

Research Article

**EFFECT OF DIFFERENT ORGANIC MANURES ON
GROWTH, YIELD, AND QUALITY OF RADISH
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Tribhuvan University, Paklihawa, Nepal**ABSTRACT**

An experiment was conducted to evaluate the influence of different organic manures on growth, yield, and quality of radish (*Raphanus sativus*) at Institute of Agriculture and Animal Science (IAAS), Rupandehi, Nepal. The experiment was laid in Randomized Complete Block Design single factorial with seven treatments and three replications. The treatments were consisted as farmyard manure (FYM) (30 tha^{-1}), poultry manure (PM) (30 tha^{-1}), FYM(15 tha^{-1}) + PM (15 tha^{-1}), FYM (15 tha^{-1}) + vermin compost (2.5 tha^{-1}) + phosphate solubilizing bacteria (PSB) (10 kgha^{-1}), FYM (15 tha^{-1}) + bone meal (5 tha^{-1}) + PSB (10 kgha^{-1}), PM (15 tha^{-1}) + vermi compost (2.5 tha^{-1}) + PSB (10 kgha^{-1}), PM (15 tha^{-1}) + bone meal (5 tha^{-1}) + PSB (10 kgha^{-1}). A significant variation was observed among the treatments. The poultry manures combined with bone meal and PSB significantly increased the growth and yield attributes viz., plant height (43.43 cm), number of leaves (20.9), shoot length (44.49 cm), root length (21.68 cm), root diameter (3.77 cm), root weight (211.3 gm plant^{-1}), shoot weight (170.9 gm plant^{-1}), biological yield (82.28 gm plant^{-1}), dry root weight (46.89 gm plant^{-1}), dry shoot weight (50.33 gm plant^{-1}), total dry weight (97.22 gm plant^{-1}), root yield (49.31 tha^{-1}), shoot yield (939.87 tha^{-1}) and biological yield (89.19 tha^{-1}) at 70 days after sowing. The vitamin-C in radish root was recorded highest (2.87 mgml^{-1}) with PM. However, the total soluble solid remains unchanged among the treatments. In total, the results suggested that poultry manures combined with bone meal and PSB is suitable to cultivate radish.

Keywords: Bone meal, Vermi compost, Farmyard manure, Phosphate solubilizing bacteria, Poultry manure, Radish.

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INTRODUCTION

Radish (*Raphanus sativus*) is a winter season vegetable, grown throughout the country and occupies 16915.7 ha with total production of 268119.6 tones and productivity 15.9 tha^{-1} (MoAD, 2017). The area covered under radish cultivation during 2011-12 to 2015-16 has decreased by 6.0 % (Ghimire et al., 2018). The global production of radish is estimated 7 Mt year^{-1} , which is about 2 % of the total world vegetables production (Ghimire et al., 2018).

Radish is a good source of vitamin-C (14.8 mg per 100gm of edible portion) and supplies variety of minerals. The pink skin radish is generally rich in ascorbic acid than white skin radish (Singh and Bhandari, 2015). The characteristic pungent flavor of radish is due to isothiocyanate (Kushwah, 2016). It is used for neurological headaches, chronic diarrhea, urinary complaints, sleeplessness, and piles (Singh and Bhandari, 2015).

Organic manures are bulky, concentrated, and organic in origin, having no definite chemical composition with low analytical value. Chemical fertilizers are used in excessive doses for higher production of vegetables. Total dependence on inorganic fertilizers has led to ill effects on soil. The demand for organic produce is increasing with increasing awareness (Bhatta et al., 2008). The global market for organic produce has surpassed 100 billion USD in 2018. However, the organic food supply lags behind the demand. Organic vegetable production was 1.1 % of the total vegetable production in 2017 (Willer and Lernoud, 2019). The 10th Five Year Plan of Nepal and the Ministry of Agricultural Development (MOAD) has prioritized the application of organic manures and bio-fertilizers over past few years (MOAC, 2004; Amgai et al., 2017).

In Nepal, researches in organic fertilizers are limited and less prioritized due to which the information on their efficacy is lacking. PM and FYM are commonly available, but their application alone is not competent to high energy demand (Henderson et al., 2016). So, these manures in combination with bone meal, PSB, and vermin compost were used. Hence, the study was conducted to assess the appropriate organic manures and their combination for optimum growth, yield, and quality of radish.

