To Determine the Effect of Seed Pelleting on Germination Percentage and Rate of Cleome Gynandra L. Seeds.

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ABSTRACT

Spider plant (Cleome gynandra L.) has small and lightweight seed that experiences low seed germination rates and inconsistent seed yield, which is a menace. Seed pelleting presents a viable solution to improve germination and seedling establishment by addressing planting challenges faced by smallholder farmers that optimize crop performance. Involves coating seeds with media to enhance their physical characteristics, which makes them easier to handle and plant, enables uniform seed distribution. Study aims to determine the effect of seed pelleting on germination percentage and rate of Cleome gynandra L. Data collected on the number of days to seed emergence (counts), seedling emergence percentage, plant height (cm), and root length (cm). Results showed variation in treatments, for the interactions, while some aspects had a considerable drop vis-à-vis slight changes due to agronomic factors that seed pelleting could not overcome. Variance in seed pelleting treatments between manure and clay was significant, variance between GA3 and manure was significant in seed emergence, and variance between treatments and control was significant. farm-saved seed experienced a low seed germination percentage as compared to improved seed cultivars (Agrovet). In addition, medium (<3.35mm) seed pelleting yielded more and even seed germination compared to large (>4.5mm) and small seeds (<2.00mm). It was concluded, medium pellet seed size (<3.5mm) recorded maximum germination, field emergence with high vigour, pelletisation efficiency with uniform pellet size, and reduced seed rate throughout sowing. Seed pellet size of medium (<3.5 mm) was recommended as the optimum. In-depth research with diverse binding media for researchers.

Keywords: Seed pelleting, Cleome gynandra L., Germination, Clay, Manure, GA3.

INTRODUCTION

Spider plant (Cleome gynandra L.), also known as African cabbage or Cat's whiskers, is a notable African Indigenous Vegetable (AIV) like other underappreciated and overlooked crops such as amaranths (Amaranthus spp.) and cowpeas (Vigna unguiculata), is a neglected and underutilized species with untapped potential (Thovhogi et al., 2025; Mativavarira et al., 2025). This vegetable is nutrient-dense and adaptable to marginal environments and low soil fertility. Its leaves are rich in nutrients such as zinc, iron, protein and vitamins A and C, and other parts of the plant have medicinal uses (Ravikumar et al., 2025; Derwand & Scholz, 2020; Singh et al., 2020; Houdegbe et al., 2022; Lubna et al., 2025) used in many cultural ceremonies where flowers are boiled and used in stews or as a leafy green side dish (Simpson et al., 2025a). It belongs to kingdom plantae, division Angiosperm, class Dicotyledonae, order capparidales, family cleomaceae, genus Cleome, and species gynandra (Lestari et al., 2025). The Capparaceae family is composed of Capparoideae, mainly woody, and Cleomoideae, mainly herbaceous (Nakyewa et al., 2021)). Spider plant (Cleome gynandra L.) is a C4 monocotyledoneae diploid plant in the Capparaceae or Cleomaceae family with thirty, thirty-two, thirty-four and thirty-six (2n=2x=30, 32, 34 or 36) chromosomes depending on the genotype (Afzal et al., 2020). The plant consists of about 150-200 different Cleome species, and 50 of them are known to occur in the tropics and sub-tropics. Spider plant is a highly polymorphic herb; it is claimed to have originated from Southern Asia to the Middle East, Africa, and South America (Blalogoe et al., 2020).

Plate 1.1 Clear photo of whole Spider plant (Cleome gynandra. L)

