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ORIGINAL PAPER

EFFECTS OF COW MANURE AND LIQUID VERMICOMPOST APPLICATIONS ON GROWTH AND SEED YIELD OF DRY BEANS*

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Abstract

With its porous structure, high water storage capacity and high levels of macro- and micronutrients, vermicompost can play an effective role in plant growth and development. The purpose of this research is to reduce the use of inorganic fertilizers in large agricultural holdings where dry beans are grown to protect soil and crop health, and to popularize the use of cow and worm manure. The research was carried out from April to August of 2020 and 2021, in the Faculty of Agriculture of Dicle University in the southeastern Anatolia of Turkey, and the aim was to evaluate the effect of separate and combined applications of cow manure (2.5, 5.0 and 10 t ha^{-1}) and liquid vermicompost (recommended 50% and 100%) on the growth, yield and yield components of dry bean (*Phaseolus vulgaris* L.). The experiment was laid out in the randomized complete block design with three iterations. The soil was treated with vermicompost as foliar spray at the crop's flowering stage and with cow manure – during sowing. Plant samples for growth parameters were collected every 20 days starting from 20 days after emergence (DAE) until maturity, and plots were harvested for yield and yield components. Differences among the applications were significant for growth, yield, and yield components. 10 t ha^{-1} of cow manure + 100% recommended dose of vermicompost produced high levels of vegetative parts, such as leaves and stems until 80 DAE, but the highest seed yield (14.2 g $plant^{-1}$) and yield components were achieved in the 5 t ha^{-1} of cow manure + 100% recommended dose of vermicompost combination. Even a separate vermicompost application increased in the vegetative parts and yield components of bean plants compared to control.

Keywords: common bean, *Phaseolus vulgaris* L., leaf area, biomass, organic fertilizer

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INTRODUCTION

The common bean (*Phaseolus vulgaris* L.) is one of the main agricultural crops in the world. The most important bean producers are Brazil, China, India, Mexico, USA, and Turkey. In Turkey, it is cultivated almost everywhere except for hot regions and drylands (Ahmadi, Arain 2021).

The general characteristics of arid and semi-arid regions are low rainfall, high temperatures, and high evaporation. The soil in these areas shows low productivity and restricted fertility due to the lack of water (Klemmedson 1989). Moreover, the soil's organic matter content is depleted due to intensive cropping and the excessive use of chemical fertilizers with little or no addition of organic manure. Low mineralization of soil organic matter occurs due to hot and arid climactic conditions, and most of these soils have less than 1.5% organic matter, like in our region, while good agricultural soil should contain at least 2% organic matter. It is necessary to improve over time the organic matter content of our region's arid and dense clay soils with a low organic content. Using efficient organic fertilizers increases crop yield and soil quality, and preserves the environment in the long-term. Traditional organic fertilizers mainly include compost, cattle and poultry manure. Cattle manure is an excellent soil amendment that can improve soil quality and provide nutrients for crop production (Elmi et al. 2021). Vermicompost, too, is an excellent soil amendment made up of digested compost. Worm castings are much richer in nutrients and microbial life and therefore are considered to be a higher value product (Adhikary 2012). Also, it is possible to improve soil quality with vermicompost (Maková et al. 2019).

Organic fertilizers are mostly used in small agricultural holdings, where mostly vegetable beans are grown. Although using organic manure is not a novel idea, it has not received the due attention with respect to cultivated lands in Turkey where dry beans are grown. Most dry bean producers use inorganic fertilizers for profitable and easy production owing to their ease of use and fast application to plants. Kumaran (2001) reported that the application of FYM + fertilizer produced higher number of matured pods per plant, pod weight per plant, test weight, pod yield, and straw yield of groundnut. However, the use of fertilizer alone resulted in a lower pod yield. Prabhakar et al. (2011) found that the application of farmyard manure with the recommended dose of chemical fertilizer led to better growth and yield parameters, such as the number of leaves, leaf area, dry matter production, number of pods, pod weight per plant, and pod length, which resulted in a significantly higher pod yield, and also this result shows that a separate application of the recommended dose of chemical fertilizer decreases productivity. Shafeek et al. (2017) reported that the highest plant height, number of leaves per plant, dry leaf weight, dry stems weight, and pod yield were achieved following the highest dose of cattle manure applied to a field of vegetable beans. Yadav, Vijayakumari (2003) revealed that vermicompost treat-

