International Journal of Current Science Research and Review
ISSN: 2581-8341
Volume 05 Issue 11 November 2022
DOI: 10.47191/ijcsrr/V5-i11-04, Impact Factor: 5.995
IJCSRR @ 2022
www.ijcsrr.org

Evaluation of Intercropping System of Sweet Corn (Zea mays-saccharata Sturt) and Vegetable Soybean (Glycine max L. Merr) in Integrated Fertilizer Application

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ABSTRACT: The purpose of this study was to evaluate the intercropping system of sweet corn and vegetable soybeans on the application of combination different sources organic fertilizer and dosage of NPK fertilizer. The research was carried out from June to August 2022 in the Giwangan Umbulharjo village, Special Region of Yogyakarta. The study was arranged in a factorial Randomized Complete Block Design with three replication. The first factor were the source of organic fertilizer consisting of three sources (cow, chicken manure and municipal compost), the second factor were dosages of NPK consisting of three levels (200, 300 and 400) kg ha^{-1}, so that obtained 27 unit of experimental plots. The observation variable include component of growth, yield and efficiency land. The statistic analysis of data with analysis of variance (ANOVA) at a significant level of 5% followed by Duncan's Multiple Range Test at a significant 5%. The result showed that the application of combination chicken manure with a dosages 300 kg ha^{-1} NPK fertilizer in the best growth and the highest yield of intercropping sweet corn and vegetable soybeans, and the component efficiency land showed the value of 1.55 Land Equivalent Ratio, 0.92 Competitive Index, 1.59 Crop System Efficiency and 1.07 Relative Yield Total.

KEYWORDS: Cropping system efficiency, Completion index, Land equivalent ratio, Municipal compost.

INTRODUCTION

Sweet corn is variety with high sugar content and high nutritional value, it is very popular with community so it has high economic velue (Santos *et al*., 2014). Local varieties have a sugar content of (9 – 11)%, while sweet corn hybrid varieties have a sugar content (16 - 18)% (Szymanek *et al*., 2015). Therefore, sweet corn is recognized as a quality and delicious food. The seeds are delicious full of sugars that are balanced with amino acids, minerals and B vitamins, and corn is a good source of fiber. Moreover, sweet corn contains phytochemicals that can improve health such as carotenoid, tocopherol and phenolic acid (Das and Singh, 2016; Srdic *et al*., 2019). In Indonesia, sweet corn was first known in the form of imported cans. In the 1980s this maize variety was cultivated in Indonesia commercially on small scale. The higher the level of public awareness, the more priority is given to health food, the higher the demand for sweet corn. Sweet corn productivity in Indonesia is still low with an average productivity of under 10 tons ha^{-1}. Likewise Subaedah *et al*. (2018) reported that sweet corn productivity only reached 8.31 tons ha^{-1} or only one third of the potential yield. Sridic et al. (2019) reported the potential yield of sweet corn reached 13.33 tons ha^{-1}, while Subaedah *et al*. (2021) the twin row system produce a cob weight of to 22.33 tons ha^{-1}.

Besides sweet corn as functional food, fresh vegetable soybeans also contain (10 – 14) % protein, rich in essential amino acids, dietary fiber, minerals and vitamin. This type of nut from Japan also contains isoflavone compounds that have a number of potential health benefits in the human body, including increasing antioxidant activity, preventing cancer, and reducing Low Density Lipoprotein (LDL) bad cholesterol that contributes to cardiovascular disease. This is what distinguishes a type of legume from japan as a source of functional food that is able to provide consumers with many additional benefits beyond basic nutritional need (Lord *et al*., 2012). These plants are also capable of binding atmospheric nitrogen, given to plant and facilitating soil nutrient circulation and water storage. Based on these benefits, legumes have high potential for conservation of agricultural soil (Stagnari *et al*., 2017). Organic fertilizers from plants and animals applied directly or after composting or other processes can supply significant nutrient for growing sweet corn. Organic fertilizers are mandatory in organic farming and are often used in conventional agriculture as a complement to fertilization or to improve soil properties. The potential value of animal faeces as fertilizer and soil enhancer depends on the rate and rate of decomposition of organic matter to release plant nutrient or build organic soil in ponds of matter. In maize production systems, simply increasing the species richness cover crop will have little impact on agroecosystem services, but designing polycultures that maximize functional diversity can lead to multifunctional agroecosystem (Ku and Wa, 2017).

