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THE EFFECT OF PLANT SPACING AND NPK FERTILIZER ON THE GROWTH AND YIELD OF SORGHUM NUMBU VARIETY

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ABSTRACT
This research examines the impact of plant spacing and NPK fertilizer treatment on the growth and yield performance of the Numbu variety of sorghum (Sorghum bicolor L. Moench). The research, conducted in Mekarjaya Village, Indramayu, West Java, from August to November 2024, using a Randomized Complete Block Design (RCBD) featuring nine treatment combinations, each replicated three times. The experimental treatments comprised plant spacing configurations of 70 × 20 cm, 70 × 25 cm, and 70 × 30 cm, in conjunction with NPK fertilizer applications of 200, 300, and 400 kg/ha. The results indicated that a spacing of 70 × 30 cm along with 400 kg/ha of NPK markedly improved plant height, leaf area index, stem diameter, root volume, and panicle characteristics. This treatment achieved the maximum dry seed weight per plant at 70.67 g. The highest dry seed production per plot (4.46 kg or 3.717 tons/ha) was achieved with a spacing of 70 × 20 cm and an application of 200 kg/ha of NPK. Correlation study revealed a moderate positive association between plant height and dry seed yield, as well as between leaf count and yield at particular growth phases. These findings highlight the essential importance of optimum spacing and NPK fertilizer concentrations in improving sorghum yield.

Keywords: Plant Spacing, NPK, Growth, Sorghum Yield

INTRODUCTION

Sorghum (Sorghum bicolor L) is a cereal crop with great potential to grow and develop in Indonesia, mainly because it adapts well to dry areas, better than other cereal crops. The advantages of sorghum include its use as a food source, bioenergy (bioethanol), and stems and leaves, which can be used as animal feed. Apart from that, sorghum also shows strong adaptability to various agroecological conditions, especially in overcoming drought, and has higher yields and resistance to pests and diseases than other food crops (Sulistyowati et al., 2021). Sorghum grain also offers various advantages, especially in food and industry. In several regions in Indonesia, such as Flores and Kupang, sorghum has become an important food alternative. However, despite high demand for sorghum, average national production is still relatively low, around 2.68 tonnes per hectare, even though it should be around 5 to 7 tonnes per hectare. Therefore, there is an urgent need to increase sorghum production (Yahfi et al., 2017).

According to data from the Ministry of Agriculture, national sorghum production in Indonesia averages 4,000 to 6,000 tonnes per year, with planting carried out in five provinces: West Java, Central Java, DI Yogyakarta, East Java and East Nusa Tenggara (BPS, 2019). In marginal areas in Africa, sorghum productivity is low, only around 1 to 2 tons per hectare, while in developed countries with better cultivation technology, the yield can reach above 4 tons per hectare. In Indonesia, sorghum productivity ranges from 2 to 5 tonnes per hectare. Variations influence this striking difference in sorghum yields in various regions or agroecosystems in cultivation techniques and environmental conditions where the plants grow (Azrai et al., 2021).

Increasing sorghum production and yields depends not only on fertilization but also on optimal spacing. This is important to achieve a level of plant population density that can increase sorghum yields. However, if the plant density is too high due to close spacing, plants will compete for sunlight, nutrients and air. In addition, at high densities, plants tend to cover each other (shade) so that the photosynthesis process cannot run effectively. Therefore, proper plant spacing is necessary to maximise sunlight absorption (Puspitasari et al., 2012).

Compound fertilizers, such as NPK, are inorganic fertilizers that efficiently enhance the availability of key macronutrients—nitrogen (N), phosphorus (P), and potassium (K)—while serving as an alternative to individual fertilizers like Urea, SP-36, and KCl, which are both difficult to acquire and costly. Phonska NPK fertilizer (15:15:15) is widely available in the market, containing 15% nitrogen (N), 15% phosphorus (P_2O_5), 15% potassium (K_2O), 10% sulfur (S), and a maximum of 2% air content. This fertilizer dissolves almost entirely in the air, allowing its nutrients to be readily absorbed and utilized by plants (Kaya, 2013).

