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Integrated Application of Chicken Manure and KCl Enhances Growth and Yield of Shallot (*Allium ascalonicum* L.) on Peat Soil

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Abstract. Peat soils present significant constraints for shallot cultivation due to poor nutrient availability and unfavorable physicochemical properties. This study evaluated the interaction and individual effects of chicken manure and potassium chloride (KCl) on shallot (*Allium ascalonicum* L.) growth and yield on peat soil. A completely randomized design with two factors—chicken manure (0, 250, 500, 750 g polybag^{-1}) and KCl (0, 0.8, 1.5, 2.2 g polybag^{-1})—was used with three replications. The combined application of 750 g polybag^{-1} chicken manure and 2.2 g polybag^{-1} KCl produced the best results: plant height (39.67 cm), earliest harvest (62.17 days), bulb diameter (27.93 mm), bulbs per clump (7.50), fresh bulb weight (42.74 g clump^{-1}), dry bulb weight (33.03 g clump^{-1}), and lowest weight loss (22.77%), compared to control values of 26.50 cm, 70.33 days, 13.08 mm, 4.17 bulbs, 19.75 g, 9.87 g, and 50.01%, respectively. Chicken manure played a dominant role by supplying nitrogen and phosphorus while improving soil properties, whereas KCl supported assimilate translocation and bulb development. However, at the highest chicken manure level, additional KCl showed no significant effects, indicating nutrient saturation. These findings highlight that integrated fertilization with 750 g chicken manure and 2.2 g KCl per polybag effectively enhances shallot productivity on peat soils, emphasizing the importance of balanced, site-specific nutrient management.

Keywords: *Chicken manure, Integrated fertilization, Peat soil, Potassium chloride, Shallot*

1. Introduction

Shallot (*Allium ascalonicum* L.) is a high-value horticultural crop that plays a vital role in food systems, particularly in Southeast Asia. Beyond its function as an essential culinary ingredient, shallot contributes significantly to farmers' livelihoods and regional economic stability. Its relatively inelastic demand makes it a strategic commodity, closely linked to food price volatility and national food security. Despite its importance, sustaining shallot production remains a persistent challenge, especially in regions where productivity fluctuates under changing environmental and land-use conditions.

Indonesia's national shallot production has exhibited modest variability in recent years, reflecting underlying constraints in cultivation systems. This variability is closely associated with production inefficiencies, seasonal dependence, and resource limitations in shallot farming systems [1], [2]. At the regional level, such as in Riau and other provinces, production fluctuations tend to be more pronounced due to local agroecological constraints and inconsistent management practices. These instabilities occur alongside steadily increasing demand driven by population growth and the strategic importance of shallots in Indonesian food systems [3], [4]. Consequently, a mismatch between production capacity and consumption demand often arises, indicating that current cultivation practices are not yet sufficiently resilient to environmental variability and resource limitations [2], [5].

A critical issue underpinning this challenge is the rapid conversion of fertile agricultural land into non-agricultural uses, which limits the availability of suitable areas for crop production. In response, attention has increasingly shifted toward the utilization of marginal lands, particularly peatlands, as an alternative for agricultural expansion. Riau Province alone contains approximately 5.09 million hectares of peatland, representing a substantial yet underutilized resource (Sirait, 2018). However, peat soils are inherently fragile and characterized by high acidity, low base saturation, and poor availability of essential macronutrients such as nitrogen (N), phosphorus (P), and potassium (K), which constrain plant growth and productivity [6].

Addressing these limitations requires a more nuanced approach to soil fertility management. One promising strategy involves the integration of organic and inorganic fertilization to improve both soil quality and nutrient availability. Organic inputs such as chicken manure have been widely recognized for their ability to enhance soil structure, increase microbial activity, and supply essential nutrients in a more sustainable manner. In peat soils, these benefits are particularly relevant, as organic amendments can help buffer acidity and improve nutrient retention. Empirical evidence suggests that chicken manure can significantly enhance the growth and yield of shallot; however, its effectiveness is highly context-dependent, with optimal application rates varying across soil types and environmental conditions [7].
Complementing organic fertilization, inorganic inputs such as potassium chloride (KCl) remain essential for meeting specific nutrient demands. Potassium plays a critical role in physiological processes, including carbohydrate translocation, bulb formation, and overall crop quality. Previous studies have demonstrated that KCl application can improve key agronomic parameters such as plant height and bulb biomass [8]. Nevertheless, the efficiency of potassium fertilization in peat soils is often limited by nutrient leaching and low retention capacity, raising important questions about how best to optimize its use in such environments.

