# Field Based Seed Germination Technologies for Domestication of Chiraito *(Swertia chirayita)* in Nepal

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## ABSTRACT

On-station and on-farm multi-location experiments were conducted at Agricultural Research Station, Pakhribas and its outreach sites on the high value wild medicinal herb Chiraito (*Swertia chirayita* (Roxb. ex Fleming) Karsten in order to develop seed germination technologies for the hill regions of Nepal. Germination researches were conducted at 4 sites located at 1800-2200 m above mean sea level for 3 years under various growing environments: treating with acid, warm and normal water, mixing with dung slurry and moist soil under nursery, cultivated and virgin land, and meadow and terrace riser conditions. Minute seeds of Chiraito 1g m-2 after treatment were mixed into 1 tea glass of sand/soil and sown/broadcast on nursery bed. Five experiments were laid out in randomized complete block and one in Latin square design with 3 to 6 treatments and 2 to 5 replicates. Plot size was 1m x 1m for each treatment. Germination started after 2 weeks, and proceeded very slowly (continued upto 2-3 months to germinate most seeds). Growth of seedlings was also slow and took 4-5 months (May-August) to reach transplantable 6-8 leaved stage. Varied numbers of emerged seedlings: 250-2000 (grand mean 850) in 1 square meter bed were counted from different trials/ treatments based on locations. Germination achieved higher by soaking seed with water for 24 hours. Improved nursery raising techniques, growing media, cultural practices and direct seeding were tested, verified and found recommendable to the growers for the first time at Agricultural Research Station Pakhribas.

**Keyords:** *Swertia chirayita*, Propagation, Nursery raising, Seedling technology, Seed germination

## 1. INTRODUCTION

Nepal is rich in plant resources. Over 5,309 species of flora are identified under 1,515 genera and 193 families (Rajbhandari et al. 2017). Of them 1624 species (> 30%) belong to medicinal and aromatic plants (MAPs) only. These include a 1515 species of angiosperms, species of gymnosperms 19, 56 species of pteridophytes, 5 species of bryophytes, 18 species of lichens and 1 species of fungi (Shrestha et al. 2000). Genus *Swertia* only enumerates 31 species of which *Swertia chirayita* (Roxb.) ex H.Karst. *syn.* S. *chirata* Buch.-Ham. ex Wall. is the medically and economically most important species. It is commonly known as Chiraito in Nepal however the name varies based on locations and ethnicities as Pothi chiraito, Kali chiraito, Lekh tite, Chireto etc. (Barakoti 2004a). Another species (*Swertia angustifolia* Buch.-Ham. *ex* D.Don) called *Bhale chiraito* is less bitter. Chiraito is called Kirata/Chirata in Sanskrit, in Hindi Chirayata and in Tibetan Tikta. It has historical, ethno-botanical, commercial and environmental values (Barakoti 2013) for Nepal.

*Swertia chirayita* grows naturally in the humid mountain region. Endemic to the high hill-alpine region, it is commonly found in between 1500 to 3200 m above mean sea level (amsl), however Bhandari et al. (2019) and Niraula and Kumari (2012) mention 1200 to 3600 m amsl. The more suitable growing condition and elevation for S. *chirayita* found 1800-2700 m amsl in eastern region (Parajuli *et al*. 1998; Barakoti, 2002). This species flourishes well in the areas with high humidity, long monsoon period, less sunshine, more cloudy period. It grows well under drained fertile humus, sandy to silt-loamy acidic soil having PH 4.7-5.8. It prefers slopy, moist place, found growing in the partial shade forest, marginal and pastureland. It grows in all 57 hill districts of Nepal having desirable altitude and favorable agro-eco-climatic conditions (Barakoti 2004).

*Swertia chirayita* growing abundantly in Nepal hill regions gradually declined in its natural habitat. Khadka *et al.* (1994) firstly reported the situation in the eastern region. Premature harvesting was the main reason behind such decline in natural populations (Parajuli et al. 1998). Therefore IUCN (2000) categorized this species under vulnerable plants group. Animal grazing, forest fire, lack of conservation and cultivation practices were other reasons (Barakoti 2000a; Shrestha *et al.* 2000). Researchers found that there was an increasing interest among farmers and forest users to cultivate Chiraito for increased production and income. But literature on propagation and cultivation was scanty as no research was done elsewhere. Seed germination in the field had been a major constraint felt by stakeholders (Barakoti 1999).

