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# Optimization of nutrient dose for growth and yield of *Silybum marianum* (L.) Gaertn. under peach based agroforestry system

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**ABSTRACT:** An experimental trial was conducted to standardize optimum dose of inorganic plus organic fertilizers for production of *Silybum marianum* (Milk thistle) under peach plants and open field condition. Milk thistle crop was grown with five integrated nutrient doses, viz., $T_1$ (Recommended doses of fertilizers), $T_2$ (75% Recommended doses of fertilizers + 25% Vermicompost), $T_3$ (50% Recommended doses of fertilizers + 50% Vermicompost), $T_4$ (25% Recommended doses of fertilizers + 75% Vermicompost) and $T_5$ (100% Vermicompost). Treatment, $T_3$ showed the best results on most of the growth and yield parameters, viz., plant height (142.15cm), number of leaves plant$^{-1}$ (147.62), number of branches plant$^{-1}$ (18.99), number of thistles plant$^{-1}$ (24.78), LAI (4.70), root-shoot ratio (0.09), total biomass production (10.01q ha$^{-1}$) and seed yield ha$^{-1}$ (2.01q ha$^{-1}$). Peach trees had a positive effect on growth and yield performance of *S. marianum,* which were found healthier and better thriving underneath its canopy than in sole cropping. Irrespective of the planting condition, soil chemical parameters viz., OC (13.92 g kg$^{-1}$), available N (312.51 kg ha$^{-1}$), available P (56.69 kg ha$^{-1}$) and available K (390.99 kg ha$^{-1}$) also showed higher value under $T_3$ treatment. However, pH (6.95) and EC (0.27 dSm$^{-1}$) were found maximum in treatments $T_4$ and $T_1$, respectively. Based on the economic analysis, it was found that *S. marianum* gave more profit under Treatment $T_1$ (recommended doses of NPK) in terms of monetary value (₹ 5,71,27 ha$^{-1}$) when intercropped with peach in comparison to other treatment combinations. From the present investigation, it can be concluded that milk thistle crop under peach based agroforestry system can be a viable option both ecologically as well as economically.

**Key words**: Integrated nutrient, milk thistle and peach based agroforestry systems.

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## 1. INTRODUCTION

Plants have been used for healing various diseases since time immemorial. In the developing world, traditional herbal medicines have long been a key component of health-care systems (Ma *et al.*, 2005). According to world health organization, approximately 80% of the human populations rely on plant derived medicines for their health care (Qureshi *et al.*, 2010). *Silybum marianum* (L.) Gaertn. (Milk thistle) belonging to family Asteraceae is one of the important medicinal plant species, which originated in the Mediterranean Basin. Seeds of *S. marianum* contain silymarin which is used for treating liver ailments, Amanita mushroom poisoning, viral hepatitis, toxic and drug diseases of the liver, psoriasis and in neuroprotective and neurotropic activity (Ghosh *et al.*, 2010). Silymarin also shows a strong antioxidant and anti-inflammatory activity; as such, it is interesting to human nutrition specialists as well as to dermatologists, oncologists and cosmetologists (Szczucinska *et al.*, 2003; Sadowska, 2006).

