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Performance of Pekin Duck *(Anas platyrhychos domesticus)* Supplemented with Different Rates of Azolla Raised Under Molave Trees

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Abstract: Sustainable and integrated farming systems increasingly focus on alternative feed supplements and agroforestry-based rearing environments, yet their combined effects on duck production remain underexplored. This study assessed the growth performance, feed efficiency, and economic viability of Pekin ducks fed varying levels of Azolla and reared under Molave (*Vitex parviflora* Juss.) trees. A total of 120 two-month-old ducks were allocated across two rearing environments (open field and under Molave canopy) and four dietary treatments: 100% commercial feed, 85% commercial + 15% Azolla, 70% commercial + 30% Azolla, and 55% commercial + 45% Azolla. Azolla supplementation did not significantly influence weight gain, feed conversion ratio, dressing percentage with giblets and liver, or gross income. In contrast, rearing environment significantly affected weight gain, feed conversion ratio, and gross income, with net income highly influenced by both environment and Azolla inclusion. The highest profitability was achieved with 55% commercial feed plus 45% Azolla. These results demonstrate that integrating Azolla with silvopastoral systems can enhance economic returns without compromising duck performance, offering a viable strategy for sustainable smallholder duck production.

Keywords: azolla, molave trees, pekin duck, silvipastoral system

INTRODUCTION

Agroforestry, the intentional integration of trees with crops and/or livestock, has emerged as a promising strategy to improve food security, environmental resilience, and rural livelihoods. Rooted in traditional land use systems, agroforestry offers a sustainable alternative to conventional agriculture by enhancing biodiversity, improving soil fertility, sequestering carbon, and diversifying farm outputs (Pantera et al., 2021; Kaur et al., 2023). It has long been recognized for its potential to address both current and future environmental and socioeconomic challenges, particularly in the Global South. In the Philippines, agroforestry continues to be a critical component in rural development programs, offering opportunities for increased household income and climate-resilient food systems (Wagayen, 2024).

Agroforestry aligns closely with Sustainable Development Goal 12 (Responsible Consumption and Production) by reducing dependency on synthetic inputs and promoting efficient resource utilization. Integrating livestock into tree-based farming systems, such as in silvopastoral systems, enhances productivity while maintaining ecological balance. Silvopasture, the combination of trees, forage, and livestock, offers various benefits, including an improved microclimate, enhanced animal welfare, and long-term income from timber or fuelwood (Smith et al., 2022). Compared to open grazing systems, silvopasture is more resilient and multifunctional. Although overall biomass production may decrease slightly under tree shade, forage quality often improves, and livestock performance remains stable or improves (Ford et al., 2019; Wilson & Lovell, 2016).

Molave (*Vitex parviflora* Juss.), a native hardwood tree species in the Philippines, is highly valued both ecologically and economically. It grows well in dry lowland forests and has been utilized in agroforestry systems for soil stabilization, microclimate regulation, and biodiversity conservation (Bareja, 2017; Caraig, 2022). Its adaptability and ecological services make it suitable for integration in silvopastoral setups. However, limited research has assessed the potential of molave trees specifically in poultry-based silvopastoral systems.

The poultry sector plays a crucial role in food production globally, contributing significantly to dietary protein through meat and eggs. However, the rising cost of commercial feed, often comprising up to 70% of total production costs, remains a major constraint for poultry farmers, especially smallholders (Attia, 2022; Lawrence, 2023). As feed prices continue to increase, driven by fluctuating grain markets and competing demands, there is a pressing need to explore alternative, cost-effective, and sustainable feed sources (Den Hartog, 2009; Pinto, 2022).

In this context, Azolla, a fast-growing aquatic fern, has garnered attention as a viable feed supplement. Known for its high protein content and richness in essential amino acids, vitamins (including beta-carotene and B12), and minerals, Azolla offers a sustainable and low-cost feed option for livestock and poultry (Prasad et al., 2019; Kumar et al., 2022). It can be cultivated easily in small ponds, making it accessible for backyard and small-scale farmers. Studies have shown that Azolla supplementation can reduce feed costs without negatively impacting animal health or performance (Sujatha et al., 2013; Tufarelli, 2016).

