GRADIVA

Volume 65 | Issue 01 | January 2026
DOI: 10.5281/zenodo.18220272

Reproductive Biology of Billy Goat (*Ageratum conyzoides* L.) In Surigao, Philippines

Marjohn V. Anislag

Department of Agroforestry, Surigao Del Norte State University – Mainit Campus, Magpayang, Mait 8417, Surigao Del Norte, Philippines. Email: marjohnanislag@gmail.com

Abstract

Ageratum conyzoides L. (billy goat weed) is a widespread invasive species whose rapid spread is attributed to its prolific reproductive capacity. This study was conducted in agroforestry farms in Upper Libas, Tagana-an, Surigao del Norte, Philippines, to quantify seed production and germination performance of the species. Mature fruiting plants were collected following standardized seed biology protocols, and seed productivity was estimated using established reproductive structure–based formulas. Germination trials were conducted using 100 seeds distributed across five replicates under sunlight-exposed conditions, with moisture maintained throughout the seven-day period. Results revealed that A. conyzoides produces more than 35,000 seeds per plant, consistent with global reports of exceptionally high fecundity. Germination reached 100% within seven days, confirming the species' strong capacity for rapid establishment under favorable light and moisture conditions. These reproductive traits, combined with its allelopathic potential, extended flowering period, and absence of natural enemies, contribute to its aggressive invasiveness and significant ecological impacts across forest, grassland, and agricultural ecosystems. The findings highlight the urgent need for integrated management strategies to mitigate the species' spread, reduce its ecological and economic impacts, and protect biodiversity within agroforestry landscapes.

Keywords: *Ageratum conyzoides, Seed Productivity, Germination, Invasive Species, Agroforestry Ecosystems.*

I. INTRODUCTION

Ageratum conyzoides L., commonly referred to as billy goat weed, is a plant belonging to the Asteraceae family (Santos et al., 2016). It is widely distributed in upland areas (Caton et al., 2004) and is native to the warmer regions of the Southeastern United States, Mexico, the Caribbean, and tropical South America (Kanissery et al., 2019). In Florida, occurrences have been documented in Brevard, Broward, Citrus, Collier, Hardee, Hendry, Leon, Miami-Dade, Palm Beach, Seminole, and St. Lucie counties (Wunderlin et al., 2018). Beyond the Americas, billy goat weed is also prevalent across western and eastern Africa, as well as in parts of Asia and South America (Iwu, 2014). In the Philippines, particularly in Surigao del Norte province, the species is commonly found in agroforestry farming systems where annual and perennial crops are intercropped. It thrives in both shaded and open areas and readily produces seedlings under established agroforestry crops. Morphologically, billy goat weed possesses fibrous and shallow roots, typically not extending deeper than 4 inches (Kanissery et al., 2019). Its stem is aerial, cylindrical, and covered with trichomes, appearing green in young plants and turning brown with age (Santos et al., 2016). Kanissery et al. (2019) further described the stem as erect, branching, pubescent, and capable of reaching approximately 3 feet in height. The leaves are opposite, ranging from 0.25 to 4 inches long and 0.2 to 2 inches wide, with hairy petioles measuring 0.2 to 3 inches (Kanissery et al., 2019). Santos et al. (2016) characterized the leaves