Furthermore, in Kenya, the Spider plant is a major contributor to the total dietary antioxidants when compared to several other indigenous vegetables. Spider plant (*Cleome gynandra L.*) is one such indigenous vegetable that has been reported to be superior to exotic vegetables such as cabbages, it has also been suggested through research that dietary polyphenolic phytochemicals such as flavonoids, polyphenols, glucosidases, terpenoids, and essential ions accumulate in the leaves of Spider plants, thus promoting health through retardation or inhibition of chronic diseases development (SP et al., 2025; Somers et al., 2020; Apriliyati & Pasan, 2024; Moyo et al., 2021). This crop has traditionally been collected from wild and fallow lands for home consumption, its production has expanded to fields and peri-urban areas, and moved to nutrition gardens (Azab, 2025). In Kenya, Spider plant vegetable is now sold in various supermarket outlets example Naivas, Chandarana, Khetias, and hotels, offering income opportunities for women and youth farmers (Mashamaite et al., 2022). Researchers should begin with the provision of high-quality seeds to the smallholder farmers, considering seed germination issues, marketing, user needs, and employing diverse methods that can be used to propagate the crop (Ndinya et al., 2020; Assongba et al., 2021; Colley et al., 2022; Okot et al., 2022). Seed germination has emerged as a top priority in Spider plant breeding, despite poor germination due to seed dormancy negatively impacting Spider plant crop establishment and yield. Studies on the seed germination of the Spider plant emphasize the importance of good germination. In contrast, poor germination has led to the rejection of the variety by smallholder farmers (Ndinya et al., 2020). To address this production challenge, there is a need for high-quality seeds, which can be achieved through seed treatment/coating, improved storage practices, and the development of improved varieties (Mativavarira et al., 2024; Sohindji et al., 2020; Thovhogi et al., 2021). Several seed pre-treatment options have been identified, which increase germination and even seedling vigour, including the use of gibberellic acid (Mativavarira et al., 2024; Sohindji et al., 2020; Tapfumaneyi et al., 2023; Zheng et al., 2024; Zou et al., 2024; Zhang et al., 2022). This helps with a fast growth rate, the capacity to produce an abundance of pods, and achieve good seed yield for smallholder farmers in drier areas. Similar observations on the lack of quality Spider plant seeds have been reported in Namibia and Malawi (Chataika et al., 2022). Over the last 20 years, several collaborative research and development efforts were initiated on indigenous vegetables, including Spider plants (Govindasamy et al., 2020). Nevertheless, studies in Kenya have shown that variety improvement does not guarantee acceptance and adoption by farmers unless the improved genotypes possess desirable traits and solve the prevailing norms on the ground (Nakyewa et al., 2021). Growing AIVs is a way of increasing crop diversity within local systems to cushion the effects of climate change. Despite its nutritional and medicinal value, the production and performance of Cleome gynandra L. are constrained by challenges related to seed quality and germination due to physiological seed dormancy that exhibits the crop (Simpson et al., 2025), The quality of seeds is critical for successful crop production, as it directly affects the growth, yield, and overall health of the plants. To improve seed quality and enhance crop performance, advanced techniques such as seed pelleting have been developed. Seed pelleting involves applying external materials to seeds to deliver beneficial compounds, such as protectants, germination promoters, and growth enhancers (Qiu et al., 2020; Riseh et al., 2024). This process not only improves the physical characteristics of seeds, such as size and shape, making them easier to handle but also ensures the even distribution of active ingredients, which can lead to more uniform germination and plant vigour and storage of seeds (Andres et al., 2024; Afzal et al., 2020). Research indicates that pelleted seeds tend to maintain higher quality during storage compared to non-pelleted seeds, which is critical for preserving seed viability and vigour. Pelleting has been shown to enhance the physiological and biochemical attributes of seeds, resulting in improved germination rates and seedling vigour. However, some studies, such as those involving tomato (*Solanum lycopersicum*), have reported delays and reductions in germination and seedling emergence. These issues may arise due to the physical constraints imposed by the pelleting materials on the emerging radicle. In contrast, for African leafy vegetables such as jute (*Corchorus olitorius*), amaranth (*Amaranthus blitum*), and Spider plant, pelleting has demonstrated potential in overcoming problems related to poor germination and seedling growth for Cleome gynandra, seed pelleting has proven beneficial in enhancing germination rates, seed vigour, and storage potential (Khatun et al., 2024). Additionally, pelleting can improve the survival and performance of plant growth-promoting rhizobacteria (PGPR), which play a crucial role in plant health and productivity. Studies have shown that pelleted seeds, especially those treated with PGPR, exhibit higher viability and longer shelf life under fluctuating environmental conditions compared to untreated seeds (Kang et al., 2021). These findings highlight the importance of seed treatments in ensuring successful crop establishment and providing protection against various biotic and abiotic stresses. The use of seed pelleting and other seed treatment techniques is increasingly recognized as an essential component of modern agricultural practices, particularly for crops like Cleome gynandra L. that are critical for food security and nutrition in many parts of Africa.

MATERIALS AND METHODS

Study Area

The study site was located in Uasin Gishu County. The County lies between longitudes 34 degrees 50’ east and 35 degrees 37’ West and latitudes 0 degrees 03’ South and 0 degrees 55’ North. It is a highland plateau with altitudes falling gently from 2,700 meters above sea level to about 1,500 meters above sea level. The County borders Trans-Nzoia County to the North, Elgeyo-Marakwet and Baringo Counties to the east, Kericho County to the South, Nandi County to the South, and Kakamega County to the west. According to 2019 Kenya Population and Housing Census, University of Eldoret, is 9 km from Eldoret town in Uasin Gishu County, the choice of the study sites was based on the fact that communities living within consume relatively more African leafy vegetables, it is diverse in cultures, a mix of urban and rural setup, highly populated thus demand and supply curve correlates hence a reliable weather and rainfall pattern in addition, extensively availability of

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fertile soils. On the site of the research experiment, soils were sampled at 30 cm depth before planting and analyzed for soil pH and nutrients at the University of Eldoret Soil Science Laboratory

