



International Journal of Research in Agronomy

E-ISSN: 2618-0618
P-ISSN: 2618-060X
© Agronomy
NAAS Rating (2026): 5.20
www.agronomyjournals.com
2026; 9(6): 384-388
Received: 21-04-2026
Accepted: 25-05-2026

The authors' details and affiliations are provided below, following the reference section

Impact of planting geometry and organic nutrient management on growth performance of *Artemisia annua* L.

Ishika Thakur, Tahir Mushtaq, PA Sofi, Peerzada Ishtiyak Ahmad, AR Malik, Arfa Ji, Irtika Bulaki, Reising Lungloo, Moamenla Jamir, Sabira Nissar, Iqra Rahim, Mohd. Shahzad, Rahat Begh, Suraya Shabir and Peerzada Tabish Fayaz

DOI: <https://www.doi.org/10.33545/2618060X.2026.v9.i6e.5719>

Abstract

Artemisia annua (sweet worm wood) belonging to the family Asteraceae. It is a species known as an important medicinal plant in Indian temperate Himalayan region. A field experiment was conducted in 2024 to find out the effect of planting geometry on *Artemisia annua* crop. The total four spacing's cm (S1:45×45, S2:45×60, S3:60×60) and four vermicompost dosage q/ha (V1: 0, V2: 100, V3:125, V4: 150) were applied and the trial was laid using factorial randomized complete block design (RCBD), accordingly the data was analyzed in R Studio, version 4.2.2, 2022 to determine the best treatment combinations for better growth of the species under temperate conditions. The growth parameters like height of plant, collar diameter, number of branches per plant, plant fresh weight (g), plant dry weight (g), essential oil were recorded. Results revealed that plant geometry with 45 × 60 cm spacing and 125 q/ha vermicompost dosage gives best results.

Keywords: *Artemisia annua*, spacing, vermicompost dosage

Introduction

Artemisia annua L., belongs to the Asteraceae family. It is a tall herb with a single main stem and alternating branches, often reaching a height of more than 2.0 meters. The leaves are aromatic; deeply split, and range in length from 2.5 to 5 cm. Trichomes, which are composed of five-celled filamentous trichomes and ten-celled biserial trichomes, are present in both the leaves and the flowers (Mojarad *et al.*, 2019) [13].

It is typically found growing in steppe vegetation in the northern parts of the provinces of Chahar and Suiyuan, at elevations between 1000 and 1500 meters above sea level. Since then, it has established itself in several nations, including the US (Ajah and Eteng, 2010; Mojarad *et al.*, 2019) [1, 13].

About 400 species of *Artemisia* are found worldwide, mostly in Asia, Europe, and North America. There are 31 species of *Artemisia* in India; 21 of those are found only in the Jammu and Kashmir region (Bhellum, 2013) [3]. The Indigenous communities in Jammu and Kashmir use a substantial number of *Artemisia* species for ethnomedical purposes. (Gairola *et al.*, 2014) [7].

Artemisia annua L. is mostly grown in China for its therapeutic qualities. It has important medicinal and commercial uses. It is commonly known that this plant is wind-pollinated and can be found in a variety of temperate northern hemisphere locations, especially arid and semi-arid ones. Its distribution in the southern hemisphere is restricted, despite its prevalence in mid-to high-latitude regions (Mohamed *et al.*, 2019) [11]. Beyond its use in medicine, *Artemisia annua* is a source of scent chemicals for the fragrance business in Europe and India (Bakuni *et al.*, 2001) [2].

