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Combined approach of intercropping and INM to improve availability of soil and leaf nutrients in fruit trees

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ABSTRACT

It becomes imperative for a fruit grower to use the vacant space between the trees to ensure a quick return on investment. The orchard floor management to obtain additional benefits, however, should not be at the cost of main crop. Therefore, it is desirable to grow some short-term crops in initial stage of orchard establishment and should continue till the fruit trees come in full bearing. Improper management of inter space of orchard make the orchard senile and non-productive. Intercropping with suitable and synergistic crop improves the fertility and protects the top soil of orchard and give additional income. The series of investigations has been carried to evaluate the efficient and economic orchard management through intercropping and Integrated Nutrient Management (INM).

The cultural practices adopted for cultivation of intercrops, had been tried to synchronize with the fruit trees in order to avoid any harmful impact on flowering and fruiting of fruit trees. Integrated approach of nutrient management have been applied for keeping soil healthy. Growing leguminous crops like mung bean and kidney bean as intercrop has been reported to be better for improving soil nutrient status of a senile orchard. Application of vermicompost as organic source of nutrient has reported to improve the health of Indian goose berry fruit trees intercropped with Elephant Foot Yam. Tuber crops like aroids, turmeric and ginger are suitable intercrops for orchard in terms of high benefit: cost ratio. The vast track of senile orchard in India can be made fertile and productive by growing compatible intercrops with integrated nutrient management approach (INM).

KEY WORDS: Aroids, Ginger, Intercropping, Kidney beans, Turmeric, Vermicompost.

1. INTRODUCTION

Orchard floor management involves managing both tree rows and alleyways. This includes suppressing weeds, stabilizing the soil, maintaining beneficial insect populations, and minimizing maintenance inputs (Rowley, 2012). The orchard floor management also bring earliness in bearing and yield (Roper, 1992). The fruit trees like Indian goose berry and guava are planted at wider spacing so there is considerable land remain vacant for several years. Once an orchard is laid out and trees are established, it becomes imperative on the part of the orchardist to use the vacant space between the trees to ensure a quick return on investment. Management of ground space of orchard for additional benefits, however, should not be at the cost of main crop. Poor management of orchard floor leads to deterioration of plant health and growth of weeds.

The integrated management of orchards through suitable cropping system and organic nutrient sources has manifold advantages in improving the productivity, soil fertility and economic potential of fruit crops (Singh, 2014). The soil fertility is better improved by additions of both organic manure and inorganic fertilizers as reported by Woomer and Swift (1994); Palm and Gachengo (2001); Vanlauwe, (2002); Vanlauwe and Giller (2006); and Tittonell, (2008), and intercropping with legumes as reported by Kimaro, (2009); Chamshama, (2006) through integrated nutrient management system (INMS). The INMS acknowledges the need for both organic and mineral inputs to sustain soil health and crop production due to positive interactions and complementarities between them (Buresh, 1997; Vanlauwe, 2002; Singh, 2012; Singh, 2015). Vanlauwe, (2002) had also reported positive interactions between urea and use of stover and other organic applications. The INM (Integrated Nutrient Management) is economically cheap, technically sound, practically feasible and capable of maintaining the sustainability in the production. The traditional organic manures and vermicompost release the nutrients slowly, hence the effect is exhibited not only on the instant crop but also it remains for prolonged period and thus has great significance for orchard management.

Intercropping with suitable, synergistic crop improves the fertility and protects the top soil of orchard and give additional income. Among the various cropping systems, intercropping of the vegetables in fruit crops provides additional income to farmers and helps in maximization of land use. In addition to this it has significant role in increasing the productivity and improvement of health of the orchards. Among different species of intercrops, growing tuber crops like elephant Foot Yam, Colocassia, Turmeric and Ginger have been reported to be suitable to perennial tree plantation. These are shade loving tuber crops, which has great potential to withstand and grow under canopy of fruit plants. It is due to its higher biological efficiency as food producers and the highest rate of dry matter production per unit area per day among all crops by efficient solar energy transfer (ESET).

