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Effect of organic manures, biofertilizers and harvesting schedules on growth and yield of asparagus, *Asparagus racemosus* under mid-hill conditions of Himachal Pradesh

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ABSTRACT

Asparagus racemosus Wild is one of the most regularly used medicinal plants as Rasayana in traditional system of Ayurveda. It is mainly known for its phytoestrogenic properties and used as galactagogue, aphrodisiac, demulcent etc. Considering the medicinal and economic importance of *A racemosus* and meagre information on it in Himachal Pradesh, study was conducted on the effect of different organic manures, biofertilizers and harvesting schedule on growth and yield of it. The maximum plant height (53.73 cm), number of branches/plant (4.5), number of roots/plant (31.15), fresh root weight (63.85 g), dry root weight (13.42 g), fresh root yield (20.58 q/ha) and dry root yield (4.97 q/ha) were recorded when the field was applied with a combination of FYM 5 tons/ha + vermicompost 2 tons/ha + PSB compared to other treatments. Harvesting 24 months after transplanting in the main field resulted in maximum yield attributes compared to the 12 and 18 months. Economic analysis revealed that highest cost of cultivation (Rs 37120/ha), total cost of production (Rs 53092/ ha) and maximum gross return was calculated for FYM 5 tons/ha + vermicompost 2 tons/ha + PSB and minimum for control (Rs/ha 15120 and 31092 respectively) but maximum benefit/cost ratio (4.12) was found for FYM 5 tons/ha + PSB.

Keywords: Asparagus; organic manures; biofertilizers; harvesting schedule

INTRODUCTION

Asparagus racemosus Wild commonly known as Shatavari, Satawar or Satamuli belongs to the family Liliaceae (Lawrence 1960) and is an important medicinal plant which is regarded as a Rasayana (plant durg promoting general well-being by increasing cellular vitality and resistance in the Ayurvedic system of medicine) (Bopana and Saxena 2007). Its medicinal importance is because of the presence of steroidal saponins and sapogenins (Goyal et al 2003) and it is mainly known for its phytoestrogenic properties with an increasing awareness about the harmful effects with synthetic oestrogens (Ashajyothi et al 2009). Traditionally the plant has been in use as a galactagogue, aphrodisiac and demulcent

and in rheumatism, diarrhoea, dysentery, tuberculosis etc (Wani et al 2011). The multiple uses of *A racemosus* has resulted in constant rise in its demand and incessant exploitation from the wild and as a result its population is depleting at an alarming pace and the supply is inadequate. Erratic seed germination combined with destructive harvesting and habitat destruction in the form of deforestation has added to the magnitude of the problem. Considering the economic and medicinal importance of this plant and environmental and health problems caused by application of chemicals it is important to cultivate it using organic manures and biofertilizers. Different organic manures and biofertilizers influence differently in terms of yield and quality. Hence it is necessary to know the best source of organic manures and biofertilizers which could help in increasing the yield and quality (Singh et al 2012). Keeping in view the importance of cultivation of *A racemosus* and meagre information on its organic cultivation in Himachal Pradesh the present study was conducted.

MATERIAL and METHOD

The experiment was conducted at experimental farm of Department of Forest Products, Dr YS Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh having altitude of 1250 m amsl and 30°52'N latitude and 70°11'E longitude. Soil samples were taken randomly from the entire experimental area before transplanting and after harvesting for evaluation of various physico-chemical properties of soil. The seeds were sown in April 2011 in nursery. The plants were transplanted during the month of March 2012 and planted in the field beds of size 3.6 x 3.6 m. Seven treatments of different organic manures and biofertilzers viz FYM 5 tons/ha, vermicompost 2 tons/ha, FYM 5 tons/ha + vermicompost 2 tons/ha, FYM 5 tons/ha + PSB, vermicompost 2 tons/ha + PSB, FYM 5 tons/ha + vermicompost 2 tons/ha + PSB and control (site soil) were applied. Biofertilizer used was PSB and was procured from the Division of Microbiology, IARI, New Delhi. The plants were harvested after 12, 18 and 24 months after the date of transplanting of seedlings in the main field. The observations were recorded on different growth characteristics and underground biomass viz plant height (cm), number of branches/plant, number of roots per plant, fresh root yield/plant (g), dry root weight/plant (g), fresh root yield (q/ha) and dry root yield (q/ha). The cost of cultivation and benefit/cost ratio were also calculated. The data given in tables are of harvesting after 24 months of transplanting.