Nepal is rich in *Swertia* species. Of the 150 species recorded globally (Joshi & Joshi, 2008), 31 species are identified in Nepal's hills and mountains where is favorable environment for *Swertia* species (Barakoti 2008), hence high diversity. Chiratas were found and used in Nepal since time unmemorable as mentioned in ancient scriptures. As Nepal's mountain region could be the center of origin of *S. chirayita*, *S. angustifolia* and other *Swertia* species, research should focus on this line to confirm this possibility. Those might be native/endemic to Nepal as there are strong historical evidences: Firstly, its Latinized scientific name *Chirata* came from Sanskrit word *Kirata*. Chi is also pronounced as Ki in English. Nepal's Eastern region was known as Kirata Pradesh (province) before as 29 kings (Yalamber to Gasti) ruled Nepal. The alpine tribe Kiratas have been dwelling in the region since generations. Kirata dynasties ruled Nepal from 900 BC-300 AD (Mahishpal to Lichchhabi) during Sindh civilization. The most valid evidence is the word Chirata (Kirata) which is a generic term in Sanskrit for the people who had territory in mountains, particularly eastern Nepal (Wikipedia: Kirata). In this context, researches should be done on ancient history and nomenclature of S. *chirayita* to validate information.

The definition of Kirata/Chirata is given in Sanskrit, mother language of Nepali, Hindi and others. Kirata and Kiratatikta are mentioned in sacred Vedas, Puranas, Ayurveda, Samhitas, Ramayana etc. In *Bhavaprakashanighantu-Haritakydinighantu* (1926, Herbs Compendium), Chiraito is defined in Sanskrit as: "Kiratatiktah kairato katutiktah kiratakah ..156.., Kandatiktoanaryatikto bhunimbo ramasenakah . Kiratakonyo Naipalah swardhatikto jwarantakah ..157.., Kirata sarako rukshya shitalastiktako-laghuh ." The meanings: The Kiratah's (plant Chiraito) is highly bitter. Its stem is bitter like non-arya's bitter plant. (Its different names are given). It's also like Neem used by Ram's army. Nepal's another semi-bitter Chiraito (*Swertia anguistifolia*) is also fever relieving. Chiraito

is ardent, cool and short time bitter (Barakoti 1999 & 2004).

**Economical and Medicinal Importance**

Chiraito is an economically important herb of Nepal. It is a good source of cash income for traders, farmers-collectors in the hills where they traded this herb since generations (Barakoti 2000a; Barakoti 2008). However its rampant collection from the natural habitats (forests) as free gift of nature by the increasing human population during past decade, population of Swertia chirayita has been drastically declined (Khadka *et al.*1994; Barakoti 2001). Therefore conservation practices in *citu* and commercial cultivation in the farmland both approach need to follow effectively. Hence awareness creation activities with the participant farmers was also started in the project locations (Barakoti 1999).

Chiraito ranks top five amongst exporting medicinal plants of the country. Nepal's production 350 to 500 metric tons per annum (Barakoti 2001; Hamro Ban 2010) fulfills about 45% of the world's consumption of dry plant per year. Major quantity (about 80%) is exported to India to fulfill demands of Ayurvedic and allopathic drugs manufacturing companies. About 15% is exported to two dozens of Asian, European and American countries, chiefly China, Singapore, Pakistan, Russia, Germany, Kenya etc. Local consumption is less than 5%. Its harvest and export is higher (>70%) from eastern and central regions. Together with *S. chirayita*, little quantity of *S. angustifolia, S. alata, S. ciliata, S. dilatata, S. multicaulis, S. nervosa*, *S. racemosa* and *S. tetragona* species are also traded (Hamro Ban 2010). Edwards (1993) reported that Chiraito traded from Hile and Basantapur alone (Koshi zone) accounted for about 14 million Rupees.

*Swertia chirayita* has important medicinal properties. Its anthelmintic, hypoglycemic and antipyretic properties are attributed to amarogentin, swerechirin, swertiamarin and other active bitter principles. Chemical constituents of the plant- chiratin, swertirin, gentiopichrin, ophelic acid are not toxic and are water soluble. Bitter principle ranges 1-2.5 %. Many researchers (Joshi & Dhawan, 2005; Bhandari *et al.* 2019) have described its properties. Whole plant is bitter, possesses broad-spectrum Ayurvedic and allopathic medicinal properties (Barakoti 2004a).

Chiraito is used in crude and processed form. It is effective to cure a number of diseases, disorders and ailments: fevers, jaundice, gastritis, de-worming, influenza, headache, diabetes, urinary disorder, skin diseases, malaria, enlarged spleen and liver, catarrh, intestinal spasm, anemia, indigestion. It is gentian substitute, antibiotic, appetizer, bitter tonic (Barakoti 2004; Joshi & Dhawan 2005). Most properties are mentioned in Sanskrit verse (*Bhabaprakash Nighantu* 1926) as: "*Sannipatajwaraswasakaphapittashradahanut* ..158.., Kasashothatrishakushthajwaravrana-krimipranut ." (Mishra 1926). Meanings: Chirata is useful for typhoid fever, asthma, influenza-cough, gallstones, idem-cough, gastritis, swelling, diabetes, leprosy, fevers, skin diseases, wounds and de-worming (Joshi & Dhawan 2005; Barakoti *et al.* 2012).

