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Effect of seed pelleting on the growth and yield performance of sesame (*Sesamum indicum* L.) cultivation

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***Abstract*—**Sesame (*Sesamum indicum* L.) is an underutilized oilseed crop that has greater potential to serve as alternative food and feed source. However, sesame cultivation is limited due to the small seed size with poor rates of germination, which has a substantial impact on crop field establishment. Hence, the present study was carried out to evaluate the effects of artificial seed coating (pelleting) on crop establishment via conventional and mechanization means. Here, six different treatments (T1 (Pelleted seeds+Seeder), T2 (Pelleted seeds+Row planting), T3 (Pelleted seeds+Broadcasting), T4 (Naked seeds+Seeder), T5 (Naked seeds+Row planting), and T6 (Naked seeds+Broadcasting)) were arranged in Randomized Complete Block Design (RCBD) with three replicates. The results showed that the germination, root, and yield characteristics of sesame plants were significantly ($p<0.05$) affected by the treatments. The germination indices were significantly higher in naked seeds compared to pelleted seeds. The highest root width (15 cm) and volume (6.11 cm^3) were recorded in T3 while the lowest was in T5 (7.7 cm) and T6 (1.71 cm^3) respectively. The highest number of capsules per plant (63) was in T3 while T4 had the lowest (18). The number of seeds per capsule was higher in T1 (53) while the lowest was in T5 (31) and T6 (32). T1 resulted in the highest total yield (1404 kg/ha) conversely, T3 gave the lowest (253 kg/ha). Thereby, pelleted seeds sown using seeders enabled successful crop establishment and yield performances compared to other treatments.

***Keywords*—**Artificial seed coating, Broadcasting, Germination indices, Row planting, Mechanization.

I. Introduction

Sesame (*Sesamum indicum* L.) is an ancient oilseed crop grown in tropical to temperate regions of the world for its flavour and high-quality oil (Kant *et al*., 2021; Rathod *et al*., 2021). It is drought tolerant and grows well in a variety of soils and temperatures. Sesame seeds are high in edible oil (50 %), as well as protein (23 %) and carbohydrates (15 %) (Ranganatha *et al*., 2012). They also have been identified as a good source of high-grade oil with a high percentage of unsaturated fatty acids and antioxidants (Dissanayake *et al*., 2017) and are used in several food products and industrial uses (Akbar *et al*., 2011). Despite its nutritional value and historic importance, sesame is still considered an under-utilized crop (Topakci *et al*., 2011). According to Grain Legumes and Oil Crops Research and Development Centre, Sri Lanka (GLOCRDC, 2017), sesame is one of the significant rain-fed oilseed crops and is grown to a total extent of 13,120 ha in 23 districts in Sri Lanka.

The primary constraints in sesame production are smaller-sized seeds, reduced yield, and seed losses (Day, 2000). Sesame seeds are often broadcast and plucked by hand, resulting in production losses (Doan *et al*., 2005). The root cause of this is the harvesting schedule, which cannot be adjusted. Since plant development is uncertain and capsules split when mature, deciding the exact time of harvesting for optimum production is tricky. The presence of underdeveloped seeds towards the top of the plant reduces the seed quality of the entire crop if plants are picked early and if plants are picked late, seeds from the earliest ripening capsules may be lost by the reducing production (Day, 2000). As a result, synchronized seed maturation is critical in avoiding harvest losses and permitting mechanized harvesting.

Plant breeding and systematic planting can assure the uniform maturity of sesame seeds (Barut Çağırgan, 2006). In uniform sowing, seeds are planted with the same spacing and depth in each row, promoting healthy and quick root and crop growth. It also makes it easier to distribute, cultivate and harvest the plants mechanically. As a result, the traditional sesame seed broadcasting approach should be replaced with uniform planting. Single seed planters and drills are commonly used for sowing row crops like maize, cotton, soybeans, and sunflowers (Onal, 2006). Tiny sesame seeds cannot be planted in these planters unless special hoppers are installed that can equally control the flow of tiny seeds

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(Afzal *et al*., 2020). Sesame seeds are about 3 to 4 mm long, 2 mm wide, and 1 mm thick (Kalaiyarasi Ramu, 2018). However, if tiny seeds, such as sesame, are to be sown by highly precise planters, various methods such as seed coating must be used to optimize their size and shape. Therefore, it is indispensable for evaluating the seed coating techniques.

