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Effect of different plant spacing's on growth and yield of *Rheum australe* D. Don: an endangered medicinal plant

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Abstract
The experiment on *Rheum australe* an endangered medicinal plant was conducted at Dr. Y.S. Parmar U.H.F, Nauni, Solan Himachal Pradesh. The experiment was conducted under Randomized Block Design (RBD) with five replications and four treatments. Different spacing's for conducting experiment were (60×60cm), (60×90cm), (90×90cm) and (90×120cm) respectively. The plants raised in polybags at experimental farm Nauni, Solan were transplanted at Forestry Research Sub-Station, Rahla (Manali) at different spacings as per treatments. Observations were recorded on different parameters such as plant height (cm), aerial biomass yield plant^{-1} (g), underground biomass yield plant^{-1} (g) and estimated underground biomass yield (q/ha) after one year interval up to three years due to perennial nature of herb. Statistical analysis revealed significant results for all the parameters. Maximum plant height (33.41 cm) was recorded in (60×60cm^2), spacing however, maximum above ground biomass (37.28 g plant^{-1}) and below ground biomass (40.22g plant $^{-1}$) was recorded in (60×90cm^2) cm spacing after 36 months. The spacing of 60×60 cm resulted in significant increase in estimated underground biomass yield (9.90qha^{-1}). There was 43.54 %, 31.32 % and 25.21 % increase in underground biomass in S_2 (60×90cm^2) spacing over planting distance of (90×120 cm^2) after 12 months, 24 months and 36 months respectively.

Keywords: Endangered, medicinal plants, spacing's, underground biomass, perennial

1. Introduction

Plants have been a major source of therapeutic agents since time immemorial. The increasing acceptance of traditional herbal systems of medicine, like Ayurveda, within India and outside has resulted in the survival of ancient traditions of medicine. Medicinal plants and their derivatives are, thus, looked upon not only as a source of affordable healthcare, but also as an important commodity item of international trade and commerce. As per World Health Organization estimates, traditional medicine mostly plant drugs, cater to the health needs of nearly 80% of the world population (Ganapathy, 2005) [4].

Most of medicinal plants, even today, are collected from wild. The continued commercial exploitation of these plants has resulted in receding the population of many species in their natural habitat. Vacuum is likely to occur in the supply of raw plant materials that are used extensively by the pharmaceutical industry as well as the traditional practitioners. Paradoxically, 90 per cent of them are collected from wild sources (forest) and only meager minority is sustainably produced and harvested through cultivation. Furthermore, 70 per cent of such collection involves destructive harvesting, wherein roots, barks, twigs, flowers, leaves, fruits, seeds and whole plants (in case of herbs) are collected for use in herbal drugs (Suman and Khanuja, 2006) [10].

Current estimates by the Threatened Plants Species Committee of the Survival (TPSSC) of IUCN indicate that 1 in 10 species of vascular plants on earth is endangered or threatened due to commercial exploitation and increasing international trade. It has been pointed out that nearly 60,000 plant species may be in danger of extinction leading to gene erosion during the next 30-40 years. The Himalaya covers 18% of the Indian sub continent and accounts for more than 50% of Indian forest and contains 405 of India's endemic species (Maikhuri *et al*. 2000; Nautiyal *et al.* 2003) [6, 7]. The Indian Himalayan Region (IHR) is a rich reservoir of biological diversity in the world. Over 1748 species of medicinal and aromatic plants have been reported from IHR which are being used in different systems of medicines. There is thus an urgent need to develop regeneration/conservation strategies for over exploited medicinal and aromatic plant species. *Rheum australe* is one of the important high value species, which has huge economic potential, being used in pharmaceutical industries and due to heavy anthropogenic pressure its natural population is threatened, which in turn has affected the natural regeneration.

Rheum australe D. Don commonly known as Gandhini, Revandcheni, Archa, Rhubarb, Chukri, Tukshu is a perennial stout herb, 1.0-3.0 m in height, distributed in the temperate and sub tropical regions of the world between 2800-3600m altitudes.The history of rhubarb dates back to ancient China and the Mediterranean region as a highly popular laxative drug and a general tonic. Indian rhubarb is used as purgative and astringent tonic; its stimulating effect combined with aperient properties renders it especially useful in atonic dyspepsia. Powdered roots are sprinkled over ulcers for healing and also used for cleaning teeth. Leaf stalks are eaten either raw or boiled, sprinkled with salt and pepper. Leaves and flowers are also edible. Root is regarded as a panacea in local home remedies and is used in stomach problems, cuts, wounds and muscular swellings, tonsillitis and mumps. It has been found as a potent anti- inflammatory drug. It is used in preparation of lavangabhaskar -churna, Ghuttis, Gripe water and several anti-diarrhoeal and anti-dysentric preparations (Anonymous, 1972; Chauhan, 1999; Nautiyal and Nautiyal, 2004) [1, 3, 8].