MATERIALS AND METHODS

Research location

The research was conducted in Institute of Agriculture and Animal Science, Rupandehi, Nepal, from December 2018 to March 2019. It is situated on the geographical coordinates of 27.4809^oN, 83.4469^oE.

Table 1. Monthly meteorological information from December 2018 to March 2019

Year	Month	Average minimum temperature (°C)	Average maximum temperature (°C)
2018	December	9.07	24.84
2019	January	8.4	23.26
2019	February	11.78	24.77
2019	March	16	32

Soil test was performed before the land preparation. Briefly, composite samples of each replication were taken from depth of 15 cm before manure application through zigzag method. Samples were mixed thoroughly and quartering was done. Two opposite quarters were discarded, remaining quarters were remixed then the process was repeated till 1 kg sample was obtained. The obtained sample was pulverized, shade dried, sieved with the help of 2 mm sieve and analyzed for different nutrient as depicted in Table 2.

Table 2. Physiochemical properties of soil sample

Properties	Contents	Remarks
pH	7.08	-
N %	0.105	Medium
P ₂ O ₅ kg ha ⁻¹	42.23	Medium
K ₂ O kg ha ⁻¹	225.1	Medium
Organic Matter %	2.06	Low
Sand %	32	-
Silt %	50.3	-
Clay %	17.7	-
Soil texture	Loam / Silty loam	-

Experimental details

The experiment was laid out on randomized complete block design with 7 treatments and 3 replications. The treatments were T₁ (farmyard manure 30 tha⁻¹), T₂ (poultry manure 30 tha⁻¹), T₃ (FYM 15 tha⁻¹ + PM 15 tha⁻¹), T₄ (FYM 15 tha⁻¹ + vermin compost 2.5 tha⁻¹ + phosphate solubilizing bacteria (PSB) 10 kgha⁻¹), T₅ (FYM 15 tha⁻¹ + bone meal 15 tha⁻¹ + PSB 10 kgha⁻¹), T₆ (PM 15 tha⁻¹ + vermin compost 2.5 tha⁻¹ + PSB 10 kgha⁻¹), T₇ (PM 15 tha⁻¹ + bone meal 5 tha⁻¹ + PSB 10 kgha⁻¹). Pseudomonas strain of PSB and vermin compost containing 1.88 % N, 1.08 % P, and 2.68 % K were used. The spacing between row to row was 20cm, plant to plant was 22 cm, plot to plot was 0.75m while replication to replication was maintained at 1m. The individual plot size was 4.5 m² (3m×1.5m).

Crop management

After completion of field preparation, organic manures, as per the treatment, were incorporated as basal dose 7 days before sowing. Good quality seeds of Tokinashi

variety were sown maintaining the depth of 2 cm on 22nd December 2018. Intercultural operations like mulching of plot for 5 days, irrigation according to the moisture requirement, re-sowing and thinning out to maintain desired plant population, weeding and earthing up at the early stage of plant growth, and plant protection measures were applied as per needed.

Sampling and data recording

From each plot, 10 random plants were considered as sample plants for data collection. The observations were recorded for growth parameters, such as plant height, number of leaves, shoot length, fresh shoot weight, dry shoot weight; yield parameters, such as root length, root diameter, fresh root weight, dry root weight; quality parameters, such as Vitamin-C content and total soluble solid (TSS). Plant height and number of leaves were recorded at 28 days after sowing (DAS), 42 DAS, 56 DAS, and 70 DAS while all other parameters were recorded at 70 DAS.

Root and shoot weight (gm)

Three plants were selected randomly from each plot at 70 DAS and weighed. After taking fresh root and shoot weight, they were dried in sun for two days followed by hot air oven at 70°C till constant weight, and dry weight was measured.

Total soluble solid

One sample from each plot was taken. 10 gm of each root below 2 cm from the crown was cut and crushed to form a homogenized sample and 10 ml distilled water was added. The juice was extracted through a muslin cloth then used for the determination of TSS using a digital refractometer.