ment was important for high yield. This is the reason why the study aimed to reduce the use of inorganic fertilizers in large farmlands where dry beans are grown to protect soil and crop health and to popularize the use of cow and worm manure.

MATERIAL AND METHODS

The field experiment was carried out in 2020 and 2021 at the Faculty of Agriculture of Dicle University, Diyarbakir, Turkey, located at 37°30′N latitude and 41°20′E longitude. The experiment area received rainfall from the winter to spring, but not in late spring and summer. Minimum and maximum temperatures recorded during the period of plant growth were 14.1°C and 34.4°C on average, respectively, and relative humidity was very low, about 12-15% during reproduction stages. The soil was relatively infertile; it was clay and clay loam in texture, containing little organic matter. The P_2O_5 and K content of the soil was very low and high, respectively (Table 1).

Akman, a common bean variety was used. It has growth habit type II and is an erect indeterminate bush. The seeds were sown in the beginning of April. Before sowing, the soil was treated with three different amounts of cow manure (Table 2) 2.5 t ha^{-1}, 5 t ha^{-1} and 10 t ha^{-1}. Before flowering, when plants reached six or seven nodes, liquid vermicompost fertilizer (Table 2) was sprayed on plants in two different recommended amounts, 50% and 100% (100% recommended dose of vermicompost 10.000 cc ha^{-1}).

The experiment was laid out in the randomized complete block design with three iterations. The unit plot size was 4 m row length and 4 rows, row

Table 1

Soil analysis before fertilization

Analysis	Result 2020	Interpretation	Result 2021	Interpretation
Soil texture	72.6	clay	63.20	clay loam
pH	7.76	….	8.15	….
Lime (%)	7.46	medium	10.59	medium
C-organic (%)	0.64	very low	0.77	very low
N-Total (%)	0.032	low	0.04	low
P_2O_5 (kg ha^{-1})	18.8	very low	-	
K_2O (kg ha^{-1})	1363	high	-	
Fe (ppm)	3.7	enough	8.86	very high
Mg (ppm)	563.9	very high	616.32	medium

Table 2

Chemical compositions of cow manure and liquid vermicompost

Sources of organic manure	N (%)	Organic matter (%)	pH	Humic + fulvic acid (%)	P_2O_5 (%)	K_2O (%)	CaO (%)
Cow manure	3.82	61.59	8.5	12.5	4	1.3	0.3
Liquid vermicompost	1	40	8.5	15	3		

spacing 0.5 m. Plots and blocks were separated by 0.5 m and 1.0 m, respectively. The plots were irrigated twice a week with total of 500 irrigation sessions through all growing seasons.

Data on different growth parameters were recorded. Plant samples were collected every 20 days starting from 20 days after emerging (DAE) until maturity (100 DAE), but no samples were collected when the plants turned yellow. The plant parts that are above-ground and root parts were segmented into different components as plant biomass, leaf, stem and pod. Leaf area was measured with WinFolia software by an HP Scanjet 3400C immediately after sampling. The partitioned plant parts were then dried in an oven at 70°C for 72 h and weighed. Also, ten plants for seed yield components and 3.0 m^2 of plots for grain yield were harvested in maturity.

Data were subjected to MSTAT-C software package to perform variance analysis (ANOVA), Duncan's multiple test was used, and all figures were performed in Excel 2013.

RESULTS

The differences among years of growing beans were found to be insignificant while the differences between the year*application interaction were found to be significant. The combined results of the analyses of productivity and productivity components are provided for two years. However, the growth parameters were measured for only one year as a two-year evaluation was found to be insignificant (2020).