RESULTS and DISSCUSSION

The data on soil analysis for various physico-chemical parameters presented in Table 1 reveal that the soil of experimental area was neutral in pH, low in organic carbon and medium in nitrogen,

Table 1. Nutrient status of the soil before transplanting and after harvesting of asparagus, *Asparagus racemosus*

Treatment	pH	Organic carbon	Available N (kg/ha)	Available P (kg/ha)	Available K (kg/ha)
Before transplanting	6.72	0.75	308.00	17.00	235.00
FYM 5 tons/ha	7.25	2.08	388.86	78.02	283.00
Vermicompost 2 tons/ha	7.14	2.14	413.95	113.76	297.46
FYM 5 tons/ha + vermicompost 2 tons/ha	7.05	2.21	408.06	117.68	285.11
FYM 5 tons/ha + PSB	7.50	2.10	391.32	121.62	283.61
Vermicompost 2 tons/ha + PSB	7.31	2.14	421.45	163.57	313.28
FYM 5 tons/ha + vermicompost 2 tons/ha + PSB	7.26	2.22	437.24	279.76	337.69

phosphorus and potassium. The highest value for organic carbon (2.22), available nitrogen (437.24 kg/ha), available phosphorus (279.76 kg/ha) and available potassium (337.69 kg/ha) was recorded for the treatment FYM 5 tons/ha + vermicompost 2 tons/ha + PSB and the maximum value of pH (7.50) was recorded for FYM 5 tons/ha + vermicompost 2 tons/ha.

The postponement of the harvest time had a positive effect on the root yield. Maximum value for different attributes of roots (number of roots/plant, fresh and dry weight/plant, fresh and dry yield/ha) were recorded for 24th month of harvesting compared to 12th and 18th months of harvesting for combination of treatment FYM 5 tons/ha + vermicompost 2 tons/ha + PSB while plant height and number of branches/plant was highest for 18th month of harvesting for the same combination of organic manures and biofertilizers (Fig 1-7). The root yield was significantly higher at the later rather than earlier harvest time (Fig 1-7). Similarly postponement of the harvest time increased the root yield of both varieties of sugarbeet variety (Jozefyova et al 2003) and in the trials conducted by Marlander (1991) the postponement of the harvest time also increased the root yield.

Different organic manures and biofertilizer were found to substantially support the growth of *A racemosus*. The data given in Table 2 elucidate that among the seven different organic manure and biofertilizer treatments, FYM 5 tons/ha + vermicompost 2 tons/ha + PSB combination was found to be more effective in enhancing the growth characteristics viz plant height (53.73 cm), number of branches/plant (4.5) and number of roots/

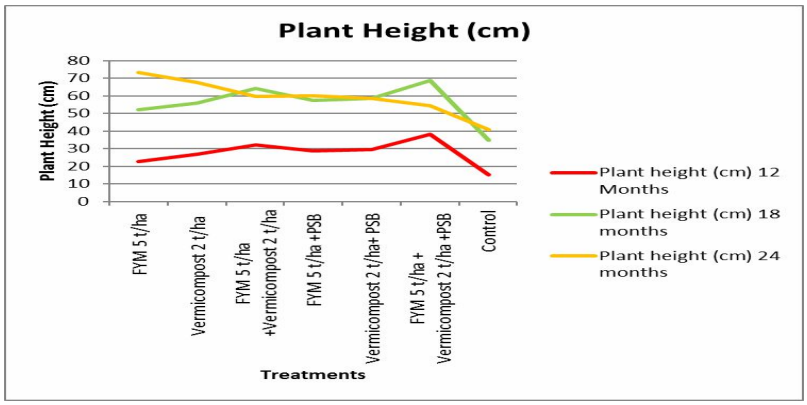

Fig 1. Effect of organic manures, biofertilizers and harvesting schedules on plant height of asparagus, *Asparagus racemosus*

