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Research article

Influence of Chicken Manure, Pig Manure, Cattle Manure, and Coconut Peat on the Growth and Yield of Melon (*Cucumis melo* L.) cv. Thunder Gold 1497

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Abstract: This study investigated the effects of organic growing media mixtures derived from chicken manure, pig manure, cattle manure, and coconut peat on the growth rate, yield quality, and production cost of melon (*Cucumis melo* L.) cultivar Thunder Gold 1497. The evaluated parameters included the growth rates of plant height, leaf width, leaf number, and stem diameter, as well as fruit sweetness (°Brix), fruit weight, and growing media cost. Mixture ratios were formulated using a mixture experimental design. The results showed that growing media composition significantly affected plant height, leaf width, leaf number, fruit weight, and fruit sweetness ($p < 0.05$). Cattle manure played a dominant role in enhancing fruit weight and stabilizing plant growth, while pig manure positively influenced fruit sweetness. Optimization using the desirability function indicated that a mixture of 50.00% cattle manure and 50.00% coco peat provided the highest desirability value (0.916), resulting in high growth performance, improved fruit quality, and reduced growing media cost.

Keywords: Mixture experimental design; organic growing media; melon; yield quality; growth rate

1. Introduction

Melon (*Cucumis melo* L.) is a highly valued economic crop. It is widely cultivated in many countries, including Thailand, due to its sweet taste and high nutritional value, particularly vitamin A and vitamin C [1]. Melon can be grown in almost all regions of Thailand because it grows well in warm to moderately hot climates, with an optimal temperature range of 25–30 °C. It requires well-drained soil or growing media and does not tolerate waterlogging. In melon production, achieving high-quality attributes such as sweetness and crispness requires proper management of production factors, particularly nutrient supply and growing media, which directly influence plant growth. Consequently, melon is an important crop in both domestic and international markets. Melon production is commonly conducted in greenhouses to facilitate pest control and reduce damage from rainfall, a major factor in leaf mold and root rot [2].

In Thailand, disease-free and readily available organic materials such as Coconut Peat, raw rice husks, and rice husk charcoal are commonly used as growing media [3]. As a result, the use of natural organic growing materials, including animal manure and agricultural waste, has gained increasing popularity because these materials improve the physical, chemical, and biological properties of growing media while reducing dependence on chemical

fertilizers. Each type of manure possesses distinct properties. Chicken manure is a rich source of nitrogen and phosphorus and is suitable for promoting leaf and stem growth [4]. Cattle manure improves the structure of growing media and enhances water-holding capacity, whereas pig manure provides balanced micronutrients and stimulates microbial activity within the growing media. However, inappropriate use of manure proportions can lead to salinity accumulation or nutrient imbalance, negatively affecting plant growth [5].

Several studies have reported that the combined use of coconut shavings and manure can improve the physical and chemical properties of growing media [6]. Studies by Qiu et al. [7] and Su and Zhang [8] found that mixing organic materials at appropriate ratios improved the quality of growing media and seedling germination. For example, the combination of rice husk ash and coconut shavings positively affected the growth of cucumber seedlings (*Cucumis sativus* L.). Similarly, Imtiaz [9] and Mejía et al. [10] reported that compost mixed with coconut shavings enhanced the growth of tomato seedlings and melons in hydroponic systems. Additionally, the use of agricultural waste materials such as sawdust, rice husk charcoal, and sugar mill sludge increased melon yield under greenhouse conditions [11]. Ab Rauf and Shahruddin [12] reported that the combination of coconut shavings (coir) with cattle manure or compost significantly promoted seedling growth and root development in melon. This finding is consistent with previous studies by Mazuela and Urrestarazu [13] and Aydi et al. [14], which demonstrated that mixed organic growing media can enhance chlorophyll content, improve nutrient accumulation in leaves, and increase fruit quality, including sweetness and firmness. The beneficial effects of such mixtures are largely attributed to the complementary physical and chemical properties of organic substrates, where coconut-based materials improve aeration and drainage, while manure provides essential nutrients and enhances water-holding capacity.

In addition, several studies have highlighted the importance of combining different types of organic manures to improve plant growth and soil fertility. For example, Diacono and Montemurro [15] and Edmeades [16] reported that mixed organic amendments significantly improve soil structure, nutrient availability, and microbial activity, thereby enhancing crop productivity. Similarly, Adekiya et al. [17] and Ojo et al [18] found that the combined application of different manures resulted in greater plant growth and yield than using a single manure source, due to synergistic effects on nutrient release and soil physical properties. These findings support the concept that integrating multiple organic materials can create a more balanced growing environment for optimal plant development. Furthermore, previous studies by Ceglie et al. [19] and Myers et al. [20] used a mixture experimental design in combination with response surface methodology (RSM) to determine optimal proportions of growing media components to maximize responses such as yield and fruit sweetness. These approaches have been widely recognized as effective tools for optimizing agricultural inputs. Consistent with these findings Choudhary and Machavaram [21] demonstrated that optimized organic amendments significantly improved crop yield and fruit quality. Therefore, the objective of this research was to investigate the effects of mixing chicken manure, pig manure, cattle manure, and coco peat on melon growth and yield. A mixture experimental design was employed to determine the optimal growing media ratio affecting growth parameters, including plant height growth rate, leaf width growth rate, leaf number growth rate, and stem diameter growth rate. Yield-related parameters included fruit sweetness (°Brix), fruit weight, and growing media cost. The analysis was conducted under greenhouse conditions using Design-Expert version 7.0 to identify appropriate growing media compositions and provide practical guidance for farmers and entrepreneurs, thereby promoting sustainable commercial production of organic melons.

