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Effect of shade and spacing on growth performance of *Bergenia ciliata:* An important medicinal plant of North-Western Himalayas

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Abstract
Bergenia ciliata, a perennial herbaceous plant native to the Himalayan region, has gained attention for its ornamental and medicinal properties (Yaginuma *et al.,* 2003) [11]. The study examines the impact of 3 distinct spacing configurations i.e., 45 cm x 45 cm (SP1), 45 cm x 60 cm (SP2) and 60 cm x 60 cm (SP3) and four varied shade treatments i.e., 0% (SD1), 25% (SD2), 50% (SD3), 75% (SD4) on six crucial growth parameters which include plant spread, number of leaves, leaf area, rhizome fresh weight, rhizome dry weight and total biomass. Through meticulous experimentation, we analyse how the interplay of spacing and shade influences the overall growth and development of *Bergenia ciliata*. Remarkably, the study revealed that the maximum growth was achieved when *Bergenia ciliata* was exposed to 50% shade (SD3) and planted with wider spacing (SP3). This is because 50% shade provide optimum environmental conditions for plant growth parameters to grow by maintaining a good water and nutrients status. Also, under shady circumstances, plant engage in various adaptations such as reducing respiration, expanding leaf area to capture more light and boosting photosynthesis efficiency per unit of light energy (Hanudin *et al.,* 2012) [2]. Wider spacing also attributed to congenial growing conditions such as more space available for growth of roots and shoots (Mounika *et al.,* 2021) [1]. It facilitated better growth outcomes as it allows improved light penetration and reduced competition among the plants. Maximum spacing provides more ample room/ space for plant to grow with minimal competition from neighbouring plant. This finding emphasizes the significance of carefully considering both shade intensity and spacing arrangements to optimize the growth of *Bergenia ciliata*.

Keywords: Shade, spacing, growth performance, *Bergenia ciliata*, medicinal plant

Introduction
Medicinal plants have been widely used to treat a variety of infectious and non-infectious diseases. In fact, 25% of commonly used medicines contain compounds extracted from plants. Several plants hold the potential to serve as a rich source for drug discovery of infectious diseases, particularly with the latest separation techniques available and the increasing number of emerging infectious diseases. These plants can be used to treat various ailments, including viral infections such as those associated with HIV-1 and 2, as well as newly emerging infectious viruses that pose a threat to human survival. Several medicinal plants have shown promise in treating a variety of viral infections, with some of them having broad-spectrum antiviral activity (Mukhtar *et al.,* 2008) [5].
Medicinal plants are traded both as raw material and as processed final products. The collection and more recent marketing of medicinal plants has provided an important source of income for communities living in the Himalayan region, particularly in Kashmir valley. Medicinal plants have been used for centuries in traditional health care systems and numerous cultures around the world still rely on plants for their basic health care. With the recent advancements in plant sciences, there has been a tremendous increase in the use of plant based health products in developing as well as developed countries. About 70-80% people around the world depend on medicinal plants for basic health care. Medicinal plants are also a source of income for thousands of families in Kashmir valley (Mushtaq *et al*., 2020) [6].

Bergenia ciliata of family Saxifragaceae is a rhizomatic herb with fleshy leaves, growing upto 30 cm tall, having a stout creeping rhizomatous rootstock with scars and intermittent axillary buds. Plant is quite hardy and able to survive frost during winter turning reddish in colour. It is evergreen and flowers in April to June. Its flowers are white-pink and purple in colour. The flowers *Bergenia ciliata* are bisexual, white, pink or purple with long cymose panicles 4-10 cm long. The fruit is a capsule and rounded in shape. Seeds are greyish in colour, minute and numerous in one capsule. Stem is short. The rhizome comes out from the crevices of rocks and hangs in the air in sloppy areas. Leaves are 5-30 cm long, glabrous, sparsely hairy in margins, broadly obovate or elliptic, finely or sparsely denticulate or shallowly sinuate-dentate (Dar *et al*., 2002) [1].