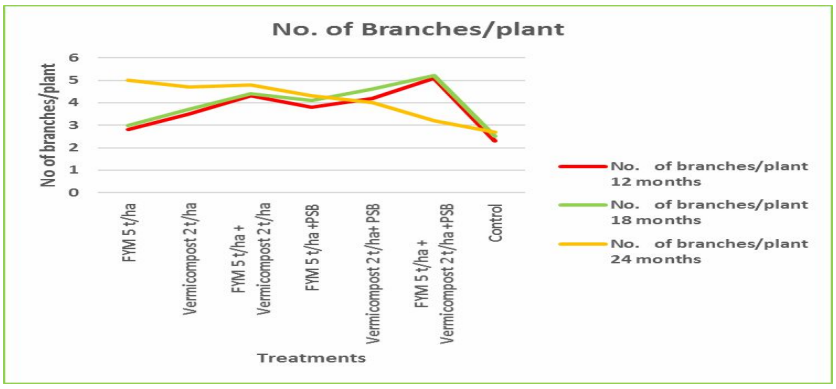

Fig 2. Effect of organic manures, biofertilizers and harvesting schedules on number of branches/ plant of asparagus, *Asparagus racemosus*

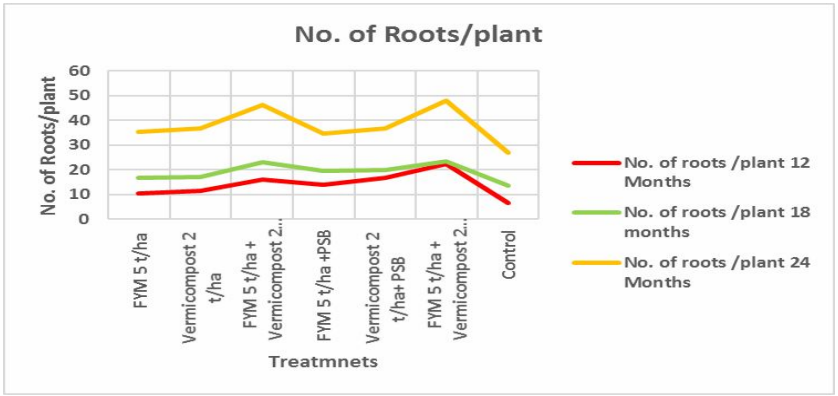

Fig 3. Effect of organic manures, biofertilizers and harvesting schedules on number of roots/ plant of asparagus, *Asparagus racemosus*

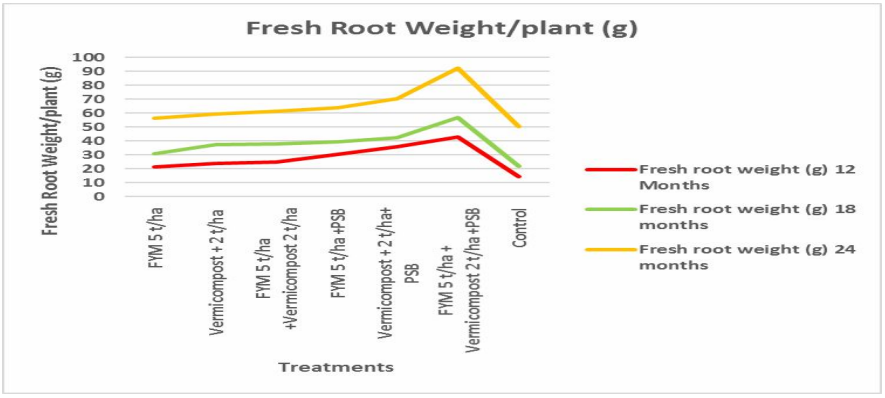

Fig 4. Effect of organic manures, biofertilizers and harvesting schedules on fresh root weight/ plant of asparagus, *Asparagus racemosus*

