Journal of Geography, Environment and Earth Science International

Volume 28, Issue 11, Page 1-8, 2024; Article no.JGEESI.125307
ISSN: 2454-7352

Effect of Land Configuration and Vermicompost on Hardening Status of *Gaillardia pulchella* under Micro-climate Conditions

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: https://doi.org/10.9734/jgeesi/2024/v28i11833

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here:
https://www.sdiarticle5.com/review-history/125307

Original Research Article

Received: 12/08/2024
Accepted: 16/10/2024
Published: 19/10/2024

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Cite as: *Ahirwar, G.K, Somil Singh Chauhan, Bhavya Kushwah, Divya Kushwah, Diksha Verma, Deepak Mukati, Shivam Hammad, and Vinayak Kushwah. 2024. "Effect of Land Configuration and Vermicompost on Hardening Status of Gaillardia Pulchella under Micro-Climate Conditions". Journal of Geography, Environment and Earth Science International 28 (11):1-8. https://doi.org/10.9734/jgeesi/2024/v28i11833.*

ABSTRACT

Gaillardia (*Gaillardia pulchella* Foug), commonly known as the blanket flower, is a herbaceous perennial renowned for its vibrant, daisy-like flowers. This paper provides a thorough examination of G. pulchella, encompassing its botanical characteristics, hardening configuration, and ecological significance. The present study investigates the impact of land configuration and vermicompost application on the growth metrics of *Gaillardia pulchella*, and discuss how different configurations affect microclimate conditions and plant acclimatization. By evaluating different land configurations and vermicompost treatments, this research aims to optimize cultivation practices for enhancing the plant's growth performance, floral quality, and overall yield. The findings provide insights into sustainable agricultural practices for improving the productivity and aesthetic value of *G. pulchella*. The present results suggest that the flat, ridge and furrow and raised bed configuration, particularly with 75% vermicompost with (33.53, 34.44 and 42.70) is optimal for cultivating Gaillardia flowers. However, minimum plant height was observed under the control plot (24.56, 17.77 and 31.72) cm for all three bed types. The maximum number of leaves count treatment were maximum (83.40, 81.46 and 99.26) with 50% vermicompost under flat, ridge and furrow and raised bed configuration. Number of new shoots per plant at hardening was found maximum (8.66, 9.33 and 9.23) under 50% vermicompost. Moreover, the survival percentage (%) were also found maximum (83.40, 81.46 and 99.26) under 50% vermicompost. It may be concluded that by assessing different land configurations and vermicompost treatments which influences the hardening process characterized by plant acclimatization to environmental stress which ultimate the research aims to enhance the resilience and establishment of *G. pulchella* in controlled environments.

Keywords: Blanket flower; gaillardia; micro climate and vermicompost.

1. INTRODUCTION

Gaillardia (*Gaillardia pulchella*), commonly known as the blanket flower, is notable for its interesting chromosomal characteristics which are critical for understanding its genetics and breeding potential. This species typically exhibits a chromosome number of 2n = 34, which is relatively unique among plants in the Asteraceae family (Bennett et al. 2014). The study of morphology, provides insights into its genetic diversity, evolutionary history, and adaptability (Garrett 1998). It is a herbaceous perennial known for its distinctive, daisy-like flowers that exhibit a range of colors from vibrant reds to yellows. Gaillardia species typically grows between 30 to 60 cm in height and thrives in well-drained soils under full sun conditions (Gurjar et al. 2020). Characterized by its lanceolate leaves and flowering heads, G. pulchella is adapted to various habitats, including prairies and open woodlands (Gurjar et al 2020). It is a vibrant and versatile species native to North America Its striking appearance, with bright red and yellow blooms, makes it a popular choice for ornamental gardening. Beyond its aesthetic appeal, *G. pulchella* plays a significant role in its ecosystems, supporting local pollinators and contributing to biodiversity (Hegde et al. 2018).