The aims of this research include:

1. To determine the effect of the combination of plant spacing and NPK fertilizer on the growth and yield of sorghum (*sorghum bicolor L Moench*) Numbu variety
2. To determine the combination of plant spacing treatment and NPK fertilizer application that can have a good effect on the yield of sorghum (*sorghum bicolor L Moench*) Numbu Variety
3. To determine the relationship between growth components and yield components of sorghum (*sorghum bicolor L Moench*) Numbu Variety

METHODS

The experiment was conducted at the Sandrem Block Research Site in Mekarjaya Village, Gantar District, Indramayu Regency, West Java, Indonesia, from August to November 2024, at an altitude of roughly 50 meters above sea level. The soil at the location is classified as latosol, and the rainfall characteristics are defined as Type C according to S. Fergusson. The experimental materials comprised Numbu variety sorghum seeds, manure, NPK compound fertilizer, insecticides, and Furadan. The utilized tools included hoes, ropes, sickles, hand sprayers, rulers, meters, digital scales, calipers, nameplates, buckets, water pumps, dippers, measuring cups, plastic sheets, sacks, jugs, paper, calculators, and writing equipment.

A Randomized Block Design (RBD) was utilized in the experimental framework, integrating various plant spacing and NPK fertilizer treatments. The study comprised nine treatment combinations, each replicated three times, for a total of 27 experimental plots. The plot dimensions measured 4 meters by 3 meters, with a 50 cm interval between plots and a 100 cm separation between replications. The evaluated planting distances were 70 cm × 20 cm, 70 cm × 25 cm, and 70 cm × 30 cm.

The combination of plant spacing and NPK fertilizer treatments tested was as follows:
A: Planting distance (70 cm x 20 cm), and NPK fertilizer 200 kg/ha.
B: Planting distance (70 cm x 20 cm), and NPK fertilizer 300 kg/ha.
C: Planting distance (70 cm x 20 cm), and NPK fertilizer 400 kg/ha.
D: Planting distance (70 cm x 25 cm), and NPK fertilizer 200 kg/ha.
E: Planting distance (70 cm x 25 cm), and NPK fertilizer 300 kg/ha
F: Planting distance (70 cm x 25 cm), and NPK fertilizer 400 kg/ha.
G: Planting distance (70 cm x 30 cm), and NPK fertilizer 200 kg/ha.
H: Planting distance (70 cm x 30 cm), and NPK fertilizer 300 kg/ha
I: Planting distance (70 cm x 30 cm), and NPK fertilizer 400 kg/ha.

This study examined data such as plant height, leaf count, leaf area index, growth rate, panicle length, panicle count per plot, dry seed weight per plant, and dry seed weight per plot. The gathered data were examined by Analysis of Variance (ANOVA) to ascertain statistical significance. Following significant ANOVA results, additional analysis was performed utilizing the Scott-Knott Cluster Test at a 5% significance threshold, in conjunction with Product Moment correlation analysis.

RESULTS AND DISCUSSION

The principal metrics measured comprised plant height, leaf count per plant, leaf area index, stem diameter, root volume, panicle length, panicle count per plot, dry seed weight per plant, and dry seed weight per plot.

Plant Height (cm)

Analysis of variance (ANOVA) indicated that both plant spacing and NPK treatments significantly affected plant height at 35, 42, and 49 days after planting (DAP).

Table 1. Effect of Plant Spacing and NPK on Plant Height at 35 DAP, 42 DAP, and 49 DAP

No	Treatment	Plant Height		
		35 DAP	42 DAP	49 DAP
1	A (70 cm x 20 cm and NPK 200 kg/ha)	43.20 a	82.20 a	125.33 a
2	B (70 cm x 20 cm and NPK 300 kg/ha)	46.60 a	93.40 b	152.00 b
3	C (70 cm x 20 cm and NPK 400 kg/ha)	50.13 b	99.67 b	166.33 b
4	D (70 cm x 25 cm and NPK 200 kg/ha)	42.27 a	86.47 a	129.33 a
5	E (70 cm x 25 cm and NPK 300 kg/ha)	46.27 a	95.40 b	147.00 b
6	F (70 cm x 25 cm and NPK 400 kg/ha)	53.67 b	100.00 b	155.33 b
7	G (70 cm x 30 cm and NPK 200 kg/ha)	44.33 a	81.13 a	129.67 a