Keeping in view the importance of this high valued endangered medicinal herb *Rheum australe*, and meager information on its cultivation, the present study has been carried out.

2. Materials and Methods

The present study was conducted at Experimental farm Nauni, Solan, and at Forestry Research Sub -Station, Rahla (Manali) of Dr. Y.S. Parmar U.H.F, Nauni Solan, Himachal Pradesh during august 2010- August 2014 having an altitude of 2800m. Regarding climate generally November, December, January, February and March are the coldest months while May and June are the hot months (at Rahla). The area receives maximum rainfall from June to September and heavy 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 experiment was conducted under Randomized Block Design (RBD) with five replications and four treatments. Different spacing's for conducting experiment were ($60 \times 60 cm^2$), ($60 \times 90 cm^2$), ($90 \times 90 cm^2$) and ($90 \times 120 cm^2$). The plants raised in polybags at experimental farm Nauni were transplanted at experimental farm Rahla at different spacings as per treatments. FYM was applied at the time of land preparation @ 20 t ha^{-1}. Irrigation was done till the establishment of plants and thereafter plants were left to grow under rainfed condition. The field was kept weeds free by doing manual weeding operation. Observations were recorded on different parameters such as plant height, aerial biomass yield $plant^{-1}$, underground biomass yield $plant^{-1}$ and estimated underground biomass yield (q ha^{-1}) after one year interval up to three years.

The test analysis revealed different values for different parameters i.e. pH: 6.96 and 6.55 Organic carbon (%): 0.45 and 0.60, Available nitrogen (kg/ha): 275 and 213, Available phosphorus (kg/ha): 22 and 17, Available potash (kg/ha): 280 and 235 for experimental farm Rahla and Nauni respectively.

The soil of the experimental area at Rahla was found to be neutral, low in organic carbon and medium in available nitrogen, available phosphorus and potash. However, the soil of the experimental area at Nauni was found to be neutral, medium in organic carbon, available phosphorus and potash and low in available nitrogen

3. Results

3.1 Plant height (cm)

Data presented in Table 1 revealed that among different plant spacings after 36 months maximum value for plant height was observed in ($60 \times 60 cm^2$) spacing i.e. (33.41 cm) which was followed by ($60 \times 90 cm^2$) spacing (29.37 cm) and ($90 \times 90 cm^2$) spacing (27.33 cm) and all were statistically different from each other. Minimum plant height was recorded in ($90 \times 120 cm^{2)}$ (25.37cm) after 36 months which was statistically different from other values. There was 13.30 %, 42.29 % and 31.69 % increase in plant height in ($60 \times 60 cm^2$) spacing over ($90 \times 120 cm^2$) spacing after 12 months, 24 months and 36 months respectively.

Table 1: Effect of different plant spacing's on plant height and above ground biomass of *R. austral*

Spacings	Plant height (cm)			Mean	above ground biomass /plant (g)			Mean
	12 months	24 months	36 months		12 months	24 months	36 months	
(60 × 60cm) S_1	11.58	23.35	33.41	22.78	12.22	20.15	32.25	21.54
(60 × 90cm) S_2	11.32	20.32	29.37	20.33	15.20	25.27	37.28	25.91
(90 × 90cm) S_3	10.41	18.37	27.33	18.70	11.17	18.15	29.36	19.56
($90 \times 120 cm^2$) S_4	10.22	16.41	25.37	17.33	10.22	15.30	24.79	16.77
Mean	10.88	19.61	28.87		12.20	19.71	30.92	
$CD_{(0.05)}$	0.40	0.12	0.10		0.38	0.48	0.84	
SE(±)	0.17	0.03	0.03		0.11	0.21	0.36	

3.2 Above ground biomass (g)

A perusal of data presented in Table 2 revealed that among different plant spacings after 36 months maximum above ground biomass was observed in ($60 \times 90 cm^2$) spacing i.e. (37.28 g) which was statistically superior to all other values which was followed by ($60 \times 60 cm^2$) spacing (32.25 g) and ($90 \times 90 cm^2$) spacing i.e. (29.36g). Minimum value for above ground biomass was observed in ($90 \times 120 cm^2$) spacing (24.79 g) which is significantly different from all other treatments. There was 48.72 %, 65.16 % and 50.38 % increase in above ground biomass in ($60 \times 90 cm^2$) spacing over ($90 \times 120 cm^2$) after 12 months, 24 months and 36 months respectively.

