International Journal of Design & Nature and Ecodynamics
Vol. 19, No. 1, February, 2024, pp. 221-228
Journal homepage: http://iieta.org/journals/ijdne

Growth, Yield and Seed Nutrient Quality of Soybean Grown in Inland Peatland as Affected by Cow Manure Application

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https://doi.org/10.18280/ijdne.190124

Received: 31 July 2023
Revised: 15 February 2024
Accepted: 21 February 2024
Available online: 29 February 2024

Keywords:
agricultural productivity, agronomic character, cow manure, proximate value, peat soils, soybean varieties

ABSTRACT

Soybean yields poorly on peat smallholder farms in Indonesia, leading to a heavy reliance on imported. Soybean productivity on peat faces low soil fertility with limited macro and micronutrients. Cow manure, as an effective alternative of organic ameliorant, is the most important factor in increasing growth and yield to overcome the nutrient content of peat soil. We evaluate the effects of cow manure, an effective alternative of organic ameliorant, and varieties on the growth, yield component, yield, and seed nutritional value of soybean growing in inland peatland. A field experiment was carried out from March to July 2021. The factorial experiment included two factors consisting of cow manure with four treatment dosages, namely 0 t ha^{-1}, 10 t ha^{-1}, 20 t ha^{-1}, and 30 t ha^{-1}, respectively, and three soybean varieties tested, namely Anjasmoro, Deja 1, and Deja 2, respectively. We determined the growth (plant height and leaves number), yield component (fresh biomass and dry biomass weight), yield (seed dry weight per plot, seed dry weight per plant, weight 100 seeds), and nutritional seed value of soybean. The combination of cow manure and soybean varieties had no significant effect on all variables observed. Application of cow manure at a dose of 30 t ha^{-1} resulted in enhanced growth, yield component, and yield of soybean grown in peatland but reduced the protein content. Anjasmoro soybeans varieties without cow manure contained the most protein. Moreover, Anjasmoro was an adaptive variety cultivated in peatland compared to Deja 1 and Deja 2. The study emphasizes the need for further research to understand the effects of cow manure on crop yield and nutrient enhancement.

1. INTRODUCTION

Soybean is a widely grown crop worldwide, known for its high protein content and nutritional value [1-4]. In Indonesia, soybeans are used for processed food, industrial raw materials, and refreshments [5]. The country consumes 2.7 million tons of soybeans annually but only meets 43% of its needs through national production. As a result, the government has to import 1.6 million tons of soybeans from other countries, incurring significant costs in foreign currency [6]. Therefore, there is a need to increase soybean production to meet the growing population's needs and fulfill the demand for raw materials [5].

It is challenging to increase soybean production in peatlands. Peatlands in tropical (mainly from inland peat) face the problem of the appearance of poor soils [7] with low soil fertility such as low pH, high total N resulting in high C/N ratio, low macro (N, P, K, Ca, Mg) and micro (Cu, B, Zn) elements [8], low base saturation [9] and substantial decomposition of organic matter takes place in both oxygen-rich and oxygen-deprived conditions in tropical peatlands [10], thus, a strategy is needed to overcome these obstacles by managing the soils properly. Soybean growth and crop yield are significantly affected by the chemical composition of the soil. When the soil has high acidity and low levels of phosphorus (P) and potassium (K) nutrients, it can hinder the development of soybean plants. To ensure optimal growth, it is crucial to maintain specific soil conditions within certain limits. These critical values include a pH level of 5.5, Al concentration below 1.33 cmol+kg^{-1}, Mn content not exceeding 3.3 µg g^{-1}, and electrical conductivity (EC) of 1.3 dS m^{-1} [11]. Additionally, the maximum allowable concentrations of aluminum and hydrogen saturation in acidic soils for soybean cultivation should not exceed 2.26 cmol+kg^{-1} of soil [12]. Therefore, effective land management practices are essential for improving soil acidity and nutrient availability, which are vital factors for successful soybean cultivation.