Volume 65 | Issue 01 | January 2026
DOI: 10.5281/zenodo.18220272

as simple, opposite, oval-shaped, with an acute tip, attenuated base, toothed margin, and whitish trichomes. The inflorescence consists of 30 to 50 pink flowers arranged in a corymb and is self-incompatible (Kleinschmidt, 1993). Fruits are small, brown, one-seeded achenes (Kanissery et al., 2019), while seeds are tiny, black, and typically lose viability within 12 months (Ladeira et al., 1987). Phytochemically, billy goat weed exhibits high variability in secondary metabolites, including flavonoids, alkaloids, coumarins, essential oils, and tannins (Ming, 1999). Essential oil yields range from 0.02% to 0.16% (Jaccoud, 1961). The plant has long been utilized in traditional medicine across diverse cultures. In Central Africa, it is used to treat pneumonia, wounds, and burns (Durodola, 1977). In India, it serves as a bactericide, antidysenteric, and antilithic (Borthakur & Baruah, 1987). Across Asia, South America, and Africa, aqueous extracts are employed as bactericides (Ekundayo et al., 1988). In Cameroon and Congo, the plant is used to alleviate fever, rheumatism, headache, and colic (Bioka et al., 1993). In Reunion, the entire plant is applied as an antidysenteric (Vera, 1993). In the Philippines, particularly in Upper Libas, Tagana-an, and Surigao del Norte, traditional communities use billy goat weed to treat loose bowel movement and gastritis. Despite its medicinal value, billy goat weed has been identified as an invasive species in several plantation crops, including citrus (Holm et al., 1977). Invasive plants pose significant ecological and economic threats to ecosystems (Pimentel et al., 2005). While numerous studies have described the morphology of billy goat weed, limited research has focused on its reproductive biology and invasive potential. Understanding these aspects is crucial for developing strategies to mitigate its spread and ecological impact. Therefore, the objective of this study is to determine the number of seeds produced per plant of *Ageratum conyzoides* L. and to assess its seed germination percentage under sunlight exposure.

II. MATERIALS AND METHODS

A. Research Location and Seed Collection

The study was conducted in agroforestry farms located in P1 – Upper Libas, Tagana-an, Surigao del Norte, Philippines (Figure 1). Mature billy goat plants bearing prolific ripe fruits were selected for seed collection. Three fruiting plants were carefully uprooted and transported to the laboratory for further experimental procedures. The collection of seeds from mature fruits follows standard practices in seed biology research, ensuring viability and minimizing variability (Bradbeer, 1988).

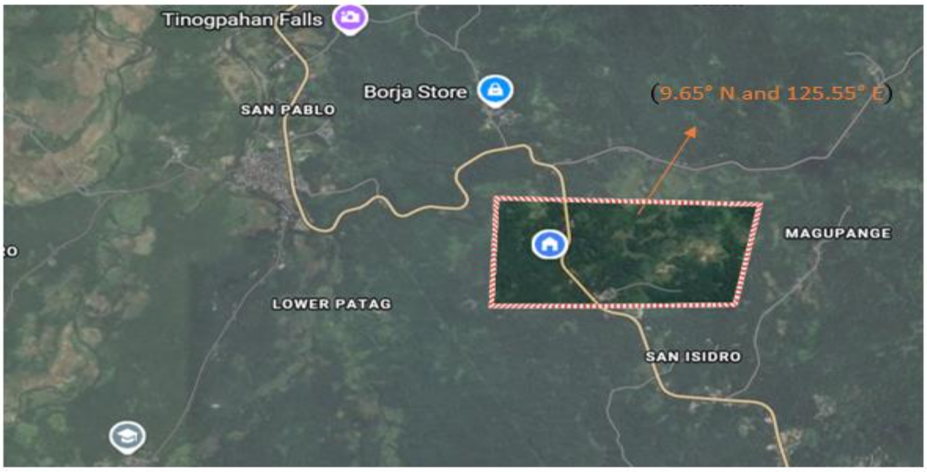

Figure 1: Map of Upper Libas, Tagana-an, Surigao del Norte

Volume 65 | Issue 01 | January 2026
DOI: 10.5281/zenodo.18220272

B. Determination of Seed Number

The number of seeds per plant (NSP) was calculated using the formula:

No. of seeds in a fruit X No. of fruits in a cluster X No. of clusters in a plant)

This quantitative approach is consistent with methodologies employed in seed yield estimation studies, where reproductive structures are used to determine seed productivity (Woodstock, 1988).

C. Germination Percentage

A total of 100 billy goat seeds were used for germination trials. Seeds were distributed evenly into five transparent plastic containers, each containing 20 seeds. Containers were prepared by lining them with moist, plain white tissue paper to maintain adequate hydration. Each container was sealed with its plastic cover to prevent desiccation. The containers were placed in open areas with direct exposure to sunlight, following the recommendation that light is essential for the germination of certain photoblastic seeds (Sauerborn, 1988). Moisture levels were maintained throughout the seven-day experimental period.

