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EFFECT OF DIFFERENT ORGANIC MANURES ON PRODUCTION OF *LEPIDIUM SATIVUM* UNDER *MORUS* BASED AGROFORESTRY SYSTEM

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Abstract

Agroforestry is a sustainable land use system that integrates trees and shrubs on farmlands and rural landscapes to enhance productivity, profitability, diversity and ecosystem sustainability. In the present study effect of different organic manures on production of *Lepidium sativum* (a veterinary galactogogue/medicinal herb) under open conditions and *Morus alba* based agroforestry system was investigated. The experiment comprised of 8 treatments. It was observed that treatment T_7 recorded higher plant height whereas other growth and yield parameter were recorded to be maximum in treatment T_6. Highest number of branches, number of main stem, number of pods, yield parameters were observed in treatment T_6 while the lowest was recorded in treatment T_4. From the economical point of view, the treatment T3 resulted in higher net return (1154.27 USD $ ha^{-1}) and BC ratio (2.44).

Introduction

Lepidium sativum (Chandarshoor) belonging to Brasicacae is widely cultivated in tropical and subtropical zones of India. The plant has its origin in Egypt and South West Asia, but is now cultivated throughout the world for its seeds (Manohar *et al.* 2011). Seeds of this plant possess diuretics and aphrodisiac properties and are recommended in inflammation, bronchitis, rhumetism and muscular pain (Sharma and Agarwal 2012). It is widely used as an analgesic, anti- spasmodic, anti-diarrhoeal, galactagogue, hepatoprotective, antioxidant, anti-inflammatory (Balgoon 2019) diuretic (Alqahtani *et al.* 2019), etc. 9.3 per cent higher milk yield of crossbred cows was recorded on supplementation of Polyherbal mixture having 50% *Lepidium sativum* composition. (Gautam *et al.* 2019). *Morus alba* (Mulberry) is a multipurpose tree which belongs to Moraceae and grown at sub-tropical region and up to higher altitudes in the Himalaya-Hindu Kush region (Imran *et al.* 2010). Mulberry foliage is an excellent source of crude protein (20-24%) and is utilized for dairy cattle feeding in lean period because it has high digestibility.

The main use of mulberry globally is a feed for silkworm. It is appreciated as a fruit, a delicious vegetable, a plant of medicinal value, for landscaping and the leaves as an animal fodder. Mulberry leaves have a great potential as an alternative protein source for livestock due to rich protein, minerals, metabolizable energy contents and negligible anti-nutritional factors like tannic acid (Saddul *et al.* 2004). Mulberry proved to be excellent and un-convention food stuff for small ruminants in general, goat and cow in particular (Venkatesh *et al.* 2015).

Agroforestry is a sustainable land use system whereby a deliberate integration is done to manage the agriculture as well as forest resources on the same piece of land in order to harvest the diversified products. It is an intensive farming and forest management shaped by intentional introduction of multiple productive species and management of their complex agro ecological