Based on the report by El-Negar and Mohamed (2019) that cow manure contains the mineral N. This process depends on the type of manure and its nutrient content, soil temperature, and humidity among other factors. Midransia *et al*. (2016) determinate that chicken manure in the most appropriate type of fertilizer to increases growth and production of sweet corn in shallow, lowland swamp areas. The chicken manure contains N (6.99 – 7.78)%, P (0.89 – 099)%, K (4.88 – 5.70)%, organic matter (37.80 – 38.09)%, bulk density (0.39-0.86)% and total porosity (31.00-60.40)% while the mineral nutrient content of compost (agricultural waste) contain N (0.51-0.53)%, P (0.21-0.23)% and K (0.60-0.65)% (Latief *et al*., 2021).

Nitrogen (N) is an essential element that is required both in terms of in influencing plant productivity and negative environmental effects. The main source of N in organic systems can come from growing N-fixing legumes alternately with sweet corn> research on land application of combined manure with NPK and its effects on crop production is even rarer (Ahmed *et al*., 2020). Nitrogen fertilizers have been widely used to increase crop yield, but inadequate N inputs result in low yields and food shortages. In modern intensive agricultural production system, up to 50% of the N fertilizer applied to agriculture soil is lost to the environment (Zhao *et al*., 2022).

Intercropping system with legumes in a symbiotic manner can provide nitrogen nutrients that are able to potentially increase environmental resources and crop yields (El-Gobashy *et al*., 2018). Intercropping is beneficial in many ways as it ensures greater use of resources, reduced population of harmful biotic agents, higher resource conservation and soil health as well as more production and sustainable system outputs. In an intercropping system, more than one plant is planted together on the same soil and utilizes it's soil nutrients, soil moisture, atmosphere and sunlight. Intercropping has a strong potential to increase yields and thereby reduce global climate impacts such as greenhouse gases. Barriers to the locking effect for increased use of intercropping in organic farming and suggest a roadmap for innovation and strategy implementation in organic farming (Jensen *et al*., 2015). In the intercropping system, complementarity between the types of cultivated plant is very important to increase the yield of the two crops (Maitra *et al*., 2021). Several reports are available on cereal-based intercropping such as: corn-bean, corn-potato, corn-cassava, corn-yam, corn-soybean and corn-peanut, among many others and corn-peanut. Recent studies on intercropping have focused on cereal-vegetable mixtures (Samsuri *et al*., 2021). Based on the description above, it is hypothesis that the application municiple compost and a dosages 300 kg ha^{-1} NPK fertilizer can increase the yield and efficiency of intercropping sweet corn-vegetable soybean.

MATERIAL AND METHODES

The research was carried out from June to Augustus 2022, in the Giwangan sub district Umbulharjo Yogyakarta. The research location is it an altitude of 115 meters above sea level, soil type gromusol, temperature (18 – 16) ^{o}C, rainfall 200 cc monthly, high light intensity, humidity (50-90)% and soil pH 5.6 -6.6.

Experiment Design, the field research was arranged in factorial Randomized Completely Block Design three replications. The first factor was the source of organic fertilizer namely chicken, cow manure and municipal compost at a dosage 20 tons $ha^{-1.}$. the second factor was the dosage of NPK compound fertilizer, namely 200, 300 and 400 kg ha^{-1}. Control treatment with cow manure, urea, TSP and KCl fertilizers. The implementation of the research includes the making of experimental plots, soil preparation, basic fertilization with the application of organic fertilizer according to the dosage and source of organic fertilizer. Seed selection and planting with sweet corn spacing (75 x25) cm and vegetable soybean (25x25) cm, so that between two rows of sweet corn plant there are two rows of vegetable soybean. Embroidery was done one week after planting. Watering until the condition if it is not raining. Control of plant pest organism manually pest by picking, killing and burying and weeds by weeding/pulling and then buried. Observation of growth variables by destruction on plants ages 1 month, followed by generative growth until harvest. Variables observed for sweet corn and vegetable soybean include fresh weight and dry weight per plant, fresh weight of cobs and pods per plant, fresh weight of corn cobs and vegetable soybean pods ha^{-1}, chlorophyll contain, sweetness level of sweet corn seeds, Land Equivalent Ratio, Crop System Efficiency, Yield Relative Total and Competion Index. Data analysis used variance at a significance level of 5%, and continued with Duncan's Multiple Range Test at a significant level of 5%.