Growth of the common bean variety, Akman, was measured by plant biomass, dry root and stem weight, number of leaves, leaf weight, and leaf area per plant under different cow manure and vermicompost doses every 20 days after emergence. It was determined that root development continues until day 100 day after the emergence of the plant and is affected by fertilization. Cow manure + vermicompost fertilizer up to day 40 after emergence increased the dry root weight per plant of common bean, but vermicompost application without cow manure fertilization up to day 45 day did not affect dry root weight (Figure 1).

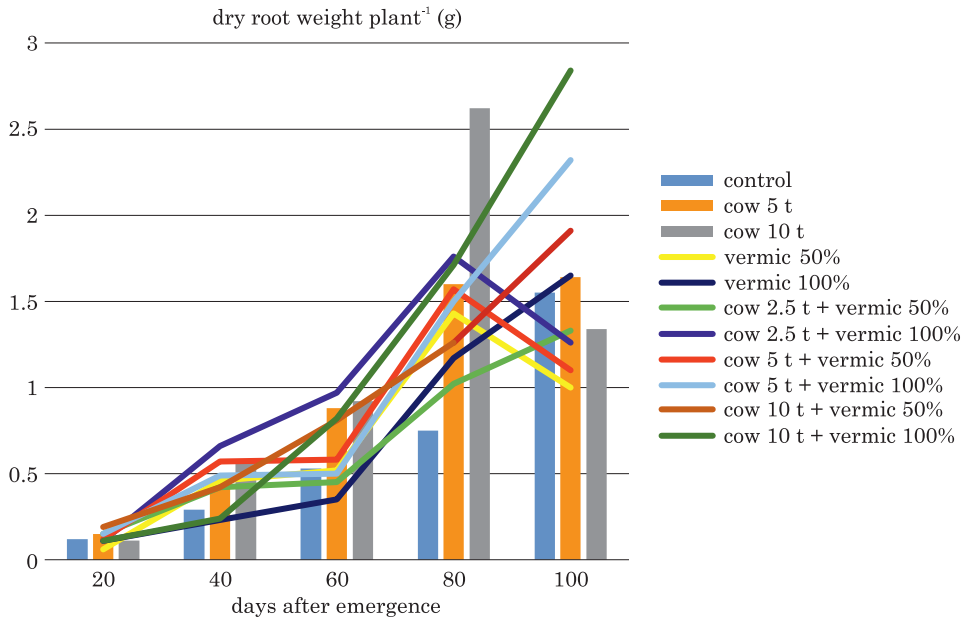

Fig.1. Dry root weight plant^{-1} of common bean under cow manure and liquid vermicompost application over the growing periods

The common bean variety reached the highest stem weight on day 80 day after emergence, then this parameter decreased in value as the plant lost its leaves until the beginning of the full maturity period. All applications increased the stem weight progressively compared to the control. The highest stem weight was achieved from the applications of cow manure 10 t ha^{-1} + 100% recommended dose of vermicompost (Figure 2).

The dry leaf weight was affected significantly by adding manure until the end of the experiment. Dry leaf weight progressively increased and achieved its maximum value (21.06 g) on day 80 day after emergence when fertilized with cow manure 10 t ha^{-1} + 100% recommended dose of vermicompost. At the same growth stage, the lowest value (4.05 g) was achieved at control (Figure 3).

As shown in Figure 4, the results indicate that leaf area was significantly affected until the end of the experiment by the addition of cow manure and vermicompost to soil. The highest value was achieved in the variant with cow manure 10 t ha^{-1} + 50% vermicompost dose. Leaf area progressively increased and achieved its maximum value (2564 cm) on day 80 after emergence, and the lowest value (640 cm) was recorded at the control treatment. Common bean plants flowered from day 45 to 50 after emergence, and reached their highest weight by 80 DAE.