8	H (70 cm x 30 cm and NPK 300 kg/ha)	51.40 b	93.87 b	154.67 b
9	I (70 cm x 30 cm and NPK 400 kg/ha)	57.20 b	107.80 b	174.33 b

Note: The average value followed by the same letter is not significantly different according to the Scott-Knott Advanced Test at a significance level of 0.05.

Based on Table 1 The highest plant height was consistently observed in treatment I (70 cm × 30 cm with NPK 400 kg/ha) at 35, 42, and 49 DAP, measuring 57.40 cm, 107.80 cm, and 174.33 cm, respectively. This treatment showed significant differences compared to several others, demonstrating that higher NPK levels significantly enhance plant growth. The combination of wider spacing and higher NPK dosage optimizes nutrient availability and supports greater biomass production. These findings align with Triyono et al. (2023) and Silva et al. (2018), who reported increased plant height and productivity with high NPK application and optimal spacing in sorghum cultivation.

Number of Leaves per Plant

The results of analysis of variance showed that setting plant spacing and NPK had a significant effect on leaf number parameters in all 49 HST observations. But there was no real effect on age 35 HST and 42 HST.

Table 2. Effect of Plant Spacing and NPK on the Number of Leaves at 35 HST, 42 HST, and 49 HST

No	Treatment	The Number of Leaves		
		35 DAP	42 DAP	49 DAP
1	A (70 cm x 20 cm and NPK 200 kg/ha)	4.40 a	6.27 a	7.93 a
2	B (70 cm x 20 cm and NPK 300 kg/ha)	4.73 a	6.27 a	8.27 a
3	C (70 cm x 20 cm and NPK 400 kg/ha)	4.47 a	6.87 a	8.33 a
4	D (70 cm x 25 cm and NPK 200 kg/ha)	5.00 a	6.47 a	8.47 a
5	E (70 cm x 25 cm and NPK 300 kg/ha)	5.00 a	6.90 a	8.20 a
6	F (70 cm x 25 cm and NPK 400 kg/ha)	5.07 a	6.97 a	8.80 a
7	G (70 cm x 30 cm and NPK 200 kg/ha)	4.60 a	6.60 a	7.80 a
8	H (70 cm x 30 cm and NPK 300 kg/ha)	4.67 a	6.73 a	8.27 a
9	I (70 cm x 30 cm and NPK 400 kg/ha)	5.53 a	7.70 a	9.27 b

Note: It is important to note that the average values denoted by identical letters do not exhibit significant differences as determined by the Scott-Knott Advanced Test at a significance level of 0.05.

Based on Table 2, At 49 DAP, treatment I (70 cm × 30 cm, NPK 400 kg/ha) produced the highest leaf count (9.27), significantly outperforming others. This result highlights the importance of NPK especially nitrogen in vegetative growth and supports findings that wider spacing and nutrient-rich conditions enhance sorghum leaf development.

Leaf Area Index

The analysis of variance indicated that the influence of plant spacing and NPK on leaf area index parameters was significant at 49 DAP, but not at 35 DAP and 42 DAP.

Table 3. Effect of Plant Spacing and NPK on leaf area index at 35 DAP, 42 DAP and 49 DAP

