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Vipin Kumar
Department of Forest Products, Dr. YSP UHF Nauni, Solan, Himachal Pradesh, India

Dr. Meenu Sood
Department of Forest Products, Dr. YSP UHF Nauni, Solan, Himachal Pradesh, India

Vinaykumar Rachappanavar
MS Swaminathan School of Agriculture, Shoolini University, Solan Himachal Pradesh, India

Sonam Raj
MS Swaminathan School of Agriculture, Shoolini University, Solan Himachal Pradesh, India

Corresponding Author:
Vipin Kumar
Department of Forest Products, Dr. YSP UHF Nauni, Solan, Himachal Pradesh, India

Assessing the growth of *Linum usitatissimum* with various organic amendments and fertilizers in a medicinal agroforestry system centered on peach cultivation

Vipin Kumar, Dr. Meenu Sood, Vinaykumar Rachappanavar and Sonam Raj

Abstract
Linum usitatissimum, commonly known as Alsi, is a medicinal plant of significant value. The mid Himalayan region is renowned for its stone fruit cultivation, with peach standing as a key stone fruit variety in Himachal Pradesh. Recognizing the potential benefits, many farmers have ventured into integrating medicinal and aromatic plants within their peach orchards. This synergistic approach has gained popularity in various states across India, offering profitable avenues for cultivation. In this study, the utilization of farmyard manure (FYM) at two different rates (2t/ha and 4t/ha), vermicompost at two rates (2t/ha and 4t/ha), and jeevamrutha (500l/ha) has been explored to minimize resource competition and enhance the performance of *Linum usitatissimum* within the peach-based agroforestry system. Among the treatments, the combination of NPK fertilizers (120:60:30 kg/ha) in T_6 demonstrated remarkable results. This treatment exhibited the tallest plant height (54.15 cm) at the harvesting stage, the highest number of branches per plant (4.85), and the maximum fresh and dry aerial biomass per plant (11.98 g/plant and 8.22 g/plant, respectively), as well as the highest seed yield (10.16 q/ha). Furthermore, this optimal treatment, T_6, yielded the highest gross return of Rs. 1,01,600 for *Linum usitatissimum*. It also generated the maximum total net return of Rs. 1,25,026, and the most favorable benefit-cost ratio of 2.13, reflecting its economic viability. In summary, the integration of *Linum usitatissimum* with peach in an intercropping system, particularly under the T_6 treatment, proved highly advantageous, surpassing other treatments in various key parameters.

Keywords: Recognizing, gained popularity, demonstrated

1. Introduction

Linum usitatissimum, commonly known as Linseed, Alsi, or flax seed, holds a prestigious place as one of the world's oldest cultivated crops, cherished for its versatile utility in the production of oil, fiber, and food (Oomah, 2001) [12]. Belonging to the Linaceae family and *Linum* genus, this annual herbaceous plant boasts a shallow root system. Cultivars cultivated primarily for seed and oil production are typically shorter in stature, characterized by abundant secondary branches and seed bolls. In contrast, those grown for fiber purposes exhibit tall growth with straight culms and fewer secondary branches. While the Mediterranean and Southwest Asia have both been suggested as potential centers of origin (Millam *et al*., 2005) [10], flax seed oil stands out as an exceptional source of the omega-3 fatty acid, linolenic acid, comprising a substantial 55% of its composition (Oomah, 2001) [12]. This high linolenic acid content endows it with rapid polymerization properties, making it an ideal choice for applications in paints, varnishes, and inks.

In the contemporary context, the increasing demand for edible oil sources rich in omega-3 fatty acids has led to the resurgence of flax seeds as a functional food. These seeds have also found a place in animal feed to enhance animal reproductive performance and overall health, as noted by Heimbach (2009) [6] and Turner *et al*. (2014) [17]. The textile properties of flax fiber surpass those of cotton, positioning flax as the third largest natural fiber crop and one of the world's top five oilseed crops.