In poultry, particularly in ducks and chickens, Azolla has been used as a partial substitute for commercial feed. Research indicates that it does not impair the digestibility of essential nutrients, and its inclusion in the diet can maintain or even enhance growth and survival rates (Patoliya, 2021). Its nitrogen-fixing properties also contribute to soil health, indirectly benefiting integrated farming systems.

The Philippines' agricultural research institutions, such as the Philippine Rice Research Institute (PhilRice), have developed Azolla cultivation technologies for use in rice-based and mixed-farming systems (Mondejar, 2017). Despite growing evidence on the nutritional value of Azolla and the benefits of agroforestry, studies exploring their combined effect, particularly on duck production, are scarce. There is a gap in understanding how Azolla-based feeding and agroforestry environments interact to influence growth performance and farm profitability.

This study aims to a) evaluate the growth, survival rate, and profitability of Pekin ducks raised under molave trees; b) determine the effects of varying levels of Azolla supplementation on the growth, survival rate, and profitability of Pekin ducks; and c) identify the optimal interaction between rearing environment (open field vs. under molave trees) and Azolla supplementation level in terms of duck performance and farm profitability.

MATERIALS AND METHODS

The study was conducted at the Agroforestry Nursery of the College of Agroforestry and Forestry, Don Mariano Marcos Memorial State University – North La Union Campus. Two rearing environments were used: an open field exposed to full sunlight and a shaded area under twelve Molave (*Vitex parviflora* Juss.) trees, each 10–15 meters tall, providing partial canopy cover. The site experiences a Type I climate, with a dry season from November to April and a wet season from May to October.

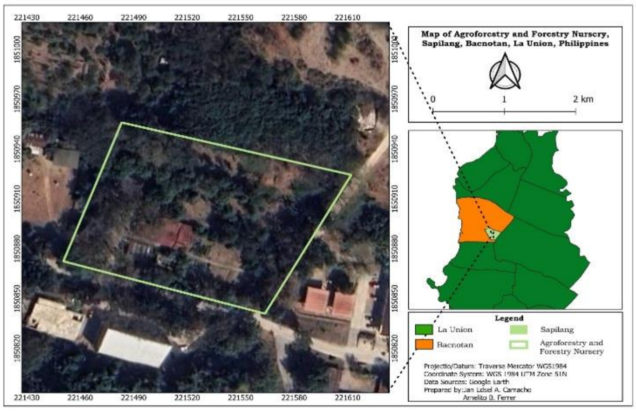

Plate 1. Map of the Study Area

Light intensity in both environments was measured using a lux meter at 9:00 AM and 3:00 PM throughout the 30-day observation period. A 2 × 4 split-plot design in three blocks was employed. The main plots were the rearing environments (open field and under molave), and the subplots were the four feed treatments:

S0: 100% commercial feed (2.1 kg),
S1: 85% commercial feed + 15% Azolla (1.785 kg + 0.45 kg),
S2: 70% commercial feed + 30% Azolla (1.47 kg + 0.9 kg),
S3: 55% commercial feed + 45% Azolla (1.155 kg + 1.35 kg).

A total of 120 two-month-old Pekin ducks sourced from Sta. Rita Norte, Agoo, La Union were randomly assigned to treatments and reared in nylon-net enclosures (24 m² per area) for 60 days. The enclosures were manually cleared and secured to prevent predator intrusion. Ducks were fed twice daily, at 9:00 AM and 5:00 PM, using combinations of commercial feed (B-MEG Integra 2000) and fresh Azolla. B-MEG Integra 2000 contains 19.5% crude protein and is fortified with essential vitamins, minerals, immuno-boosters, and probiotics to support optimal growth and health.

Data collected included weight gain, survival rate, and feed conversion efficiency. Normality of data was assessed using the Shapiro-Wilk test, and all variables conformed to normal distribution. Statistical analysis was performed using the ANOVA for a split-plot design at 0.05 and 0.01 significance levels. Significant differences among means were further analyzed using Tukey's Honest Significant Difference (HSD) test. Analyses were conducted using RStudio Statistical Software v.2024 (Posit team, 2024).

