40% increase in pod setting, seed setting and seed weight respectively, in cabbage.

Since there was no formation of siliqua in the plants raised in the net house of dimensions of 3 × 2 × 2.25 m, no yield could be recorded. Table 2 presents the data recorded on yield in the net house of dimensions of 15 × 7 × 4.5 m during two years. It can be seen from the table that during 2011–12, 550 g (from 40 plants) and during 2012–13, 900 g (from 70 plants) of seed was produced. The mean yield (per plant) and weight of 1000 seeds for two years were calculated to be 13.31 g and 4.03 g respectively.

There are variable reports on the cabbage seed yield under open field conditions which depend on various factors. Seed yields of 568 kg/ha from India and 500–600 kg/ha from Bangladesh have been documented[4,5]. In USA, seed yield to the extent of 22.5 g per cabbage plant has been reported and 1000 seeds were found to weigh 3.2 g (ref. 6).

From this study, it can be concluded that *A. mellifera* requires a minimum spacing for successful foraging in the net house and thus a net house of at least 15 × 7 × 4.5 m dimensions may be used for seed production in cabbage.

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Y. S. CHANDEL[1,*]
VIDYA SAGAR[2]
S. PARMAR[3]

[1]*Department of Entomology,*
[2]*Department of Vegetable Crops and Floriculture,*
[3]*Directorate of Extension Education,*
CSK Himachal Pradesh Krishi Vishvavidyalaya,
Palampur 176 062, India
**For correspondence.*
e-mail: chandel_hpau@rediffmail.com

Propagation techniques of *Zanthoxylum alatum* Roxb. (a Himalayan toothache shrub)

Uttarakhand Himalaya has a rich diversity of medicinal plants. *Zanthoxylum alatum* is a large evergreen shrub distributed mainly between 900 and 2100 m elevation. It is locally known as Timur or Timru[1]. It has high medicinal value and whole plant parts are used as medicine. Locally, it is used as a condiment and for water purification. Its dried fruits on steam distillation yield 2.3% essential oil. The chief content of oil is linalool and root bark contains spilanthol. The oil has anti-fungal activity; essential oil possesses antiseptic, disinfectant, deodorant properties; extract of fruits is useful in expelling roundworms[2]. Similarly, the seed and bark are used as a tonic in fever, dyspepsia and cholera, and twigs of branches are used for toothache[3].

Z. alatum is a well-known medicinal plant in the hills of Uttarakhand Himalaya; local harvesters have been collecting it from forest areas for many years for either local or commercial purpose. At present, this plant species has become scarce in the forest due to climate change, insufficient regeneration, unscientific and excessive harvesting, and human interference in its habitat. Rapidly increasing demand in the market and human pressure are having an adverse effect on its population. In future, it can become endangered or rare in the absence of sufficient natural regeneration and conservation measures. Currently, there is a need for mass propagation for future plantation along with creating awareness among the indigenous people, villagers and various forest divisions to conserve and protect this valuable species by means of plantation.

The present study was conducted in the forest nursery of Silviculturist (Silva Hill), Nainital, Uttarakhand during 2010–2013. The area is located at 29°22.751′N lat. and 79°25.955′E long. at an altitude of 1775 m. The climate of the area is temperate. Temperature ranges from 1°C to 30°C, with 1800 mm annual rainfall. The major portion of rainfall is received during July and August (monsoon period). Frost occurs from December to February.

Z. alatum leading shoots cuttings were collected from healthy and vigorous

Table 1. Effect of different indole 3-butyric acid (IBA) concentrations on sprouting (%) and rooting (%) parameters in *Zanthoxylum alatum*

Treatment	Sprouting (%)	Standard error of mean	Rooting (%)	Standard error of mean
MT1P	47.78	4.84	37.78	1.11
MT2P	53.33	1.92	50.00	1.92
MT3P	46.66	1.11	38.89	3.33
MCP	32.22	2.94	18.88	5.87

M, Sand; T1, IBA 4000 ppm; T2, IBA 5000 ppm; T3, IBA 6000 ppm; C, Control and P, Mist chamber.