While the individual effects of organic and inorganic fertilizers have been widely studied, most existing research has focused on mineral soils, leaving a significant knowledge gap regarding their combined application in peat-based systems. This gap is particularly important given the distinct physicochemical properties of peat soils, which may alter nutrient dynamics and plant responses in ways that are not yet fully understood. Moreover, there is limited empirical evidence on how integrated fertilization strategies influence both growth and yield performance of shallot under these conditions.

Therefore, this study seeks to address this gap by examining the interactive effects of chicken manure and KCl fertilizer on the growth and yield of shallot cultivated on peat soils. By situating the analysis within the specific agroecological context of peatlands, this research aims not only to generate practical recommendations for nutrient management but also to contribute to a broader understanding of sustainable crop production in marginal environments. Ultimately, improving shallot productivity on peatlands represents a critical step toward enhancing agricultural resilience and ensuring food security in regions facing increasing land constraints.

2. Research Methods

2.2 Experimental Design

The experiment was conducted from February to May 2025 at the Experimental Farm of the Faculty of Agriculture, Universitas Islam Riau, Pekanbaru, Indonesia, using a completely randomized design (CRD) with a factorial arrangement of two factors. The first factor was chicken manure dosage at four levels: 0, 250, 500, and 750 g polybag^{-1}. The second factor was KCl fertilizer at four levels: 0, 0.8, 1.5, and 2.2 g polybag^{-1}. These treatments formed 16 combinations, each replicated three times, totaling 48 experimental units, with four plants per unit and two sample plants, making 192 plants in total

2.3 Soil Preparation and Planting Medium

.Peat soil (sapric type) was collected from 0–20 cm depth and placed into 25 × 25 cm polybags at 5 kg per polybag. Soil pH was adjusted from 4.5 to approximately 6.5 using dolomite (16 g polybag^{-1}) two weeks before planting.

2.3 Fertilization Application

Chicken manure was applied one week before planting, while KCl was applied at planting, 2, and 4 weeks after planting (WAP) using band placement 5 cm from the plant base. Basal fertilizers included SP-36 (0.6 g polybag^{-1}) and urea (0.1 g polybag^{-1}) at planting, with additional urea at 15 DAP. Shallot bulbs cv. Bima Brebes were trimmed (one-third of the tip) and planted individually per polybag. Standard practices included daily irrigation, manual weeding, mulching, and pest control. Fusarium wilt was controlled with Dithane M-45 and Amistar-Top fungicides as needed.

2.4 Data Collection

Growth and yield parameters measured included plant height and leaf number at 14, 21, 28, and 35 DAP, harvest age, bulb diameter, bulbs per clump, fresh and dry bulb weight, and weight loss percentage.

2.5 Data Analysis

Data were analyzed using ANOVA, with significant differences tested using HSD at 5% significance level.

3. Results and Discussion

3.1 Plant Height

The results of the analysis of variance indicated that both the main effects and the interaction between chicken manure and KCl fertilizer significantly influenced shallot plant height at 35 days after planting (DAP) . The highest plant height (39.67 cm) was observed under the combined application of 750 g polybag^{-1} chicken manure and 2.2 g polybag^{-1} KCl, while the lowest value (26.50 cm) occurred in the unfertilized control treatment. This trend clearly demonstrates that increasing fertilizer inputs, particularly under combined organic–inorganic fertilization, enhances vegetative growth in shallot (Table 1).

