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Review Article

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Rheum australe: an Endangered High-Value Medicinal Herb of North Western Himalayas

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Abstract

Rheum australe, a medicinal herb of therapeutic potential has been extensively used as a source of medicine since antiquity to cure a broad range of ailments without any documented adverse effects. The available scientific literature on this plant species, as presented in this review, reveals that it is an important medicinal plant used in a wide range of ethnomedical treatments across borders as also mentioned in different traditional systems of medicine, including Ayurveda, Homeopathic, Tibetan, Unani and Chinese systems. Moreover, the plant species is a rich reservoir of some major phytoconstituents, particularly anthraquinones, with well-known pharmacological efficacy against a spectrum of health ailments.

Keywords: Endangered, medicinal herb, phytochemicals

1. Introduction

The demand for medicinal plants has increased globally because of wide interest and acceptability in herbal medicines. Most of the demand is being met through collection of large quantity of medicinal plants and plant part from wild populations. However, the methods of collection of medicinal plants are not well refined and not organized. As a result, the rates of exploitation may exceed those of local natural regeneration and the natural habitat is depleting at a faster rate. The Himalayan region of India is a rich reservoir of biological diversity. This region has many high value medicinal herbs, has a rich local tribal tradition of herbal medicine. 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% of them are collected from wild sources (forest) and only meager minority is sustainably produced and harvested through cultivation. Furthermore, 70% 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). Current estimates by the Threatened Plants Species Committee of the Survival (TPSSC) of IUCN indicated 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).

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* is a high altitude endangered medicinal plant commonly known as Revandchini belongs to family Polygonaceae. The roots of the plant contain number of anthraquinones derivatives consisting of emodin, emodin 3-monoethylether, chrysophanol and rhein. Roots are purgative, astringent, tonic, stomachic and aperient. The petioles are pickled; powdered roots are used for cleaning the teeth and sprinkled over ulcers for quick healing (Anonymous, 1972; Chopra, 1958; Nautiyal et al., 2003). It is of special use for infant's stomach problems. It has been found as potent anti-inflammatory drug (Nautiyal and Nautiyal, 2004; Chauhan, 1999). Due to these properties, the species has excessive demand, which leads to illegal exploitation from natural habitat, resulting in habitat destruction.

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 ulcer 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; Rhizomes roots are purgative, astringent, tonic, stomachic and aperient. The petioles are pickled. Powdered roots in action are aperient, astringent, diuretic emmenagogue, expectorant, purgative stomachic and tonic. It is of special use for infant's stomach problems. Root is regarded as a panacea in local home remedies and is used in stomach problems, cuts, wound 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-diarrheal and anti-dysenteric preparations**.**

2. Botanical Description

Rheum australe is a tall (1.5–3 m), robust and leafy perennial herb. The stem is glabrous or pubescent, streaked green and brown with purple to red shade. Rhizomes are 6–12 inches long with a dull orange to yellowish brown surface, inferior in aroma, coarser and untrimmed (Aslam et al., 2012). Roots and rhizomes are the main parts used as drug and are collected in October to November. Leaves are roundish with a heart-shaped base. The roots are purgative, astringent and tonic, while as tuber is pungent and bitter. The upper leaves are smaller, while as basal leaves can be quite large up to 60 cm across with thick blades. The leaves are thick, dull green, highly wrinkled with distinctly rough surface, orbicular or broadly ovate, cordate based on 5–7 nerves, sub scaberulous above and papillose beneath, entire margin and sinuolate with an obtuse apex (Malik et al., 2016; Rokaya et al., 2012). The plant has dark reddish-purple flowers in densely branched clusters in a long panicle inflorescence which can be 1 foot long (Pandith et al., 2018). The inflorescence is fastigiate branched and densely papilliferous which greatly enlarges in fruit. The flowers are small, 3 mm in diameter, in axillary panicles (Malik et al., 2016). The perianth is spreading, 3–3.5 mm in diameter with outer parts smaller and oblong-elliptic (Rokaya et al., 2012). Fruit is ovoid-oblong, ovoid-ellipsoid or broadly ellipsoid, 13 mm long and purple in color. The base is cordate and notched at apex with wings more narrow than thick. Ovary is rhomboid-obovoid, and the stigma is muricate and oblate (Kritikar and Basu, 2003). *Rheum australe* flowers from June to August and fruits from July to September.