Bergenia genus comprises of 6 species and is distributed in the temperate Himalayas region form Kashmir to Nepal, Central and East Asia, Pakistan etc. It is commonly foundon rocky areas at an altitude of 1200-2700 metres above m.s.l (Islam *et al.*, 2002) [3].

Bergenia species have been used in the traditional medicines for a long time. In Unani and Ayurvedic systems of medicine, *Bergenia* rhizomes have been used for curing kidney and, bladder diseases, dysuria, heart diseases, lung and liver diseases, spleen enlargement, tumours, ulcers, piles, dysentery, menorrhagia, hydrophobia, biliousness, eyesores, cough, and fever. The burns or wounds may be treated with rhizome paste for three to four days. The paste can be applied on dislocated bones after setting, or consumed to treat diarrhoea or along with honey in fevers. The leaf extract of *B. Ciliata* possesses antimalarial property. Its leaves are revered to as "Pashanabheda", which designates the litholytic property. In Nepal, 1:1 mixture (one teaspoon) of the dried *B. ciliata* rhizome-juice and honey is administered to post-partum women 2–3 times a day as a tonic and remedy for digestive disorders (carminative). The rhizome-decoction may also be consumed orally as antipyretic and antihelmintic (Yaginuma *et al*. 2003) [11].

Materials and Methods

Study Site

Kashmir valley is located in the north-western extremity of India. It is a meso-geographical region with an area around 15,948 m^2. The valley stretches between 32°22′ to 34°43North latitude and 73°52′ to 75°42′ East longitude. Average altitude of Kashmir valley ranges between 1, 500 to 2, 300 m above sea level (Shabir *et al.*, 2021) [10].

The experimental site, Faculty of Forestry, SKUAST-Kashmir, Benihama village (Tehsil- Lar, District- Ganderbal) lies on the southern aspect at 34°16' 4" North latitude and 74°46' 31" East longitude. The study area is located at an elevation of 1, 783m (5850 feet) above the mean sea level. The site falls in a mid to high altitude characterized by hot summer and very cold winters. The average precipitation is 690-1150 mm most of which is received from December to April in the form of snow and rains. The climate is generally temperate; winter is severe extending from December to March. The region faces a wide temperature range from -8° c in winter to maximum of 33° c in summer. Winter frost is common and medium to heavy snowfall is also witnessed (Rafeeq *et al.*, 2020) [9].

Treatments

The research was conducted to study the propagation of *Bergenia ciliata* through rhizomes. The rhizomes were collected from the natural habitat and were planted at 03 different spacing's (SP1= 45 cm × 45 cm, SP2 = 45 cm × 60 cm and SP3 = 60 cm × 60 cm) and 04 shading treatments (SD1 = 0%, SD2 = 25%, SD3 = 50% and SD4 = 75%) at 03 replications to find out growth performance of the species.

Statistical Design

Current research study was carried out on the propagation and growth, analysing the effect of shade and spacing on growth of *Bergenia ciliata* using factorial Randomized Complete Block Design.

Observation Recorded

1. **Plant spread (cm^2):** It was measured with the help of measuring scale.
2. **No. of leaves per plant:** It was counted manually.
3. **Leaf area (cm^2):** It was measured with the help of leaf area meter.
4. **Rhizome fresh weight (g):** Freshly collected rhizomes were weighed by using top pan balance.
5. **Rhizome dry weight (g):** Rhizomes were shade dried till constant weighed was achieved and dry weight was determined by using top pan balance.
6. **Total biomass (g):** Above ground biomass + below ground biomass.