Ancient civilizations, such as Egypt, recognized the value of flax for wrapping royal mummies and utilizing linseed oil in embalming deceased Pharaohs.

Beyond its historical significance, flaxseed stands out for its richness in soluble and insoluble fibers and lignans, positioning it as a valuable dietary supplement. Consumption of flaxseed in daily diets has been linked to a reduced risk of cardiovascular diseases like coronary heart disease and stroke, as well as anticancer effects in breast, prostate, and colon cancers. Additionally, its dietary inclusion helps alleviate issues like constipation. Beyond its applications in nutrition, flax offers versatile industrial use, contributing to the textile industry with the production of linen cloth, thread, canvas, duck, strong twine, carpets, and even insulating materials. The uses of flax fibers extend beyond textiles, finding application in manufacturing fish and seine lines, cigarette paper, writing paper, and insulating materials.

Moreover, linen, derived from flax, boasts several advantages, including being allergy-free, moisture-absorbent, breathable, antistatic, antibacterial, and minimally elastic. Linen can be laundered repeatedly without deterioration, and its moisture-absorbing capacity reaches up to 20 times its own weight before feeling damp. The residues left behind after linseed oil extraction, comprising approximately 35-40% protein and 3-4% oil, serve as a valuable source of cattle feed. Furthermore, linseed is classified as a natural substance and falls under the category of bulk-forming agents, finding applications in the treatment of respiratory tract disorders, eye conditions, infections, and various ailments like cold, flu, fever, rheumatism, and gout.

The traditional agroforestry systems in Himachal Pradesh demonstrate the inherent wisdom of farmers who understand the benefits of mixed crop cultivation, often integrating three to six layers of trees in and around their fields. The mid-hills of this region, known for their abundant stone fruit production, have witnessed a surge in peach orchard cultivation. Agroforestry presents a practical strategy for promoting these endeavors while conserving the environment. In particular, the horti-medicinal system has emerged as a favorable approach, advocating for the interplanting of medicinal and aromatic plants alongside stone fruit crops. This synergy not only enhances growers' income but also contributes to environmental amelioration.

2. Materials and Methods

The current study was carried out between 2016 and 2018 at two key locations within the YSP University of Horticulture and Forestry in Nauni, Solan (Himachal Pradesh). Specifically, the research was conducted at the Department of Fruit Science, based in the College of Horticulture, as well as the Medicinal and Aromatic Plant Research Farm. Additionally, the Laboratory of the Department of Forest Products, situated within the College of Forestry, played a crucial role in the study. These research sites are nestled in the mid-hills of Himachal Pradesh, standing at an elevation of 1270 meters above sea level. They are approximately 15 kilometers southeast of Solan town, marking the transitional zone between the sub-tropical and sub-temperate regions.

The study comprised two structural and functional components: Peach (*Prunus persica* L. var. July Elberta), a woody perennial fruit tree, and medicinal and aromatic plants as intercrops. Additionally, the study examined the influence of three different organic manures and fertilizers on the growth and productivity of these medicinal and aromatic plants, both in association with and independently of peach.

The experiment consisted of nine treatments, namely T_1 (Peach + *Linum usitatissimum* + Peach + FYM 2t/ha), T_2 (Peach + *Linum usitatissimum* + FYM 4t/ha), T_3 (Peach + *Linum usitatissimum* + Vermicompost 2t/ha), T_4 (Peach + *Linum usitatissimum* + Vermicompost 4t/ha), T_5 (Peach + *Linum usitatissimum* + Jeevamarutha 500 l/ha), T_6 (Peach + *Linum usitatissimum* + RDF 120:60:30 NPK kg/ha), T_7 (Peach + *Linum usitatissimum*), T_8 (*Linum usitatissimum* + RDF 120:60:30 NPK kg/ha), and T_9 (Control). Seeds were sown during the last fortnight of October in rows with a spacing of 30 x 10 cm for two consecutive years. Data on plant growth and yield were recorded and subsequently analyzed. The recorded data underwent statistical analysis using a Randomized Block Design. An analysis of variance was conducted, and the critical difference at a 5 percent level of significance was calculated using the latest computer software.

