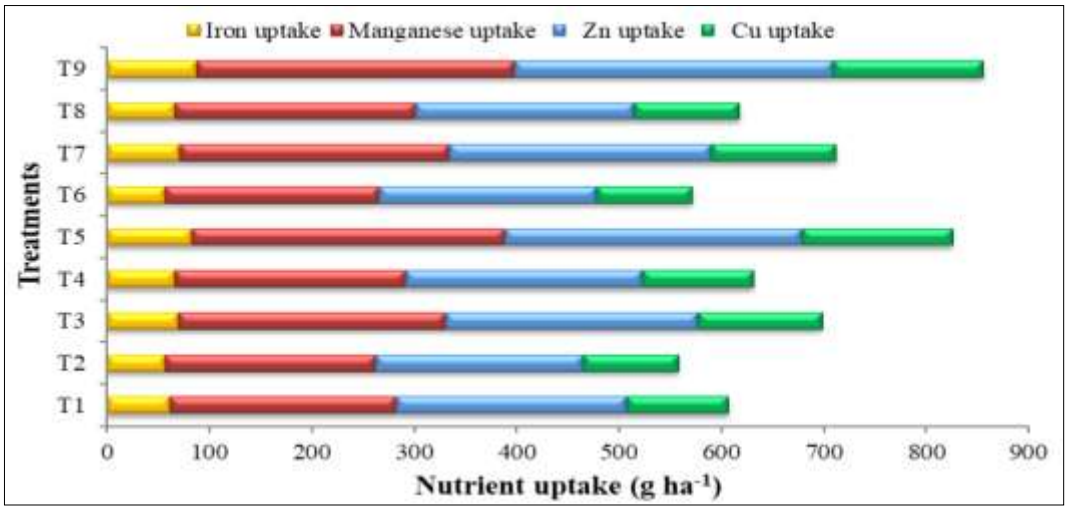

Fig 3: Total micro nutrients uptake by radish as influenced by application different liquid organic manures

Table 7: Effect of liquid organic manures on moisture and chlorophyll content in radish

Treatment	Moisture content (%)								Chlorophyll (SPAD)			
	Root				Shoot							
	15 DAS	30 DAS	45 DAS	At harvest	15 DAS	30 DAS	45 DAS	At harvest	15 DAS	30 DAS	45 DAS	At harvest
T_1	71.07	74.84	77.86	81.64	70.35	73.06	75.28	78.96	22.92	23.59	24.85	23.61
T_2	79.17	83.25	81.99	83.63	78.45	81.47	84.36	86.04	23.03	24.23	24.94	24.37
T_3	80.50	83.62	86.03	88.60	78.78	81.84	87.73	89.41	23.28	24.54	26.51	26.34
T_4	84.94	87.14	85.13	86.04	83.22	85.36	86.25	87.93	24.95	25.39	25.23	25.41
T_5	85.52	87.91	92.15	94.97	83.80	86.13	90.39	92.07	25.19	26.17	28.19	27.25
T_6	82.45	85.55	86.22	87.46	80.73	83.77	85.33	87.01	23.80	25.33	26.06	25.35
T_7	83.57	85.92	89.89	93.13	81.85	84.14	86.70	88.38	24.16	25.99	27.07	26.59
T_8	88.39	91.76	88.77	89.35	86.67	89.02	89.24	90.92	25.07	26.07	26.35	25.90
T_9	89.64	92.78	94.39	95.41	87.92	89.20	92.53	93.61	25.77	26.94	28.72	27.73

T_1 :100% RDN through FYM	
T_2: 50% RDN through FYM + one time application of Jeevamrutha	T_6:50% RDN through FYM + one time application of Panchagavya
T_3: 50% RDN through FYM + two times application of Jeevamrutha	T_7:50% RDN through FYM + two times application of Panchagavya
T_4: 75% RDN through FYM + one time application of Jeevamrutha	T_8: 75% RDN through FYM + one time application of Panchagavya
T_5: 75% RDN through FYM + two times application of Jeevamrutha	T_9: 75% RDN through FYM + two times application of Panchagavya

Table 8: Effect of liquid organic manures on protein, ash and crude fiber content in radish root and shoot