Agroforestry is practiced by small and marginal farmers since ages. It provides opportunity for diversification of existing land use systems and beneficial environmental impacts and higher return as compared to sole cropping systems (Chaturvedi, 1991). The deliberate integration of medicinal plants with fruit trees on the same land management unit has been studied relatively less as compared to the other forms of agroforestry association. The emergence of peach (*Prunus persica* (L.) Batcsh) as a suitable tree species component of agroforestry in the mid hill zone of Himachal Pradesh is fast gaining recognition owing to the highly congenial agroclimate for its successful cultivation. Peach cultivation in India extends from northern plains to an elevation of 2000 m a.m.s.l. (above mean sea level). In Himachal Pradesh, mid hill zone area, especially Rajgarh (Sirmour) and Kullu Valley areas are the main pockets of peach cultivation because of its climatic suitability. In India, it occupies 20,300 ha area with the production of 90,800 MT, while in Himachal Pradesh it is grown in an area of 5,200 ha with a production of 5,100 MT (Anonymous, 2012). Search for new crop combinations have always been attempted that could give higher yields and monetary returns. Cultural practices based on scientific research play a vital role in enhancing the yield of crops. Many medicinal crops have been tested and cultivated as sole crops in state but a very few of it have been tested under tree based agroforestry systems. Cultivation of *S. marianum* with peach trees could be economically and ecologically viable option for small land holder farmers of the mid-hill zone of Himachal Pradesh, since this crop will be raised at a time when the peach trees are in leafless conditions (November-March). Therefore, the present study was undertaken to evaluate the performance of milk thistle as an intercrop with peach trees under mid-hill sub humid conditions of Himachal Pradesh.

## 2. MATERIALS AND METHODS

An experiment was conducted in the experimental field of the Department of Silviculture and Agroforestry, Dr. YSP University of Horticulture and Forestry, Nauni, Solan (H P) during the rabi season of years 2013–2014. The experimental site falls in the mid-hill zone of Himachal Pradesh lying at 30°51'N latitude and 76° 11' E longitude and having an elevation of about 1200 m amsl. The climate of the area is transition between sub-tropical to sub temperate. In general, May and June are the hottest months and, December and January are the coldest ones. The annual rainfall varies from 1000-1400 mm and about 75 per cent of it is received during monsoon period (mid June to mid September). The soils of the area belong to Typic Eutrochrept at subgroup level according to Soil Taxonomy of USDA. The important chemical properties of the experimental sites for 0-15 cm depth are: pH (1:2): 6.92; EC (1:2): 0.24; organic carbon (g $kg^{-1}$): 13.12; available nitrogen (kg $ha^{-1}$): 292.91; available phosphorus (kg $ha^{-1}$): 42.17 and available potassium (kg $ha^{-1}$): 376.4.