## 2. MATERIALS AND METHODS

Numbers of seed germination experiments in Chiraito were conducted employing innovative seed treatment and nursery raising techniques designed by the main researcher (Barakoti 1999, 2000). Research trials and treatments were designed aiming higher germination. Experimental plots were laid out during April to May. On-farm experiments were carried out collaborating with participant farmers. Germination of seed was evaluated and calculated on the basis of emerged seedlings, not on numbers of seeds sown (ca. 30,000 per gram). Emerged seedlings were counted at weekly, fortnightly, and monthly intervals due to slow emergence of seed, but all data are not presented here. Statistical analysis of the recorded data was performed as per one-way analysis of variance (Fisher 1918).

***Location:*** The experiments were conducted at Pakhribas station and its outreach sites in three districts. The details are presented in tabulated form below (Table 1)

**Table 1:** Details of locations, treatments, sowing dates, elevation of the experiments

| Location/ Site | Year | Treatment of Seed | Replicates | Sowing date | Elevation | Design |
|---|---|---|---|---|---|---|
| ARS Pakhribas Nursery, Dhankuta | 1999-2000 | Soaked into warm water for 24 hrs* | 3 | April last week. | 1850 m | RCBD** |
| | Soaked into tap water for 24 hrs | | | | | |
| | Refrigerated at $5^0$C for 24 hrs | | | | | |
| | Treated by 5% HCl (aq) for 1 hr. | | | | | |
| | Control | | | | | |
| Basantapur outreach site, Terhathum | 1999-2000 | Soaked into warm water for 24 hrs | 3 | May 2nd week. | 2000 m | RCBD |
| | Soaked into tap water for 24 hrs | | | | | |
| | Control | | | | | |
| Okhre community forest, Sankhuwasabha | 1999-2000 | Soaked into warm water for 24 hrs | 4 | April 20 | 1950 m | RCBD |
| | Soaked into tap water for 24 hrs | | | | | |
| | Control | | | | | |
| Chaite community Forest, Basantapur Meadow, Terhathum | 2000-2001 | Seed sown on tilled land | 5 | May 3rd week. | 2100 m | Latin Square |
| | Seed soaked into warm water for 24 hrs, Pakhribas practice | | | | | |
| | Seed sown on forest soil | | | | | |
| | Seed sown on barren (virgin) land | | | | | |
| | Control | | | | | |
| Basantapur outreach site, Terhathum | 2000-2001 | Seed sown on slice-burn terrace-riser with moist soil | 2 | May 18 | 2000 m | RCBD |
| | Seed sown on grass cut terrace-riser with moist soil | | | | | |
| | Seed sown on grass uprooted terrace-riser with moist soil | | | | | |
| | Seed sown on slice-burn terrace-riser with dung slurry | | | | | |
| | Seed sown on grass cut terrace-riser with dung slurry | | | | | |
| | Seed sown on grass uprooted terrace-riser with dung slurry | | | | | |
| Basantapur outreach site, Terhathum | 1999-2001 | Seed sown in rows on 1 inch (grass root) sliced terrace-riser | 3 | May 1st wk. | 2050 m | RCBD |
| | Seed broadcast on 1 inch (grass root) sliced terrace-riser | | | | | |
| | Seed broadcast over grass cut terrace-riser | | | | | |
| | Seed broadcast over grass terrace-riser (Control) | | | | | |

***Design:*** Five field experiments were laid out in randomized complete block design (RCBD) and one experiment at Chaite community forest (CF) was in Latin square design with 5 blocks. The experiments were comprised of 3 to 6 treatments and 2 to 5 replications. Plot size was 1 m x 1 m (1 sq. m) for each treatment.

***Nursery establishment:*** After selecting suitable site, surface soil of 4-5 cm with weeds of the nursery bed was removed (nursery trial in Pakhribas and Basantapur). The beds were filled with virgin sub-surface soil and covered with bamboo planks 10-12 cm wide. Roofing was made with thatch/ plastic sheets to protect the beds from rain and hailstones at all locations except in terrace riser trials. Roofs were removed after 4-6 months when most seeds gave rise seedlings.

***Substrate:*** The substrate of nursery bed was fertile forest soil under Alder/ Uttis (*Alnus nepalensis)* forest, well decomposed farmyard manure and sand. These collected substrates were sieved through a mesh (<5 mm) and mixed at 1:1:1 ratio, then filled with thin (2-3 cm) layer on the top of the bed of nurseries. The substrates were not needed for the terrace riser trials and also in special treatment beds.