Treatment	Protein (g $100g^{-1}$)		Ash (%)		Crude fiber (%)	
	Root	Shoot	Root	Shoot	Root	Shoot
T_1: 100% RDN through FYM	0.49	1.51	1.49	0.62	0.24	0.52
T_2: 50% RDN through FYM + one time application of Jeevamrutha	0.52	1.52	1.54	0.63	0.25	0.54
T_3: 50% RDN through FYM+ two times application of Jeevamrutha	0.60	1.57	1.57	0.67	0.28	0.58
T_4: 75% RDN through FYM+ one time application of Jeevamrutha	0.58	1.55	1.55	0.65	0.26	0.55
T_5: 75% RDN through FYM+ two times application of Jeevamrutha	0.63	1.80	1.69	0.74	0.31	0.63
T_6: 50% RDN through FYM + one time application of Panchagavya	0.57	1.56	1.55	0.64	0.26	0.56
T_7: 50% RDN through FYM + two times application of Panchagavya	0.65	1.78	1.60	0.69	0.30	0.59
T_8: 75% RDN through FYM + one time application of Panchagavya	0.59	1.72	1.56	0.66	0.27	0.57
T_9: 75% RDN through FYM + two times application of Panchagavya	0.72	2.06	1.74	0.76	0.33	0.64
S.Em ±	0.03	0.11	0.03	0.11	0.01	0.02
CD@ 5%	0.08	0.32	0.09	0.33	0.04	0.07

Application of liquid organic manures produced significant effect on protein content in radish root and shoot as shown in Table 8. It is evident from the data that the highest protein content 0.72 and 2.06 g $100g^{-1}$ both in root and shoot was recorded with application of 75% RDN through FYM + two times application of Panchagavya (T_9) which was on par with (T_5) (0.63 and 1.80 g $100g^{-1}$) and T_7 (0.65 and 1.78 g $100g^{-1}$) and lowest protein (0.49 and 1.51 g $100g^{-1}$) was found in T_1.

The highest protein content in root and shoot was observed in the treatment which received 75% RDN through FYM + two times application of Panchagavya. Since it composed of high N fixers which made more N available to plant that has directly contributed to build up of protein. Nitrogen thus obtained was metabolized via ammonia into alpha-keto glutamic acid. Carbon skeleton provided by photosynthesis was incorporated in the process of amino acid synthesis which was converted to protein and is in confirmity with the findings of Sheeba (2004) [35] and Alphonse (2020) [2].

Data regarding ash content of radish are presented in Table 8 and the results revealed that application of liquid organic manures had a significant influence on this property. Lowest ash content of 1.49% in root and 0.62% in shoot was recorded in treatment with the application of 100% RDN through FYM (T_1) and highest ash content of 1.74 and 0.76% in root and shoot respectively was recorded in T_9 (75% RDN through FYM + two times application of Panchagavya) similar results are also observed by Goyeneche *et al*. (2015) [17].

The effect of liquid organic manures on crude fiber content of radish was found to be significant and data are been presented in Table 8.

The maximum crude fiber content of 0.33 and 0.64% in root and shoot, respectively was recorded in T_9 and was on par with T_5 treatment (0.31 and 0.63% in root and shoot, respectively) and T_7 (0.30 and 0.59% in root and shoot, respectively) and significant with rest of the treatments. The minimum crude fiber content (0.24 and 0.52% in root and shoot, respectively) was recorded in T_1 treatment. Several reports supporting this observation had been made by Goyeneche *et al*. (2015) [17] and Khede *et al*. (2019) [20].