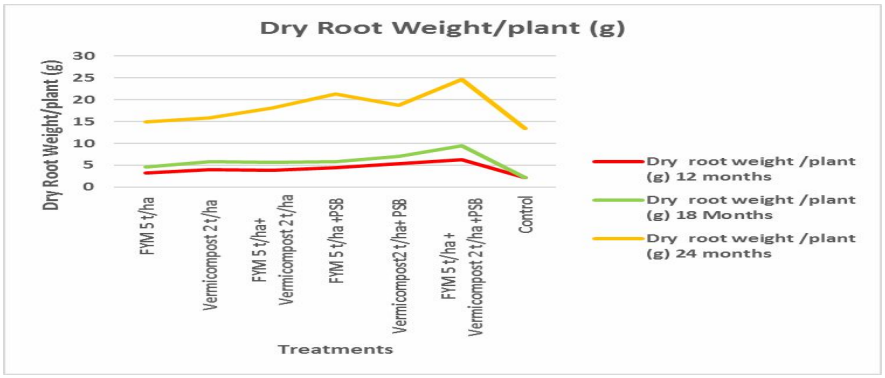

Fig 5. Effect of organic manures, biofertilizers and harvesting schedules on dry root weight/ plant of asparagus, *Asparagus racemosus*

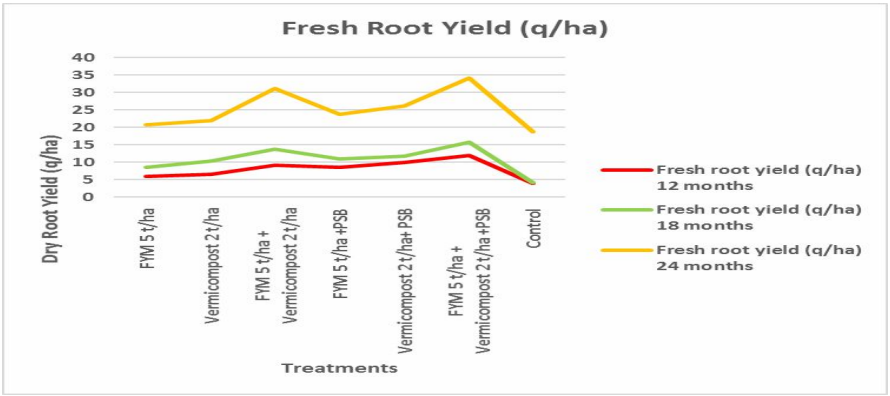

Fig 6. Effect of organic manures, biofertilizers and harvesting schedules on fresh root yield of asparagus, *Asparagus racemosus*

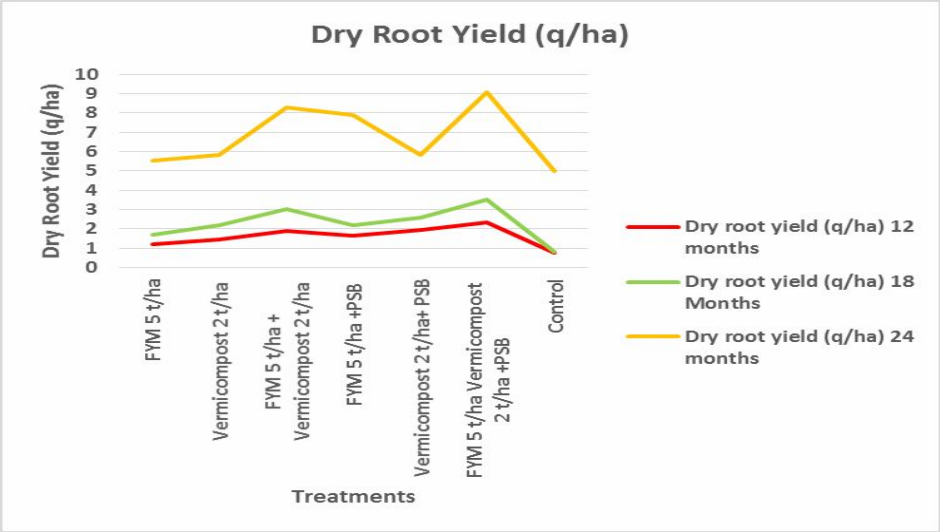

Fig 7. Effect of organic manures, biofertilizers and harvesting schedules on dry root yield of asparagus, *Asparagus racemosus*

Table 2. Effect of different organic manures and biofertilizer on growth characters of asparagus, *Asparagus racemosus* 24 months after transplanting