The most important factor influencing the success or failure of plant establishment is seed germination (Kader and Jutzi, 2004) [9]. A unique set of conditions is needed for each species for

Corresponding Author:

Tahir Mushtaq

Division of Forest Products and Utilization, Faculty of Forestry, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Jammu and Kashmir, India

seed germination because of environmental changes and adaptive radiation (Thompson, 1974) [22]. Seeds and seedlings are exposed to many environmental conditions in nature, such as salinity, temperature, and wetness. Inability to overcome the hardship brought on by these extremes causes poor germination, poor development of seedlings, and ultimately lower agricultural yields (Helmerick and Pfeifer 1954; Onen, 2006) [8, 15]. The herb's other benefits include lowering fever, eliminating parasites, guarding against ulcers, and lowering inflammation (Sanja *et al.*, 2012) [20]. Artemisinin is a widely used medicine for malaria that is expensive and hard to come by on the global market (Enserink, 2005) [5]. To meet the increasing demand for artemisinin, it is necessary to expand *Artemisia annua* cultivation to different geographical areas (Rezelman and Goris, 2008) [18]. Famous for its medicinal qualities, *Artemisia annua* is especially valued for being a natural source of artemisinin. Artemisinin is a powerful substance that is categorized as a cadinane-type sesquiterpene lactone with an endoperoxide bridge. It is extremely effective against strains of *Plasmodium falciparum* that are resistant to quinine and chloroquine, as well as other parasites that cause malaria (Pandey *et al.*, 1999) [16]. Ayurvedic, homeopathic, and folk medicine systems all use *Artemisia annua*, a highly powerful antimalarial herb. Historical records from China reveal that aqueous extracts of the dried plant were traditionally used to cure many maladies including fever, malaria, skin disorders, jaundice, and hemorrhoids (Nofal *et al.*, 2009; Kumaresan *et al.*, 2014) [14, 10].

Materials and Methods

Study Area: The study was carried out in Nursery of Division of Forest products and Utilization, Faculty of Forestry, SKUAST-Kashmir, Jammu and Kashmir, India in the year 2024 for standardization of cultivation techniques of *Artemisiaannua* species. The experimental site falls in a mid to high altitude characterized by hot summers and very cold winters. The average precipitation is 690mm, most of which was received from December to April in the form of snow and rain. The total rainfall (mm) during the experimentation period was 281.2 and 418.80 mm, respectively and means temperature was 24 °C.

Treatment details

The experiment was laid using 10 cuttings per treatment in three replication under four levels of spacing cm (S1:45×45,S2:45×60 and S3:60×60) and four levels of vermicompost application q/ha (V1: 0, V2: 100, V3:125, V4: 150) through two factorial randomized complete block design (RCBD), accordingly the data was analyzed in R Studio, version 4.2.2, 2022 (R Development Core Team, 2022).

Duration of the study

The study was carried out for 1 year. The seeds of *Artemisia annua* were collected in March2024 from the RCFC North II, Wadura, Sopore, Kashmir region of Jammu and Kashmir State and were sown in trays. The Seedlings were transplanted in field in May 2024 and data for observations were recorded in October 2024 and harvested in November.

Observations Recorded

Height of plant (cm), Collar diameter (mm), No. of branches/plant, Plant fresh weight (g), Plant Dry weight (g), Essential oil.

Results and Discussion

Artemisia annua native to the Himalayan region is one of the

most popular medicinal plant species around the world. The leaves have immense medicinal uses, particularly anti-malarial properties. The species is listed in prioritized medicinal plants by the National medicinal plant board of the country. The data in Table 1 illustrates that significant differences were found among spacing and nitrogen applications, where maximum height was observed in the case of S1 (223 cm) and V4 (242 cm). It was also found that there exists a significant interaction between spacing and application of vermicompost where a maximum height of 245 cm was observed in case of S1XV4. The results are in concurrence with the study of Choudhari *et al.*,(2013) [4] and Reddy *et al.*, (2017) [17] who studied the effect of plant spacing and vermicompost dosage on plant height, herbage yield and essential oil yields and nutrient uptake.

Table 1: Effect of spacing and vermicompost on height of plant (cm) of *Artemisia annua*.