RESULTS AND DISCUSSION

Weight Gain After 30 Days

Effects of Field Conditions. The weight gain ranged from 0.16 kg to 0.26 kg. Ducks raised under Molave trees (M2) had the highest mean monthly gain of 0.26 kg, while those raised in an open field (M1) had 0.16 kg after 30 days. The results indicate a statistically significant difference in weight

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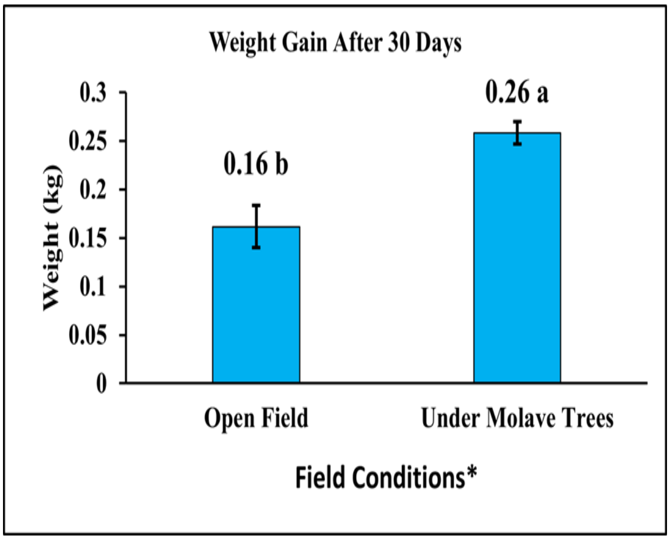
gain between ducks raised in open field conditions and those raised under Molave trees. Ducks under Molave trees (M_2) achieved a mean weight gain of 0.26 kg, significantly higher than the 0.16 kg observed in ducks raised in the open field (M_1).

Figure 1 presents the weight gain (kg) of Pekin ducks raised in two different field conditions.. The results show a significant difference at $p < 0.05$, indicating that field conditions can directly affect duck growth. Ducks raised under Molave trees (M2) had a higher mean weight gain of 0.26 kg, while those raised in the open field (M1) had a lower mean weight gain of 0.16 kg.



*=Significant at $p<0.05$. Treatment means in each bar with different letters are significantly different from each other based on Tukey's HSD test. Error bars represent standard deviation.

Fig 1. Weight Gain After 30 Days as Affected by Field Conditions

These results suggest that shaded environments, such as those provided by Molave trees, may support better growth in ducks. The increased weight gain under molave trees may be due to more favorable microclimatic conditions, particularly reduced exposure to direct sunlight and lower heat stress. Ducks in shaded areas are likely more comfortable and better able to maintain feed intake, which supports improved growth performance. According to Taşkesen et al. (2024), exposure to high ambient temperatures reduces feed intake and live weight in poultry, emphasizing the importance of minimizing heat stress to support optimal growth.

Effects of Different Rates of Azolla. Table 1 presents the weight gain of Pekin ducks as affected by different rates of azolla. The weight gain ranged from 0.16 kg to 0.25 kg. Ducks given 85% CF + 15% Azolla (S1) had a mean weight gain of 0.25 kg, followed by 100% Commercial Feeds (Control) (S0) at 0.22 kg, 70% CF + 30% Azolla (S2) at 0.199 kg, and 55% CF + 45% Azolla (S3) at 0.164 kg.

