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Effect of enriched compost and humic acid on quality and nutrient status of soil after harvest of Safed Musli under inceptisols

Priya Dhayal, AB Age, SD Jadhao and AA Magdum

Abstract
The present investigation entitled, "Effect of enriched compost and humic acid on quality and nutrient status of soil after harvest of Safed Musli under inceptisols" was conducted during kharif, 2021-22 at Research Farm, Nagarjun Medicinal Plants Garden, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra. The soil of the experimental site was moderately alkaline in reaction, low in available nitrogen, medium in available phosphorus and high in available potassium. The objectives were to study the effect of enrich NPS compost and foliar application of humic acid on quality of Safed Musli and to assess the effect of enrich NPS compost and humic acid on the fertility status of soils. The results showed that, the quality parameters such as saponin content (%) and saponin yield (kg ha^{-1}), protein content (%), fiber content (%) and carbohydrate content (%) in roots of Safed Musli were recorded significantly highest in the treatment NPS compost @ 4.5 t ha^{-1} + 2 sprays of 0.5% humic acid. Whereas the significant improvement in chemical properties of soil were recorded in the same treatment which was found at par with the application NPS compost @ 3.0 t ha^{-1} + 2 sprays of 0.5% humic acid.

Keywords: Safed musli, quality parameters, yield, available NPK, fresh root yield, medicinal crop, carbohydrate content

Introduction
Safed Musli (*Chlorophytum borivilianum)* is one of the important medicinal root herbs in the Liliaceae family. It is widely spread throughout India, especially in the Himalayan valley, Satpuda, Vindhya, and Aravalli, as well as in some regions of Rajasthan, Gujarat, and Maharashtra. In Maharashtra, particularly in Vidarbha, Safed Musli found widely in the forest of Melghat, chikhaldara and Satpuda hills nearby Akot (Akola) and Jalgaon Jamod (Buldana). Safed Musli's fasciculated storage roots are economically important because they have aphrodisiac properties and are used in herbal tonics (Kirtikar and Basu, 1975) [18]. The major constituents of Safed Musli are carbohydrates (42%), proteins (8-9%), root fibers (3-4%), saponin (2-17%) reported by Bordia *et al.* (1995). The roots of Safed Musli have also been scientifically proven to have anti stress and antioxidant properties and hence its potential in the herbal industry. Due to its high saponin content, the roots of Safed Musli are extremely valuable as a medicinal plant and are frequently used in Ayurvedic treatments (Wankhede *et al.* 2004) [32]. Foreign demand has been estimated as 300-400 tons annually (Kothari and Singh, 2003) [19]. For obtaining good quality roots, the plant growth medium should be porous with optimum fertility status. In that context, the application of organic source might be proved best for improving physical properties of soil as well as provide nutrients to the crop. Application of nitrogen, phosphorous, potassium and along with the organic sources accelerate the growth which in turn provide efficient framework for high rate of nutrient absorption and net assimilation for productive metabolism of Safed Musli.

Intensive cropping has made the soil deficient in macro as well as micronutrients. This has resulted decline in productivity and deterioration in soil health and productivity. Use of organic manure may prove a viable option for sustaining the productivity (Tejada *et al.* 2009) [27]. It was also reported that the application of organic nutrients improves the quality of medicinal and aromatic plants (Khan *et al.* 2015) [17]. In general, the bulky organic manures like FYM and compost contain, on an average, 0.5-1.0% N, 0.2-0.5% P_2O_5, 0.5-1.0% K_2O. To overcome this problem, preparation of enriched compost by adding nitrogen, phosphorus, potassium, Sulphur, and micronutrients either alone or in combination is the viable option. Extraction of humic substances from bulky organic manures and their use may help to solve many problems associated with organic manures. Humic substances play a vital role in soil fertility and plant nutrition. Humic substances are criteria of soil fertilization because in addition to supplying the plants needed nitrogen, they provide the best suitable perimeter for plant growing. In this context, an attempt has been made to extract the humic substances from vermicompost available at the site to check its effects on Safed Musli applied through foliar application.