No	Treatment	Leaf Area Index		
		35 DAP	42 DAP	49 DAP
1	A (70 cm x 20 cm and NPK 200 kg/ha)	0.20 a	0.30 a	0.46 a
2	B (70 cm x 20 cm and NPK 300 kg/ha)	0.20 a	0.31 a	0.47 a
3	C (70 cm x 20 cm and NPK 400 kg/ha)	0.23 a	0.42 a	0.53 b
4	D (70 cm x 25 cm and NPK 200 kg/ha)	0.16 a	0.31 a	0.45 a
5	E (70 cm x 25 cm and NPK 300 kg/ha)	0.20 a	0.32 a	0.46 a
6	F (70 cm x 25 cm and NPK 400 kg/ha)	0.20 a	0.46 a	0.47 a
7	G (70 cm x 30 cm and NPK 200 kg/ha)	0.12 a	0.30 a	0.36 a
8	H (70 cm x 30 cm and NPK 300 kg/ha)	0.24 a	0.47 a	0.56 b
9	I (70 cm x 30 cm and NPK 400 kg/ha)	0.20 a	0.48 a	0.65 b

Note: The average values denoted by identical letters are not statistically different based on the Scott-Knott Advanced Test at a significance level of 0.05.

Based on Table 3, it shows that Leaf area index (LAI) showed no significant difference at 35 and 42 DAP across treatments, as plants were in early vegetative stages. However, at 49 DAP, treatment I (70 cm × 30 cm, NPK 400 kg/ha) had the highest LAI (0.65), highlighting the effect of wider spacing and optimal fertilization.

Bar Diameter (cm)

The analysis of variance data indicated that plant spacing and NPK exerted statistically distinct impacts on stem diameter at 35 DAP, 42 DAP, and 49 DAP.

Table 4. Effect of Plant Spacing and NPK Settings on Stem Diameter at 35 DAP, 42 DAP and 49 DAP

No	Treatment	Rod Diameter		
		35 DAP	42 DAP	49 DAP
1	A (70 cm x 20 cm and NPK 200 kg/ha)	1.53 a	1.96 a	2.15 a
2	B (70 cm x 20 cm and NPK 300 kg/ha)	1.71 b	2.09 a	2.25 a
3	C (70 cm x 20 cm and NPK 400 kg/ha)	1.73 b	2.27 b	2.35 b
4	D (70 cm x 25 cm and NPK 200 kg/ha)	1.61 a	2.02 a	2.19 a
5	E (70 cm x 25 cm and NPK 300 kg/ha)	1.71 b	2.05 a	2.17 a
6	F (70 cm x 25 cm and NPK 400 kg/ha)	1.73 b	2.18 b	2.26 a
7	G (70 cm x 30 cm and NPK 200 kg/ha)	1.57 a	2.01 a	2.14 a
8	H (70 cm x 30 cm and NPK 300 kg/ha)	1.82 b	2.17 b	2.29 a
9	I (70 cm x 30 cm and NPK 400 kg/ha)	1.86 b	2.37 b	2.47 b

Note: The average values denoted by identical letters are not substantially different as per the Scott-Knott Advanced Test at a significance level of 0.05.

Based on Table. 4 shows that treatment I (70 cm × 30 cm, NPK 400 kg/ha) produced the highest stem diameters at 35, 42, and 49 DAP—1.86 cm, 2.37 cm, and 2.47 cm, respectively. Wider spacing and higher NPK levels enhanced nutrient availability, promoting stronger stem growth and aligning with findings from Qadri and Dinberu.

Root Volume (m3)

The analysis of variance revealed that the influence of plant spacing and NPK on root volume was substantially different at 35 DAP and 49 DAP, but not at 42 DAP.

Table 5. Effect of Plant Spacing and NPK Settings on Root Volume at 35 DAP, 42 DAP, and 49 DAP

No	Treatment	Root Volume (m3)		
		35 DAP	42 DAP	49 DAP
1	A (70 cm x 20 cm and NPK 200 kg/ha)	23.33 a	116.67 a	266.67 a
2	B (70 cm x 20 cm and NPK 300 kg/ha)	26.67 a	133.33 a	266.67 a
3	C (70 cm x 20 cm and NPK 400 kg/ha)	23.33 a	166.67 a	333.33 a
4	D (70 cm x 25 cm and NPK 200 kg/ha)	30.00 a	166.67 a	283.33 a
5	E (70 cm x 25 cm and NPK 300 kg/ha)	33.33 a	183.33 a	350.00 a
6	F (70 cm x 25 cm and NPK 400 kg/ha)	35.00 a	216.67 a	416.67 b
7	G (70 cm x 30 cm and NPK 200 kg/ha)	28.33 a	183.33 a	316.67 a
8	H (70 cm x 30 cm and NPK 300 kg/ha)	33.33 a	216.67 a	400.00 b
9	I (70 cm x 30 cm and NPK 400 kg/ha)	46.67 b	300.00 a	533.33 b

Note: The average values denoted by the identical letter do not exhibit significant differences as per the Scott-Knott Advanced Test at a significance level of 0.05.