***Seed rate and sowing:*** Chiraito seed rate for field germination test was estimated to be appropriate 1 gram per 1 m2 bed/ treatment plot. The seeds were mixed with fine sand to ease sowing/ broadcasting and evenly covering the bed. The mixed proportion of seed and sand was 1g seed in one tea glass sand (approximately 1:100 ratios) for each experimental plot. Then sowing was done on the surface evenly. Both line sowing and broadcasting method used. In an experiment at Basantapur seeds were dressed with moist soil and dung slurry for comparison. Sowing was done during April to May.

***Mulching:*** After seeding mulching of bed with thin layer of local mulch: thatch, wheat/rice straw was done to protect bed, conserve moisture and control weed. Mulch was removed when germination seen after 5-7 weeks. No mulching was done in the terrace riser and in Chaite forest (CF) trial.

***Watering:*** Moisture was found to be a crucial factor for Chiraito. Lack or excess of water in soil affected germination and vigor. Therefore, irrigation was done at 1-2 days interval regularly. Sprayer was used for evenly watering without stirring soil surface.

**Weeding:** In the initial stage (1-2 months), weed infestation was higher. Weeding was a compulsory practice as weeds grow very fast, can suppress slow growing small Chiraito seedlings. Therefore uprooting weeds by hand pulling was done at weekly interval.

***Seed Soaking:*** Normal tap water was boiled and kept till mild warm while touching. The weighed seeds, 1 g for each plot was put into small pieces of white cloth for each experiment and kept inside room for 24 hours before sowing.

***Bed Condition:*** Nursery in Okhre was established in open and protected forest land. Trial in Chaite was done on the grazing meadow. Here bamboo cottage with plastic roofing was constructed to protect seed-beds (Photo 4). Trials in terrace riser were laid out in the equally heighted risers. Seeds were mixed with moist soil and fresh cow-dung 200 g per 1 g of seed and broadcasted. In other treatments 100 ml of water per plot was added to the dung, stirred properly and the slurry sprayed with bamboo *Pachaka*/broom evenly.

## 3. RESULTS AND DISCUSSION

### 3.1 Germination/ Emergence of Chiraito Seed

Germination of Chiraito (*Swertia chirayita*) seeds tested for first time at various locations in eastern hills of Nepal gave encouraging and promising results. The germination was based on emerged numbers of seedlings. Despite fast germination in the lab (within two weeks), seeds in the field condition germinated very slow, continued 3 to 6 months. It might be due to temperature fluctuation at day and night, lack of moisture, soil cover over seed, unevenly matured seeds etc. (Barakoti 2008).

No literature and field experience of *Swertia chirayita* growing was found as no research conducted globally. Our Himalayan range might be the only favorable growing environment for this species. Then technical personnel of forestry and NGOs had opined that Chiraito seeds might not germinate in the field. But present researches proved, it can germinate under on-farm condition. In spite of big variation in germination percentage with locations and treatments, it was encouraging for the farmers to grow chiraito in the hill region (1800 to 2200 m amsl).

Chiraito seeds started to germinate/ emerge after 2-3 weeks of sowing, however the seedling number was few and size was too small. It was confirmed by chewing and testing bitterness. At the age of 1-2 month, 2-leaved, 1-2 cm high tiny seedling were seen and it took more than 3 months to reach transplantable size.

Therefore observations were started after 2 months (Barakoti 2000a). Basnet (2001) had also reported similar pattern of seedlings growth.

### 3.2 Result of ARS Pakhribas Nursery Trial

The emergence of Chiraito seeds at Pakhribas were counted at weekly intervals after one month. However due to low number, emergence counted at 3 months is presented. It gave 610 to 761 seedlings from 1 g seed sown in 1 square meter (Table 2). Seeds soaked in warmed and normal tap water for 24 hr. had the higher numbers of emergence (740-761) followed by control (712). The lower germination (610-660) was seen in the refrigerated and acid treated seeds. The reason of low germination from refrigerated seed might be less heat and hardening the seed coat by chilling temperature. In case of acid treated seed, acid scarification might have affected embryo to rise up. It was happened in the lab and field condition in the previous research also (Barakoti, 2000). One-way analysis of variance (ANOVA) data showed insignificant results. The overall result indicated that soaking seed in the water is preferable (Barakoti 2008). Representing photos are presented (Photo 1 and 2).