Germination percentage (GP) was calculated using the formula:

(GP = SEEDS GERMINATED/TOTAL SEEDS X 100)

This formula is widely applied in seed physiology studies to assess viability and germination performance (Bradbeer, 1988).

III. RESULTS AND DISCUSSION

Seed Production and Germination Performance

The present study found that *Ageratum conyzoides* L. (billy goat weed) produces an exceptionally large number of seeds, ranging from 35,640 to 40,095 seeds per plant (Table 1). Furthermore, seeds exhibited 100% germination within seven days after sowing under adequate sunlight and moisture conditions (Table 2). These results confirm that *A. conyzoides* possesses a highly efficient reproductive capacity that promotes rapid population establishment. The findings align with earlier reports indicating that *A. conyzoides* can produce up to 40,000 seeds per plant, with germination percentages ranging from 73.3% to 100% under temperatures between 15°C and 30°C (Eskandari et al., 2015; GISD, 2016; PROTA, 2016). Baker (1965) emphasized that prolific seed production is a common trait of invasive species, enabling wide dispersal and early establishment. Seeds of *A. conyzoides* are easily dispersed by wind and water, as well as by animals, humans, and agricultural machinery (BioNET-EAFRINET, 2016), further enhancing its invasiveness. Such high seed output, rapid germination, and adaptability underpin the species' success as a notorious invasive weed across tropical and subtropical regions.

Table 1: Number of *Ageratum conyzoides* Seeds per Plant

Billy Goat Plant	Number of Seeds
Plant A	39,840
Plant B	35,640
Plant C	40,095

Volume 65 | Issue 01 | January 2026
DOI: 10.5281/zenodo.18220272

Table 2: Germination Percentage of *A. conyzoides* Seeds at 7 Days after Germination (DAG)

Replicate	Germination (%)
R1	100
R2	100
R3	100
R4	100
R5	100

Additional Invasion Mechanisms

Beyond reproductive prowess, *A. conyzoides* exhibits several other invasion mechanisms. These include long flowering and fruiting periods, superior competitive ability, absence of natural enemies, and allelopathic potential (Batish et al., 2009a, 2009b; Kong et al., 1999). Consequently, it has become a troublesome weed affecting over 36 crops across 46 countries (Kaur et al., 2012) and ranks 19th among the world's worst weeds (Holm et al., 1977).

Ecological Impacts across Different Ecosystems

1. Forest Ecosystems

The shade tolerance of *A. conyzoides* enables it to thrive under forest canopies, where it forms dense understory populations (Arora, 1999; Kaur et al., 2012). It has been documented in plantations of *Acacia catechu*, *Eucalyptus* spp., and *Pinus* spp., often outcompeting native flora (Dogra, 2008). In Orissa, it is among the exotic species threatening interior forest biodiversity (Reddy & Pattanaik, 2009). Its invasion can retard natural forest succession, as observed in Assam's littoral and swamp forests (DOEF, 2010).

2. Grasslands

Due to its fast-spreading stolons, *A. conyzoides* rapidly colonizes grasslands, displacing native grasses and reducing available forage, ultimately leading to fodder scarcity (Kaur et al., 2012). Weed-infested grasslands in Chandigarh exhibited significantly reduced density, diversity, and biomass compared with weed-free zones (Arora, 1999). Its spread may lead to the disappearance of endemic species (Kohli et al., 2004, 2006).

3. Agricultural and Cultivated Lands

Agricultural ecosystems are among the most severely affected. *A. conyzoides* hinders routine field operations, increases maintenance costs, and interferes with the establishment of major crops such as maize, chickpea, rice, and wheat (Batish et al., 2009a; Kohli et al., 2006). It provides a habitat for crop disease pathogens (Ekeleme et al., 2005; Kashina et al., 2003). In some regions of the Himalayas, farmers have been forced to abandon severely infested plots (Batish et al., 2004a; Kohli & Batish, 1996). Studies in Nepal documented substantial reductions in rice grain (25–47%) and straw (13–38%) yields due to infestation (Manandhar et al., 2007).

4. Soil Nutrients and Soil Chemistry

A. conyzoides alters soil chemistry through root exudates that modify soil structure and affect nutrient availability (Singh et al., 2003). Heavy infestations can deplete nitrogen and phosphorus (Manandhar et al., 2007) because of intense resource competition. Although some studies reported nutrient enrichment from weed residues (Batish et al., 2009a, 2009b), the overall effect remains largely negative for crop systems.