two-year-old seedlings originated from seeds. Indole 3-butyric acid (IBA) concentration of 4000, 5000 and 6000 ppm, and control were used in the experiment. Cuttings 7–10 cm long with three nodes were prepared and immediately treated with IBA; both treated and untreated cuttings were tagged and planted in the mist chamber in sand beds at 5 cm spacing. The humidity maintained was more than 60%, temperature 25–35°C and fogging at 30 min interval. The experiment consists of four treatments and each treatment was replicated thrice with 30 cuttings per treatment. *Z. alatum* seeds were collected from Nainital region during September and seed-dried for one week in a shady area. Sixty-five seed weight was found in 1 g cleaned and viable seeds were sown in the germination tray after 7 days of seed collection under different media (sand, sand + soil, soil) and places (mist chamber, shade house, open beds). Pre-sowing treatments (normal water soaking for 12 h, and hot water soaking for 12 h) and control were used to study seed germination. Seed experiment consists of 27 treatments and each treatment was replicated thrice with 100 seeds per treatment. Seed germination data were collected at 7 days interval till 9 months. One-way analysis of variance (ANOVA) was applied for statistical analysis. Dunnet test was applied for comparison of control with different IBA treatments.

Development of nursery technique is an important tool to raise desired genetic plants in a short period and fulfiling the aim of enhancing the desired population and species conservation. Different IBA concentrations were studied to understand their effect in promoting sprouting and rooting per cent in *Z. alatum* in sand beds under mist chamber. The results clearly show that cuttings treated with 5000 ppm IBA produced 53.33% (53.33 ± 1.92) sprouting and 50% (50.00 ± 1.92) rooting (Table 1; Figures 1 and 2), while control treatment produced 32.22% (32.22 ± 2.98) sprouting and 18.88% (18.88 ± 5.87) rooting. Also, 6000 ppm IBA reduced rooting and sprouting to 38.89% and 46.66% respectively; enhancing IBA concentration above 5000 ppm showed reduction in sprouting and rooting percentage (Table 1 and Figure 3).

Seed germination and growth of seedlings are regulated by exogenous hormones[4]. Seed with hard seed coat requires pre-sowing treatments. The oily seeds tend to have lesser germination viability. Earlier studies have shown that seeds require cold stratification and cold atmosphere to germinate and this might take more than one year. Seeds are best sown in a greenhouse as soon as they are ripe in autumn. Stored seeds may require up to 3 months cold stratification, though scarification may also help[5]. The different pre-sowing water treatments, media and places were studied to analyse seed germination. The results of seed sowing in Table 2 indicate that normal water soaking for 12 h (T1) was recorded maximum 34.33% (34.33 ± 0.66) germination in shade house (P2) with sand + soil (M2) and the minimum 11.33% (11.33 ± 1.33) germination in open beds (P3) with soil (M3; Table 2 and Figure 4) while hot-water soaking for 12 h (T2) was recorded maximum 28.67% (28.67 ± 4.17) germination in shade house (P2) with soil (M3) and minimum 6% (6 ± 6.00) in mist chamber (P1) with soil (M3; Figure 5). Control treatment was recorded maximum 28.33 (28.33 ± 1.20) germination in shade house (P2) with sand + soil (T2) and minimum 10% (10 ± 1.0) germination with soil (M3) in open beds (P3; Figure 6). The results of seed sowing clearly show that highest 34.33% (34.33 ± 0.66) germination found in normal water soaking for 12 h followed by 33% (33.33 ± 0.66), while hot-water soaking for 12 h and control treatment decreased germination percentage to 28.67 (28.67 ± 4.17) and 28.33 (28.33 ± 1.20) respectively. Seed germination was found to be highly significant (Sig. – 0.000, Table 3). The cuttings treated with different concentrations of IBA showed overall significant difference ($P < 0.05$) for rooting and sprouting compared to control treatment (Table 4).

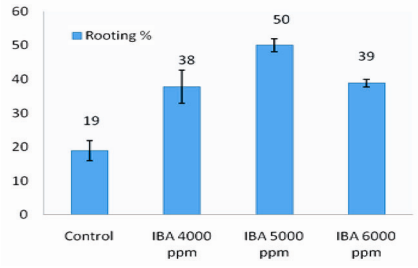

Figure 1. Effect of indole 3-butyric acid (IBA) treatment on rooting percentage.