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RESULTS AND DISCUSSION

The effect of types of organic and dosages of NPK fertilizers on plant growth. There was an interaction between sources of organic fertilizer and a dosage of NPK on plant dry weight and chlorophyll content, while other variables did not interaction, namely fresh weight of plant, sweet corn cob weight ha^{-1}, sweetness level and fresh weight of vegetable soybean pod ha^{-1}.

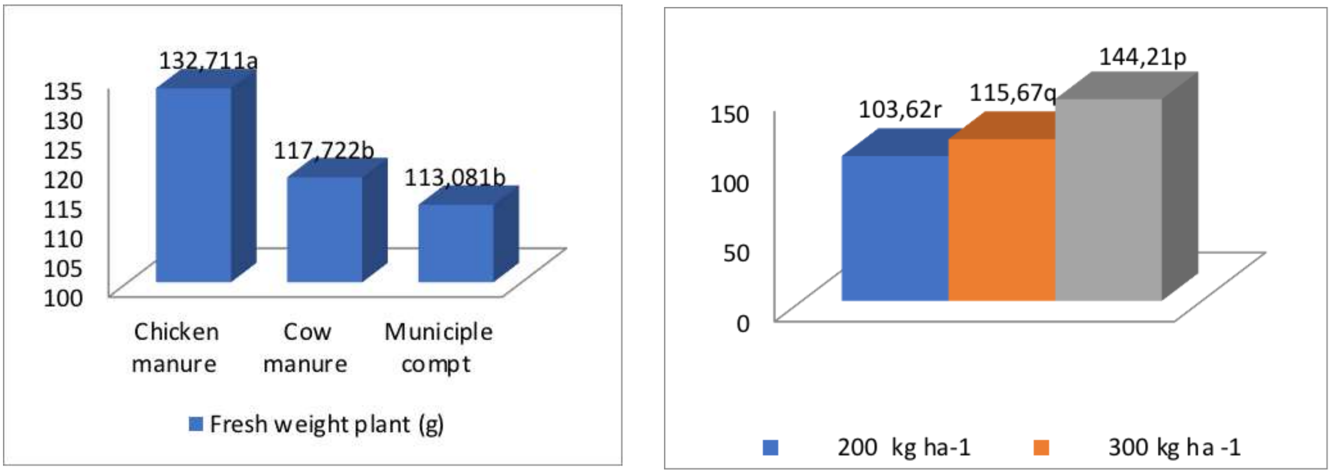

Figure 1. Effect of different kind (a) and dosage (b) of fertilizer to fresh weight plant

Figure 1. shown that there is an interaction between various source organic fertilizer and the dosage of NPK fertilizer (significant P < 0.05%). The dry weight of sweet corn obtained from the combination of chicken manure with a dosage 400 kg NPK fertilizer was not significantly and the highest with the combination of chicken manure and dosage NPK 300 kg ha^{-1} fertilizer and higher with the application with cow manure and NPK dosage 400 kg ha $^{-1}$. The lowest dry weight was obtained in the combination municipal compost with 200 kg NPK dosages fertilizer. The accordance report Pangaribuan *et al*. (2018) stated that the combination of chicken organic manure and urea fertilizer at a dosage of 300 kg ha^{-1} increased the growth, yield and quality of vegetable soybean. Ahmed *et al*. (2020) reported combining compost increased dry matter yield compared to control by 17-53% and increased grain yield by 1.8 to 3.1 times in both varieties of sorghum. Grain yield from plots treated with NPK, single similar for both varieties in both seasons.

