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Impact of Vermicompost, Poultry Manure and *Jeevaamrit* on Growth Parameters of Kiwifruit (*Actinidia deliciosa*) cv. Allison

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Authors' contributions

This work was carried out in collaboration among all authors. Author AKG performed the field experiment, wrote the protocol, performed the statistical analysis and wrote the first draft of the manuscript. Author RK designed and funded the study. Authors RK and VSR managed the analyses of the data and the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

The present investigation was conducted on 6 years old kiwifruit vines cultivar 'Allison' at a spacing of 4.0 m × 6.0 m for two consecutive years 2018-19 and 2019-20 at experimental block of Department of Fruit Science, Dr YS Parmar University of Horticulture and Forestry, Nauni, Solan (HP). The experiment was laid out in triplicate in Randomized Block Design with 8 treatments under three farming systems *viz*., Inorganic Fertilizer Based System (IFBS), Organic Farming Based System (OFBS) and Subhash Palekar's Natural Farming System (SPNFS). The maximum leaf area (158.1 cm^2), leaf area index (4.36), chlorophyll index (51.2), comparative photosynthetically active radiation (612 μ mol quanta m^{-2} s^{-1}) was found in the treatment (T_8) receiving 30 liters of jeevaamrit (*JM*) + 3 kg *ghana jeevaamrit* and 40 kg FYM per vine under SPNFS. Among OFBS, the treatment T_2 (100% recommended dose of nitrogen (RDN) through vermicompost and poultry manure on

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50:50 basis) observed maximum leaf area (151.8 cm^2), leaf area index (4.35), comparative photosynthetically active radiation (642 μ mol quanta m^{-2} s^{-1}) but lower significantly lower chlorophyll index (51.2) over T_1 (Recommended dose of inorganic fertilizers + FYM) treatment of IFBS. Hence application of 30 litres *jeevaamrit* and 3 kg *ghana jeevaamrit* (both in 3 equal splits first in end of January, second in February and third in the month of April) along with 40 kg FYM per vine or alternatively substitution of 100% RDN through vermicompost and poultry manure on 50:50 basis along with 40 kg FYM were found to be best and alternate different option in place of inorganic fertilizers to 'Allison' cultivar of kiwifruit under mid-hill conditions of Himachal Pradesh, India. Furthermore, the research emphases mainly on improving soil health without compromising growth and yield of kiwifruits in the region. By using alternative sources of nutrients, farmers can obtain the comparable growth and yield of kiwifruits.

Keywords: Vermicompost; poultry manure; jeevaamrit; Ghana jeevaamrit; kiwifruit; leaf area; chlorophyll index.

1. INTRODUCTION

Kiwifruit (*Actinidia deliciosa*) has originated in China, but commercially exploited in New Zealand. Its fruits are rusty brown with hairy surface, oblong in shape, light green flesh and small soft seeds. Himachal Pradesh contributes only 3.2% of total production of kiwifruit in India from an area of only 123 ha [1]. Kiwifruit vines requires 700-800 chilling hours below 7°C besides appropriate amount of manure and fertilizers for optimum vegetative growth and quality fruit production. Kiwifruit makes such vegetative growth and yield heavily with an adequate nutrient management. After 5 years, 40 kg FYM along with 800 g of N, 600 g P_2O_5 and 800 g K_2O per vine is recommended each year in mid-hills of Himachal Pradesh. Full dose of P and K along with FYM was applied in December-January and half of N should be applied one month before flowering and remaining half one month after fruit set. The heavy production of fruits year after year depletes the soil nutrient reserves and necessitates nutrient element application in order to have economic returns every year and to maintain soil fertility at optimum level. The nutrients run-off and leaching losses in Himalayan region, increasing cost of inputs like fertilizers, and their negative effects on soil health has led to exaggerated attempts to increased use of different organic manures like vermicompost, poultry manure and natural liquid manures like *jeevaamrit* and powdered *ghana jeevaamrit.* The organic and biological sources of nutrients are environment friendly, renewable source of energy and low-cost agro-inputs. Therefore, developments of such system in which equally higher level of production using organic and natural sources are desirable for good quality produce without any detrimental effects on the environment. Vermicompost considerably reduced the incidence of diseases, proportion fruits free from any physiological disorders [2]. Poultry Manure is another possibility that can be used as a nutrient source and soil amendment. The droppings of chicken have been found to consider as a store house of nutrients. Fresh poultry manure in our experiment contained 1.65% N and 1.02% P which is double and 3-4 times than present in FYM, respectively. Dry form of PM contains more quantities of N and P than the fresh form therefore, aged PM is more preferable. Another substitute viz. Subhash Palekar's Natural Farming (SPNF) is a type of farming which has practiced in several states in India and it means without using any credit and without spending any money on purchased inputs. These strategies involve balanced supply of nutrients through organic manures by improving the soil physicochemical and biological properties and increase availability of nutrient in the soil for next season crop. Therefore, present study was planned to study the effect of application of different nutrient sources on growth parameters of kiwifruit.

