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INTERCROPPING SWEET CORN (*ZEA MAYS S*ACCHARATA STURT) AND PAKCHOY (*BRASSICA JUNCEA*) IN THE DIFFERENT ORGANIC MATTER COMPOSITIONS

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ABSTRACT

A field experiment was conducted to compare the growth and the yield of mono culture sweet corn (*Zea mays* Saccharata Sturt) and that of intercropped with pak choy (*Brassica juncea*) with different kind of organic matter resources. The study was also aimed to explore the possibility of replacing inorganic fertilizer with organic materials. There were 8 treatments, i.e. (P0) Sweet corn mono cropping system applied with inorganic fertilizer, (P1) Sweet corn mono cropping system applied with 27.11 t/ha cow manure, (P2) sweet corn intercrop with pakchoy fertilized with inorganic fertilizer, (P3) sweet corn intercropped with pakchoy applied with 27.11 t/ha cow manure, (P4) sweet corn intercropped with pakchoy applied with 13.56 t/ha cow manure and 6.10 t/ha *Tithonia diversifolia,* (P5) sweet corn intercropped with pakchoy applied 13.56 t/ha cow manure and 7.11 t/ha *C.juncea* ,(P6) sweet corn intercropped with pakchoy applied with 6.78 t/ha cow manure and 9.16 t/ha *Tithonia diversifolia,* (P7) sweet corn intercropped with pakchoy applied with 6.78 t/ha cow manure and 10.69 t/ha *C. juncea*, which were arranged in a Randomized Block Design with 3 replications. The result shows that the growth and yield of sweet corn did not significantly by the cropping system and kind of organic matter resources. Kinds of organic resources also did not significantly influence the growth and yield of pakchoy intercropped with sweet corn. Organic materials used in this experiment had a potential to replace inorganic fertilizer. The most beneficial treatments was Sweet corn intercropped with pakchoy + cow manure + *C.juncea* (1:3) which had R/C ratio of 1.37

Keywords: cow manure, *Tithonia diversifolia*, *Crotalaria juncea*, sweet corn, intercropping, chemical fertilizer

INTRODUCTION

Modern technology of agriculture has boosted the productivity of crops. More grain, vegetables or other crop yields per hectare have been produced. In other word more food can be produced per person labor through high external inputs. However, this amazing technology cannot be accessed by many smallholders in the developing countries who facing more problems in food availability [1][2][3]. In many developing countries, the increase of external inputs such as synthetic fertilizers and pesticides are also increase debt to afford it [4]. Furthermore, modern technology practices have led to pollution, biodiversity and natural degradation [5]. Therefore, smallholders will primarily depend on the organic resources and ecological processes of nutrient cycling to improve soil fertility, weed and pest control to protect crops from damage and losses.

Utilization of animal and green manures as fertilizer in organic agriculture has been practiced in the traditional farming system. However, lack studies on these issues resulted on the negative image of this alternative farming merely as an old method [6]. Conversely, combination of traditional, innovation and sciences as part of organic agriculture definition will benefit the shared environment and good quality of life [7]. Animals and green manure are prospective organic fertilizer resources when it is well managed. Cow manure contains of 1% N, 0.2% P, and 1% K [8]. While N,P, and K content of *Crotalaria juncea* and *Titonia diversifolia* are 3.2%, 2.3%, 0.39 and 3.5%, 0.37%, 4.1%, respectively [9,10]. The effect of organic matter to the sweet corn growth and yield was reported similar to chemical synthetic fertilizer and even better [11][12].

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Furthermore efficiency of land use through intercropping for small scale farm can be an alternative for smallholders to increase land productivity, labor utilization per unit area, and input efficiency. Moreover, inter species interaction during crop growth led to increase biodiversity that support ecological processes of pest suppression [13][14]. Crop choices to be intercropping may determine the successful of intercropping. The different rooting system, life cycle period, nutrient and light requirement and even economic values can be considered to decide the intercropping combination. Sweet corn and maize in general is a spacious crop in its cultivation method. Therefore, utilization of space between maize row to be cultivated with other crops that have shorter life period can optimize the land use. In many studies it was reported that maize can be intercrop with many types of crop without reduce maize yield [15][16].

In some developing countries, the number of livestock is relatively low. In addition, in many cases small farmers in this area do not mix crop with animals due to livestock price is not affordable for small farmers. Therefore, application of animal manure or cow manure specifically needs to be transported to the crop field. As consequence, both factors of less stock availability and transportation cost make cow manure is more expensive than green manure that can be grown in the short periods or periodically available when it is grown as border. Alternatively, combining cow manure and green manure may reduce the costs. Thus, suitable alternative combination of kinds of organic matter that can be produced on farm to replace chemical synthetic fertilizers will be able to reduce input costs. Furthermore, additional products of intercropping systems will increase land use and labor efficiency, and hence increase farmer's income.

We conducted a field trial to compare economical yields of sweet corn (*Zea mays* Saccharata Sturt) under mono cropping and intercropping with pakchoy (*Brassica juncea*) in the different kind of organic matter combinations. The experiment was also aimed to obtain the best treatment based on the nutrient residues in the soil and economic advantage.