Materials and Methods

The field experiment was conducted at Research Farm, Nagarjun Medicinal Plant Garden, Department of Soil Science and Agricultural Chemistry, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during kharif season 2021-22 which lies in the subtropical region at the latitude of 22° 42' 19.2" North and 77° 03' 43.2" East at the altitude of 30.78 (m) above mean sea level (MSL). The experiment was laid out in Randomized Block Design with nine treatments replicated in three replications. The treatments comprised of T_1-absolute control, T_2-Vermicompost @ 5 t ha^{-1}, T_3-NPS compost @ 3 t ha^{-1},T_4-Vermicompost @ 2.5 t ha^{-1} + 2 sprays of 0.5% humic acid, T_5-Vermicompost @ 5.0 t ha^{-1} + 2 sprays of 0.5% humic acid, T_6-Vermicompost @ 7.5 t ha^{-1} + 2 sprays of 0.5% humic acid, T_7-NPS compost @ 1.5 t ha^{-1} + 2 sprays of 0.5% humic acid, T_8-NPS compost @ 3.0 t ha^{-1} + 2 sprays of 0.5% humic acid, T_9-NPS compost @ 4.5 t ha^{-1} + 2 sprays of 0.5% humic acid. The humic acid sprayed at 45 and 75 days after planting of safed musli. Fasciculated roots @ 3.33 lakh sprouted roots ha^{-1} were planted at 30 × 10 cm on broad bed furrows in third week of June. Uniform cultivation practices were followed during the growth period of crop. The quality parameters of Safed Musli viz., saponin content (%), saponin yield (kg ha^{-1}), protein content (%), fiber content (%) and carbohydrate content (%) were recorded. Saponin content was estimated by root extract was treated with Chloroform and Ethyl acetate by Gravimetric method as described by Brik *et al.* (1963). The protein content was determined by multiplying the percent N in root and leaves sample by constant factor 6.25 for Safed Musli as described by A.O.A.C. (1975). The fiber content was estimated by root digestion in acid and alkali by Acid-Alkali method as described by Maynard (1970) [22]. Carbohydrate content was estimated by Anthrone method (Ludwig *et al*. 1956) [21]. The soil samples collected before sowing and after harvest were analysed for the soil properties viz., pH, EC, organic carbon content, available nitrogen, phosphorus, potassium, sulphur and DTPA – Fe, Mn, Zn, Cu. Soil organic carbon was determined by using wet oxidation method (Walkley and Black, 1934) [31]. The available nitrogen was determined by using steam distillation method (Subbiah and Asija, 1956) [26]. Available phosphorus was determined Colorimetrically by Olsen's method. Available potassium in soil samples were determined by using the method of Jackson, 1973 [16]. Available sulphur content in soil samples were measured following the method outlined by Chesnin and Yien, 1951 [8]. Available Zn, Fe, Mn and Cu were determined by following the method described by Lindsay and Norvell, 1978 [20]. The data was subjected to analysis of variance (ANOVA) in randomized block design (RBD) and interpreted as described by Gomez and Gomez (1984) [13].

Results and Discussion

Quality parameters of Safed Musli.

Saponin content and Saponin Yield

The perusal of data on effect of NPS enriched compost and humic acid on saponin content and saponin yield of Safed Musli is presented in Table 1. Saponin content in roots of Safed Musli under different treatments varied from 6.03% to 7.27%. Further, it was observed that total saponin content in roots of safed musli was recorded significantly highest with the application of NPS compost @ 4.5 t ha^{-1} + 2 sprays of 0.5% humic acid at 45 and 75 DAP (7.27%) which was found at par with application of NPS compost @ 3.0 t ha^{-1} + 2 sprays of 0.5% humic acid at 45 and 75 DAP (7.18%), vermicompost @ 7.5 t ha^{-1} + 2 sprays of 0.5% humic acid at 45 and 75 DAP (6.90%) and found superior over rest of treatments. The lowest saponin content in roots of Safed Musli was found in absolute control (6.03%). Similarly, the saponin yield was obtained significantly highest with application of NPS compost @ 4.5 t ha^{-1} + 2 sprays of 0.5% humic acid at 45 and 75 DAP (32.00 kg ha^{-1}) which was found at par with the application of NPS compost @ 3.0 t ha^{-1} + 2 sprays of 0.5% humic acid at 45 and 75 DAP (31.49 kg ha^{-1}) and Vermicompost @ 7.5 t ha^{-1} + 2 sprays of 0.5% humic acid at 45 and 75 DAP (29.32 kg ha^{-1}) and found superior over rest of the treatments. This might be due to proper availability and uptake of nitrogen which lead to balanced C:N ratio and increased plant metabolic activity resulted into increased saponin content reported by Gaikwad *et al.* (2014) [12]. Also, humic acid resulted better quality in terms of saponin is the active ingredient might be due to proper utilization of solar light with balanced nutrition resulted in better synthesis of secondary metabolites and ultimately good root quality. These results are in line with the results of Wankhede *et al*. (2004) [32], Gaikwad *et al*. (2014) [12] and Aishwath and Tarafdar (2017) [2].