2. Materials and Methods

Thunder Gold 1497 (Sweet Green) melon seeds were transplanted into 104- cell seedling trays filled with peat moss. The seedlings were watered thoroughly twice daily (morning and evening). After 15 days of growth, the seedlings were transplanted into 8 × 13-inch white planting bags containing mixed growing media prepared according to each experimental formulation. The planting spacing was 40 × 50 cm. between plants. During cultivation, lateral shoots emerging from nodes 1 to 8 were pruned, while shoots from nodes 9 to 12 and above were retained. When the fruit reached approximately the size of a chicken egg, only one fruit was retained per plant. Subsequently, the 25th leaf was removed to terminate vegetative growth and promote

nutrient allocation toward fruit development. Melon fruits were harvested approximately 35–40 days after fruit set, based on external indicators such as skin color, aroma, netting development, and the appearance of cracks around the fruit peduncle. The experiment was conducted in a closed-system greenhouse with controlled temperature (25–32 °C) and relative humidity (60–75%). Plants were grown in growing media corresponding to each formulation, and drip irrigation was applied to supply water according to plant requirements at each growth stage. Chemical fertilizers were applied weekly during the first 30 days using a N- P- K fertilizer (15–15–15) at a rate of 5 g per plant. From 31 days after planting, a N- P- K fertilizer (20–8–20) was applied at 10 g per plant once per week. At 56–60 days after planting, a N- P- K fertilizer (15–5–35)was applied at a rate of 10–15 g per plant. In addition, drip irrigation was adjusted to provide approximately 1,500 mL of water per plant. The experiment was arranged in a completely randomized design (CRD) with one plant per replicate. The experimental design is presented in Table 1. [22]

2.1 Data Collection

Melon growth and yield parameters were analyzed, including plant height measured at 45 days after seeding. Plant height was measured from the soil surface at the base of the plant to the base of the fully expanded leaf using a measuring tape. The number of main leaves and the size of the third fully expanded leaf were recorded three weeks after transplanting. Leaf width was measured at the widest point using a ruler. Stem diameter was measured at the thickest part above the cotyledon using a vernier caliper. Fruit weight (g) was determined using a digital scale with a resolution of 0.01 g. Fruit sweetness was measured as total soluble solids (°Brix) using a refractometer, with juice extracted from the center of the fruit pulp. All measurements were recorded as the average of three plants per mixture ratio. Growth rate (%) was calculated using Equation (1), and the resulting data were used to analyze factors affecting melon growth and yield quality [19, 20].

$$\text{growth rate (\%)} = \frac{\text{Final measurement value} - \text{Initial measurement value}}{\text{Initial measurement value}} \times 100 \quad (1)$$

2.2 Mixture experimental design

A mixture experimental design was employed to determine the optimal proportions of animal manure and coconut shavings using statistical models. The total proportion of growing media was fixed at 100% (wt%) of the total volume [19]. Chicken manure (A), pig manure (B), cattle manure (C), and coconut shavings (D) were defined within a range of 0–100% of the mixture, as shown in Table 1. Experimental design, modeling, and response analysis were performed using Design-Expert software version 7.0 (Stat-Ease Inc., USA), following the principles of mixture design described [11]. For the preparation of the growing media and organic manures, coco peat was initially soaked in water for 24 h and subsequently washed repeatedly until the electrical conductivity (EC) value decreased to 0.3 dS cm^{-1}, which was considered suitable for melon cultivation. In addition, four types of animal manure were composted before use. The composting process involved applying 1 g of microbial inoculant (PD1), 1 kg of molasses, and 20 L of water, which were thoroughly mixed and evenly applied to each compost pile containing 100 kg of cattle manure, pig manure, chicken manure, and goat manure, respectively. During the composting period, water was supplied daily to maintain adequate moisture content, and each compost pile was manually turned three times per week to improve aeration and oxygen availability. This practice enhanced microbial activity and promoted efficient decomposition of organic matter.



Figure 1. Shows the growth of melons grown in a soilless crop regime.

Table 1. Typical nutrient composition of various animal manures.

Animal manure	Total Nitrogen (kg/t)	Total Phosphate (kg/t)	Total Potash (kg/t)	Ammonium Nitrogen (kg/t)	Nitrate Nitrogen (kg/t)	Dry Matter (%)
Broiler	30	25	18	6.2	0.2	60
Pig	7	8	6.0	0.9	0.1	25
Cattle	6	8	3.2	0.5	0.1	25

Table 2. Ingredients and limitations of ingredients used in experimental design

Ingredients	Factors	Ratio Limitations (Percentage)
Chicken manure	A	$0 \leq A \leq 50$
Pig manure	B	$0 \leq B \leq 50$
Cattle manure	C	$0 \leq C \leq 50$
Coconut shavings	D	$50 \leq D \leq 100$

3. Experimental results and discussion of results

The experimental results presented in Table 2 were used to select appropriate statistical regression models and to perform analysis of variance for the growth rate of melon plant height, leaf width growth rate, leaf number growth rate, stem diameter growth rate, fruit sweetness (°Brix), fruit weight, and growing media cost using Design-Expert software version 7.0. The pseudo-components included melon plant height growth rate, leaf width growth rate, leaf number growth rate, stem diameter growth rate, fruit sweetness (°Brix), fruit weight, and growing media cost, as expressed in Equations (2)–(8), respectively. The results indicated that linear models adequately described the growth rates of melon plant height and stem diameter, fruit weight, fruit sweetness, and growing media cost. In contrast, the growth rates of leaf width and leaf number were best fitted by special cubic models. The selection of these models was based on their p-values, all of which were less than 0.05 at the selected significance level, indicating that the regression models were statistically significant and suitable for describing the experimental data. In addition, the coefficients of determination (R^2) and predicted R^2 values for all selected models were relatively high and close to unity, further confirming the adequacy and reliability of the regression models.

Table 3. The Results of Growth Rate of Plant Height, Growth rate of the number of leaves, and growth rate of the number of leaves. Growth rate of stem size, yield weight, and sweetness

No.	A	B	C	D	Plant height (%)	Width of leaf (%)	Number of leaves per plant	Stem girth (%)	Weight (g)	Sweetness (Brix)	Cost (Baht)
1	0	0	0	100	22.5	5.3	16.67	6.56	320.24	8.5	20.2
2	25	25	0	50	42.8	11.52	18.89	8.26	780.72	13.2	10.8
3	50	0	0	50	28.4	7.74	12.04	12.22	520	10.8	10.8
4	31.228	6.07	6.408	56.294	32.6	5.3	9.03	10.1	615.84	11.5	12
5	0	0	50	50	48.2	14.47	31.48	18.75	920.05	12.6	10.8
6	0	0	25	75	35.2	6.17	20.37	8.64	620.53	11.7	15.5
7	12.5	12.5	12.5	62.5	40.95	10.36	15.74	15.12	740.5	12.1	13.2
8	0	25	0	75	32.8	6.29	13.33	7.22	480.29	11.5	15.5
9	0	50	0	50	38.6	8.08	15.74	4.45	650.32	14.2	10.8
10	12.251	12.52	12.474	62.756	37.2	11.37	14.81	12.22	695.09	12.3	13.2
11	5.888	6.139	6.474	81.499	29.59	11.11	20.83	11.9	545.54	10.4	16.7
12	5.97	31.482	6.487	56.062	40.25	9.55	20	12.12	760.86	13.3	12
13	5.971	6.096	31.51	56.423	44.6	13.08	13.89	22.22	810.15	11.7	12
14	0	25	25	50	43.44	12.04	11.11	17.22	785.89	14.5	10.8
15	25	0	25	50	38.08	5.63	11.11	11.64	720.44	12.6	10.8
16	25	0	0	75	25.4	7	15.56	11.42	420.22	11.5	15.5