The number of leaves plant^{-1} was significantly affected with the addition of cow manure compared to only vermicompost. Number of leaves plant^{-1}

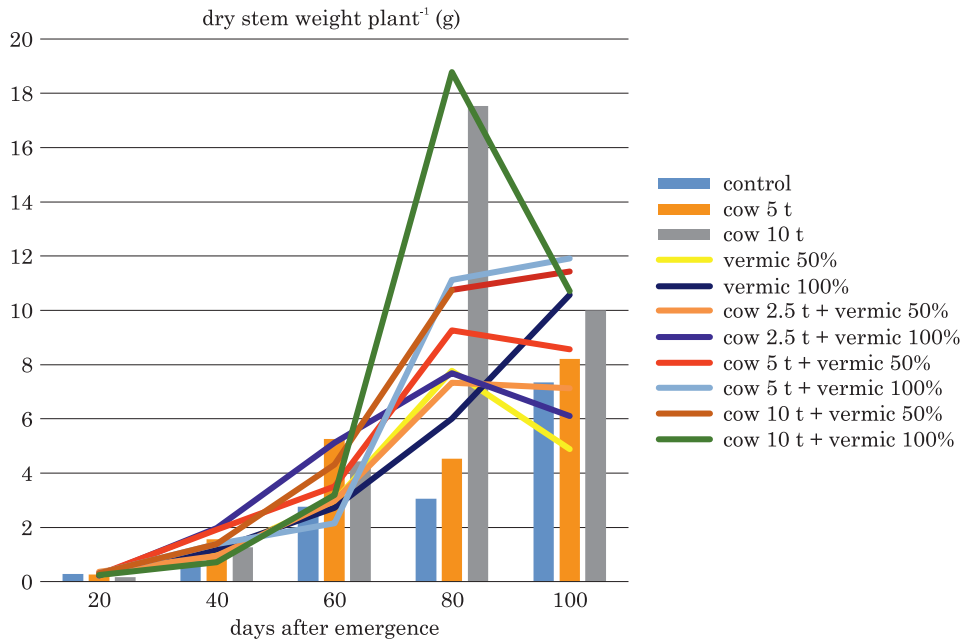

Fig. 2. Dry stem weight plant^{-1} of common bean under cow manure and liquid vermicompost application over the growing periods

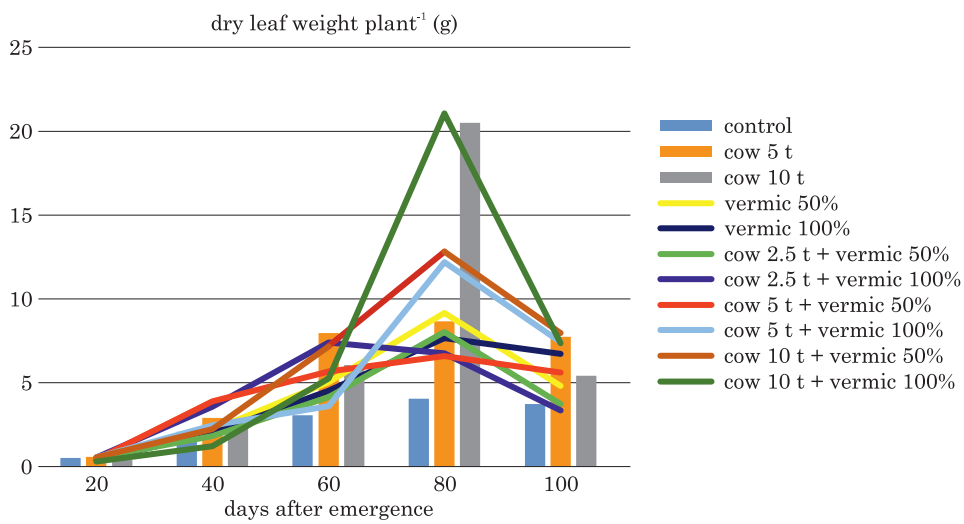

Fig. 3. Dry leaf weight plant^{-1} of common bean under cow manure and liquid vermicompost application over the growing periods

increased and reached its maximum value (177.4) on day 80 after emergence in variants with cow manure 10 t ha^{-1} and cow manure 10 t ha^{-1} + 100% recommended dose of vermicompost. At the same growth stage, the lowest