**Table 2:** Germination of Chiraito seeds at Pakhribas nursery trial, Dhankuta

| Treatments | Counted on July 1st week (3 months after sowing) | | | Mean No. |
|---|---|---|---|---|
| | Rep I | Rep II | Rep III | |
| Seeds soaked in warm water for 24 hrs. | 567 | 640 | 820 | 740 |
| Seeds soaked in cold water for 24 hrs. | 669 | 789 | 825 | 761 |
| Seeds refrigerated at $5^0$C for 24 hrs. | 560 | 632 | 790 | 660 |
| Seeds treated with 5% HCl for 0.5 hr. | 538 | 613 | 679 | 610 |
| Seed not treated (Control) | 662 | 757 | 718 | 712 |
| ANOVA result | F-statistic value 1.07 | | P -value 0.42 | |

*Photo 1: Observing seedling of Chiraito*


*Photo 2: Nursery raised seedlings of Chiraito transplanted into poly-bag, AARS Pakhribas*

### 3.3. Result of Basantapur Nursery Trial

Counting of emerged seedlings was done four times (July to May). The results showed markedly lower emergence than in Pakhribas for all treatments. Its main reason might be shade of terrace riser and moist bed. The mean germination increased (348-397) in September (Fig. 1) and decreased slightly in November possibly due to chilling weather. Later in May of succeeding year, there was some increment in seed germination for all treatments (446-450 seedlings) at final count. Rise in emergence was possibly due to onset of warm weather and rain after March. Water soaked treatments favored retain more seedlings. The grand means presented (Fig. 1) clearly shows the differences between the dates and treatments. However ANOVA has been missing technically.

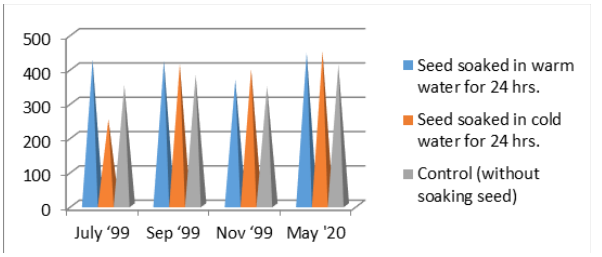


*Fig.1: Mean No. of germinated seedlings of Chiraito at Basantapur*

### 3.4 Result of Germination at Okhre community forest (CF) Site Trial

The germination results (Table 3) of Okhre showed longevity in emergence and high differences between initial (July) and final (October) count. Overall treatment means of July was 92 whereas that of October was 716 seedlings. Warm water soaked seed out-emerged (830) over cold water soaked (645) and control (675). The means revealed that soaking seed with warm water for 24 hours had highest emergence (740) as compared to soaking seeds with cold water (566-570) and control treatments (570). The data revealed that special treatment for Chiraito seeds is unnecessary. ANOVA data gave insignificant results. One year old seedlings in the nursery trial is presented (Photo 3)

**Table 3:** Germination of Chiraito seeds at Okhre CF nursery, Sankhuwasabha

| Treatment | Rep-I | | Rep-II | | Rep-III | | Rep-IV | |
|---|---|---|---|---|---|---|---|---|
| | Initial Nos. Jul | Final Nos. Oct | Initial Nos. Jul | Final Nos. Oct | Initial Nos. Jul | Final Nos. Oct | Initial Nos. Jul | Final Nos. Oct |
| Seed soaked in warm water for 24 hrs. | 123 | 617 | 163 | 767 | 191 | 830 | 149 | 745 |
| Seed soaked in cold water for 24 hrs. | 81 | 443 | 113 | 567 | 159 | 645 | 122 | 610 |
| Seed not treated (Control) | 72 | 358 | 118 | 588 | 152 | 675 | 144 | 658 |
| Mean | 92 | 473 | 131 | 641 | 167 | 716 | 138 | 671 |

*Photo 3: Mature seedlings of Chiraito grown at Okhre nursery*

### 3.5 Result of Chiraito germination in Chaite Community Forest Nursery Trial

Emergence of seeds initiated after one month of sowing, counting started after 3 months. Data monitoring was done at monthly interval from July 1 to March 2. Emergence numbers were highest (2119) in August and in March 2 (1556) of the following year from seeds treated with warm water. ,. Emergence was found higher up to November, and then declined gradually (1313-1348) (Table 3). This phenomenon was possibly due to lower temperature during winter months. Grand means of treatments showed 462 seedlings less at final count than first count. There was higher emergence of seeds in all treatments compared to other experiments however no definite trend was followed among the treatments. The final number of retained/ survived seedlings was highest in seeds treated with warm water (1556) followed by those sown on tilled land (1390) and control (1345). The results were encouraging in all treatments (Barakoti 2004a). ANOVA results for Latin Square design are presented (Table 4).