Protein, fiber and carbohydrate content

The perusal of data on effect of NPS enrich compost and humic acid on protein content, fiber and carbohydrate content in roots of Safed Musli are presented in Table 2. The protein content in roots of Safed Musli ranged from 13.54 to 14.38%. The results revealed that, the protein content in roots of Safed Musli was obtained maximum with the application of NPS compost @ 4.5 t ha^{-1} + 2 sprays of 0.5% humic acid at 45 and 75 DAP (14.38%) followed by NPS compost @ 3.0 t ha^{-1} + 2 sprays of 0.5% humic acid at 45 and 75 DAP (14.21%). The lowest protein content was found in absolute control (13.54%).

However, significantly highest fiber content in roots of Safed Musli was recorded with the application of NPS compost @ 4.5 t ha^{-1} + 2 sprays of 0.5% humic acid at 45 and 75 DAP (4.63%) which was found on par with treatment NPS compost @ 3.0 t ha^{-1} + 2 sprays of 0.5% humic acid at 45 and 75 DAP (4.42%), NPS compost @ 3.0 t ha^{-1} (4.32%) and rest of the treatments and found superior over absolute control. The lowest fiber content of Safed Musli was recorded in absolute control (3.21%).

Whereas, the NPS Compost @ 4.5 t ha^{-1} + 2 sprays of 0.5% humic acid at 45 and 75 DAP was recorded significantly highest carbohydrate content (41.75%) which was found at par with NPS compost @ 3.0 t ha^{-1} + 2 sprays of 0.5% humic acid at 45 and 75 DAP (40.47%) and Vermicompost @ 7.5 t ha^{-1} + 2 sprays of 0.5% humic acid at 45 and 75 DAP (39.42%) and found superior over absolute control. This increment in carbohydrate content might be due to promising role of compost to supply the growing plants with required macro and micro nutrients which play important role in metabolic process as photosynthesis, respiration and carbohydrate synthesis. Also, humic compounds prevent creation of insoluble phosphorus salts and phosphorus stimulates rubisco enzyme activity which resulted in an increased in the amounts of carbohydrate. These findings are in accordance with Yadav and Yadav (2010) [34] and Fouda (2021) [11].

Fertility status of soil

pH, EC and Organic carbon

The data pertaining to pH, EC and organic carbon after harvest of Safed Musli are presented in Table 3. The data showed that, soil pH was varied from 8.11-8.07. Soil pH of soil after harvest of Safed Musli were recorded non-significant among all the treatments. Numerical reduction of pH was recorded with the application of NPS compost @ 4.5 t ha^{-1} + 2 sprays of 0.5% humic acid at 45 and 75 DAP (8.07) followed by NPS compost @ 3.0 t ha^{-1} + 2 sprays of 0.5% humic acid at 45 and 75 DAP (8.08).