2. MATERIALS AND METHODS

The present study was carried out at experimental block of Department of Fruit Science, Dr YS Parmar University of Horticulture and Forestry, Nauni, Solan (HP) for two consecutive years 2018-19 and 2019-20 on 8 years old kiwifruit vines cultivar 'Allison' at a spacing of 4.0 m × 6.0 m. The experimental site is situated at an elevation of 1260 m above mean sea level (msl) with latitude of 30º 50' North and longitude of 77º 11'30' East. The average annual rainfall of the area is about 100-130 cm and major amount of which is received during July to September months. Summer is moderately hot during May-June, while winter is severe during

December-January months. The experiment was laid out in triplicate in Randomized Block Design with 8 treatments under three farming systems *viz*., Inorganic Fertilizer Based System (IFBS), Organic Farming Based System (OFBS) and Subhash Palekar's Natural Farming System (SPNFS). The eight treatments are T_1 (N: 800 g, P_2O_5: 600 g, K_2O: 800 g + 40 kg FYM per vine) under IFBS, four treatments under OFBS namely, T_2 {100% Recommended dose of N (RDN) through vermicompost (VC) and poultry manure (PM) on 50: 50 basis + 40 kg FYM per vine}, T_3 (90% RDN through VC and PM on 50: 50 basis + 40 kg FYM per vine) and T_4 (80% RDN through VC and PM on 50: 50 basis + 40 kg FYM per vine) and T_5 (70% RDN through VC and PM on 50: 50 basis + 40 kg FYM per vine) and three treatments under SPNFS namely, T_6 {15 litres of *Jeevaamrit* (JM) + 3 kg of *Ghana Jeevaamrit* (GJ) + 40 kg FYM per vine}, T_7 (22.5 litres of JM + 3 kg of GJ + 40 kg FYM per vine) and T_8 (30 litres of JM + 3 kg of GJ + 40 kg FYM per vine). Initial surface soil samples were recorded soil pH value: 6.54, soil EC: 0.128 d S m^{-1}, soil organic carbon: 14.1 g kg^{-1}; soil available N: 282.2kg ha^{-1}; soil available P: 100.8kg P_2O_5 ha^{-1} and soil available K : 302.4kg K_2O ha^{-1}.

Jeevaamrit, a fermented microbial culture prepared from locally available natural resources, was prepared at experimental site using 10 kg local cow dung and 10 litres of local cow urine. Both of these ingredients were mixed properly with the help of wooden stick in a plastic drum of 200 litres capacity. To the well mixed cow dung and cow urine, 2 kg old jaggery, 1 kg pulse flour and 1 kg live soil from the bund of the farm were mixed thoroughly in drum having 180 litres of water and final volume was made to 200 litres. Drum was covered with wet gunny bags and kept in shade for 48 hours for fermentation. Stirring of the solution was done clockwise twice a day for 5-10 minutes. The process of fermentation was completed within 7 days and *Jeevaamrit* was ready to use. Prepared stock solution was diluted 10 times with water and used for drenching. *Ghana jeevaamrit* (GJ), a dry powdered organic manure, in which the present micro-organisms start working after getting moisture. It may protect the plants from severe hot and cold injury by strengthening the plant's power. It augments growth of plant, induce early flowering and improve quality of fruits, provides energy to tolerate adverse conditions, increases availability and absorption of nutrients etc. It was prepared by mixing of 100 kg fresh *desi* cow dung, 2 kg jaggery, 2 kg pulses flour and handful soil from the bund. All ingredients were mixed well by adding 5 litres of cow urine. The mixture was then spread on floor under shade for drying and after that it was made in powdered form using wood hammer. The prepared powdered material was stored in plastic drum and it can be used up to six months. The manures and fertilizers were broadcasted in the basin under the spread of trees 30 cm away from the trunk of vine and thoroughly mixed with soil.