Melon Height Growth Rate = 34.67A + 37.24B + 74.12C + 22.26D - 227.01AB – 1.69AC - 0.17AD + 34.96BD + 752.19ABD – 518.47AC(A-C) (2)

Leaf Width Growth Rate = 6.33A + 14.04B + 53.34C + 5.30D + 857.17AB – 994.53AC – 7.73AD – 2237.31BC – 6.35BD – 59.39CD – 3161.36ABC -1598.73ABD + 1813ACD+ 4499.20BCD (3)

Leaf Growth Rate = 10.18A + 16.75B + 44.41C + 16.68D – 171.21AC – 180.52BC + 1074.14BC(B-C) (4)

Growth rate of stem size = 19.02A – 10.56B + 63.14C + 7.39D – 59.92AC – 893BC + 23.19BD – 64.85CD +1974.52BCD – 686.51AC(A-C) (5)

Melon Fruit Weight = 688.91A + 988.12B + 1528.47C + 327.71D – 14723.7AB + 34.17AD - 42.71BD + 35680.69 – 8433.07AB(A-B) (6)

Sweetness = 2.16A + 20.40B + 17.44C + 8.68D + 8.53AD (7)

Cost = 1.41A + 1.41B + 1.41C + 20.19D – 0.02AB - 0.02AC – 0.01BC + 15.85ABC + 6.73BC(B-C) (8)

Based on the regression Equations (2)–(8), response surface contours were constructed. The contour plots for melon plant height growth rate, leaf width growth rate, leaf number growth rate, stem diameter growth rate, fruit sweetness (°Brix), fruit weight, and growing media cost are presented in Figures 2(a)–8(a), respectively. The plots indicate normal data dispersion, with no apparent outliers or abnormal patterns. Figures 2(b)–8(b) present the constant variance plots for melon plant height growth rate, leaf width growth rate, leaf number growth rate, stem diameter growth rate, fruit sweetness (°Brix), fruit weight, and growing media cost. These plots illustrate the relationship between residuals and predicted values. The results show no clear relationship between stochastic deviation and predicted values, indicating homoscedasticity of the data. Figures 2(c–e)–8(c–e) show the trace plots of each response, which were used to analyze the influence of individual components on melon growth and yield based on the trends of the response curves. Linear or curved trends indicate the extent to which mixture components affect changes in melon growth rate and yield. The analysis revealed that increasing the proportions of chicken manure (A), pig manure (B), and coconut shavings (D) decreased melon plant height growth rate, whereas increasing the proportion of cattle manure (C) increased melon plant height growth rate.

An increase in the proportions of chicken manure, pig manure, cattle manure, and coconut shavings tended to improve both leaf width growth rate and leaf number growth rate. Similarly, increasing the proportions of chicken manure, cattle manure, and coconut shavings was associated with higher stem diameter growth rates, whereas a higher proportion of pig manure tended to reduce stem diameter growth rates. In terms of melon yield, greater proportions of chicken manure, pig manure, and cattle manure were associated with increased fruit weight, while a higher proportion of coconut shavings tended to decrease fruit weight. Fruit sweetness increased with higher proportions of pig and cattle manure, whereas higher proportions of chicken manure and coconut shavings were associated with reduced sweetness. From an economic perspective, increasing the proportion of animal manure contributed to lowering overall growing media costs, whereas a higher proportion of coconut shavings increased costs.

The optimal mixture ratio was determined by simultaneously optimizing melon growth, fruit quality, and growing media cost. Overlay contour analysis identified a formulation consisting of 50.00% cattle manure and 50.00% coconut shavings as the optimal treatment. Under this condition, melon plants achieved plant height, leaf width, leaf number, and stem diameter growth rates of 48.19%, 14.47%, 30.55%, and 19.05%, respectively, together with a fruit sweetness of 12.97 °Brix, an average fruit weight of 928.09 g, and a growing media cost of 10.80 THB per bag. The overall desirability value was 0.916, indicating a favorable balance among growth, yield, quality, and economic responses. These findings are consistent with previous studies demonstrating that optimized organic substrates can improve plant growth, productivity, and crop quality by enhancing the physical and nutritional properties of the growing medium [23]. The superior performance of

this mixture may be attributed to the complementary functions of cattle manure and coconut-based materials. Cattle manure has been reported to improve nutrient availability, water-holding capacity, and microbial activity, thereby enhancing root development and nutrient uptake efficiency [23]. In contrast, coconut shavings improve substrate aeration and drainage, which are essential for maintaining adequate oxygen supply for root respiration and preventing waterlogging [24]. The combination of these materials therefore provides a balanced root-zone environment that supports vegetative growth and yield performance. Furthermore, the present findings are consistent with those of Phankaen and Kumpanuch [25], who demonstrated that proper management of EC, pH, and nutrient availability in controlled cultivation systems significantly improved melon fruit weight, sweetness, and overall fruit quality. Similarly, Pimonrat et al. [26] reported that excessive accumulation of organic substrate components could increase EC and pH levels, thereby negatively affecting melon growth and biomass accumulation. These findings support the present study, indicating that balanced proportions of organic materials are essential for maintaining suitable root-zone conditions, improving nutrient uptake efficiency, and enhancing melon productivity and fruit quality. From a physiological perspective, improved root-zone conditions may enhance water and nutrient absorption, thereby supporting photosynthetic activity and assimilate production, which are necessary for fruit [27]. Enhanced translocation of photoassimilates to developing fruits is likely associated with increased fruit weight and sugar accumulation, as reflected by the observed fruit sweetness of 12.97 °Brix. Similar findings have been reported in studies where optimized organic substrates improved both yield and fruit quality, particularly soluble solids content and fruit development [28]. Therefore, the 50:50 mixture ratio appears to provide an effective balance between the physical and nutritional properties of the growing medium. However, the optimal ratio identified in this study may vary depending on environmental conditions, crop management practices, and melon cultivar differences.