3. Result and Discussion

The data analysis revealed a significant impact of the application of organic manures and fertilizers on the height of *Linum usitatissimum*. In the 2016-17 season, the maximum plant height (54.15 cm) was observed in T_6 (Peach + *Linum usitatissimum* + RDF NPK 120:60:30 kg/ha), and this height was statistically superior to all other values. It was followed by T_4 (Peach + *Linum usitatissimum* + Vermicompost 4t/ha) at 52.84 cm and T_2 (Peach + *Linum usitatissimum* + FYM 4t/ha) at 50.64 cm. Additionally, T_3 (Peach + *Linum usitatissimum* + Vermicompost 2t/ha) registered 49.65 cm, and T_1 (Peach + *Linum usitatissimum* + FYM 2t/ha) recorded 48.25 cm. T_5 (Peach + *Linum usitatissimum* + Jevaamarutha) at 46.72 cm was statistically comparable to T_8 (*Linum usitatissimum* + RDF NPK 120:60:30) at 46.95 cm.

This pattern of plant height was consistent during the 2017-18 season. The results underscore the essential role of nitrogen in promoting proper plant growth, aligning with the findings of Tisdale *et al.* (2003) [16], emphasizing the necessity of nitrogen for numerous physiological growth processes and the adverse effects of its absence or deficiency.

The number of branches per *Linum usitatissimum* plant was evaluated at the harvesting stage. Data indicated that the maximum number of branches per plant (4.85) was recorded in T_6, which was statistically superior. Conversely, the minimum (2.25) was observed in T_9 (control), where no fertilizers or manures were applied in the 2016-17 season. Similar trends in the number of branches were observed in the 2017-18 season, with T_6 registering the highest number of branches per plant (4.23), once again being statistically superior, while T_9 recorded the lowest number of branches per plant (1.57).

The study also assessed the impact of different doses of fertilizers and organic manures on the fresh and dry weights of *Linum usitatissimum* over two consecutive years. It was observed that relatively higher fresh yield per plant (11.98 g) was recorded in T_6 in the 2016-17 season, and this was statistically superior. In contrast, the minimum fresh aerial biomass (6.09 g per plant) was found in T_9. In the 2017-18 season, the maximum aerial fresh weight per plant (9.75 g) was recorded in T_6, where plants were grown alongside peach and supplied with NPK 120:60:30 kg/ha, and this was statistically superior compared to other treatments. On the other hand, the minimum aerial fresh weight per plant (4.18 g) was recorded in T_9, where medicinal plants were grown without peach and received no fertilizers or organic manures.

Table 1: The data recorded *Linum usitatissimum* under peach based Agroforestry system in 2016-17

Characters Treatments	Plant height (cm)	Number of branches/plant	Fresh aerial biomass/plant (g)	Estimated fresh aerial biomass (q/ha)	Dry aerial biomass/plant (g)	Estimated dry aerial biomass (q/ha)	Seed yield/plant (g)	Estimated seed yield (q/ha)
T_1	48.25	2.85	8.45	28.16	4.70	15.67	2.87	9.55
T_2	50.64	3.15	9.84	32.80	6.09	20.30	2.92	9.73
T_3	49.65	2.85	8.79	29.30	5.04	16.80	2.89	9.62
T_4	52.84	3.95	10.54	35.13	6.79	22.63	2.99	9.97
T_5	46.72	2.74	7.25	24.17	3.49	11.63	2.85	9.50
T_6	54.15	4.85	11.98	39.93	8.22	27.40	3.05	10.16
T_7	45.58	2.15	6.89	22.97	3.13	10.43	2.28	7.60
T_8	46.95	3.14	7.98	26.60	4.22	14.07	2.83	9.44
T_9	40.23	2.25	6.09	20.30	2.33	7.77	2.05	6.82
Mean	48.33	3.10	8.65	28.82	4.89	16.30	2.75	9.15
CD at 5%	0.44	0.07	0.16	0.54	0.16	0.65	0.03	0.10

These results align with the studies of Mohsin *et al.* (1999) [11], who reported on biomass production in intercropped plantations with *Mentha* species, *Cymbopogon* species, and pure stands (*Populus deltoids*) clone 'G-3'. Bisht *et al.* (2000) [3] also reported on biomass production in *Zingiber Officinale* and *Curcuma longa* under different tree species.