Full dose of 40kg FYM, 3.75 kg single super phosphate, 1.33kg of muriate of potash was applied per vine to T_1 treatment under IFBS during start of the experiment in 2019 and repeated in the next year trial. Urea (1.74kg) was applied in two equal dressings. First dose of 870 g urea was applied slightly before bud burst (February) and second final equal dose was applied at the flowering (last week of April). The VC contained 1.09 and 1.19% N in 2019 and 2020, respectively. Similarly, PM contained 1.71 and 1.60% N in 2019 and 2020, respectively. The amount of VC and PM (calculated on the basis on N content) was added on N equivalent basis as mentioned in Table 1. Three equal split doses of VC and PM was applied during last week of January, February and April respectively. *Jeevaamrit* was used for drenching of the basin area 30 cm away from the tree trunk and applied @ 5. 7.5 and 10kg each and one kg of *ghana jeevaamrit* per tree in the end of January, February and April, in T_6, T_7 and T_8, respectively.

Leaf area of 10 fully expanded leaves collected in the month of last week of July to first week of August was recorded by using digital CI-202 portable laser leaf area meter. Leaf area index (LAI) is measured as the leaf area (m^2) per ground area (m^{-2}) and is unit-less. LAI and photosynthetic active radiation (PAR) were measured in the field using LP-80 PAR/LAI Ceptometer.

Chlorophyll index was measured by hand held Konica Minolta SPAD-502 meter. It instantly provides an estimate of leaf N status as chlorophyll content by clamping the unplucked leafy tissue in themeter.Leaf chlorophyll index is displayed in arbitrary units (0–99.9). The statistical analysis of the data was done at 5% level of significance [3].

Table 1. Quantity of vermicompost and poultry manure (kg) used in 50:50 ratio on N equivalence basis during 2019 and 2020

Treatments detail	Vermicompost (kg)*		Poultry Manure (kg)*	
	2019	2020	2019	2020
T_2: {100% Recommended dose of N (RDN) through VC and PM on 50: 50 basis + 40 kg FYM per vine}	36.70	33.61	23.39	25.00
T_3: 90% RDN through VC and PM on 50: 50 basis + 40 kg FYM per vine	33.03	30.25	21.05	22.50
T_3: 80% RDN through VC and PM on 50: 50 basis + 40 kg FYM per vine	29.36	26.89	18.71	20.00
T_3: 70% RDN through VC and PM on 50: 50 basis + 40 kg FYM per vine	25.69	23.53	16.37	17.50

**The amount of VC (for example 36.70 kg) and PM (for example 23.39 kg) was applied in 3 equal splits (12.23 kg each of VC and 7.80 kg each of PM) in last week of January, February and April in 2019. Similar calculations were done for the year 2020*

3. RESULTS AND DISCUSSION

3.1 Leaf Area and Leaf Area Index (LAI)

The application of different sources of nutrient had significant effect on the leaf area; however, the interaction effect was non-significant in subsequent years (Table 2). Among different treatments, pooled data of two years (2019 and 2020) revealed that treatment T_8 (30 liters *Jeevaamrit* + 3 kg *Ghana Jeevaamrit* + 40 kg FYM per vine) under SPNFS exhibited maximum leaf area (158.1 cm^2) which was significantly different from all other treatments. Among OFBS farming system, application of 50% RDN through VC and 50% by PM in treatment T_2 (VC_{400} PM_{400} + FYM_{40}) was recorded significantly highest leaf area (151.8cm^2). In the first year of the experiment (2019), the leaf area of inorganic fertilizer treatment T_1 (FYM: 40 kg, N: 800 g, P_2O_5: 600 g, K_2O: 800 g) was at par with T_2 (VC_{400} PM_{400} + FYM_{40}. The corresponding increase in leaf area during 2019 and 2020 was 3.84, 10.70 and 8.72, 10.65%, respectively.