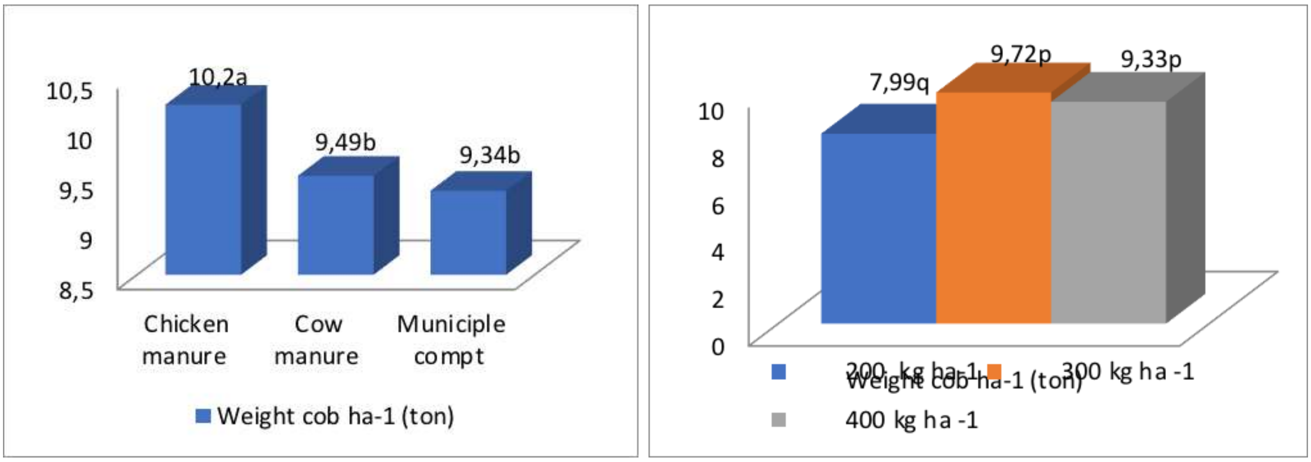

Figure 2. Effect of different kind (a) and dosage (b) of fertilizer to weight cob

Figure 2. There was an interaction between the sources of organic manure with the dosage of NPK fertilizer (significant P< 0.05). The highest leaf chlorophyll content was obtained in a combination of chicken manure and NPK dosages 300-400 kg ha

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$^{-1}$ fertilizer. Lower chlorophyll content was obtained in the combination of cow manure with NPK fertilizer at dosages 300- 400 kg ha^{-1} which was no different with municipal compost and NPK dosages 300-400 kg ha^{-1} fertilizer. The lowest leaf chlorophyll content was obtained in the combination of municipal compost with NPK fertilizer dosage 200 kg ha^{-1} the supported (Latief *et al*., 2018).

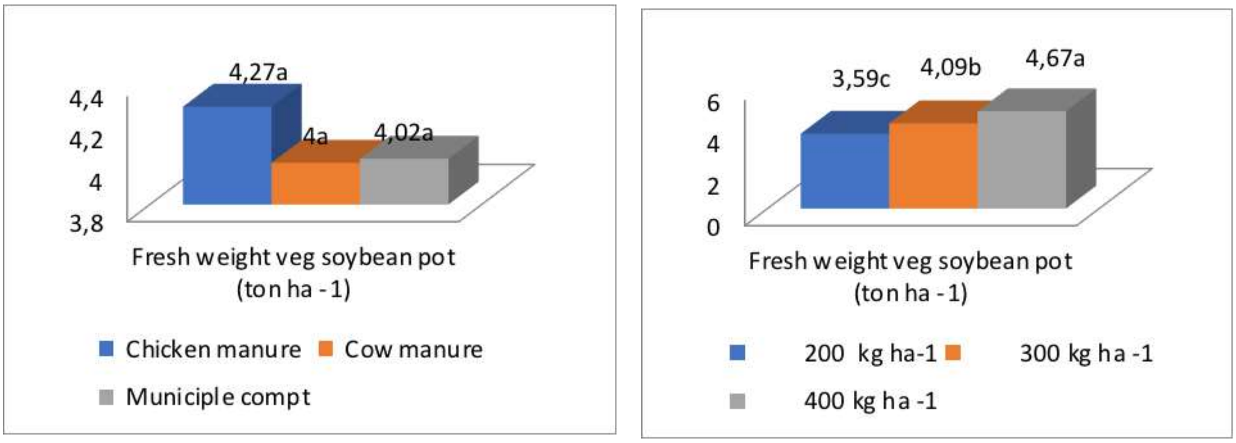

Figure 3. Effect of different kind (a) and dosage (b) of fertilizer to weight of soybean pot