	V1	V2	V3	V4	Mean
S1	180	225	245	244	223
S2	165	200	243	243	212
S3	155	195	238	238	206
Mean	166	206	242	241	
CD (p≤0.05)	S= 3.72S1:45x45 cm, S2:45x60 cm, S3:60x60 cm V= 4.29V1:0, V2:100 q/ha., V3:125 q/ha, V4: 150 q/ha S x V=7.44				

The color diameter was recorded highest in S2 and V4 and in treatment combination S2V4 (Table-2). This may be because up to certain spacing plant growth occurs in *Artemisia annua* and after full growth there is no effect of spacing. The same result was also shown by Tahir *et al*, 2023 [21], while studying the growth parameters of *Artemisia absinthium* under different spacings. The species also shows higher growth as vermicompost dosage were optimumbecause either the soil is deficient in nutrient, or the species requires abundant nutrient for its growth.

Table 2: Effect of spacing and Vermicompost on collar diameter (mm)

	V1	V2	V3	V4	Mean
S1	13.70	14.90	15.37	15.35	14.83
S2	14.85	15.98	16.82	16.81	16.11
S3	13.80	14.92	15.40	15.38	14.87
Mean	14.11	15.26	15.86	15.84	
CD (p≤0.05)	S = 0.59S1:45×45 cm, S2:45×60 cm, S3:60×60 cm V= 0.61V1:0, V2:100 q/ha., V3:125 q/ha, V4: 150 q/ha S x V=0.27				

The other growth parameters like no. of branches, plant fresh weight (g), plant dry weight (g), essential oil were also recorded highest in S2, V4 treatments and S2V4 treatment combination. (Table-3,4,5,6) due to the reason that *Artemisia annua* needs appropriate spacing for its growth and plant spread and optimum dosages of vermicompost for higher biomass and seed weight and concluded in the studies of Gaibi *et al.*, (2019) [6] and Sabira *et al.*, (2024) [19].

Table 3: Effect of spacing and vermicompost on number of branches per plant of *Artemisia annua*

	V1	V2	V3	V4	Mean
S1	40	63	65	64	58
S2	47	65	75	74	65
S3	45	65	60	65	59
Mean	44	64	67	66	
CD (p≤0.05)	S = 1.48S1:45×45 cm, S2:45×60 cm, S3:60×60 cm V= 1.71V1:0, V2:100 q/ha., V3:125 q/ha, V4: 150 q/ha S x V=2.96				

Table 4: Effect of spacing and vermicompost on fresh weight of *Artemisia annua*.

	V1	V2	V3	V4	Mean
S1	515	750	1150	1155	892
S2	645	800	1215	1210	989
S3	785	800	1192	1179	967
Mean	648	783	1185	1181	
c	S = 11.71S1:45×45 cm, S2:45×60 cm, S3:60×60 cm V = 13.53V1:0, V2:100 q/ha., V3:125 q/ha, V4: 150 q/ha S x V = 23.43				