On the basis of pooled data, the increase in leaf area was 6.23 and 10.63% by the application of VC + PM on 50:50 basis (T_2) under OFBS and 30 liters JM + 3 kg GJ (T_8) under SPNFS, respectively over inorganic fertilizer and FYM treatment (T_1). This indicates that the leaf area response to treatments were not affected by climate. The results of higher leaf area on replacement of inorganic fertilizer with organic manures (VC and PM) and liquid formulations (*JM* and *GJ*) might be due to the more soil organic matter and microbial activities which might have resulted in availability of nutrients for longer period of time particularly for N that has resulted in more vegetative growth. The data on increase in soil organic carbon, nitrogen content with the application of VC and PM as well as *JM* and *GJ* in the respective treatments also confirmed the better nutrient availability, hence resulted in more leaf area. The positive correlation between leaf area and SOC (r=0.583*, p=0.05) and between leaf area and soil available N (r=0.715**, p=0.01) further support the results. The better efficiency of organic manures might be due to the fact that organic manures would have provided the micronutrients (data not given) to an optimum level. Application of VC @ 12.5 t ha^{-1} registered significant increase in the growth attributes as plant height, number of functional leaves, leaf area index and 100 seed weight as compared with rest of the manurial treatments and control [4]. Similarly [5] also revealed that VC significantly increased the leaf area and shoot biomass of the strawberry plant when incorporated into the top 10 cm soil @ 5-10 t ha^{-1}. These results are further supported by the findings of [6,7].

Leaf area index (LAI) expresses the ratio of leaf surface (one side only) to the ground area occupied by the crop. The assimilatory surface area of a crop stand and its increase has a direct relation to the amount of solar energy intercepted by canopy and represented the productive capacity of a crop [8]. Maximum LAI index (4.36) was recorded in T_8 (JM_{30} GJ_3 + FYM_{40}) of SPNFS system followed by 4.35 in T_2 (VC_{400} PM_{400} + FYM_{40}) of OFBS system over T_1 treatment (inorganic fertilizer treatment). This higher value of LAI in liquid organic manure treatment (T_2 and T_8) was attributed to efficient production of photosynthates that increases the size of the existing leaves (Table 3). The leaf area was also recorded maximum in the respective treatments (Table 2). Similar results were obtained by [9] who reported significantly higher values of LAI, soybean plant height, number of branches, dry matter accumulation, seed yield with the application of organic manures in combination with fermented organics viz. *jeevaamrit*, *beejamrit*, *panchgavya* over the application of organics alone. However, lowest LAI (3.38) was recorded in vine treated with T_7 ($JM_{22.5}$ GJ_3 + FYM_{40}) of SPNFS. The LAI values of all OFBS vines were statistically at par but followed decreasing trend from 4.35 in T_2 (VC_{400} PM_{400} + FYM_{40}) to 3.67 in T_5 (VC_{280} PM_{280} + FYM_{40}). Significantly increased plant height, LAI, dry matter production and number of tillers hill^{-1} were also recorded by [10]. With the application of 100% N through PM in combination with foliar spray of panchagavya 3% at 30 and 45 days after transplanting followed by application of 100% N through PM + 3% *jeevaamrit* spray at 30 & 45 DAT. Similar results were also observed with the findings of [11,12,13].