Table 2: The data recorded of *Linum usitatissimum* under peach based Agroforestry system in 2017-18

Characters Treatments	Plant height (cm)	Number of branches/plant	Fresh aerial biomass/plant (g)	Estimated fresh aerial biomass (q/ha)	Dry aerial biomass/plant (g)	Estimated dry aerial biomass (q/ha)	Seed yield/plant (g)	Estimated seed yield (q/ha)
T_1	44.30	2.09	6.46	21.53	4.28	14.28	2.21	7.36
T_2	47.02	2.50	7.87	26.23	5.05	16.83	2.29	7.63
T_3	45.27	2.17	6.86	22.87	4.04	13.47	2.27	7.56
T_4	48.96	3.27	8.83	29.43	6.01	20.03	2.33	7.76
T_5	42.15	2.08	5.24	17.47	2.42	8.07	2.10	6.99
T_6	50.80	4.23	9.75	32.50	6.93	23.10	2.41	8.03
T_7	41.45	1.54	4.86	16.20	2.04	6.80	1.69	5.64
T_8	42.69	2.47	5.94	19.80	3.12	10.40	2.07	6.91
T_9	36.62	1.57	4.18	13.93	1.36	4.53	1.60	5.35
Mean	44.36	2.44	6.67	22.22	3.92	13.06	2.11	7.03
CD at 5%	0.45	0.10	0.19	0.64	0.19	0.64	0.03	0.10

Furthermore, among different treatments, T_6 demonstrated a relatively higher estimated fresh aerial biomass per hectare (39.93 q/ha) in the 2016-17 season, and this was statistically superior. Conversely, T_9 recorded the minimum fresh aerial biomass per hectare (20.30 q/ha). In the 2017-18 season, T_6 again registered the highest estimated fresh aerial biomass per hectare (32.50 q/ha), being statistically superior. The lowest estimated fresh aerial biomass per hectare (13.93 q/ha) was recorded in T_9, where plants were grown without peach and without the application of organic manures and fertilizers. The data emphasized the effectiveness of fertilizers in increasing the fresh aerial biomass per plant of *L. usitatissimum* compared to organic manures under peach. This finding is in line with the results reported by Sehgal and Thakur (2008) [14], who noted that the application of organic manures improved the performance and production efficiency of medicinal herbs intercropped with trees.

The data analysis indicated a significant influence of different doses of organic manures and fertilizers on the dry aerial biomass per plant of *L. usitatissimum*. In the 2016-2017 season, the maximum average dry aerial biomass per plant (8.22 g) was observed in T_6, where *L. usitatissimum* was cultivated alongside peach and supplied with NPK 120:60:30 kg/ha. This was statistically superior to all other treatments. Conversely, the minimum average dry aerial biomass per plant (2.33 g) was recorded in T_9, where *L. usitatissimum* was grown in an open field without peach or any application of organic manures and fertilizers.

These results for dry aerial biomass per plant followed a similar trend in the 2017-18 season. It is evident that the presence of peach and the application of organic manures and fertilizers significantly impacted the dry aerial biomass per plant of *L. usitatissimum*. These findings are in line with the studies of Palada *et al.* (2005) [13], Maheshwari *et al.* (2000) [8], and Menon (2003) [9], which reported higher yields when plants were intercropped with tree species as opposed to the control.