Table 1. The plant height average of shallot at 35 days post treatments of chicken manure and KCl (cm)

Chicken Manure (g/polybag)	KCl (g/polybag)				Average
	0 (K0)	0,8 (K1)	1,5 (K2)	2,2 (K3)	
0 (A0)	26,50 g	27,50 fg	26,83 g	26,83 g	26,92 d
250 (A1)	28,83 efg	28,50 efg	27,83 fg	30,17 d-g	28,83 c
500 (A2)	32,83 cde	32,33 c-f	34,00 bcd	34,50 bcd	33,42 b
750 (A3)	33,00 cde	36,00 abc	38,17 ab	39,67 a	36,71 a
Average	30,29 b	31,08 ab	31,71 ab	32,79 a	
CV= 5,22 %		HSD A&K = 1,82		HSD AK = 5,00	

Numbers in columns and rows followed by the same lowercase letter indicate no significant difference according to the HSD test at the 5% level.

The application of chicken manure and KCl fertilizer significantly improved shallot plant height on peat soil, with the best results achieved at the highest doses (750 g polybag^{-1} chicken manure + 2.2 g polybag^{-1} KCl), producing a plant height of 39.67 cm compared to 26.50 cm in the control treatment. Chicken manure played a dominant role by supplying essential nutrients, particularly nitrogen, which promotes cell division and chlorophyll synthesis, while also improving soil physical and biological properties [9], [10]. KCl contributed to plant height through potassium's role in enzyme activation, photosynthesis, and assimilate translocation, though its effect was less pronounced [11], [12]. Interestingly, at the highest chicken manure level (750 g polybag^{-1}), increasing KCl doses did not produce statistically significant differences, indicating that potassium requirements were already met by the organic amendment. This reflects the concept of nutrient sufficiency and diminishing returns, where additional fertilizer inputs no longer proportionally increase growth once optimal nutrient thresholds are reached [13], [6]. The interaction between both fertilizers showed synergistic effects at moderate levels but diminishing benefits at higher doses, with plant height increasing progressively from 14 to 35 DAP

3.2 Harvest Age

The application of chicken manure and KCl significantly influenced shallot harvest age, with the earliest harvest (62.17 days) achieved at 750 g polybag^{-1} chicken manure + 2.2 g polybag^{-1} KCl, compared to the latest harvest (70.33 days) in the unfertilized controL (Table 2).

Tabel 2. The harvest age average of shallot in post treatments of chicken manure and KCl (days)

Chicken Manure (g/polybag)	KCl (g/polybag)				Average
	0 (K0)	0,8 (K1)	1,5 (K2)	2,2 (K3)	
0 (A0)	70,33 f	69,83 ef	69,00 ef	68,33 ef	69,38 d
250 (A1)	67,83 de	68,50 ef	68,33 ef	68,17 e	68,21 c
500 (A2)	65,33 bc	66,00 cd	65,67 c	65,83 cd	65,71 b
750 (A3)	65,00 bc	63,50 ab	63,50 ab	62,17 a	63,54 a
Average	67,13 b	66,96 b	66,63 ab	66,13 a	
CV= 1,07 %	HSD A&K = 0,79			HSD AK = 2,16	

Numbers in columns and rows followed by the same lowercase letter indicate no significant difference according to the HSD test at the 5% level.

Chicken manure played a dominant role in accelerating maturity by supplying nitrogen and phosphorus, which promote rapid vegetative growth, cell division, and root development, enabling earlier transition to the reproductive phase [4]. KCl contributed to earlier harvest through potassium's role in assimilate translocation, enzyme activation, and water balance regulation, which enhance bulb formation and maturation [3]. However, at the highest chicken manure level, increasing KCl doses did not further reduce harvest age, indicating nutrient saturation where additional potassium provided no additional benefit once optimal nutrient levels were achieved [5]. with potassium effectiveness in peat soils further limited by low retention capacity and leaching potential [1]. From a physiological perspective, balanced nutrient supply enhances metabolic activity, photosynthetic efficiency, and biomass accumulation, facilitating earlier transition from vegetative to generative phase, while nutrient deficiency limits photosynthetic capacity and delays maturity [15]-[17], [21], [22].

Environmental factors such as excessive rainfall can also prolong crop development despite adequate fertilization (6,18). Overall, chicken manure accelerates shallot maturity by improving soil fertility, while KCl serves as a complementary input supporting bulb development, with integrated fertilization shortening the growth cycle through synergistic effects [15], [18], [23]. Although excessive fertilization beyond optimal levels provides no additional benefits due to nutrient saturation and reduced efficiency (17,20), emphasizing the need for site-specific and balanced nutrient management to optimize harvest time in peatland agroecosystems. [17], [20].