Ascorbic acid content (mgml⁻¹ of juice)

For the preparation of the dye solution, 50 mg of sodium salt of 2,6-dichlorophenolindophenol (DCIP) in approximately 100ml of distilled water was heated on a hot plate. It was left to cool down and diluted with distilled water to 200 ml. 0.5gm of oxalic acid was dissolved in 100ml distilled water. For standard ascorbic acid, 0.01gm of ascorbic acid was weighed, diluted with oxalic acid and the final volume was prepared to 10 ml. In the standardization of dye 10ml of oxalic acid and 1ml of standard ascorbic solution were taken in a conical flask. The solution was titrated against the dye solution until the pink color was obtained which persisted for 15 seconds. Then 1ml of juice in 10ml of oxalic acid was taken as a sample. Similarly, for the assay of ascorbic acid, a 10ml sample was taken and titrated against the standard dye to a pink color which persisted for 15 seconds (Ranganna, 1995). The ascorbic acid content of the sample was calculated using the following formula:

Concentration of Vitamin C in juice (mgml⁻¹)

$$= \frac{\text{DCIP (ml) used to titrate the radish juice}}{\text{DCIP (ml) used to titrate standard solution}} \times 1 \text{mgml}^{-1}$$

Statistical data analysis

Each treatment was replicated three times and data were recorded from 10 randomly sampled plants. Hence, the experiment contained three biological and 10 analytical replicates. Data were statistically analyzed following analysis of variance (ANOVA) and Duncan's Multiple Range Test (DMRT) with the help of MSTAT computer package program. The significant difference among treatment means was compared by the least significant difference (LSD) at 5% level of probability.

RESULT AND DISCUSSION

Effect of organic manures on growth parameters

Organic manures play significant role in improvement of soil condition and are helpful in balancing nutrient availability which boosts the growth of plants. The results of this study revealed good response of radish to organic manures and their combination. At 70 DAS, the plant height (43.43 cm) and number of leaves (20.9) were maximum in T₇ which was at par with T₅ and were significantly different ($p < 0.05$) from other organic manures whereas plant height (11 cm) and number of leaves (8.13) were observed minimum in both T₄ and T₁ (Figure 1 and 2).