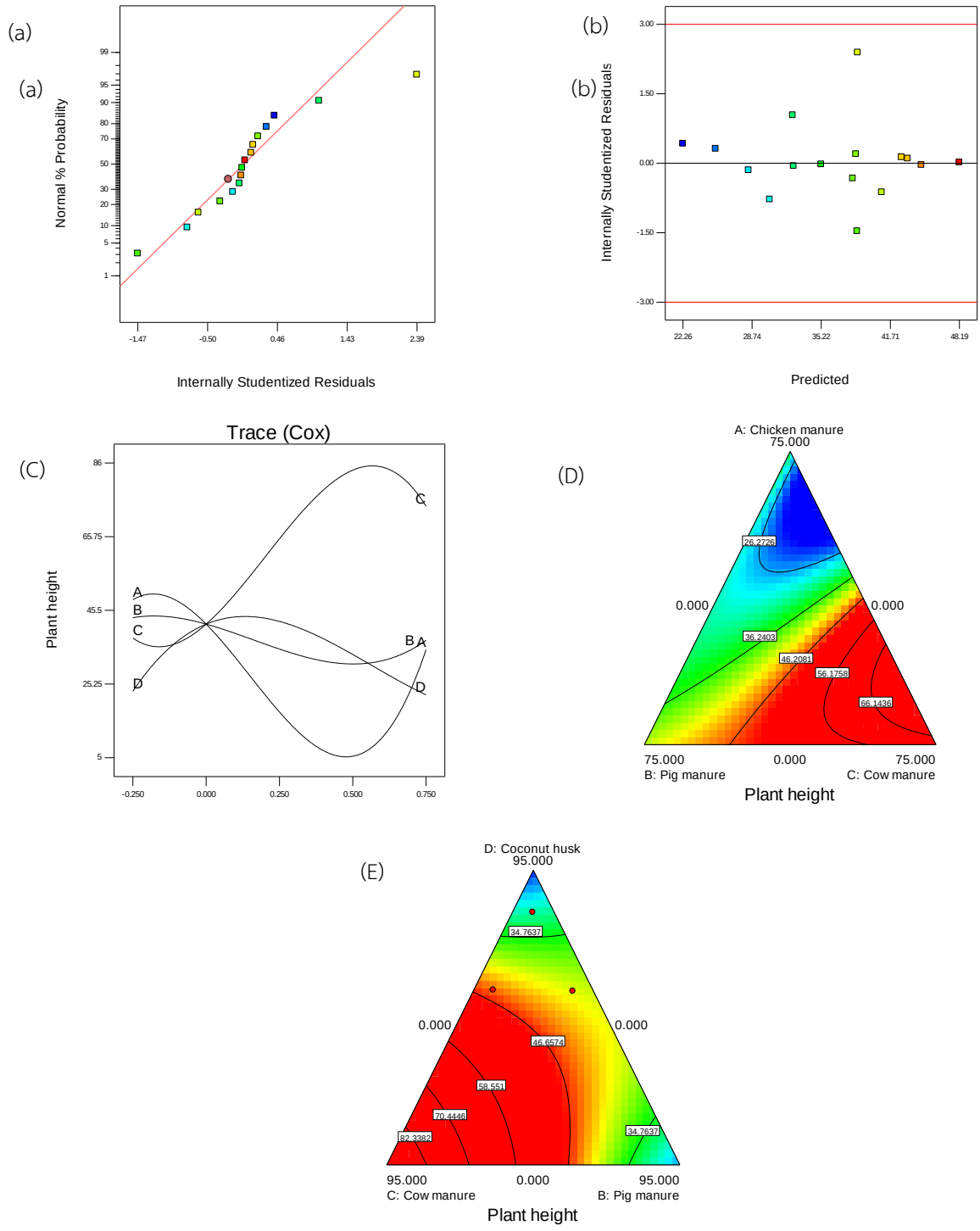


Figure 2. Random residual plot for the growth rate of melon plant height: (A) normal probability plot of the residuals, (B) residuals versus predicted values (constant variance test), (C) trace plot of plant height growth rate (%), and (D–E) response contour plots of melon plant height growth rate.