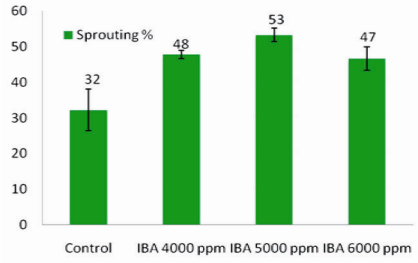

Figure 2. Effect of IBA treatment on sprouting percentage.

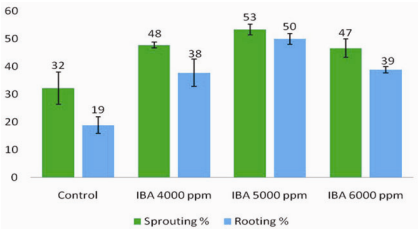

Figure 3. Comparison between sprouting and rooting percentage after IBA treatment.

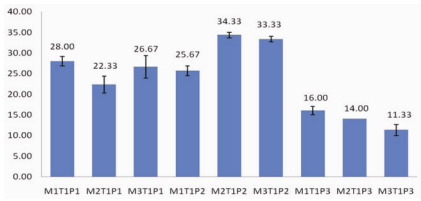

Figure 4. Effect of normal water soaking for 12 h on seed germination in different media and different places.

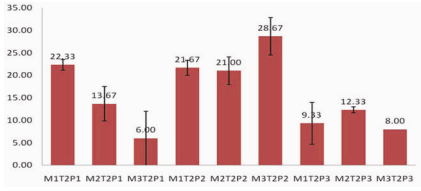

Figure 5. Effect of hot-water soaking for 12 h on seed germination in different media and different places.

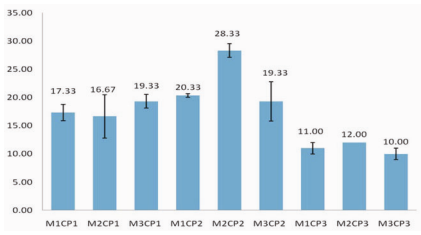

Figure 6. Control seed germination in different media and different places.

Table 2. Germination (%) of *Z. alatum* under different pre-sowing water treatments, media and places

Medium	Germination (%)		
	Mist chamber (P1)	Shade house (P2)	Open beds (P3)
Treatment (T1) – normal water soaking for 12 h			
Sand (M1)	28.00 ± 1.15	25.67 ± 1.20	16.00 ± 1.00
Sand + soil (M2)	22.33 ± 2.02	34.33 ± 0.66	14.00 ± 0.00
Soil (M3)	26.67 ± 2.72	33.33 ± 0.66	11.33 ± 1.33
Treatment (T2) – hot-water soaking for 12 h			
Sand (M1)	22.33 ± 1.20	21.67 ± 1.66	9.33 ± 4.66
Sand + soil (M2)	13.67 ± 3.84	21.00 ± 3.05	12.33 ± 0.66
Soil (M3)	6.00 ± 6.00	28.67 ± 4.17	8.00 ± 0.00
Control (C)			
Sand (M1)	17.33 ± 1.45	20.33 ± 0.33	11.00 ± 1.00
Sand + soil (M2)	16.67 ± 3.84	28.33 ± 1.20	12.00 ± 0.00
Soil (M3)	19.33 ± 1.20	19.33 ± 3.48	10.00 ± 1.00

Table 3. ANOVA table representing significant difference for different treatments of seed germination

		Sum of squares	d*f*	Mean square	*F*	Sig.
Germination % * Treatment	Between groups (combined)	4774.222	26	183.624	10.594	0.000

*The mean difference is highly significant for different treatments and germination percentage.

Figure 7. ***a***, Rooted cuttings; ***b***, Leaf sprouting in cuttings; ***c***, Cleaned seeds; ***d***, Germination in shade house; ***e***, Transplanted in root-trainers; ***f***, Established seedling in poly bags; ***g***, A plant of *Zanthoxylum alatum*.