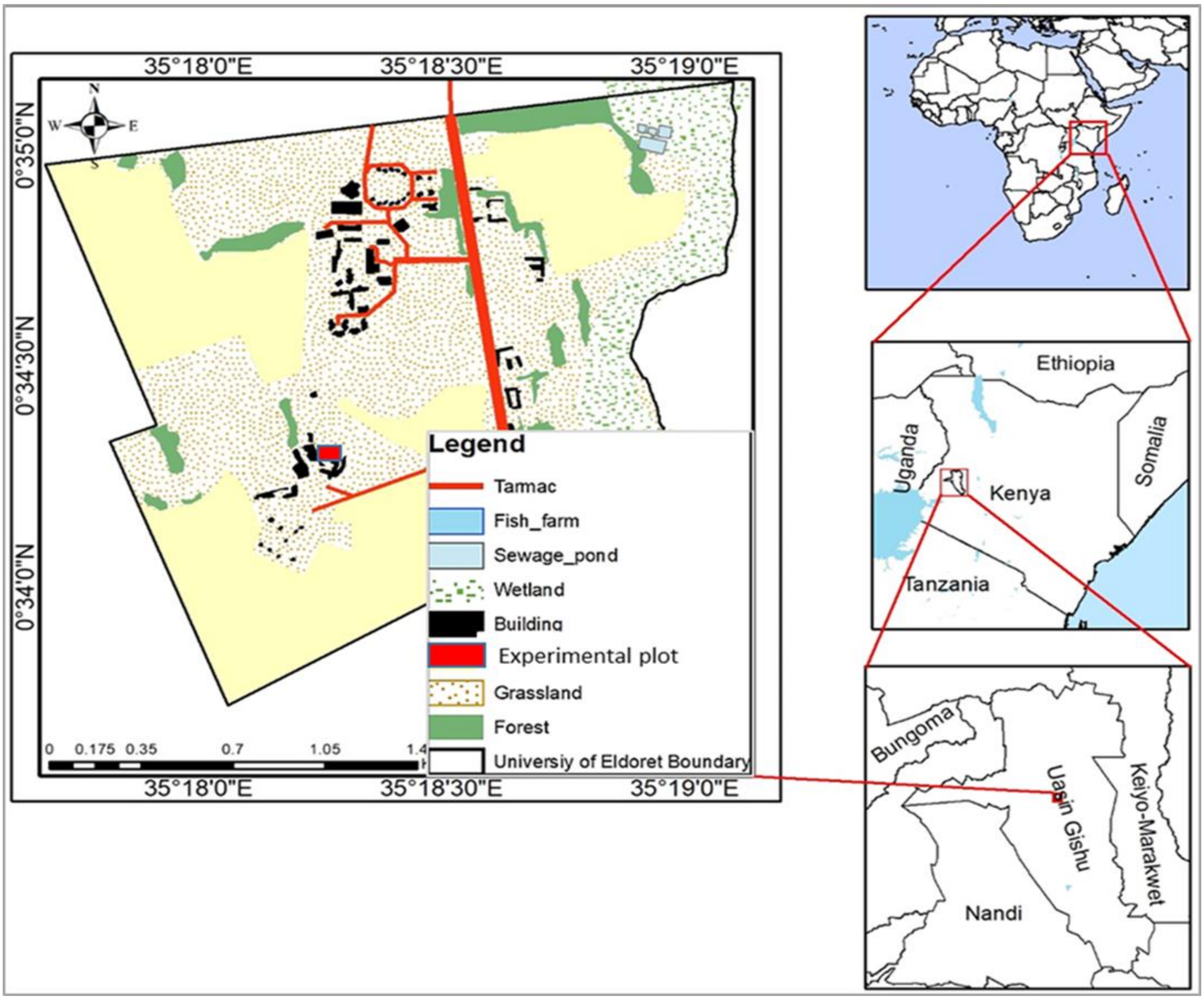

Figure 3.1: Location of the experimental site, University of Eldoret

Experimental Design

The field experiment was laid out in a Randomized Complete Block Design (RCBD), with twenty different treatments and three replicates for 60 trial plots. The experimental field was slashed to clear the land, trash collected and placed at the corner of the plot for decomposition, then tilled using a disc plough to evenly turn the soil and harrowed using a faima spined-toothed harrow to a fine tilth using a tractor. The experimental plot size was 2.0m × 2.0 m. blocks were each separated by a 1 m path, while the inner walk path measured 0.5m each. At planting, seeds were broadcast within each row for even coverage of seeds on each treatment planted within rows and later thinned to 20 plants per plot. No chemicals were used to control weeds as weeding was done manually using a fork 'jembe' for clean seedlings and to reduce competition for water. Treatments were based on the same planting methods without inorganic fertilizer and seed pellets only. Surface irrigation was done using a 20-litre plastic watering can on each treatment. The experiment was carried out from November 2021 to March 2022 during the dry season.

Treatment structure and layout

Seed coating used in this experiment is defined as pelleting because the size and weight of the seed were increased (Mativavarira et al., 2024). The treatments tested in this study were:

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1. Control farmer- NCS
2. Farmer gibberellin small-NCSGAS
3. Farmer gibberellin medium-NCSGAM
4. Farmer gibberellin large- NCSGAL
5. Farmer manure small-NCSMAS
6. Farmer manure medium-NCSMAM
7. Farmer manure large- NCSMAL
8. Farmer clay small- NCSCS
9. Farmer clay medium-NCSCM
10. Farmer clay large- NCSCL
11. Agrovet control- CS
12. Agrovet clay small- CSCS
13. Agrovet clay medium- CSCM
14. Agrovet clay large- CSCL
15. Agrovet manure small- CSMAS
16. Agrovet manure medium-CSMAM
17. Agrovet manure large- CSMAL
18. Agrovet gibberellin small- CSGAS
19. Agrovet gibberellin medium- CSGAM
20. Agrovet gibberellin large- CSGAL

Sizes of pelleting in the Experiment

- S-small, (<2.00 mm)
- M-medium, (<3.35 mm)
- L-large (>4.50 mm)

Data collection

On the field experiment, in Uasin Gishu County, Kenya. Data was collected on number of days to seed emergence, seedling emergence percentage, plant height (cm), and root length (cm). In the field six plants were randomly selected from each treatment for data collection.