3.3 Bulb Diameter

The analysis of variance demonstrated that both the main effects and the interaction between chicken manure and KCl fertilizer significantly influenced shallot bulb diameter, with the largest bulb diameter (3.77 cm or 27.93 mm) obtained under 750 g polybag^{-1} chicken manure + 2.2 g polybag^{-1} KCl, compared to the smallest diameter (2.10 cm or 13.08 mm) in the control treatment (Table 3).

Table 3. Bulb diameter average of shallot in post treatments of chicken manure and KCl (mm)

Chicken Manure (g/polybag)	KCl (g/polybag)				Average
	0 (K0)	0,8 (K1)	1,5 (K2)	2,2 (K3)	
0 (A0)	13,08 g	13,45 g	14,17 g	14,68 g	13,85 d
250 (A1)	16,41 efg	18,46 def	15,61 fg	19,77 de	17,56 c
500 (A2)	21,19 cd	21,66 cd	23,66 bc	23,75 bc	22,57 b
750 (A3)	23,84 bc	25,45 ab	25,73 ab	27,93 a	25,74 a
Average	18,63 b	19,76 b	19,80 b	21,53 a	
CV= 5,59 %		HSD A&K = 1,23		HSD AK = 3,39	

Numbers in columns and rows followed by the same lowercase letter indicate no significant difference according to the HSD test at the 5% level.

Chicken manure positively affected bulb diameter by improving soil fertility and nutrient availability in peat soils through supplying macronutrients (N, P, K) critical for growth and yield formation, with nitrogen supporting vegetative growth and photosynthesis, phosphorus enhancing root development and energy transfer, and organic matter improving soil physical and biological properties including microbial activity, cation exchange capacity, and nutrient holding capacity [15]–[17], [21], [22], [24]. Potassium from KCl fertilizer played a central role in bulb diameter through direct involvement in carbohydrate metabolism, enzyme activation, assimilate translocation from leaves to bulbs, and regulation of osmotic balance and turgor pressure essential for cell enlargement during bulb development [14],[15],[18]-[20]. However, at the highest chicken manure dose (750 g polybag^{-1}), increasing KCl application did not produce statistically significant differences in bulb diameter, indicating that potassium availability had already reached optimal levels due to potassium content in chicken manure itself, with nutrient responses plateauing once optimal levels are achieved (18,23,24).

3.4 Fresh Bulb Weight per Clump

The analysis showed that chicken manure and KCl significantly influenced fresh bulb weight per clump, with the highest weight (136.67 g) at 750 g chicken manure + 2.2 g KCl and the lowest (62.33 g) in the control (Tabel 4).

Table 4. The average of fresh bulb weight per clump of shallot in post treatments of chicken manure and KCl (g)

Chicken Manure (g/polybag)	KCl (g/polybag)				Average
	0 (K0)	0,8 (K1)	1,5 (K2)	2,2 (K3)	
0 (A0)	19,75 f	24,65 ef	28,94 de	30,67 cde	26,00 d
250 (A1)	30,75 cde	30,28 cde	29,95 cde	32,66 bcd	30,91 c
500 (A2)	34,47 bcd	34,45 bcd	35,60 a-d	35,88 a-d	35,10 b
750 (A3)	36,45 a-d	37,23 abc	38,42 ab	42,74 a	38,71 a
Average	30,35 c	31,65 bc	33,23ab	35,49 a	
CV= 7,70 %		HSD A&K = 2,79		HSD AK = 7,66	

Numbers in columns and rows followed by the same lowercase letter indicate no significant difference according to the HSD test at the 5% level.

Chicken manure enhanced fresh weight by supplying N, P, and K, improving soil structure and microbial activity, which promoted root development, vegetative growth, and photosynthetic capacity, leading to greater assimilate production for bulb formation [6],[15]-[17], [21], [22], [24]. KCl contributed through potassium's role in photosynthesis, enzyme activation, assimilate translocation, and water balance regulation, enhancing carbohydrate accumulation and cell expansion in bulbs [14], [15], [18]-[20]. The interaction showed synergistic effects at moderate levels, where organic amendments improved nutrient retention and inorganic fertilizer efficiency [15], [18], [21]. However, at the highest chicken manure level, additional KCl did not significantly increase fresh weight, indicating nutrient sufficiency where potassium needs were already met [17], with diminishing returns at higher nutrient levels [18, [23], [24] and reduced potassium effectiveness in peat soils due to low CEC and leaching [6].

