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THE EFFECT OF PLANTING DISTANCE AND UREA FERTILISER DOSAGE ON THE GROWTH OF LEMONGRASS IN A POLYCULTURE SYSTEM

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ABSTRACT

This study aimed to determine the effect of planting distance and urea fertilizer dosage on the growth of fragrant lemongrass in a polyculture cultivation system under rubber stands. The research was conducted on Jl. Sei Putih Rispa, Kelapa Satu Village, Galang District, Deli Serdang Regency, North Sumatra, at an altitude of about 65 m above sea level from May to August 2025. The experiment used a factorial Randomized Block Design (RBD) with two factors: planting distance and urea dosage. Planting distance consisted of three levels, namely J1 (20 × 40 cm), J2 (20 × 60 cm), and J3 (20 × 80 cm). Urea dosage consisted of four levels: U0 (0 g/plant), U1 (5 g/plant), U2 (10 g/plant), and U3 (20 g/plant). These treatments produced 12 combinations with three replications, resulting in 36 plots, each with four samples, totaling 144 plants. Observations were made at harvest, including root fresh weight, shoot fresh weight, root volume, root dry weight, shoot dry weight, and root-shoot ratio. The results indicated that planting distance significantly influenced root fresh weight, shoot fresh weight, root volume, root dry weight, and shoot dry weight, whereas urea dosage did not show a significant effect on the measured parameters. The most favorable planting distance for fragrant lemongrass growth was 20 × 80 cm, followed by 20 × 60 cm, suggesting that wider spacing supported better plant development in a polyculture system under rubber stands.

Keywords: fragrant lemongrass, planting distance, urea fertilizer dosage

INTRODUCTION

Fragrant lemongrass (*Cymbopogon nardus*) is an economically important aromatic grass cultivated for culinary, medicinal, and essential-oil uses, and it is widely grown in tropical regions for both smallholder and commercial production. Studies show that vegetative growth, biomass yield, and essential-oil production of lemongrass are highly responsive to soil fertility and cultural practices, particularly nitrogen management and plant spacing (Mwithiga *et al*., 2024). Fragrant lemongrass production in Indonesia has shown quite dynamic development in recent years. According to data from the Central Statistics Agency (BPS, 2024) in Horticultural Statistics, national production of fragrant lemongrass was recorded at approximately 51.56 thousand tons per year, indicating that the production scale of this biopharmaceutical remains quite large. At the regional level, Lampung Province, as one of the main production centers, recorded production reaching 2,136 tons in 2023 (Lampung, 2024). This figure indicates that despite fluctuations in planted area in several regions, fragrant lemongrass productivity has remained relatively stable.

When compared with data from the previous period (2009–2013), when production increased from 1,700 tons/ha to 2,600 tons/ha despite a decrease in land area from 20,000 ha to 19,000 ha, this trend underscores the importance of increasing productivity without having to expand land, for example by optimizing plant spacing, fertilization, and utilizing intercropping with perennial plants such as rubber.Given these conditions, it is necessary to increase lemongrass production without clearing new land, namely by utilising the space between hardwood crops such as rubber.

Intercropping aromatic or medicinal crops beneath tree crops such as rubber (*Hevea brasiliensis*) has received growing attention as a means to diversify farm income, improve land-use efficiency, and enhance agroecosystem resilience. Recent reviews and field studies indicate that well-managed intercropping systems in rubber stands can increase total system productivity and provide socioeconomic benefits, although agronomic outcomes depend strongly on light availability, belowground competition, and management practices (Sabarivasan *et al*., 2024).

Planting distance is an important factor that determines the utilisation of resources (light, water, and nutrients) and the level of competition between plants. This affects the number of tillers, root development, and the yield of fragrant lemongrass (Nofrita *et al*., 2021). Several experiments have reported that wide planting distances tend to increase biomass per plant, while close planting distances can increase yield per unit area, but have the potential to reduce plant vigour and oil quality when nutrient availability is limited (Mwithiga *et al*., 2024).