Data analysis

Statistical analysis on the data was performed using R statistical software v4.5.1. The normality was checked for each variable using the Shapiro-Wilk test. An LMER model was used to evaluate the effects of binding material, seed source and size on different plant variables. The binding materials, sources, and pellet sizes were fixed factors while the replicates were treated as a random factor. Further, significant interactive effects of sources and sizes were assessed separately for each binding material using the lmer function. Thereafter, the means were separated at 5% level of significance. Variability within each quantitative trait was calculated using statistical measures of mean. The values are means of replicates ± Standard error (SE); (within a column, means followed by the same letter are not significantly different, p = 0.05).

RESULTS AND DISCUSSIONS

The Number of Days to Seedling Emergence

Spider plant (*Cleome gynandra L.*) treatments varied ($P < 0.05$) in the number of days to seedling emergence (figure 4.1). In the field experiment, GA3 manure×clay ×control ×spider plant interaction significantly affected the number of days to seedling emergence. GA3 treatment had an average of 3 days from sowing to emergence compared to an average of 9.4 days to emergence recorded in the field. About 75% of seedling emergence was recorded an average of 4 days to seedling emergence, while 55% of seed pellets with manure emerged in 7

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days. And 38% of the seed pelleted with clay and 25% on the control, respectively. Days to seedling emergence ranged from 0-4 days per treatment, as observed in Figure 4.1. These variations may be attributed to possible differences in seed enhancement materials. The consequence of using seed enhancement media GA3 showed dominance in fastening the germination index, unlike clay, which took a long time to germinate due to the complexity in soil structure that resulted in a poor final plant germination, hence revealing low growth per plot per unit area in the replicates on the field. The control emerged after 8 days in the field, compared to GA3 treatment, which took 4 days, recording an early emergence. Spider plant seed pellet treatments varied significantly at $P<0.05$ in seedling emergence for the field-grown experiment. In the field experiment, the treatment × size of spider plant seed pellet interaction had significant effects on seedling emergence. In the field experiment GA3 recorded an average seedling emergence of 72.9% compared to 41.8 % for manure, 34% for clay and 30% for control within 5 days from the day of planting thus clearly showing a higher seedling emergence than the control in comparison, Seedling emergence percentage among the seed pellet size also varied with germination percentage in which medium pellet showed an continuous curve in terms of growth which was regular germination across the board this attributed by the even spread of binding material to seed. The differential response of seed pellet to germination indicated the difference in binding material, respectively, to growth and development, which led to recording higher seedling emergence than other treatments. The variability in seedling emergence in the two seed source types was attributed to variations of genotype between improved cultivar as compared to farmer saved seed marked during the seedling emergence in (Figure 4.1)

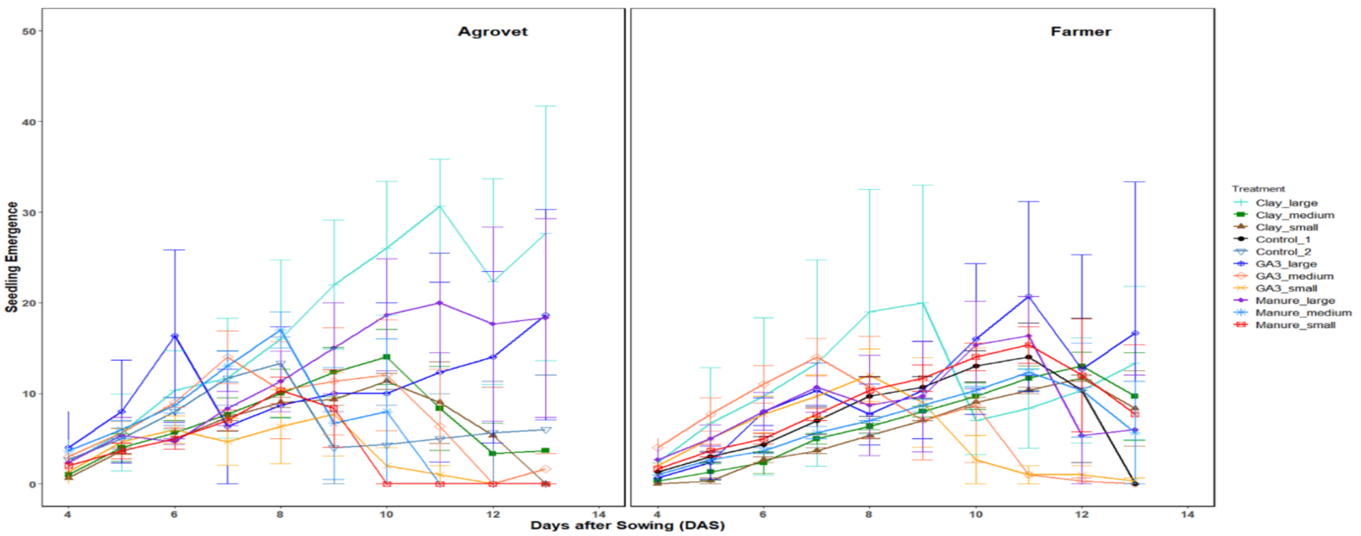

Figure 4.1: Seed emergence across different binding materials and pellet sizes, days after planting in the field experiment