A factorial Randomized Block Design (RBD) replicated thrice comprising of ten treatments combinations [5(doses of fertilizers) × 2 (planting conditions)] was laid out to study the performance of *S. marianum* in it. Four years old peach plants (var. nectarine) ($P_1$) having an average height of 3.34 m, DBH of 7.89 cm and average crown spread of 2.21 m planted at a spacing of 9 m × 4 m were used vis-a-vis sole cropping ($P_2$). The seedlings of Milk thistle were transplanted at a spacing of 60 cm × 60 cm in the interspaces of peach plantation ($P_1$) and also under sole cropping ($P_2$) during the first week of December 2013, and supplied with five doses of integrated nutrients, viz., $T_1$: recommended doses of fertilizers (NPK); $T_2$: 75% recommended doses of fertilizers (NPK) + 25% vermicompost; $T_3$: 50% recommended doses of fertilizers (NPK) + 50% vermicompost; $T_4$: 25% recommended doses of fertilizers (NPK) + 75% vermicompost and $T_5$: 100% vermicompost. The entire dose of phosphorus, potassium and half dose of nitrogen as per treatment combination were applied by broadcasting method before transplanting of seedlings and was thoroughly mixed up with the surface layer (0-15cm) of soil. The remaining dose of nitrogen was applied at the end of first month of planting. The inter-cultural operations, such as weeding, hoeing etc. were carried out during the growth season to ensure healthy crop. Irrigations were applied as and when required. The observations on growth and yield attributes of *S. marianum, viz.,* plant height (cm), number of branches $plant^{-1}$, number of leaves $plant^{-1}$, number of flowers/thistles $plant^{-1}$ were recorded on the basis of ten randomly selected plants from each replication of all the treatments. Each value is the mean of three replications within each treatment. The number of plant $m^{-2}$ were taken by counting number of plants in three 1 $m^2$ sample unit from each replication of all treatments and mean number of plants $m^{-2}$ was worked out. LAI was measured with the help of pre-calibrated, pre-programmed LAI-2000 plant canopy analyzer LICOR-USA. Each value was computed on the basis of one open and four beneath canopy readings. Sensor of the canopy analyzer was held parallel to the eyes above the canopy of the ground crops to record open reading. Thereafter, the sensor was held underneath the canopy near the base of crops 2-4 cm above the ground level to take reading below the plant canopy. Open and below canopy readings were taken using 45° view cap. Each value of LAI is the mean of three replications and has been expressed as unit less attribute. Observations were recorded for the medicinal plant growing both on East and West to tree trunk at each tree spacing. The root-shoot ratio was worked out on dry weight basis by dividing the weight of dry root by the weight of dry shoot of plant on the basis of ten randomly selected plants from each replication of all the treatments. Seed yield (q $ha^{-1}$) was worked out by weighing the seeds obtained from the ten randomly selected plants from each plots and same is expressed in q $ha^{-1}$. Five tagged plants were selected for uprooting from each plot at final picking stage. The total green parts obtained from the plants were put in the oven till constant weight is obtained to calculate the separate dry matter accumulation and the uprooted plants after harvesting were washed with tap water. The samples were dried in an oven at 60 °C till constant weight is obtained. Dry weight thus obtained was expressed in g $plant^{-1}$ for total biomass production of each plant, which was then calculated in terms of q $ha^{-1}$. Harvest index were recorded at the time of harvest using the following formula; Harvest index = (economical yield/ biological yield) × 100. For soil analysis, viz., pH, EC, organic carbon, available N, P and K, composite soil samples were collected from 0–15cm depth from each plot, before sowing (December, 2013) and after harvesting of crops (April, 2014), air dried and sieved to pass a 2 mm screen. The pH and electrical conductivity of soil were determined by using 1:2.5 soil: water suspension (Jackson, 1973). Organic carbon, available nitrogen and available phosphorus were determined by using rapid titration method (Walkley and Black, 1934); alkaline potassium permanganate method by Subbiah and Asija (1956) and Olsen *et al.,* (1954), respectively. Whereas, available potassium was estimated using neutral 1 N ammonium acetate solution (Merwin and Peech, 1951). Bio-economics of system was analyzed by calculating the cost of cultivation, gross and net returns per hectare. All these parameters were calculated on the basis of market price prevailing at the time of termination of experiment. The data thus recorded for different parameters were subjected to appropriate statistical analysis as per the standard procedure (Gomez and Gomez, 1984).

## 3. RESULTS AND DISCUSSION

### Effect of different doses of integrated fertilizer treatments on growth and yield attributes of *S. marianum*

Growth, broadly speaking, refers to the irreversible increase in the shape, size, and weight of an organism/ plant whereas yield refers to the amount harvested at the end of the cropping cycle. Inevitably higher growth rate will accumulate more fresh and/or dry weight by the plant resulting in higher yield. Ergo, higher the growth rate, the more will be the yield. This growth and yield relationship may be affected by various factors, like climatic, edaphic and topographic factors. Among them, one of the most important factors is the maintenance of appropriate nutrient status in the soil. The organic manures are said to contribute to the organic matter and nutrient status of the soil and their favourable effects mediated through improved nutrient status of soil and quality and quantity of produce. All growth and yield parameters of *S. marianum* were significantly affected by different integrated nutrient doses (Table 1). Results