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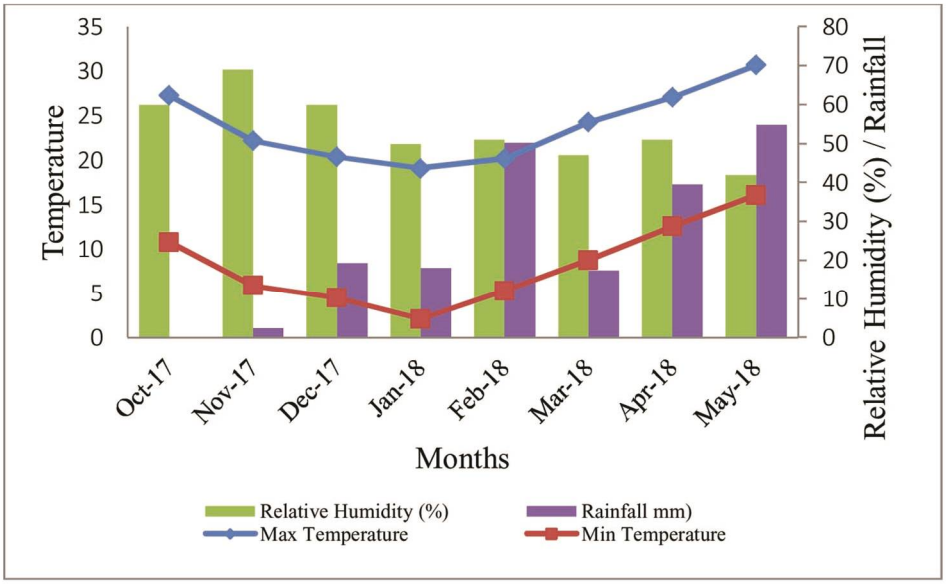
interactions (Gold *et al.* 2009). Considerable attention has been given to the use of chemical fertilizers in conjunction to maintain soil health and productivity. Improvement of environmental conditions and public health are important reasons for advocating increased use of organic materials (Seifritz 2011). Apart from using conventional farm based products there is an increasing demand for improvised materials like Jeevamrut which is liquid organic manure prepared from cow dung, cow urine, unpurified sugar, chickpea flour and soil from underneath the wild trees and water. It acts as an agent to increase the microbial activity and if used consistently, it minimize the need of for chemical fertilizers (Palekar 2006, Ravusehab 2008, Sreenivasa 2010). Jeevamrut is low cost improvised preparation that enriches the soil with indigenous microorganisms required for mineralization of the soil (Gore and Sreenivasa 2011, Vasanthkumar 2006). Application of vermicompost to crop has also been reported to improve early root initiation, increased root biomass, enhanced plant growth and development. Different organic manures and bio fertilizers influence differently in terms of yield and quality of produce of different crops. Hence the present study was aimed to find out the best source of organic manures and bio fertilizers which could help in increasing the yield and quality of the crop (Singh *et al.* 2012).

Material and Methods

The present study was conducted to assess the effect of different organic manures on yield and biomass production of *Lepidium sativum* under open conditions and *Morus alba* based agroforestry system at the experimental farm of Department of Silviculture and Agroforestry, Dr. Y.S. Parmar University of Horticulture and forestry, Nauni, Solan (H.P.) during the year 2017-2018. The experimental farm is located at 30˚51' N latitude and 76˚11' E longitude with an elevation of 1200 m above mean sea level and slope of 7-8 per cent which falls in subtropical sub-humid temperate agro-climatic zone of Himachal Pradesh. The area receives an annual rainfall varying from 1000 mm to 1600 and 75 per cent is received during monsoon season(July-September). The physic-chemical property of soils of the experimental site from the composite soil sample of 0-30 cm depth was analyzed *i.e.* soil moisture (9.14 %), EC (dS/m), Ph (6.26), soil organic carbon (1.49 %), Nitrogen (308 kg/ha), Phosphorus (41.38 kg/ha), Potassium (230.49 kg/ha) and texture (Sandy loam). The soil characteristics of the experimental site was sandy loam with neutral pH and climate of the experimental site during the course of trial are provided in Fig. 1.

The experiment consists of two structural and functional components *i.e. Morus alba* fodder tree as woody perennial and *Lepidium sativum* a galactogauge herb and aromatic plants as intercrop. Rows of *Morus alba* tree consisting of spacing 3 × 3 m were planted in the year July 2003 with rows running in East to West direction. In, addition the impact of three organic manures on the biomass and yield of *Lepidium sativum*, growing along with and without *Morus alba* was studied. The study was conducted in a Randomized Block design factorial with three replications and comprised of eight treatments *i.e.* (T_1: Lepidium + Morus + FYM@ 4 t/ha, (T_2: Lepidium + Morus +Vermicopost@ 1.12 tonnes/ha), (T_3: Lepidium + Morus + Jeevamrut@ 500Litre/ha), (T_4: Lepidium + Morus +no manure), (T_5: Lepidium + FYM @ 4tonnes/ha), (T_6: Lepidium + Vermicompost @ 1.12 tonnes/ha), (T_7: Lepidium + Jeevamrut@ 500Litre/ha), (T_8: Control without Morus and no manure). According to Plaekar (2006) Jeevamrut is prepared by mixing cow dung (10.00 kg) with cow urine (10.00 litres), jaggery (1.5 kg), pulse flour (1.5 kg), 1 kg of soil brought from the bunds of the field where cultivation is to be taken up and 200 litres of water to be added.

