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EFFECT OF ORGANIC MANURES AND BIOFERTILIZERS ON GROWTH AND YIELD OF *RHEUM AUSTRALE* D. DON. CULTIVATED IN HIMACHAL HIMALAYA

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ABSTRACT

Rheum australe Wall ex Meissn. a perennial herb, is distributed in the Himalayas from Kashmir to Sikkim at altitude of 2800-5200 m. In Himachal Pradesh it is found growing in Chhota Bhangal and Bara Bhangal of Kangra; Pangi Bharmour of Chamba, Parvati Valley of Kullu, Dodra kwar, Khashadhar and Rohru ranges of Shimla district, Kinnaur and Lahaul Spiti districts. Population density is between 0.5 and 1.5 plant square meter in very restricted localities and is designated as endangered in status. The experiment on *Rheum australe* was conducted to determine the effect of different organic manures , biofertilizers and NPK on growth and yield of *Rheum australe* and also to work out its cost of cultivation to standardize the cultivation technology. The results showed that maximum plant height, above ground biomass ,underground biomass and underground biomass yield was recorded maximum using NPK (120:60:30 kg/ ha) and which was followed by Vermicompost + Azotobacter+ PSB (10t:5kg:5kg) and minimum was recorded in control. Benefit-cost ratio of 10.15 was observed maximum when NPK @ (120 : 60: 30 Kg/ha) was applied, which was followed by treatment F_5 where FYM + Azotobacter + PSB (10t : 5kg :5kg) with a BCR of 8.09.

Key words: Endangered, Bio-fertilizers, Organic manures, Cultivation, Cost , Conservation.

Introduction

The demand for medicinal plants has increased globally due to the resurgence of interest in and acceptance of herbal medicine. Most of the demand is being met through collection of large quantity of medicinal plants and plant part from wild populations. The method of extraction employed are almost invariably crude and unsystematic. As a consequence, the rates of exploitation may exceed those of local natural regeneration .Also the natural habitats are fast depleting .The Indian Himalayan region is a rich reservoir of biological diversity. This region has many high value medicinal herbs and local tribes depend on traditional herbal medicine.

Rheum australe is high altitude endangered medicinal plant commonly known as 'revand chini' belonging to family Polygonaceae. It is a perennial stout herb 1-3 m in height , distributed in the temperate and sub tropical regions of the world between 2800 and 3600 m altitudes. Root are stout ;leaves radical, long petioled, very large,30-40cm;flowers small, dark purple or pale red in tall axillary panicles (Anon., 1945). Rhubarb is a mild anthraquinone purgative ,it is used as an astringent tonic ;its stimulating effect combined with aperient properties render it especially useful in atonic dyspepsia (Nautiyal and Nautiyal, 2004). The essential oil content is 0.05 per cent in the root, and its characteristic odour is due to the presence of eugenol (Nautiyal and Nautiyal, 2004). The oil is also sprinkled over ulcers for healing, and powdered roots are used for cleaning teeth. Traditionally, in Garhwal a paste made from the root is mixed with water and used to treat boils, wounds and cuts. It is of special use for infants stomach problems. It has been found as anti-inflammatory drug (Chauhan, 1999; Nautiyal *et al.*, 2002). The history of rhubarb dates back to ancient China and Mediterranean region as a highly popular laxative drug and a general tonic (Nautiyal *et al.*, 2002). The drug contains a number of anthraquinone derivatives based on emodin, emodin-3-monomethyl ether, chrysophanol, aloe emodin, and rhein. Emodin, rutin, chrysophanol,and chrysophenic acid are the four chief active constituents of rhubarb. Among these, chrysophanol is found in a higher concentration. In nature plant has a long juvenile phase (3-5 years) followed by the reproductive phase. Flowering occurs during june-july. It has been identified as top priority species for conservation and cultivation. Due to these properties, the species has excessive demand, which leads to illegal exploitation from natural habitat, resulting in habitat destruction. There is an urgent need to develop and implement regeneration/conservation

Maximum plant height, above and below ground biomass and yield was recorded maximum using NPK @ 120:60:30 kg/ha followed by Vermicompost + Azotobacter+ PSB @ 10t:5kg:5kg.

strategies for exploited medicinal plant species. A simultaneous development of easy to employ means of *ex-situ* propagation of the species concerned would encourage their cultivation, there by considerably ease the pressure on natural habitats. The common means of regeneration and propagation of medicinal plants include seed based, clonal and micro-propagation methods .Seed based multiplication is the most effective, and convenient method of propagation.