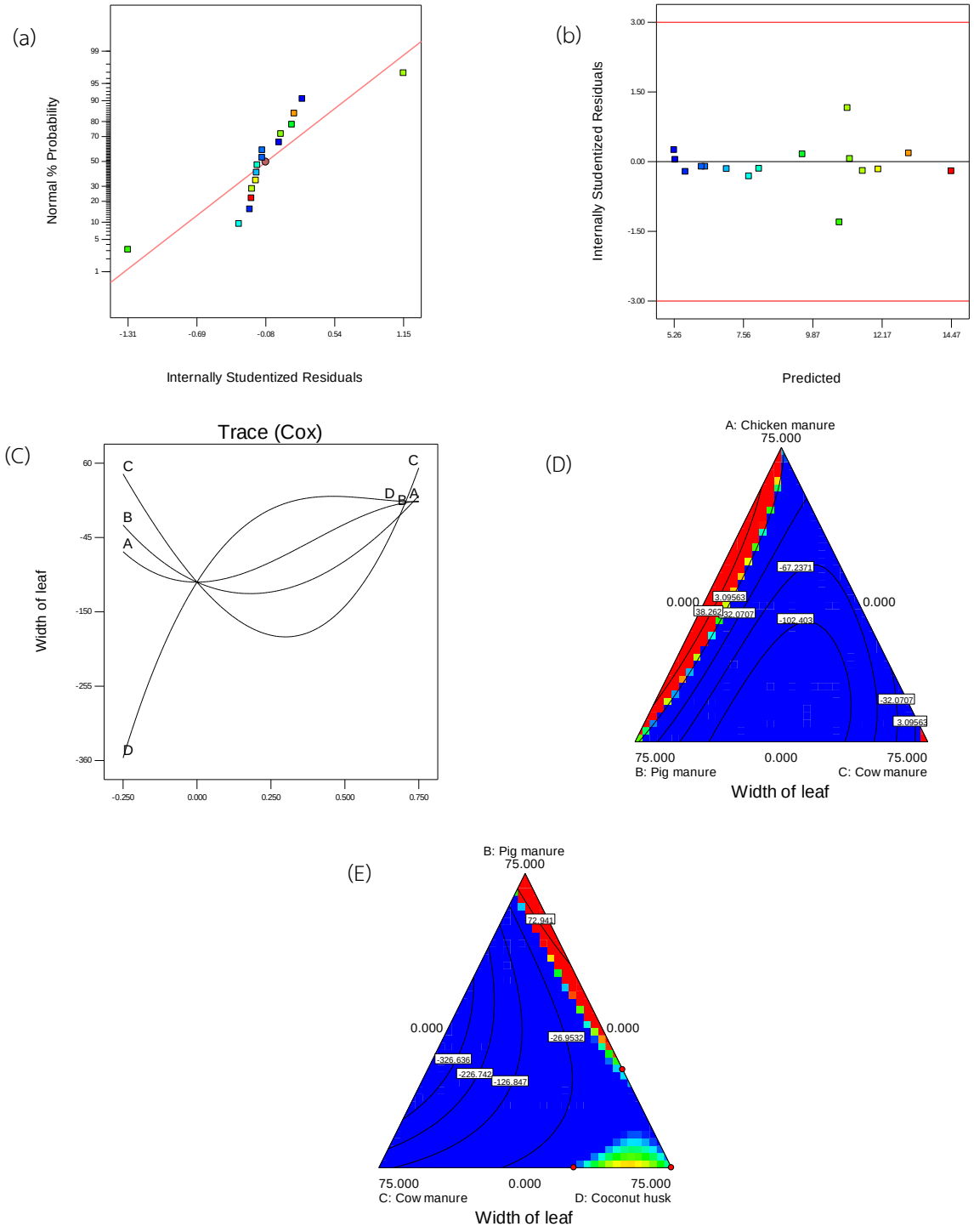


Figure 3. Random residual plot for leaf width growth rate: (A) normal probability plot of the residuals, (B) residuals versus predicted values (constant variance test), (C) trace plot of leaf width growth rate (%), and (D–E) response contour plots of leaf width growth rate.

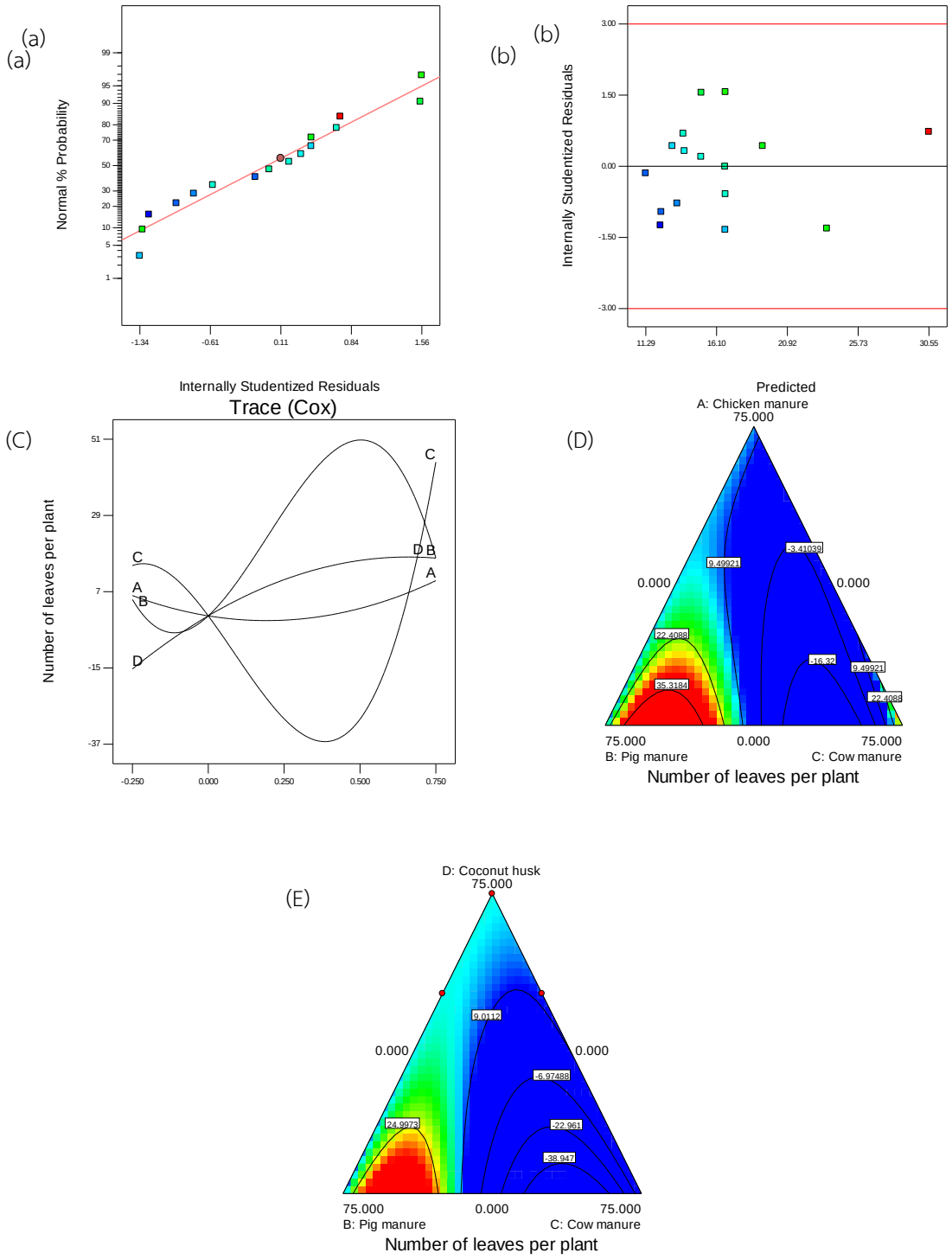


Figure 4. Random residual plot for leaf number growth rate: (A) normal probability plot of the residuals, (B) residuals versus predicted values (constant variance test), (C) trace plot of leaf number growth rate (%), and (D–E) response contour plots of leaf number growth rate.