Appropriate fertilizers will help to improve the physio-chemical properties of soils providing a good substrate for plant growth [5, 13] resulting in increasing plant available water holding capacity and crop productivity [14]. At present, organic fertilizer could be one of the appropriate, sustainable, and eco-friendly technologies to improve soybean productivity grown on peat soils. Sugiyama [3] reported that fertilizers supplied are required to soybean fields to maximize yield. One of which is by applying cow manure. Cow manure as soil enhancers and nutrient suppliers can be applied to overcome the nutrient content of peat soil. Application of cow manure of 15 t ha^{-1} combined with 2.25 t ha^{-1} of fish waste was recommended for the cultivation on peat soil resulting in the best pH soil, NPK total, and uptake of NPK [9]. Crop production on acid soil can be improved greatly by cattle manure by adjusting to neutrality pH to 6.0 resulting in macro and micronutrient uptake [15]. Application of cow manure significantly increased N, P, and K in the leaves of ornamental foliage plants rather than those grown only in peat media [16]. Study by Budianta et al. [17] also indicated that cow manure could improve the growth and yield of soybeans in acidic Ultisol. The addition of cow manure to soil improves its fertility by providing essential nutrients, balancing pH, enhancing soil structure, and increasing water-holding capacity [18]. The use of organic matter, specifically 2.5 t ha^{-1} cow manure and 7.5 t ha^{-1} swallow manure, led to the greatest plant height during weeks 6-12, suggesting that these materials enhance plant growth [19]. Hence, the purpose of the research was to determine the agronomic characteristics and seed chemical value of soybeans cultivated on peat soils by adding locally available cow manure as an organic amendment and utilizing the proper soybean varieties. The study hypothesizes that the use of cow manure fertilizer can enhance the growth, yield, and nutrient quality of soybeans cultivated in peat soil.

2. MATERIALS AND METHODS

2.1 Study site and materials

The field experiment was installed in the Kalampangan sub-district, district Palangka Raya, Central Kalimantan Province (2°16'S, 144°01'E), 18 km south of Palangka Raya. The peat thickness was 3.2 m. The peatland used has never been used for crop production. Analysis of peat soil characteristics were conducted at the Laboratory of Soil Department and Land Resources, Faculty of Agriculture, Bogor Agricultural University, namely measurement of soil pH H_2O 1:5 using electrode glass method, total nitrogen (N) by Kjeldahl, phosphorus (P)-available calculated by Bray-I method cation exchangeable capacity (CEC) and bases cations exchangeable (with extracted by 1N NH_4OAc pH 7 and atomic absorption spectrophotometry). Base saturation obtained by calculated [(Σ base cations exchangeable/CEC)*100%] (Soil Research Institute, 2005).

Determining of seed chemical value was performed at the Laboratory of Biochemistry of the Faculty of Medicine University of Lambung Mangkurat South Kalimantan. The measurement of variables observed was at the Laboratory of the Agronomy Department University of Palangka Raya. Soybean varieties used were Anjasmoro, Deja 1, and Deja 2, respectively, with a high tolerance of acid soils, kindly donated from Balitkabi (Peanuts and Tubers Crops Research Institute) Malang East Java. The Indonesian government issued Decree numbers 537/Kpts/TP.240/10/2001, 388/Kpts/TP.030/5/2017, and 339/Kpts/TP.030/5/2017 to release Anjasmoro, Deja 1, and Deja 2 soybean varieties. Cow manure was collected from local peoples' farms in Kalampangan Palangka Raya, attributing with slightly dark color and lack of heat. It was measured at the Laboratory of Soil Department of Soil, Faculty of the Agriculture University of Lambung Mangkurat.