Root length

The general effect of the binding material, pellet size, and seed source on the root length is shown in **Error! Reference source not found.**. When using clay as a pelleting material, the source of seed influenced the root length ($p < 0.05$; Figure 4.2), with farmer-saved seeds exhibiting the longest root length of 8.3 cm compared to the 7.3 cm in the certified seeds from the agrovet, across different pellet sizes. On the other hand, there was no root length variation as influenced by the pellet size ($p > 0.05$), with the root length varying between 7.8 and 8.0 cm across the two sources. Overall, medium-sized pellets sourced from farmer-saved seeds had the longest roots, 8.4 cm, relative to the other pellet sizes across the two sources. When using manure as a pelleting material, no variations were observed regardless of the seed source ($p > 0.05$; **Error! Reference source not found.**), with certified seeds slightly edging the farmer-saved seeds by 0.3 cm across the different sizes. There was a significant interaction effect of seed source and pellet size on the root length ($p < 0.05$). The longest roots were observed in the medium-sized pellets obtained from the certified seeds (agrovet) – 9.9 cm, while the rest varied from 8.7 to 9.5 cm (**Error! Reference source not found.**). When using GA3 as a pelleting material, there was a significant main and interaction effect of seed source and source and size on the root length ($p > 0.05$); however, the pellet sizes did not influence the root length ($p > 0.05$). On average, seeds sourced from the

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farmer had extended root length (8.2 cm) compared to the certified seeds from the agrovet (7.5 cm) (**Error! Reference source not found.**). Lastly, the non-pelletized seeds did not exhibit any variations between the two sources ($p > 0.05$); however, the certified seeds (from the agrovet) had the longest roots, measuring 7.2 cm, while the farmer-saved seeds measured 7.1 cm (**Error! Reference source not found.**).

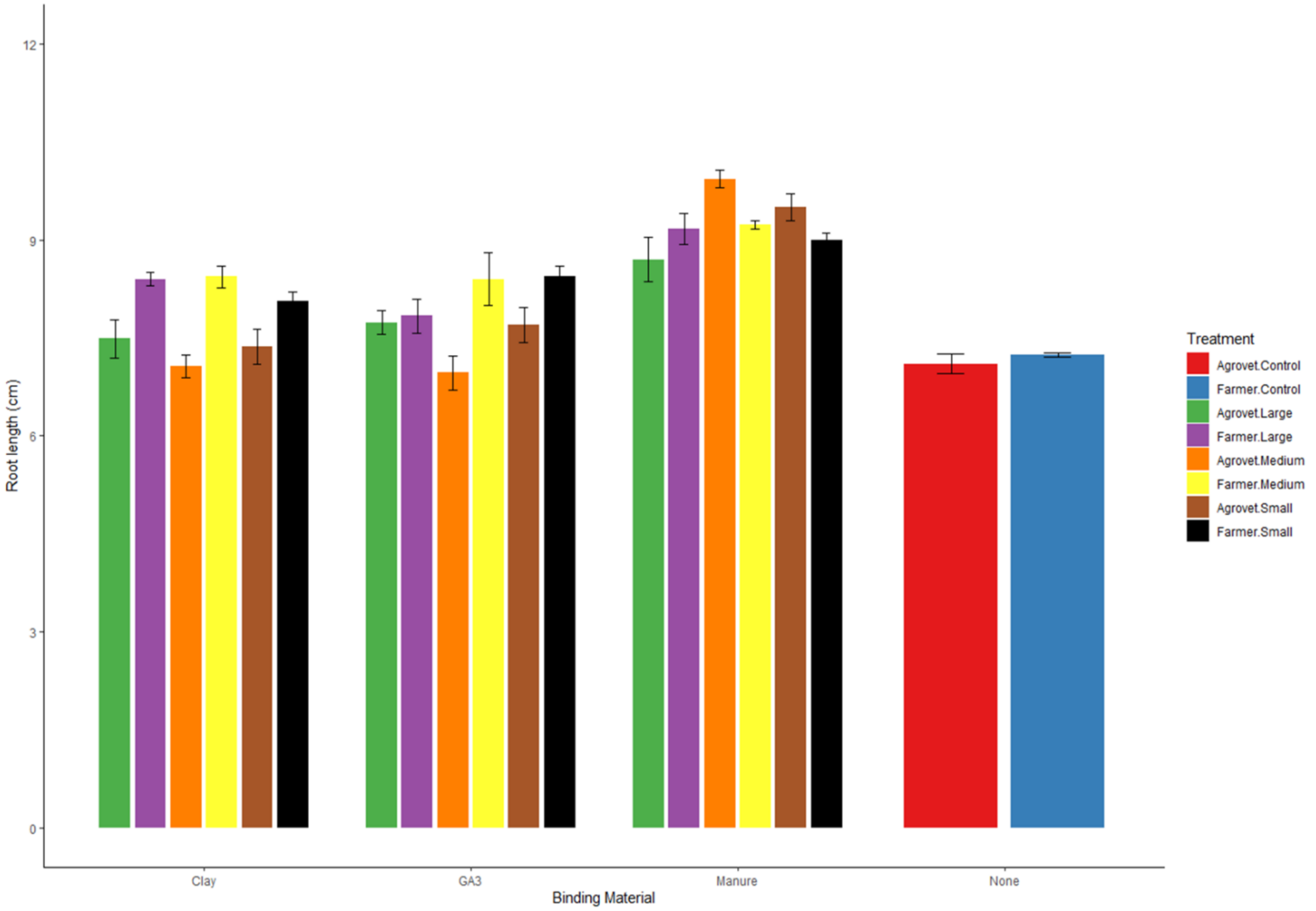

Figure 4.2: Measure of root length (cm) of the spider plant (Cleome gynandra L.) against different binding materials.