Artificial seed coating/pelleting technology has been practiced for small, rough, and shapeless seeds to change their size and shape to improve the machine sowing and plant establishment (Barut, 2008). Moreover, it has the advantages of improving seed germination and protecting the seeds from pests, and cold and wet soil (Coombs *et al*., 2004; Doğan *et al*., 2005). Generally, pelleting a seed includes four key components; seeds, pelleting materials, binding agent, and coating machine. Different pelleting materials, including sand, clay, limestone, sawdust, chalk, peat, and calcium carbonate have been utilized to cover tiny vegetables and flower seeds (Halmer, 2000). In contrast, starch, cellulose, and polyvinyl have been used as binders. The composition and thickness of the pelleting materials directly influence the water and oxygen transfer to the embryo and modify the seed germination (Grellier *et al*. 1999).

Previous studies have proven the success of the artificial seed coating technique in many crops, including rice (Zeng *et al*., 2009), maize (Yang *et al*., 2014), wheat (Oliveira *et al*., 2016), cowpea (Rocha *et al*., 2019), tomato (Koohakan *et al*., 2020), cucumber (Keawkham *et al*., 2014), okra (Prasher *et al*., 2020), sunflower (Dawar *et al*., 2008) and sesame (Barut Çağırgan, 2006). Hence, this study aimed to investigate the effects of the artificial seed coating in facilitating the mechanization of sesame seeds in the Dry Zone of Sri Lanka.

II. Materials and Methodology

A. Study area

The research study was conducted at Grain Legume and Oil Crops Research and Development Center (GLORDC), Angunakolapelessa (6º 27' N and 81º 1' E), situated in the DL1b agro-ecological zone of the Southern Dry zone of Sri Lanka, during the Maha season (September to March) of 2020/2021. The soil of the experiment site was reddish-brown earth.

B. Preparation of pelleted seed granules

The sesame seeds of a variety of Uma were used in this study. Seeds were cleaned, and all the foreign matters including stones, dirt, and broken seeds were removed. Seed coating was done utilizing the ingredients in ratios as shown in Table 1 using a mini concrete machine. Initially, seeds and soil were mixed well by adding water and transferred to the machine. Then sugar syrup and lime were added. Sugar syrup was used as binding material, whereas lime was added as a drying agent. After preparing pelleted seed granules, they were dried under direct sunlight. Finally, the prepared granules were sieved using a sieve (no 5) to obtain uniform-sized seeds with an average diameter of 3.9 mm.

Table I: The total amount of ingredients used to prepare pelleted seed granules per ha.

Ingredients	Amount
Seeds	10 kg
Clay	420 kg
Poultry manure	19 kg
Water	180 l
Lime	0.7 kg
Sugar syrup	0.7 l

Table II: Different treatment combinations used in the field evaluation

Treatment No	Treatments
T1	Pelleted seeds + Seeder
T2	Pelleted seeds + Row planting
T3	Pelleted seed + Broadcasting
T4	Naked seed + Seeder
T5	Naked seed + Row planting
T6	Naked seed + Broadcasting (Control)

C. Plant establishment and field evaluation

The field experiment was laid out in Randomized Complete Block Design (RCBD), with six different treatments (Table 2) and three replicates for 18 trial plots. Each plot was 2m long and 2m wide. Treatments were based on different planting methods and seed coating. The broadcasting method at the rate of 7 kg/ha was done as a control treatment while row planting with the spacing of 30 cm x 15 cm and planting with a manually operated multi-functional hand push planter with the spacing of 15 cm were evaluated as treatments for both pelleted and naked seeds. Surface irrigation was done with fungicide application.