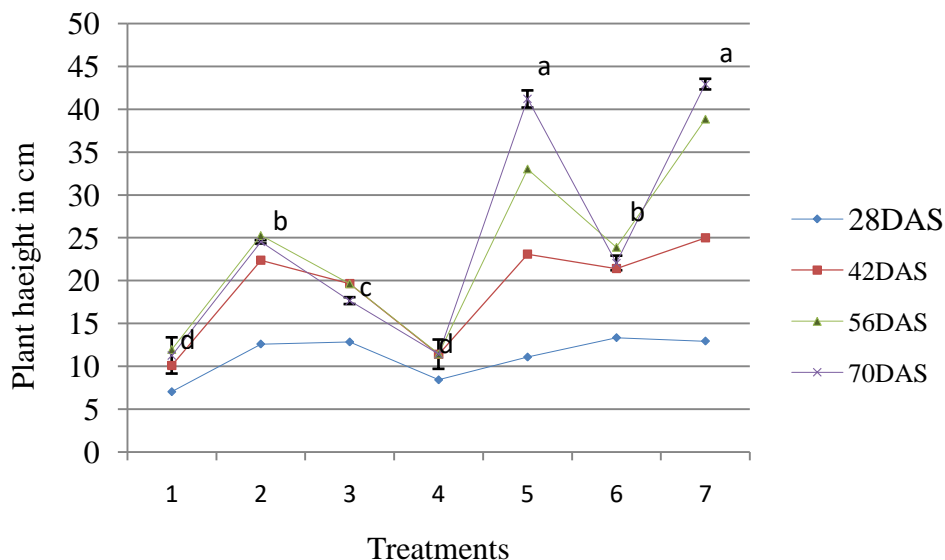


Figure1. Effect of organic manures on plant height of radish

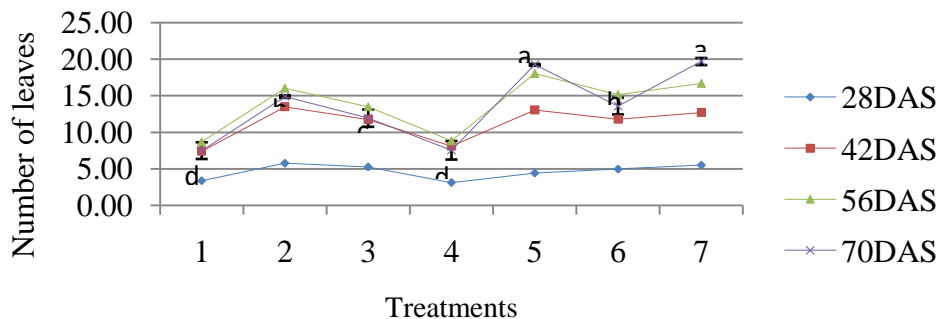


Figure 2. Effect of organic manures on number of leaves of radish

The root length in T₁ and T₄ were significantly lower than other treatments. The highest (22.80 cm) and lowest root length (12.98 cm) was observed in T₇ and T₄ respectively (Figure 3). Similarly, shoot length was significantly higher (44.49 cm) in T₇ and lower (12.73 cm) in T₁ (Figure 3). The increased growth parameters attributed to beneficial effect of PM has been reported by Uddain et al. (2010) and Subedi et al. (2018) in radish, Sylvester et al. (2015) in carrot and Jagadeesh et al. (2018) in beetroot.

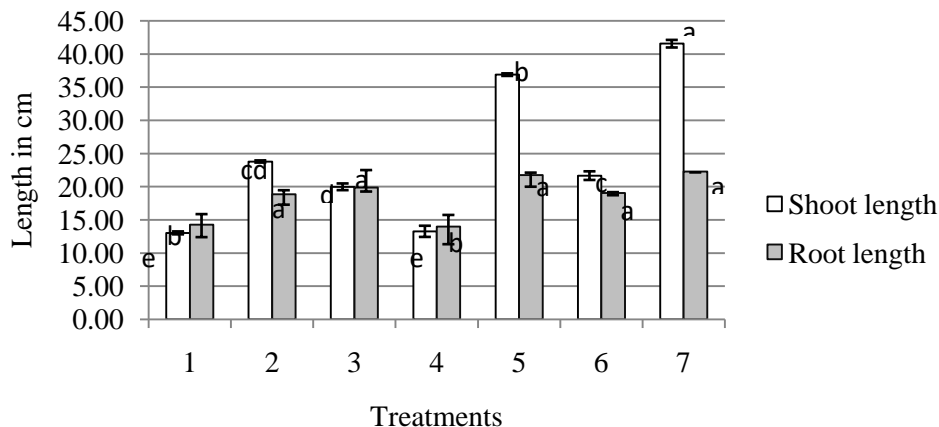


Figure 3. Effect of organic manures on root and shoot length of radish

As a fast-growing vegetable, radish requires a higher amount of nutrients (Baloch et al., 2014). PM contains 13 essential nutrients: N, P, K, Ca, Mg, S, Mn, B, Zn, Cu, Fe, Cl, Mo (Chastain et al., 2010). PM contained 30% readily available nitrogen form (Sunassee, 2002). Bonemeal contains mainly Ca, P, and some N (BARC, 2012). PSB enhances phosphorus availability to plant (Hasanuzzaman et al., 2018; Yang et al., 2018). Nitrogen has a direct effect on vegetative growth, playing role in cell division, cell enlargement, and protein synthesis (Kattab et al., 2019). Besides

the synergistic effect of N with P and K in optimal doses increased the plant height and the total number of leaves (Razaq et al., 2017; Debbarma et al., 2017) eventually increasing the photosynthate assimilation (Baloch et al., 2014) and shoot weight. This might be the reason for higher growth parameters in T₇.

Effect of organic manures on yield parameters

The root diameter was found to be significantly higher ($p < 0.05$) in T₇ (3.77 cm) and lower in T₁ (1.487 cm) followed by T₄ (1.62 cm) (Figure 4).