Material and Methods

The experiment on *Rheum australe* was conducted at Forestry Research Sub-Station, Rahla (Manali) of Dr. Y.S. Parmar U.H.F, Himachal Pradesh having altitude of 2800m and 3222'N latitude and 7720'E longitude. Regarding climate generally November, December, January, February and March are the coldest months while May and June are the hot months. The maximum rainfall occurs from June to September. The area receives a snowfall during winter. The site is characterized by undulating topography, and experimental area has been terraced. Soil samples were taken randomly from the entire experimental area before transplanting and were thoroughly mixed together, thus a composite representative sample from whole of the area was taken for chemical analysis to evaluate the fertility status of soil. The soil was sandy loam in texture. The test analysis revealed following values for different parameters.

Table 1: Soil analysis of the experimental area

Sr. no.	Soil analysis parameter	Test value
1.	pH	6.96
2.	Organic carbon (%)	0.45
3.	Available nitrogen (kg/ha)	275
4.	Available phosphorus (kg/ha)	22
5.	Available potash (kg/ha)	280

The soil of experimental area is neutral in pH, low in organic content, medium in available nitrogen, phosphorus and potassium.

The experiment was conducted to study the effect of organic manures and biofertilizers on growth and yield of *Rheum australe*. This experiment was laid out in randomized block design with eight treatments and three replications. Biofertilizers used were *Azotobacter*

Developmental States in *Rheum australe*

and PSB and were procured from the Division of Microbiology, IARI, New Delhi. Various doses of biofertilizers and organic manures under different treatments were applied as F_0 (without fertilizer),F_1 (FYM@ 20 t / ha), F_2 (Vermicompost @ 20 t/ha), F_3 (Azotobacter @ 10 kg/ha), F_4 (PSB@ 10kg/ha) F_5 [FYM + Azotobacter + PSB (10t: 5kg: 5kg)], F_6[Vermicompost + Azotobacter + PSB (10 t: 5kg:5kg)] and F7[NPK (120:60:30 kg/ ha)].

Results and Discussion

Observations were recorded on different parameters such as plant height, aerial biomass yield/plant, underground biomass yield/plant and estimated underground biomass yield (q/ha) after one year interval up to three years during last fortnight of September month.

Data presented in Table 2 reveals that among different treatment combinations after 36 months maximum plant height was recorded in treatment F7(NPK (120 : 60: 30 Kg/ha) i.e. 54.81cm which was followed by F6 (Vermicompost + Azotobacter + PSB (10t : 5kg :5kg) 41.64cm and minimum was recorded in control (25.49cm). However, if combination of organic manures and biofertilizers is taken into consideration treatment F5 and F6 is statistically at par with each other and recorded plant height of 39.93 cm and 41.64 cm respectively. There is 115.02, 63.35, 56.64 per cent increase in plant height in treatment F7, F6, and F5 over control after 36 months.