Before the execution of the experiment the field was well ploughed by tractor followed by planking 3 days prior to actual date of sowing of seeds. Bed sizes of 4 × 2m were made and line sowing was done in the October 2017. Before the sowing of seeds N_{20}: P_{40}: K_{10} kg/hectare was applied in the form of FYM and Vermicompost in the individual plots. Jeevamrut is applied as soil drench @ 0.4 litre per plot diluted in 7.6 litre water one time before sowing of seeds and 4 times after sowing at an interval of 15 days with total five applications.



Source: Meteorological observatory, Department of environment science, Dr Y S Parmar University of Horticulture and Forestry, Nauni, Solan, HP 173230

Fig. 1. Mean monthly temperature (°C), rainfall (mm) and relative humidity (%) during cropping season

The plants were harvested after five months from the date of sowing of seeds in the main field. Plant height (cm), number of main stem/plant, number of branches/plant, number of pods/plant, fresh aerial biomass/plant (g) Dry aerial biomass/plant (g), fresh root biomass (g) and dry root biomass (g) were recorded as growth parameters. Growth and yield parameters were recorded on 25 randomly selected plants for each replication of the treatment. Plant height of *Lepidium sativum* was recorded with the help of scale from the base to the tip of the plant at the time of final harvesting. Number of main stem, branches and pods per plant were counted and average of ten plants from each bed was expressed as a mean. Fresh aerial and root biomass was recorded with the help of electronic balance and expressed (g). Above and below ground parts of *Lepidium sativum* was dried in oven at 40°C for two weeks and their weight was recorded. Different yield parameters *viz* number of seeds per pod-^{1}, seed yield plant^{1}, 1000 seed weight (g) and seed yield (kg/ha). Economic parameters like net return and B:C ratio were analysed for estimating the economic viability of the treatment combination. While estimating the cost of cultivation, few considerations were made to incorporate the cost of initial establishment, annual lopping cost by using the annuity method. During return calculations, leaf fodder and fuel wood return were also considered.

The data were analysed using RBD factorial "Analysis of Variance (Anova)" given by Gomez and Gomez (1984).

Results and Discussion

The study revealed that various growth parameters of *Lepidium sativum* grown with and without *Morus alba* were highly influenced by different organic manure doses. The mean plant height of *Lepidium sativum* was significantly influenced by different organic manures. The maximum plant height (69.71 cm) was observed in T_7 whereas; minimum (57.58 cm) was recorded in treatment T_8, other parameters *viz.* number of main stem/plant, number of branches/plant and number of pods/plant) were significantly influenced by the application of Vermicompost @ 1.12 tonnes/ha which is closely followed by Jeevamrut @500 Liter/ha, FYM @ 4tonnes/ha and control respectively (Table 1). The data presented in Table 1 revealed that both planting conditions and organic manures had a significant effect on plant height, number of main stem plant^{-1}, number of branches/plant and number of pods/plant of *Lepidium sativum.* Average plant height (67.39 cm), number of main stem/plant(1.28), number of branches/plant (18.22) and number of pods/plant (1714.74) were significantly higher under open conditions as compared to *Morus alba* based agroforestry system (62.46 cm), (1.00), (13.57), and (1364.06), respectively.

These results are in conformity with the previous study where they reported poplar and maple based agroforestry system reduced the plant height of soy bean as compared to open condition (Reynolds *et al.* 2007). Reduction in plant height might be due root competition between trees and crop for moisture and nutrients. While comparing the shading effect of trees and intraspecific competition between the two components of the system *i.e.* medicinal and aromatic herbs grown under hedgerows of Leucaena and Morus (Thakur *et al.* 2006), less availability of photo-synthetically active radiation, nutrients and water to the crop growing under agroforestry system as compared to open conditions. Similar results had also been reported in senna (Rathod *et al.* 2010), *Indigofera tinctoria* (Nanda *et al.* 2008) and patchouli (Venugopal *et al.* 2008). Safal amrit (Jeevamrut) has also been reported to increase the plant height of chick pea (Kumari *et al.* 2015).