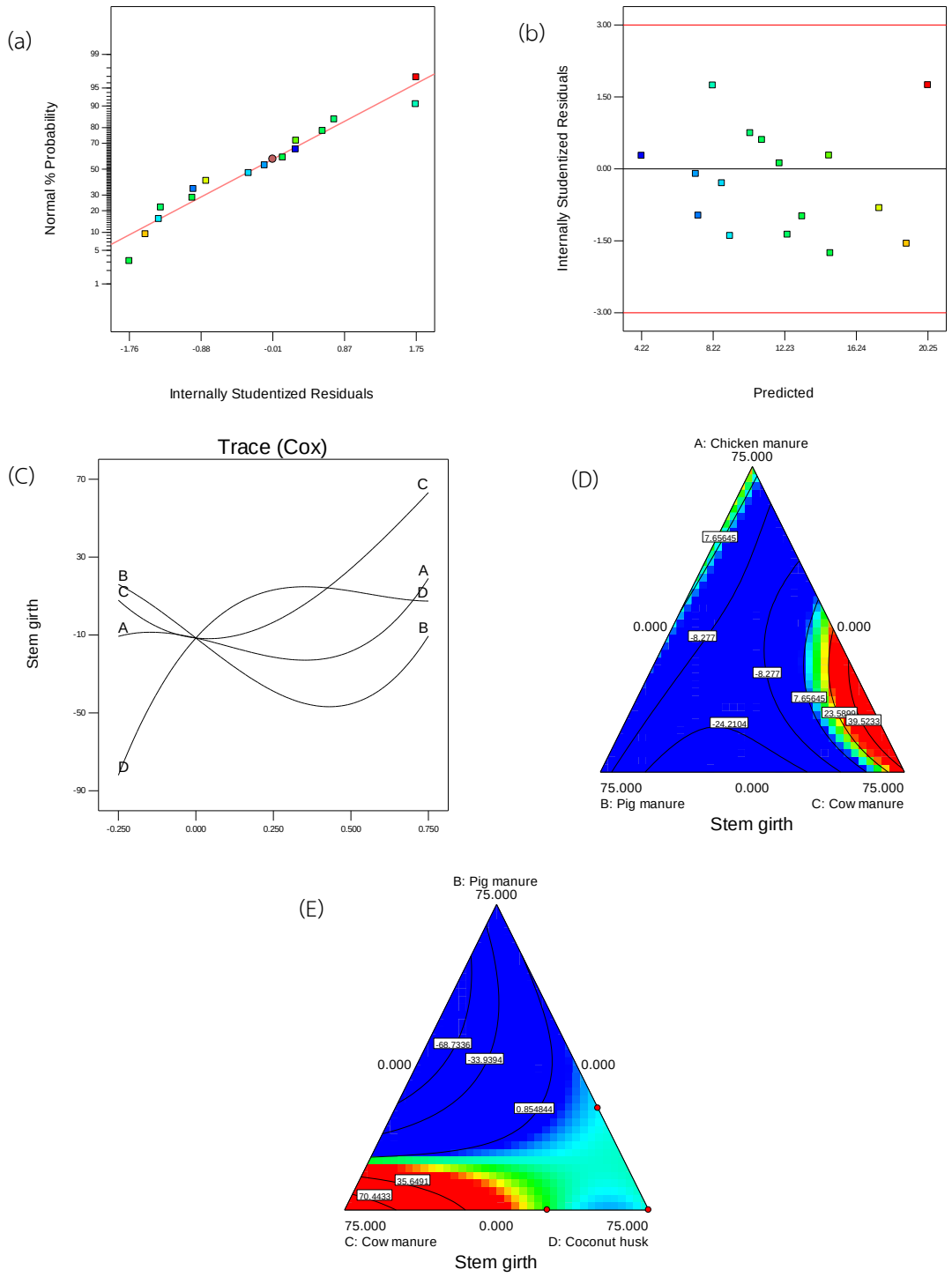


Figure 5. Random residual plot for stem diameter growth rate: (A) normal probability plot of the residuals, (B) residuals versus predicted values (constant variance test), (C) trace plot of stem diameter growth rate (%), and (D–E) response contour plots of stem diameter growth rate.