Results and Discussion

The result of investigation entitled "Effect of Shade and Spacing on Growth Performance of *Bergenia ciliata:* an important Medicinal Plant of North-Western Himalayas." is explained by graphical representation below:

Effect of shade and spacing on plant growth Parameters:

Our study revealed that spacing had a significant effect on all the growth parameters of the rhizomes of *Bergenia ciliata* i.e., plant spread, leaf area, No. of leaves per plant, rhizome fresh weight, rhizome dry weight and total biomass. Maximum plant spread (73.82 cm^2), number of leaves (5.16), leaf area (48.37 cm^2), rhizome fresh weight (64.60 g), rhizome dry weight (34.75 g) and total biomass (57.84 g) was observed in rhizomes at wider spacing i.e., SP3 (60 cm x 60 cm spacing). It is clear that more number of leaves had contributed to higher leaf area and eventually more photosynthetic surface at wide orientation. This was because wider spacing was attributed to congenial growing conditions such as more space available for growth of roots and shoots (Mounika *et al.*, 2021) [1]. Our findings were supported by Rafiq *et al.*, (2020) [9] who narrated that the propagation of *B. ciliata* at maximum spacing is more proficient than others in terms of different growth parameters. Bhat *et al.*, (2020) [8] also revealed that that maximum growth and essential oil content of *Acorus calamus* was obtained at wider spacing of 60 cm x 70 cm and minimum growth and essential oil content was observed at narrow spacing of 60 cm x30 cm.

Optimizing spacing is a critical aspect for growth, biomass, yield etc of medicinal plants. By understanding the effects of spacing on growth parameters, cultivars can make informed decision to enhance plant health, yield and quality. Through the application of proper spacing practices, the cultivation of medicinal plants can be improved, ultimately benefiting both producers and consumers in the field of herbal medicine. Increasing plant density does not affect the individual plants if the plant density is below the level at which the competition occurs between the plants. However, when the plant density is too high and there is competition between the plants, yield decreases and vice-versa. Therefore, the yield increases at wider spacing because of

decreasing effect of competition among plants for all growth factors such as water, light and nutrient (Jehan *et al.*, 2013) [5].

Interaction effect of shade and spacing on growth

Our study reveals that shade and spacing has a significant effect on different growth parameters of *Bergenia ciliata* viz., plant spread, Number of leaves, leaf area, rhizome fresh weight, rhizome dry weight and total biomass. Rhizomes under SD3SP3 (50% shade and 60 cm x 60 cm) exhibited maximum plant spread (85.8 cm^2). No. of leaves (7), leaf area (60.1 cm^2), rhizome fresh weight (70.90 g), rhizome dry weight (37.45 g) and total biomass (65.22 g) as compared to the rhizomes under SD1SP1 (45 cm x 45 cm spacing and 0% shade). Our results are closely related with Nida *et al.*, (2020) [8] where maximum growth was recorded at highest shading and spacing treatments.