Plant height

In the experiment, the Spider plant varied in plant height between certified and farmer-saved seeds across different pelleting materials. When using clay to pelletize the seeds, the interaction effect of pellet size and seed source on the plant height was not observed ($p > 0.05$; **Error! Reference source not found.**). The plant height averaged 24 cm, with height values ranging between 20 and 26.9 cm in the small-sized pellets (< 2.0 mm) sourced from certified seeds and large pellets (> 4.00 mm) from farmer-saved seeds, respectively (Figure 1). When using manure, significant variations were observed across the individual main effects of the two sources of seeds and pellet size, as well as their interaction ($p < 0.05$). Large agrovet pelletized seeds attained the most height (47 cm), while the rest were under 45 cm (Figure 1). While using GA3 as a pelleting material, there was a significant main effect of individual source and size on the overall plant height ($p < 0.05$). The largest plant height was attained when the pellets were large, 88.3 and 97.3 cm, certified and farmer-saved seeds, respectively (Figure 1). The non-pelletized seeds did not exhibit any variations in terms of plant height, regardless of the source, 21.4 and 19.4 cm for certified and farmer-saved seeds, respectively. Plant height is an important agronomic parameter that reveals the crop's vegetative growth behavior. tallness is important for good vigor, enabling the plant to grow to the height required for easier weeding and harvesting during production. Tallness facilitates free air circulation in the plant, thus preventing pests and diseases. In agreement with the findings of SP. et al., 2023, Thovhogi et al., 2025. There was a strong, significant positive

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correlation between plant height and the number of leaves per plant. In vegetable crops, short plants and low plant density lead to a low rate of photosynthesis, resulting in low leaf yield