3. Historic Overview and Geographical Distribution

The word 'Rhubarb' is of Latin origin. In ancient times, Romans imported Rhubarb roots from barbarian lands which were beyond the Rha, Vogue or Volga River. Imported from the unknown barbarian lands across the Rha River, the plant became rhabarbarum. The English word Rhubarb is derived from Latin rhabarbarum, 'rha' (river) and 'barb' (barbarian land). Moreover, according to Lindley's Treasury of Botany, and in allusion to the purgative properties of the root, some authorities are known to derive the name from the Greek rheo (to flow) (Malik et al., 2016).

Rheum australe has a long history of cultivation originating in the mountains of North-Western provinces of China and Tibet. The Chinese appear to be familiar with the curative properties of Rhubarb since 2700 BC (Dymock et al., 1890), and the plant was first documented in the earliest global book on Materia Medica, 'The ShenNong Ben Cao Jing' (Fang et al., 2011). Its occurrence in West was via Turkey and Russia and was first planted in England in 1777 (Lloyd, 1921). *Rheum australe* is currently reported to be endemic to the Himalayan region, covering the areas of Bhutan, China, India, Myanmar, Nepal and Pakistan. It grows in grassy or rocky slopes, forest margins, crevices and moraines, between boulders and near streams in specific zones. In India, the species is distributed in the temperate and subtropical regions from Kashmir to Sikkim at elevations ranging from 1600 to 4200 masl (Press et al., 2000).

4. Agro-techniques

Plant propagation is done by seeds and intact or chopped rootstocks. Mature seeds show successful germination rate when sown immediately after harvesting. It takes 7–10 days for seeds to germinate which may last up to one month. Better germination is observed when seeds are pre-soaked in water for 10–12 h before sowing (Bhattarai and Ghimire, 2006; Sharma and Singh, 2002). Humus-rich, porous and well-drained soil and exposed or partially shaded habitat are more suitable for its cultivation (Rokaya et al., 2012).

Cultivation of *Rheum emodi* was carried out at two sites *viz*., Tala (1800 masl) between 30°31¢N lat and 79°07¢E long and Pothivasa (2200 masl) between 30°28¢N lat and 79°16¢E long in Rudraprayag district of Garhwal Himalaya, India. On the basis of experiments conducted the following facts are endorsed for cultivation of *R. emodi.* (1) To raise maximum seedlings, polyhouse conditions, sandy soil with litter treatments (1: 2) during October and June with higher moisture and 15–35°C temperature are optimum conditions. Since the seedlings are transplanted during March–April at lower altitude, best seed sowing time was observed during October just after collecting and drying the seeds. In October, seed viability is maximum and seedlings are well developed by the end of February or in March and suitable for transplantation. Germination is fast and the first leaf emerges within a short period without any hormonal treatment and can be adopted easily by local growers and farmers. (2) For cultivation it requires sandy, porous soil with rich rotten manure and can be cultivated up to 1800 m. (3) FL was found suitable for maximum production, although manure requirements can vary from site to site and at different altitude. (4) Although plant survival, productivity and active contents decreased at lower altitude, cultivation was found to be cost beneficial. (5) Mature plants had maximum percentage of active contents and hence 4–5-year-old plants are recommended for harvesting. Further, production per plant is also high and local people can cultivate this plant as a cash crop and as an option for self-employment (Nautiyal et al., 2003)

The study was conducted to determine the seed germination and growth behavior *of Rheum australe* under different field conditions *viz*., open, glass house and shade net house and different time of sowings at lower altitude of 1250 m of mid hill conditions of Himachal Pradesh. Seeds were harvested during October month from different natural ecological zones of Himachal Pradesh. Seed germinability was tested in the mixture of soil+sand+vermicompost+cocopeat (2:1:1:1). The experiment was carried out for two years with three replications. The results revealed that maximum seed germination, seedling emergence, seedling shoot and root length, was recorded under shade net house conditions in soil + sand + vermicompost+cocopeat (2:1:1:1) media, when the seeds were sown during November month (Bhardwaj and Sood, 2015). The experiment was conducted under different planting densities in Himachal Pradesh. The plants raised in polybags at experimental farm Nauni, Solan Himachal Pradesh were transplanted at Forestry Research Sub-Station, Rahla (Manali) Himachal Pradesh at different spacings. Maximum plant height (33.41 cm) was recorded in (60×60cm), spacing however, maximum above ground biomass (37.28 g plant-1) and below ground biomass (40.22g plant^{-1}) was recorded in (60×90cm) spacing after 36 months. The spacing of 60×60 cm resulted in significant increase in estimated underground biomass yield (9.90 q ha^{-1}) (Bhardwaj et al., 2020).