Nitrogen, commonly applied as urea, is a key driver of vegetative growth in lemongrass; however, responses vary with application rate, timing, form (soil vs foliar), and interactions with other agronomic factors. Some recent field experiments found positive effects of urea or nitrogen levels on growth and oil yield, while other studies emphasize the role of integrated fertilizer management (including biofertilizers) to optimize yield and quality (Sulastri *et al*., 2025).

Although the effects of planting distance and nitrogen on lemongrass growth have been widely reported, empirical evidence assessing both factors simultaneously in polyculture systems under rubber trees is still limited, especially in Indonesian agroecosystem conditions. This research is important to obtain practical recommendations that can optimise lemongrass growth while adapting to light limitations and root competition in rubber plantations. Therefore, this study aims to examine the effect of the combination of planting distance and urea fertiliser dosage on lemongrass growth in a polyculture system under rubber trees.

METHODS

This study was conducted on Jl. Sei Putih Rispa, Kelapa Satu Village, Galang District, Deli Serdang Regency, North Sumatra, at an altitude of approximately 65 m above sea level. The research was carried out from May to August 2025. The tools used in this study included an oven, large envelopes, sacks, an analytical balance, a notebook, a cutter, jerry cans, label paper, a UV-Vis spectrophotometer, cuvettes, test tubes, scissors, a mortar, a hoe, and a centrifuge. The materials used were fragrant lemongrass plants and urea fertilizer.

The experimental design was based on a factorial Randomized Block Design (RBD), consisting of two factors: planting distance and urea fertilizer dosage. The first factor, planting distance (denoted as “J”), consisted of three levels: J1 (20 × 40 cm), J2 (20 × 60 cm), and J3 (20 × 80 cm). The second factor, urea dosage (denoted as

"U"), consisted of four levels: U0 (0 g/plant), U1 (5 g/plant), U2 (10 g/plant), and U3 (20 g/plant). The implementation of the research included land preparation, seedling preparation, planting, maintenance, harvesting, and observations.

The observed parameters included root fresh weight, shoot fresh weight, root volume, root dry weight, and shoot dry weight. Root and shoot fresh weights were measured at harvest. Root volume was determined after the roots were cleaned from soil and air-dried, using a measuring cylinder; the root volume was obtained by subtracting the initial water volume from the final volume after root immersion. Root and shoot dry weights were determined after oven-drying for 24 hours (to constant weight). The dried roots and shoots were then weighed to obtain their dry weights.

RESULTS AND DISCUSSION

Root Fresh Weight

Table 1. Effect of different planting distances and urea fertilizer dosages on root fresh weight (g) of fragrant lemongrass grown under rubber stands.

Urea Fertilizer Dosage	Plaanting Distance			Mean
	20 x 40 cm	20 x 60 cm	20 x 80 cm	
0 g/plant	67,13a	111,10b	121,28c	33,28
5 g/plant	58,25a	100,15b	153,48c	34,65
10 g/plant	61,15a	94,15b	119,93c	30,58
20 g/plant	85,45a	102,53b	113,58c	33,51
Mean	22,66a	33,99b	42,35c	33,00

Note: Numbers followed by the same letter are not significantly different according to DMRT at the 5% level.

It can be observed that the wider the *fragrant lemongrass* planting distance, the higher the root fresh weight. Conversely, the narrower planting distances result in lower root fresh weight. This is also influenced by other factors such as compact soil, which reduces looseness so that roots struggle to penetrate soil layers—causing root growth under the 20 × 40 cm spacing (22.66 g) to be slightly constrained. This matches the assertion by (Peralta Ogorek *et al*., 2025), who stated that due to dense soil contour—meaning low porosity and permeability—the circulation of water and air is impeded, thereby hampering the rate of root penetration.

According to research (Holz *et al*., 2024), planting distance and urea fertilizer dose have a substantial effect on fragrant lemongrass development under rubber trees. A planting spacing of 20 x 80 cm yields the best results for practically all criteria (root wet and dry weight, root volume, and shoot wet and dry weight), but a close planting distance (20 x 40 cm) inhibits growth owing to intense competition. Urea fertilizer increases growth, but its effectiveness is influenced by planting distance, so a combination of wide planting distance with a moderate urea dosage is recommended for optimal growth (Kaur *et al*., 2023).