2.2 Experimental design

The experiment was arranged in factorial randomized completely block design (RCBD) with 3 replications. The first factor was soybean varieties used namely Anjasmoro, Deja 1, and Deja 2. The second factor was the cow manure dosage of 0 t ha^{-1}, 10 t ha^{-1}, 20 t ha^{-1}, and 30 t ha^{-1}, respectively. Soil tillage of land preparation was done to suitability growth media, arranged, then, plotting size of 2×2 m with 40 cm high as much as 36 plots. The liming using dolomite at 2 t ha^{-1} was evenly broadcast to each plot for increasing soil pH. Surface placement cow manure was applied before sowing as a basal fertilizer at the dose of 0 kg $plot^{-1}$, 4 kg $plot^{-1}$, 8 kg $plot^{-1}$, and 12 kg $plot^{-1}$. Sowing was done manually a single week after cow manure application by putting 2 seeds in the 5 cm deep hole with 25×25 cm spacing. Seed treatment was performed with inoculation with Rhizobium of Rhizoka commercial product as 40 g per 8 kg seeds. To protect against pest and disease attacks, surface-placed Furadan was applied as 20 kg ha^{-1} equal to 2 g per plot at planting. The aphid attack was controlled using the insecticide Winder 100 EC, meanwhile, the fungus attack was protected by the use of Calcium Super. Watering uniformly was twice a day except it was rain throughout the growing season. At 2 weeks after planting (wap), the best seedling was left for further experiment. Weeding was done two times (2 wap and 6 wap) by hand-pulling of weeds. Mineral fertilizers were done 50% of soybean dosage recommendation including Urea 25 kg ha^{-1}, SP-36 300 kg ha^{-1}, and KCl 150 kg ha^{-1} equal to 5 g Urea per plot, 60 g SP-36 per plot, 60 g KCl per plot, respectively, by shallow deep banding at 20 wap. Harvesting for Deja 1, and Deja 2 was performed at 79 days after planting (dap), while, at 86 daps for Anjasmoro. Harvesting was manually done by pulling out the whole plant, then, the agricultural properties, yield, and components of the plant were determined after harvesting. Variables observed were plant height, leaf number, fresh biomass weight per plant, dry biomass weight per plant, dry weight of grain, and dry weight of 100 seeds per plot. We measured plant height from the root neck to the highest growing point, and counted the number of leaves on fully opened leaves at 2, 3, 4, 5, and 6 wap. Plant fresh and dry weight weighed after harvesting. Plants were dried at 70℃ for 48 hours to determine their dry weight. Dry seed weight per plot was determined by weighing all dry seeds in grams, while dry seed weight per plant was determined by weighing all seeds from sample plants. 100 dry seeds were weighed per plot on analytical scale after harvesting. Seed chemical value included moisture, ash, protein, lipid, and carbohydrate of the seed determined using AOAC methods [20].

2.3 Data analysis

The obtained data were subjected to analysis of variance (ANOVA) followed by the Least Significant Difference (LSD) test to estimate the difference among treatment means at 5% and 1% levels of probability. Pearson correlations were used to investigate the relationships among the parameters observed. SPSS 16.0 software was used for statistical analysis.

3. RESULTS AND DISCUSSIONS

3.1 Soil and cow manure properties

As typical of tropical peat soil, the chemical attributes of the soil used were shown in Table 1. Peat soil has a high soil acidity (pH 3.32), indicating that the exchange complex has become saturated by acid cations, specifically H and Al. The H ions are derived from the dissociation of organic acids, which are typically dominated by fulvic and humic acids. Organic acids also play a significant role in the low pH of peat soils. The content of C-organic is very high attributing to its decomposition process, conversely, the N-total is low (0.51%). According Maftu'Ah et al.'s study [21], in peatlands that have undergone intensive cultivation, there has been a significant reduction in nitrogen by approximately 0.6%. The decrease is due to a substantial amount of nitrogen mineralization from the peat as a result of the land being converted into cultivated fields with the ameliorants and fertilizers added. The high level of available P (89.95 ppm) (Table 1) indicates that the peat used has reached a mature state. The availability of P in the soil is determined by the amount of P in the adsorption complex (P-total), whose availability mechanism is regulated by pH and organic matter present. The value of CEC is low attributed to the ombrogenous peat soil which has low pH, additionally, the CEC value is significantly dependent on the proportion of lignin and humic substances. Soil cationic bases (K, Ca, Mg, and Na) play an important role in supporting plant growth. The comparison of the values of cations in acidic and basic is crucial when it comes to the application of fertilization and the process of increasing the soil pH value. The K-available value was considered to be very low (1.03 cmol+ kg^{-1}) (Table 1). The K content on peatlands varies depending on the level of decomposition and mineralization of peat [21]. In soybeans, soil acidity was found to be a critical factor negatively affecting plant growth and yield due to the unavailability of macro- and micronutrients, including N, P, K, Ca, Mg, Fe, and Zn [22].

Table 1. Peat soil chemical properties

Chemical Properties	Value	Category*
pH H_2O (1:5)	3.32	Very acid
C-organic (Walkley & Black)	16.83%	Very high
Total N (Kjeldahl)	0.51%	High
P_2O_5 (Bray I)	89.95 ppm	High
CEC (*N* NH_4OAc pH 7.0)	13.28 cmol+ kg^{-1}	Low
Base saturation	56.94%	Medium
Base saturation exchangeable		
Ca (*N* NH_4OAc pH 7.0)	1.42 cmol+ kg^{-1}	Very low
Mg (*N* NH_4OAc pH 7.0)	4.95 cmol+ kg^{-1}	High
K (*N* NH_4OAc pH 7.0)	1.03 cmol+ kg^{-1}	Very low
Na (*N* NH_4OAc pH 7.0)	0.16 cmol+ kg^{-1}	Low

*Institute of Soil Research, 2009.