The study also examined the dry aerial biomass per hectare in *L. usitatissimum* under various treatments. In the 2016-17 season, the maximum average estimated dry aerial biomass per hectare (27.40 q/ha) was recorded in T_6, where *L. usitatissimum* was cultivated alongside peach and supplied with NPK 120:60:30 kg/ha, and this was statistically superior. Conversely, the minimum biomass (7.77 q/ha) was observed in T_9, where no peach, no fertilizers, and no manures were applied. Similar observations for dry aerial biomass per hectare were made during the 2017-18 season. T_6 again recorded the highest aerial biomass per hectare (23.10 q/ha), while T_9 registered the lowest dry aerial biomass per hectare (4.53 q/ha). It's worth noting that the dry aerial biomass per hectare was higher in the first year of the study compared to the second year.

The examination of *L. usitatissimum* revealed that the maximum average seed yield (3.05 gm/plant) was recorded in T_6 during the 2016-17 season. In this treatment, plants were grown alongside peach and supplied with NPK 120:60:30 kg/ha, and this yield was statistically superior to all other treatments. T_4 (Peach + *Linum usitatissimum* + Vermicompost 4t/ha) followed with an average seed yield of 2.99 g/plant, and T_2 (Peach + *Linum usitatissimum* + FYM 4t/ha) with 2.92

g/plant. T_3 (Peach + *Linum usitatissimum* + Vermicompost 2t/ha) recorded 2.89 g/plant, and T_1 (Peach + *Linum usitatissimum* + FYM 2t/ha) had an average seed yield of 2.87 g/plant. Treatment T_5 (Peach + *Linum usitatissimum* + Jevaamarutha) yielded 2.85 g/plant, statistically on par with T_8 (*Linum usitatissimum* + RDF NPK 120:60:30) at 2.83 g/plant. The minimum seed yield (2.05 g/plant) was observed in T_9, where plants were grown without peach and received no fertilizers or organic manures.

In the 2017-18 season, the maximum average seed yield per plant (2.41 g) was observed in T_6 (Peach + *L. usitatissimum* + RDF NPK 120:60:30 kg/ha), which was statistically distinct from all other treatments. The minimum seed yield (1.60 g) was recorded in T_9 (no peach + no fertilizers + no organic manures). The data underscores the effectiveness of fertilizers in enhancing the seed yield of *L. usitatissimum* compared to organic manures when cultivated alongside peach. These results align with the work of Baig *et al.* (2004) [2], which reported the significant impact of the application of *Sesbania esculanta* and FYM on the grain and straw yield of rice.

The maximum seed yield of *L. usitatissimum* (10.16 q/ha) was recorded in T_6 (Peach + *Linum usitatissimum* + RDF NPK 120:60:30 kg/ha) and was statistically distinct from all other treatments. T_4 (Peach + *Linum usitatissimum* + Vermicompost 4t/ha) followed with an average yield of 9.97 q/ha, and T_2 (Peach + *Linum usitatissimum* + FYM 4t/ha) yielded 9.73 q/ha. T_3 (Peach + *Linum usitatissimum* + Vermicompost 2t/ha) had an average yield of 9.62 q/ha, and T_1 (Peach + *Linum usitatissimum* + FYM 2t/ha) produced 9.55 q/ha. T_5 (Peach + *Linum usitatissimum* + Jevaamarutha) achieved 9.50 q/ha, statistically comparable to T_8 (*Linum usitatissimum* + RDF NPK 120:60:30) at 9.44 q/ha. The lowest seed yield (6.82 q/ha) was recorded in T_9, where no peach, no fertilizers, and no organic manures were applied during the 2016-17 season. Similar results for seed yield were obtained during the 2017-18 season, with T_6 achieving the highest seed yield (8.03 q/ha), which was statistically different from all other values. T_4 followed with 7.76 q/ha, and T_2 with 7.63 q/ha, while T_3 produced an average of 7.56 q/ha, and T_1 yielded 7.36 q/ha. T_5 achieved a seed yield of 6.99 q/ha, statistically on par with T_8 at 6.91 q/ha. The lowest estimated seed yield (5.35 q/ha) was recorded in T_9. Thus, the data indicates that when organic manures and fertilizers were applied, higher seed yield under peach was obtained compared to a sole crop. This is consistent with the findings of Channanbasappa *et al.* (2009) [4] in *Ocimum sanctum*, *Stevia rabudiana*, *Mentha arvensis*, *Periwinkle*, *Withania somnifera*, *Centella asiatica*, and *Eclipta alba* under areca nut.