Table 1. Effect of different doses of integrated fertilizer treatments on growth and yield attributes of *Silybum marianum*

| Observations | Treatments (Doses of inorganic fertilizers + organic fertilizers) | | | | |
|---|---|---|---|---|---|
| | $T_1$ | $T_2$ | $T_3$ | $T_4$ | $T_5$ |
| Plant height (cm) | 116.29$^d$ | 133.06$^b$ | 142.15$^a$ | 123.82$^c$ | 122.04$^c$ |
| No of leaves $plant^{-1}$ | 112.69$^e$ | 132.54$^b$ | 147.62$^a$ | 122.17$^c$ | 118.04$^d$ |
| No of branch $plant^{-1}$ | 11.42$^d$ | 15.24$^b$ | 18.99$^a$ | 14.46$^c$ | 14.23$^c$ |
| No of thistles $plant^{-1}$ | 16.35$^d$ | 19.93$^b$ | 24.78$^a$ | 18.93$^b$ | 18.35$^c$ |
| LAI | 3.90$^c$ | 4.42$^b$ | 4.70$^a$ | 4.20$^b$ | 3.90$^c$ |
| No of thistles flowering $head^{-1}$ | 4.17$^b$ | 5.00$^a$ | 5.67$^a$ | 5.50$^a$ | 4.67$^b$ |
| Root-shoot ratio | 0.06$^c$ | 0.07$^b$ | 0.09$^a$ | 0.07$^b$ | 0.06$^c$ |
| Total Biomass production (kg $ha^{-1}$) | 724$^e$ | 889$^b$ | 1001$^a$ | 806$^c$ | 786$^d$ |
| Harvest Index | 1.80$^b$ | 2.02$^a$ | 1.92$^a$ | 2.04$^a$ | 1.88$^b$ |
| Seed yield $plant^{-1}$ (g) | 7.58$^e$ | 7.89$^b$ | 8.04$^a$ | 7.73$^c$ | 7.63$^d$ |
| Seed yield (q $ha^{-1}$) | 1.90$^d$ | 1.96$^b$ | 2.01$^a$ | 1.93$^c$ | 1.91$^c$ |

Mean values of each growth and yield parameters followed by the same letter are not significantly different at P = 0.05

*$T_1$: recommended doses of fertilizers (NPK); $T_2$: 75% recommended doses of fertilizers (NPK) + 25% vermicompost; $T_3$: 50% recommended doses of fertilizers (NPK) + 50% vermicompost; $T_4$: 25% recommended doses of fertilizers (NPK) + 75% vermicompost and $T_5$: 100% vermicompost

showed that *S. marianum* achieved higher values of growth and yield parameters, viz., plant height (142.15 cm), number of leaves plant$^{-1}$ (147.62), number of branches plant$^{-1}$ (18.99), number of thistles plant$^{-1}$ (24.78), LAI (4.70), root-shoot ratio (0.09), total biomass production (1001 kg ha$^{-1}$), seed yield ha$^{-1}$ (2.01 q ha$^{-1}$) values under $T_3$, where plants were supplied with 50% recommended dose of fertilizers + 50% vermicompost. Whereas, minimum values of these growth and yield parameters of *S. marianum* were recorded under $T_1$ (recommended dose of fertilizers). The combined application of organic and inorganic doses instead of their sole application has shown positive impact, which may be due to the beneficial effect of vermicompost on soil environment; which encourage proliferous root growth resulting in better absorption of moisture and nutrients, which leads to higher productivity. This can also be ascribed to the easy and fast availability of nutrients in fertilizers required by the plants in the early stage of the growth and later by vermicompost as it releases nutrients steadily due to slow mineralization, which helps in availability of nutrients to the plants throughout its growth and thus resulting in higher growth as compared to other treatment combinations, where the fraction of NPK and vermicompost may be in unbalanced proportion. Our results are in consonance with the findings of Scheffer *et al*., (1993), Paturde *et al*., (2002) and Zohra *et al*., (2005).