D. Data Collection

The days taken to seedling emergence, the number of seeds germinated, mean germination time, and Germination Index (GI) of sesame plants were recorded. GI was calculated using the following formula (Szafraniec *et al*., 2019).

$$Germination\ index\ (GI) = \frac{No.of\ germinating\ seeds}{Days\ of\ the\ first\ count} + \ldots + \frac{No.of\ germinating\ seeds}{Days\ of\ the\ final\ count} \quad (1)$$

Plant height was recorded from 2 WAP (Weeks After Planting) up to 9 weeks from 6 plants in each replicate weekly. In addition to that, days taken to 50 % flowering and maturity were also recorded. The number of capsules per plant, seeds per capsule, and total yield were obtained from 10 plants per plot at harvest. Under root characteristics, root length, width, and volume of 3 plants in each replicate were measured. Root length and width were measured using a 30 cm ruler, while root volume was measured using the volume displacement method (Zuno-Altoveros *et al*., 1990; Himasha *et al*., 2022).

E. Data analysis

Data analysis was done using SPSS software (Version 25), and the one-way analysis of variance (ANOVA) was used for the statistical comparison of the treatments. At 0.05

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Table III: The effect of seed coating treatments on germination index and mean germination time of sesame plants.

Treatment	Germination index	Mean germination time (Days)
T1	10.7±1.2^{bc}	13.3±0.3^{a}
T2	6.4±1.8^{c}	13.0±0.0^{a}
T3	1.2±0.3^{c}	13.0±0.0^{a}
T4	25.1±1.8^{ab}	12.7±0.3^{a}
T5	26.6±5.4^{ab}	12.3±0.3^{a}
T6	36.3±5.5^{a}	12.3±0.3^{a}
P-value	<0.0001	0.122
CV (%)	77.6	4.3

The values are means of replicates ± Standard error (SE); Within a column, means followed by the same letter are not significantly different Tukey's posthoc test at p = 0.05.

probability levels, Tukey's posthoc test was performed to find a significant difference between treatment means.

The values are means of replicates ± Standard error (SE); Within a column, means followed by the same letter are not significantly different Tukey's posthoc test at p = 0.05.

III. Results and Discussion

A. Germination of sesame plants

There was a significant (p<0.05) difference between treatments for the number of germinated plants/m2 and germination index, but not for the mean germination time (p>0.05). Figure 1 shows the effect of different treatments on germinated seeds/m2. According to that, the naked seeds reported higher germination compared to the pelleted seeds. The highest number of germinated plants/m2 in the first, second, and third week (185, 416, and 469 respectively) and the germination index (36.3) were reported when broadcasting naked seeds (T6). The lowest number of germinated plants/m2 (2, 13, and 15 respectively) were observed in T3 together with the lowest germination index (1.2) (Table 3). Moreover, pelleted seeds had a significantly lower germination index compared to naked seeds. This can be due to the pelleting material and its thickness either hindering or delaying germination. Barut (2008) also found that sesame seed germination is delayed due to seed covering.

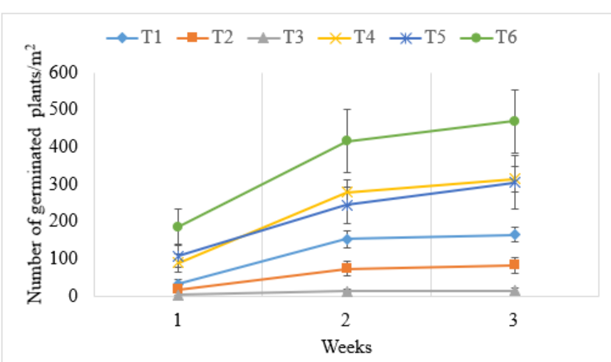

Figure 1: The effect of seed coating treatments on germination of sesame plants. (Vertical bars represent ± standard error)