However, soil EC was recorded significantly lowest with the application of NPS compost @ 4.5 t ha^{-1} + 2 sprays of 0.5% humic acid at 45 and 75 DAP (0.38 dSm^{-1}) which was found at par with NPS compost @ 3.0 t ha^{-1} + 2 sprays of 0.5% humic acid at 45 and 75 DAP (0.39 dSm^{-1}), NPS Compost @ 1.5 t ha^{-1} + 2 sprays of 0.5% Humic acid at 45 and 75 DAP (0.39 dSm^{-1}) and NPS Compost @ 3 t ha^{-1} (0.39 dSm^{-1}) over the absolute control. The highest pH and EC were recorded in absolute control. The lowest pH and EC were recorded with the application of NPS compost @ 4.5 t ha^{-1} + 2 sprays of 0.5% humic acid which might be due to release of organic acids during the process of decomposition of organic manures might be attributed to decline in pH, which can be attributed to the buffering effect caused due to organic matter, however the lowering of EC values under same treatments is ascribed to the increased permeability and consequently the leaching of salts (Halemani *et al.* 2004) [15].

Whereas, the organic carbon was recorded significantly highest with the application of NPS compost @ 4.5 t ha^{-1} + 2 sprays of 0.5% humic acid at 45 and 75 DAP (5.68 g kg^{-1}) which was found at par with NPS compost @ 3.0 t ha^{-1} + 2 sprays of 0.5% humic acid + 2 sprays of 0.5% humic acid at 45 and 75 DAP (5.56 g kg^{-1}), vermicompost @ 7.0 t ha^{-1} at 45 and 75 DAP (5.54 g kg^{-1}) and NPS Compost @ 3 t ha^{-1} (5.52 g kg^{-1}) over rest of organic treatments and superior over absolute control. The initial organic carbon before sowing was 5.16 g kg^{-1} which was increased to 5.68 g kg^{-1} in NPS compost @ 4.5 t ha^{-1} + 2 sprays of 0.5% humic acid at 45 and 75 DAP might be attributed to the application of organic manures that encouraged the proliferation of the soil microbial environment and biomass of root system might have resulted in increased carbon content. It could be also due to addition of organic manures that decreased the soil bulk density due to better aggregation, and the increase in porosity resulted in higher soil organic carbon. These results were conformity with the findings of Nagar *et al.* (2016) [23]

Available macro and micro-nutrients of soil after harvest of Safed Musli

Available N, P and K

The data pertaining to available nitrogen, phosphorus and potassium after harvest of Safed Musli indicating that enriched compost and humic acid application had significance influence on it and are presented in Table 4. The results revealed that, significantly highest available nitrogen was recorded with application of NPS compost @ 4.5 t ha^{-1} + 2 sprays of 0.5% humic acid at 45 and 75 DAP (266.83 kg ha^{-1}) which was found at par with application of NPS compost @ 3.0 t ha^{-1} + 2 sprays of 0.5% humic acid at 45 and 75 DAP (262.50 kg ha^{-1}) and Vermicompost @ 7.5 t ha^{-1} + 2 sprays of 0.5% humic acid 45 and 75 DAP (259.83 kg ha^{-1}) with rest of organic treatments and found superior over absolute control. The significant improvement in available N status was recorded in treatment NPS compost @ 4.5 t ha^{-1} + 2 sprays of 0.5% humic acid might be due to higher available N contents that attributed to the formation of phosphor-protein which is less susceptible to volatilization. The proteins are decomposed by soil bacteria and changed into ammonium that is further nitrified by nitrifying bacteria. This form of nitrogen from compost is slowly available to the plants having fewer chances of loss through volatilization. The escape of ammonia from soil decreases if the nitrogen source is compost. These results are accordance with the observations of Ansari *et al.* (2008) [3], Canellas *et al.* (2015) [7] and Nagar et al. (2016) [23].

However, significantly highest available phosphorus was recorded with application NPS compost @ 4.5 t ha^{-1} + 2 sprays of 0.5% humic acid at 45 and 75 DAP (30.04 kg ha^{-1}) which was found at par with NPS compost @ 3.0 t ha^{-1} + 2 sprays of 0.5% humic acid at 45 and 75 DAP (29.37 kg ha^{-1}) and NPS compost @ 1.5 t ha^{-1} + 2 sprays of 0.5% humic acid at 45 and 75 DAP (29.05 kg ha^{-1}) with rest of organic treatments and found superior over absolute control. The increased in available phosphorus status in treatment NPS compost @ 4.5 t ha^{-1} + 2 sprays of humic acid might be attributed to narrow down C: N ratio of soil which might have produced more humic acid and humic substances form chelates with phosphorus. The chelated phosphorous has been reported to be more soluble in water, which could make it easily available to crops reported by Gopinath et al. (2009) [14], Nagar *et al.* (2016) [23].