**Effect of planting conditions on growth and yield attributes of *S. marianum***

The planting conditions also brought significant influence on the growth and yield attributes of milk thistle (Table 2). Marked increased in yield was found under peach canopy ($P_1$). This may attributed to the improved soil properties underneath peach compared to the open. The yield increase might also be due to the minimum competition between different components. Since under this investigation, *S. marianum* was grown in the inter space of optimally spaced peach plants, which were leafless for most of the time of crop season. Similarly,

Table 2. Effect of planting conditions on growth and yield attributes of *Silybum marianum*

| Observations | Planting Condition | |
|---|---|---|
| | $P_1$ | $P_2$ |
| Plant height (cm) | 128.75$^a$ | 126.20$^b$ |
| No of leaves plant$^{-1}$ | 129.35$^a$ | 123.87$^b$ |
| No of branch plant$^{-1}$ | 15.32$^a$ | 14.42$^b$ |
| No of thistles plant-1 | 20.30$^a$ | 19.03$^b$ |
| LAI | 4.33$^a$ | 4.16$^b$ |
| No of thistles flowering head$^{-1}$ | 5.07$^a$ | 4.93$^a$ |
| Root-shoot ratio | 0.08$^a$ | 0.06$^b$ |
| Total Biomass production (kg ha$^{-1}$) | 859$^a$ | 822$^b$ |
| Harvest Index | 1.94$^a$ | 1.92$^a$ |
| Seed yield plant$^{-1}$ (g) | 7.82$^a$ | 7.72$^b$ |
| Seed yield (q ha$^{-1}$) | 1.95$^a$ | 1.93$^b$ |

*Mean values of each growth and yield parameters followed by the same letter are not significantly different at P= 0.05

*$P_1$: Peach based system; $P_2$: Sole cropping system

Table 3. Interaction effect of different doses of integrated fertilizer treatments and planting conditions on growth and yield attributes of *Silybum marianum*

| Observations / Treatment combinations | Plant height (cm) | No of leaves plant$^{-1}$ | No of branch plant$^{-1}$ | No of thistles plant$^{-1}$ | LAI | Root-shoot ratio | Total Biomass production (kg ha$^{-1}$) | Seed yield plant$^{-1}$ (g) | Seed yield (q ha$^{-1}$) |
|---|---|---|---|---|---|---|---|---|---|
| $T_1P_1$ | 114.32$^f$ | 117.56$^d$ | 11.03$^e$ | 16.34$^d$ | 4.03$^c$ | 0.08$^a$ | 730$^d$ | 7.87$^b$ | 1.98$^b$ |
| $T_1P_2$ | 118.26$^e$ | 107.82$^e$ | 11.82$^d$ | 16.37$^d$ | 3.77$^d$ | 0.05$^b$ | 718$^d$ | 7.22$^f$ | 1.81$^f$ |
| $T_2P_1$ | 135.97$^b$ | 128.18$^c$ | 15.52$^c$ | 18.67$^c$ | 4.47$^b$ | 0.07$^a$ | 844$^c$ | 7.94$^b$ | 1.97$^b$ |
| $T_2P_2$ | 130.14$^c$ | 136.90$^b$ | 14.96$^c$ | 21.19$^b$ | 4.37$^b$ | 0.07$^a$ | 933$^b$ | 7.83$^c$ | 1.96$^b$ |
| $T_3P_1$ | 147.37$^a$ | 153.97$^a$ | 20.82$^a$ | 27.48$^a$ | 4.90$^a$ | 0.09$^a$ | 1118$^a$ | 8.22$^a$ | 2.05$^a$ |
| $T_3P_2$ | 136.93$^b$ | 141.26$^b$ | 17.15$^b$ | 22.07$^b$ | 4.50$^b$ | 0.08$^a$ | 881$^c$ | 7.86$^b$ | 1.97$^b$ |
| $T_4P_1$ | 127.92$^c$ | 119.04$^d$ | 13.82$^d$ | 19.19$^c$ | 4.10$^c$ | 0.09$^a$ | 762$^d$ | 7.82$^c$ | 1.96$^b$ |
| $T_4P_2$ | 119.73$^e$ | 125.30$^c$ | 15.11$^c$ | 18.66$^c$ | 4.30$^b$ | 0.04$^b$ | 840$^c$ | 7.81$^c$ | 1.91$^d$ |
| $T_5P_1$ | 117.20$^e$ | 128.00$^c$ | 15.41$^c$ | 20.37$^b$ | 4.23$^b$ | 0.06$^b$ | 849$^c$ | 7.64$^d$ | 1.95$^c$ |
| $T_5P_2$ | 126.89$^d$ | 108.07$^e$ | 13.04$^d$ | 16.34$^d$ | 3.77$^d$ | 0.06$^b$ | 731$^d$ | 7.46$^e$ | 1.87$^e$ |