MATERIALS AND METHODS

Site studies and procedures

The on-farm field experiment was conducted from June to August 2011, in Siman village, Kepung sub-district, Kediri district, East Java, Indonesia. The site is at 500 m above sea level, and based on the field description the soil was classified as Entisols. Eight combination treatments, i.e.: (P0) Sweet corn mono cropping system applied with inorganic fertilizer, (P1) Sweet corn mono cropping system applied with 27.11 t/ha cow manure, (P2) sweet corn intercrop with pakchoy fertilized with inorganic fertilizer, (P3) sweet corn intercropped with pakchoy applied with 27.11 t/ha cow manure, (P4) sweet corn intercropped with pakchoy applied with 13.56 t/ha cow manure and 6.10 t/ha *Tithonia diversifolia,* (P5) sweet corn intercropped with pakchoy applied 13.56 t/ha cow manure and 7.11 t/ha *C.juncea* ,(P6) sweet corn intercropped with pakchoy applied with 6.78 t/ha cow manure and 9.16 t/ha *Tithonia diversifolia,* (P7) sweet corn intercropped with pakchoy applied with 6.78 t/ha cow manure and 10.69 t/ha *C. juncea.* The inorganic fertilizer was applied as 300 kg ha^{-1} urea,150 kg ha^{-1} P_2O_5 and 50 kg ha^{-1} K_2O. Combination rates of cow manure and the green manure in treatments (P4), (P5), (P6) and (P7) were calculated in such a way so that the amount of organic-C in this combination was equal to that of 27.22 t/ha cow manure. These 8 treatment combination was arranged in Randomized Block Design with 3 replications.

Some properties of the soil and organic resources used in the experiment were presented in Table 1.

Table 1 Properties of the soil and organic resources in the experiment

Resources	pH soluble		C organic	N total	C/N	P_2O_5	K_2O
	H2O	KCl	(%)	(%)		(ppm)	(ppm)
Soil	6.02	5.1	1.20	0.11	10.53	10.90	0.52
Cow manure	8.11	7.2	18.89	0.86	21.88	2.11	1.26
C.juncea			24.82	2.24	11.06	2.60	0.82
T.divorsifolia			23.79	2.39	10.02	2.80	0.75

Sweet corn (*Zea mays s*accharata Sturt, v. Bisi Super Sweet) was sowed (two seeds per hole) with a planting distance of 75 x 20 cm, and 10 days after planting it was thinned and left 1 plant/hole. At the same time of sweet corn planting, nine days old of Pakchoy seedlings were transplanted in sweet corn rows with a planting distance of 25 x 20 cm.. Urea was applied three time, 1/3 at planting date, 1/3 applied at 30 days after planting, and the rest 1/3 at 45 day after transplanting, respectively. Cow manure and green manure were applied two weeks before planting. Weeding was done at 14 days after sowing and sub irrigation was applied at sowing and transplanting, at fertilizer application, flower initiation, and grain filling initiation. No pesticide application. Pakchoy and sweet corn were harvested at 28 and 78 days after transplanting and sowing, respectively.

Measurements

Two plants of sweet corn per plot were harvested and measured at 12 days interval for leaf area index measurement. Four pakchoy plants were harvested at 6 days interval for leaf area index measurement. To measure the economic yield for both sweet corn and pakchoy was harvested at 78 and 30 days after planting respectively. Light interception was measured on the upper part of pakchoy plants at 12 days and 24 days after planting.

Organic-C, N, P, and K of the soil and organic matter resources were determined with Walkley and Black, Kejdahl, Bray 2, and ammonium acetate solution respectively. Soil properties were analyzed before and after the experiment. Costs for all inputs and labor were logged. Revenues were calculated from all sold products. Finally, the profit was calculated from the revenue and costs ratio.

The data was analyzed with analysis of variance, and if there was a significant different the Fisher's Least Significant Difference (LSD) test was used to test between treatments (p=0.05)

RESULTS AND DISCUSSION

The experimental result show in Table 2 show that the leaf area index (LAI) of pakchoy was not significantly influenced by the application of different kind of organic matter combinations, The experimental result in Table 2 also show that intercropped pakchoy in sweet corn did not negatively affect the sweet corn growth. The leaf area index (LAI) of sweet corn reached a maximum value of about 6 at 60 days after sowing.

Table 2.Leaf area index of sweet corn and pakchoy at different day after sowing and transplanting