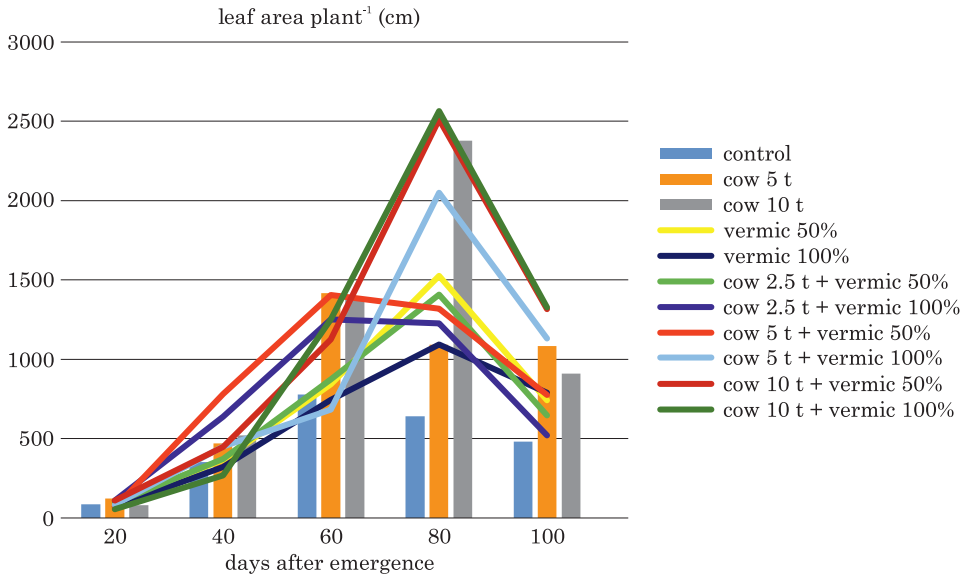

Fig. 4. Leaf area plant^{-1} of common bean under cow manure and liquid vermicompost application over the growing periods

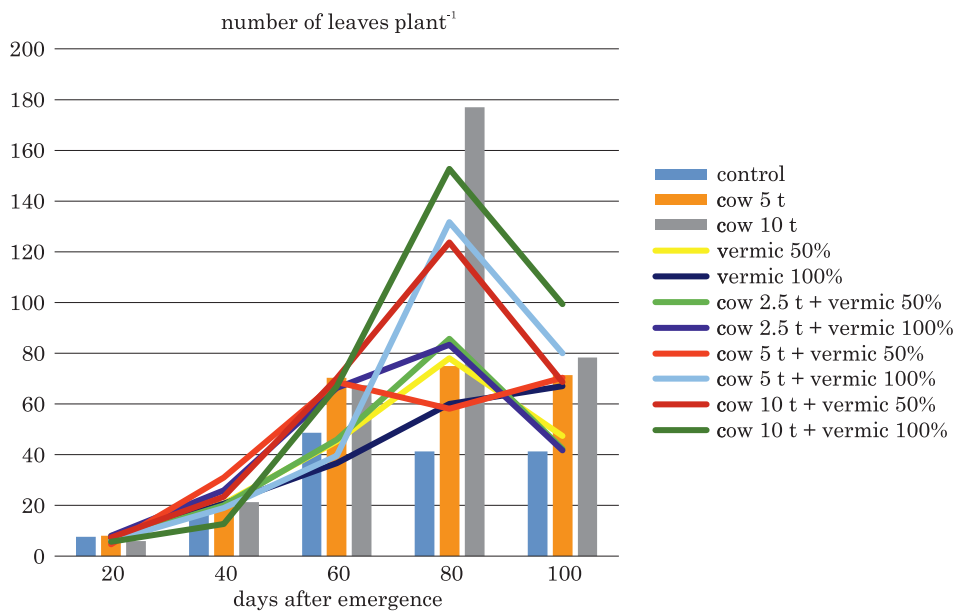

Fig. 5. Number of leaves plant^{-1} of common bean under cow manure and liquid vermicompost application over the growing periods