*Mean values of each growth and yield parameters followed by the same letter are not significantly different at P= 0.05

*$T_1$: recommended doses of fertilizers (NPK); $T_2$: 75% recommended doses of fertilizers (NPK) + 25% vermicompost; $T_3$: 50% recommended doses of fertilizers (NPK) + 50% vermicompost; $T_4$: 25% recommended doses of fertilizers (NPK) + 75% vermicompost and $T_5$: 100% vermicompost

*$P_1$: Peach based system; $P_2$: Sole cropping system

Bhutia *et al.*, (2015) also observed that the pea crop can be intercropped with optimally spaced peach plant, without any reduction in yield.

### Interaction effect of different doses of integrated fertilizer treatments and planting conditions on growth and yield attributes of *S. marianum*

All the interaction between different doses of integrated fertilizer treatments and planting conditions displayed significant influence on the growth and yield attributes of *S. marianum*, except in number of thistles plant$^{-1}$ and harvest index. Maximum value in most of the growth and yield attributes was found in combination of $T_3P_1$ in which milk thistle plants were grown under peach canopy and supplied with fertilizer in the combination of 50% recommended doses of fertilizers + 50% vermicompost. This can again be attributed to the different nutrients provided by the organic manures and fertilizers and improvement in soil properties at micro level as indicated in Table 4. Further, increased leaf area intercepts more photosynthetically active solar radiation by providing more photosynthetic surface in plants. Sehgal (2007) also reported improved growth of medicinal and aromatic plants, namely *Ocimum sanctum* and *Tagetes minuta* when supplied with organic manures under agroforestry system. Maheswarappa *et al.*, (1998) and George and Pillai (2000) also reported that vermicompost stimulated the growth of intercrop grown under coconut trees. Similar effects on growth and yield increment by combination of inorganic fertilizers and vermicompost were also reported by Haj Seyed Hadi *et al.*, (2008), Singh (2011) and Zeinab *et al.*, (2014) in different crops.

### Effect of different doses of integrated fertilizer treatments and planting conditions and their interactions on chemical properties of soil

Soil pH as determined after harvesting was significantly affected by the application of varying doses of inorganic fertilizers and vermicompost (Table 4). pH of the soil ranged from 6.93 ($T_1$) to 6.95 ($T_4$), which means that it is normal and no treatment is required. The reason behind the minimum difference of pH between different doses of inorganic fertilizers may be due to buffering capacity of the soil and neutral nature of inorganic or organic fertilizers used in the experiment. The differences in soil pH for planting conditions showed non-significant variations. The values for EC (Table 4) ranged from 0.22-0.27 dSm$^{-1}$ indicating the concentration of soluble salts in the soil is low and is suitable for growth of all kinds of crops. The planting conditions does not exerted significant variations on the EC while, significant variations were found among different doses of inorganic fertilizers on the EC value of soil. The maximum EC value was recorded under $T_1$ (0.27 dSm$^{-1}$), followed by $T_2$, which, was however at par with $T_3$ (0.26 dSm$^{-1}$), whereas, minimum (0.22 dSm$^{-1}$) was recorded in $T_5$. The reason behind higher value of EC with the higher dose of inorganic fertilizers may be due to increase in soluble salts in the soil with increasing levels of fertilizer doses. The data pertaining to organic