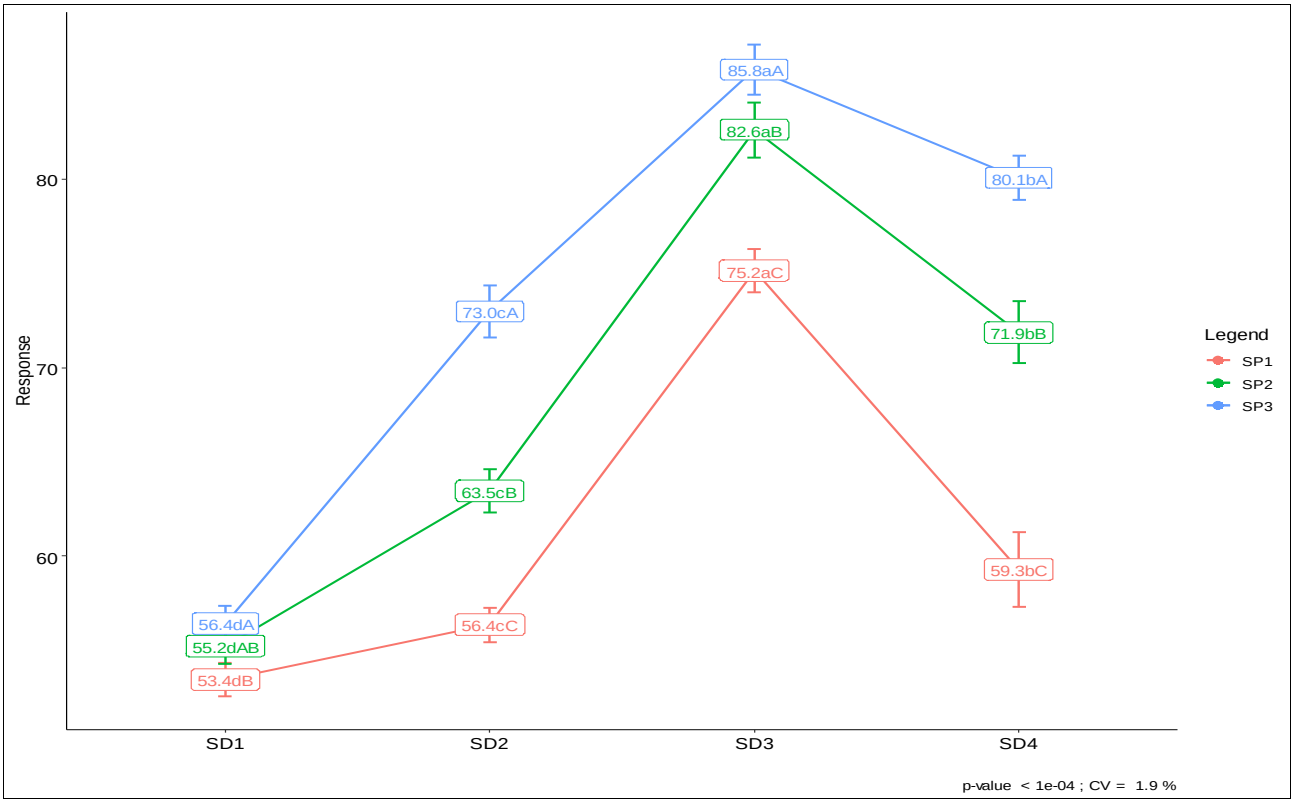

Fig 1: Effect of shade and spacing on plant spread (cm^2)