Table 5: Effect of spacing and vermicompost on dry weight of *Artemisia annua*

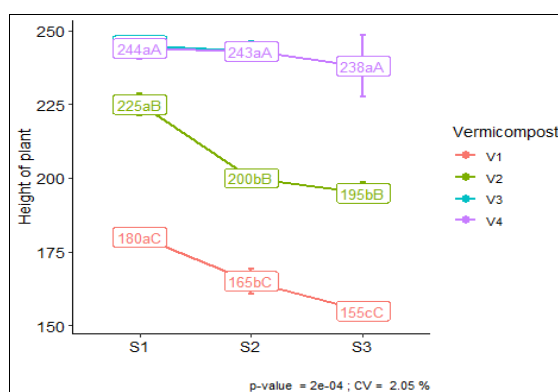
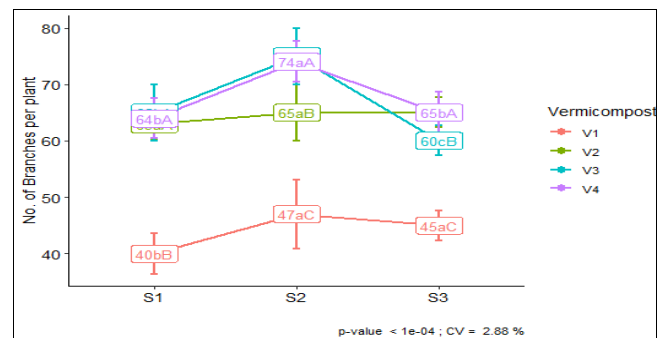
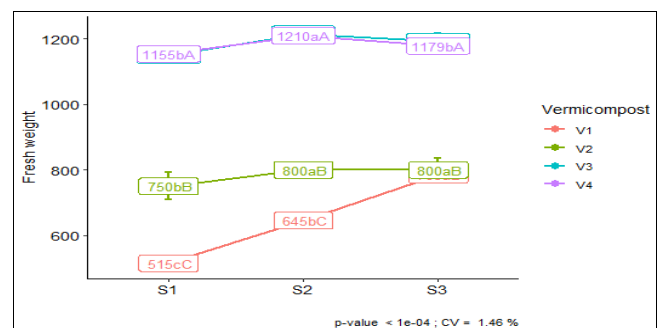
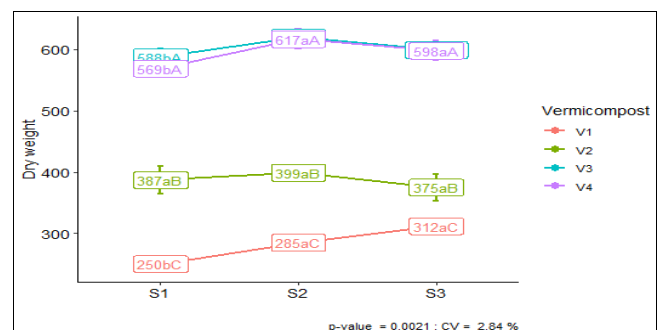
	V1	V2	V3	V4	Mean
S1	250	387	588	569	448
S2	285	399	619	617	480
S3	312	375	599	598	474
Mean	282	387	602	594	
CD (p<0.05)	S = 11.19S1:45×45 cm, S2:45×60 cm, S3:60×60 cm V = 12.93V1:0, V2:100 q/ha., V3:125 q/ha, V4: 150 q/ha S x V = 22.39				

Table 6: Effect of spacing and vermicompost on essential oil yield of *Artemisia annua*.

	V1	V2	V3	V4	Mean
S1	0.90	1.25	1.42	1.40	1.24
S2	1.20	1.35	1.50	1.47	1.38
S3	1.00	1.30	1.48	1.42	1.30
Mean	1.03	1.30	1.46	1.43	
CD (p<0.05)	S = 0.21S1:45×45 cm, S2:45×60 cm, S3:60×60 cm V = 0.18 V1:0, V2:100 q/ha., V3:125 q/ha, V4: 150 q/ha S x V = 0.37				

Interaction effect of spacing and vermicompost on growth

Our study reveals that spacing and vermicompost have a significant effect on different growth parameters viz., height of plant, number of branches per plant, fresh weight and dry weight of *Artemisia annua* viz., height of plant under S1V3 (45cm x 45cm and 125q/ha) exhibited maximum plant height, while in collar diameter, number of branches per plant, fresh weight, and dry weight plant under S2V3 (45 cm x 60 cm and 125 q/ha). No. of branches per plant (75), fresh weight (1215g), dry weight (619g) and essential oil (1.50 ml) as compared to the plants under S1V1 (45 cm x 45 cm spacing and 0% vermicompost). Also spacing and vermicompost have a non-significant effect on collar diameter and essential oil. Our results are closely related with the study of Mohamed *et al.*, (2023) [12] who studied "Influence of planting distances in presence of chemical fertilization and compost on growth, essential oil, artemisinin content and chemical constituents of *Artemisia annua* L.