Economic Analysis of *Linum usitatissimum* under peach based Agroforestry system

The economic analysis of the peach-based horti-medicinal agroforestry system, which includes medicinal plants and *Linum usitatissimum* as an intercrop, was conducted. The cost of cultivation, gross returns, and net returns of *L. usitatissimum* were determined both in the presence and absence of peach to assess the economic profitability of this tree-crop combination. The prices of peach fruit and *Linum usitatissimum* were set at Rs. 30/kg and Rs. 150/kg, respectively, for the year 2016-17.

The data revealed that the highest gross return (Rs. 1,01,600) for *L. usitatissimum* was achieved in T_6 within the horti-medicinal agroforestry system, where plants received NPK 120:60:30 kg/ha. This result was statistically superior to all other treatments. Conversely, among the various treatments, the minimum gross return (Rs. 68,200) was observed in T_9 (control), where no peach, fertilizers, or organic manures were used during the 2016-17 season. In 2017-18, the highest gross income (Rs. 80,300) was recorded in T_6 (Peach + *Linum usitatissimum* + RDF NPK 120:60:30 kg/ha), and the lowest gross income (Rs. 53,500) was observed in T_9 (Control).

Table 3: Economic analysis of *Linum usitatissimum* under peach based agroforestry system 2016-17

Characters Treatments	Gross return from intercrop (Rs/ha)	Cost of cultivation (Rs/ha)	Net Income from intercrop (Rs/ha)	Average net return from peach (Rs/ha)	Total net return from AF system (Rs/ha)	B:C
T_1	95,500	59,624.15	35,875.85	83,550	1,19,426	2.00
T_2	97,300	63,124.15	34,175.85	83,550	1,17,726	1.86
T_3	96,200	86,124.15	10,075.85	83,550	93,626	1.09
T_4	99,700	1,16,124.2	-16,424.2	83,550	67,126	0.58
T_5	95,000	57,124.15	37,875.85	83,550	1,21,426	2.13
T_6	1,01,600	60,124.15	41,475.85	83,550	1,25,026	2.08
T_7	76,000	56,124.15	19,875.85	83,550	1,03,426	1.84
T_8	94,400	55,124.15	39,275.85	-	-	1.71
T_9	68,200	51,124.15	17,075.85	-	-	1.33
Mean	91,544	67,179.71	24,364.73	83,550	106,826	1.62

The total net return from the agroforestry system was calculated by combining the net returns obtained from intercrops and the tree component growing within the agroforestry system. Among the different treatments, the maximum total net return from the agroforestry system (Rs. 1,25,026) was achieved in T_6, where plants were grown alongside peach with the application of NPK 120:60:30 kg/ha. This result was significantly different from all other values. The minimum net return was recorded in T_9 (Rs. 17,075.85) during the 2016-17 season, where plants were grown without peach and received no fertilizers or organic manures. In 2017-18, the maximum total net return from the agroforestry system (Rs. 98,185.85) was observed under T_6 (Peach + *Linum usitatissimum* + RDF NPK 120:60:30 kg/ha), and this result was statistically distinct from the other treatments. The lowest net return was recorded in T_4 (Peach + *Linum usitatissimum* + Vermicompost 4t/ha) at Rs. -39,024.20. It is noteworthy that the total net return was higher in the first year compared to the second year of the study.