Organic fertilizer made from cow manure has advantages when compared to other manure. One of its advantages is its higher fiber content, particularly cellulose, which is beneficial for plants. Additionally, it provides both macro and micronutrients to the soil and helps to improve water absorption. Using organic cow manure as fertilizer can enhance soil fertility, as well as its physical, chemical, and biological properties. It can increase macro and micro nutrients available to plants, enhance the soil's water retention, and increase the soil's ability to exchange positively charged ions (i.e., cations) with the plant roots [23].

In peat soils, organic acid compounds like humic acid and fulvic acid have a significant contribution to the low pH. The application of alkaline ameliorants (pH above 7) helps in binding H^+ ions or peat organic acids, thereby increasing the soil pH. As a result, it promotes the release of nutrients in the soil [24].

Table 2. Cow manure chemical properties

Chemical Properties	Value	Quality Standards*
pH H_2O(1:5)	7.38	4 - 9
C- organic (Walkley&Black)	22.48%	> 15%
Σ (N-total (H_2SO_4) + P_2O_5 (H_2SO_4) + K_2O (H_2SO_4)	6.13%	> 2%
Fe	602.33 ppm	< 15.000 ppm
N-NH_4 (KCl 2 M)	19.29 ppm	
N-NO_3 (KCl 2 M)	301.47 ppm	

* Ministry of Agriculture, 2011

Table 2 shows that pH of cow manure applied has a 7.38 pH. Soil pH plays an important role in the nutrient solubility in soil by affecting the amount and strength of nutrients adsorption to the soil surface because of hydrogen ions. When manure is applied to soil, various acids are formed during the nitrification and decomposition of manure. Solid manures have a higher amount of organic matter compared to liquid manures. The organic matter can act as a pH buffer. This means that it can release H^+ ions (acidity) when alkaline materials are added, and it can accept H+ ions (alkaline) when acidic materials are added [25]. The content of C-org (22.48%) (Table 2) is intricately linked to soil fertility, playing a crucial role in preserving soil moisture, furnishing plants with essential nutrients, and improving the airflow in the soil. In addition, a C/N ratio of 5.69 is considered low. This indicates that the manure is suitable for direct use on agricultural land, as it can effectively promote growth. This is in accordance with Yusnaeni et al.'s study [23] that cow manure should be composted until it becomes compost, which should have a C/N ratio below 20. Unripe or improperly composted manure may have detrimental effects on plants.

Generally, the recommended application rates for cow manure are based on its nitrogen content [26]. The concentration of N-NH_4 is 19.29 ppm, whereas, the level of N-NO_3 is much higher at 301.47 ppm (Table 2). The amount of N-NO_3 in soil fluctuates over time, as it is prone to leaching and disruption by water and microbial activity. On the other hand, the concentration of N-NH_4 can be influenced by various factors such as temperature, humidity, soil pH, as well as microbial and plant activity [26]. Nitrate is transported to the roots through mass flow because it's highly soluble, has a negative charge, and is not attached to soil particles. As a result, the entire root zone can provide NO_3 to the plant since it can be absorbed along with the water that is required for normal transpiration. NH_4 is also soluble, but it has a positive charge that is attracted to negatively charged. This means that NH_4 does not mobile in soil and can only travel short distances to the roots through diffusion [25]. In Japan, soil N supply and pH are thought to be the key factor in increasing soybean yield [27].

3.2 Effects of cow manure and varieties on plant growth

Plant growth which is characterized by plant height and leaf number was influenced by the administration of cow manure and varieties. In our study, the soybean variety also had an impact on plant growth at some growth stages. This was consistent with the findings of [5, 28]. It is a very slightly increased plant height when entering 4 wap to 6 wap (Figure 1).