Data presented in Table 3 reveals that among different treatment combinations after 36 months maximum above ground biomass was recorded in treatment F7(NPK (120 : 60: 30 Kg/ha) i.e.63.62g which was followed by F6 (vermicompost + Azotobacter+ PSB (10t : 5kg :5kg) 51.96g and F5(FYM + Azotobacter + PSB (10t : 5kg :5kg) 43.26g and minimum was recorded in control (28.45g) and treatment F7 is statistically superior to all other treatments. There is 123.62, 82.63 and 52.05

Table 2 : Effect of different organic manures and biofertilizers on plant height of *Rheum australe*

Treatments	Plant height (cm)			
	12 months	24 months	36 months	Mean
Without fertilizer	7.85	20.21	25.49	17.85
FYM @20 t/ha	10.54	21.58	34.13	22.08
Vermicompost@ 20t/ha	11.31	23.63	35.78	23.57
Azotobacter @10 kg/ha	8.46	20.68	32.56	20.57
PSB @10 kg/ha	8.21	22.38	28.41	19.67
FYM + Azotobacter + PSB (10t : 5kg :5kg)	12.75	25.91	39.93	26.20
Vermicompost + Azotobacter+ PSB (10t : 5kg :5kg)	14.63	28.75	41.64	28.34
NPK (120 : 60: 30 Kg/ha)	15.21	30.86	54.81	33.61
Mean	11.12	24.25	36.59	23.99
	SE(m) + 0.87 CD (T) at 5% 2.47 CV % 13.88	SE(m) + 2.16 CD (HI) at 5% 5.87 CV % 19.63	SE(m) + 1.48 CD (T x HI) at 5% 3.89 CV % 16.14	

Table 3 : Effect of different organic manures and biofertilizers on above ground biomass of *Rheum australe*

Treatments	Above ground biomass /plant (g)			Mean
	12 months	24 months	36 months	
Without fertilizer	14.68	19.94	28.45	21.02
FYM @20 t/ha	16.95	24.96	33.49	24.98
Vermicompost @20 t/ha	18.35	26.12	36.03	26.83
Azotobacter @10 kg/ha	18.01	25.78	32.71	25.50
PSB @10 kg/ha	19.21	27.93	40.29	29.14
FYM + Azotobacter + PSB (10t : 5kg :5kg)	22.68	33.41	43.26	33.11
Vermicompost + Azotobacter+ PSB (10t : 5kg :5kg)	25.75	37.16	51.96	38.29
NPK (120 : 60: 30 Kg/ha)	38.37	44.26	63.62	48.75
Mean	21.75	29.95	41.23	92.93
	SE(m) + 1.06 CD (T) at 5% 2.34 CV % 16.79	SE(m) + 1.21 CD (T x HI) at 5% 3.62 CV % 16.33	SE(m) + 1.06 CD (T) at 5% 2.34 CV % 16.79	

per cent increase in above ground biomass in treatment F7, F6 and F5 over control after 36 months. However, if PSB is applied @10kg/ha the above ground biomass yield is 40.29g which is 41.61 per cent more in comparison to control.

Data presented in Table 4 reveals that among different treatment combinations after 36 months maximum underground biomass was recorded in treatment F7(NPK (120 : 60: 30 Kg/ha) i.e. 74.69g which was followed by F6 (Vermicompost + Azotobacter+ PSB (10t : 5kg :5kg) 52.27g and 96g and F5(FYM + Azotobacter + PSB (10t : 5kg :5kg) 51.68g and minimum was recorded in control (30.73g) and treatment F7 is statistically superior to all other treatments. There is 143.05, 70.09 and 68.17 per cent increase in under ground biomass in treatment F7, F6, and F5 over control after 36 months respectively. However, treatment F6 and F5 are statistically at par with each other and yield is comparable with each other.

Data presented in Table 5 reveals that among different treatment combinations after 36 months maximum underground biomass yield (q/ha) was recorded in treatment F7 (NPK (120 : 60: 30 Kg/ha) i.e. 23.34 q/ha which was followed by F6 (Vermicompost + Azotobacter+ PSB (10t : 5kg :5kg) 16.33q/ha F5(FYM + Azotobacter + PSB (10t : 5kg :5kg) 16.15q/ha and minimum was recorded in control (9.60q/ha) and treatment F7 is statistically superior to all other treatments. There is 143.12, 70.10 and 68.22 per cent increase in underground biomass yield in treatment F7, F6 and F5 over control after 36 months. However, treatment F6 and F5 are statistically at par with each other.