The estimated area under flower growing in the country is about 3.07 lakh hectares with 18.05 lakh MT productions of loose flowers and 7.04 Lakh number productions of cut flowers (2021-22). The area under cultivation is maximum (52.37 thousand hectares) in Karnataka, while highest loose flower production (4.26 lakh tonnes) in Tamil nadu and cut flower production is maximum in West Bengal (2.03 lakh tonnes) (Gurjar et al. 2020). Maharashtra is a pioneer state with flower cultivation being an integral part of its culture. In Maharashtra, total area under floriculture is 12230 ha with a total production of 35150 MT cut flowers and 71610 MT loose flowers (Garrett 1998).

However, optimizing its cultivation requires an understanding of how different agricultural practices affect its growth and yield. This study focuses on two key factors: land configuration and vermicompost application. Land configuration can influence water management and root development, while vermicompost, an organic fertilizer, is known for improving soil fertility and plant health (Lim et al. 2015). This research aims to explore how these factors affect the growth, quality, and yield of *G. pulchella*.

Vermicompost, produced through the decomposition of organic matter by earthworms, plays a crucial role in enhancing the hardening process of plants under protected cultivation. (Lowe et al 2021). Vermicompost improves soil structure by increasing soil porosity and aeration. This promotes healthy root development, allowing plants to establish stronger root systems that can better handle environmental stressors. (Makkar et al. 2023). The nutrients in vermicompost are released slowly, ensuring a steady supply over time. Incorporating vermicompost into cultivation practices can lead to stronger, more resilient plants that are better equipped to handle the challenges of hardening and transition to less controlled conditions. (Marlowe et al. 2007).

Further this paper will delve into its botanical features, including its morphology, and growth habits, providing an ultimate overview of its role within its native ecosystems and its horticultural value. However, plant's ecological significance, potential medicinal uses, and its horticultural applications, aiming to provide a comprehensive understanding of its survival in microclimatic environments under different planting configuration.

2. MATERIALS AND METHODS

The experiment was carried out during *Rabi* 2023-2024 was carried at the protected structure located at Medi-Caps, University, (Madhya Pradesh). The released variety Gaillardia DGS-1 was released and procured from University of Agricultural Sciences (UAS), Dharwad in Karnataka, India. Greenhouse configuration components are specifically designed to create and maintain microclimates. By controlling factors such as temperature, humidity, light, and airflow, these components help optimize growing conditions for plants. This can include elements like:

1. **Structure**: The shape and materials of the greenhouse influence heat retention and light distribution.
2. **Ventilation**: Proper airflow helps regulate temperature and humidity.
3. **Heating Systems**: These maintain optimal temperatures during colder periods.
4. **Shade Cloths**: These reduce heat and light exposure during hot weather.
5. **Humidity Control**: Systems like misters or dehumidifiers manage moisture levels.
   Together, these components allow for a tailored environment that can significantly enhance plant growth and productivity.

2.1 Protected Structure

Green house configuration: The greenhouse was covered with a single layer of 200 micron (800 gauge) UV-stabilized low-density polyethylene film (LDPE) for natural ventilation and pest protection. Both sides were clad with white, insect-proof high-density polyethylene (HDPE) fabric with a 40 x 40 mesh, leaving a 1-meter LDPE-covered space from the ground. Each span included a 1-meter wide 40 mesh net on the roof for thermal buoyancy ventilation. The total naturally ventilated area was 120 m^2, or 33.3% of the total floor area. Additionally, rollable flaps of 200-micron thick LDPE were fitted outside to regulate temperature, humidity, and protect from rain.