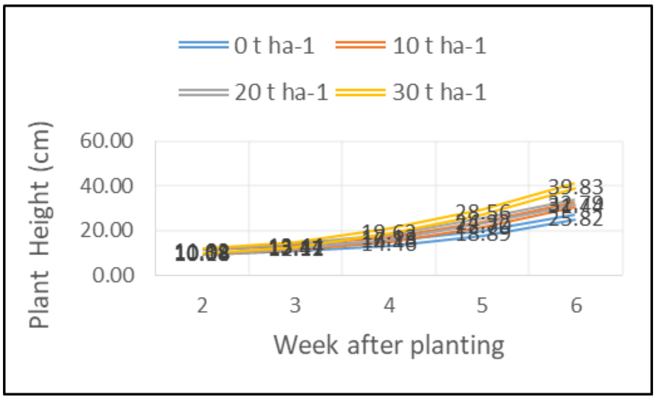

Figure 1. Effect of cow manure on plant height of soybean planted in peatland

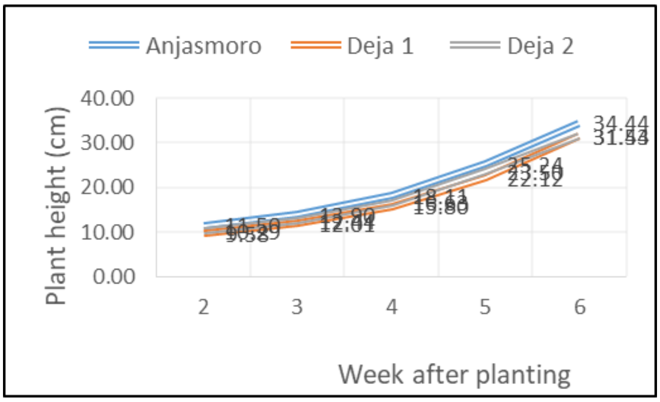

Figure 2. Effect of varieties on plant height of soybean planted in peatland

Utilization of 30 t ha^{-1} manure impacted the highest plant height at 6 wap followed by 20 t ha^{-1}, 10 t ha^{-1}, and 0 t ha^{-1}, respectively, by 54.26%, 26.99%, and 21.77% of increment. This increment might be due to the high amount of nutrients applied through cow manure application, indicating that organic manure can improve the soybean growth cultivated in peatland. Equally, studies [17, 29] also obtained a similar result in soybean. In addition, several literature reviews highlighted cow manure's significant potential to enhance plant growth and soil reaction manipulation [26, 29] due to a higher C-organic content [17, 30] and saturation base [30].

Among the three varieties, the shortest plant height was Deja 2 and the tallest one was Anjasmoro at 6 wap. Anjasmoro lead to be a superior variety in terms of plant height planted in peatland at the whole week plant height observation (Figure 2). Anjasmoro had a plant height of 29.47-48.87 cm measured at 8 wap grown in acidic soil [17]. Currently, the optimal height for commercial soybean cultivars is 70-90 cm, with shorter or taller stands resulting in yield reductions. Plant height, as a quantitative trait, shows significant variation across genetic backgrounds [31]. Application of organic manure and lime singly or in combination produced significantly taller soybean plants than those in inorganic fertilizers treatment due to the nutrients providing needed and nutrients absorbing optimally [32] resulting the higher nutrient absorbance and photosynthesis rates [33]. Anjasmoro was the tallest, highest leaves number, and widest leaves in the soybean organic fertilizer treatment. The addition of organic fertilizers improves soil physical properties which facilitate root penetration as well as water and nutrient absorption [33].

