GROWTH AND YIELD RESPONSES OF SHALLOT (*ALLIUM ASCALONICUM L.)* ON VARIOUS PLANTING DISTANCES AND FERTILISER RATES

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ABSTRACT

A study had been done in MARDI Serdang to investigate the growth and yield response of shallot (Allium ascalonicum var. Sanren F1) in various planting distance and fertilizer rate. The objective of this study is to determine the suitable planting distance and optimum rate of NPK 15:15:15 fertilizer based on growth and yield of shallot in mineral soils. The experiment was done in a plot, consist of sandy clay soil type at the period of January to March 2022. The experimental plot was laid out in Split Plot Design, with planting distance as main plot while fertilizer rate as sub plot in three replications. The planting distance treatments were J1: 15cm x 15cm (control), J2: 15cm x 10cm and J3: 10cm x 10cm. The fertilizer rate use was N: 300kg/ha, N2:400kg/ha, N3:500kg/ha and N4: 600kg/ha (control). Overall, the result of this study showed interaction between planting distance and fertilizer rate on plant height, bulb diameter and fresh weight. J1 and J2 on N2, N3 and N4 were significantly affected the plant height, bulb diameter and fresh weight compare with other treatments. However, no interaction was found on leaf numbers, bulb numbers and marketable yield. This study concluded that the application of 600kg/ha NPK 15:15:15 fertilizer with 15cm (between row) x 15cm (in the row) planting distance can be used for optimum growth and yield of Sanren F1 variety shallot production in mineral soils.

Keywords: shallot, planting distance, fertilizer rate, yield, sandy clay

INTRODUCTION

Shallots are essential commodities in Malaysian cuisine, serving as widely-used condiments and spices. However, Malaysia currently relies on importing shallot bulbs from major producer countries like India, China, Bangladesh, and Pakistan. Local agropreneurs are hesitant to grow shallots due to the lower market price. This reliance on imports has led to fluctuating prices in the retail market, ranging from RM3-4/kg and sometimes rising to RM8-12/kg when the main exporters face production issues caused by natural disasters or pandemics. This supply shortage poses a threat to the nation's food security. In response, MARDI has included a main project in the 12th Malaysian Plan to study the feasibility of shallot production in Malaysia.

Like other Alliaceae family members, such as onions and leeks, shallots are biennial crops that tend to produce bulbs in an aggregate form. The bulbs are tear-drop shaped and covered with thin, red scales, while the leaves are cylindrical with a flattened upper part. Shallots thrive in sandy loam soil that is high in organic matter and has a pH range of 6 to 7. They can grow well at low altitudes with a temperature range of 24-36°C but require higher altitude conditions with a temperature range of 15-24°C for seed production.

Successful commercial production of shallots relies on implementing the correct agronomic practices. According to Kebede (2003), selecting a suitable variety, choosing an appropriate agroclimatic zone, managing nutrients, and determining plant density is crucial to achieving profitable yields. Ideal plant density is necessary to promote optimum growth, considering factors such as solar absorption, aeration, and nutrient competition (Afifati, 2021). While tighter spacing may result in smaller yields and bulb size due to greater plant competition (Fikadu, 2015), reducing the number of plants per hectare may also negatively affect overall yield (Rahmawati, 2017). Furthermore, allowing greater spacing between plants may lead to weed growth, as weeds tend to have a higher growth rate than shallots (Afifati, 2021). The Indonesia Agency of Agriculture Research and Development (IAARD) recommends plant densities of 20cm x 15cm, 20cm x 20cm, and 15cm x 15cm, depending on the type of seedling, bulb seed size, and soil type (Pusdatin, 2016).

Nutrient availability is a crucial factor in optimising the growth of shallots, as they have similar nutritional requirements to other Allium species (Zahara et al., 1994). Inorganic fertilisers have been found to significantly increase the growth and yield of shallots (Muammar et al., 2022). The three primary nutrients in compound fertilisers - nitrogen (N), phosphorus (P), and potassium (K) - can increase bulb size, fresh weight, and bulb yield per hectare (Thabet, 1994). These elements are considered macronutrients because plants require them in large quantities compared to other elements (Marschner, 2015).

The Indonesia Agency of Agriculture Research and Development (IAARD) recommends applying 600kg/ha of compound NPK 16:16:16 fertiliser for most production areas in Indonesia. Using single fertilisers is not advisable because farmers may experience difficulties in the application process (Andi, 2021). Furthermore, compound fertilisers are more homogeneous and practical to apply, providing precise and controlled release of nutrients (Andi, 2021).