Indian goose berry (*Emblica officinalis* G.) also known as aonla, is an ancient fruit of Indian origin. Indian goose berry has good tolerance to salinity, alkalinity and has ability to withstand drought condition. However, the

ignorance during summer can be detrimental for Indian goose berry production, so, this phase can be effectively utilized for cultivation of intercrops under plantation of Indian goose berry. Soil nutrient manipulation through integrated system of nutrient management during intercropping is beneficial for improving nutrient level of Indian goose berry trees so improves the fruit yield and quality of Indian goose berry. Proper orchard floor management through intercropping and INM after fruit set results in better fruit growth, yield and fruit quality.

Guava (*Psidium guajava* L.), the apple of tropics, is fourth mostly grown fruit crops in India after Mango, Banana and Citrus. The most limiting factor in guava production is the old and seedling propagated orchard with poor floor management (Singh, 2014). Intercropping can not only improve the health of orchard but also generate additional income and employment to the farmers, without any adverse effect on guava production. Intercropping of vegetable crops also improves health of soil of guava orchard.

2. MATERIALS AND METHODS

The investigation was carried out in orchard of a progressive farmer of Faizabad district of UP with the objectives to evaluate the efficiency and economic potential of vegetable crops as intercrop for orchard floor management in guava and Indian goose berry plantation.

Experimental Layout Plan: Two experiments were conducted separately in Indian goose berry orchard and guava orchard. First investigation was carried out in the orchard area of about 1536 m^2 in which 24 Indian goose berry trees were planted at the spacing of 8m X 8m. There were 24 plots with 6 treatments [T_1- Indian goose berry+ Suran+ N solely from Urea; T_2- Indian goose berry+ Suran+ N from Vermicompost and Urea in 1:3; T_3- Indian goose berry+ Suran+ N from Vermicompost and Urea in 1:1; T_4- Indian goose berry+ Suran+ N from Vermicompost and Urea in 3:1; T_5- Indian goose berry+ Suran+ N solely from Vermicompost; T_6- Indian goose berry as sole crop] and four replications. Each plot was with size of 56.24 m^2 (excluding area under ridges) whereas the area covered by suran intercrop was 53.1 m^2 (excluding the area around tree). Second investigation was carried out in the orchard area of about 720 m^2 in which 20 guava trees were planted at the spacing of 6m X 6m. There were 20 plots with 5 treatments [T_1- Guava + Arvi; T_2- Guava + Bunda; T_3- Guava + Suran; T_4- Guava + Turmeric; T_5- Guava sole crop] and four replications. Each plot was with size of 31.63 m^2 (excluding area under ridges) whereas the area covered by intercrops was 28.49 m^2 (excluding the area around tree).

Cultural Practices: The cultural practices were adopted as per the recommendation of Indian goose berry and guava trees which were based on the growth, flowering and fruiting behaviour of the fruit trees. The cultural practices adopted for cultivation of intercrops, had been tried to synchronize with the fruit trees in order to avoid any harmful impact on flowering and fruiting of trees.

The well decomposed compost @ 10 tonnes/ha was applied during the field preparation while N: P: K @ 40:30:50 (in kg/ha) was applied by different sources viz. urea, vermicompost, SSP (Single Super Phosphate) and MOP (Meurrate of Potash) as per different treatments**.** First irrigation was given after 25 days of planting and subsequently 3 irrigations were given at the interval of one month. The first weeding and earthing up was done after the first irrigation and second after one month of first weeding.

Nutrients status of fruit trees: The nutrients content of Indian goose berry trees were estimated by sampling three months old shoots taken from the middle portion of the indeterminate shoots during December. The nutrients content of guava trees were estimated by sampling leaves at full maturity of spring flush i.e. in month of August. Thirty leaves from third and fourth pairs from the apex were collected from five shoots. The sampled leaves were washed thoroughly with tap water and dipped in 0.1 N HCl, distilled water, and then oven dried at 60^0C for constant weight. The digestion of the plant materials for various nutrients was done in di-acid mixture (AR graded distilled H_2SO_4 and AR graded per-chloric acid) in 3:1 ratio.

The dry matter content of leaves was taken from the fresh weight of sampled shoots and dry weight at oven temperature (60^0C). The dry matter content of leaves was estimated by using the following formula.

$$\text{Dry matter content (\%)} = \frac{\text{Dry weight}}{\text{Fresh weight}} \times 100$$

Available nitrogen was determined by Micro-Kjeldhal method, the P content of leaves was determined by using ammonium molybdate: ammonium meta vanedate and light intensity was detected by using a spectrophotometer whereas available potassium was determined by Flame photometer as suggested by Baruah and Banthakur (1998).