Shoot Fresh Weight

Table 2. Effect of different planting distances and urea fertilizer dosages on shoot fresh weight (g) of fragrant lemongrass grown under rubber stands.

Urea Fertilizer Dosage	Planting Distance			Mean
	20 x 40 cm	20 x 60 cm	20 x 80 cm	
0 g/tan	159,00a	348,20b	381,23c	98,71
5 g/tan	204,83a	457,75b	554,93c	135,28
10 g/tan	277,68a	398,65b	575,38c	139,08
20 g/tan	279,78a	356,20b	434,68c	118,96
Mean	76,77a	130,07b	162,18c	123,01

Note: Numbers followed by the same letter are not significantly different according to DMRT at the 5% level.

It is evident that the planting distance of 20 × 80 cm (mean = 162.18 g) produces the greatest shoot fresh weight of fragrant lemongrass. The shoot fresh weight increases in direct proportion to the planting distance; the wider the spacing, the higher the shoot fresh weight. Conversely, when planting distance is too narrow, shoot fresh weight is lower. Dense planting not only reduces sunlight reaching lower leaves but also increases mutual shading, which can limit photosynthesis and reduce biomass accumulation in the shoots. Therefore, optimizing spacing is essential providing enough distance allows fragrant lemongrass to fully exploit its photosynthetic potential, especially in intercropping systems like under rubber stands where light is a limiting resource (Mircea *et al*., 2023). Found that increased planting density frequently increases intraspecific competition, decreasing photosynthetic rates and assimilate translocation to aboveground biomass. Similarly (Martano *et al*., 2023) noted that the interplay between planting distance and resource use efficiency is a critical factor influencing biomass yield in fragrant crops like fragrant lemongrass.

Root Volume

Table 3. Effect of different planting distances and urea fertilizer dosages on root volume (ml) of fragrant lemongrass grown under rubber stands.

Urea Fertilizer Dosage	Planting Distance			Mean
	20 x 40 cm	20 x 60 cm	20 x 80 cm	
0 g/tan	40,35a	61,28b	97,05c	22,08
5 g/tan	39,78a	72,25b	117,25c	25,48
10 g/tan	52,73a	66,80b	88,83c	23,15
20 g/tan	56,85a	60,60b	85,78c	22,58
Mean	15,81a	21,74b	32,41c	23,32

Note: Numbers followed by the same letter are not significantly different according to DMRT at the 5% level.

The data in Table 3 also show an interesting interaction between urea dosage and planting distance while all spacing levels benefit from wider distance in terms of root volume, the increase from narrower to wider distances is more pronounced at lower to moderate urea levels (0 g/plant and 5 g/plant). At higher urea dosages (10

g/plant and 20 g/plant), The incremental increase in root volume with wider planting distances becomes less pronounced at higher urea dosages. This suggests that after a certain nutrient threshold, physical space and environmental factors such as soil aeration, root restriction due to compacted soil, and inter-plant competition play a larger role in limiting root expansion than do additional nutrients. Accordingly, optimizing both planting distance and nutrient input is crucial for maximizing root volume and thereby overall growth of fragrant lemongrass under rubber stands (Mwithiga *et al*., 2024).

Research by (Piza *et al*., 2023), who observed that in aromatic grasses, root volume responds strongly to spacing but tends to plateau at higher nitrogen inputs due to shifts in biomass partitioning towards aboveground tissues. This implies that the balance between planting distance and nitrogen supply is key for optimizing belowground growth and overall resource-use efficiency in fragrant lemongrass cultivated under rubber stands.

Root Dry Weight

Table 4. Effect of different planting distances and urea fertilizer dosages on root dry weight (g) of fragrant lemongrass grown under rubber stands.