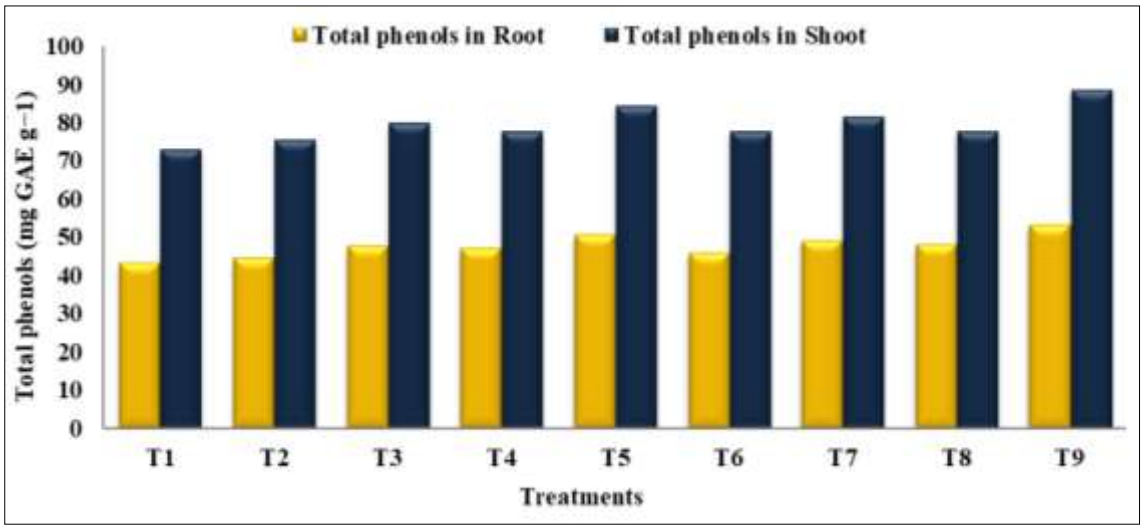

Fig 4: Total phenols content in radish root and shoot as influenced by application of different liquid organic manures

The effect of application different liquid organic manures on total phenols content of radish root and shoot was found to be significant and data are been presented in Fig. 4.

Significantly maximum content of total phenols in root and shoot was recorded in T_9 treatment (53.12 and 88.67 mg GAE g^{-1}, respectively) over all the treatments except T_5 (75% RDN through FYM + two times application of Jeevamrutha) (50.34 and 84.56, mg GAE g^{-1} respectively). Lowest content of 43.00 and 73.16 mg GAE g^{-1} was recorded in T_1 (100% RDN through FYM). Alphonse (2020) [2] and Shehata (2014) [36] recorded the similar results in radish.

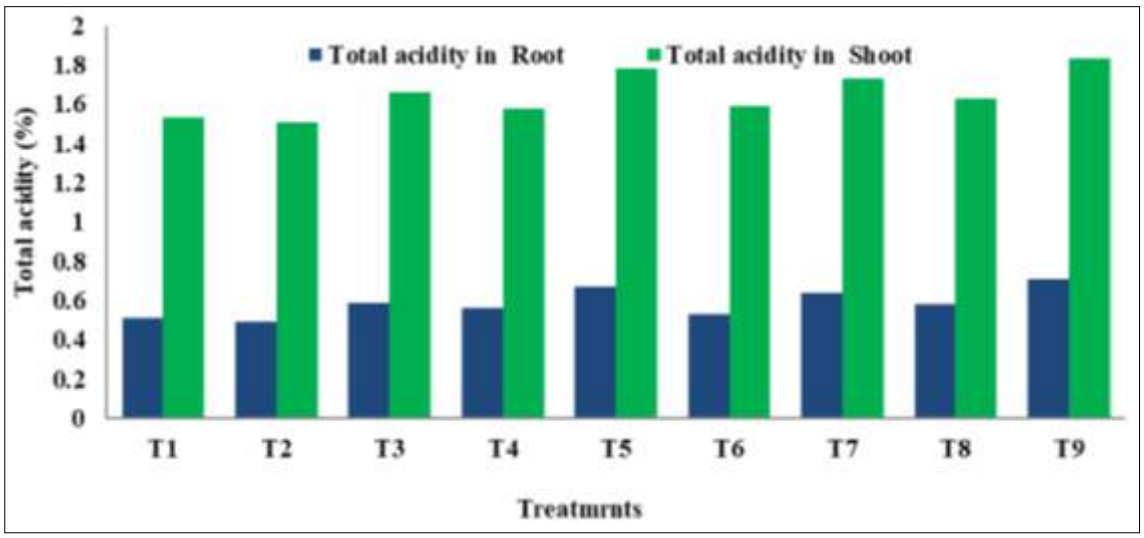

Fig 5: Total acidity content in radish root and shoot as influenced by application of different liquid organic manures

The effect of application different liquid organic manures on total acidity of radish root and shoot was found to be significant and data are been presented in Fig. 5.

Analysis of total acidity content in radish root and shoot indicated that, lowest content of 0.49 and 1.51% was recorded in T_2 (50% RDN through FYM + one time application of Jeevamrutha) which increased to 0.71 and 1.83% in treatment T_9 (75% RDN through FYM + two times application of Panchagavya) which was on par with T_5 (0.67 and 1.78%) and T_7 (0.64 and 1.73%) and significant with all other treatments. These results are also in conformity with those findings of Ayub *et al*., (2013) [8].