Nutrient status of soil of orchard: The observations on various parameters of nutrient status of soil were recorded before growing of intercrops and after harvesting of intercrops. The soil samples were collected with the help of screw type auger before and after the experiment. The soil from 4 places was randomly collected from each plot and mixed together to get representative samples. The soil samples were carried out the laboratory and dried in the oven at the temperature of 105^0C till the constant weight was obtained. The soil samples were used for analysis of following nutrients.

Organic matter was estimated by Walkley and Black (1934) "Rapid titration method" as described by Baruah and Barthakur (1998). Soil pH was obtained with the help of digital pH meter using 1:2.5 soil-water suspensions. Available nitrogen was estimated by alkaline potassium permagnate ($KMnO_4$) method (Subbiah and Asija, 1956) as suggested by Baruah and Barthakur (1998). Available phosphorus was estimated by Olsen's method as described by Baruah and Burthakur (1998). Available potassium was estimated by flame photometer with the use of saturation extract of soil as described by Baruah and Barthakur (1998).

Benefit- Cost ratio: The benefit: cost ratio of different intercrops was calculated by dividing the net income by respective cost of cultivation of different cropping system using the following formula:

$$\text{Benefit: cost ratio} = \frac{\text{Net Income from different cropping system}}{\text{Cost of cultivation}}$$

3. RESULT AND DISCUSSION

Nutrients status of fruit trees: The data recorded on Indian goose berry leaf nutrient status [Figure-1(a)] clearly exhibited dry matter content ranged from 74.59% (T_1) to 78.53% (T_3), nitrogen from 1.963% (T_3) to 2.09% (T_6), phosphorous from 0.195% (T_1 and T_6) to 0.207% (T_3), and potassium from 1.38% (T_6) to 1.477% (T_3). It is observed from the data presented that the dry matter, nitrogen, phosphorous and potassium content in Indian goose berry leaves was maximum in T_3 (Vermicompost and urea in 1:1 as N source) and T_2 (Vermicompost and Urea in 1:3 as N source) as compared to other treatments and sole crop.

The data recorded on guava leaf analysis for dry matter, N, P and K is shown in Figure-1(b), which clearly exhibited that there was no significant differences in nutrient levels of guava leaves, due to intercropping of seasonal vegetable crops. The dry matter content in guava leaves ranged from 79.42% (T_4) to 80.00% (T_5), nitrogen from 1.82% (T_5) to 1.86% (T_1 and T_2), phosphorous from 0.41% (T_4 and T_5) to 0.44% (T_1 and T_2) and potassium from 1.53% (T_5) to 1.57% (T_1). There is no any research work report has cited which can justify the influence of intercropping on leaf nutrient status of perennial trees but use of vermicompost might have positive impact on leaf nutrient status.