Based on Table. 5 shows that At 35 DAP, treatment I (70 cm × 30 cm, NPK 400 kg/ha) showed the highest root volume (46.67 mm), significantly differing from other treatments. This early vegetative phase is critical for root development, which responds quickly to nutrient availability. At 42 DAP, differences were insignificant, likely due to uniform environmental and genetic factors. However, at 49 DAP, treatment I again showed the highest root volume (533.33 m³), significantly different from most treatments. These results align with studies by Davydenko, Patil, and Astuti, which confirm that optimal spacing and higher NPK levels enhance nutrient uptake and support stronger root development in sorghum.

Panicle Length, Number of Panicles per Plant and Panicle Weight per Plant

The analysis of variance revealed that the influence of plant spacing and NPK significantly affected panicle length, number of pines per plant, and panicle weight per plant.

Table 6. Effect of Plant Spacing and NPK Treatment on Panicle Length Parameters, Number of Panicles per Plant, and Panicle Weight per Plant

No	Treatment	Result Components		
		Panicle Length (cm)	Number of Panicles per Plant	Panicle Weight per Plant (g)
1	A (70 cm x 20 cm and NPK 200 kg/ha)	30.67 a	76.44 a	183.00 a
2	B (70 cm x 20 cm and NPK 300 kg/ha)	31.33 a	78.00 a	183.67 a
3	C (70 cm x 20 cm and NPK 400 kg/ha)	32.33 a	82.58 b	192.33 b
4	D (70 cm x 25 cm and NPK 200 kg/ha)	31.00 a	75.93 a	181.67 a
5	E (70 cm x 25 cm and NPK 300 kg/ha)	31.33 a	76.67 a	183.67 a
6	F (70 cm x 25 cm and NPK 400 kg/ha)	32.00 a	83.00 b	192.33 b
7	G (70 cm x 30 cm and NPK 200 kg/ha)	31.67 a	77.00 a	182.33 a
8	H (70 cm x 30 cm and NPK 300 kg/ha)	31.67 a	78.00 a	184.67 a
9	I (70 cm x 30 cm and NPK 400 kg/ha)	33.67 b	84.67 b	194.33 b

Note: The average value followed by the same letter is not significantly different according to the Scott-Knott Advanced Test at a significance level of 0.05.

Based on Table 6, it was found that Treatment I (70 cm × 30 cm, NPK 400 kg/ha) produced the highest panicle length (33.67 cm), panicles per plant (84.67), and panicle weight (194.33 g), significantly outperforming most other treatments. The wider spacing allows better light penetration and nutrient distribution, while higher NPK levels enhance photosynthesis and grain filling. These results support findings from Sunaryo and Astuti (2020), Djamaluddin et al. (2023), and Widodo et al. (2016), showing that 400 kg/ha of NPK fertilizer combined with optimal spacing improves nutrient availability, promoting panicle formation and yield in sorghum through more effective nutrient absorption and biomass distribution.

Dry Seed Weight per Plant and Dry Seed Weight per Plot

The analysis of variance results indicated that plant spacing and NPK had no significant impact on the 1,000 seed weight parameter, but significantly affected both the dry seed weight per plant and the total dry seed weight per plant.