Vermicompost carries rich and diverse microbial populations, particularly fungi and bacteria. The use of vermicompost hastens many reactions in plant by releasing certain hormones *viz.*, gibberellic acid, Indol-3-acetic acid and dihydrozen, which in turn improves the growth rate and number of branches in plants (Arancon *et al.* 2004). Vermicompost improves the overall soil health, nutrient retention and their availability (Baziramakenga and Simard 2001, Theunissen *et al.* 2010).

Above and below ground biomass of *Lepidium sativum* were highly influenced by different organic manure doses. The mean above ground fresh biomass/plant, above ground dry biomass/plant, below ground fresh biomass/plant and below ground dry biomass/plant were significantly higher on application of Vermicompost @ 1.12 tonnes/ha followed by Jeevamrut @500 Litre/ha, FYM @ 4tonnes/ha and control respectively, (Table 1). The data presented in Table 1 depicts that the planting condition and organic manures had a significant effect on above ground fresh biomass, above ground dry biomass, below ground fresh biomass and below ground dry biomass of *Lepidium sativum*. Average above ground fresh biomass (23.42 g) above ground dry biomass (14.36 g) below ground fresh biomass/plant (1.38 g) and below ground dry biomass (0.77 g) were significantly higher in open condition as compared to Morus based agroforestry system where these parameters lies in the tune of (15.55 g), (7.62 g), (1.15 g) and (0.65 g), respectively.

Table 1. Effect of different types of organic manure on growth parameters of *Lepidium sativum* under *Morus alba* and open conditions.

Organic Manure Planting Condition	FYM	Vermicompost	Jeevamrut	Control	Mean
			Plant height (cm)		
Under *Morus alba*	63.73	64.00	66.16	55.96	**62.46**
Open condition	68.00	69.10	73.26	59.20	**67.39**
Mean	**65.86**	**66.55**	**69.71**	**57.58**	
$CD_{0.05}$		P: 3.230	O: 4.568	P×O: NS	
No. of main stem/plant					
Under *Morus alba*	1.00	1.03	1.00	1.00	**1.00**
Open condition	1.10	1.56	1.46	1.00	**1.28**
Mean	**1.05**	**1.30**	**1.23**	**1.00**	
$CD_{0.05}$		P: 0.15	O:0.22	P×O: NS	
No. of branches/plant					
Under *Morus alba*	13.66	15.70	14.50	10.40	**13.57**
Open condition	17.13	23.60	14.50	10.40	**13.57**
Mean	**15.40**	**19.65**	**17.23**	**11.30**	
$CD_{0.05}$		P:0.167	O:2.36	P×O: NS	
No. of pods/plant					
Under *Morus alba*	1488.57	1706.43	1528.10	733.167	**1364.06**
Open condition	1824.16	2192.96	1921.20	920.63	**1714.74**
Mean	**1656.36**	**1949.70**	**1724.65**	**826.90**	
$CD_{0.05}$		P:233.94	O:330.84	P×O: NS	
Above ground biomass fresh (g/plant)					
Under *Morus alba*	15.77	19.67	17.18	9.53	**15.55**
Open condition	23.87	28.65	26.39	14.70	**23.42**
Mean	**19.82**	**24.16**	**21.78**	**12.17**	
$CD_{0.05}$		P:3.12	O:4.42	P×O: NS	
Above ground biomass dry (g/plant)					
Under *Morus alba*	7.79	9.48	8.63	4.59	**7.62**
Open condition	15.97	17.85	16.92	6.70	**14.36**
Mean	**11.88**	**13.66**	**12.77**	**5.64**	
$CD_{0.05}$		P: 2.25	O:3.18	P×O: NS	
Below ground biomass fresh (g/plant)					
Under *Morus alba*	1.20	1.34	1.30	0.77	**1.15**
Open condition	1.47	1.74	1.51	0.81	**1.38**
Mean	**1.33**	**1.54**	**1.41**	**0.79**	
$CD_{0.05}$		P: 0.20	O:0.28	P×O: NS	
Below ground biomass dry (g/plant)					
Under *Morus alba*	0.69	0.77	0.74	0.42	**0.65**
Open condition	0.79	0.95	0.83	0.49	**0.77**
Mean	**0.74**	**0.86**	**0.78**	**0.45**	
$CD_{0.05}$		P:NS	O:0.18	P×O: NS	