The experiment was conducted to study the seed germination and growth behaviour of *Rheum australe* under different field conditions and growing media. Maximum germination percentage, early initiation and completion of germination, maximum mean daily germination and maximum peak value was under shade net house conditions and soil+cocopeat + vermicompost (1:1:1) media (Bhardwaj and Sood, 2016).

Experiment was conducted overcome seed dormancy and enhance germination percentage of seeds of the two endangered and medicinally important species namely *Rheum australe* D. Don (syn. *Rheum emodi* Wall. ex Meissn.)/ rhubarb and *Podophyllum hexandrum* Royle for their effective conservation. The propagation of these species through seeds takes lot of time, due to dormancy and poor germination rate. Germination of seeds in *R. australe* was monitored up to 25th day of the treatment. The best results were recorded in 50 days chilled seeds with 92% germination; followed by 86 and 82% germinations in 40- and 30-day chilled seeds, respectively. Treatment CHl3 (50-day chilled seeds) was statistically different from all other treatments including chilling treatments chl1 (30-day chilled seeds) and chl2 (40-day chilled seeds). Treatments GA31 (Gibbrellic acid 10-3 M) and GA32 (Gibbrellic acid 10-4 M) with 80% and 75% germination, respectively, were at par with each other. Coefficient of variation for all the treatments was 43%, indicating that the treatments were variable with respect to each other. Across days, highest mean (±standard deviation) (60.45±26.38) and range (0-92) was observed on 14th day. In *P. hexandrum,* germination started on 27th day and was completed by 90th day. Maximum germination percentage of (66%) was observed in treatment Comb1 (H_2SO_4 treatment for 8 minutes, GA31 = 10-3 M) and the least (8%) in treatment S2 (H_2SO_4 treatment for 8 minutes). No germination was observed in all the three chilling treatments (Ch1; Ch2; Ch3) as well as in potassium nitrate (K1 =0.2%: K2= 0.3%) and control treatments. All the treatments were varied statistically from each other. The coefficient of variation and mean (±SD) across days varied from 48.41 to 230.86 and 1.18±2.72 to 51.36±24.84, respectively. Highest mean (±S. D) (16.63±23.39) across days was recorded in 73–81-day interval and least (0.36±1.14) in 19–27-day interval) (Bano et al., 2017).

The experiment on viability of seeds in *Rheum australe* was conducted at Dr. Y.S. Parmar U.H.F, Nauni, Solan Himachal Pradesh. Result showed that seed stored at room temperature exhibited lesser viability after 12 months storage as compared to storage under refrigerated conditions with polythene bags as the best storage containers than others. The experiment on effect of different organic manures, biofertilizers and NPK on growth and yield of *Rheum australe* was conducted at Forestry Research Sub -Station, Rahla (Manali) of Dr. Y.S. Parmar U.H.F, Nauni, Solan Himachal Pradesh having altitude of 2800 m. The maximum plant height, above ground biomass, underground biomass and underground biomass yield was recorded maximum using NPK (120:60:30 kg ha^{-1}) and which was followed by Vermicompost+Azotobacter+PSB (10 t:5 kg :5 kg) and minimum was recorded in control (Bhardwaj and Sood, 2015).

An attempt was made to standardize the cultivation practices using organic manures and inorganic fertilizers and their impact on the amount of Rhein content in *R. australe* in the Experimental Field of Division of Floriculture, landscape and Architecture, Sher-e-Kashmir University of Agricultural Sciences and Technology Kashmir, Shalimar, Jammu and Kashmir, India. The experiment comprised of 28 treatments, with three replications each, including one control treatment. The dry root weight recorded by the application of poultry, sheep and farm yard manure was 3878.40, 3200.0 and 3010.0 kg ha^{-1}, respectively. Dry root yield increased significantly with increasing levels of phosphorus and nitrogen as well. Application of organic manure and higher levels of inorganic fertilizers resulted in increase in the root weight, although the effect of their interaction was non-significant. Maximum dry root weight (6012.00 kg ha^{-1}) was observed in M1P2N2 (20 tones poultry manure ha^{-1}, 100 kg phosphorus ha^{-1}, and 150 kg nitrogen ha^{-1}) compared to the lowest yield (2200.00 kg ha^{-1}) in M3P0N1 (25 tones farm yard manure ha^{-1}, 0 kg phosphorus ha^{-1} and 100 kg nitrogen ha^{-1}). The highest amount of Rhein content (0.393%) was observed in treatment M1P2N2, displaying the maximum root weight, however, the least content (0.153) was observed in control treatment (Bano et al, 2017).