Table 1. Weight Gain of Pekin Ducks as Affected by Different Rates of Azolla

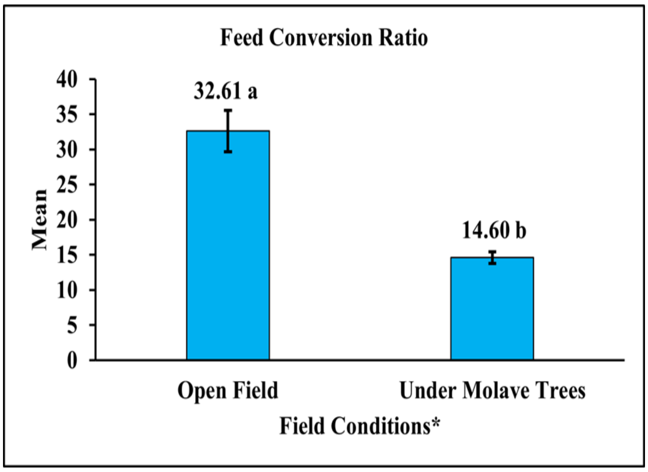
Rates of Azolla	Mean^{+}
S_0 – 100% Commercial Feeds (Control)	1.88
S_1 – 85% CF + 15% Azolla	1.91
S_2 – 70% CF + 30% Azolla	1.92
S_3 – 55% CF + 45% Azolla	1.90

$^{+}$= Not significant at $p<0.05$

The analysis of variance revealed no significant difference in the weight gain of Pekin ducks across different Azolla supplementation rates. This implies that varying the rates of azolla supplementation from 0% to 45% resulted in comparable weight gains.

Feed Conversion Ratio (FCR)

Effects of Field Conditions. The Feed Conversion Ratio ranged from 14.60 to 32.61, with ducks raised in the open field (M1) exhibiting the higher mean FCR of 32.61, while those raised under Molave trees (M2) had a lower mean FCR of 14.60.



*= Significant at $p < 0.05$. Treatment means with different letters are significantly different from each other based on Tukey's HSD test. Error bars represent standard deviation

Fig 2. Feed Conversion Ratio as Affected by Field Conditions

Analysis of variance revealed significant effects of field conditions on the feed conversion ratio of Pekin ducks. Ducks raised under the Molave trees (M2) had the lowest FCR 14.60, indicating better feed efficiency, while those raised in the open field (M1) had the highest FCR 32.61, suggesting poorer feed efficiency. The improved FCR in

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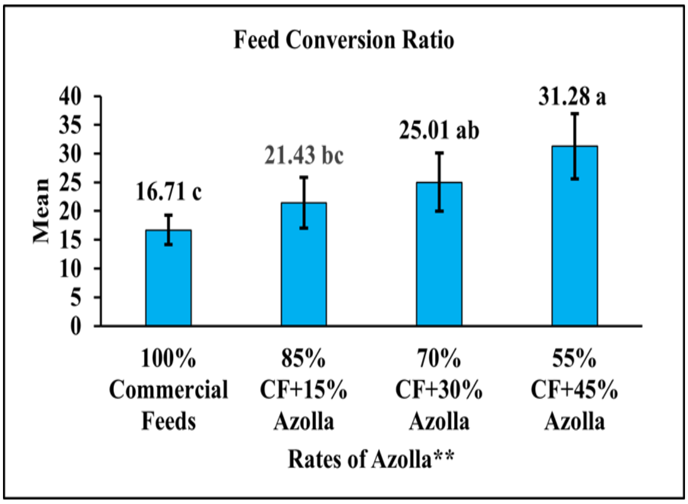
ducks raised under Molave trees may be attributed to reduced heat stress and improved environmental conditions, which likely enhanced their ability to utilize feed more efficiently. Extreme heat stress in the open area (M1) largely explains the higher FCR, as ducks reduce feed intake to limit metabolic heat and expend more energy panting for cooling, diverting resources from growth. The findings of Ghanima et al. (2020) indicate that heat stress exerts a substantial and immediate negative influence on bird welfare and performance.

Effects of Different Rates of Azolla. The FCR ranged from 16.71 to 31.28, with ducks fed 100% commercial feed (S0) having the highest feed conversion (FCR of 31.28), while those fed 55% commercial feed + 45% Azolla (S3) had the lowest feed conversion (FCR of 16.71).