Upon perusing the data presented in Table 3 to Table 4, it was observed that the maximum benefit-cost ratio (2.13) was recorded in T_5 (Peach + Jeevamrutha), while the minimum benefit-cost ratio (0.58) was found in T_4 (Peach + 4t/ha Vermicompost) during the 2016-17 season. These values displayed a statistically significant difference from all other values.

Table 4: Economic analysis of *Linum usitatissimum* under peach based agroforestry system 2017-18.

Characters Treatments	Gross return from intercrop (Rs/ha)	Cost of cultivation (Rs/ha)	Net Income from intercrop (Rs/ha)	Average net return from peach (Rs/ha)	Total net return from AF system (Rs/ha)	B:C
T_1	73,600	60,124.15	13,475.85	78,510	91,985.85	1.53
T_2	76,300	63,624.15	12,675.85	78,510	91,185.85	1.43
T_3	75,600	86,624.15	-11,024.2	78,510	67,485.85	0.78
T_4	77,600	1,16,624.2	-39,024.2	78,510	39,485.85	0.34
T_5	69,900	57,624.15	12,275.85	78,510	90,785.85	1.58
T_6	80,300	60,624.15	19,675.85	78,510	98,185.85	1.62
T_7	56,400	56,624.15	-224.15	78,510	78,285.85	1.38
T_8	69,100	55,624.15	13,475.85	-	-	1.24
T_9	53,500	51,624.15	1,875.85	-	-	1.03
Mean	70,256	67,679.71	2,575.84	78,510	79,628.71	1.21

Conclusion

The investigations were carried out over two consecutive years (2016-17 and 2017-18) to assess the impact of organic manures and fertilizers in conjunction with peach trees on the growth and productivity of *Linum usitatissimum*, while also conducting an economic evaluation of the system. The objective of these studies was to explore the feasibility of cultivating medicinal and aromatic plants as intercrops within a fruit-based agroforestry system, with the aim of diversifying and enhancing farmers' economic prospects.

The findings demonstrated that various growth parameters of *Linum usitatissimum*, including plant height and the number of branches per plant, exhibited significant variations as a result of fertilizer and organic manure applications in the horti-medicinal agroforestry system. These studies revealed that the use of fertilizers had a positive impact on the growth of medicinal and aromatic plants, both in the presence and absence of trees. The results obtained from this research indicated that *Linum usitatissimum* performed well within the horti-medicinal agroforestry system, outperforming sole-crop cultivation. The growth, yield, and physiological characteristics of medicinal herbs were not adversely affected by the presence of peach trees.

Both inorganic fertilizers and organic manures influenced the growth and yield parameters of *Linum usitatissimum*. In general, the application of the NPK 120:60:30 fertilizer dose in the respective crops was the most effective in enhancing the growth and yield attributes of medicinal plants intercropped with peach trees, followed by organic manures, and it had the least effect in sole-crop cultivation.

Intercropping medicinal and aromatic plants (MAPs) with peach trees proved to be more advantageous compared to sole-crop cultivation. The results highlighted that the horti-medicinal agroforestry system is more profitable, and the utilization of fertilizers and organic manures enhanced growth by improving soil physicochemical properties, stimulating microbial activity, and increasing nutrient availability to the plants, ultimately leading to higher yields of medicinal herbs within the horti-medicinal agroforestry system. The use of NPK fertilizers notably increased nutrient availability to the plants.

Based on the current findings, it can be concluded that *Linum usitatissimum* can be successfully cultivated within a peach-based agroforestry system to achieve more favorable economic returns.

In the 2017-18 season, the maximum benefit-cost ratio (1.62) was documented in T_6 (Peach + NPK 120:60:30 kg/ha), and the minimum ratio (0.34) was noted in T_4 (Peach + 4t/ha Vermicompost). Similar results were corroborated by Thakur and Raj Kumar (2006) [15] in Tagetes minuta and Ocimum basilicum under Leucaena leucocephala and Morus alba, as well as Chauhan *et al*. (1997) [5] in Citronella java under *Eucalyptus*, who reported higher returns from intercropped plants compared to sole crops.

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