The progressive improvement in ash, crude fiber, total phenols and total acidity of radish with the use of liquid organic manures might be due to increase in growth parameters, which might have resulted in improved uptake of nutrients and enzymatic activities. Similar increase in the ash, crude fiber, total phenols and total acidity enhanced were recorded by Kopta and Pokluda (2013) [21] and Jurica *et al*. (2014) [19], Shanikumar *et al*. (2016) [34] and Singh *et al*. (2016) [37].

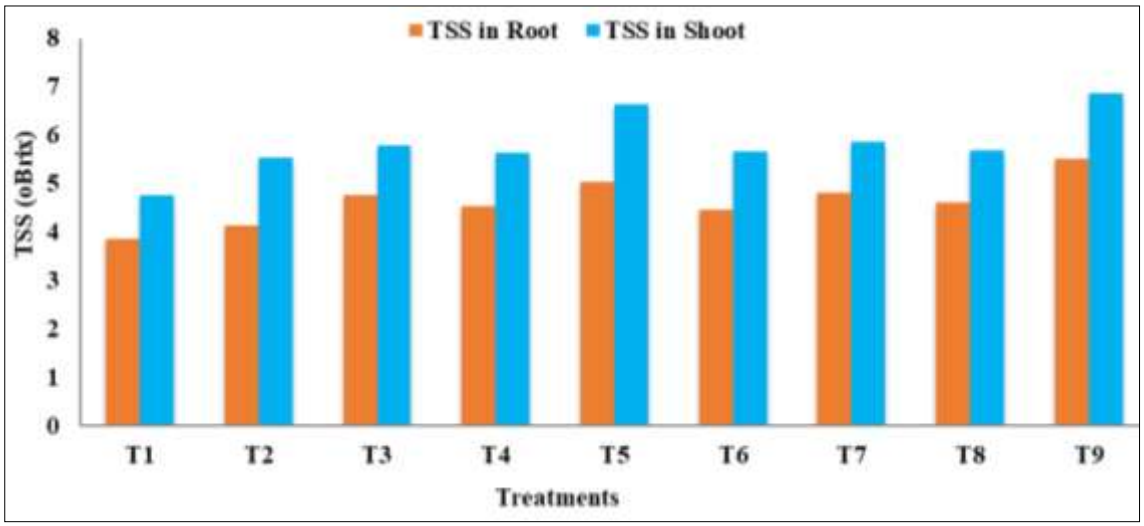

Fig 6: TSS content in radish root and shoot as influenced by application different liquid organic manures

Data regarding TSS content are presented in Fig. 6. The total soluble sugars content of 5.52 and 6.87 ^{o}Brix (in root and shoot) was recorded in treatment with application of 75% RDN through FYM + two times application of Panchagavya (T_9) followed by T_5 (5.04 and 6.63 ^{o}Brix) and were significantly higher than all other treatments. Lowest total soluble sugars content of 3.85 and 4.76 ^{o}Brix was recorded in T_1 (100% RDN through FYM). It might be due to accumulation of more reserve substances in root or may be attributed to the increased availability and absorption of necessary elements required for the production of total soluble sugars. Similar findings were noticed by Gyewali *et al*. (2020) in radish where application of organic manures not only increased the total soluble sugars but also elevated the ascorbic acid. Similar increase in the total soluble sugars of produce was reported by Singh *et al*. (2016) [37], Dongarwar *et al*. (2017) [13], Pathak *et al*. (2017) [29] and Shanikumar *et al*. (2016) [34] in radish.

Table 9: Effect of liquid organic manures on ascorbic acid, nitrate-N and glucosinolate content in radish root and shoot

Treatment	Ascorbic acid (mg 100g^{-1})		Nitrate-N (µg NO_3^{-1} -N g^{-1})		Glucosinolate (µmol g^{-1})	
	Root	Shoot	Root	Root	Shoot	Root
T_1: 100% RDN through FYM	16.79	26.67	1258.20	16.79	26.67	1258.20
T_2: 50% RDN through FYM + one time application of Jeevamrutha	17.35	27.02	1247.96	17.35	27.02	1247.96
T_3: 50% RDN through FYM+ two times application of Jeevamrutha	18.56	28.59	1234.12	18.56	28.59	1234.12
T_4: 75% RDN through FYM+ one time application of Jeevamrutha	18.12	28.35	1225.06	18.12	28.35	1225.06
T_5: 75% RDN through FYM+ two times application of Jeevamrutha	19.43	30.26	1197.78	19.43	30.26	1197.78
T_6: 50% RDN through FYM + one time application of Panchagavya	18.29	27.45	1240.94	18.29	27.45	1240.94
T_7: 50% RDN through FYM + two times application of Panchagavya	18.65	29.23	1230.16	18.65	29.23	1230.16
T_8: 75% RDN through FYM + one time application of Panchagavya	18.34	26.95	1220.19	18.34	26.95	1220.19
T_9: 75% RDN through FYM + two times application of Panchagavya	21.52	33.02	1187.02	21.52	33.02	1187.02
S.Em ±	0.80	1.26	34.30	0.80	1.26	34.30
CD@ 5%	2.39	3.77	NS	2.39	3.77	NS