Treatment	Plant height	# branches/plant	# roots/ plant
FYM 5 tons/ha	49.33	3.6	20.76
Vermicompost 2 tons/ha	50.05	3.9	21.87
FYM 5 tons/ha + vermicompost 2 tons/ha	52.02	4.5	28.42
FYM 5 tons/ha + PSB	48.66	4.1	22.70
Vermicompost 2 tons/ha + PSB	48.94	2.9	24.53
FYM 5 tons/ha + vermicompost 2 tons/ha + PSB	53.73	4.5	31.15
Control	30.22	2.5	15.57
Mean	142.68	11.7	68.74
$CD_{0.05}$	2.74	1.16	3.14

plant (31.15). This was closely followed by FYM 5 tons/ha + vermicompost 2 tons/ha and minimum was recorded in control (site soil). There was 43.76, 44.44 and 50.02 per cent increase over control for plant height, number of branches/plant and number of roots/plant respectively. Increase in growth parameters following application of organic manures and inoculation with biofertilizers may be due to better utilization of nutrients in the soil through inoculation of efficient microorganisms. Vermicomposts

are finely divided peat-like materials with high porosity, aeration, drainage and water holding capacity and usually contain most nutrients in the available form such as nitrates, phosphates, exchangeable calcium and soluble potassium (Atiyeh et al 2002; Arancon et al 2004). Phosphate solubilizing microorganisms such as bacteria and fungi are effective in releasing P from inorganic and organic pools of total soil P (excess/ unused phosphorus) through solubilization and mineralization (Chen 2006, Darzi et al 2012). Combined effect of these lead to the increase in the growth of the plant compared to the control. Tabrizi et al (2008) reported that application of biofertilizers enhanced yield and other plant criteria in hyssop. Similar results on growth characteristics have been reported in *Calendula officinallis* L and *Matricaria recutita* L by Leithy et al (2006). Darzi et al (2012) also reported that plant height increase in anise (*Pimpinella anisum* L) was due to the application of 10 tons/ha vermicompost and use of PSB twice. Increase in growth characteristics of *Stevia rebaudiana* Bert which followed the order of VAM + PSB + AZO >VAM + PSB >PSB + AZO >AZO >PSB >VAM + AZO >VAM >control (Das et al 2007) behaved very similar to present study as combination of organic manures and biofertilizers gave better results than alone.

Underground biomass attributes varied significantly due to different organic manures and biofertilizers. Among all the treatments FYM 5 tons/ha + vermicompost 2 tons/ha + PSB treatment showed significant effect in increase on fresh root weight (63.85 g/plant), dry root weight (13.42 g/plant), fresh root yield (20.58 q/ ha) and dry root yield (4.97 q/ha) (Table 3). However minimum was recorded in control (site soil). There was 58.50, 55.96, 56.71 and 55.94 per cent increase over control for fresh root weight/plant, dry root weight/plant, fresh root yield and dry root yield respectively. It can be attributed to increased dry matter production and its accumulation in different plant parts which in turn reflected the translocation of photosynthates from source to sink. Thus due to higher photosynthates the root characters might have developed to the maximum extent and resulted in higher root yields. The beneficial effects of these treatments in plant on yield and yield attributes could be attributed to the fact that after decomposition and mineralization, the organic manures supply available nutrients directly to the plants and also have stabilizing effect on fixed form of nutrients in soil besides the nutrients supplying capacity. These organic manures build the soil organic matter reservoir which increases the water holding capacity, porosity and structural stability in the soil. Thus improvement in soil physical and chemical environment must have helped in proliferation of beneficial soil microbial population, improved enzymatic activity and encouraged proliferation of roots which helped in absorption of more water and nutrients from larger area. This must

Table 3. Effect of different organic manures and biofertilizer on underground biomass of asparagus, *Asparagus racemosus* 24 months after transplanting

Treatment	Fresh root weight/plant (g)	Dry root weight/plant (g)	Fresh root yield (q/ha)	Dry root yield (q/ha)
FYM 5 tons/ha	36.13	7.60	11.77	2.81
Vermicompost 2 tons/ha	40.03	8.54	12.95	3.15
FYM 5 tons/ha + vermicompost 2 tons/ha	41.34	9.17	17.98	4.40
FYM 5 tons/ha + PSB	44.61	10.55	14.37	3.91
Vermicompost 2 tons/ha + PSB	49.45	10.36	15.91	3.46
FYM 5 tons/ha + vermicompost 2 tons/ha + PSB	63.85	13.42	20.58	4.97
Control	26.50	5.91	8.91	2.19
Mean	139.16	30.42	43.90	24.89
$CD_{0.05}$	4.14	1.52	2.16	1.18