Similarly, the available potassium in soil after harvest of Safed Musli was recorded significantly highest with the application NPS compost @ 4.5 t ha^{-1} + 2 sprays of 0.5% humic acid at 45 and 75 DAP (289.92 kg ha^{-1}) which was found at par with application of NPS compost @ 3.0 t ha^{-1} + 2 sprays of 0.5% humic acid at 45 and 75 DAP (287.70 kg ha^{-1}), NPS compost @ 3.0 t ha^{-1} (284.73 kg ha^{-1}), and Vermicompost @ 7.5 t ha^{-1} + 2 sprays of 0.5% humic acid at 45 and 75 DAP (284.66 kg ha^{-1}) with rest of organic treatments and found superior over absolute control.The lowest available Nitrogen, phosphorus and potassium were recorded in absolute control. The increased in available K status in treatment NPS compost @ 4.5 t ha^{-1} + 2 sprays of humic acid might be due to the reason that during the process of decomposition of various organic manures, organic acids were secreted, resulting in the mineralization of fixed K and increased K availability. Furthermore, humus holds divalent cations (Ca^{+2}, Mg^{+2}) better than monovalent cations. Potassium retention is expected to be lower as compared to Ca^{+2} and Mg^{+2}, that would enhance K availability in soil. These results are accordance with Gopinath *et al.* (2009) [14], Arjumend *et al.* (2015) [4] and Nagar *et al.* (2016) [23].

Available Sulphur

The data pertaining to available Sulphur after harvest of Safed Musli was significantly influenced by NPS enriched compost and humic acid are presented in Table 2. The significantly highest available sulphur was recorded with application of NPS compost @ 4.5 t ha^{-1}+ 2 sprays of 0.5% humic acid at 45 and 75 DAP (13.10 mg kg^{-1}) which was found at par with Vermicompost @ 7.5 t ha^{-1} + 2 sprays of 0.5% humic acid at 45 and 75 DAP (12.83 mg kg^{-1}), NPS compost @ 3.0 t ha^{-1} + 2 sprays of 0.5% humic acid at 45 and 75 DAP (12.81 mg kg^{-1}) and Vermicompost @ 5.0 t ha^{-1} + 2 sprays of 0.5% humic acid at 45 and 75 DAP (12.54 mg ha^{-1}) over rest of the treatments and superior over the absolute control. The increased in available sulphur might be due to addition of NPS compost @ 4.5 t ha^{-1} improved soil physical and microbiological properties that resulted in S solubilization in addition to the direct supply of S through organic materials. Similar observations were reported by Ullah *et al.* (2008) [28], Das and Singh (2014) [10] and Sheoran *et al*. (2020) [25].

DTPA-extractable micro-nutrients (Fe, Mn, Zn and Cu)

The perusal of data on effect of enriched NPS compost and humic acid on DTPA extractable Fe, Mn, Zn and Cu of soil after harvest of Safed Musli was significantly influenced and is presented in Table 5. The availability of ferrous in soil after harvest of safed musli was recorded significantly highest with application of NPS compost @ 4.5 t ha^{-1} + 2 sprays of 0.5% humic acid at 45 and 75 DAP (4.92 mg kg^{-1}) which was found at par with rest of the treatments and superior over the absolute control. Further, it was noted that available manganese was recorded significantly highest with the application of NPS compost @ 4.5 t ha^{-1} + 2 sprays of 0.5% humic acid at 45 and 75 DAP (8.17 mg kg^{-1}) which was found at par with rest of the treatments and superior over absolute control.

Whereas, the available zinc was recorded significantly highest with application of NPS compost @ 4.5 t ha^{-1} + 2 sprays of 0.5% humic acid (0.74 mg kg^{-1}) which was found at par with NPS compost @ 3.0 t ha^{-1} + 2 sprays of 0.5% humic acid (0.71 mg kg^{-1}) and NPS compost @3.0 t ha^{-1} (0.69 mg kg^{-1}) over the absolute control. Similarly, the availability of copper was recorded significantly highest with application of NPS compost @ 4.5 t ha^{-1} + 2 sprays of 0.5% humic acid at 45 and 75 DAP (2.56 mg kg^{-1}) which was found at par with rest of treatments and found superior over absolute control.