Therefore, MARDI conducted a study to determine the best plant density and fertiliser rate, using compound fertiliser, to develop a standard operational procedure for shallot cultivation and encourage agropreneurs and researchers to adopt the SOP. In addition, the study aimed to determine the effects of different planting distances and fertiliser rates on shallots' growth and yield responses.

MATERIALS AND METHODS

Research Site and Duration

The experiment was conducted at the Vegetables Research Plot of the Horticulture Research Centre, located at MARDI Headquarters in Serdang, Selangor. The plot was 43 meters above sea level and consisted of sandy clay soil. The experiment was carried out on a raised bed plot from January to March 2022.

Experimental Design

The experimental plot was designed using a Split Plot Design, with the fertiliser rate as the main plot and planting distance as the subplot. The experiment was conducted in three replications using a granular compound fertiliser, NPK 15:15:15, which contains 15% Nitrogen (N), 15% Phosphorus Pentoxide (P205), and 15% Potassium oxide (K20). The fertiliser rates used were N1: 300kg/ha, N2: 400kg/ha, N3: 500kg/ha, and N4: 600kg/ha (control). For the planting distance treatments, the following were used: J1: 15cm x 15cm (control), J2: 15cm x 10cm, and J3: 10cm x 10cm.

Research Management

The research plot was prepared using standard procedures for vegetable planting. First, the soil was ploughed to a depth of 30cm for aeration and to remove any pests in the soil. After a week, the soil was rotor-tilled to further improve aeration and amended with 1 tonne/hectare of bio-organic material, 1 tonne/hectare of chicken manure, and 500kg/hectare of Ground Magnesium Lime (GML) for liming. The raised beds were 0.2m tall, with a width of 1.0m and a length of 45.0m using a bed ridger. Seedlings were prepared in seedling trays using peatmoss as a germination medium. The Sanren F1 variety from East West Seeds was used, with the seeds sown and grown for 30 days before transplanting to the research plot. The plants were watered frequently, and weeds were removed manually. Pest and disease control measures were implemented based on the intensity and severity of attacks. Samples were harvested 75 days after transplanting based on yellowing symptoms on the leaf tips, hollow turnips on the bulb, and easy detachment of the bulbs. Harvesting was done manually by pulling out the shallot bulbs, and all parameters were measured during harvesting.

Parameter Measured

At harvest, several parameters were measured, including plant height, leaf number, bulb number, bulb diameter, fresh weight, and dry weight at 75 days after transplanting. Then, the bulbs were solar-dried on a bench under a transparent plastic rain shelter at 32-36°C for 14 days to obtain the dry weight. This dry weight was considered as the marketable yield weight.

Statistical Analysis

The data obtained from the samples were analysed using Analysis of Variance (ANOVA) with SAS Software ver. 9.2. The means with significant differences were further analysed using the Least Significant Difference (LSD) at $p \leq 0.05$. Regression analysis was performed using Microsoft Excel version 365.

RESULTS AND DISCUSSION

Effect on Plant Growth and Yield

All plant samples responded well in the experiment, as depicted in Picture 1. Table 1 shows various combination results for each parameter. The analysis revealed that applying compound fertiliser at various planting distances had a significant effect on the parameters, and there was also a significant interaction between the study's main plot and sub-plot.

The planting distance significantly impacted the number of bulbs per plant parameter. The number of bulbs per plant on J1 (8.75) and J2 (9.42) was significantly higher compared to J3 (5.29), and the number of bulbs per plant decreased as the planting distance became closer. This is likely due to higher competition between plants resulting in poor growth and yield (Indrayanti, 2010). The dry weight of shallots showed significant results for both the fertiliser and planting distance factors. The N4 application (74.06) gave a significantly higher yield compared to N2 (58.56) and N1 (59.46), and for planting distance, J2 (94.06) was significantly different from J1 (70.15) and J3 (26.70). Balanced quantities of fertiliser subsequently increase the yield and biomass of shallots (Sumarni, 2016). However, there was no significant difference in the leaf numbers parameter for both factors.