Ascorbic acid content in radish root ad shoot was varied significantly due to application of liquid organic manures and are indicated in Table 9.

Ascorbic acid content differed significantly due to application of liquid organic manures. Significantly highest ascorbic acid content (21.52 and 33.02 mg 100g^{-1} in root and shoot, respectively) was recorded in 75% RDN through FYM + two times application of Panchagavya and was on par with T_5 (19.43 and 30.26 mg 100 g^{-1} in root and shoot, respectively). Lowest content was recorded in treatment receiving 100% RDN through FYM (16.79 and 26.67 mg 100g^{-1} in root and shoot, respectively).

The increase in ascorbic acid content might be due to better availability and uptake of plant required nutrients and also favorable conditions resulted by the application of Panchagavya which help in the synthesis of chlorophyll and increased ascorbic acid conent. Similar increase in the ascorbic acid of produce was reported by Singh *et al*. (2016) [37], Dongarwar *et al*. (2017) [13], Pathak *et al*. (2017) [29] and Shanikumar *et al*. (2016) [34] in radish.

Data regarding nitrate-N content are presented in Table 9. The results revealed that application of liquid organic manures had non-significant influence on nitrate-N content. However, nitrate-N content in root and shoot value ranged from 1187.02 and 451.21 µg NO_3^{-1} -N g^{-1}, respectively with the application of 75% RDN through FYM + two times application of Panchagavya, 1197.78 and 462.14 µg NO_3^{-1} -N g^{-1}, respectively with 75% RDN through FYM + two times application of Jeevamrutha to 1258.20 and 522.19 µg NO_3^{-1} -N g^{-1}, respectively with 100% RDN through FYM. Nitrate content in root and shoot of radish plays an important role in consumer health, because nitrates are precursor of dangerous nitrites and nitrosamines, which are especially dangerous for children. Lowest nitrate accumulation was observed in the treatment which received 75% RDN through + two times application of Panchagavya this might be due to presence of more amount of ascorbic acid and phenols which facilitate in the non enzymatic reduction of toxic nitrite to beneficial nitric oxide thereby reducing the chances of nitrite

reacting with secondary amines to form nitrosamines some of which are carcinogenic, teratogenic and mutagenic in nature (Zhou *et al*., 2000) [42]. These findings corroborate with results obtained by Amr and Rayyan (2016) [4] and Kowalskia and Kaniszewski (2017) [22].

The results showed that, significantly highest GSLs content of 20.88 and 60.57 µmol g^{-1} in shoot and root, respectively was recorded in treatment T_9 followed by T_5 (19.13 and 55.48 µmol g^{-1}). Lowest content of GSLs was recorded in T_1 (100% RDN through FYM) (14.43 and 41.86 µmol g^{-1}, respectively). GSLs are a group of sulfur-containing glucosides that are hydrolyzed by the endogenous enzyme myrosinase into isothiocynates, thiocynates, and nitrites. GSLs and their products have different biological functions including anticancer, anti-bacterial, anti-fungal, anti-oxidative and allelopathic properties. Increase in GSLs content in organically grown radish may be due to presence of more content of sulphur and increased availability of major as well as minor nutrients especially nitrogen and potassium, as they play vital role in enhancing the quality parameters. Similar results were obtained by Levine *et al*. (2008) [25] in radish when it was grown in reduced atmospheric conditions, Ishida *et al*. (2012) [18] in conventionally grown radish crop and Bhandari *et al*. (2015) [9].

Conclusion

Application of 75% RDN through FYM + two times application of Panchagavya at basal and 30 DAS is found to be economical in obtaining higher profitable by saving 25% FYM input resulting in greater resource use efficiency. Further, 75% RDN through FYM + two times application of Jeevamrutha at basal and 30 DAS is also found to be beneficial in obtaining higher soil nutrient status.

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