**Fig 1:** Effect of spacing and vermicompost on height of plant**Fig 2:** Effect of spacing and vermicompost on number of branches per plant**Fig 3:** Effect of spacing and vermicompost on fresh weight of plant**Fig 4:** Effect of spacing and vermicompost on dry weight of plant**Conclusion**

Artemisia annua was cultivated in division of forest products and utilization to standardize its cultivation techniques under different spacing's and vermicompost dosages. Total three spacing's and four vermicompost treatments were analyzed to determine the best treatment combinations for better growth of the species under temperate conditions. It was concluded that the species can be cultivated as cash crops under temperate conditions of Kashmir valley subjected to 45 x 60 cm spacing and 125 q/t of vermicompost per hectare.

References

1. Ajah PO, Eteng MU. Phytochemical screening and histopathological effects of single acute dose administration of *Artemisia annua* L. Afr J Biochem Res. 2010;4(7):179-185.
2. Bakuni RS, Jain DC, Sharma RP, Kumar S. Secondary metabolites and biological activities of *Artemisia annua*. Curr Sci. 2001;80:35-48.
3. Bhellum BL. Diversity of tribe Anthemideae (Asteraceae) in flora of Jammu and Kashmir State. J Biol Earth Sci. 2013;3(1):24-29.
4. Choudhari R, Sunita TP, Roshan C, Aanandi LJ. Effect of planting geometry on *Artemisia annua*. Environ Ecol.

- 2013;31(2A):701-703.
5. Enserink M. The source of new hope against malaria is in short supply. *Science*. 2005;307:33.
 6. Gaibi ZL, Roviqowati F, Yunus A, Purwanto E. Vermicompost and arbuscular mycorrhiza application on growth and yield of *Artemisia annua* in the low land. *IOP Conf Ser Earth Environ Sci*. 2019;250:012008.
 7. Gairola S, Sharma J, Bedi YS. A cross-cultural analysis of Jammu, Kashmir and Ladakh (India) medicinal plant use. *J Ethnopharmacol*. 2014;155:925-986.
 8. Helmerick RN, Pfeifer RP. Differential varietal responses of winter germination and early growth to controlled limited moisture conditions. *Agron J*. 1954;46:560-562.
 9. Kader MA, Jutzi SC. Effect of thermal and salt treatments during imbibition on germination and seedling growth of sorghum at 42/19 °C. *J Agron Crop Sci*. 2004;190:35-38.
 10. Kumaresan A, Virendra S, Rana VB, Satyabrata M. Effect of plant spacing on herb, essential oil and artemisinin yields in the antimalarial herb *Artemisia annua*. *Indian J Agron*. 2014;59(1):163-167.
 11. Mohamed AEH, Sayed MA, Hegazy ME, Helaly SE, Esmail AM, Mohamed NS. Chemical constituents and biological activities of *Artemisia annua*. *Rec Nat Prod*. 2019;4(1):1-25.
 12. Mohamed SM, Mohamed YFY, Saleh DM. Influence of planting distances in presence of chemical fertilization and compost on growth, essential oil, artemisinin content and chemical constituents of *Artemisia annua* L. plant. *J Plant Prod*. 2023;14(2):31-43.
 13. Mojarad TB, Roghani M, Zare N. Effect of sub-chronic administration of aqueous *Artemisia annua* extract on adrenoceptor agonist-induced contraction of isolated aorta in rat. *Iran Biomed J*. 2019;9(2):57-62.
 14. Nofal SM, Mahmoud SS, Ramadan A, Soliman GA, Fawzy R. Antidiabetic effect of *Artemisia judaica* extracts. *Res J Med Med Sci*. 2009;4(1):42-48.
 15. Onen H. The influence of temperature and light on seed germination of mugwort (*Artemisia vulgaris* L.). *J Plant Dis Prot*. 2006;20:393-399.
 16. Pandey AV, Tekwani BL, Singh RL, Chauhan VS. Artemisinin, an endoperoxide antimalarial, disrupts the hemoglobin catabolism and detoxification systems in malaria parasites. *J Biol Chem*. 1999;274(27):19383-19388.
 17. Reddy AR, Kumar RB, Deepthi M, Sastry KP. Influence of different doses of vermicompost on growth of herb *Ocimum tenuiflorum* var. CIM-Ayu. *Res J Pharm Technol*. 2017;10(7):2146-2152.
 18. Rezelman D, Goris HR. The role of herbal products containing *Artemisia annua* in malaria treatment. *Afr J Complement Altern Med*. 2008;4(1):121-123.
 19. Sabira N, Tahir M, Sofi PA, Amerjeet S, Malik AR, Peerzada IA, et al. Effect of shade and spacing on growth performance of *Bergenia ciliata*: an important medicinal plant of North Western Himalayas. *Int J Res Agron*. 2024;7(1):373-378.
 20. Sanja C, Milka M, Danijela V, Adisa P. Chemical composition, antioxidant and antimicrobial activity of essential oil of *Artemisia annua* L. from Bosnia. *Ind Crops Prod*. 2012;37:479-485.
 21. Tahir M, Sofi PA, Peerzada IA, Malik AR, Jeelani MI, Sabira N, et al. Standardization of cultivation techniques of *Artemisia absinthium*: an important medicinal plant of Kashmir Himalayas. *SKUAST J Res*. 2023;25(4):608-613.
 22. Thompson PA. Germination of celery (*Apium graveolens*