**Table 4:** Germination of Chiraito seeds at Chaite CF Basantapur site, Terhathum

| Treatment | Germinated seedlings counted at monthly interval | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2000 July 1 | 2000Aug 2 | 2000Sep 1 | 2000Oct 1 | 2000Nov 2 | 2000Dec 1 | 2001 Jan 2 | 2001 Feb 1 | 2001 Mar 2 |
| Seed sown in tilled land | 1736 | 1827 | 1778 | 1721 | 1529 | 1314 | 1204 | 1277 | 1390 |
| Seed soaked with warm water | 1982 | 2119 | 1987 | 2058 | 1957 | 1557 | 1326 | 1304 | 1556 |
| Seed sown on forest soil | 1878 | 2009 | 1874 | 1980 | 1622 | 1524 | 1484 | 1284 | 1241 |
| Seed sown on virgin land | 1514 | 1618 | 1708 | 1806 | 1737 | 1694 | 1463 | 1382 | 1208 |
| Seed not treated (Control) | 1743 | 1745 | 1802 | 1858 | 1639 | 1537 | 1447 | 1321 | 1345 |

| | | | | |
|---|---|---|---|---|
| ANOVA result df=4 | MS=5435 | F test 0.27 (ns) | Rows=2.95 | Columns=13.3 |
| | Colm/Row=1614 | Error=20296 | F-statistic=1.34 | P-value=0.26 |

*Photo 4: Nursery trial at Chaite CF meadow nursery, Basantapur*

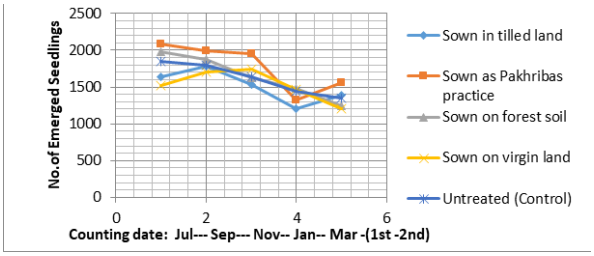


*Fig.2: Chiraito germination (bi-monthly) in nursery trial at Chaite CF at Basantapur, Terhathum*

The germination data of Basantapur community forest nursery are presented in Fig. 2 below. Emerged seedlings bi-monthly that varied 1204 to 2119. The emergence increased up to third count in November first (1500-2000), then few seedlings died during winter. The number of emerged seedlings rose again in March. Higher number of seedlings survived in the tilled land also (Barakoti 2003).

1. Seed sown in tilled land (green), 2. Seed soaked with warm water (red), 3. Seed sown on forest soil (brown), 4. Seed sown on virgin land (blue) and 5. Seed untreated (Control, yellow)

### 3.6(a) Result of Terrace-riser Trial at Basantapur Site

Germination of Chiraito seeds tested sowing directly on the terrace riser of cropping land (first year 2 and second year 1) are presented in Table 5. As usual emergence of seed was low at first count in all treatments, it increased in second after 2 months, then at third count the germinated numbers again decreased while passing winter (Barakoti 2003). The means of three dates as grand means varied as: highest (274 seedlings) in the slash-burn plot seed mixing with cow-dung slurry and seed mixing with moist soil (228 seedlings). There was big variation between the treatments although One-way ANOVA gave non-significant result. The emergence data are clearly shown in Fig. 3 as well.

**Table 5:** Germination of Chiraito at Basantapur, Terhathum

| Treatments | Observation dates | | | Grand mean |
|---|---|---|---|---|
| | '20.7.2 | '20.9.3 | '01.4.1 | |
| Slash-burn terrace-riser; seed mixing with moist soil | 149 | 246 | 113 | 169 |
| Grass cut terrace-riser; seed mixing with moist soil | 232 | 313 | 138 | 228 |
| Grass uprooted terrace-riser; seed mixing with moist soil | 162 | 176 | 144 | 161 |
| Slash-burn terrace-riser; seed mixing with dung slurry | 248 | 381 | 192 | 274 |
| Grass cut terrace-riser; seed mixing with dung slurry | 188 | 209 | 121 | 173 |
| Grass uprooted terrace-riser; seed mixing with dung slurry | 219 | 303 | 135 | 219 |
| One-way ANOVA result | F-statistic value 0.66 | | P-Value 0.63 | |

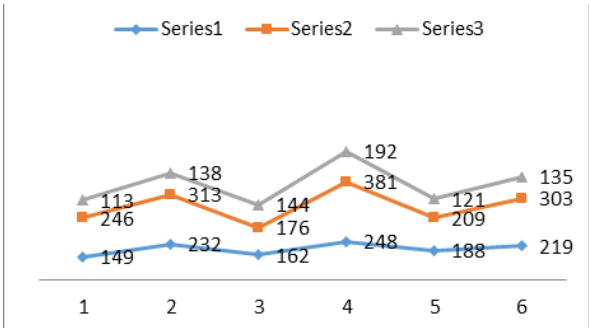


*Fig.3: Germination of Chiraito seeds on terrace-riser, Basantapur*

**Legends**: Upper line (green)- Emerged seeds at third count (1.4.2001)

Middle line (red)- Emerged seeds at second count (3.9.2000)