It is also evident from the data presented in Table 1 that higher above ground fresh biomass was recorded with application of vermicompost as compared to the control where no manure was applied. Application of vermicompost @ 1.12 tonnes/ha resulted into higher above and below ground, fresh and dry biomass in open conditions as compared to *Lepidium sativum* cultivated under morus based agroforestry system. Vermicompost has rich population of microbes that help

to degrade and mobilize the nutrients to the available forms, as the exudates of earthworms support the growth of microorganisms which secrete plant growth hormones and thereby improves the growth parameters of the crop (Goswami *et al.* 2001). Application of vermicompost to crop has also been reported to improve early root initiation, increased root biomass, enhanced plant growth and development. The above ground fresh biomass per plant in mustard (92.88 g) was higher with application of RDF+ vermicompost as compared to control with a value of (51.66 g) (Kumar and Singh 2017). Several studies have also reported that application of vermicompost results in better growth and increase in biomass of some medicinal plants such as basil (Singh and Ramesh 2002), plantago (Anwar *et al.* 2005), fennel (Sanchez *et al.* 2008) and cumin (Darzi *et al.* 2007, Saeid *et al.* 2011),

The data on various yield parameters *viz.* number of seeds/pod, seed yield/plant, 1000-seed weight (g) and seed yield (kg/ha) were recorded and presented in Fig 2. These parameters were highly influenced by application of T_6 with a value of (2.45), (4.43 g) (2.29 g) and (1460.57 kg/ha) respectively. On the other hand T_7 proved a best application for these parameters with a value of (2.3) (4.228 g) (2.23 g) and (1395.26 85 kg/ha). Whereas, application of T_7 proved a third best dose. The lowest yield parameters were recorded in control where no manure was applied to the *Lepidium sativum* under open condition. Both planting condition and organic manure had a significant effect on various yield parameters. Higher yield parameters such as number of seeds/pod (2.3), seed yield/plant (4.1 g), 1000-seed weight (2.22 g) and seed yield (1354.26 kg/ha) were recorded in open condition (*i.e.* without *Morus alba*) whereas these parameter were recorded lowest in Morus based agroforestry system with a value of (2.1), (3.45 g), (2.05) and (1136.85 kg/ha) respectively (Fig. 2).

These findings are in conformity with the report of (Gill *et al.* 2018) who reported that decline in wheat grain yield under poplar based agroforestry system. It was also observed that the application T_6 resulted in maximum number of seeds per siliqua in mustard under open conditions (Kansotia *et al.* 2013). Higher seed yield per plant in mustard (*Brassica juncea*) was recorded in combined application of RDF+vermicompost (Kumar and Singh 2017). This might be due to the fact that application of vermicompost results in improving the physical, chemical and biological properties of soil and also provide N, P and K to plants (Baziramakenga and Simard 2001). Similar results were reported in strawberries (Arancon *et al.* 2006) bedding plants (Bachman *et al.* 2008) and cucumber (Ghasem *et al.* 2014).

Economics analysis revealed that growing of *Lepidium sativum* under *Morus alba* provided to be more profitable that sole cropping of *Lepidium sativum* in open condition. The cost of was more under *Morus alba* based agroforestry system as compared to sole cropping of *Lepidium sativum*; this is due to the additional cost incurred in the agroforestry system on the tree component for initial establishment and yearly lopping. Maximum cost of cultivation (993.31 USD $/ha) and gross return (1974.24 USD $/ha) were recorded in T_2 where vermicompost was applied @ 1.12 tonnes/ha as organic manure. The treatment T_3 resulted in higher net return (1154.27 USD $/ha) with a B:C ratio of 2.44 when 500 l/ha Jeevamrut was applied as organic manure (Table 2). Higher net returns and B:C ratio recorded in the T_3 is mainly due to the fact that the inputs required for manufacture of Jeevamrut were cheaper as compared to the other organic manures. The results in the present study are in agreement with the previous studies that maximum returns were recorded with medicinal and aromatic plants under agroforestry system (Karikalan *et al.* 2002, Singh and Ramesh 2002, Chauhan 2000).