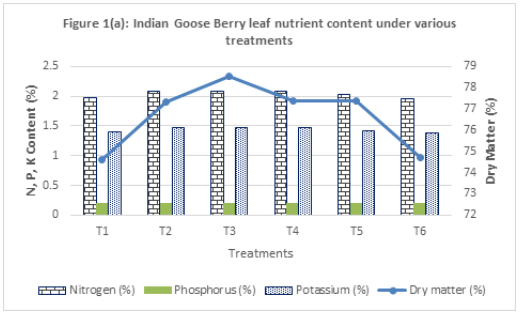

Figure. 1(a). Indian Goose Berry leaf nutrient content under various treatments

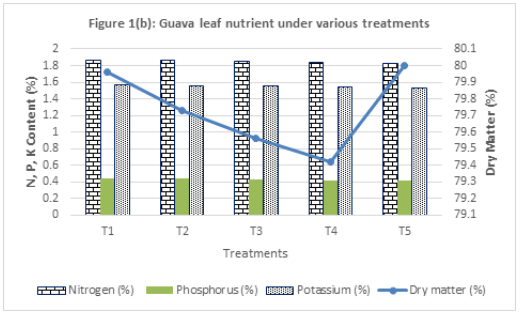

Figure. 1(b). Guava leaf nutrient under various treatments

Nutrient status of soil of orchard: The soil analysis was done for determination of nutrient status of soil due to influence of intercropping of suran under Indian goose berry plantation [Figure. 2 (a, b, c)]. The data recorded on soil O.M. indicates that organic matter of soil was improved in all intercropping systems from 0.62% which was before growing of intercrops. It was highest in T_3 (0.68%) followed by T_2 (0.67%). The soil pH was also reported to get reduced from 7.82 to 7.12 (T_5) followed by 7.17 (T_3). The available N, P and K from soil of Indian goose berry orchard indicates that nitrogen ranged from 175.68 kg (T_6) to 186.66 kg/ha (T_2), phosphorus from 22.56 kg (T_6) to 24.09 kg/ha (T_3), and potassium from 270.72 kg (T_6) to 289.05 kg/ha (T_6). It is apparent from the data recorded on nutrient levels of soil due to intercropping of suran that nutrients level were not much influenced due to growing of suran as inter crop with different sources of nitrogen.

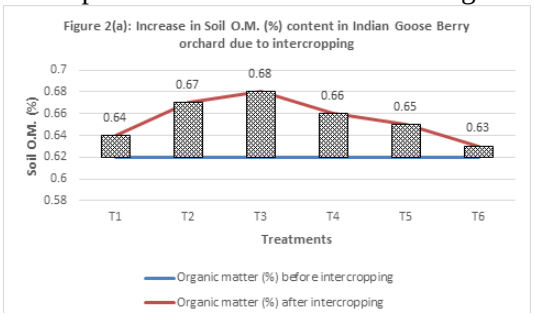

Figure. 2(a). Increase in soil O.M.(%) content in Indian Goose Berry orchard due to intercropping

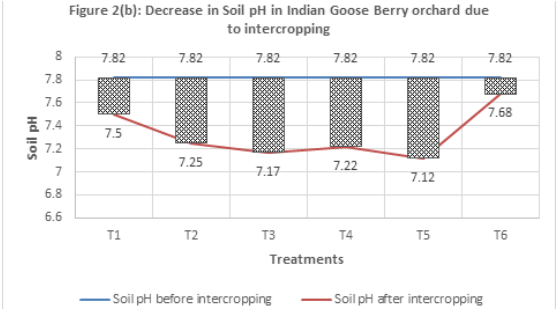

Figure. 2(b). Decrease in soil pH in Indian Goose Berry orchard due to intercropping

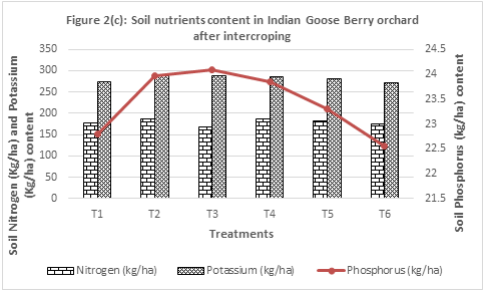

Figure. 2(c). Soil nutrients content in Indian Goose Berry orchard after intercropping

The data recorded on soil analysis for O.M., pH, N, P and K content of soil of guava orchard is presented in Figure. 3 (a, b, c) which clearly indicates that there was no significant effect of intercropping on increase of nutrient status of soil. The organic matter content of soil was improved from 0.65% before growing intercrops to 0.78% (T_1) followed by 0.76% (T_2) after harvesting of intercrops. The pH was reported to be reduced from 7.98 to 7.32 in T_1 followed by 7.4 in T_2 while soil without intercropping (T_5) retained maximum pH (7.65). The available soil nitrogen, phosphorus and potassium content ranged from 182.50 kg to 186.08 kg/ha, from 22.18 kg to 22.96 kg/ha and from 285.85 kg to 292.33 kg/ha.

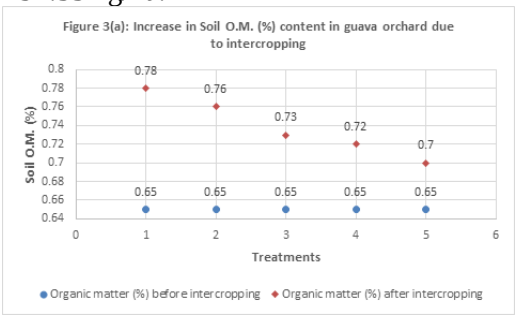

Figure. 3(a). Increase in Soil O.M. (%) content in Guava orchad due ot intercropping