Table 1: Plant growth and yield response Means with the same letter(s) within a column are not significantly different from each other

Treatments	Height (cm)	Leaf numbers	Bulb per plant	Bulb diameter (mm)	Fresh weight (g)	Dry weight (g)
Main Plot						
N1	38.09[b]	27.28	7.17	28.59b[b]	93.99[b]	59.46[b]
N2	40.71[ab]	29.61	7.56	29.63ab[ab]	94.03[b]	58.56[b]
N3	42.85[a]	26.83	7.78	30.88ab[ab]	99.35[ab]	62.48[ab]
N4 (C)	42.42[a]	28.39	8.78	31.05[a]	113.23[a]	74.06[a]
P≤0.05 LSD	*	ns	ns	*	*	*
Sub Plot						
J1 (C)	42.16[b]	32.29	8.75[a]	30.16[ab]	109.63[a]	70.15[b]
J2	46.25[a]	33.25	9.42[a]	30.99[a]	129.39[a]	94.06[a]
J3	34.65[c]	18.54	5.29[b]	28.97[b]	61.43[b]	26.70[c]
P≤0.05 LSD	*	ns	*	*	*	*
Interaction J*N	*	ns	ns	*	*	ns

(*p<0.05, **p<0.01,***p<0.001, ns: not significant)

Interaction effect of treatments on plant height

Figure 1 presents the interaction between fertiliser rate and planting distance on plant height. The results show that N3 and N4 had a significant effect compared to N1, while N2 did not differ significantly among treatments. Additionally, J2 demonstrated a significant effect compared to J1 and J3 for N3 and N4. Therefore, the combination of J2 with N3 and N4 significantly affected plant height compared to other interactions. These findings indicate that applying appropriate inorganic fertiliser rates significantly affects plant height. Even though J2 was planted closer to J1, sufficient nutrients prevented competition between the plants (Fikadu, 2015).

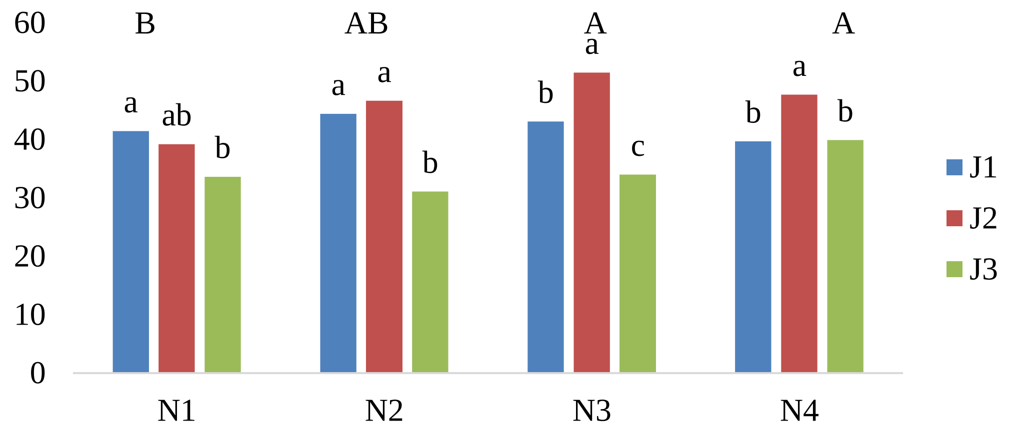


Fig 1: Interaction of fertiliser rate and planting distance on plant height
Means with the same letter(s) within a column are not significantly different from each other (*p<0.05, **p<0.01,***p<0.001, ns: not significant)

Interaction effect of treatments on bulb diameter

Figure 2 presents the interaction effect of fertiliser rate and planting distance on bulb diameter. N4 significantly differs from N1 while N2 and N3 do not significantly differ from both N1 and N4. In this particular analysis, the fertiliser rate of N2, N3 and N4 with a planting distance of J1 and J2 was the optimum combination of bulb diameter. Planting distance and fertiliser rate affected the size of the bulb. Previous data show the same trend with the bulb size; an increased plant height will significantly increase the bulb's fresh and dry weight, thus increasing the yield.