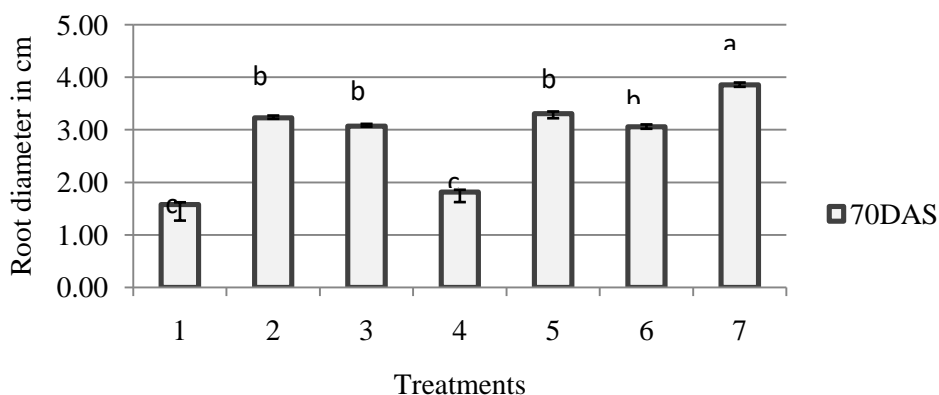


Figure 4. Effect of organic manures on root diameter of radish

The root weight, shoot weight, and biological yield were significantly higher ($p < 0.05$) in T₇ with values 211.3 gm, 170.9 gm and 382.28 gm, respectively whereas lower in T₁ with values 19.67 gm, 8.22 gm, and 27.89 gm, respectively (Table 3).

Table 3. Effect of organic manures on root weight, shoot weight and biological yield per plant at 70 DAS

Treatment	Root weight/ plant/plot (gm)	Shoot weight/ plant/plot (gm)	Biological yield /plant/plot (gm)
FYM 30 tha ⁻¹	19.67 ^d	8.223 ^d	27.89 ^e
Poultry Manure 30 tha ⁻¹	135.0 ^{bc}	41.22 ^c	176.2 ^{cd}
FYM 15 tha ⁻¹ + Poultry Manure 15 tha ⁻¹	117.7 ^c	27.22 ^c	144.9 ^d
FYM 15 tha ⁻¹ + Vermi compost 2.5 tha ⁻¹ + PSB 10 kg ha ⁻¹	26.67 ^d	8.780 ^d	35.45 ^e
FYM 15 tha ⁻¹ + Bone meal 5 tha ⁻¹ + PSB 10 kgha ⁻¹	161.0 ^b	116.4 ^b	277.4 ^b
Poultry Manure 15 tha ⁻¹ + Vermi compost 2.5 tha ⁻¹ + PSB 10 kgha ⁻¹	141.7 ^{bc}	43.44 ^c	185.1 ^c
Poultry Manure 15 tha ⁻¹ + Bone meal 5tha ⁻¹ + PSB 10 kgha ⁻¹	211.3 ^a	170.9 ^a	382.28 ^a
Sem	9.2013	5.8941	12.9472
LSD	28.35	18.16	39.89
CV %	13.72	17.17	12.77
Grand Mean	116.143	59.461	175.604

There was a significant difference ($p < 0.05$) among organic manures on dry root weight, dry shoot weight, and total dry weight per plant and found maximum in T₇ with values 46.89 gm, 50.33 gm, and 97.22 gm, respectively while minimum dry shoot weight (5.45 gm), minimum total dry weight (15 gm) were found in T₄ and dry root weight was obtained minimum (7 gm) in T₁ (Table 4).

Table 4. Effect of organic manures on dry root weight, dry shoot weight and total dry weight per plant