B. Height of sesame plants

Different seed treatments had a significant (p<0.05) effect on the seedling height of sesame except at the 7th week of plant establishment. For the first 2nd, 3rd, and 4th weeks, the tallest plants (5.9 cm, 15.3 cm, and 32.4 cm respectively) were observed when used seeder with the naked seeds (T4) while T3 recorded the lowest plant height until 6 weeks of plant establishment (5.9 cm, 7.2 cm, 21.6 cm, 44.7 cm, and 68.0 cm). In the last 3 weeks, T2 recorded the highest plant height (106.9 cm, 115.5 cm, and 120.7 cm respectively) in contrast, T6 denoted the lowest values (89.5 cm, 94 cm, and 101.1 cm) (Figure 2). The results showed that, during the early days, seed coating has delayed the plant growth however, in the later stages plant growth has been enhanced by seed coating. Moreover, seeder and row planting methods have facilitated sesame plant growth compared to the conventional broadcasting method. It may be due to the availability of proper space among the plants ensuring maximum resources utility such as light and nutrients.

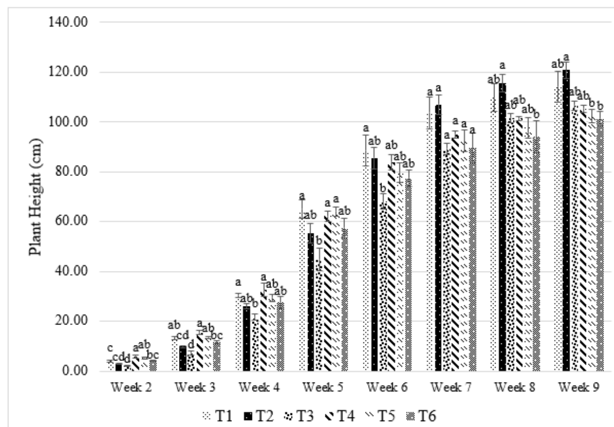

Figure 2: The effect of seed coating and planting method on plant height of sesame. (Vertical bars represent ± standard error. Bars with the same letter are not significantly different at Tukey's posthoc test at p = 0.05)

According to Dogan Zeybek, (2009) the higher values for sesame plant height (126. 6 cm – 140.0 cm) were obtained from pelleted seeds compared to regular seeds (107.3 cm – 127.0 cm) at harvest. They used a pneumatic spacing planter to sow the pelleted seeds, and Broadcasting was carried out for non-pelleted seed sowing. Similarly, Alex *et al.* (2017) reported that the greater plant height when used pelleted seeds (113.8 cm) than non-pelleted sesame seeds (108.9 cm).

C. Flowering characteristics of sesame plants

The number of days taken for 50 % flowering was significantly (p<0.05) varied based on different treatments; conversely, no significant (p>0.05) effect was observed in the number of days taken for maturity. Plants were grown under T2 treatment and recorded for 33 days for 50 % flowering while 32 days were taken for all the other treatments (Table 4). Pelleted seed materials took significantly higher days for flowering compared to naked seeds.

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Table IV: The effect of different treatments on flowering characteristics of sesame plants

Treatments	No. of days taken for 50 % flowering	No. of days taken to maturity
T1	32.0±0.0[b]	73.7±1.3[a]
T2	33.3±0.7[a]	75.0±0.0[a]
T3	32.0±0.0[b]	75.0±0.0[a]
T4	32.0±0.0[b]	71.0±0.0[a]
T5	32.0±0.0[b]	73.7±1.3[a]
T6	32.0±0.0[b]	73.7±1.3[a]
P value	0.023	0.1
CV (%)	2.00	2.63

The values are means of replicates ± Standard error (SE); Within a column, means followed by the same letter are not significantly different Tukey's posthoc test at p = 0.05. CV = Coefficient of Variance.

D. Root characteristics of sesame plants in each treatment

Figure 3, shows the root characteristics of sesame plants at harvesting. Significant ($p<0.05$) differences were observed in root width and volume ($p<0.05$), but not in root length ($p>0.05$) of sesame plants. The highest root width (15 cm) and volume (6.11 cm^3) were recorded in T3, while the lowest root width and volume were recorded in T5 (7.7 cm) and T6 (1.71 cm^3) respectively. Pelleted seeds performed better than naked seed materials based on the overall root characteristics. Suma *et al*. (2010) studied the influence of nutrient pelleting on seed quality of sesame and obtained average root length in the range of 10.5 cm to 11.9 cm for pelleted seeds while control treatment (non-pelleted seeds) had 8.2 cm.