**=Highly significant at $p<0.01$. Treatment means with different letters are significantly different from each other based on Tukey's HSD test. Error bars represent standard deviation

Fig. 3 Feed Conversion Ratio as Affected by Different Rates of Azolla

Analysis of variance revealed highly significant effects of supplementation on the feed conversion ratio. Ducks fed 100% commercial feeds (S0) had the most efficient feed conversion, 16.71, while those with higher rates of azolla had higher FCR values, indicating reduced feed efficiency. The increase in feed conversion ratio with higher rates of azolla suggests that while azolla can be a useful alternative feed ingredient, excessive substitution may negatively impact feed efficiency, possibly due to differences in nutrient digestibility and availability. This finding is supported by Danayit (2024), who reported that anti-nutritional factors such as tannins, oxalates, and phytates in Azolla can interfere with nutrient absorption and limit digestibility at higher inclusion levels, leading to reduced feed intake and growth performance.

Dressing Percentage with Giblets

Effect of Field Conditions. Table 2 presents the dressing percentage with giblets as affected by field conditions. The dressing percentage ranged from 85.52% to 86.29%. Ducks raised under Molave trees had a mean dressing percentage of 86.29%, while those raised in an open field had 85.52%.

Table 2. Dressing Percentage (%) with Giblets as Affected by Field Conditions

Field Conditions	Mean^{+}
M_1 – Open Field	85.52
M_2 – Under Molave Trees	86.29

$^{+}$= Not significant at $p<0.05$

Analysis of Variance showed no significant difference in the dressing percentage with giblets of Pekin ducks as affected by field conditions. This means that raising Pekin ducks in an open field or under Molave trees resulted in similar dressing percentages.

Effects of Different Rates of Azolla. Table 3 presents the dressing percentage with giblets of different rates of Azolla. The dressing percentage ranged from 84.58% to 87.12%. Ducks fed 70% CF + 30% Azolla (S2) had the highest mean dressing percentage of 87.12%, while the lowest was from ducks fed 85% CF + 15% Azolla (S1) at 84.58%. Likewise, the mean liver weight ranged from 0.06 kg to 0.07 kg. Ducks fed with 70% commercial feed (CF) + 30% Azolla (S2) and 55% commercial feed + 45% Azolla (S3) both recorded the heaviest liver weight at 0.07 kg, while those in the control group fed with 100% commercial feed (S0) had the lightest liver weight at 0.06 kg.

Table 3. Dressing Percentage with Giblets and Liver as Affected by Different Rates of Azolla

Rates of Azolla	Giblets Mean^{+}	Liver Mean^{+}
S_0 – 100% Commercial Feeds (Control)	**85.96**	**0.06**
S_1 – 85% CF + 15% Azolla	**84.58**	**0.06**
S_2 – 70% CF + 30% Azolla	**87.12**	**0.07**
S_3 – 55% CF + 45% Azolla	**85.96**	**0.07**

$^{+}$= Not significant at $p<0.05$

Analysis of variance showed no significant difference in dressing percentage with giblets and liver among the different rates of azolla. This implies that different levels of Azolla did not affect dressing percentage. Acharya et al. (2016) reported that feeding White Pekin ducks with 0%,

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5%, and 10% fresh Azolla did not significantly affect dressing percentage, eviscerated yield, or most carcass traits, although slight variations were observed in giblet yield. Similarly, a study published in Livestock Research for Rural Development found that replacing soybean meal with increasing levels of Azolla in the diet of growing ducks did not produce significant differences in liver weight across treatments. In contrast, Balaji et al. (2018) observed that broiler chickens fed up to 4.5% sun-dried Azolla showed a significant increase in giblet yield, although dressing percentage and eviscerated yield remained unaffected. These studies generally support the present findings that different levels of Azolla have no effect on dressing percentage and liver weight, although results on giblet yield may vary depending on species and inclusion level.

Carcass Dressing Percentage (%)

Table 4 shows the interaction between field conditions and different rates of azolla on carcass dressing percentage. The means ranged from 69.29% to 72.72%. Ducks raised under Molave trees and fed 100% commercial feeds (M2S0) recorded a dressing percentage of 72.72%, whereas those fed 85% commercial feed and 15% Azolla (M2S1) under the same field conditions had a dressing percentage of 69.29%.