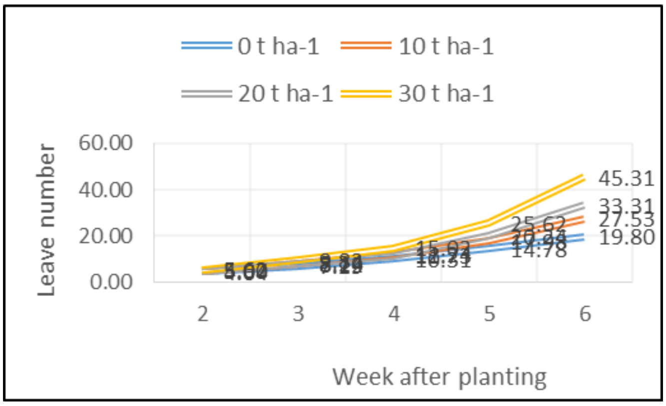

Figure 3. Effect of cow manure on leaves number of soybean planted in peatland

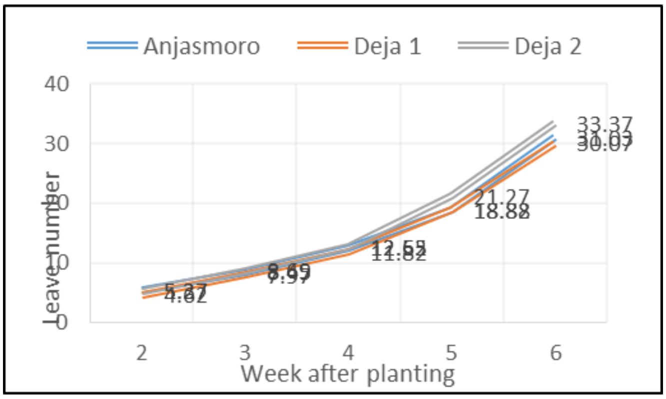

Figure 4. Effect of varieties on leaves number of soybean planted in peatland

Figure 3 presents that the higher the cow manure dose given, the higher the leaves number. The dose of 30 t ha^{-1} provided the highest leaf formation. Moreover, compared to the control, the increment of leaves number is 7.76%, 9.27%, and 21.12% at the initial growth and 39.04%, 68.23%, and 128.84% at the 6 weeks observation, respectively. Deja 2 had the superior leaves number compared to the others. According to study [14], the higher number of leaflets was due to organic manure's ability to promote plant growth by increasing nutrient availability and producing plant hormones that support beneficial microorganism activity, accelerate mineralization, and similarly certain nutrient uptake. Deja 2 has a superior leaf number (Figure 4) attributing that each variety has its advantages and genetic characteristics resulting in different responses to growth and production rate. Anjasmoro reached a height of 64-68 cm and produced the highest plant height at 6 wap when compared to cv. Grobogan [5].

3.3 Effects of cow manure and varieties on plant yield component and yield

Cow manure significantly impacted both fresh and dry weight of biomass, seed dry weight per plot, and seed dry weight per plant, whereas varieties were affected by the weight of 100 seeds ($p < 0.05$). Table 3 shows that soybean treated with cow manure result in the biggest accumulation of fresh biomass as well as dry biomass weight. Conversely, the lowest values were obtained for control treatment which differed from those observed resulting in the plant's needs are not met, then, its growth and development will suffer.

Table 3. Fresh biomass, dry biomass weight per plant, seed dry weight, and weight of 100 seeds

Cow Manure	Varieties			Average
	Anjasmoro	Deja 1	Deja 2	
Fresh biomass weight (g)				
0 t ha^{-1}	6.03	7.49	7.46	6.99 a
10 t ha^{-1}	11.76	10.95	19.39	14.03b
20 t ha^{-1}	16.27	19.11	23.26	19.55b
30 t ha^{-1}	22.00	34.40	24.69	27.03c
Average	14.01	17.99	18.70	
LSD 5% = 6.18				
Dry biomass weight (g)				
0 t ha^{-1}	2.47	3.25	2.55	2.75 a
10 t ha^{-1}	5.00	4.46	6.10	5.19 b
20 t ha^{-1}	7.22	6.37	7.77	7.12 b
30 t ha^{-1}	9.71	12.10	9.13	10.31 c
Average	6.10	6.55	6.39	
LSD 5% = 1.98				
Seed dry weight per plot (g)				
0 t ha^{-1}	24.11	45.26	58.27	42.55 a
10 t ha^{-1}	142.61	102.38	133.96	126.32 b
20 t ha^{-1}	171.27	170.46	142.07	161.27 b
30 t ha^{-1}	273.65	234.26	250.66	252.86 c
Average	152.91	138.09	146.24	
LSD 5% = 50.48				
Seed dry weight per plant (g)				
0 t ha^{-1}	5.09	7.61	7.14	6.61 a
10 t ha^{-1}	17.94	13.84	16.85	16.21 b
20 t ha^{-1}	23.95	24.91	23.04	23.97 c
30 t ha^{-1}	42.85	38.94	30.45	37.41 d
Average	22.46	21.32	19.37	
LSD 5% = 6.86				
Weight 100 seeds (g)				
0 t ha^{-1}	12.47	11.56	11.86	11.96
10 t ha^{-1}	14.85	11.94	12.25	13.40
20 t ha^{-1}	13.61	11.57	12.47	12.55
30 t ha^{-1}	14.77	12.15	11.76	12.89
Average	13.92 b	11.81 a	12.08 a	
LSD 5% = 1.67				

Note: Means followed by the same letter in the same column and variables were not significant at LSD 5%.