The increment in DTPA-extractable micro-nutrients in soil after harvest of crop might be associated with incorporation of NPS compost @ 4.5 t ha^{-1} along with two sprays of humic acid that might be attributed to the chelating action of organic sources that are liberated due to decomposition of organic sources that advantages in availability of micronutrients through prevention of some particular processes like fixation, oxidation, precipitation and leaching. Also, during the decomposition of organic manures liberated a number of organic acids, lowered the soil pH and increased the intensity of reduction in soil as a result availability of micronutrients increases. These results are accordance with Prakash *et al.* (2002) [25], Biswas *et al.* (2012) [5], Danyaei *et al.* (2017) [9] and Venkatesh *et al.* (2017) [29], Walia *et al*. (2008) [30].

Table 1: Effect of NPS enriched compost and foliar application of humic acid on saponin content and saponin yield of Safed Musli roots.

Treatments		Saponin content (%)	Saponin yield (kg ha^{-1})
T_1	Absolute control	6.03	19.52
T_2	Vermicompost @ 5 t ha^{-1}	6.49	24.13
T_3	NPS Compost @ 3 t ha^{-1}	6.53	26.25
T_4	Vermicompost @ 2.5 t ha^{-1} + 2 sprays of 0.5% Humic acid	6.29	23.81
T_5	Vermicompost @ 5.0 t ha^{-1} + 2 sprays of 0.5% Humic acid	6.63	26.71
T_6	Vermicompost @ 7.5 t ha^{-1} + 2 sprays of 0.5% Humic acid	6.90	29.32
T_7	NPS Compost @ 1.5 t ha^{-1} + 2 sprays of 0.5% Humic acid	6.27	25.06
T_8	NPS Compost @ 3.0 t ha^{-1} + 2 sprays of 0.5% Humic acid	7.18	31.49
T_9	NPS Compost @ 4.5 t ha^{-1} + 2 sprays of 0.5% Humic acid	7.27	32.00
SE (m) ±		0.13	1.16
CD at 5%		0.39	3.48

Table 2: Effect of NPS enriched compost and foliar application of humic acid on protein, fiber and carbohydrate content in roots of Safed Musli.

Treatments		Protein content in roots (%)	Fiber content in roots (%)	Carbo. Content in roots (%)
T_1	Absolute control	13.54	3.21	37.27
T_2	Vermicompost @ 5 t ha^{-1}	13.96	3.97	38.22
T_3	NPS Compost @ 3 t ha^{-1}	14.17	4.32	38.96
T_4	Vermicompost @ 2.5 t ha^{-1} + 2 sprays of 0.5% Humic acid	13.85	3.59	37.71
T_5	Vermicompost @ 5.0 t ha^{-1} + 2 sprays of 0.5% Humic acid	14.00	4.11	37.73
T_6	Vermicompost @ 7.5 t ha^{-1} + 2 sprays of 0.5% Humic acid	14.17	4.32	39.42
T_7	NPS Compost @ 1.5 t ha^{-1} + 2 sprays of 0.5% Humic acid	13.96	3.53	38.83
T_8	NPS Compost @ 3.0 t ha^{-1} + 2 sprays of 0.5% Humic acid	14.21	4.42	40.47
T_9	NPS Compost @ 4.5 t ha^{-1} + 2 sprays of 0.5% Humic acid	14.38	4.63	41.75
SE (m) ±		0.43	0.43	0.53
CD at 5%		NS	1.29	1.60

Table 3: Effect of NPS enriched compost and foliar application of humic acid on pH, EC, and Organic Carbon