Greenhouse dimensions:

- Width:9 meters (29.52 feet)
- Length:24 meters (78.74 feet)
- Ridge Height:5 meters (16.40 feet)
- Eave Height:3.5 meters (11.48 feet)
- Gutter Height:3 meters (9.84 feet)
  Poly house dimensions:
- Width: 12 meters (39.37 feet)
- Length: 30 meters (98.42 feet)
- Ridge Height: 6 meters (19.68 feet)
- Eave Height: 4 meters (13.12 feet)
- Gutter Height: 3.5 meters (11.5 feet)

Land Configurations: The study evaluates various land configurations, including flat bed, ridge &furrow bed and raised beds. The dimension of flat bed (4.20×1.5) m^2, ridge & furrow bed (4.20×0.60) $m^2$with height of ridge 30 cm, depth of furrow 20 cm and raised beds (4.20×1.5) m^2. with height and depth of raised bed (30×120) cm. The net plot size was (6.30)m^2. Each configuration is designed to assess its effect on morphological characters *viz.*, Plant height, number of leaves, Number of new shoots and survival percentage.

Vermicompost application: Different levels of vermicompost are applied, including T_0control (no vermicompost), T_1 (50%Vermicompost), T_2(75% Vermicompost), T_3 (100% Vermicompost). The impact of these levels on plant growth, floral and yield is analyzed.

The present experiment was conducted in a completely randomized design (CRD) design at 0.05% with three replication to appraise the performance of gaillardia which was selected based upon their performance for various traits.

Survival Percentage(%) = (Number of Surviving Plants /Total Number of Plants Planted) ×100.

Overall, greenhouse configuration components are integral to creating and managing microclimates. By controlling environmental factors, these components significantly enhance plant growth and productivity, demonstrating their essential role in modern agriculture.

3. RESULTS AND DISCUSSION

Plant height (cm): The study evaluated the impact of different treatments of vermicompost on the plant height of Gaillardia flowers at 105 days after transplantation. The data collected under three distinct bed types—flat bed, ridge and furrow, and raised bed—are summarized in Table 1. The results indicate a significant variation in plant height among different treatments and bed types. The highest average plant height was observed in the raised bed treatment with 75% vermicompost (42.70 cm), suggesting that this combination is particularly beneficial for the growth of Gaillardia flowers. The flat bed with 75% vermicompost also exhibited enhanced growth (33.53 cm) compared to the control but did not surpass the raised bed treatment.In contrast, the ridge and furrow system showed less variability in plant height across treatments, with the maximum height recorded at (34.44 cm with 75% vermicompost, indicating that this bed type may not be as effective as raised beds for enhancing the growth of Gaillardia flowers.The control plot consistently displayed the lowest growth across all bed types, reinforcing the positive impact of vermicompost on plant height. The results suggest that while all treatments involving vermicompost promote growth, the raised bed configuration, particularly with 75% vermicompost, is optimal for cultivating Gaillardia flowers. However, minimum plant height was observed under the control plot (24.56, 17.77 and 31.72) cm for all three bed types.

The present experiment provides insights into how land configuration and vermicompost application affect the hardening status of Gaillardia pulchella under protected cultivation. Optimal practices identified in this research can be utilized to enhance cultivation efficiency and improve the ornamental value of this species. Understanding these factors can help optimize cultivation practices to enhance plant resilience and establishment. The present results thus obtained contradict with that of (Makkar 2023, Marlowe 2007, Priya 2023, Sinha 2013).

Number of leaves: The present investigation delve into the number of leaves of Gaillardia flowers at 105 days after transplantation revealed significant differences among the various treatments and bed configurations. The data is presented in Table 2. The results indicate a noteworthy variation in the number of leaves produced under different treatments and bed types. The treatment with 50% vermicompost in the flat bed configuration resulted in the highest leaf count (83.40), significantly surpassing the control and other treatments in that bed type. Conversely, the ridge and furrow system showed a substantial decline in leaf production with 50% vermicompost (50.86), suggesting that this bed type may not support optimal growth under lower vermicompost conditions. Interestingly, the raised bed consistently produced high leaf counts across various treatments, particularly with the control and 100% vermicompost, both reaching 99.26 leaves. This emphasizes the raised bed's efficacy in promoting leaf development. However, minimum number of leaves of Gaillardia flowers was observed under the control plot (61.33, 50.86 and 66.66) for all three bed types.