The increase indicates that cow manure application could improve the yield component of soybean grown in peatland. The highest increment was 286.70% followed by 179.69% and 100.72% in fresh biomass weight. Cow manure as 30 t ha^{-1} yielded a high dry biomass weight compared to the other dosage. The increment reached 274.91% compared to without cow fertilizer (Table 3). In soybean, the greatest accumulation of biomass occurred at full flowering and it turns out that this affects increasing production components such as the number of pods [34]. In addition, applying cow manure can replace inorganic fertilizers and increase yields of cowpea and soybean in acidic soil [35]. Manure also improves the physical properties and helps balance its pH levels. Its serve as a buffer, saturating the soil's cation exchange capacity with exchangeable base cations (base saturation), which is a complicated physicochemical parameter that estimates the interactions between exchangeable basic and acidic cations and other soil properties [36].

3.4 Plant yield

Seed dry weight per plant and plot was influenced by cow manure application ($p < 0.05$). There was a significant dosage of 30 t ha^{-1} which resulted in higher seed weight (465.96%) and (494.27%) compared with the control (Table 3). This is in line with the findings of Sebayang and Fatimah [37]. The difference can be attributable to the availability of nutrients in cow manure which might ameliorate the poor peatland for better yield of soybean. Rahayu et al. [33] stated that organic manure amended water binding ability and water holding capacity which is related to soil structure and texture. In addition, the application of organic fertilizer produced soybean high yields by increasing nodulation, number of the bean, and seed yield [38]. Study [17] presumed that soybean seed weight accumulation is influenced by soil fertility, climatic condition, and the dose of organic matter used. The lowest of both seed dry weight per plot and plant were obtained without manure application (Table 3) resulting in stunting growth in terms of plant height, pod number, and number of seeds due to soybean being very intolerant in acidic soils. According to Yusnaeni et al.'s study [23], cow manure has advantages over other manure such as having a high fiber content such as cellulose, providing macro and micronutrients for plants, and improving water absorption in the soil. It accordingly improved soil physical, chemical, and biological fertility namely increasing macro and micro nutrients, water holding, and cation exchange capacity. In addition, the application of high cow manure stimulates N availability and plant growth [17]. Timotiwu et al. [5] presumed that nutrients given could increase the metabolic process for optimizing seed production due to the availability of assimilates during maximum seed filling.

There was also a significant variety utilization induced by the increase in weight of 100 seeds ($p < 0.05$). Further, Anjasmoro was detected as having a superior 100 seeds weight compared to others (Table 3). Based on the report of Rahayu et al. [33], local soybean germplasm Anjasmoro is widely cultivated with a potential yield of 2.03 to 2.25 t ha^{-1}, mature pods 82.5 to 92.5, and a weight of 100 seeds 14.8 to 15.3 g and 14.53 to 17.23 g [39] indicating that the large size seed (> 14 g per100 seeds) provide more food reserves for germination, more adaptable and tolerant on acid dry land [40]. In the current study, the weight of 100 seeds was lower than those found by Otieno et al. [32] at 13.92 g (Table 3). Soybean varieties have a significant impact on yield. Varieties are important in soybean production because their genetic potential is largely responsible for high yield. The interaction of genetic factors and environmental conditions management influences potential yield in the field [33, 41]. In addition, Timotiwu et al. [5] obtained that Anjasmoro had a greater total pod number, filled pod, and seed dry weight compared to other varieties evaluated.

There were significant positive correlations among treatments to almost all descriptors evaluated. The plant yield (SP and SPP) presented a high magnitude correlation ($p < 0.01$) with almost all descriptors evaluated except the weight of 100 seeds (Table 4). This parameter is one of the most important in soybean productivity [42]. A significant positive correlation with high magnitude also occurred between plant growth (PH and LN) × plant yield component (FBW and DBW), plant growth (PH and LN) × plant yield (SP and SPP), plant yield component (FBW and DBW) × plant yield (SP and SPP).