Table 4. Effect of different doses of integrated fertilizer treatments and planting conditions on chemical properties of soil

| Treatments<br>Doses of inorganic fertilizers + organic fertilizers | Organic carbon (g kg$^{-1}$) | Available N (kg ha$^{-1}$) | Available P (kg ha$^{-1}$) | Available K (kg ha$^{-1}$) | pH (1:2) | EC (dS m$^{-1}$) |
|---|---|---|---|---|---|---|
| $T_1$ | 13.22$^d$ | 293.07$^e$ | 44.32$^e$ | 377.22$^e$ | 6.93$^b$ | 0.27$^a$ |
| $T_2$ | 13.45$^c$ | 306.63$^b$ | 52.73$^b$ | 384.45$^c$ | 6.94$^a$ | 0.26$^a$ |
| $T_3$ | 13.92$^a$ | 312.62$^a$ | 56.69$^a$ | 390.99$^a$ | 6.94$^a$ | 0.26$^a$ |
| $T_4$ | 13.84$^a$ | 302.79$^c$ | 46.22$^d$ | 388.85$^b$ | 6.95$^a$ | 0.24$^b$ |
| $T_5$ | 13.62$^b$ | 296.75$^d$ | 48.41$^c$ | 379.12$^d$ | 6.94$^a$ | 0.22$^c$ |
| Planting condition | | | | | | |
| $P_1$ | 13.68$^a$ | 302.37$^a$ | 49.76$^a$ | 384.01$^a$ | 6.94$^a$ | 0.25$^a$ |
| $P_2$ | 13.58$^a$ | 302.15$^b$ | 49.58$^b$ | 384.24$^a$ | 6.94$^a$ | 0.25$^a$ |

*Mean values of each growth and yield parameters followed by the same letter are not significantly different at P= 0.05

*$T_1$: recommended doses of fertilizers (NPK); $T_2$: 75% recommended doses of fertilizers (NPK) + 25% vermicompost; $T_3$: 50% recommended doses of fertilizers (NPK) + 50% vermicompost; $T_4$: 25% recommended doses of fertilizers (NPK) + 75% vermicompost and $T_5$: 100% vermicompost

*$P_1$: Peach based system; $P_2$: Sole cropping system

carbon (Table 4) reveal that application of organic manures significantly influenced organic carbon percentage during the study period. Soil organic carbon content increased significantly in the plots that had conjointly received inorganic fertilizers and vermicompost. The organic carbon contents of soil ranged from 13.22 g $kg^{-1}$ ($T_1$) - 13.92 g $kg^{-1}$ ($T_3$). The increase in organic carbon content might be attributed to addition of organic materials and better root growth. These results are in line with the findings of Mukherjee *et al.*, (1999) and Tolanur and Badanur (2003). Marimuthu *et al.*, (2001) also reported that application of organic sources (FYM or farm residue) along with inorganic fertilizers increased the OC content of soils compared to those which received sole applications of chemical fertilizers. There was no significant difference in soil organic carbon after crop harvest for planting conditions which may be due wider spacing between peach plants, which were also leafless for most of the time during investigation. Data depicted in Table 4 revealed that different combinations of organic and chemical fertilizers significantly influenced the amount of available N, P and K in surface soils. Maximum values of available N, P and K 312.51 kg $ha^{-1}$, 56.69 kg $ha^{-1}$ and 390.99 kg $ha^{-1}$, respectively were found in $T_3$ whereas, minimum available N, P and K (293.01 kg $ha^{-1}$, 44.32 kg $ha^{-1}$ and 377.22 kg $ha^{-1}$, respectively) were found in $T_1$. Addition of organic manures might have increased the microbial activity, thereby, accelerating the rate of decomposition of native soil organic matter (a positive priming effect), thus, leading to higher mineralization and release of nutrient elements. These results are in the line of the findings found by Kumar *et al*. (2005), Raina and Goswami (1988) and Singh *et al*., (2002). The planting conditions also exerted significant influences on soil available N and P. The higher values of these nutrients were found under peach based agroforestry system than sole cropping system. However, the content of available K was at par in two systems. Interaction effects were found to have non-significant influence on all the chemical properties of soil.