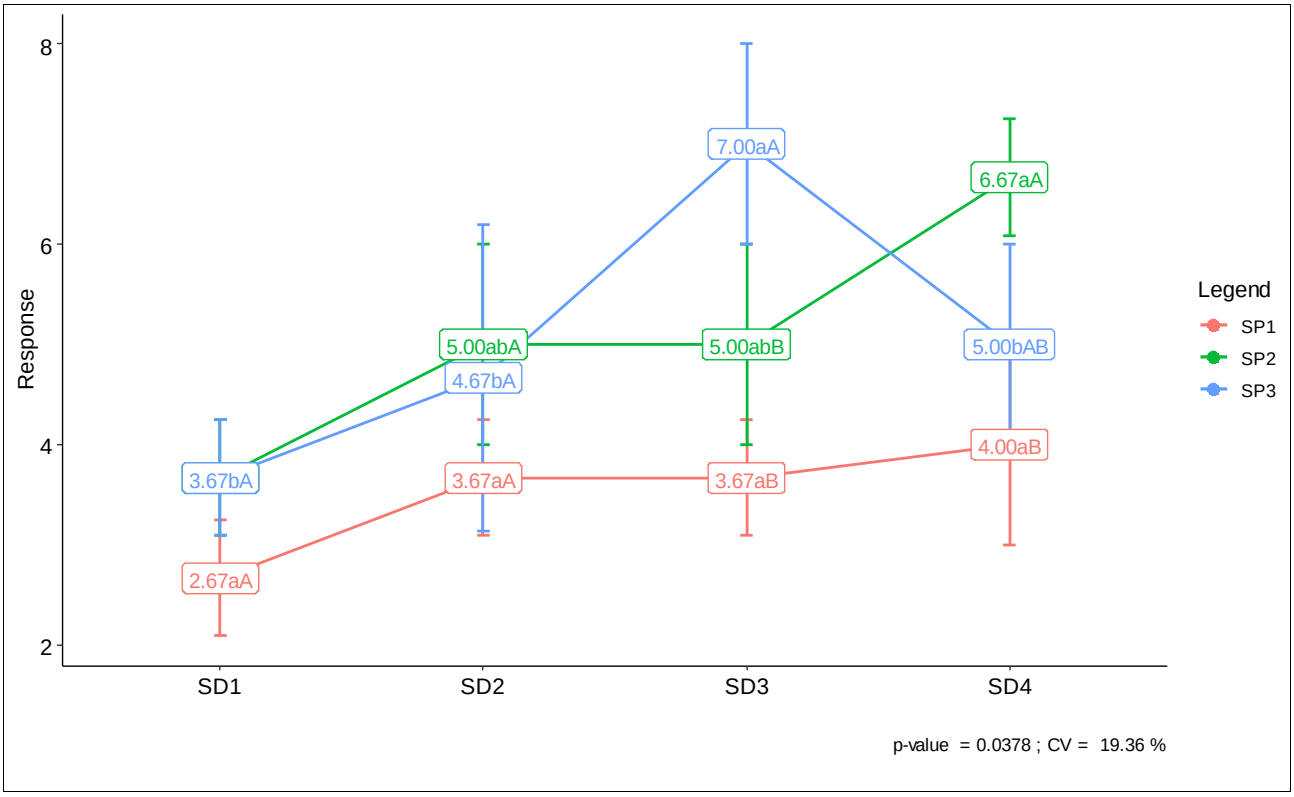

Fig 2: Effect of shade and spacing on number of leaves per plant

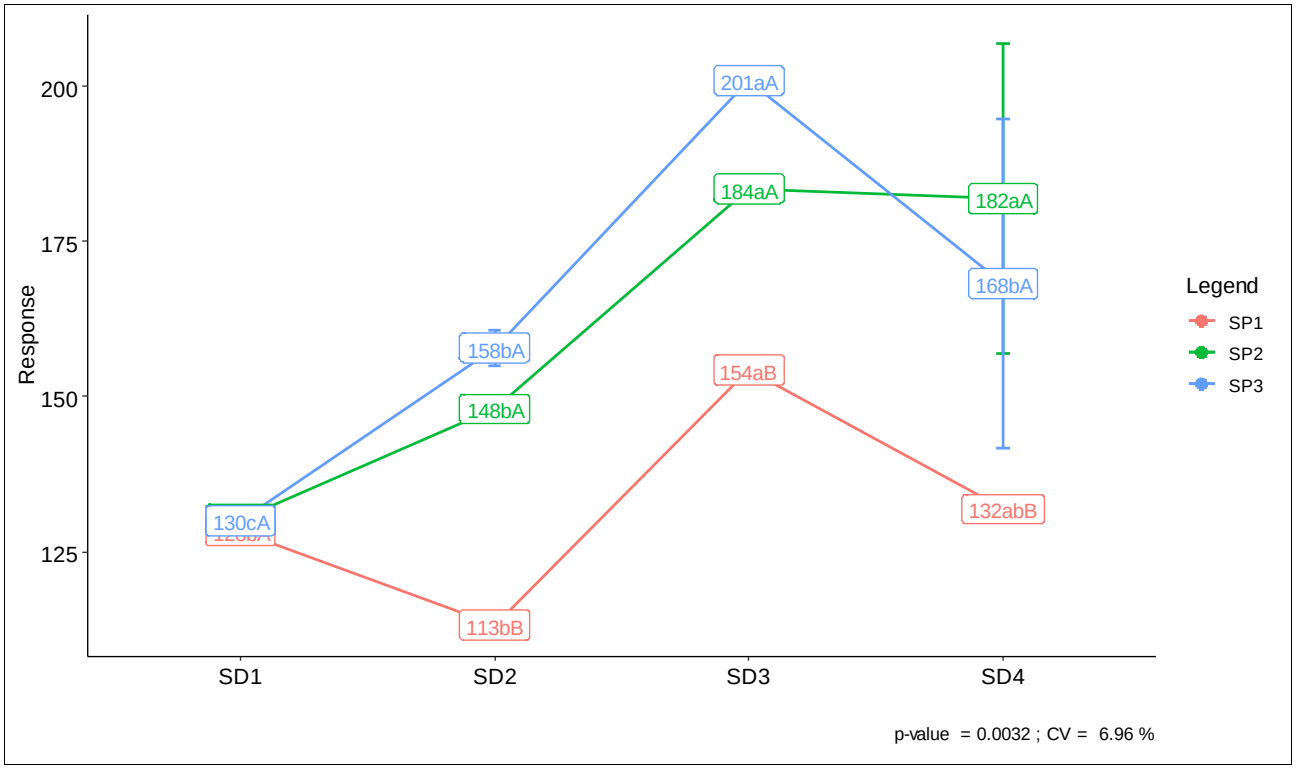