Lower line (blue)- Emerged seeds at first count (2.7.2000)

### 3.6(b) Result of Terrace-riser Trial at Basantapur

Germination of Chiraito seeds tested in different configured terrace risers but having height 4 feet and replicated 5 times is sown in Table 6, Photo 5. The data highly varied based on replications (91-1315) and treatments. However the treatment means were 512-997 emergence, except in over grass sown plots (119-124). The emergence was more in first counting (August) than the second counting in general due to chilling weather in winter. The emergence was significantly higher in the sliced/ grass cleared terrace riser and in the broadcasted plot than line sowing (Barakoti 2003 & 2004). The Pie chart (Fig. 4) shows clearly the differences among the types of beds and methods of sowing.

**Table 6:** Comparing germination of Chiraito on terrace risers (means of 5 replicates) before and after winter at Basantapur site, Terhathum

| Treatment | Before winter, Nov | After winter, May | Grand mean |
|---|---|---|---|
| Seed sown in row on sliced T-riser | 819 | 512 | 665 |
| Seed broadcasted on sliced T-riser | 997 | 792 | 894 |
| Seed broadcasted over grass cut T-riser | 631 | 694 | 662 |
| Seed broadcasted over grass bed T-riser (Control) | 119 | 124 | 121 |

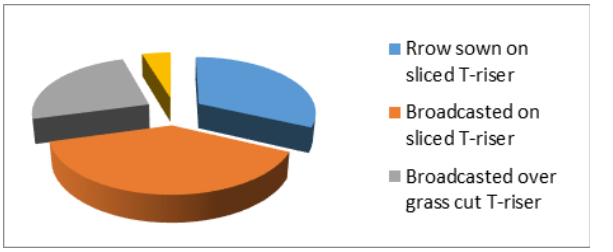


*Fig.4: Germination of Chiraito on terrace risers (means) at Basantapur site, Terhathum*

*Photo 5: Researcher observing Chiraito seedlings in the terrace riser trial at Basantapur*

## 4. CONCLUSION AND RECOMMENDATIONS

Swertia chirayita seed germination results obtained from various field experiments for the first time at ARS Pakhribas, NARC and its outreach sites are promising. The growing methods are easy and affordable to the farmers and commercial growers. The findings are useful to technical personnel and researchers as well. It has been supporting domestication of Chiraito as hill farmers have already adopted this technology for cultivation. However Pradhan and Badola (2011) have conducted germination researches after identification of successful technology from Nepal. It might be due to unavailability of research findings. Following conclusions and recommendations are based on the identified results.

Germination of Chiraito seeds can be seen at two weeks but seedling emergence is very low. Due to slow emergence in the field it takes 3 to 6 months for most seeds to germinate.

Chiraito seeds may germinate under different land conditions and elevations (1800-2200 m amsl). It can germinate and grow in the virgin meadow too.

One gram of seed can produce up to 2100 seedlings (means 1000-1500) in one square meter. But seed must be healthy, mature, pure and fresh.

Special care should be taken in bed preparation, seeding, mulching, irrigating, weeding and protecting from animals and rain.

Chiraito can also be propagated successfully without special seed treatment but soaking seeds in water for 24 hours enhances germination.

The germination is better in the terrace riser than in slightly sliced/ grass cut surface.

The methods and technologies employed here in various experiments for better germination of seed are recommended for domestication of Chiraito.

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## REFERENCES

Barakoti, T. P. (1999). Chiraito- An Introduction-Chiraito Mala- 1 (Technical Booklet, in Nepali), 33 pp, ARS Pakhribas, Dhankuta, Nepal.

Barakoti, T. P. (2000a). Chiraito to Boost Income. *The Kathmandu Post National Daily / Sunday Post*, Dec. 17, Kathmandu, Nepal.

Barakoti, T. P. (2000b). Germination of Chiretta (*Swertia chirayita*) Seeds Tested through Various Methods under different Conditions in the Eastern Hills of Nepal. In: Proceedings of Nepal-Japan Joint Symposium on Conservation & Utilization of Himalayan Medicinal Resources, held 6-11, 271-278, Kathmandu, Nepal.

Barakoti, T. P. (2001). Developing Propagation and Management Techniques for Domestication of Chiraito (*Swertia chirayita),* Project Completion Report (HARP '98/98), ARS Pakhribas, Dhankuta, Nepal.

Barakoti, T. P. (Ed.) (2002). Proceeding of Chiraito Workshop, 45pp, ARS Pakhribas, Dhankuta, Nepal.

Barakoti, T. P. (2003). Lessons learned from the Experiences of Uptake Pathways of Chiraito Domestication. In: Proceedings on Uptake Pathways and Scaling-up of Agricultural Technologies to Enhance Livelihoods of Nepalese Farmers, 73-81, Kathmandu, Nepal.