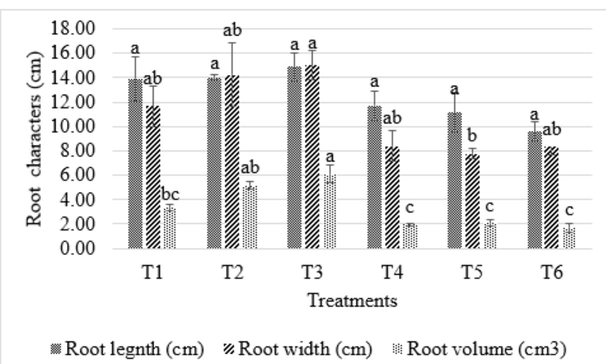

Figure 3: Root characteristics of sesame plants in each treatment.
(Vertical bars represent ± standard error. Bars with the same letter are not significantly different at Tukey's posthoc test at p = 0.05)

E. Yield characteristics of sesame plants

According to Table 5, the number of capsules per plant, number of seeds per capsule, and total yield (kg/ha) were significantly ($p<0.05$) affected by different treatments. The highest number of capsules per plant (63) was obtained in T3, while the lowest was obtained in T4 (18). The highest number of seeds per capsule was recorded in T1 (53), while the lowest was recorded in T5 (31) and T6 (32). Moreover, T1 gave the highest value for total yield (1404 kg/ha); conversely, T3 gave the lowest value (253 kg/ha).

Table V: The effect of seed coating treatments on yield attributing characters.

Treatments	No. of capsule/plant	No. of seeds/capsule	Total yield (kg/ha)
T1	38±2.4[bc]	53±2.7[a]	1404±0.05[a]
T2	50±3.9[ab]	48±3.6[a]	1052±0.21[ab]
T3	63±7.9[a]	50±4.1[a]	253±0.10[c]
T4	18±1.7[c]	34±4.3[b]	575±0.05[bc]
T5	23±2.2[c]	31±2.9[b]	937±0.05[ab]
T6	23±3.2[c]	32±2.6[b]	939±0.05[ab]
P value	<0.0001	0.050	<0.0001
CV (%)	1.98	1.98	2.24

The values are means of replicates ± Standard error (SE); Within a column, means followed by the same letter are not significantly different Tukey's posthoc test at p = 0.05. CV = Coefficient of Variance.

Plants grown from naked sesame seeds had lower values for the number of capsules per plant and seeds per capsule compared to pelleted seeds. As a result, it can be inferred that this strategy might be a viable option for enhancing sesame crop production. The possible reason for this high yield attributing characteristics in pelleted seeds may be due to the increased nutritional availability from the coating material for the seedling emergence and growth, and further coating supports the plants in the hardening process resists the diseases.

Concerning the number of capsules per plant, Dogan Zeybek, (2009) obtained a mean value of 140- 166 for pelleted sesame seeds, while regular sesame seeds had 106 - 142 capsules per plant. They also obtained a higher seed yield (1605 kg/ha –2346 kg/ha) from pelleted seeds than non-pelleted seeds (1197 kg/ha – 1288 kg/ha). A similar result has been obtained by Alex *et al*. (2017). They stated that pelleted seeds registered a significantly higher number of capsules per plant (143) and seeds per capsule (52) compared to non-pelleted seeds (124 and 48, respectively). Moreover, in their research, pelleted sesame seeds yielded 659 kg/ha, while non-pelleted seeds yielded 614 kg/ha.

IV. Conclusions

Although it seems the initial seed germination was impeded by seed coating due to physical barriers, the subsequent crop growth and development attributed to superior crop yield. Further, the seed coating facilitates row planting where by seeders can be used to successfully establish crop stands. Therefore, based on results, it can be concluded seed coating supplemented with seeders is recommended for crop establishment than practicing the conventional (without seed coating) method. Further studies are needed on different seed coating materials and thicknesses to increase the efficiency of the seed coating technique.

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