3.2 Chlorophyll Index and Photosynthetically Active Radiation (PAR)

The chlorophyll content is the main index showing leaf photosynthesis ability and plant health condition [14]. During estimation of chlorophyll content by laboratory analysis method significant pigment losses occurs during the extraction that may lead to a high variability in the results [15]. Whereas, SPAD-502 chlorophyll meter is a simple, portable diagnostic tool that measures the relative chlorophyll content of leaves [16] with substantial time saving. By measuring the leaf transmittance in two wave bands SPAD meter quantifies the relative amount of chlorophyll with a reading in arbitrary unit (SPAD-502 Chlorophyll Index) that is proportional to the leaf chlorophyll concentration [17]. High correlations between SPAD-502 index and chlorophyll content have been reported for several crops. Hence, in the present study SPAD meter is used for assessing chlorophyll index. A perusal of data presented in Table 3 revealed that different nutrient source under different farming systems exhibited a significant influence on leaf chlorophyll index. Pooled analysis results showed that all treatments (T_6, T_7 and T_8) under SPNF system recorded significantly higher chlorophyll index (ranging from 49.6 to 51.6) than OFBS treatments but they are statistically at par with the vines treated with inorganic fertilizer treatment T_1 (FYM: 40kg, N: 800 g, P_2O_5: 600g, K_2O: 800g) (Fig. 1).

A significant finding of the study is in congruence with the earlier study carried out by [18] in which they observed increased chlorophyll content in leaf tissues of rice plants treated with *Jeevaamrit*. This may be due to presence of increased population of photosynthetic bacteria in this organic formulation. The use of liquid manures (*JA* and *GJ*) with FYM have increased N content in the leaves (Fig. 1) and might have enhanced the Mg absorption from the soil. The chlorophyll is an essential component for photosynthesis occurs in chloroplasts a green pigment in all photosynthetic plant tissues, so more chlorophyll content in plants may be attributed to more uptake of nitrogen by the plants. Being main constituents of chlorophyll, N and Mg contents attributed to increased chlorophyll content in the leaves which is represented by SPAD chlorophyll index values. Moreover, N is the main constituent of all amino acids in protein and lipids that act as a structural compound of the chloroplast. Although percent leaf nitrogen of treatment T_2 (VC_{400} PM_{400} + FYM_{40}) of OFBS and T_8 (JM_{30} GJ_3 + FYM_{40}) of SPNFS systems are comparable but chlorophyll index values are comparable only with SPNFS system that may be due to the increased photosynthetic efficiency by liquid organic manures as the later supplied adequate amount of nutrients to the plants speedily. Furthermore, the soil organic carbon, soil available nitrogen, soil available phosphorus and soil bacterial count has been increased by 21, 15, 3 and 277% over inorganic fertilizer treatment, respectively in 0-15 cm soil layer in treatment T_8. The results were found in conformity to those of [19] in paprika. SPAD values of all the treatments under OFBS were significantly lower than IFBS and SPNFS.

In contrast, [20] reported increased chlorophyll content in wheat leaves due to the application of VC and FYM. In general, southern side of the orchard showed higher chlorophyll index values than northern side (Table 3). The pooled analysis of 2-year data revealed that SPAD chlorophyll index values between years didn't varied significantly and non-significant "Treatment ×Year" interaction also indicated that chlorophyll index response to treatments has not affected by climate.

Table 2. Effect of different nutrient sources under different farming systems on leaf area and leaf area index (LAI) in kiwifruit during the year 2019 and 2020