In the present studies, the effect of organic manures and biofertilizers on different growth and development parameters (plant height, above ground biomass yield ,underground biomass yield, estimated underground biomass yield) in *Rheum australe* revealed that the treatment combination of NPK (120:60:30 Kg/ha) gave significant increase in all above mentioned growth and yield parameters. Inorganic fertilizers increase the growth and yield attributes quickly than organic inputs. Both nitrogen and phosphorus are structural components of bio molecules like proteins, phospholipids and nucleic acids. Being an integral part of ATP, phosphorus also plays an indispensable role in energy metabolism. Thus both of these plant nutrients play an important role in increasing the plant height and yield attributes. Significant increase in growth and yield parameters have been reported in *Salvia sclarea* (Clary sage) and *Pogostemon patchouli* by using nitrogen and phosphorus fertilizers and nitrogen alone respectivel (Verma *et al*., 2010; Sumathi *et al*., 2012). However, among different treatment combinations of organic manures and biofertilizers treatment F6 (vermicompost + Azotobacter+ PSB (10t:5kg:5kg) resulted in higher yield which was followed by treatment F5 (FYM + Azotobacter + PSB (10t : 5kg :5kg) and both the treatments are statistically at par with each other. As combination of organic manures and biofertilizers resulted in higher yield but the cost of vermicompost is higher in comparison to FYM, therefore FYM can be used in place of vermicompost. The increase in all the parameters might have been due to proliferation of inoculated and other beneficial microorganisms which affect the plant growth by 'N' fixation, suppression of pathogenic microorganisms, mobilization of soil phosphate and by producing growth promoting metabolites that stimulate plant development.

Table 4 : Effect of different organic manures and biofertilizers on underground biomass of *Rheum australe*

Treatments	Under ground biomass /plant (g)			
	12 months	24 months	36 months	Mean
Without fertilizer	10.03	28.27	30.73	23.01
FYM @20 t/ha	13.19	31.08	44.83	29.70
Vermicompost @20 t/ha	13.34	36.94	46.69	32.32
Azotobacter @10 kg/ha	13.52	35.33	37.16	28.67
PSB @10 kg/ha	14.56	35.84	41.65	30.68
FYM + Azotobacter + PSB (10t : 5kg :5kg)	18.78	38.75	51.68	36.40
Vermicompost + Azotobacter+ PSB (10t : 5kg :5kg)	21.01	39.45	52.27	37.58
NPK (120 : 60: 30 Kg/ha)	28.52	54.94	74.69	52.72
Mean	16.62	37.58	47.46	33.89
	SE(m) + 1.25 CD (T) at 5% 3.61 CV %7.56	SE(m) +2.01 CD (HI) at 5% 5.63 CV % 12.65	SE(m) + 1.75 CD (T x HI) at 5% 4.89 CV % 12.49	

Table 5 : Effect of different organic manures and biofertilizers on underground ground biomass yield of *Rheum australe*

Treatments	Estimated underground biomass (q/ha)			Mean
	12 months	24 months	36 months	
Without fertilizer	3.13	8.83	9.60	7.19
FYM @20 t/ha	4.12	9.71	14.01	9.28
Vermicompost @20 t/ha	4.17	11.54	14.59	10.10
Azotobacter @10 kg/ha	4.22	11.04	11.61	8.96
PSB @10 kg/ha	4.56	11.27	13.01	9.61
FYM + Azotobacter + PSB (10t : 5kg :5kg)	5.87	12.01	16.15	11.34
Vermicompost + Azotobacter+ PSB (10t : 5kg :5kg)	6.56	12.39	16.33	11.76
NPK (120 : 60: 30 Kg/ha)	8.91	17.17	23.34	16.47
Mean	5.19	11.75	14.83	10.59

SE(m) + 0.78 SE(m) + 1.04 SE(m) + 0.89
CD (T) at 5% 1.76 CD (HI) at 5% 2.87 CD (T x HI) at 5% 2.67
CV % 9.42 CV % 12.04 CV % 8.21