value (41.3) was recorded at control. The increasing number of new shoots, leaves, flowers, pods and plant biomass may be caused by the N supply in the cow manure and vermicompost (Figures 5, 6).

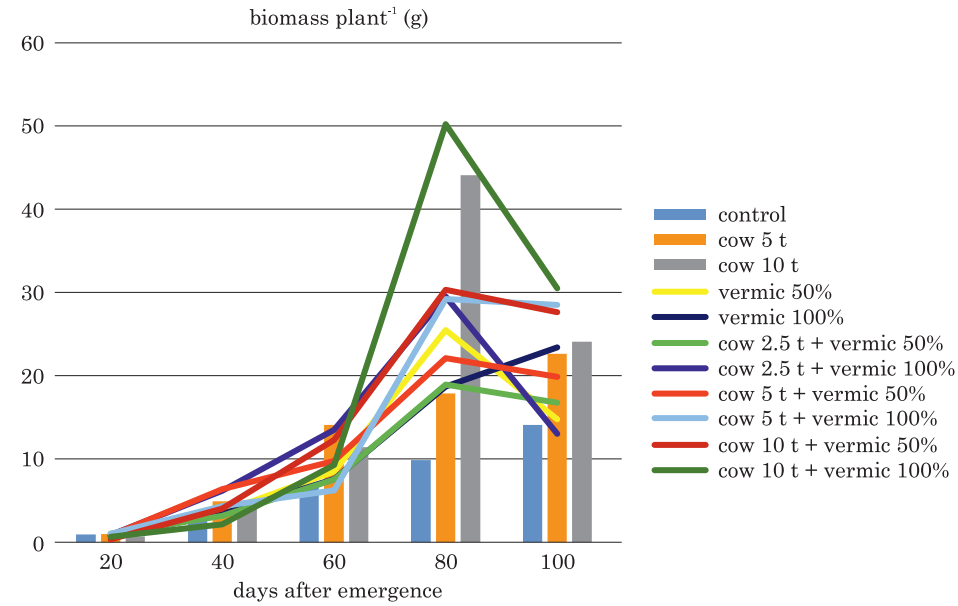

Fig. 6. Biomass plant^{-1} of common bean under cow manure and liquid vermicompost application over the growing periods

Data presented in Table 3 show that cow manure and vermicompost significantly affect plant height, plant biomass, seed yield, pod weight, number of pods plant^{-1}, and seed yield (kg ha^{-1}) – Figures 1-7 of the common bean variety.

Plant height, number of pods, pod weight, and seed yield plant^{-1} increased with cow manure and vermicompost application. The highest plant height (58.5 cm) was achieved with the application of 5 t ha^{-1} cow manure + 100% recommended dose of vermicompost and the lowest (35.6 cm) from the control treatment. The highest number of pods plant^{-1} (18.9) was recorded at 5 t ha^{-1} cow manure + 100% recommended dose of vermicompost. The number of pods per plant was affected more by the application compared to other characteristics, and the lowest value (11.5) was achieved from the control group. However, the 10 t ha^{-1} cow manure + 50% recommended dose of vermicompost application in terms of the number of pods per plant achieved almost the same low yield as the control group. The highest pod weight and seed yield plant^{-1} was obtained from 5 t ha^{-1} cow manure + 100% recommended dose of vermicompost, but 10 t ha^{-1} cow manure, 10 t ha^{-1} + 50% recommended dose of vermicompost and control were similar for pod weight (Table 3).