3.3 Underground biomass (g)

Data presented in table 3 revealed that among different plant spacings after 36 months maximum underground biomass was recorded in ($60 \times 90 cm^2$) spacing i.e. (40.22 g) which was followed by ($60 \times 60 cm^2$) spacing (37.15 g) and ($90 \times 90 cm^2$) spacing (34.80 g) and planting density of ($60 \times 90 cm^2$) was statistically superior to all other treatments. Minimum value for underground biomass was recorded in ($90 \times 120 cm^2$) spacing (32.12g) after 36 months. An increase of 43.54 %, 31.32 % and 25.21 % underground biomass in ($60 \times 90 cm^2$) spacing over ($90 \times 120 cm^2$) after 12 months, 24 months and 36 months was recorded respectively.

Table 2: Effect of different plant spacing's on underground biomass and estimated underground biomass of *R.australe*

Spacing's	Underground biomass/plant(g)			Mean	Estimated underground biomass (q /ha)			
	12 months	24 months	36 months		12 months	24 months	36 months	
(60 × 60cm) S_1	12.70	27.25	37.15	25.70	3.38	7.26	9.90	6.84
(60 × 90cm) S_2	14.67	30.27	40.22	28.38	2.68	5.54	7.37	5.19
(90 × 90c^2) S_3	10.02	25.05	34.80	23.29	1.16	2.88	4.05	2.70
(90 × 120 cm) S_4	10.22	23.05	32.12	21.79	0.67	1.91	2.67	1.75
Mean	11.90	26.40	36.07		1.97	4.40	5.99	
$CD_{(0.05)}$	1.00	0.79	0.75		0.25	0.18	0.16	
SE(±)	0.43	0.34	0.33		0.07	0.05	0.07	

3.4 Estimated underground biomass (q ha^{-1})

A perusal of data presented in Table 4 revealed that among different plant spacings after 36 months maximum estimated underground biomass (q/ha) was recorded in (60 × 60cm^2) spacing (9.90q ha $^{-1}$) which was followed by (60 × 90cm^2) i.e. (7.37) and (90 × 90cm^2) spacing (4.05). Minimum value for estimated underground biomass was observed in (90 × 120 cm^2) spacing (2.67 q ha $^{-1}$). However all the treatments differ significantly from each other.

In the present investigations, higher rhizome yield per unit area recorded at closer spacing (60 × 60cm^2) accrued primarily due to the increase in plant population, despite compromise in per plant yield. Maximum plant height (33.41 cm) was recorded in (60 × 60cm^2) spacing however, maximum above ground biomass (37.28) and below ground biomass (40.22) was recorded in (60 × 90cm ^{2}) spacing after 36 months. The spacing of (60 × 60cm^2) gave the significant increase in estimated underground biomass yield (9.90qha^{-1}).

4. Discussion

Spacing play an important role in growth and development of any plant as different plant respond differently at different spacings, which gets reflected in terms of different yield attributes. In the present investigations the effect of plant spacings on different growth and development parameters (plant height, above ground biomass and below ground biomass) in *Rheum australe* revealed that the spacing of (60 × 60cm) recorded maximum Plant height (11.58 cm, 23.35 cm and 33.41 cm) after 12, 24 and 36 months respectively. Maximum above ground biomass (37.28g) and below ground biomass (40.22g) was recorded in (60 × 90cm^2) spacing after 36 months. The spacing of (60 × 60cm^2) gave the significant increase in estimated underground biomass yield (9.90qha^{-1}). It may be due to more number of plants per unit area which contributes more towards increase in herb yield. Such a phenomenon of higher yield at closer spacing has also been reported by Singh and Nand (1979) in *Mentha spicata*. Low herb yield in *Rheum australe* may be due to less number of plants per unit area at wider spacing and moreover wider row spacing does not cover the space between two rows, thus resulting in more weed growth and lesser radiant energy utilization.

In *R. australe* rhizome is the economic part of the plant. The agronomic manipulations and practices aimed at improving the yield of rhizomes through optimizing source-sink ratio are of more practical significance. Optimum spacing provided to each plant helps to utilize growth resources optimally resulting in better yields. The rhizome yield of *R. australe* differed significantly due to spacing levels (60 × 60cm^2) (60 × 90cm ^{2}) (90 × 90cm^2) (90 × 120 cm^2)

The spacing of (60 × 60cm^2) recorded significantly higher dry yield (9.90 q/ha) than the other spacing levels. The increase in yield per unit area with decrease in spacing could be attributed to the increase in plant population. The crop yield per unit area is a function of plant density and per plant yield. With increase in the number of plants per unit area the crowding of plant community also increases which leads to decrease in freeness to the individual plant and increase in competition for growth factors from effective root zone. The present findings are in line with those of Veeraraghavathatham (1985) [11], Patil and Hulamani (1999) [9], Jayalakshmi (2003) [5], and Chandrasekhar *et al.* (2007) [2] as they have reported in coleus.

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