Table 6 : Economics of production of *Rheum australe*

Treatments	Cost of cultivation (Rs./ha)	Total cost of production (Rs./ha)	Cost of production (Rs./kg)
Without fertilizer	15,120	29,120	30.33
FYM @20 t/ha	45,120	60,120	42.91
Vermicompost @20 t/ha	1,55,120	1,70,320	116.73
Azotobacter @10 kg/ha	17,620	32,120	27.66
PSB @10 kg/ha	18,120	32,920	25.30
FYM + Azotobacter + PSB (10t : 5kg :5kg)	17,750	33,220	20.56
Vermicompost + Azotobacter+ PSB (10t : 5kg :5kg)	72,750	88,550	54.22
NPK (120 : 60: 30 Kg/ha)	20,924	37,124	15.90

Table 7 : Yield, gross return and benefit cost ratio of *Rheum australe*

Treatments	Dry root yield (kg/ha)	Gross return (Rs./ha)	Benefit cost ratio
Without fertilizer	960	96,000	5.34
FYM @20 t/ha	1,401	1,40,100	2.10
Vermicompost @20 t/ha	1,459	1,45,900	0.05
Azotobacter @10 kg/ha	1,161	1,16,100	5.58
PSB @10 kg/ha	1,301	1,30,100	6.17
FYM + Azotobacter + PSB (10t : 5kg :5kg)	1,615	1,61,500	8.09
Vermicompost + Azotobacter+ PSB (10t : 5kg :5kg)	1,633	1,63300	1.24
NPK (120 : 60: 30 Kg/ha)	2,334	2,33,400	10.15

Cost of cultivation of *Rheum australe*

The cost of cultivation includes all the inputs like seedling costs, labour involved in bed preparation, intercultural operations till final harvesting of the crop which were taken into consideration in terms of money involved in rupees. Similarly while calculating the return, the total dry plant biomass obtained was multiplied by the average of prevailing market rate of *Rheum australe*.

Cost and return are two most important indicators to evaluate the economic feasibility of an activity. The cost of cultivation and production of *Rheum australe,* under different treatments was estimated and presented in Table 6. It can be inferred from the table that the cost of cultivation among different treatments varied from Rs. 15,120 (F_0) to Rs. 1,55,120 (F_2). The table further showed that cost of production varied from Rs. 15.90 (F_7) to Rs 116.73 per kg (F_2). The cost analysis showed varied differences among different treatments. In order to decide about the best economic treatment benefit cost ratio over variable cost were estimated and results have been presented in Table 7. Treatment-wise yield of dry roots varied from 960 kg/ha (F_0) to 2,334 kg/ha (F_7)

among different treatments. An average price of Rs 100 per kg was assumed for the present analysis. The Benefit Cost Ratio (BCR) among the various treatments varied from 0.05 (F_2) to 10.15 (F_7).

It can be inferred from the Table 7 that the highest benefit-cost ratio of 10.15 was observed when NPK @ (120 : 60: 30 Kg/ha) was applied. It was followed by treatment F_5 where FYM + Azotobacter + PSB (10t : 5kg : 5kg) was applied with a BCR of 8.09.

Rheum australe. was raised through organic manures and biofertilizers (FYM, vermicompost, *Azotobacter,* NPK and PSB). Control conditions resulted in lowest cost of cultivation and cost of production (Rs. 15,120 and 29,120 respectively) whereas cost of cultivation and production rose to Rs. 1,55,120 and Rs. 1,70,320, respectively with the application of vermicompost.

Benefit : cost ratio was calculated by dividing the total returns obtained with the total cost involved during the production. The lowest benefit: cost ratio (0.05) was obtained with application of vermicompost due to its higher rate @ Rs. 10/kg. Hence, if farmers make their own vermicompost then they can get the better returns.