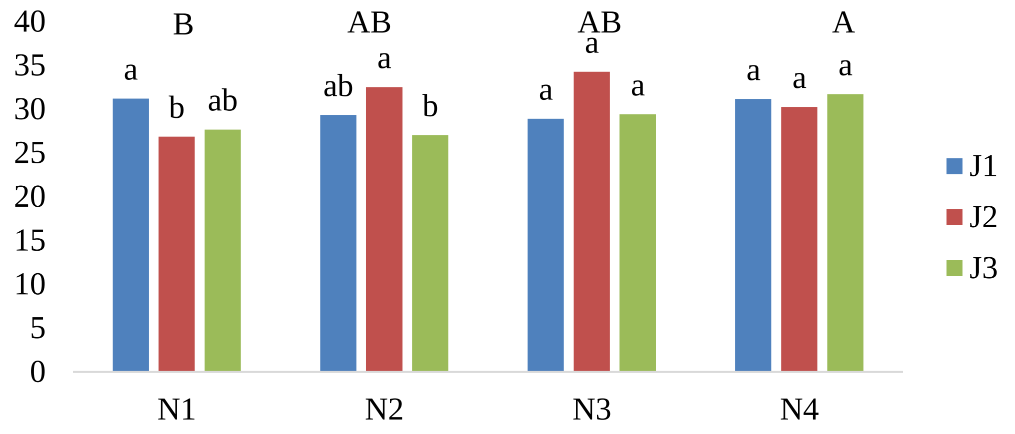


Fig 2: Interaction of fertiliser rate and planting distance on bulb diameter
Means with the same letter(s) within a column are not significantly different from each other (*p<0.05, **p<0.01,***p<0.001, ns: not significant)

Interaction effect of treatments on fresh weight

Figure 3 presents the interaction effect of treatments on fresh weight. N4 significantly differed from N1 and N2, while N3 did not significantly differ on all fertiliser rates. At all fertiliser rate treatments, J1 and J2 show significant differences with J3. Therefore, the combination of N3 and N4 with J1 and J2 was the best on fresh weight. Despite J1 and J2 having no significant difference in fresh weight, increasing the number of plants per area increases the overall yield per hectare. The decreasing population increase the bulb weight (Andre, 2006).