Fig 3: Effect of shade and spacing on leaf area (cm^2)

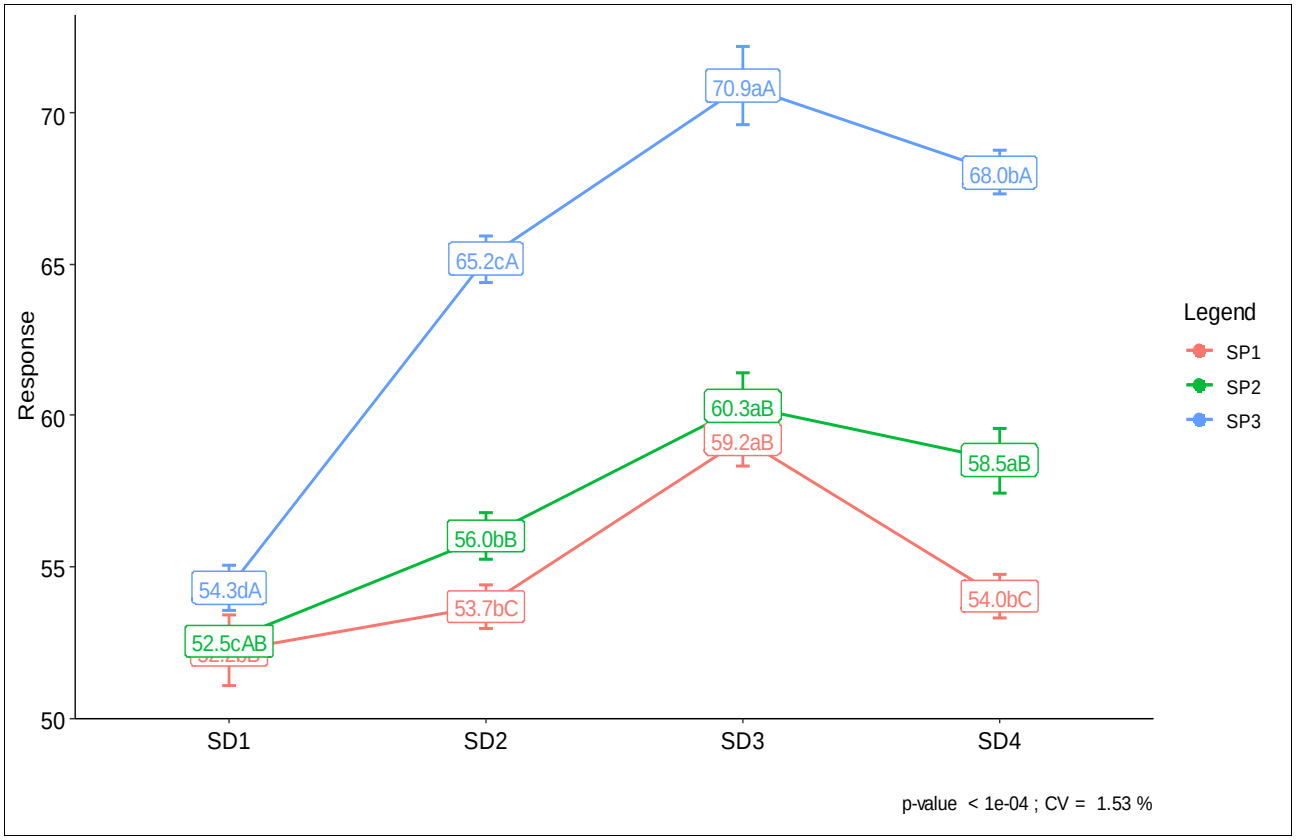

Fig 4: Effect of shade and spacing on rhizome fresh weight (g).