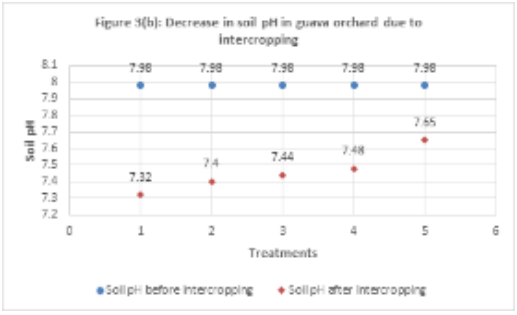

Figure. 3(b). Decrease in Soil pH in guava orchad due to Intercropping

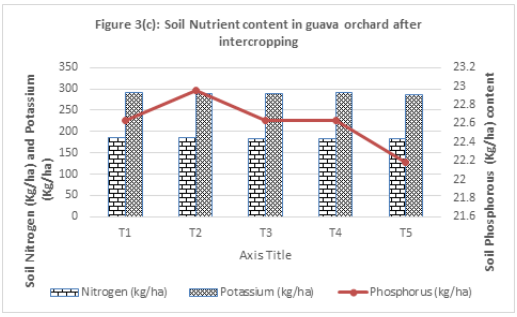

Figure. 3(c). Soil Nutrient conternt in guava orchard After intercropping

Reduction in soil pH after harvesting intercrops may be due to addition of more organic matters through intercrops and application of organic sources of nutrients like vermicompost which have greater buffering capacity to soil reaction. Organic inputs are also major sources of energy and nutrients for soil microbial communities which promote soil aggregation and buffering capacity (Snapp, 1998). The pH, conductivity and soil organic carbon were not significantly altered by berseem, chillies, cotton and peas intercrop.

The slight increase in nitrogen content might be due to increase in organic matter content or due to application of additional doses of chemical fertilizers or various sources of nitrogen. In general, growing of leguminous crops as intercrops, were found better in respect to increase of nitrogen, because they fix atmospheric nitrogen to the soil as reported by Subbiah, (1980). However, the growing of tuber crops vegetables did not add any atmospheric nitrogen, but they might be helpful in improving the soil texture and adding the organic matter by decomposing the foliage parts, which improve the available nitrogen content in soil. Increase in available nitrogen due to intercropping of cowpea and corn (non-leguminous crop) in cassava in an organic system was also reported by Devide, (2009). The highest soil organic carbon and available nitrogen due to application of vermicompost has been confirmed by Ramesh, (2008).

The increase in soil phosphorous and potassium might be due to application of additional doses of fertilizers and less uptake of P and K by these intercrops. Similar observations have also been recorded by Chundawat (1993). Brown, (1994) had documented the role of manures and plant residues as nutrient suppliers in soils. The highest available K in case of integrated use of inorganic fertilizers and organic manures (vermicompost) might be due to

the release of non-exchangeable K from the soil and applied K through fertilizers which not only meet crop requirements but also build up available K content in soil. The results are in conformity with Laxminarayan and Patiram (2006); Saha, (2008) and Singh (2008).

Benefit- Cost ratio: The assessment of economic values of Indian goose berry intercropping systems in terms of gross-income, net-income and benefit - cost ratio, presented in Table.1, clearly indicated that the highest gross income was estimated in T_3 (Rs. 3.890 x 10^5/ha) followed by T_2 (Rs. 3.817 x 10^5/ha) as compared to Indian goose berry grown as sole crop (Rs. 52,420/ha). The net income also followed similar trend. The present findings revealed that growing of intercrops in Indian goose berry orchard increased the net return per ha due to additional income obtained by intercrops. The present observations is in agreement with findings in citrus-based cropping system (citrus + potato), papaya-based cropping system (Papaya + Rajma-Suran), intercropping of vegetables in guava plantation with high return per hectare. The estimated benefit: cost ratio obtained from different cropping systems have clearly indicated that the highest benefit - cost ratio (2.961:1) was recorded from T_3 (Aonla+ Suran+ N from Vermicompost and Urea in 1:1) followed by 2.960:1 in T_2 (Aonla+ Suran+ N from Vermicompost and Urea in 1:3) and 2.773 in T_4 (Aonla+ Suran+ N from Vermicompost and Urea in 3:1) as compared to sole crop Indian goose berry (2.640:1); whereas the least benefit: cost ratio (2.345:1) was estimated in T_1 (Indian goose berry + Suran + 100% N_2 from urea).