Table 7. Effect of Plant Distance and NPK Treatment on the Weight of 1,000 Dry Seeds, Dry Seed Weight per Plant and Dry Seed Weight per Plot

No	Treatment	Crop Results		
		Weight of 1,000 seeds (g)	Dry Seed Weight Per Plant (g)	Dry Seed Weight Per Plot (kg)
1	A (70 cm x 20 cm and NPK 200 kg/ha)	37.33 a	68.67 a	4.46 b
2	B (70 cm x 20 cm and NPK 300 kg/ha)	38.00 a	68.67 a	4.41 a
3	C (70 cm x 20 cm and NPK 400 kg/ha)	39.33 a	69.00 a	4.43 b

4	D (70 cm x 25 cm and NPK 200 kg/ha)	37.67 a	68.33 a	4.43 b
5	E (70 cm x 25 cm and NPK 300 kg/ha)	38.67 a	69.33 a	4.39 a
6	F (70 cm x 25 cm and NPK 400 kg/ha)	39.67 a	68.67 a	4.36 a
7	G (70 cm x 30 cm and NPK 200 kg/ha)	38.33 a	68.33 a	4.44 b
8	H (70 cm x 30 cm and NPK 300 kg/ha)	38.67 a	69.33 a	4.40 a
9	I (70 cm x 30 cm and NPK 400 kg/ha)	40.33 a	70.67 b	4.38 a

Note: The average value followed by the same letter is not significantly different according to the Scott-Knott Advanced Test at a significance level of 0.05.

Table 7 shows that the 1,000 seed weight was not significantly affected by any treatment, confirming findings by Patil et al. (2018) and Warganda & Maulidi (2022) that nutrient levels and spacing have limited influence on individual seed weight. However, treatment I (70 cm × 30 cm, NPK 400 kg/ha) produced the highest dry seed weight per plant (70.67 g), while treatment A (70 cm × 20 cm, NPK 200 kg/ha) resulted in the highest dry seed weight per plot (4.46 kg). Closer spacing increased plant density, boosting total yield per plot despite lower per-plant seed weight, as supported by Dinberu (2023).

Correlation Analysis between Growth Components and Results

Correlation between Plant Height (35 DAP, 42 DAP and 49 DAP) and Dry Seed Weight per Plot

Pearson correlation analysis showed a significant relationship between plant height at 35, 42, and 49 DAP and dry seed weight per plot. At 35 DAP, the correlation coefficient was 0.48 ($r^2 = 0.230$); at 42 and 49 DAP, it was 0.62 ($r^2 = 0.384$), indicating moderate correlations. These results suggest that as plant height increases, dry seed weight per plot also tends to rise. The percentage of variation in seed weight explained by plant height was 23% at 35 DAP and 38.4% at 42 and 49 DAP. Taller plants contribute more to yield due to improved biomass and resource distribution.

Table 8. Correlation between Plant Height (35 DAP, 42 DAP, and 49 DAP) and Dry Seed Weight per Plot

No	Correlation Coefficient	Plant Height		
		35 DAP	42 DAP	49 DAP
1	r	0.48	0.62	0.62
2	r Category	Moderate	Moderate	Moderate
3	Sig.	0.012	0.001	0.001
4	r^2	0.230	0.384	0.384
5	Conclusion	Real	Real	Real

The plant height variable contributed to an increase in dry seed weight per plot at 35 HST, 42 HST, and 49 DAP. As plant height increases, the growth of stems, leaves, and root volume likewise escalates, positively influencing the dry seed weight per plot. The augmentation in plant height is attributed to nutrient absorption via the roots, thereafter disseminated for growth and development through the stems and leaves. Research findings (Arunah et al., 2015) indicated that plant height had a highly significant correlation with total dry matter and panicle weight, both of which contributed to overall weight. Research findings (Prakash et al., 2023) indicate a significant positive correlation between plant height and dry weight per plant, directly influencing seed weight. Additionally, findings from Silva et al. (2023) demonstrate that taller plants are positively associated with other traits that enhance yield, thereby augmenting the potential for selecting high-yielding genotypes.