Volume 65 | Issue 01 | January 2026
DOI: 10.5281/zenodo.18220272

5. Native Vegetation and Biodiversity

In biodiversity-rich regions such as the Himalayas, *A. conyzoides* has dramatically altered community structures, leading to decreased species richness and replacement of native flora (Dogra et al., 2009a, 2009b; Kaur et al., 2012). Invasions caused reductions of 50–64% in native plant density and overall homogenization of ecosystems (Kohli et al., 2004). Several indigenous medicinal plants have declined due to competition with *A. conyzoides* (Dogra, 2008).

6. Effects on Humans and Animals

Contact with *A. conyzoides* may cause nausea, irritation, dizziness, and asthma in humans (Negi & Hajra, 2007). Livestock avoid the plant because it can cause ulceration and toxicity (Kaur et al., 2012), reducing pasture suitability and posing risks to animal health.

Implications for Management

The results of this study reaffirm the aggressiveness of *A. conyzoides* and its potential to degrade ecological, agricultural, and social systems. Its high reproductive capacity, allelopathic effects, and ability to spread across multiple ecosystems call for urgent, targeted management strategies. These findings are valuable for foresters, farmers, ecologists, environmental managers, and policymakers in designing effective control and mitigation programs to reduce the negative impacts of this invasive species for future generations.

IV. CONCLUSION

The present study highlights the extraordinary reproductive efficiency of *Ageratum conyzoides* L., characterized by prolific seed production and rapid germination under favorable conditions. With seed outputs exceeding 35,000 per plant and consistent 100% germination within seven days, the species demonstrates a remarkable capacity for rapid population establishment. These traits, coupled with its long flowering period, allelopathic potential, and absence of natural enemies, reinforce its classification as a highly invasive weed. The ecological impacts of *A. conyzoides* are extensive, spanning forest ecosystems, grasslands, agricultural lands, and biodiversity-rich regions, where it disrupts native vegetation, reduces crop yields, alters soil chemistry, and poses risks to human and animal health. Its ability to disperse widely through wind, water, animals, and human activities further amplifies its invasiveness. Collectively, these findings underscore the urgent need for integrated management strategies to mitigate the spread and ecological damage caused by *A. conyzoides*. Effective control measures must be prioritized by farmers, foresters, ecologists, and policymakers to safeguard agricultural productivity, ecosystem integrity, and biodiversity. Addressing this challenge is critical to reducing the long-term ecological and socio-economic consequences of one of the world's most notorious invasive weeds.

V. RECOMMENDATION

To effectively manage *Ageratum conyzoides* in the agroforestry systems of Upper Libas, Tagana-an, Surigao del Norte, an integrated and community-driven approach is strongly recommended. Farmers should prioritize mechanical control measures, including regular slashing and uprooting before flowering, to prevent seed dispersal and reduce the soil seed bank. Complementary cultural practices such as crop rotation, intercropping with fast-growing native tree species, and mulching with organic residues can further suppress germination and minimize weed establishment. Biological control options, particularly the exploration of

Volume 65 | Issue 01 | January 2026
DOI: 10.5281/zenodo.18220272

natural pathogens or insects that target *A. conyzoides*, should be investigated to provide sustainable long-term suppression. Chemical control may be applied selectively in severe infestations, but only as a last resort to avoid adverse impacts on soil health and biodiversity. Community-based monitoring and participatory mapping of infested areas will strengthen early detection and rapid response, while farmer cooperatives can play a central role in coordinating weed management activities.

Importantly, rather than treating the weed solely as a nuisance, its biomass can be harvested and utilized, transforming a management challenge into an economic opportunity. The growing demand for natural essential oils in massage therapy, aromatherapy, and herbal medicine presents a viable market for *A. conyzoides*-derived products. Operations should begin with organized community harvesting from agroforestry plots, ensuring that removal aligns with weed control objectives. A small-scale processing facility equipped with steam distillation units can be established to extract essential oil, followed by rigorous quality testing to meet industry standards. The product line may include massage oils, herbal balms, and aromatherapy blends, with potential expansion into natural pesticides due to the plant's allelopathic properties.