Table.1. Benefit Cost ratio of Indian Goose Berry based intercropping system

Cropping systems (Treatments)	Cultivation Cost (Lakhs Rupees per hectare)	Gross Income (Lakhs Rupees per hectare)	Net Income (Lakhs Rupees per hectare)	Benefit: Cost ratio
T_1- Indian goose berry+ Suran+ N solely from Urea	0.945	3.170	2.225	2.354:1
T_2- Indian goose berry+ Suran+ N from Vermicompost and Urea in 1:3	0.964	3.817	2.853	2.960:1
T_3- Indian goose berry+ Suran+ N from Vermicompost and Urea in 1:1	0.982	3.890	2.908	2.961:1
T_4- Indian goose berry+ Suran+ N from Vermicompost and Urea in 3:1	1.000	3.773	2.773	2.773:1
T_5- Indian goose berry+ Suran+ N solely from Vermicompost	1.018	3.336	2.318	2.277:1
T_6- Indian goose berry as sole crop	0.144	0.524	0.380	2.640:1

The economic analysis was done in respect to cost of cultivation, gross income, net income and benefit: cost ratio of guava based cropping system and has been presented in Table. 2. The highest gross income and net return was obtained due to intercropping of Elephant Foot Yam (T_3) (Rs. 2.334 x 10^5/ha and Rs. 1.844 x 10^5/ha, respectively) followed by Bunda (Rs. 1.421 x 10^5/ha and Rs. 1.131 x 10^5/ha, respectively) and arvi (Rs. 1.247 x 10^5/ha and Rs. 0.972 x 10^5/ha, respectively) and lowest was in sole crop of guava (Rs. 0.570 x 10^5 and 0.445 x 10^5/ha, respectively). The highest benefit: cost ratio was obtained from Guava + Bunda (3.90:1) followed by Guava + Arvi (3.76:1), Guava + Turmeric (3.68:1) and Guava + Suran (3.53:1) cropping system as compared to sole crop guava (3.07:1).

Table.2. Benefit Cost guava based intercropping system

Cropping systems (Treatments)	Cultivation Cost (Lakhs Rupees per hectare)	Gross Income (Lakhs Rupees per hectare)	Net Income (Lakhs Rupees per hectare)	Benefit: Cost ratio
T_1- Guava + Arvi	0.275	1.247	0.972	3.53:1
T_2- Guava + Bunda	0.29	1.421	1.131	3.90:1
T_3- Guava + Suran	0.49	2.334	1.844	3.76:1
T_4- Guava + Turmeric	0.215	1.007	0.792	3.68:1
T_5- Guava sole crop	0.145	0.59	0.445	3.07:1

The high benefit: cost ratio of these cropping systems may be due to high corms yield and market price of produce with low investment involved in their cultivation. Thus, it is clear from the present results that intercropping of vegetable crops has been found economically superior as compared to sole crops of Indian goose berry or guava as justified by Singh (2015). Nedunchezhiyan, (2008) also recommended the application of N: P: K along with mulching for elephant foot yam + green gram intercropping system for optimum yield and higher benefit: cost ratio (2.02). The findings of Jha, (2008) on various Amorphophallus based intercropping systems are also supporting the present findings. Hnamte, (2013) has reported highest gross return from the lemon + French bean intercropping system and the lowest gross return from sole lemon for two years in a row whereas the highest benefit - cost ratio was recorded in lemon + French bean intercropped (3.94), followed by T_7 (3.70) and T_4 (3.54).

4. CONCLUSION

Application of vermicompost as organic source of nutrient has reported to improve the health of Indian goose berry fruit trees intercropped with Elephant Foot Yam. Tuber crops like aroids, turmeric and ginger are suitable intercrops for orchard in terms of high benefit: cost ratio. The estimated benefit: cost ratio obtained from different cropping systems have clearly indicated that the highest benefit - cost ratio (2.961:1) was recorded when N_2 was provided from Vermicompost and Urea in 1:1 followed by 2.960:1 when N_2 provided through Vermicompost and Urea in 1:3 and 2.773 when N_2 provided through Vermicompost and Urea in 3:1) as compared to sole crop Indian goose berry (2.640:1).

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