The data suggests that vermicompost application significantly enhances leaf production in Gaillardia flowers, with raised beds providing optimal growth conditions. The results underscore the importance of both the type of organic amendment and the bed configuration in maximizing leaf number, offering insights for future cultivation practices aimed at improving yield and overall plant health. Further investigations should assess the influence of these treatments on flowering and overall plant vigor. Previous studies were in similar lines with our study as per by (Olson 2021, Qiang et al 2014, Shahrajabian 2023, Sorrie et al.)

Number of new shoots per plant: The assessment of the number of new shoots per plant at the hardening stage revealed varying responses to different treatments and bed types for Gaillardia flowers. The detailed findings are summarized in Table 3. The results indicate that the control treatment consistently yielded the highest number of new shoots across all bed types, with ridge and furrow beds showing the greatest average (9.33 shoots). This suggests that without any vermicompost amendment, plants are capable of producing a robust number of new shoots. In contrast, the application of 50% vermicompost notably decreased the number of new shoots across all bed types, with flat beds yielding the lowest average (3.33 shoots). This unexpected reduction may indicate that the nutrient balance or soil structure provided by this specific treatment was not conducive to shoot development. The treatment with 75% vermicompost resulted in a moderate increase in new shoots compared to the 50% vermicompost, particularly in ridge and furrow systems (8.00 shoots). This suggests that a higher concentration of vermicompost may provide more beneficial conditions for shoot formation. The 100% vermicompost treatment showed variable results, with flat beds yielding a relatively high number of shoots (8.33) while the ridge and furrow system produced significantly fewer (4.66). This variability highlights the importance of bed type in determining the effectiveness of organic amendments. The findings indicate that the control treatment significantly enhances shoot production in Gaillardia flowers, while the introduction of vermicompost, especially at lower levels, can hinder this growth. The results underscore the importance of optimizing vermicompost levels and selecting suitable bed configurations to promote healthy shoot development. Further research is warranted to explore the underlying mechanisms influencing these outcomes and to identify the optimal balance of organic amendments for maximizing shoot growth. Previous studies were in similar lines with our study as per by (Olson 2021, Qiang 2014, Shahrajabian 2023, Sorrie et al).

Table 1. Effect of land configuration and vermicompost on growth attributes in gaillardia

S.no.	**Plant height (cm) at 105 days after transplantation**			
	Treatments	**Flat bed**	**Ridge and Furrow**	**Raised bed**
T_0	Control	24.56	17.77	31.72
T_1	50% Vermicompost	31.56	23.18	36.35
T_2	75% Vermicompost	33.53	34.44	42.70
T_3	100% Vermicompost	30.18	31.67	36.68
	SEm ±	0.16	0.14	1.60
	C.D.(*p*=0.05%)	0.55	0.47	2.30

Table 2. Effect of land configuration and vermicompost on growth attributes in gaillardia

S.no.	**Number of leaves at 105 days after transplantation**			
	Treatments	**Flat bed**	**Ridge and Furrow**	**Raised bed**
T_0	Control	61.33	50.86	66.66
T_1	50% Vermicompost	83.40	81.66	99.26
T_2	75% Vermicompost	78.06	80.33	96.73
T_3	100% Vermicompost	64.80	79.80	99.26
	SEm ±	1.01	1.40	1.64
	C.D.(*p*=0.05%)	2.44	3.16	3.01

Table 3. Effect of land configuration and vermicompost on hardening in gaillardia

S.no.	**Number of new shoots per plant at hardening**			
	Treatments	**Flat bed**	**Ridge and Furrow**	**Raised bed**
T_0	Control	3.33	5.00	3.66
T_1	50% Vermicompost	8.66	9.33	9.23
T_2	75% Vermicompost	6.00	8.00	7.33
T_3	100% Vermicompost	8.33	4.66	6.66
	SEm ±	0.61	0.39	0.78
	C.D.(*p*=0.05%)	2.17	1.40	2.77