Treatment code and detail	Leaf area (cm^2)			LAI
	2019	2020	Pooled	
Inorganic Fertilizer Based System (IFBS)				
T_1 (N_{800} P_{600} K_{800} + FYM_{40}): (FYM:40kg, N:800g, P_2O_5:600g, K_2O:800g)	145.8	139.9	142.9	4.32
Organic Farming Based System (OFBS)				
T_2 ($VC_{400}PM_{400}$ + FYM_{40}): 100% RD of N through VC+PM (50:50) +40kg FYM	151.4	152.1	151.8	4.35
T_3 (VC_{360} PM_{360} + FYM_{40}): 90% RDN through VC+PM (50:50) +40kg FYM	140.9	140.7	140.8	4.01
T_4 (VC_{320} PM_{320} + FYM_{40}): 80% RDN through VC+PM (50:50) + 40 kg FYM	137.9	136.7	137.3	3.71
T_5 (VC_{280} PM_{280} + FYM_{40}): 70% RDN through VC+PM (50:50) + 40 kg FYM	130.9	134.7	132.8	3.67
Subhash Palekar's Natural Farming System (SPNFS)				
T_6 (JM_{15} GJ_3 + FYM_{40}): 15 liters of *JM* + 3kg of *GJ* + 40 kg FYM	144.9	141.2	143.1	3.99
T_7 ($JM_{22.5}$ GJ_3 + FYM_{40}): 22.5 liters *JM* + 3 kg GJ + 40 kg FYM	150.2	145.4	147.8	3.38
T_8 (JM_{30} GJ_3 + FYM_{40}): 30.0 liters *JM* + 3 kg GJ + 40 kg FYM	161.4	154.8	158.1	4.36
Mean	145.4	143.2	144.3	3.97
$CD_{0.05}$ = *Treatment =*	9.2	8.5	6.0	0.46
Year =			*NS**	-
Year × Treatment =			*NS*	-

**NS=non-significant*

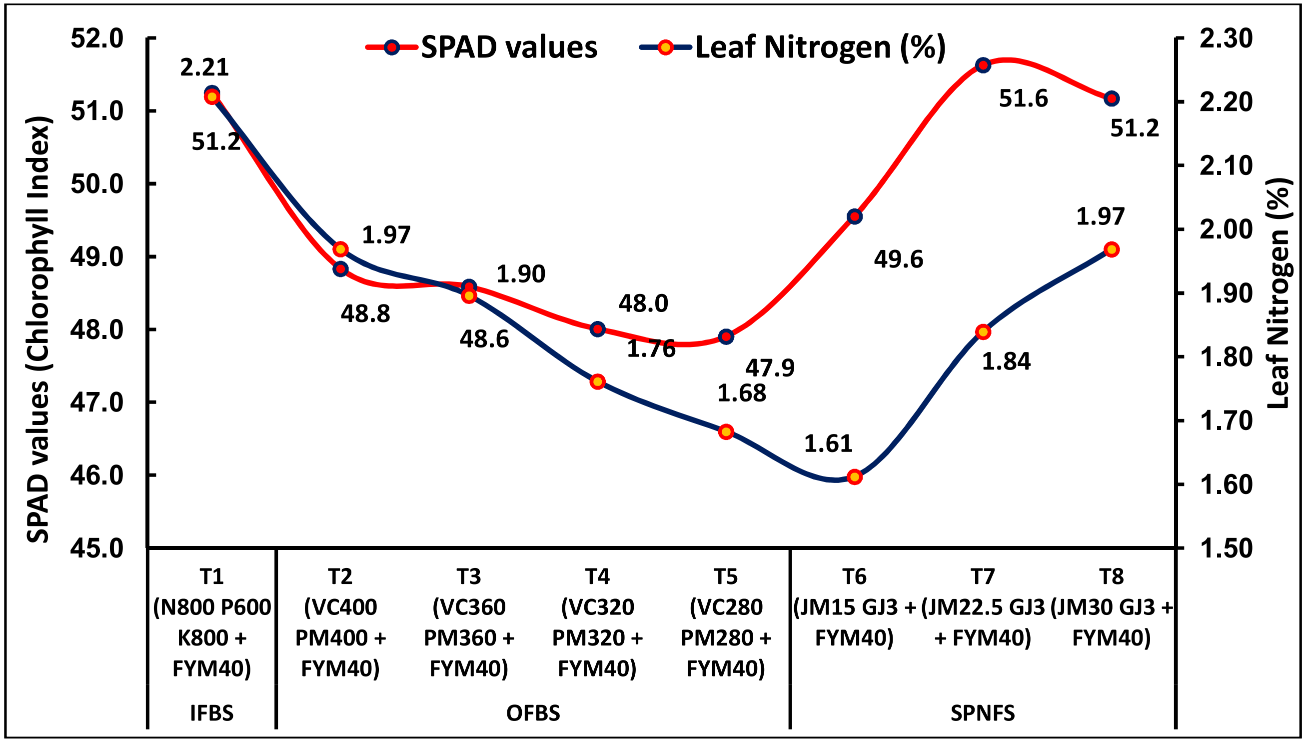

Fig. 1. Summarized relationship between SPAD values and leaf N content (%) in kiwifruit leaves supplied with different nutrient sources under different farming systems