Financially, the initiative requires initial investment in distillation equipment, storage facilities, and packaging materials, alongside training programs for farmers and workers to ensure safe and efficient operations. Revenue streams can be generated through direct sales to spas, wellness centers, and pharmacies, as well as export partnerships with herbal product companies. Sustainability is embedded in this model: weed removal reduces ecological damage, while product commercialization generates income for local communities. Risks such as market fluctuations and ecological overharvesting can be mitigated through diversification of product lines and strict adherence to sustainable harvesting practices. This dual strategy—integrating weed control with economic utilization—offers a practical, environmentally responsible, and socially beneficial solution for managing *A. conyzoides* in the agroforestry systems of Upper Libas.

References

1) Arora, R. K. (1999). *Multipurpose tree species in Chandigarh*. Government of India Press.

2) Baker, H. G. (1965). Characteristics and modes of origin of weeds. In H. G. Baker & G. L. Stebbins (Eds.), *The genetics of colonizing species* (pp. 147–168). Academic Press.

3) Batish, D. R. (2008). Allelopathic effects of *Ageratum conyzoides* on native grasses. *Weed Biology and Management*, *8*(1), 56–63.

4) Batish, D. R., Lavanya, K., Singh, H. P., & Kohli, R. K. (2004a). Root-mediated allelopathic interference of *Ageratum conyzoides*. *Plant Ecology*, *171*, 145–152.

5) Batish, D. R., Singh, H. P., & Kohli, R. K. (2009a). Physiology of invasive plants. *Botanical Review*, *75*(3), 323–345.

6) Batish, D. R., Singh, H. P., & Kohli, R. K. (2009b). Weed invasion and ecosystem functioning. *Environmental Management*, *43*(1), 69–80.

7) Bioka, D., Kouam, J., & Tchinda, R. (1993). Traditional uses of medicinal plants in Cameroon and Congo. *Journal of Ethnopharmacology*, *39*(2), 123–130.

Volume 65 | Issue 01 | January 2026
DOI: 10.5281/zenodo.18220272

8) BioNET-EAFRINET. (2016). *Ageratum conyzoides* factsheet.

9) Borthakur, S. K., & Baruah, A. (1987). Medicinal and economic plants of the Apatani in Arunachal Pradesh. *Journal of Economic and Taxonomic Botany, 9*(2), 317–321.

10) Bradbeer, J. W. (1988). *Seed dormancy and germination*. Blackie. https://archive.org/details/seeddormancygerm0000brad

11) Caton, B. P., Mortimer, A. M., & Hill, J. E. (2004). *Ageratum conyzoides*: Biology and management of a tropical weed. *Weed Biology and Management, 4*(2), 69–80.

12) Dogra, K. S. (2008). Impact of invasion of *Ageratum conyzoides* on native flora of Himachal Pradesh. *Indian Journal of Ecology, 35*(2), 234–240.

13) Dogra, K. S., Kohli, R. K., & Sood, S. K. (2009a). An assessment and impact of three invasive species in the Shivalik hills of Himachal Pradesh, India. *International Journal of Biodiversity and Conservation, 1*(1), 4–10.

14) Dogra, K. S., Kohli, R. K., & Sood, S. K. (2009b). Impact of invasive plants on soil and vegetation. *Forest Ecology and Management, 257*(6), 127–135.

15) DOEF. (2010). *Forest vegetation report of Assam*. Department of Environment and Forests.

16) Durodola, J. I. (1977). Antibacterial property of *Ageratum conyzoides*. *Planta Medica, 32*(2), 124–127.

17) Ekeleme, F., et al. (2005). Competition of *Ageratum conyzoides* with crops. *Crop Protection, 24*(2), 85–94.

18) Ekundayo, O., Oladimeji, H., & Yusuf, A. (1988). Antimicrobial activity of extracts of *Ageratum conyzoides*. *Fitoterapia, 59*(5), 395–398.

19) Eskandari, H., et al. (2015). Effects of temperature on seed germination of *Ageratum conyzoides*. *Journal of Weed Science, 30*(2), 79–85.