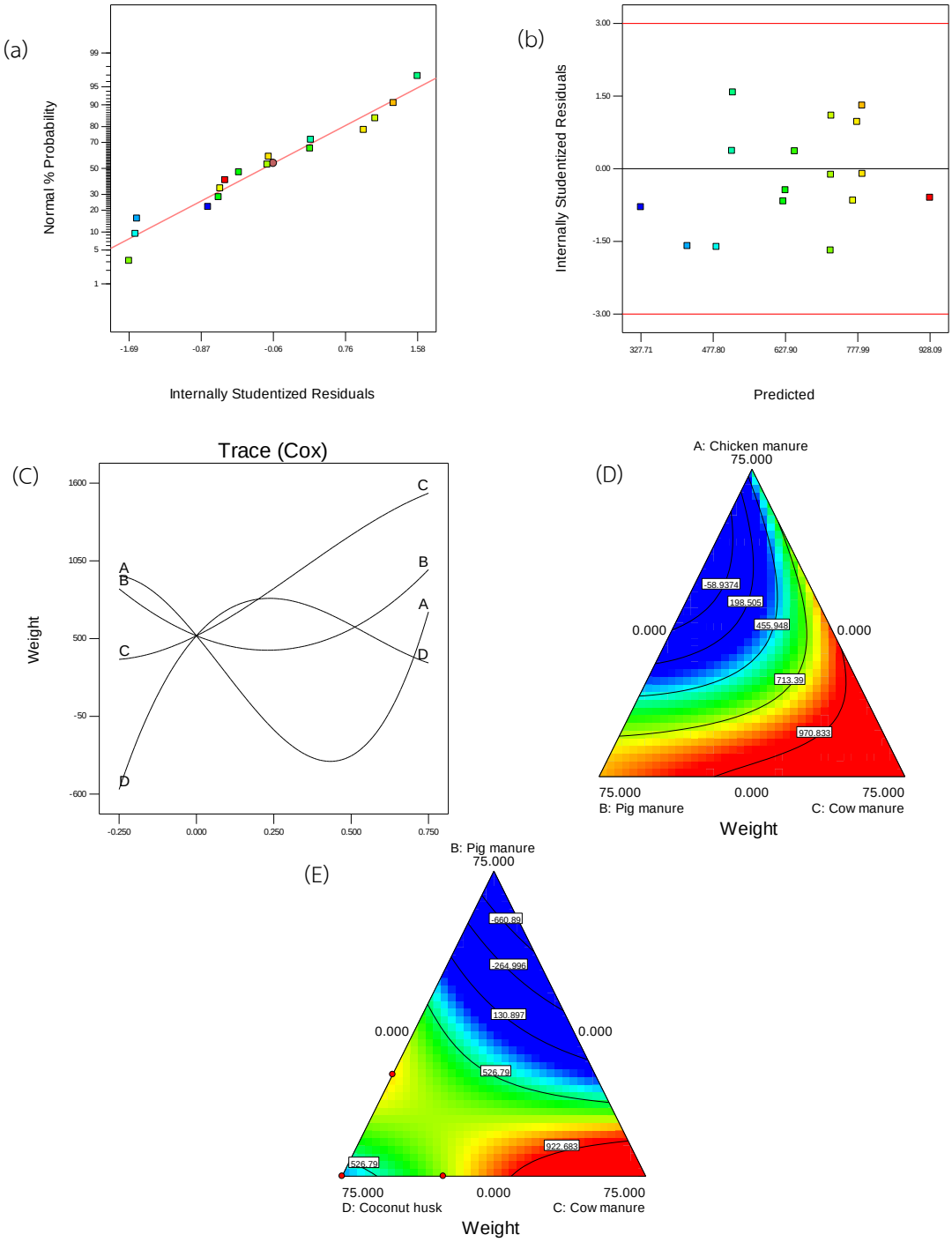


Figure 6. Random residual plot for melon fruit weight: (A) normal probability plot of the residuals, (B) residuals versus predicted values (constant variance test), (C) trace plot of fruit weight (g), and (D–E) response contour plots of melon fruit weight.

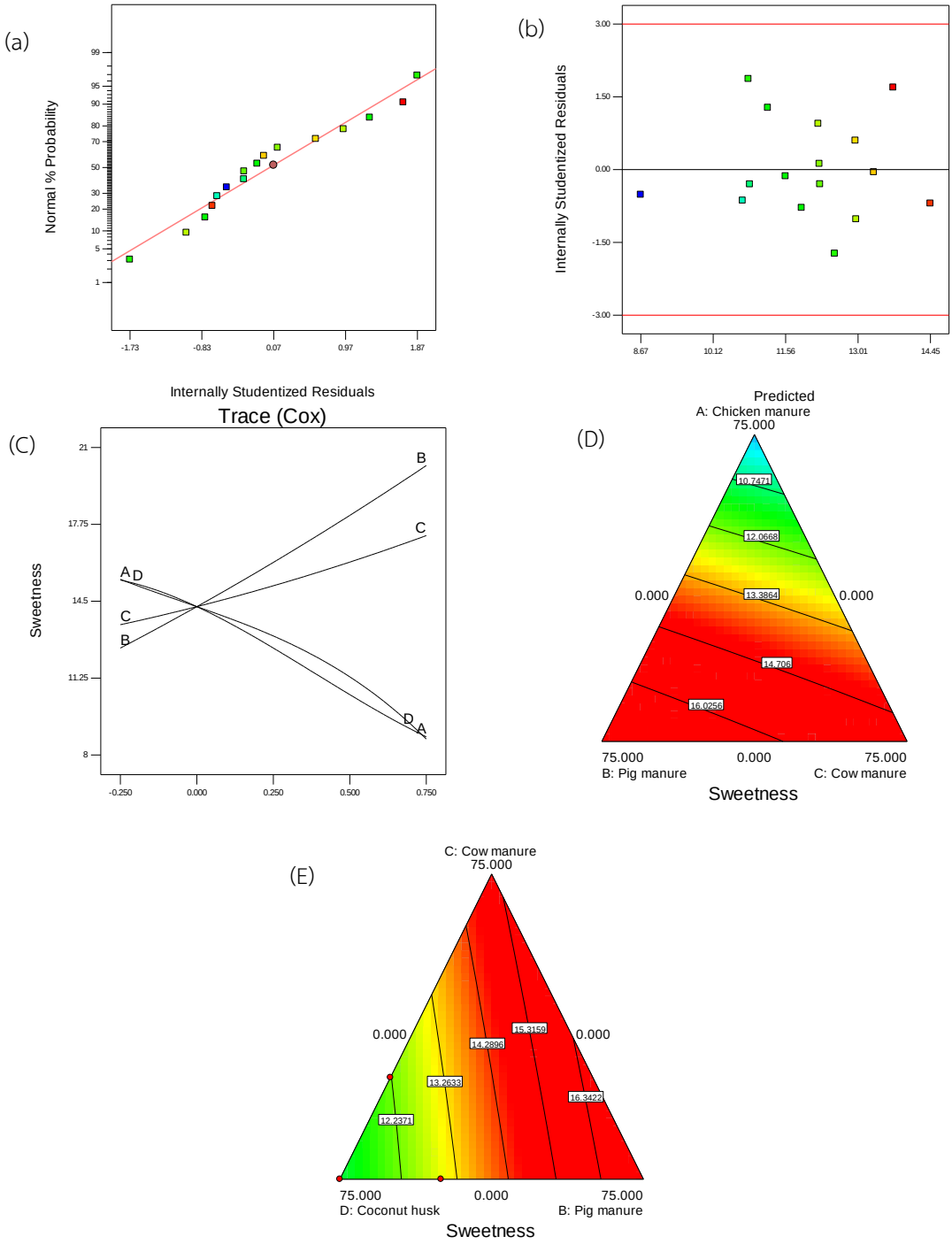


Figure 7. Random residual plot for fruit sweetness (°Brix): (A) normal probability plot of the residuals, (B) residuals versus predicted values (constant variance test), (C) trace plot of fruit sweetness (°Brix), and (D–E) response contour plots of fruit sweetness.