Urea Fertilizer Dosage	Planting Distance			Mean
	20 x 40 cm	20 x 60 cm	20 x 80 cm	
0 g/tan	25,63a	29,30b	45,35c	11,14
5 g/tan	16,25a	32,28b	55,70c	11,58
10 g/tan	27,45a	32,28b	31,40c	10,13
20 g/tan	32,73a	39,58b	36,90c	12,13
Mean	8,50a	11,12b	14,11c	11,25

Note: Numbers followed by the same letter are not significantly different according to DMRT at the 5% level.

In table 4. It can be explained that the highest root dry weight is obtained at the planting distance of 20 × 80 cm (14.11 g). This indicates that planting distance is directly proportional to root dry weight: when the distance is too narrow, root dry weight becomes lower. Root dry weight increases are influenced by root volume and root number obtained; this is in line with the findings of (Kumar *et al*., 2021). This relationship is supported by (Mwithiga *et al*., 2024), who found that lemongrass spaced more widely showed significantly higher root biomass and better root architecture under good soil fertility conditions.

Furthermore, while urea dosage contributes to root dry weight increment, the data suggest that beyond moderate nitrogen levels, its effect diminishes if planting distance remains narrow. Narrow spacing restricts root expansion physically and increases competition among plants, reducing dry matter allocation to roots. Conversely, wider planting distance reduces competition, improves aeration, and allows roots to develop more fully—factors that contribute to higher dry root weight. Research (Niu *et al*., 2024) provides evidence that excessive nitrogen application can even reduce root growth under certain conditions, reinforcing the importance of balancing fertilizer input and planting spacing.

Shoot Dry Weight

Table 5. Effect of different planting distances and urea fertilizer dosages on shoot dry weight (g) of fragrant lemongrass grown under rubber stands.

Urea fertilizer Dosage	Planting Distance			Mean
	20 x 40 cm	20 x 60 cm	20 x 80 cm	
0 g/tan	62,53a	169,00b	133,19c	40,52
5 g/tan	80,23a	139,83b	174,55c	43,84
10 g/tan	110,40a	151,33b	164,35c	47,34
20 g/tan	119,23a	133,30b	130,33c	42,54
Mean	31,03a	49,45b	50,20c	43,56

Note: Numbers followed by the same letter are not significantly different according to DMRT at the 5% level.

It can be observed that planting distance significantly increases shoot dry weight of fragrant lemongrass. The highest shoot dry weight is obtained at 20 × 80 cm spacing (50.20 g), followed by 20 × 60 cm spacing (49.45 g), and the lowest at 20 × 40 cm (31.03 g). Shoot dry weight is strongly determined by root activity in transporting nutrients and water that are translocated to the above-ground parts of the pant. Beyond light, shoot dry weight is closely linked to root function an expanded root system improves water and nutrient uptake and supports greater assimilate supply to shoots. (Mahmoud *et al*., 2022) demonstrate that adequate nitrogen and water management markedly improve vegetative growth and shoot biomass in lemongrass, indicating that root-mediated resource supply is a key determinant of shoot dry weight. The table also shows the interaction between urea dose and plant spacing. While moderate nitrogen application can increase shoot dry weight, excessive nitrogen application without plant spacing can result in reduced yield due to competition for light and belowground resources. This pattern, where plant spacing primarily promotes biomass partitioning after basic nutrient requirements are met, has also been reported in studies of fragrant lemongrass and other perennial aromatic grasses. This study emphasized that plant spacing has a strong influence on yield per plant, even with variations in fertilizer application. Therefore, optimizing plant spacing and fertilizer application is crucial to maximize shoot dry weight of fragrant lemongrass planted under rubber stands (Holz *et al*., 2024).

CONCLUSION

Research shows that planting distance and urea fertilizer dosage significantly affect the growth of fragrant lemongrass under rubber trees. A planting distance of 20 x 80 cm produces the best results for almost all parameters (root wet and dry weight, root volume, and shoot wet and dry weight), while a close planting distance (20 x 40 cm) reduces growth due to high competition. Urea fertilizer increases growth, but its effectiveness is influenced by planting distance, so a combination of wide planting distance with a moderate urea dosage is recommended for optimal growth.

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