Table 4. Estimates of the correlations between plant height (PH), leaves number (LN), fresh biomass weight (FBW), dry biomass weight (DBW), seed dry weight per plot (SP), seed dry weight per plant (SPP), and weight 100 seeds (WS) of three soybean varieties cultivated in inland peatland

Descriptors	LN	FBW (g)	DBW (g)	SP (g)	SPP (g)	WS (g)
PH (cm)	0.904**	0.746**	0.859**	0.963**	0.935**	0.519*
LN		0.899**	0.946**	0.973**	0.942**	0.211
FBW (g)			0.966**	0.844**	0.874**	0.024
DBW (g)				0.923**	0.955**	0.204
SP (g)					0.970**	0.350
SPP (g)						0.357

Note: * and ** significant at 5% and 1% probability, respectively, by t-test.

Table 5. The seed nutrients of soybean grown in inland peatland by applying of combination of cow manure and varieties

Treatments	Moisture (%)	Ash (%)	Protein (%)	Fat (%)	Carbohydrate (%)
K0V1	12.44	4.81	38.89	14.62	29.24
K0V2	10.40	4.98	38.33	15.78	30.51
K0V3	10.54	4.87	36.09	15.21	33.29
Avg	11.13	4.89	37.77	15.20	31.01
K1V1	12.78	5.11	37.97	14.22	29.92
K1V2	13.39	5.22	36.31	14.59	30.49
K1V3	10.95	4.54	37.66	15.63	31.22
Avg	12.37	4.96	37.31	14.81	30.54
K2V1	10.49	5.36	36.58	15.31	32.26
K2V2	10.89	5.52	36.65	15.62	31.32
K2V3	11.40	5.40	37.38	16.09	29.73
Avg	10.93	5.43	36.87	15.67	31.10
K3V1	13.22	5.72	37.64	15.05	28.37
K3V2	13.02	5.04	36.45	14.87	30.62
K3V3	13.75	5.78	36.49	15.82	28.16
Avg	13.33	5.51	36.86	15.25	29.05

Note: K0=0 t ha-1; K1=10 t ha-1; K2=20 t ha-1; K3=30 t ha-1; V1=Anjasmoro; V2=Deja 1; V3=Deja 2.

These findings demonstrated that the utilization of cow manure contributes to both the vegetative and reproductive of soybean in peat soils, simultaneously. This suggests that cow manure could be a beneficial agricultural practice for soybean cultivation, as it provides essential nutrients and organic matter to the soil, promoting healthy plant development and improving overall productivity. This information could guide farmers in making informed decisions about soil fertility management, potentially leading to increased crop yields and improved agricultural sustainability.

Cow manure applied of three varieties of soybean seed moisture ranged from 10.40 to 13.75%, ash from 4.54 to 5.78%, protein from 36.31 to 38.89%, fat from 14.22 to 16.09%, and carbohydrate from 28.16 to 33.29%, respectively (Table 5). Notably, the application of cow manure produced high soybean moisture, ash, fat, and carbohydrate at 12.21%, 5.3%, 15.24%, and 30.23%, respectively. On the other hand, mean seed protein was lower in the manure-applied versus manure-unapplied (37.01 versus 37.77%), which was unexpected, but the improvement of plant yield (Table 3). This could be demonstrated by the need for other manure, particularly in low soil fertility as an option for improved soybean seed nutrients, accordingly, study [2] recommend that in low soils fertility, there is a need to investigate various nutrient replenishment to establish best management practices for improved soybean production.

4. CONCLUSIONS

Cow manure significantly improved growth and yield of plants in peat soils, enhancing biomass, seed production, and soil fertility. In peatland, cow manure was applied at a dose of 30 t ha^{-1} to increase soybean growth and yield, but the Anjasmoro proved to be more adaptable and provided higher seed nutrients. The study on cow manure and soybean varieties in peatland has limitations, including a narrow focus on growth, yield, and seed nutritional value, a specific region and time period, and only four dosage levels. It also fails to address the long-term impact on soil fertility and sustainability, which could be influenced by continuous cow manure use. Future research should explore soybean varieties, dosage, long-term effects on soil fertility, and interactions between manure application, soil properties, and plant growth. In the real-world, the use of cow manure in peatland soybean cultivation is a sustainable and environmentally friendly approach to improving crop production.

ACKNOWLEDGMENT

We extend our gratitude to Airlangga Editing Program of Airlangga University for its contribution in preparing this manuscript guided by Prof. Hery Purnobasuki as a key scientist.

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