The highest seed yield (2364 kg ha^{-1}) was fertilized with 5 t ha^{-1} cow manure + 100% recommended dose of vermicompost followed by 2.5 t ha^{-1} cow manure + 100% recommended dose of vermicompost (2083 kg ha^{-1}) and the lowest yield (1137 kg ha^{-1}) was achieved from control (Figure 7).

Table 3

The effect on yield and yield components of dry bean to cow manure and liquid vermicompost

Treatments	Biomass plant^{-1} (g)	Plant height (cm)	Number of pods plant^{-1}	Pod weight plant^{-1} (g)	Number of seeds pod^{-1}	Number of primary branches plant^{-1}	Number of secondary branches plant^{-1}	Seed yield plant^{-1} (g)
Control	23.1 *d*	35.6 *e*	11.5 *c*	11.7 *c*	4.4	2.5	1.5 *d*	8.4 *b*
Cow manure (ton ha^{-1})								
5	42.2 *a*	55.0 *ab*	17.0 *ab*	21.5 *ab*	3.6	3.2	2.9 *ab*	10.3 *ab*
10	24.2 *cd*	45.1 *cd*	15.4 *abc*	14.0 *c*	3.9	2.8	2.8 *ab*	8.8 *b*
Vermicompost (recommended)								
50%	26.3 *cd*	45.3 *cd*	14.1 *abc*	16.2 *bc*	4.0	2.7	3.4 *a*	10.8 *ab*
100%	27.1 *cd*	41.1 *de*	13.6 *abc*	15.2 *bc*	4.0	2.7	1.8 *cd*	11.0 *ab*
Cow manure + vermicompost								
2.5 + 50%	32.2 *bcd*	45.9 *cd*	15.5 *abc*	17.1 *abc*	3.7	3.2	2.3 *bcd*	12.8 *ab*
2.5 + 100%	33.3 *abc*	50.3 *bc*	16.0 *abc*	16.0 *bc*	4.3	2.5	2.1 *bcd*	10.3 *ab*
5 + 50%	30.2 *cd*	47.8 *bcd*	15.8 *abc*	17.7 *abc*	3.6	2.5	1.9 *cd*	9.6 *ab*
5 +100%	40.9 *ab*	58.5 *a*	18.9 *a*	23.6 *a*	3.8	3.0	2.1 *bcd*	14.2 *a*
10 +50%	25.0 *cd*	44.4 *cd*	12.6 *bc*	13.4 *c*	3.6	2.5	2.1 *bcd*	7.6 *b*
10 +100%	26.0 *cd*	44.3 *cd*	15.6 *abc*	18.7 *abc*	3.5	2.8	2.5 *abc*	10.8 *ab*
2020	27.9	46.4	14.0	16.6	3.8	2.7	2.03	10.3
2021	32.2	47.0	16.1	17.0	3.9	2.9	2.5	10.5

The means in columns followed by the same letter are not significantly different from each other.

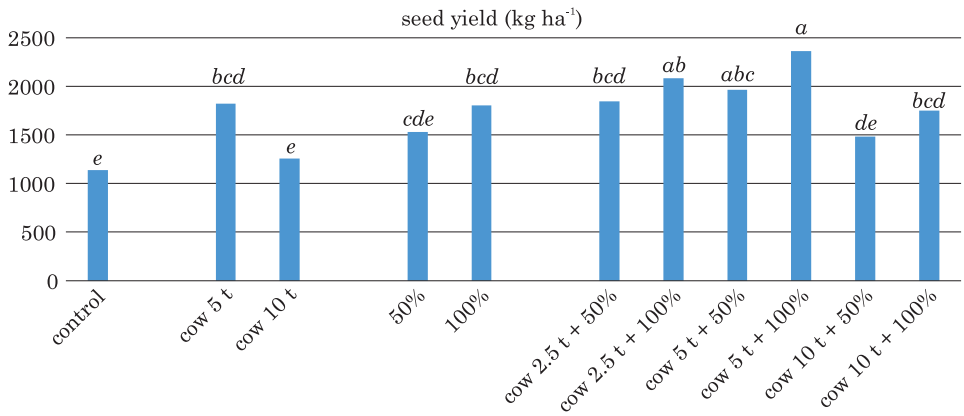

Fig. 7. Seed yield (kg ha^{-1}) of common bean under cow manure and vermicompost application