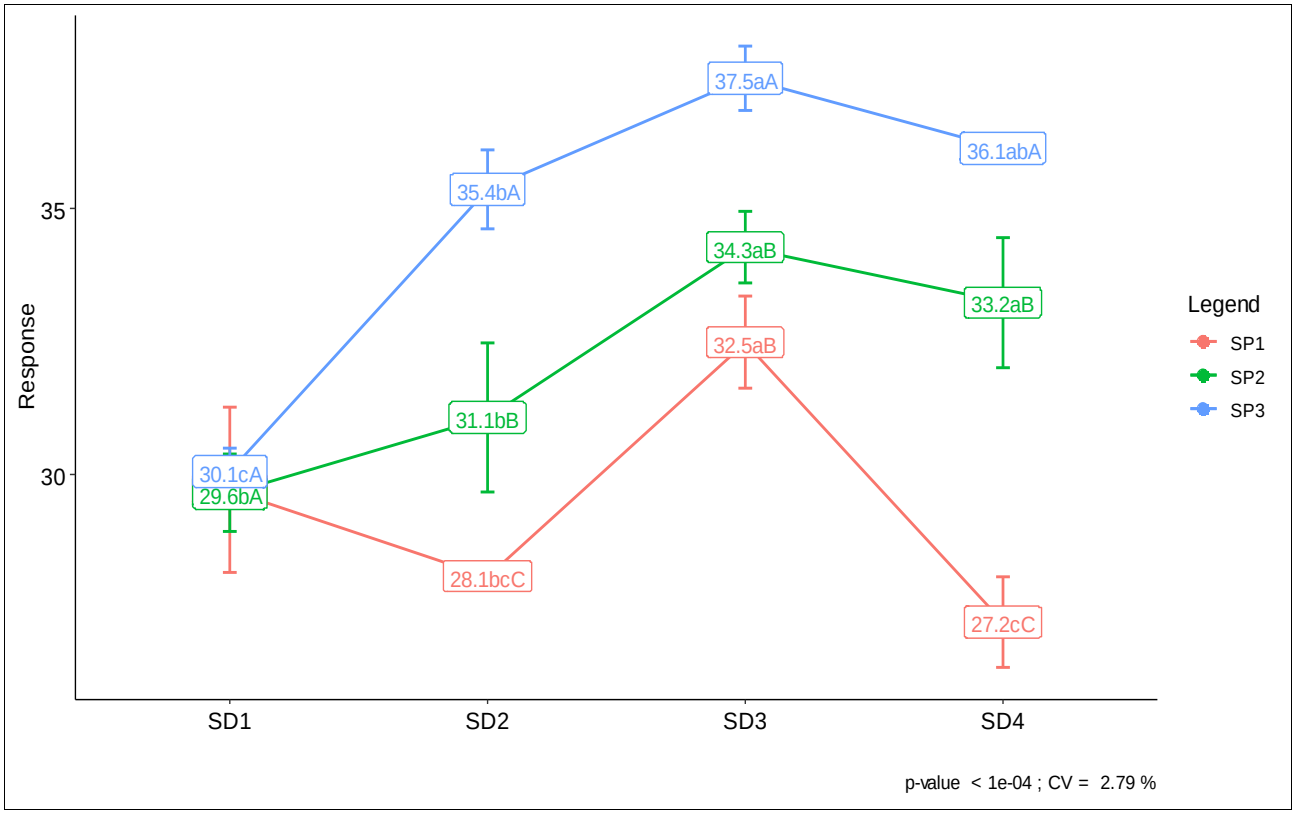

Fig 5: Effect of shade and spacing on rhizome dry weight (g) of *Bergenia*

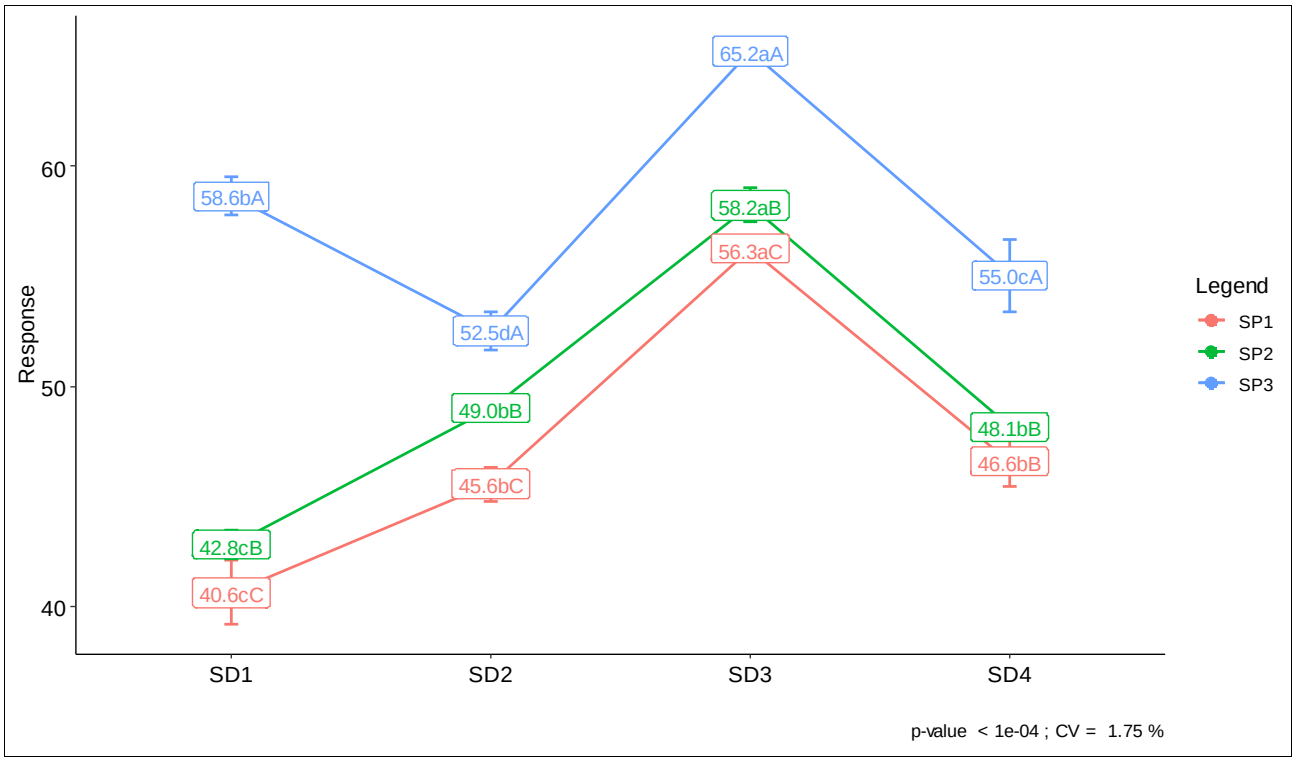

Fig 6: Effect of shade and spacing on total biomass (g) of *Bergenia ciliata*

Conclusion

Studies on effect of shade and spacing on growth of *Bergenia ciliata* revealed that the specie grows best under 50% shade and at wider spacing (60 cm x 60 cm). All the seven growth parameters recorded were found maximum at 50% of shade and at spacing of 60 cm x 60 cm.

It is important to note that while shading it is beneficial to provide the appropriate level of shade that mimics their natural habitat. Too much shade can inhibit growth and results in elongated, weak stems, while insufficient shade can lead to excessive light stress. Therefore, finding the right balance of shade intensity and duration is crucial for optimizing the growth and medicinal properties of shade loving medicinal plants.

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