Barakoti, T. P. (2004). Attempts made for Domestication, Conservation and Sustainable Development of Chiretta (*Swertia chirayita*), (A Compilation), 162 pp, ARS Pakhribas, Dhankuta, Nepal.

Barakoti, T. P. (2008). Chiretta Technologies -*Swertia chirayita*(Roxb. ex Fleming) Karsten. In: NARC Research Highlights 2002/03-2006/07, 71-72pp, Nepal Agricultural Research Council, Kathmandu, Nepal.

Barakoti, T. P., Tiwari, N. N. & Yonzen, M. (2012). Quality of Chiretta (*Swertia chirayita*) in Cultivated and Wild Samples Collected from Different Districts of Nepal. Nepal Journal of Science and Technology, 13(2), 57-62. *Nepal Academy of Science and Technology*, Lalitpur, Nepal. DOI: 10.3126/njst.v13i2.7715

Barakoti, T. P. (2013). Country Status Report on Medicinal and Aromatic Plants of Nepal. In: Proceedings of Expert Consultation on Medicinal and Aromatic Plants in Asia and the Pacific, (pp…17) held in 2-3 December, Bangkok, Thailand.

Basnet, D. B. (2001). Evolving nursery practices and methods of cultivation of high value medicinal plant *Swertia chirayita, Environment and Ecology,* 935-938.

Bhandari, L., Bista, B. B., Bhatta, M. R., Khanal, C., Khanal, S., Ranjitkar, R. and Bhandari, D. P. (2019). Phytoconstituents, Antioxident and Bitterness Value of Swertia chirayita from Four Different Geographical Regions of Nepal, *J. Plant Res.* 17(1), 104-111.

Edwards, D. M. (1993). The marketing of non-timber forest products from the Himalayas: The trade between east Nepal and India. *Rural Development Forestry Network Paper*, 15b (ODI).

Fisher, R. A. (1918). One-way analysis of variance (ANOVA) of variable biological data.

Hamro Ban. (2010). Manual/Book. Regular publication of the Department of Forest, MoFSC, Nepal.

IUCN. (2000). National Register of Medicinal Plants. IUCN/MFSC, 161 pp., Nepal.

Joshi, K. & Joshi, A. (2008). *Swertia L*. (Gentianaceae) in Nepal Himalaya: Ethno botany and Conservation Status. *Ethno botanical Leaflets 12: 361-372.*

Joshi, P. & Dhawan, V. (2005). Swertia chirayita -An Overview. *Current Science, 89, 635-640.*

Khadka, R. J., Gurung, B. D., Tiwari, T. P., Gurung, G. B., Ghimire, R. P., Adhikari, K.

B. & Shrestha, D. N. (1994). A study on Chiraito, the high altitude cash crop of the eastern hills of Nepal. PAC Working Paper No. 107, Dhankuta, Nepal.

Mishra, B.P. (1926). *Bhavaprakashanighantu-Haritakyadinighantu, Bha. Tee.*

(Herbs Compendium), 34-35pp,. *ShreeVainkteswar* Stem Press, Bombay, India.

Nepal Monarchy: Kirata Dynasty. Wikipedia of Kirata, Google.

Niroula, B. & Kumari, A. (2012). Swertia Chirayita (Roxb. ex Fleming) Karsten Cultivation in Nepal Himalayas: Mini Review. In: Recent Advances in Medicinal Plants and their Cultivation (pp.94-99). First edition, Chapter: 9. Mangalam Publishers, Delhi, India.,

Parajuli, D. P., Gyanwali, A. R. & Shrestha, B. M. (1998). Manual of important non-timber forest products in Nepal. Institute of Forestry/ ITTOP, Nepal.

Pradhan, B. K. & Badola, H. K. (2011). Assessment of seedling emergence and vigor for quality planting material in thirteen populations of Swertia chirayita- a high value endangered medicinal herb, using substrate combinations, *Journal of Medicinal and Spice Plants*, 16 (1), 34-41. DOI: 10.1100/2012/128105
PMID: 22619581 PMCID: PMC3349092

Rajbhandari, S., Siwakoti, M., Rai, S. K. & Jha, P. K. (2017). An Overview of Plant Diversity in

Nepal, In: Plant Diversity in Nepal, (Book, pp 1-15), Botanical Society of Nepal, 2020.

Shrestha, K. K., Tiwari, N. N. & Ghimire, S. K. (2000). Medicinal and aromatic plant database of Nepal. The Himalayan Plants. In: Proceedings of Nepal-Japan Joint Symposium on Conservation and Utilization of Himalayan Medicinal Resources, Kathmandu, Nepal.