Table 4. ANOVA and Dunnett (two-sided) test representing the overall significant difference for different treatments of rooting and sprouting

		Sum of squares	d*f*	Mean square	*F*	Sig.
Rooting * Treatment	Between (combined) groups	1499.343	3	499.781	17.992	0.001
Sprouting * Treatment	Between (combined) groups	729.837	3	243.279	6.408	0.016

Dependent variable	Treatment *I*	Treatment *J*	Mean difference (*I* – *J*)	Standard error	Sig.	95% Confidence interval	
						Lower bound	Upper bound
Dunnett *t* (two-sided)							
Rooting	IBA 4000 ppm	Control	18.893*	4.303	0.006	6.50	31.29
	IBA 5000 ppm	Control	31.113*	4.303	0.000	18.72	43.51
	IBA 6000 ppm	Control	20.003*	4.303	0.004	7.61	32.40
Sprouting	IBA 4000 ppm	Control	15.560*	5.031	0.037	1.07	30.05
	IBA 5000 ppm	Control	21.113*	5.031	0.008	6.63	35.60
	IBA 6000 ppm	Control	14.447	5.031	0.051	–0.04	28.93

*The mean difference is significant at 0.05 level.

Results show that vegetative propagation from leading shoot cuttings is more suitable than seed sowing because seed germination is slow. Seed germination was observed till 9 months from seed sowing, while cuttings were rooted within 3–4 months (Figure 7).

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PARVEZ DAUDI*
KUBER SINGH BISHT
VIVEK PANDEY

Division of Silviculture,
Uttarakhand Forest Department,
Nainital 263 002, India
**For correspondence.*
e-mail: parvez931@gmail.com

Rediscovery of *Phyllanthus macrocalyx* Mull. Arg. (Phyllanthaceae), a rare endemic species of the Western Ghats, India

Genus *Phyllanthus* has ca. 900 species distributed all over the world[1]. In India, the genus is represented by 51 species[2]. During a recent floristic exploration trip, the present authors collected a species of *Phyllanthus* from Pooyyamkutty evergreen forest, Ernakulam District, Kerala, India. The specimen was later identified as *Phyllanthus macrocalyx*, which is a rare endemic plant of the Western Ghats belonging to the section *Eriococcus* and subsection *Macrocalyci* of family Phyllanthaceae.

P. macrocalyx was first described by Johannes Müller Argoviensis in 1863 based on the collection of Stocks from Malabar, Concan[2]. Apart from this collection, only three other collections were made; Lawson from Bababudan hills, Mysore (1861)[3], Wight from Shevagherry hills (1836) and Beddome from Tirunelveli district, Tamil Nadu (1873)[4]. Perusal of available data[2–5] shows that this species was not collected from anywhere after Beddome's collection in 1873. Hence, the present collection of *P. macrocalyx* from Pooyyamkutty forest is a rediscovery after a long gap of 142 years. During the studies we have observed some minor variations, especially on the pedicel length of male and female flowers. This may be due to availability of a few specimens, wherein the full range of variation is not represented.

Phyllanthus macrocalyx Mull. Arg., *Linnaea*, 32: 48. 1863 and in DC, *Prodr.* 15(2): 423. 1866; Hook. f., *Fl. Brit. India* 5: 301.1887; Chandrab. in A. N. Henry *et al.*, *Fl. Tamil Nadu, Ser.1. Analysis* 2: 237. 1987; N. P. Balakr. and T. Chakrab., *Fam. Euphorbiaceae India* 373. 2007; N. P. Balakr *et al.*, *Fl. India*. 23: 456. 2012. *Diasperus macrocalyx* (Müll. Arg.) Kuntze, *Revis. Gen. Pl. 2: 600.1891. Reidia macrocalyx* (Mull. Arg.) *Gamble, Fl. Madras* 1292. 1925; B. D. Sharma *et al.*, *Fl. Karnataka*. 2: 255. 1984. *Reidia latifolia* Wight, *Icon. Pl. Ind. Orient*. 5(2): 28, t. 1904 (2). 1852.

Erect, glabrous, sparsely branched shrub up to 2.5 m tall; branchlets resembling pinnate leaves, 22–40 cm long, green, slightly compressed towards apices. Leaves ovate or elliptic–ovate or ovate–lanceolate, 4–8.5 × 1.6–4.8 cm, rounded at base, entire at margins, acute to obtuse at apex, glabrous, membranous, glaucous beneath, dark green above; lateral nerves 6–9 pairs; petiole 2–5 mm long; stipules 4–7.5 × 1–2 mm, deltoid, broad at base, long acuminate at apex, persistent. Flowers axillary; male flowers at the proximal