Treatments	Dry root weight per plant (gm)	Dry shoot weight per plant (gm)	Total Dry weight per plant (gm)
FYM 30 tha ⁻¹ (T ₁)	7 ^d	8.67 ^{cd}	15.67 ^c
Poultry Manure 30 tha ⁻¹ (T ₂)	37.44 ^{abc}	20.68 ^b	58.12 ^{cd}
FYM 15 tha ⁻¹ + Poultry Manure 15 tha ⁻¹ (T ₃)	30.00 ^c	15.44 ^{bc}	45.45 ^d
FYM 15 tha ⁻¹ + Vermi compost 2.5 tha ⁻¹ + PSB 10 kg ha ⁻¹ (T ₄)	9.56 ^d	5.45 ^d	15.00 ^e
FYM 15 tha ⁻¹ + Bone meal 5 tha ⁻¹ + PSB 10 kg ha ⁻¹ (T ₅)	35.44 ^{bc}	41.78 ^a	77.22 ^b
Poultry Manure 15 tha ⁻¹ + Vermi compost 2.5 tha ⁻¹ + PSB 10 kg ha ⁻¹ (T ₆)	43.78 ^{ab}	23.31 ^b	67.09 ^{bc}
Poultry Manure 15 tha ⁻¹ + Bone meal 5 tha ⁻¹ + PSB 10 kg ha ⁻¹ (T ₇)	46.89 ^a	50.33 ^a	97.22 ^a
Sem±	3.01	2.99	4.97
LSD	9.52	9.24	15.33
CV %	17.82	21.96	16.06
Grand Mean	30.02	23.67	53.68

The root yield, shoot yield, and biological yield were significantly ($p < 0.05$) higher in T₇, with values 49.31 tha⁻¹, 39.87 tha⁻¹, and 89.19 tha⁻¹ respectively followed by T₅. But, they were significantly lower in T₁, with values 4.58 tha⁻¹, 1.91 tha⁻¹, and 6.5 tha⁻¹, respectively, which was at par with T₄ (Table 5). The results are in conformity with the findings of Kumar et al. (2014) in respect of fresh weight and dry weight recorded highest by applying PM (50%) and Vermi compost (50%) in radish.

Table 5. Effect of organic manures on root yield per hectare, shoot yield per hectare and biological yield per hectare

Treatments	Shoot yield per hectare (tha ⁻¹)	Root yield per hectare (tha ⁻¹)	Biological yield per hectare (tha ⁻¹)
FYM 30 tha ⁻¹ (T ₁)	1.91 ^d	4.58 ^d	6.5 ^e
Poultry manure 30 tha ⁻¹ (T ₂)	9.61 ^c	31.5 ^{bc}	41.12 ^{cd}
FYM 15 tha ⁻¹ + Poultry manure 15 tha ⁻¹ (T ₃)	6.35 ^c	27.46 ^c	33.81 ^d
FYM 15 tha ⁻¹ + Vermi compost 2.5 tha ⁻¹ + PSB 10 kgha ⁻¹ (T ₄)	2.04 ^d	6.2 ^d	8.27 ^e
FYM 15 tha ⁻¹ + Bone meal 5 tha ⁻¹ + PSB 10 kg ha ⁻¹ (T ₅)	27.17 ^b	37.57 ^b	64.74 ^b
Poultry manure 15 tha ⁻¹ + Vermi compost 2.5 tha ⁻¹ + PSB 10 kg ha ⁻¹ (T ₆)	10.14 ^c	33.06 ^{bc}	43.19 ^c
Poultry manure 15 tha ⁻¹ + Bone meal 5 tha ⁻¹ + PSB 10 kg ha ⁻¹ (T ₇)	39.87 ^a	49.31 ^a	89.19 ^a
Sem ±	1.37	2.14	3.02
LSD	4.23	6.61	9.3
CV %	17.17	13.72	12.77
Grand Mean	13.87	27.1	40.97

More number of leaves, accumulates more photo synthates, utilized in root cell differentiation, elongation, and is also stored in roots (Shrestha and Thapa, 2018). This has led to significantly higher root length and diameter (Figure 3 and 4) in T₇. PM combined with bone meal and PSB has higher phosphorus availability which largely influences the root growth by helping in cell division, photosynthesis, carbohydrate metabolism, enzyme activation, and nutrient translocation. Subedi et al. (2018) observed longer and wider roots of radish in the treatments containing PM either alone or in combination with chemical fertilizer due to higher organic manure and nutrient content (NPK and micro nutrients). Similarly, Khatri et al. (2019) assigned the highest biomass in PM than FYM to the low C/N ratio of PM contributing to faster decomposition and quick release of nutrients. Debbarma et al. (2018) reported that vermi compost and PM increased the nitrogen constituent in cell sap of the meri-statimatic tissue ensuring enhanced vegetative growth and accumulating more carbohydrate for increase in root size. Researches have shown PSB and bone meal to be alternative nutrient supplementation. Silva et al. (2019)