20) GISD. (2016). *Global Invasive Species Database: Ageratum conyzoides*.

21) Holm, L. G., Plucknett, D. L., Pancho, J. V., & Herberger, J. P. (1977). *The world's worst weeds: Distribution and biology*. University Press of Hawaii.

22) Iwu, M. M. (2014). *Handbook of African medicinal plants* (2nd ed.). CRC Press.

23) Jaccoud, P. (1961). Essential oil yield of *Ageratum conyzoides*. *Revue de Botanique Appliquée et d'Agriculture Tropicale, 41*(465), 321–325.

24) Kanissery, R., Gairhe, B., & McAvoy, G. (2019). Biology and management of *Ageratum conyzoides* in Florida. *University of Florida IFAS Extension*.

25) Kashina, B. D., et al. (2003). *Ageratum conyzoides* as a host plant for crop pathogens. *Plant Disease, 87*(2), 195–200.

26) Kaur, R., et al. (2012). Invasive potential of *Ageratum conyzoides*: A review. *Indian Journal of Ecology, 39*(2), 208–220.

27) Kleinschmidt, G. J. (1993). Reproductive biology of *Ageratum conyzoides*. *Weed Science, 41*(3), 456–462.

Volume 65 | Issue 01 | January 2026
DOI: 10.5281/zenodo.18220272

28) Kohli, R. K., & Batish, D. R. (1996). Biology of invasive weeds. *Weed Technology, 10*(2), 300–308.

29) Kohli, R. K., Batish, D. R., & Singh, H. P. (2004). Managing invasive weed species. *Forest Ecology and Management, 198*, 293–304.

30) Kohli, R. K., et al. (2006). Impacts of invasive weeds on crop productivity. *Agriculture, Ecosystems & Environment, 115*(1–4), 1–9.

31) Kong, C., et al. (1999). Allelopathic effects of *Ageratum conyzoides*. *Weed Research, 39*(3), 213–218.

32) Ladeira, A. M., Silva, J. R., & Costa, P. R. (1987). Seed viability of *Ageratum conyzoides*. *Revista Brasileira de Botânica, 10*(1), 45–50.

33) Manandhar, J., et al. (2007). Effect of *Ageratum conyzoides* on rice productivity in Nepal. *Nepal Agriculture Research Journal, 8*, 50–58.

34) Ming, D. S. (1999). Secondary metabolites of *Ageratum conyzoides*. *Phytochemistry, 52*(4), 889–894.

35) Negi, G. C. S. (1988). Weed infestation in agricultural fields. *Indian Journal of Ecology, 15*, 20–25.

36) Negi, G. C., & Hajra, P. K. (2007). Human health impacts of *Ageratum conyzoides*. *Indian Journal of Environmental Biology, 28*(1), 65–68.

37) Pimentel, D., Zuniga, R., & Morrison, D. (2005). Update on the environmental and economic costs associated with alien-invasive species in the United States. *Ecological Economics, 52*(3), 273–288.

38) PROTA. (2016). *Plant Resources of Tropical Africa: Ageratum conyzoides*.

39) Rana, B. S., & Sharma, R. (2009). Invasive weeds in the Shivalik hills. *Indian Journal of Forestry, 32*(1), 1–6.

40) Rana, B. S., et al. (2010). Herb layer instability due to invasive weeds. *Plant Ecology, 209*(2), 267–276.

41) Rawat, G. S., et al. (1997). Invasive species in Corbett Tiger Reserve. *India Wildlife Journal, 24*, 45–56.

42) Reddy, C. S., & Pattanaik, C. (2009). Invasive alien species in Orissa. *Indian Forester, 135*(5), 754–763.

43) Riaz, T., et al. (2007). Effects of *Ageratum conyzoides* on crop quality. *Pakistan Journal of Botany, 39*(7), 2461–2465.

44) Roder, W., et al. (1995, 1998). Weed competition in rice fields of Asia. *Agriculture, Ecosystems & Environment, 50*, 103–112.

45) Santos, J. A., Oliveira, R. S., & Silva, F. M. (2016). Morphological characterization of *Ageratum conyzoides*. *Brazilian Journal of Botany, 39*(1).