Figure 3. shown there was no interaction between source of organic manure with NPK fertilizer dosages 200 – 400 kg ha^{-1} on fresh weight plant, weight of cob ha^{-1} and sweet corn sweetness level (significant $P < 0{,}05$). Fresh weight of plant, fresh weight of cob and sweet corn sweetness level showed that there was significant. Fertilizer was compared to cow manure and municipal compost and both no significant different.

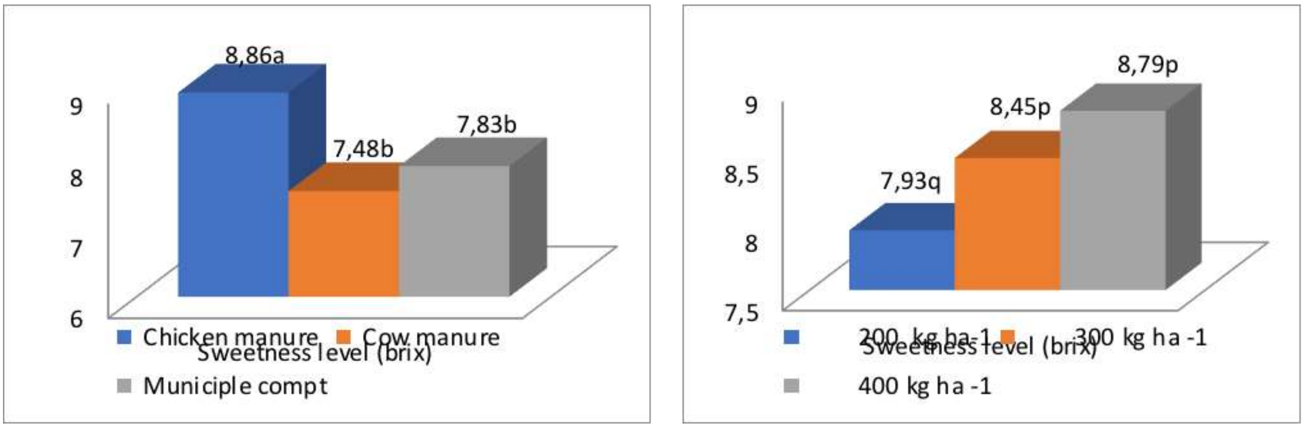

Figure 4. Effect different kind of fertilizer to the sweetness level of sweet corn

Figure 4. Likewise, the dosage of NPK fertilizer showed significant different fresh weight plant, fresh weight of cob ha^{-1} sweetness level and the highest vegetable soybean pod weight were obtained at a dosages of 400 kg ha^{-1} and lower dosages also produced lower yield. The higher of the sugar content, the better the quality. Organic fertilizer gives a greater sugar content of sweet corn. The potential sugar content of sweet corn cultivar jamboree is 13.5°Brix, while the average of sweet corn sugar content produced the research for application without organic fertilizer is 13.89 °Brix and application of organic manure is 15.30 °Brix. Latief *et al*. (2021) reported that the combined application gypsum and compost increased pod yield by 67 and 65% during 2018 and 2019 respectively compared the controls. Crude protein 21% and oil content 9.0% also increased substantially in the combined application. In addition the combined application of gypsum and agriculture compost significantly retain soil moisture and reduce soil density.

The current findings indicate that the integrated use of agriculture compost and gypsum under field condition can increase crop productivity, crude protein, oil content, moisture percentage and reduce soil density thereby improving overall soil heath. Darini *et al.* (2020) reported that application of a combination of cow manure at a dosages 10 ton ha^{-1} with ammonium sulphate fertilizer 200 kg dosages increase the growth and yield of vegetable soybean pods on volcanic soil. With a dosage of nitrogen fertilizer of 200 kg ha^{-1} and a corn plant density of 8.25 million. A maximum yield of 9321.21 kg ha^{-1} can be achieved (Meng *et al*., 2020).