Table 3. Effect of different nutrient sources under different farming systems on chlorophyll index (SPAD reading) in kiwifruit leaves of 2019 and 2020 and photosynthetically active radiation (PAR)

Treatment Code*	SPAD values (Chlorophyll Index)									PAR (μ mol quanta m^{-2} s^{-1})	
	2019			2020			Pooled				
	North side	South side	Mean	North side	South side	Mean	North side	South side	Mean	Upper Canopy	Lower Canopy
Inorganic fertilizer based system (IFBS)											
T_1 (N_{800} P_{600} K_{800} + FYM_{40})	50.7	51.2	50.9	51.4	51.7	51.6	51.1	51.4	51.2	1913	577
Organic farming based system (OFBS)											
T_2 (VC_{400} PM_{400} + FYM_{40})	47.7	49.7	48.7	47.8	50.1	48.9	47.8	49.9	48.8	2027	642
T_3 (VC_{360} PM_{360} + FYM_{40})	47.7	49.3	48.5	47.3	50.0	48.7	47.5	49.7	48.6	2019	575
T_4 (VC_{320} PM_{320} + FYM_{40})	47.4	48.9	48.1	46.4	49.4	47.9	46.9	49.1	48.0	1983	571
T_5 (VC_{280} PM_{280} + FYM_{40})	47.2	48.3	47.8	47.2	48.9	48.0	47.2	48.6	47.9	1964	532
Subhash Palekar's natural farming system (SPNFS)											
T_6 (JM_{15} GJ_3 + FYM_{40})	49.9	50.3	50.1	47.5	50.5	49.0	48.7	50.4	49.6	1955	574
T_7 ($JM_{22.5}$ GJ_3 + FYM_{40})	50.9	51.2	51.1	51.7	52.7	52.2	51.3	52.0	51.6	1757	468
T_8 (JM_{30} GJ_3 + FYM_{40})	50.6	51.8	51.2	49.8	52.5	51.2	50.2	52.2	51.2	2020	612
Mean	49.0	50.1	49.5	48.6	50.7	49.7	48.8	50.4	49.6	1955	569
$CD_{0.05}$ =	1.28	1.08	0.74	3.01	2.32	1.95	1.56	1.22	0.99	105	93
						Year =	*NS***	*0.61*	*NS*	-	-
						Year × Treatment =	*NS*	*NS*	*NS*	-	-

**For details of treatment code, refer to Table 2; **NS=non-significant*

Photosynthetically active radiation (PAR) is light of wavelengths 400-700 nm and is the portion of the light spectrum utilized by the plants for photosynthesis. PAR of lower canopy was recorded highest value of 642 μ mol quanta m^{-2} s^{-1} in T_2 followed by 612 μ mol quanta m^{-2} s^{-1} in T_8, although both these values are at par with inorganic fertilizer treatment (T_1). PAR of upper canopy recorded highest value of 2027 μ mol quanta m^{-2} s^{-1} in T_2 followed by 2020 μ mol quanta m^{-2} s^{-1} in T_8, which were significantly higher than T_1 treatment of IFBS.

4. CONCLUSION

Overall results on plant growth parameters *viz.* leaf area, LAI and chlorophyll index showed that leaf area and LAI values was recorded highest in T_8 (30 liters *Jeevaamrit* + 3 kg *Ghana Jeevaamrit* + 40 kg FYM per vine) under SPNFS, and leaf chlorophyll index of T_8 was at par with recommended dose of fertilizers i.e. T_1. Therefore, SPNFS system was found superior with respect to plant growth parameters over other treatments.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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