A 60 months study was carried out to assess the seed longevity and effect of duration of storage period on viability, germination and seedling vigour in *Rheum australe* D. Don. (rubarb), a highly valued medicinal herb. The species is in high demand and has endangered status therefore, required conservation/cultivation interventions. The study was carried out using seeds of same lot after storage of every six months (0, 6, 12, 18 and so on) till complete loss of seed viability. Freshly harvested seeds exhibited high seed viability (94%) and were non-dormant; above 80% germination occurred within a week. The above status was completely retained till 12 months storage. Beyond this period both seed viability and germination declined consistently with the progression of storage period. A complete loss of viability was observed beyond 60 months storage. Seed pre-treatments tested namely, GA_3, KNO_3 and chilling neither affected significantly the final germination of fresh seeds (86, 80 and 78%, respectively) nor differentially stored seeds. However, GA3 (1 mM) and chilling significantly reduced the time required for germination. The seed longevity (time taken for 50% decline in seed viability) of R. australe was about 45 months, but a storage period of no longer than 24 months can be recommended. During 24 months storage period the seed viability and germination were reasonably high and resulted in the production of healthy seedlings with high survival rate. The outcome was favourable for the conservation/cultivation of the species (Sharma and Sharma, 2016).

5. Phytochemical Constiuents

The drug contains a number of anthraquinone derivatives based on emodin, emodin-3-monomethyl ether, chrysophanol, aloe emodin and rhein. These occur free and as quinone, anthrone or dianthrone glycosides. The astringent principle consists chiefly of gallic acid, present as glucogallin, together with small amounts of tannin and possibly catechin. Glucogallin on hydrolysis yields gallic acid and glucose. The drug also contains cinamic and rheinolic acids, volatile oil, starch and calcium oxalate (Chopra,1958). Emodin, rutin, chrysophanol and chrysophenic acid are the four chief active constituents of rhubarb. Among these chrysophanol is found in a higher concentration (Nautiyal and Nautiyal, 2004).

Indian Rhubarb, which is official in the Indian Pharmacopoeia, consists of the dried rhizomes of *Rheum emodi*. The major phytoconstituents reported to have been isolated from the rhizomes are: free anthraquinones and their glycosides. The anthraquinones, both with and without carboxyl groups are found in *Rheum emodi.* Anthraquinones with carboxyl group include rhein, while those without carboxyl group include chrysophanol, aloe-emodin, emodin, physcion (emodin monomethylether), chrysophanein and emodin glycoside (Malik et al., 2010). Some alkyl derivatives of anthraquinones, like 6-methyl rhein and 6-methyl aloe-emodin have also been reported.

Another chemical group which has been isolated from *R. emodi* is anthrone C-glucosides. These anthrones occur in the form of 10- hydroxycascaroside C, 10-hydroxycascaroside D, 10R-chrysaloin 1- O-b-D-glucopyranoside, cascaroside C, cascaroside D and cassialoin (Krenn et al., 2004). Different derivatives of oxanthrone have been isolated. These include oxanthrone ether (revandchinone-4), oxanthrone esters (revandchinone-1 and revandchinone-2), and revandchinone-3 (Babu et al., 2003). Other compounds, namely, naphthoquinones, rutin, rheinal, rhein 11-O-b-D-glucoside, torachrysone 8-O-b-D-glucoside, epicatechin, auronols (carpusin and maesopsin), the sulfated anthraquinone glycoside sulfemodin 8-O-b-D-glucoside (Krenn et al., 2003), b-asarone and some stilbene compounds (e.g., rhaponticin) have also been isolated.

6. Conclusion

The habitat specificity and overexploitation for herbal drug preparations have made *R. australe* to figure prominently among endangered plant species. Effective measures must be taken to preserve the dwindling wild populations of this plant species. Cultivation techniques should be formulated for effective and sustainable utilization of the plant at commercial scale.

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