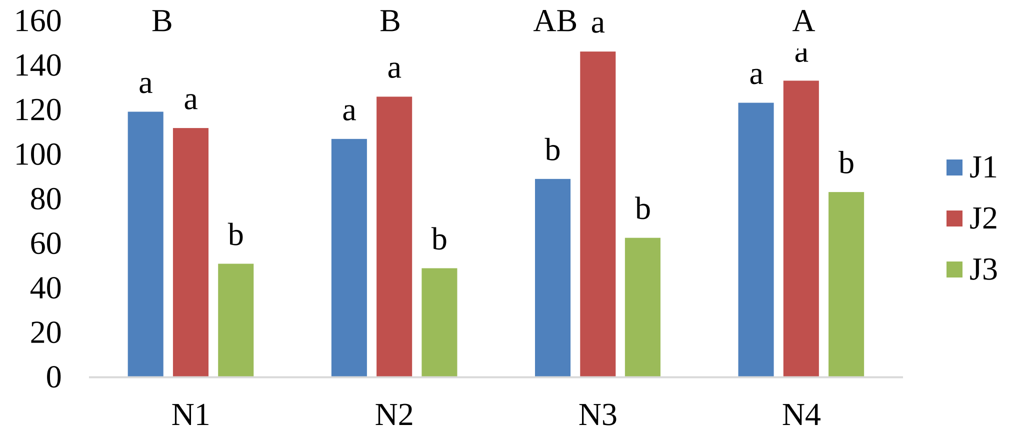
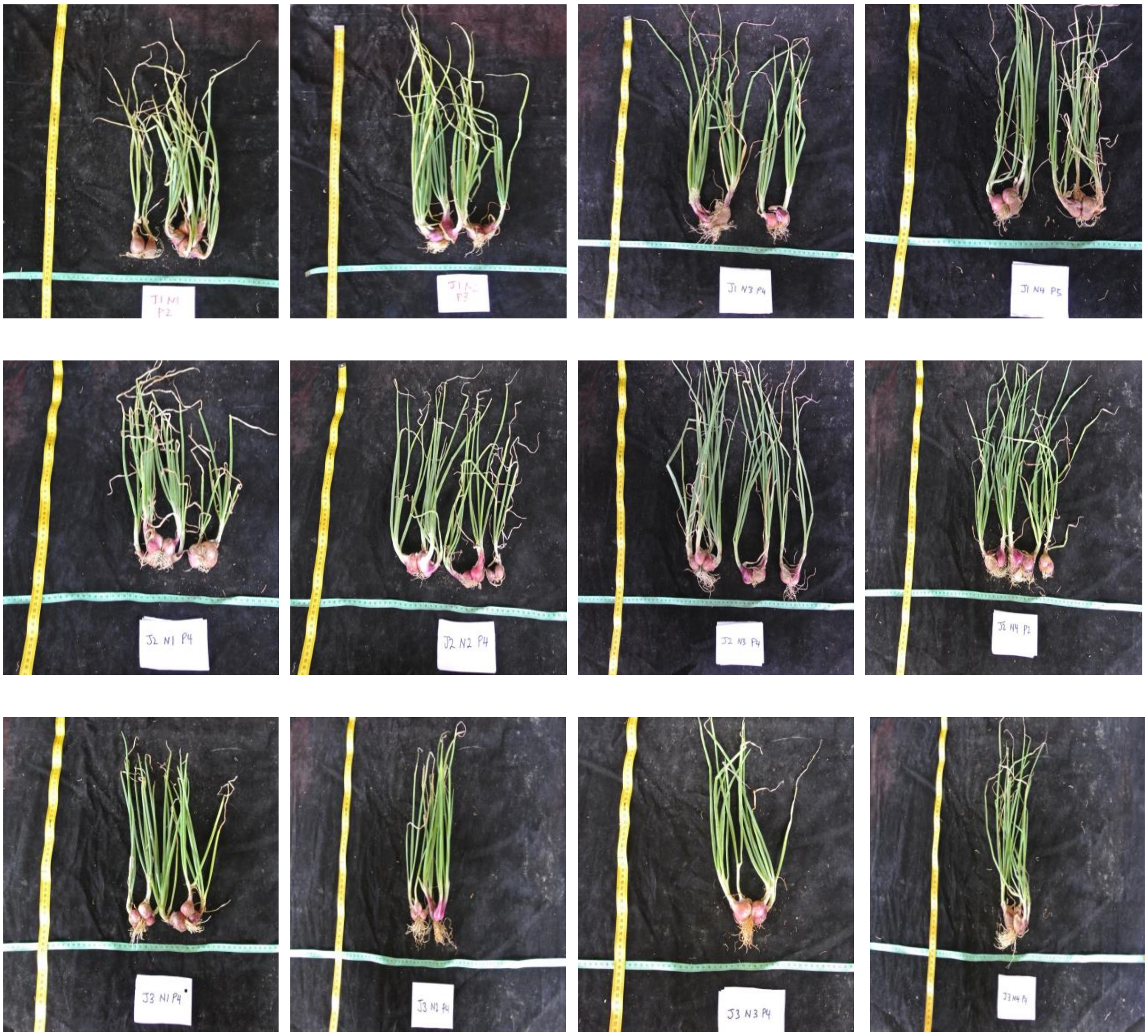


Fig 3: Interaction of fertiliser rate and planting distance on fresh weight
Means with the same letter(s) within a column are not significantly different from each other (*p<0.05, **p<0.01,***p<0.001, ns: not significant)



Picture 1: Effect of treatments on visual appearance

Analytical analysis on regression and correlation.

Overall, from this study, the fresh weight on applying 500-600kg/ha of fertiliser combined with a 15cm x 10cm planting distance is 99.35 – 113.32g per plant, while the dry weight is 62.48-74.06g. This data shows that the marketable yield on a hectare basis is 6.99 – 8.29 tonne/ha. Therefore, it is considered a lower yield than the result obtained by Andi (2021) using NPK 16:16:16 with the application rate of 700-900kg/ha with 14.5-16.3 tonne/ha. Although the yield can be increased by increasing the fertiliser rate, production viability needs to be considered.

Besides, the data were interpreted using correlation and regression analysis to search for the optimum application of NPK 15:15:15 at 15cm x 10cm planting distance for production on the marketable yield basis. According to the analysis result, it was revealed that increasing the fresh weight will increase the marketable yield. Hence, from this correlation analysis result, the regression analysis discloses that the amount needed for producing 6.99-8.29 tonne/ha marketable yield is 526kg/ha.

CONCLUSION

Typically, this study's result suggested that applying 526kg/ha NPK 15:15:15 fertiliser at 15cm x 10cm planting distance offers the best condition to produce optimum yield. However, more repeated experiments need to be done to conclude the best fertiliser rate and planting distance option for producing shallot in sandy clay soil. Furthermore, other factors that affect the shallot production yield need to be clarified, such as climatic zone, soil type and environment for viable and economical production in this country.

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