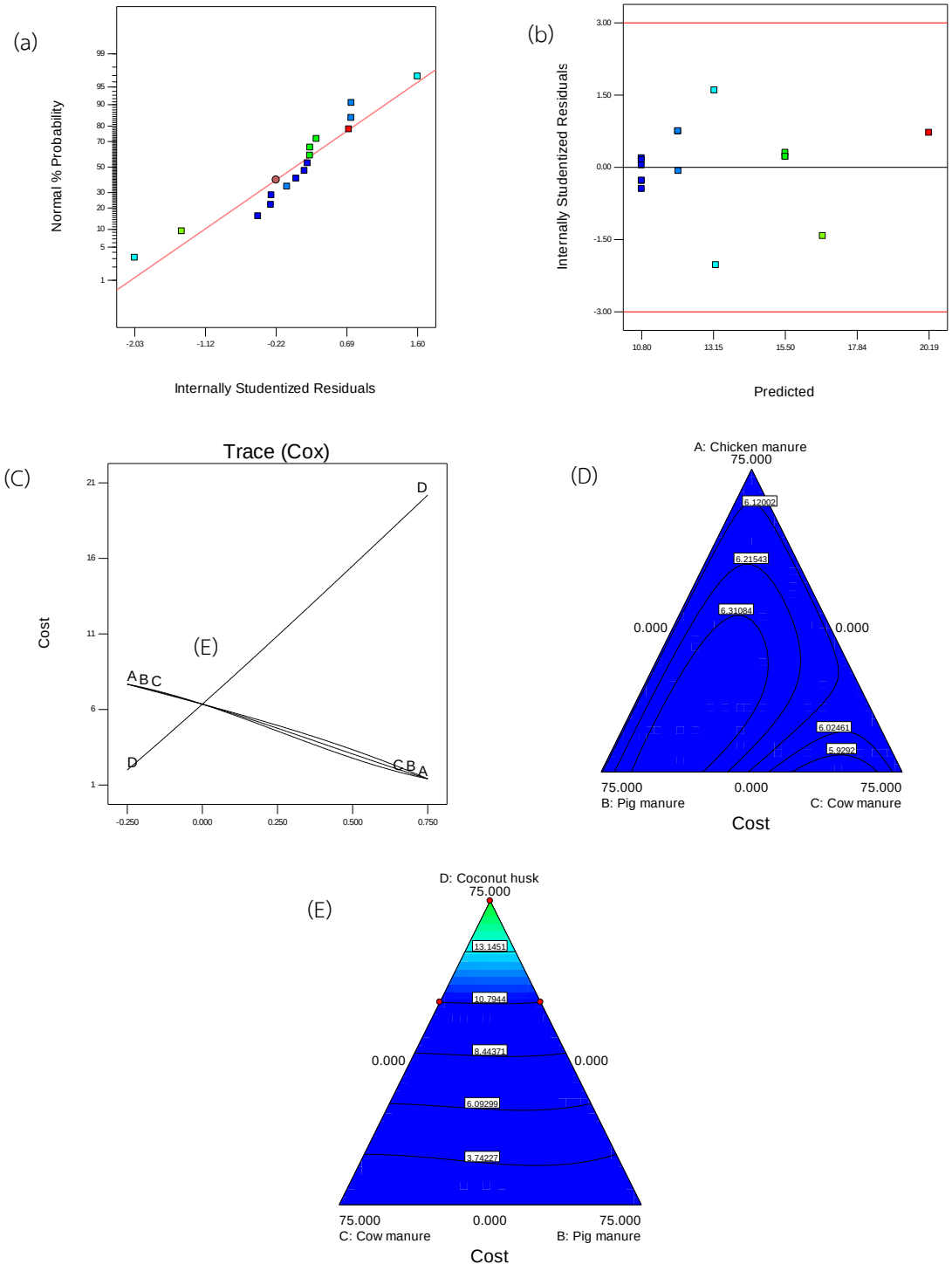
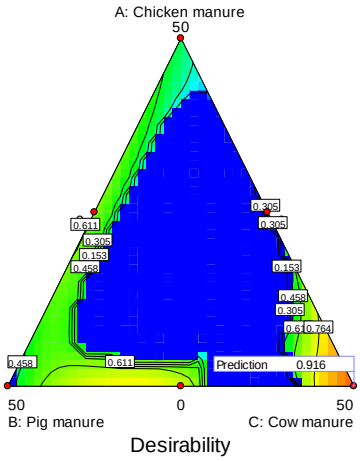


Figure 8. Random residual plot for growing media cost (THB): (A) normal probability plot of the residuals, (B) residuals versus predicted values (constant variance test), (C) trace plot of growing media cost (THB), and (D–E) response contour plots of growing media cost.



(b)

Constraints

Name	Goal	Lower Limit	Upper Limit	Lower Weight	Upper Weight	Importance
Chicken manure	is in range	0	50	1	1	3
Pig manure	is in range	0	50	1	1	3
Cow manure	is in range	0	50	1	1	3
Coconut husk	is in range	50	100	1	1	3
Weight	maximize	320.24	920.05	1	1	3
Sweetness	maximize	8.5	14.5	1	1	5
Plant height	maximize	22.5	48.2	1	1	3
Width of leaf	maximize	5.3	14.47	1	1	3
Number of leave	maximize	9.03	31.48	1	1	3
Stem girth	maximize	4.45	22.22	1	1	3
Cost	minimize	10.8	20.2	1	1	5

Solutions

Number	Chicken manu	Pig manure	Cow manure	Coconut husk	Weight	Sweetness	Plant height	Width of leaf	Number of lea	Stem girth	Cost	Desirability	
1	0.000	0.000	50.000	50.000	928.085	12.9732	48.1894	14.4725	30.5483	19.0545	10.802	0.916	Selected
2	0.000	32.444	15.807	51.748	724.61	13.7841	41.1855	14.47	20.9948	15.5749	11.1874	0.778	
3	20.931	29.069	0.000	50.000	824.034	13.2434	43.3427	11.4595	15.3408	7.98029	10.7998	0.614	

Figure 9. Optimal points of the growing media mixture: (A) overlay plot indicating the optimal region of the growing media mixture and (B) desirability function plot illustrating the optimization results.

4. Conclusions

This study demonstrates that mixture design is an effective tool for determining the optimal proportions of organic growing media to optimize the growth and yield quality of the melon cultivar Thunder Gold 1497 under greenhouse conditions. The analysis of growth responses, yield quality, and production costs showed that mixtures of different types of manure and coconut shavings significantly influenced plant responses. In particular, cattle manure played a prominent role in enhancing fruit weight, productivity, and growth stability, while pig manure positively affected the accumulation of fruit sweetness. Optimizing melon growing media using the desirability function revealed that a mixture of 50.00% cattle manure and 50.00% coconut shavings yielded the highest overall desirability (0.916). Under this optimal condition, the melon plants achieved a plant height growth rate of 48.19%, a leaf width growth rate of 14.47%, a leaf number growth rate of 30.55%, a stem diameter growth rate of 19.05%, a fruit sweetness value of 12.97 °Brix, an average fruit weight of 928.09 g, and a growing media cost of 10.80 THB per bag. This study provides a practical guideline for developing effective and sustainable organic growing media formulations for commercial melon production and can be extended to other economic crops cultivated under greenhouse systems or modern agricultural practices. Future studies should focus on the long-term effects of organic growing media on substrate properties to strengthen knowledge on sustainable management of organic growing media at the agricultural industry level.

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