DISCUSSION

Vermicompost as foliar spray had a significant positive effect on yield and yield components. Vermicompost even when used alone increased the yield of dry bean. However, vermicompost did not increase the vegetative parts of bean plants (Figures 2-6). Valdez-Perez et al. (2011) noted that the addition of vermicompost to soil resulted in the best development of the bean plant. Arancon et al. (2005) suggested that vermicompost also adds plant growth regulators, such as humic acids, which stimulate plant growth. In this study, vermicompost + cow manure application improved growth and yield components, such as plant height, number of leaves, dry stem weight, dry leaf weight, and the best results were achieved from high doses of vermicompost with cow manure (Figures 1-7, Table 3). Sankhyan et al. (2001), Kumaran (2001) and Singh, Chauhan (2009) reported that farmyard manure and FYM + vermicompost treatment and Islam et al. (2016) reported that only vermicompost application resulted in better performance for total biomass production, plant height, number of pods plant^{-1}, pod weight and the photosynthetic rate at the different vegetative stages and seed yield. Alkobaisy, Mutlag (2021) reported that the combination of vermicompost, rhizobia and mineral fertilizer was the best application for plant height, root weight and yield components, such as the number of pods plant^{-1}, weight of pods plant^{-1}, weight 1000 seeds (g) and total yield.

In this study, the application of vermicompost alone and 10 t ha^{-1} of cow manure applications were not as effective as 5 t ha^{-1} cow manure and vermicompost application for seed yield and yield components.

Although 10 t ha^{-1} of cow manure achieved the highest values on day 80 after emergence, Figures 1 to 6 show that the effect decreased towards maturity (100 DAE) for growth parameters. 10 t ha^{-1} of cow manure + 100%

recommended dose of vermicompost produced high levels of vegetative parts such as leaves and stems during flowering and podding stages (Figures 2-5), but seed yield and its components decreased at the same manure level (Figure 7, Table 1). The 5 t ha^{-1} manure + vermicompost application was more effective in increasing yield components compared to 10 t ha^{-1} (Figure 7). Other researchers reported that application of a recommended dose of fertilizer of FYM 20 t ha^{-1} + NPK 30: 40: 20 kg ha^{-1} (Saikia et al. 2018) and vermicompost + FYM + Rhizobium + rock phosphate (Sarma et al. 2014) significantly increased growth parameters, yield and yield components. Berova et al. (2013) reported that using vermicompost increased vegetative parts and final yield. Al-Obaidi, Ratha (2021) determined a significant advantage of the bacterial combination biofertilizer with vermicompost and 50% mineral fertilizer compared to the treatment of full fertilizer recommendation in most of the growth and yield parameters of green beans. El-Gabrey et al. (2019) found that use of organic amendments, such as chicken manure, farmyard manure and compost, had the highest impact on the harvest index.

CONCLUSIONS

Vermicompost and cow manure applications were found to have a significant effect on dry bean cultivation. It was determined that the use of cow manure would be appropriate to improve soil and to obtain a high yield in soils with low organic matter. It was determined that the application of vermicompost directly to leaves has a similar effect to the use of cow manure. The combined application of vermicompost and cow manure was found to achieve better results than their separate application. The application of the recommended doses and the half of the higher doses of both cow manure and vermicompost resulted in the same efficiency as their higher doses. The application of 5 t ha^{-1} cow manure + vermicompost at the flowering stage was found suitable for high seed yield and yield components. Even though the applications have positive effects on growth and seed yield, their economic analyses could not be performed.

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