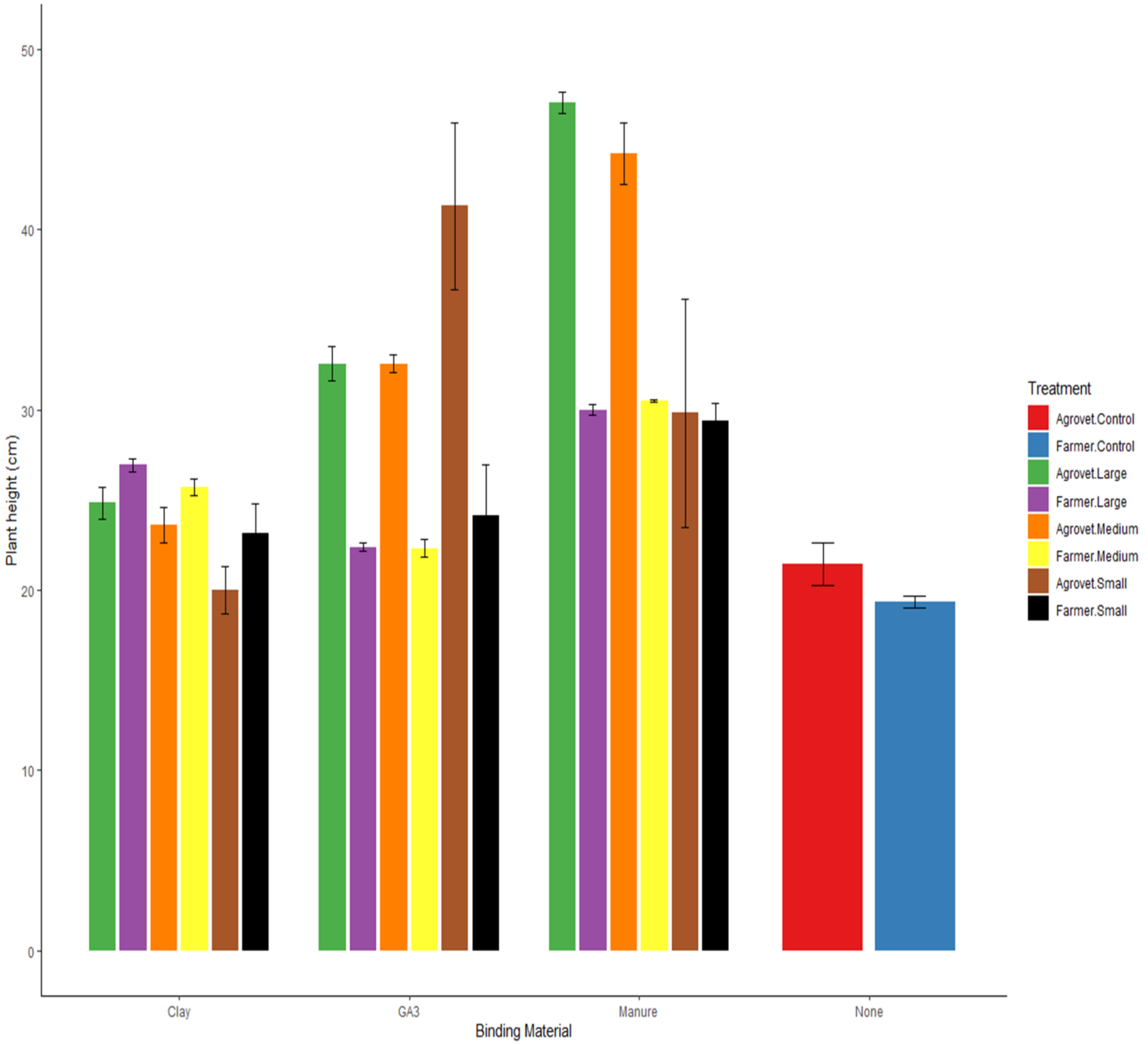

Figure 1.3: Effect of seed pelleting on the plant height of spider plant (Cleome gynandra L.)

The Number of Leaves Per Plant

The general effect of the pelleting material on the number of leaves is shown in

Figure 4.4. When using clay as a pelleting material, the main effect of pellet size and source of seeds did not seem to improve the number of leaves in the spider plant ($p > 0.05$). However, large-sized pellets exhibited the highest number of leaves, 11, followed by the medium and small-sized pellets, 10 and 9, respectively, across the different sources. On average, the highest number of leaves was observed in the large-sized pellets sourced from the farmer seeds (12) compared to the rest, which averaged 9 leaves. When using manure, there was a positive effect of pellet size and the interaction between source and size ($p < 0.05$; **Error! Reference source not found.**), which increased the number of leaves on the spider plant, with numbers ranging between 7 and 13 leaves across different pellet sizes and seed sources (

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Figure 4.4). The highest number of leaves was recorded in the medium-sized pellets sourced from farmer-saved seeds, which differed significantly from the rest. On the other hand, the least was also from the farmer-saved seeds, but of small-sized pellets (

Figure 4.4). When using GA3 as a pelleting material, the source of seeds markedly influenced the number of leaves observed (

Figure 4.4), with large-sized pelletized certified seeds exhibiting the highest number of leaves (13) while the rest averaged below 11. On average, the non-pelletized seeds did not exhibit any variations between the two sources; however, certified seeds (from the agrovet) had the highest number of leaves (7) while farmer-saved seeds had the least (6) (

Figure 4.4).