Table 1. Efficiency of intercropping system sweet corn and vegetable soybean

Combin Organic sources/NPK dosages (kg.ha^{-1})	Land Equeva-lent Ratio	Crop System Efficiency	Relative Yield Total	Competion Index
Chicken -200	1.21 b	1.35 c	0.99 b	0.85 b
Chicken -300	1.56 ab	1.59 b	1.07 a	0.92 a
Chicken -400	1.66 a	1.71 a	0.92 b	0.90 a
Cow - 200	1.33 b	1.28 c	0.93 b	0.79 b
Cow - 300	1.44 b	1.41 b	0.97 b	0.81 b
Cow - 400	1.60 a	1.53 b	0.96 b	0.85 b
Municiple -200	1.27 b	1.22 c	0.85 c	0.71 b
Municiple -300	1.43 b	1.37 c	0.90 b	0.79 b
Municiple -400	1.56 ab	1.49 b	0.94 b	0.82 b

Table 1. Land efficiency in the intercropping of sweet corn with vegetable soybean is very high, this is indicate the Land Equivalent Ratio value of 1.56 – 1.66, other efficiency values are Crop System Efficiency, Relative Yield Total and Competition Index. This is supported by the result of various studies, based of the report Bantie *et al*. (2014) that the intercropping of lupine and barley crop increase land efficiency by increasing the Land Equivalent Ratio (LER) and Area Time Equivalent Ratio (ATER) and reducing Competition Index. Dhonde *et al*. (2016) reported that the intercropping system of maize and long bean in arrow ratio of 2:2 increased the Land Equity Ratio to 1.15. The LER value is generally higher than indicating a higher yield advantage over monoculture. Likewise, Aswe and Maimela (2020) reported that intercropping the pathway system between cowpea and corn increased the yield, grain yield, LER and net yield. Not influenced by cropping pattern LER, ATER, A, CR were higher than sesame. In addition, planting cotton among sesame has higher monetary benefits than sesame monoculture (Donyavian *et al*., 2018). The highest seed yield was obtained in intercropping through 2 row of cowpea plants between maize plant. The land equivalent ratio is greater than for each intercropping (Nawar *et al*., 2020). Increasing the yield of long beans and corn in the intercropping system by giving a dosage of P fertilizer of 30 kg ha^{-1} and increasing the land equivalent ratio (Asiwe *et al*., 2021). The value of competition index show 0.92 the supported by Mekuanint (2017) that corn are more dominant than legume members.

CONCLUSION

Based on the description above, it can be concluded as follows:

1. There was an interaction between the source of organic fertilizer and the dosage of NPK fertilizer of 200-400 kg ha^{-1} on the dry weight of the plant and the chlorophyll content of the leaves of sweet corn, while other variables did not interaction.
2. The best growth of sweet corn intercropping with vegetable soybean was obtained from a combination of chicken manure or cow manure and 400 kg of NPK fertilizer. The growth of sweet corm plant with cow manure was not significantly different from municipal compost.
3. The highest yield of sweet corn cobs was obtained from the application of chicken manure, the lower yield was obtained from the application of cow manure and was not different from that of municipal compost.

4. The highest efficiency of intercropping was obtained in the combination of chicken or cow manure with NPK fertilizer dosage 400 kg ha^{-1} with a LER value 1.66, lower efficiency was obtained in the combination of cow manure and 300 kg of NPK not different from combination of municipal compost and NPK dosage 400 kg ha^{-1} with a value of reaching a LER of 1.56.

ACKNOWLEDGMENT
The author would like to thank Ministry of Research, Technology, and Higher Education for providing financial support for this study through No. PDUPT.DIKTI.01/UST/LP2M/K/VI/2022

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Cite this Article: Maria Theresia Darini, Sri Widata, Evi Setiawati, Ari Astuti (2022). Evaluation of Intercropping System of Sweet Corn (Zea mays-saccharata Sturt) and Vegetable Soybean (Glycine max L. Merr) in Integrated Fertilizer Application. International Journal of Current Science Research and Review, 5(11), 4099-4105