demonstrated increase in height, number of node, phosphorus content in plant tissue of sugarcanes with phosphate fertilization by bone meal. PSB in conjunction with mineral fertilizer had highest seed yield in sunflower due to efficient mobilization of soil phosphorus (Ekin, 2010). In addition the interactions between nutrients are also important for yield in plants. Hasanuzzaman et al. (2018) reported the synergistic effect of Mg and B with P. Chowdhury et al. (2015) observed higher test weight due to the interaction between B and P. Nitrogen and phosphorus are limiting nutrient in plant growth and development (Khandaker et al., 2017), any of their deficiency affect the plant health (Gholizadeh et al., 2009). FYM being the poor source (Kushwah et al., 2020; BARC, 2012) cannot escalate the plant growth. Therefore, yield was observed lowest in FYM (30 tha^{-1}).

Effect of organic manures on quality parameters

Vitamin C content was significantly ($p < 0.05$) higher in T_2 (2.87 mgml^{-1}) and lower in T_1 (1.93 mgml^{-1}), while all other treatments showed similar result which were intermediate between T_2 and T_1 . There was no significant difference ($p < 0.05$) among the organic manures in TSS content. However, the highest TSS (2.20° Brix) was observed in T_5 and T_2 (Table 6). According to Singh et al. (2016) maximum TSS and vitamin-C content was recorded in FYM (50 %) and PM (50 %) in radish. However, the beneficial effect in growth, yield and quality parameters were observed in vermi compost (50 %) and PM (50 %) (Singh et al., 2016).

Table 6. Effect of organic manures on Vitamin-C and TSS Content

Treatment	Vitamin-C	TSS Content (° brix)
FYM 30 tha^{-1}	1.927 ^b	2.167 ^a
Poultry manure 30 tha^{-1}	2.870 ^a	2.200 ^a
FYM 15 tha^{-1} + Poultry manure 15 tha^{-1}	2.683 ^a	2.033 ^a
FYM 15 tha^{-1} + Vermi compost 2.5 tha^{-1} + PSB 10 kg ha^{-1}	2.340 ^{ab}	1.867 ^a
FYM 15 tha^{-1} + Bone meal 5 tha^{-1} + PSB 10 kg ha^{-1}	2.307 ^{ab}	2.200 ^a
Poultry manure 15 tha^{-1} + Vermi compost 2.5 tha^{-1} + PSB 10 kg ha^{-1}	2.757 ^a	2.000 ^a
Poultry manure 15 tha^{-1} + Bone meal 5 tha^{-1} + PSB 10 kg ha^{-1}	2.460 ^{ab}	2.033 ^a
Sem \pm	0.21	0.21
LSD	0.6561	0.6390
CV %	14.91%	17.35%
Grand Mean	2.478	2.071

Note: Sem= Standard error of mean, LSD= Least Significant Difference, CV= Coefficient of Variations. Treatments means are separated by Duncan's Multiple Range Test (DMRT) and the columns are represented by same letter(s) are non-significantly different among each other at 5 % level of significance.

The higher vitamin-C content in the PM could be attributed to higher potassium content as it improves the quality of crops. Peter et al. (2014) had derived the quadratic relationship between broiler litter and vitamin-C content. Fontes et al. (2000) reported increased ascorbic acid, total acidity, and sugars in tomato due to potassium. Abanto-Rodriguez et al. (2016) observed positive relation of ascorbic acid to the concentration of Mg and P in camucamu plants.

CONCLUSION

The organic manures had statistically significant variation ($p < 0.05$) in all the growth and yield parameters including vitamin-C in quality parameter but no significant difference was found in TSS content. The performance of T₇ was found superior in all recorded growth and yield parameters followed by T₅. Therefore, PM 15 tha^{-1} + bone meal 5 tha^{-1} + PSB 10 kg ha^{-1} may be suggested to the radish growers of Nepal. This experiment should be conducted in a different agro domain for further validation. It should be conducted with different doses of the PM + bone meal + PSB as well.

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