## Economic values of the intercropping and monocropping systems

The economics of the growing *S. marianum* both under peach based agroforestry ($P_1$) and sole cropping systems ($P_2$) revealed that the cost of cultivation was maximum i.e. ₹ 1,08,877.5 $ha^{-1}$ incurred in the practice, where milk thistle were grown with peach and supplied with 100% vermicompost ($T_5P_1$), while minimum cost of cultivation to the tune of ₹ 41,049 $ha^{-1}$ was obtained, where milk thistle were supplied with 100% recommended doses of NPK under sole cropping system ($T_1P_2$). Intercropping of *S. marianum* with peach and supplemented with the recommended doses of fertilizers in inorganic form ($T_1P_1$) gave higher net return

Table 5. Cost – return analysis (₹ $ha^{-1}$) of intercropping of *Silybum marianum* with peach vis –a-vis sole cropping

| Treatments | Peach based system ($P_1$) | | | | |
|---|---|---|---|---|---|
| | Cost of cultivation (₹ $ha^{-1}$) | Gross return from intercrop (₹ $ha^{-1}$) | Net return from intercrop (₹ $ha^{-1}$) | Average net return from peach (₹ $ha^{-1}$) | Total net return from AF system (₹ $ha^{-1}$) |
| $T_1$ | 41049 | 592860 | 551811 | 19460 | 571271 |
| $T_2$ | 57559 | 589620 | 532061 | 19460 | 551521 |
| $T_3$ | 74069 | 614160 | 540091 | 19460 | 559551 |
| $T_4$ | 91829.75 | 580860 | 489030.3 | 19460 | 508490.3 |
| $T_5$ | 108877.5 | 586110 | 477232.5 | 19460 | 496692.5 |
| Mean | 74676.85 | 592722 | 518045.2 | 19460 | 537505.2 |
| | Sole cropping system ($P_2$) | | | | |
| $T_1$ | 37449 | 542190 | 504741 | - | 504741 |
| $T_2$ | 53959 | 588750 | 534791 | - | 534791 |
| $T_3$ | 70469 | 589560 | 519091 | - | 519091 |
| $T_4$ | 88229.75 | 574080 | 485850.3 | - | 485850.3 |
| $T_5$ | 105277.50 | 560160 | 454882.5 | - | 454882.5 |
| Mean | 71076.85 | 570948 | 499871.2 | - | 499871.2 |

*$T_1$: recommended doses of fertilizers (NPK); $T_2$: 75% recommended doses of fertilizers (NPK) + 25% vermicompost; $T_3$: 50% recommended doses of fertilizers (NPK) + 50% vermicompost; $T_4$: 25% recommended doses of fertilizers (NPK) + 75% vermicompost and $T_5$: 100% vermicompost

*Cost- benefit analysis was carried out on the 2013-14 rate basis i.e. ₹ 5,71,271 $ha^{-1}$ than other treatment combinations. The reason may be due higher seed yield (productivity) and market price of milk thistle as well as the low cost of inorganic fertilizers used in the treatment combinations. Comparatively more returns were obtained from agroforestry systems than in sole cropping. It is due to the additional income procured from the peach trees. The results are in line with the findings of Rajput (2010), who has reported very high return, to the tune of 7.32 lakhs $ha^{-1}$ $yr^{-1}$ from agrihorticulture system in Kullu valley of Himachal Pradesh. Sood (1999) also reported that agrihorticulture system provides more return as compared to sole crop.

## 4. CONCLUSION

Results obtained from the present investigation indicate that the combined application of organic and inorganic fertilizers i.e. $T_3$ (50% recommended dose of fertilizers + 50% vermiompost) is the best strategy, which can be employed for the enhancement of growth and yield of *S. marianum* without deteriorating the chemical traits of soil since it had a positive impact irrespective of the presence or absence of peach trees. Bioeconomics analysis of the system revealed that this crop can be successfully grown for commercial cultivation in the mid hill zone of Himachal Pradesh under peach agri-horticulture system.

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