3.5 Dry Bulb Weight per Clump

The analysis of variance showed that both chicken manure and KCl significantly affected dry bulb weight per clump, with the highest weight (102.33 g) at 750 g chicken manure + 2.2 g KCl and the lowest (45.67 g) in the control (Table 5).

Table 5. The average of Dry Bulb Weight per Clump of shallot in post treatments of chicken manure and KCl (g)

Chicken Manure (g/polybag)	KCl (g/polybag)				Average
	0 (K0)	0,8 (K1)	1,5 (K2)	2,2 (K3)	
0 (A0)	9,87 g	14,94 fg	19,56 ef	21,29 c-f	16,41 d
250 (A1)	21,37 c-f	20,73 def	20,57 def	23,28 b-e	21,49 c
500 (A2)	25,09 b-e	25,07 b-e	25,72 b-e	26,50 a-d	25,60 b
750 (A3)	27,07 a-d	27,85 abc	29,04 ab	33,03 a	29,25 a
Average	20,85 c	22,15 bc	23,72 ab	26,02 a	
CV= 9,44 %		HSD A&K = 2,43		HSD AK = 6,66	

Numbers in columns and rows followed by the same lowercase letter indicate no significant difference according to the HSD test at the 5% level.

Chicken manure increased dry weight by supplying N, P, and K, enhancing vegetative growth, photosynthetic capacity, and root development, while improving soil physical properties, microbial activity, and cation exchange capacity, particularly important in peat soils with low nutrient retention [6],[15]-[17], [21], [22], [24]. KCl contributed through potassium's role in carbohydrate synthesis, enzyme activation, and assimilate translocation from leaves to storage organs [14], [15], [18]-[20].

The interaction showed synergistic effects at moderate levels, where organic fertilization enhanced inorganic fertilizer efficiency [15], [18], [21]. However, at the highest chicken manure level, additional KCl did not significantly increase dry weight, indicating nutrient sufficiency and diminishing returns [17], [18], [23], [24], with potassium effectiveness in peat soils further limited by low CEC and leaching potential [6].

Overall, these findings confirm that integrated organic–inorganic fertilization effectively overcomes peat soil fertility constraints in shallot cultivation. Chicken manure played a dominant role by supplying essential macronutrients and improving the inherently poor physical, chemical, and biological properties of peat soil, while KCl acted as a catalyst for assimilate translocation and bulb formation. However, a plateau response at the highest doses indicated a fertilization efficiency threshold, beyond which additional inputs provided no significant agronomic benefits—likely due to peat's low cation exchange capacity (CEC) and high leaching potential, underscoring the need for precise KCl timing and dosing. A balanced, site-specific approach—specifically 750 g chicken manure + 2.2 g KCl polybag^{-1}—significantly boosted shallot productivity and offers a sustainable strategy for utilizing marginal peatlands. Practically, this approach reduces reliance on single synthetic fertilizers, lowers production costs, and preserves long-term soil health. Future field-scale studies are necessary to validate this formula across diverse peat types and evaluate its effects on bulb quality and post-harvest storage life.

4. Conclusions

Integrated fertilization of 750 g polybag^{-1} chicken manure and 2.2 g polybag^{-1} KCl produced the best shallot performance on peat soil, including highest plant height (39.67 cm), earliest harvest (62.17 days), largest bulb diameter (27.93 mm), highest fresh and dry bulb weight (42.74 g and 33.03 g clump^{-1}), and lowest weight loss (22.77%). Chicken manure played a dominant role by improving soil fertility and supplying essential nutrients, while KCl served as a complementary nutrient source supporting bulb development. However, additional KCl beyond optimal levels under high organic input showed no significant benefits due to nutrient saturation and low potassium retention in peat soils. Therefore, balanced and site-specific fertilization with 750 g chicken manure and 2.2 g KCl per polybag is recommended to optimize shallot productivity and quality on peatlands..

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