Table 4. Interaction Effect Between Field Conditions and Rates of Azolla

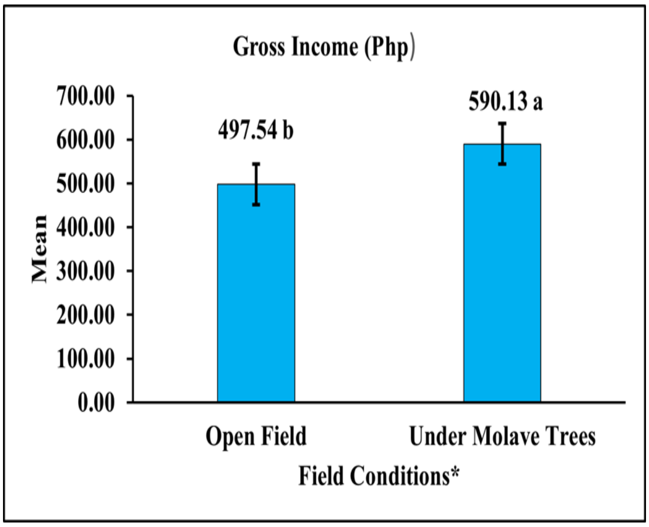
Treatment	Mean^{+}
M_1S_0	72.16
M_1S_1	71.83
M_1S_2	71.53
M_1S_3	70.51
M_2S_0	72.72
M_2S_1	69.29
M_2S_2	72.13
M_2S_3	72.35

$^{+}$= Not significant at p<0.05

The analysis of variance indicated no significant interaction effect between field conditions and Azolla supplementation rates. This means that the combination of these factors did not influence the carcass dressing percentage.

Gross Income (Php)

Effect of Field Conditions. The gross income ranged from Php 590.13 to Php 497.54. Ducks raised under Molave trees (M2) had a significantly higher mean gross income of Php 590.13, while those raised in an open field (M1) had a lower mean gross income of Php 497.54



*=Significant at p<0.05. Treatment means with different letters are significantly different from each other based on Tukey's HSD test. Error bars represent standard deviation

Fig. 4 Effect of Field Conditions on the Gross Income of Pekin Ducks

Analysis of variance in Figure 4 revealed a significant difference in the gross income of Pekin ducks in terms of field conditions. It indicates that the environment where ducks are raised can greatly affect gross income. Since the shade lessens heat stress and enhances comfort, feed intake, and growth, ducks raised under Molave trees generated a higher gross income (Php 590.13) than those raised in open areas (Php 497.54). In contrast, exposure to direct sunlight in open areas might have resulted in stress and decreased productivity, which would have decreased income. Similarly, Wasti et al. (2020) found that when poultry experience heat stress, their feed intake goes down, they do not grow as well, and their feed efficiency gets worse, which can lead to lower income for farmers. They also pointed out that making the environment better, like by giving shade, can help birds stay healthier and grow better even when it is hot. This supports the result of the study, showing that raising ducks under Molave trees is a smart and practical way to increase income.

Effect of Different Rates of Azolla. Table 5 presents the gross income (Php) of Pekin ducks as affected by different rates of Azolla. The highest gross income was observed in ducks fed with 100% commercial feeds (control) with a mean of Php 2,753.38, followed by those given 70% commercial feed + 30% Azolla (Php 2,740.46) and 85% commercial feed + 15% Azolla (Php 2,726.67). The lowest gross income was recorded from ducks fed with 55% commercial feed + 45% Azolla, with a mean of Php 2,656.17.

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Table 5. Gross Income as Affected by Different Rates of Azolla

Rates of Azolla	Mean+
S_0 – 100% Commercial Feeds (Control)	2753.38
S_1 – 85% CF + 15% Azolla	2726.67
S_2 – 70% CF + 30% Azolla	2740.46
S_3 – 55% CF + 45% Azolla	2656.17

+= Not significant at $p<0.05$

Analysis of variance showed no significant difference in the gross income of Pekin ducks fed with different rates of Azolla. This means that the gross income was found comparable regardless of the field conditions and different azolla supplementation levels.Net Income (Php)

Effect of Field Condition. Table 6 presents the net income of Pekin ducks raised under Molave trees and in an open area. The values ranged from Php 358.96 to Php 862.53. The highest net income was produced by ducks raised under Molave trees (M2) at Php 862.53, while the lowest was recorded in ducks raised in an open field (M1) at Php 358.96.