Table 4. Economics of production of asparagus, *Asparagus racemosus* under different treatments 24 months after transplanting

Treatment	Cost of cultivation (Rs/ha)	Total cost of production (Rs/ha)
FYM 5 tons/ha	22,620	38,592
Vermicompost 2 tons/ha	29,120	45,092
FYM 5 tons/ha + vermicompost 2 tons/ha	36,620	52,592
FYM 5 tons/ha + PSB	23,120	39,092
Vermicompost 2 tons/ha + PSB	29,620	45,592
FYM 5 tons/ha + vermicompost 2 tons/ha + PSB	37,120	53,092
Control	15,120	31,092

Table 5. Yield, average price, gross return and benefit:cost ratio for asparagus, *Asparagus racemosus* under different treatments 24 months after transplanting

Treatment	Estimated dry root yield (kg/ha)	Average price (Rs/kg)	Gross return (Rs/ha)	Benefit:cost ratio
FYM 5 tons/ha	554	150	83,100	2.67
Vermicompost 2 tons/ha	584	150	87,600	2.00
FYM 5 tons/ha + vermicompost 2 tons/ha	830	150	1,24,500	2.39
FYM 5 tons/ha + PSB	790	150	1,18,500	4.12
Vermicompost 2 tons/ha + PSB	583	150	87,450	1.95
FYM 5 tons/ha + vermicompost 2 tons/ha + PSB	910	150	1,36,500	2.67
Control	499	150	74,850	3.95

have been responsible for increase in underground biomass. The difference in yield, yield parameters and dry matter production could also be attributed to the significant increase in the growth components like plant height, number of leaves, leaf size, leaf area and number of roots. All these parameters have an indirect positive impact on the yield components and yield of plant. Several studies have shown that vermicompost could increase the growth and yield of some medicinal plants and other crops such as garlic (Arguello et al 2006) and application of biofertilizer combined with growth hormones in dill promoted root growth that improved the yield (Nejatzadeh-Barandozi and Gholami-Borujeni 2014). Singh et al (2012) have also reported that application of combination of biofertilizers (NPK 180:90:90 kg/ha + *Azotobactor chrococcum* 2.5 kg/ha + *Pseudomonas floriscence* 2.5 kg/ha) in turmeric significantly increased the yield and all yield attributes and present study is in agreement with these results. These findings are also in conformity with the findings of Vadiraj et al (1998) and Krishnamurthy et al (1999) in turmeric and Patil (1995) and Khalil et al (2002) in onion and turmeric. Similar results were obtained by Blay et al (2002) in onion.

Maximum cost of cultivation (Rs 37120/ha) and total cost of production (Rs 53092/ha) were calculated for FYM 5 tons/ha + vermicompost 2 tons/ha + PSB and minimum for control (Rs 15120/ha and Rs 31092/ha respectively) followed by FYM 5 tons/ha (Rs 22620/ha and Rs 38592/ha respectively) for higher values than minimum (Table 4). Maximum gross return (Rs 136500/ha) was calculated for FYM 5 tons/ha + vermicompost 2 tons/ha + PSB for which estimated dry root yield (910 kg/ha) was maximum and minimum was observed for control at average market price of 150 Rs/kg (74,850 Rs/ha). Maximum benefit/cost ratio (4.12) was observed for FYM 5 tons/ha + PSB and minimum (1.95) for vermicompost 2 tons/ha + PSB (Table 5). Promising effect of application of biological fertilizers on dill has been reported by Nejatzadeh-Barandozi and Gholami-Borujeni (2014) who recommended that the mineral nitrogen and phosphate fertilizers be replaced with biofertilizers to reduce production costs and stop damages to the environment due to the use of chemical fertilizers especially nitrogen as nitrate.

In the present study the highest yield was found in FYM 5 tons/ha + vermicompost 2 tons/ha + PSB combination but the best economic combination with maximum profit was found to be FYM 5 tons/ha + PSB at 24th month of harvesting as this gave the maximum cost/benefit ratio compared to other treatments.

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