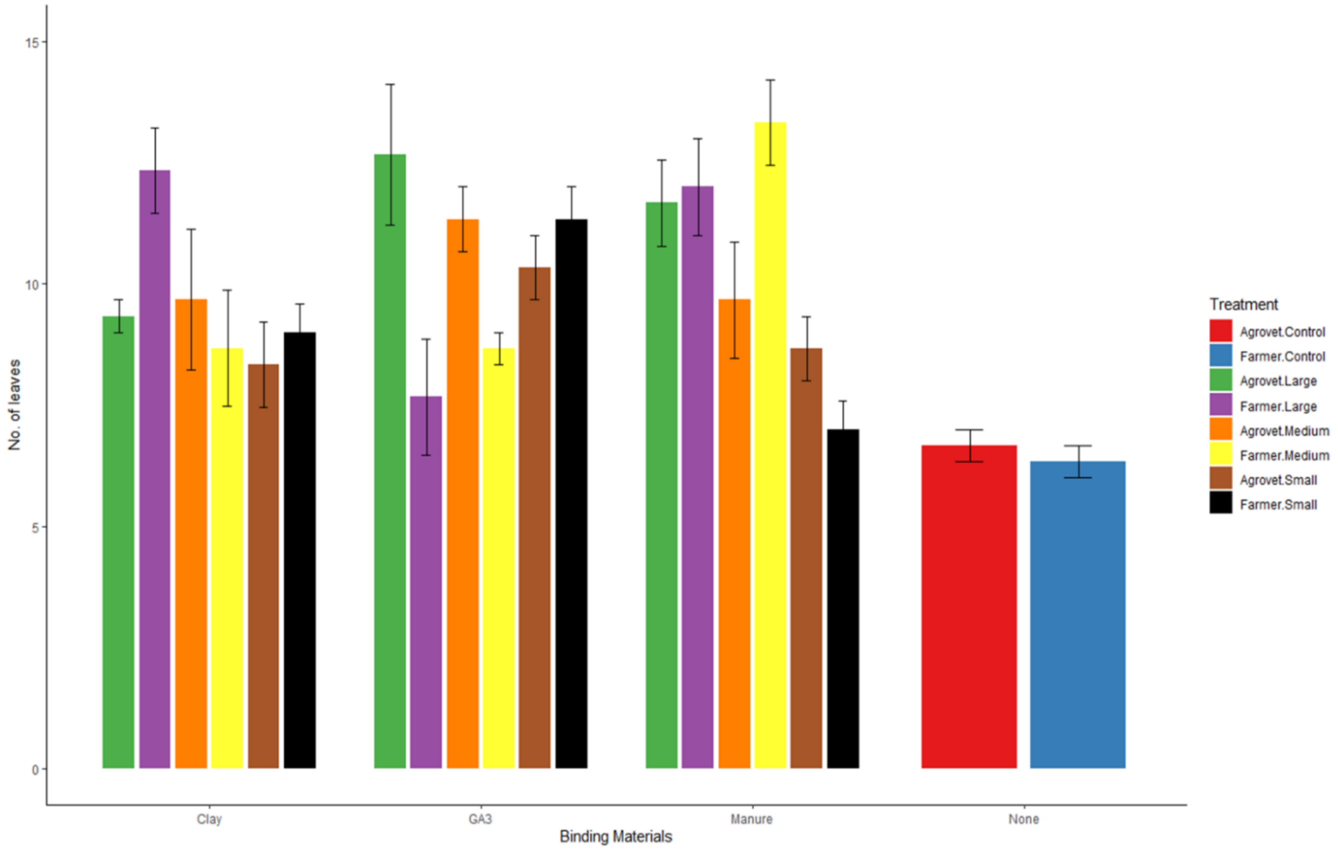

Figure 4.4: Number of leaves per plant of spider plant (Cleome gynandra L.) against binding material

DISCUSSION

Seeds that have attained physiological maturity will germinate once the dormancy is broken and when the necessary germination conditions are available. Days to seedling emergence varied with treatments GA3 48, clay 32, manure 19, control 10, implying that the longer it took for seeds to grow, which resulted in more days to seedling emergence resulted in reduced plant vigor as exhibited in shorter plants and lower pod number, leading to low seed and leaf yield. Seeds that take longer in the soil before germinating are prone to higher chances of attack by soil-borne pests and diseases that reduce their emergence (Afzal et al., 2020). Dadlani (2025) reported that a high seedling emergence percentage is a prerequisite for successful commercial vegetable production. Germination percent and seedling emergence increase with high 1000-seed weight (Riseh et al., 2024). In the field experiment, the number of leaves had a significant effect on fresh weight, with a similar study by Mativavarira et al. (2025). Seed pelleting of farmer variety (*Cleome gynandra L.*) (17g) was outperformed by 90% of the Agrovet variety (75g) in 1000 seed weight. However, leaves are the primary sites of photosynthesis in crop plants; therefore, in the field experiment, one might assume that the higher the number of leaves in the spider plant seedling, the better the interception of sunlight and the higher the leaf yield (Simpson et al., 2025). The number of leaves per plant recorded a significantly positive correlation with plant height, respectively. An increase in the number of leaves is associated with an increase in pod formation (Gomez et al., 2025). GA3 Agrovet large pelleted using manure recorded the highest number of leaves per plant (14 leaves) in the field experiment. Tallness facilitates free air circulation in the plant, thus preventing pests and diseases. There was a strong, significant positive correlation between plant height and the number of leaves per plant (Figure 4.4). In vegetable crops, short plants and low plant density lead to a low rate of photosynthesis, resulting in low leaf yield (Zheng et al., 2025). The poor seedling emergence recorded among the treatments presents a key parameter of focus by breeders in spider plant improvement programs. The research showed that pelleted Cleome gynandra seeds had higher germination rates and better seedling establishment than non-pelleted seeds. This research was focused on seed pelleting as a major seed enhancement technique on various seed quality parameters. The use of seed enhancement technologies is the future, as it maximizes profit minimizing production costs due to mechanization at the propagation level, provides a relatively sufficient amount of seed rate per plot, manages losses in terms of seed as an input of production, and is easier to handle (pellet size), resulting in even distribution of small seeds and a reduction in the number of seeds required to plant a given area compared to traditional planting methods.

CONCLUSION AND RECOMMENDATIONS.

In the experiment, different seed pelleting treatments exhibited significant differences in germination. farm-saved seed experienced a low seed germination percentage as compared to improved seed cultivars (Agrovet). In addition, medium seed pelleting yielded more and even seed germination compared to large and small seeds. It was concluded that medium pellet seed size (<3.5mm) recorded maximum germination, seedling quality characteristics, field emergence with high vigour, pelletisation efficiency with uniform pellet size, and reduced seed rate throughout sowing. Seed pellet size of <3.5 mm was recommended as the optimum pellet size for smallholder farmers sowing Cleome gynandra seeds. In the experiment, the decrease in germination and seedling vigour parameters with increasing storage period could be attributed to the damage to membranal enzyme, proteins and nucleic acids resulting in the complete disorganization of membranes and cell organelles in the seed unlike the potential summation on reasons behind the observed improvement and maintenance of high germination rates through the use of a micronutrient mixture are attributed to various factors related to plant secondary metabolites, membrane stabilization, and free radical detoxification facilitated by the mineral elements present in seed pelleting mixture. The appropriate seed pelleting materials to use is manure this is because; in general manure performed better than clay across the germination performance treatment on the field more so in terms of socio-economics status on most of smallholder farmers, it is cost effective, readily available, organic thus improves soil structure in addition increase soil fertility thus nourishes the seed during germination and growth.

Statements and Declarations

Conflict of Interest: I declare that this is an original scientific field research that was undertaken at School of Agriculture and biotechnology, University of Eldoret, Kenya. The authors have no competing interests to declare, that are relevant to the content of this article.

Competing Interests:

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Data availability:

All data have been surrendered to the publisher journal for public review and use.

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