Table 6. Effect of Field Conditions on the Net Income of Pekin Ducks

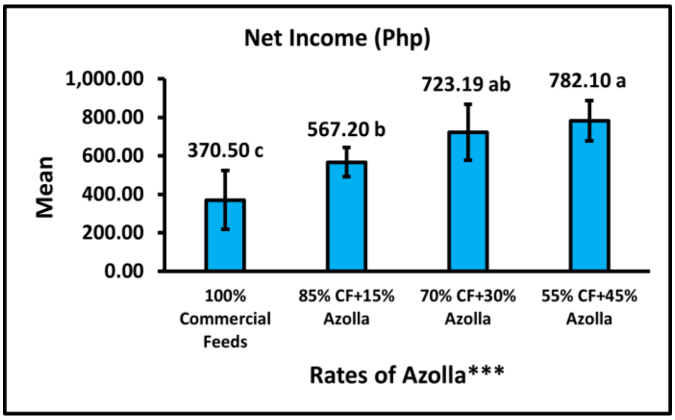
Table 6 presents the net income of Pekin ducks raised under Molave trees and in an open area. The values ranged from Php 358.96 to Php 862.53. The highest net income was produced by ducks raised under Molave trees (M2) at Php 862.53, while the lowest was recorded in ducks raised in an open field (M1) at Php 358.96.

Field Conditions	Mean**
M_1 – Open Field	358.96 b
M_2 – Under Molave Trees	862.53 a

**Highly significant at $p<0.01$. Means followed by different letters are significantly different based on Tukey's HSD test.

The Analysis of Variance revealed a highly significant difference between the two field conditions. This implies that ducks raised under molave trees resulted in higher net income compared to those raised in an open field.

Effect of Different Rates of Azolla. Figure 5 presents the net income of Pekin ducks fed with different rates of Azolla supplementation. The values ranged from Php 370.50 to Php 782.10. The highest net income was recorded in ducks given 55% CF + 45% Azolla (S3) at Php 782.10, while the lowest net income was observed in ducks fed with 100% Commercial Feeds (S0) at Php 370.50.



**=Highly significant at $p<0.01$. Treatment means with different letters are significantly different from each other based on Tukey's HSD test.

Fig. 5 Effect of Different Rates of Azolla on the Net Income of Pekin Ducks

The Analysis of Variance revealed a highly significant difference between the different rates of Azolla. This indicates that adding Azolla to the diet of Pekin ducks, particularly at higher levels of 30% to 45%, results in a noticeable increase in net income. This strategy not only reduces feed costs but also makes duck production more profitable and sustainable.

CONCLUSION

This study evaluated the performance, feed efficiency, and economic viability of Pekin ducks raised under a silvopastoral system integrating Molave (*Vitex parviflora* Juss.) trees and varying levels of Azolla supplementation. A total of 120 two-month-old ducks were subjected to four dietary treatments, ranging from 100% commercial feed to 55% commercial feed + 45% Azolla, and two rearing environments: open field and under Molave canopy.

The results of the study demonstrate that Azolla supplementation had no significant effects on weight gain, feed conversion ratio, dressing percentage (with giblets and liver), or gross income of ducks. In contrast, field conditions (under molave trees versus open area) significantly influenced weight gain, feed conversion ratio, and gross income, and showed a highly significant effect on net income. Notably, net income was also highly affected by the level of Azolla inclusion, with the highest profitability achieved at 55% commercial feeds combined with 45% Azolla, while the lowest net income was recorded in ducks fed 100% commercial feeds. These findings suggest that while Azolla does not markedly influence growth performance or carcass yield, its appropriate inclusion can improve economic returns, particularly when combined with favorable field conditions.

Conflict of Interest

There are no conflicts of interest declared by the authors.

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