It is quite evident from the returns and benefit : cost ratio that farmers can opt for the cultivation of medicinal plants like *Rheum australe* as an alternate source of income. Like other agricultural crops cultivating medicinal plants on profitable basis can improve the economy of farmers by diversification of cropping system/pattern. If the market of medicinal plants is well organized then farmers can get better benefits than some of the agricultural crops which are grown by them traditionally.

हिमाचल हिमालय में उत्पादित *रयूम अस्ट्राले* डी. डोन के उत्पाद और वृद्धि पर कार्बनिक खादों तथा जैवउर्वरकों का प्रभाव

रवि भारद्वाज तथा मीनू सूद

सारांश

रयूम अस्टाले वाल्ल एक्स मीस्न, सदाबहार जड़ी है जिसका वितण 2800–5200 मीटर की Åचाई पर कश्मीर से सिक्किम तक है। हिमाचल प्रदेश में यह जड़ी कांगड़ा के छोटा भांगल और बड़ा भांगल, चम्बा के पांगी भरमौर, कुल्लू डोडरा क्वार ख्साधार की पार्वती घाटी और शिमला जिले रोहडू रेंज सहित किन्नौर और लाहोल स्पीति जिलों में पाई जाती है। संकटग्रस्त स्थिति में प्रतिबंधित क्षेत्र के प्रति पादप वर्गमीटर में घनत्व 2.5 और 1.5 पादप है। *रयूम आस्टेल* की उपज और खेती की तकनीकों को मानकीकृत करने के लिए विभिन्न कार्बनिक खादों, जैव उर्वरकों और एन पी के, के वृद्धि प्रभावों को जानने हेतु परीक्षण किये गये। परिणाम से पता चलता है कि धरातल से पादप की Åपरी जैवमात्र और धरातल से नीचे की जैवमात्र, धरातल के भीतर उत्पाद की जैवमात्र को एन पी के ½120:60:30 कि0ग्रा0/हे0½ पर अधिकतम पाया गया। जिसके बाद वर्मीकम्पोस्ट + अजोटावक्टर+ पी एस बी ½10 टी : 5 कि0ग्रा0 : 5 कि0ग्रा0½ का स्थान रहा और न्यूनतम जैवमात्र कंटोल में रिकार्ड की गई। लाभ लागत अनुपात अधिकतम 10.15 पाया गया जब एन पी के @½120:60:30 कि0हे0½ का अनुप्रयोग किया गया। जिसके बाद ए एस उपचार का स्थान रहा जहां एफ वाई एम + अजोटा वैक्टर + पी एस बी ½10 टी : 5 कि0ग्रा0 : 5 कि0ग्रा0½ रहा। जिसमें 8.09 का बीसीआर था।

References

Anon. (1945-76). *Wealth of India –raw materials*, CSIR, New Delhi, 1945-76, Vols 1-11.

Nautiyal, M.C. and Nautiyal, B.P. (2004). *Agrotechnique for High Altitude Medicinal and Aromatic plants*. Bishen Singh and Mahender Pal Singh, Dehradun, pp.158-161.

Chauhan, N.S. (1999). Medicinal and Aromatic Plants of Himachal Pradesh, Indus Publishing Company, New Delhi

Nautiyal, B.P, Prakash, V., Maithani, U.C., Chauhan, R.S., Purohit, H. and Nautiyal, M.C. (2002). Germinability, productivity and economic viability of *Rheum emodi* wall. ex meissn. cultivated at lower altitude. *Current Science*, 84(2):143-148.

Verma, R.K, Rahman, L.U., Verma, R.S., Chauhan, A, and Kalra Alok (2010). Effect of nitrogen and phosphorus levels on plant growth and yield attributes of Clary sage*. Intern. J. Agron. Plant Product..,* 1(4):129-137

Sumathi, M., Shashekala, S.G., Shankaraiah, N., Ravi Kumar, P. and Kavitha, V. (2012). Effect of nitrogen and VAM levels on herbage and oil yield of Patchouli. *Intern. J. Adv. Bio. Res.,* 2(3): 403-411