Table 4. Effect of land configuration and vermicompost on hardening in gaillardia

S.no.	Survival percentage (%)			
	Treatments	**Flat bed**	**Ridge and Furrow**	**Raised bed**
T_0	Control	37.03	42.01	40.98
T_1	50% Vermicompost	68.79	72.01	62.83
T_2	75% Vermicompost	48.66	50.16	74.42
T_3	100% Vermicompost	66.63	64.05	72.00
	SEm ±	1.02	1.01	1.08
	C.D.(*p*=0.05%)	2.25	2.81	2.29

Survival percentage (%): The analysis of survival percentage of Gaillardia across different treatments and bed types revealed significant variations. The findings are detailed in Table 4. The survival percentage data indicate a strong influence of both treatment and bed type on the viability of Gaillardia plants. The control group exhibited the highest survival rates across all configurations, with raised beds achieving the highest percentage at 74.42%. In contrast, the application of 50% vermicompost significantly reduced survival rates, particularly in flat beds, which recorded only 37.03%. This suggests that this treatment may have adversely affected plant health, potentially due to excessive nutrient availability or other stress factors. The survival rates improved with the application of 75% vermicompost, yet they remained below the control levels, indicating that while some benefits were observed, they were not sufficient to match the control group. The ridge and furrow system displayed a consistent survival rate with this treatment (50.16%). The 100% vermicompost treatment showed promising survival percentages, particularly in flat beds (66.63%) and raised beds (72.00%), highlighting that higher concentrations of vermicompost can support plant survival, although they did not exceed control levels. However, minimum survival percentages of plants were observed was recorded under the control plot (37.02, 42.01 and 40.98) for all three bed types. Statistical analysis confirms the significance of these differences, as indicated by the standard error of mean (SEm) and critical difference (C.D.) values, reinforcing the need for careful consideration of vermicompost application rates and bed types to optimize plant survival.

The results demonstrate that vermicompost can enhance certain aspects of plant growth, its application especially at lower concentrations can negatively impact the survival rates of Gaillardia flowers. The control treatment consistently yielded the highest survival percentages across all configurations. Similar studies were highlighted by (Sorrie et al, Szitár et al. 2022, Turner et al. 1992, Warzecha et al.2021).

4. CONCLUSION

This study successfully elucidates the effects of land configuration and vermicompost on the hardening status of *Gaillardia pulchella* under controlled micro-climate conditions. The findings demonstrate that both the choice of land configuration and the application of vermicompost significantly influence key growth parameters such as survival percentage, number of new shoots, and plant height. Raised bed configurations, in conjunction with optimal levels of vermicompost (specifically 75%), proved to be the most effective in enhancing the hardening status of *G. pulchella*. This combination not only improved plant resilience but also promoted healthier growth, suggesting that these practices can be strategically employed to maximize productivity in protected cultivation systems. Furthermore, the study highlights the importance of micro-climate conditions in influencing plant development, emphasizing the need for careful management of these environments to optimize outcomes. Future research should focus on the long-term impacts of these treatments on flowering, overall plant health, and yield, as well as explore other organic amendments that may further enhance growth and resilience. Overall, the insights gained from this study provide valuable guidance for horticulturists and farmers aiming to improve the cultivation of *Gaillardia pulchella* and potentially other ornamental species in protected environments. A study focused on optimizing greenhouse configurations can provide valuable insights and practical benefits for the farming community.

Finally, it may be concluded that the effects of land configuration and vermicompost on the hardening status of *Gaillardia pulchella* not only enhance plant growth and soil health but also promote sustainable agricultural practices, ultimately benefiting the farming community economically and environmentally.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Authors declare Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators not been used during the entire writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/125307