Treatments		pH (1: 2.5)	EC (dSm^{-1})	OC ($g\ kg^{-1}$)
T_1	Absolute control	8.11	0.42	5.24
T_2	Vermicompost @ 5 t ha^{-1}	8.10	0.40	5.39
T_3	NPS Compost @ 3 t ha^{-1}	8.08	0.39	5.52
T_4	Vermicompost @ 2.5 t ha^{-1} + 2 sprays of 0.5 % Humic acid	8.10	0.41	5.42
T_5	Vermicompost @ 5.0 t ha^{-1} + 2 sprays of 0.5 % Humic acid	8.09	0.40	5.43
T_6	Vermicompost @ 7.5 t ha^{-1} + 2 sprays of 0.5 % Humic acid	8.08	0.40	5.54
T_7	NPS Compost @ 1.5 t ha^{-1} + 2 sprays of 0.5 % Humic acid	8.09	0.39	5.47
T_8	NPS Compost @ 3.0 t ha^{-1} + 2 sprays of 0.5 % Humic acid	8.08	0.39	5.56
T_9	NPS Compost @ 4.5 t ha^{-1} + 2 sprays of 0.5 % Humic acid	8.07	0.38	5.68
SE (m) ±		0.014	0.003	0.047
CD at 5 %		NS	0.010	0.141

Table 4: Effect of NPS enriched compost and foliar spray of humic acid on available sulphur of soil after harvest of Safed Musli.

Treatments		Available Sulphur ($mg\ kg^{-1}$)
T_1	Absolute control	9.58
T_2	Vermicompost @ 5 t ha^{-1}	11.52
T_3	NPS Compost @ 3 t ha^{-1}	11.35
T_4	Vermicompost @ 2.5 t ha^{-1} + 2 sprays of 0.5% Humic acid	11.01
T_5	Vermicompost @ 5.0 t ha^{-1} + 2 sprays of 0.5% Humic acid	12.54
T_6	Vermicompost @ 7.5 t ha^{-1} + 2 sprays of 0.5% Humic acid	12.83
T_7	NPS Compost @ 1.5 t ha^{-1} + 2 sprays of 0.5% Humic acid	11.26
T_8	NPS Compost @ 3.0 t ha^{-1} + 2 sprays of 0.5% Humic acid	12.81
T_9	NPS Compost @ 4.5 t ha^{-1} + 2 sprays of 0.5% Humic acid	13.10
SE (m) ±		0.49
CD at 5%		1.47

Table 5: Effect of NPS enriched compost and foliar application of humic acid on micronutrients status of soil after harvest of Safed Musli.

Treatments		Available nutrients ($mg\ kg^{-1}$)			
		Zn	Fe	Mn	Cu
T_1	Absolute control	0.62	4.77	7.96	2.40
T_2	Vermicompost @ 5 t ha^{-1}	0.66	4.84	8.07	2.49
T_3	NPS Compost @ 3 t ha^{-1}	0.69	4.87	8.09	2.52
T_4	Vermicompost @ 2.5 t ha^{-1} + 2 sprays of 0.5% Humic acid	0.67	4.83	8.06	2.44
T_5	Vermicompost @ 5.0 t ha^{-1} + 2 sprays of 0.5% Humic acid	0.68	4.85	8.09	2.50
T_6	Vermicompost @ 7.5 t ha^{-1} + 2 sprays of 0.5% Humic acid	0.68	4.87	8.11	2.53
T_7	NPS Compost @ 1.5 t ha^{-1} + 2 sprays of 0.5% Humic acid	0.68	4.86	8.08	2.51
T_8	NPS Compost @ 3.0 t ha^{-1} + 2 sprays of 0.5% Humic acid	0.71	4.88	8.11	2.53
T_9	NPS Compost @ 4.5 t ha^{-1} + 2 sprays of 0.5% Humic acid	0.74	4.92	8.17	2.56
SE (m) ±		0.036	0.044	0.03	0.037
CD at 5%		0.11	0.14	0.11	0.11

Conclusion

It is concluded that, the application of NPS compost @ 4.5 t ha^{-1} along with two sprays of 0.5% humic acid at 45 and 75 DAP recorded significantly highest quality parameters viz., protein content, saponin content and yield, fiber content and carbohydrate content in roots of Safed Musli as well as improvement in soil fertility status after harvest of Safed Musli were recorded with the application of NPS compost @ 4.5 t ha^{-1} along with two sprays of 0.5% humic acid at 45 and 75 DAP.

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