L.) in response to fluctuating temperatures. *J Exp Bot*. 1974;25:156-163.

Author's details

Ishika Thakur

Division of Forest Products and Utilization, Faculty of Forestry, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Jammu and Kashmir, India

Tahir Mushtaq

Division of Forest Products and Utilization, Faculty of Forestry, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Jammu and Kashmir, India

PA Sofi

Division of Forest Products and Utilization, Faculty of Forestry, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Jammu and Kashmir, India

Peerzada Ishtiyak Ahmad

Division of Forest Products and Utilization, Faculty of Forestry, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Jammu and Kashmir, India

AR Malik

Division of Forest Products and Utilization, Faculty of Forestry, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Jammu and Kashmir, India

Arfa Ji

Division of Forest Products and Utilization, Faculty of Forestry, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Jammu and Kashmir, India

Irtika Bulaki

Division of Forest Products and Utilization, Faculty of Forestry, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Jammu and Kashmir, India

Reising Lungloo

Division of Forest Products and Utilization, Faculty of Forestry, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Jammu and Kashmir, India

Moamenla Jamir

Division of Forest Products and Utilization, Faculty of Forestry, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Jammu and Kashmir, India

Sabira Nissar

Division of Forest Products and Utilization, Faculty of Forestry, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Jammu and Kashmir, India

Iqra Rahim

Division of Forest Products and Utilization, Faculty of Forestry, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Jammu and Kashmir, India

Mohd. Shahzad

Division of Forest Products and Utilization, Faculty of Forestry, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Jammu and Kashmir, India

Rahat Begh

Division of Forest Products and Utilization, Faculty of Forestry,
Sher-e-Kashmir University of Agricultural Sciences and
Technology of Kashmir, Jammu and Kashmir, India

Suraya Shabir

Division of Forest Products and Utilization, Faculty of Forestry,
Sher-e-Kashmir University of Agricultural Sciences and
Technology of Kashmir, Jammu and Kashmir, India

Peerzada Tabish Fayaz

Division of Forest Products and Utilization, Faculty of Forestry,
Sher-e-Kashmir University of Agricultural Sciences and
Technology of Kashmir, Jammu and Kashmir, India