Correlation between Number of Leaves (35 DAP, 42 DAP and 49 DAP) and Seed Weight per Plot

Pearson correlation analysis, performed with Smartstatxl, revealed a significant positive correlation between the number of leaves at 35 and 42 days after planting (DAP) and the dry seed weight per plot, whereas the number of leaves at 49 DAP did not demonstrate a significant correlation with dry seed weight per plot. Table 9 illustrates a statistically significant correlation between the leaf count at 35 DAP and dry seed weight per plot, with a correlation coefficient of 0.40 ($p = 0.038$), suggesting a weak association. At 42 days after planting, the quantity of leaves exhibited a moderate positive connection with the dry seed weight per plot, indicated by a coefficient of 0.42 ($p = 0.031$). At 49 days after planting (DAP), the correlation between leaf count and dry seed weight was not significant ($p = 0.063$), with a correlation value of 0.36, suggesting a weak association. The coefficients of determination (r^2) for the correlations between the number of leaves at 35 DAP, 42 DAP, and 49 DAP with dry seed weight per plot were 0.160, 0.176, and 0.130, respectively. The leaf counts at 35, 42, and 49 days after planting account for 16.0%, 17.6%, and 13.0% of the variance in dry seed weight per plot.

Table 9. Correlation between Number of Leaves (35 DAP, 42 DAP, and 49 DAP) and Dry Seed Weight per Plot

No	Koefisien Korelasi	The Number of Leaves		
		35 DAP	42 DAP	49 DAP
1	r	0.40	0.42	0.36
2	r Category	Low	Moderate	Low
3	Sig.	0.038	0.031	0.063
4	r^2	0.160	0.176	0.130
5	Conclusion	Real	Real	Not Real

The Pearson Product Moment correlation analysis in Table 9 indicates a weak positive correlation between the number of leaves and dry seed weight per plot at 35 DAP and 49 DAP, with correlation coefficients of 0.40 and 0.36, respectively. This signifies a minimal degree of association. The quantity of leaves at 42 DAP has a moderate positive connection with dry seed weight per plot, indicated by a coefficient of 0.42, implying a moderate link. The conclusions derived from the correlations at 35 DAP and 42 DAP are substantial, as the augmentation in leaf count at these stages markedly affects the dry seed weight per plot. This discovery substantiates the notion that an increased leaf count during these phases can augment biomass production and forage yield, as leaf attributes are intricately linked to yield components (Tiwari et al., 2024). Khandelwal (2015) observed a favorable association between leaf count and fresh weight per plant, suggesting that an increase in leaf quantity greatly enhances dry weight.

The link between the number of leaves at 49 DAP and dry seed weight per plot is insignificant, with a correlation coefficient of 0.36, indicating a weak relationship. The correlation analysis at 49 DAP proved unreliable due to the plants' change from vegetative to generative growth at this stage. Seed filling generally culminates at the conclusion of the generative phase, indicating that the leaf count during this period does not substantially influence seed yield. Mulualem's (2018) research on Ethiopian sorghum genotypes identified a favorable association between grain yield and various parameters, including the number of heads per plot, but not with the number of leaves. Kalpande et al. (2015) also identified a negative association between leaf count and grain output per plant in kharif sorghum, indicating that an increase in leaf quantity does not inherently lead to greater seed weight.

CONCLUSION

Upon analyzing and discussing the research results, the subsequent conclusions can be derived:

1. The interplay of plant spacing and NPK fertilizer markedly affected numerous growth and yield metrics, encompassing plant height at 35, 42, and 49 days after planting (DAP); leaf area index at 49 DAP; stem diameter at 35, 42, and 49 DAP; root volume at 35 and 49 DAP; panicle length; seed count per plant; panicle weight per plant; dry seed weight per plant; and dry seed weight per plot.
2. The ideal combination of plant spacing and NPK was identified in treatment A, utilizing a spacing of 70 cm x 20 cm and 200 kg/ha of NPK, yielding a dry seed weight of 4.46 kg per plot (equal to 3,717 kg per hectare). This treatment markedly differed from treatments B, E, F, H, and I, but not from treatments C, D, and G.
3. A notable moderate connection was detected between plant height and dry seed weight per plot at 35, 42, and 49 days after planting (DAP). A moderate association was seen between the number of leaves and dry seed weight per plot at the 35 and 42 days after planting observations.

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