Comparative studies on the effects of different organic manure on yield and biomass production of *Lepidium sativum* under open and Morus based agroforestry system concluded that growth and yield parameters of *Lepidium sativum* were significantly higher in open conditions as compared to Morus based agroforestry system. Application of organic manures in the form of

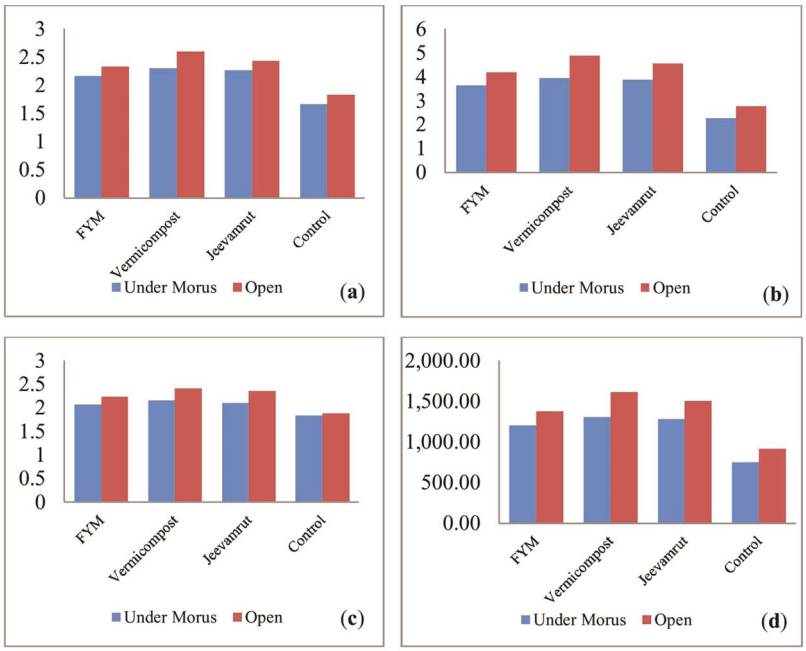


Fig. 2. Effect of different types of organic manure on yield parameters of *Lepidium sativum* under *Morus alba* and open conditions where; (a) No. of seeds/pod, (b) Seed yield/plant (c) 1000 seed weight (g) and (d) Seed yield (kg/hectare).

Table 2. Bioeconomic appraisal of *Lepidium sativum* under Morus and open conditions.

Treatment groups	Total cost (US$/ha)	Gross return (US$/ha)	Net return (US$/ha)	B:C ratio
T_1 : Lepidium + Morus +FYM@ 4 t/ha (3.2 kg/plot)	913.70	1888.64	974.94	2.06
T_2 : Lepidium + Morus +Vermicopost@ 1.12 t/ha (0.9 kg/plot)	993.31	1974.24	980.93	1.98
T_3 : Lepidium + Morus +Jeevamrut @ 500 l/ha (0.4 l/plot)	800.64	1954.91	1154.27	2.44
T_4 : Lepidium + Morus + No Manure	764.65	1522.34	757.69	1.99
T_5 : Lepidium + FYM	641.46	1122.36	480.90	1.75
T_6 : Lepidium + Vermicompost	721.07	1311.43	590.36	1.82
T_7 : Lepidium + Jeevamrut	518.24	1224.56	706.31	2.36
T_8 : Control (without Morus and no Manure)	492.41	745.71	253.30	1.51

vermicompost resulted into better growth and yield parameters of *Lepidium sativum* as compared to other manures. It is obvious that yield under Morus based agroforestry system will be lesser but that yield loss generally compensated by tree components yield *viz.* leaf fodder and fuel wood. It was observed that from economical point of view, the higher net returns were recorded when Jeevamrut was applied to the *Lepidium sativum* crop under agroforestry system. Based on an economic point of view, the cultivation of *Lepidium sativum* along with the application of Jeevamrut is the best for its production.

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