Treatments	**Leaf area index at …… (days after sowing)**								
	Pakchoy				Sweet corn				
	6	12	18	24	12	24	36	48	60
Sweet corn mono crop + inorganic fertilizer					0.01	0.14	0.64	2.86	6.05
Sweet corn mono crop + cow manure					0.01	0.13	0.76	2.95	5.80
Sweet corn intercropped with pakchoy + inorganic fertilizer	0.02	0.09	0.75	0.75	0.01	0.19	0.80	2.80	5.81
Sweet corn intercropped with pakchoy + cow manure	0.02	0.08	0.69	0.95	0.01	0 .19	0 .89	2.81	5.53
Sweet corn intercropped with pakchoy + cow manure + *T.diforsifolia* (1:1)*)	0.02	0.15	0.70	0.86	0.01	0.18	0.84	2.88	5.85
Sweet corn intercropped with pakchoy + cow manure + *C.juncea* (1:1)	0.01	0.09	0.85	0.78	0.01	0.16	0.82	3.00	5.91
Sweet corn intercropped with pakchoy + cow manure + *T.diforsifolia*(1:3)	0.01	0.06	0.63	0.73	0.01	0.17	0.77	3.00	5.93
Sweet corn intercropped with pakchoy + cow manure + *C.juncea* (1:3)	0.02	0.12	0.69	0.94	0.01	0.18	0.73	2.84	5.55
	NS**)	NS	NS	NS	NS	NS	NS	NS	NS

*) this ratio means the ratio of organic-C in cow manure with that in the desired green manure
**) Ns: non significant

At 12 days observation, light interception (measured on pakchoy crop) between treatments varied from 70 % to 80 % decrease to 45% - 65 %(at 24 days observation 30% - 35% at 60 days observation (Table 2). Thus during the fast growth phase of pakchoy there was enough sun light for photosynthesis, and therefore the LAI of pakchoy plants did not significantly influence by the treatments. The data which show that the LAI of sweet corn of monocropping and intercropping system did not significantly different indicated that intercropped of pakchoy in sweet corn did not make any negative competition. From light interception it is clear enough because sweet corn is higher than pakchoy. Li, Sun and Zhang (17) suggested that the late maturity species occupy greater below ground space at later growth phase because the combined-shallow root crop occupied soil surface. Therefore, the root of sweet corn penetrates soil deeper to fulfill nutrient need. At the end, when the earlier maturity crops are harvested, sweet corn got more sufficient nutrient both from surface and deeper layer of soil.

Table 3 Mean light interception (measured on the upper part of pakchoy plants) at 12 and 24 days after planting

Treatments	**Light interception at …… (days after sowing)**	
	%	
	12	24
Sweet corn intercropped with pakchoy + inorganic fertilizer	90	50 ab**)
Sweet corn intercropped with pakchoy + cow manure	89	58 bc
Sweet corn intercropped with pakchoy + cow manure + *T.diforsifolia* (1:1)*)	84	60 c
Sweet corn intercropped with pakchoy + cow manure + *C.juncea* (1:1)	86	45 a
Sweet corn intercropped with pakchoy + cow manure + *T.diforsifolia*(1:3)	87	62 c
Sweet corn intercropped with pakchoy + cow manure + *C.juncea* (1:3)	87	65 c
NS		

*) this ratio means the ratio of organic-C in cow manure with that in the desired green manure
**) means followed by the same letters are not significantly different (p=0.05); Ns: non significant

There was an indication of organic-C enhancement on the treatments with organic matter amendment but not with N, P and K residues on the soil (Table 4). The highest soil organic-C was observed on the treatment **of** Sweet corn intercropped with pakchoy + cow manure + *T.diforsifolia*(1:3). It seems that organic-C from *T.diforsifolia* was more resistant to decomposition compared to that from *C.juncea.*

Table 4 Some soil properties before and after the experiment

Treatments	pH	C organic	N total	C/N	P2O5	K2O
	H2O	(%)	(%)		(ppm)	(ppm)
Before experiment	6.02	1.20 a	0.11	10.53	10.90	0.52
After harvesting sweet corn						
Sweet corn mono crop + inorganic fertilizer	6.97	1.20 a	0.14	9.29	18.00	0.80
Sweet corn mono crop + cow manure	7.16	1.30 b	0.14	8.63	18.20	0.82
Sweet corn intercropped with pakchoy + inorganic fertilizer	7.31	1.26 ab	0.14	9.20	19.80	0.72
Sweet corn intercropped with pakchoy + cow manure	7.21	1.40 cd	0.14	10.29	17.10	0.83
Sweet corn intercropped with pakchoy + cow manure + *T.diforsifolia* (1:1)[*)]	7.37	1.36 bc	0.13	10.15	17.50	0.84
Sweet corn intercropped with pakchoy + cow manure + *C.juncea* (1:1)	7.17	1.32 ab	0.13	10.00	17.00	0.73
Sweet corn intercropped with pakchoy + cow manure + *T.diforsifolia*(1:3)	7.24	1.49 d	0.13	11.37	18.50	0.79
Sweet corn intercropped with pakchoy + cow manure + *C.juncea* (1:3)	7.31	1.39 bc	0.13	10.69	19.00	0.84
	NS		NS	NS	NS	NS

[*)] this ratio means the ratio of organic-C in cow manure with that in the desired green manure
[**)] means followed by the same letters are not significantly different (p=0.05); NS: non significant

The experimental result presented in Figure 1 show that the use of organic materials such as cow manure and green manure to inorganic fertilizers could obtain economic yield of paakchoy and sweet corn as high as the inorganic fertilizer treatment. The highest economical yield of sweet corn in this experiment was 14 t ha^{-1} which was obtained by the treatment of inorganic fertilizer, but not significantly different from the other treatments

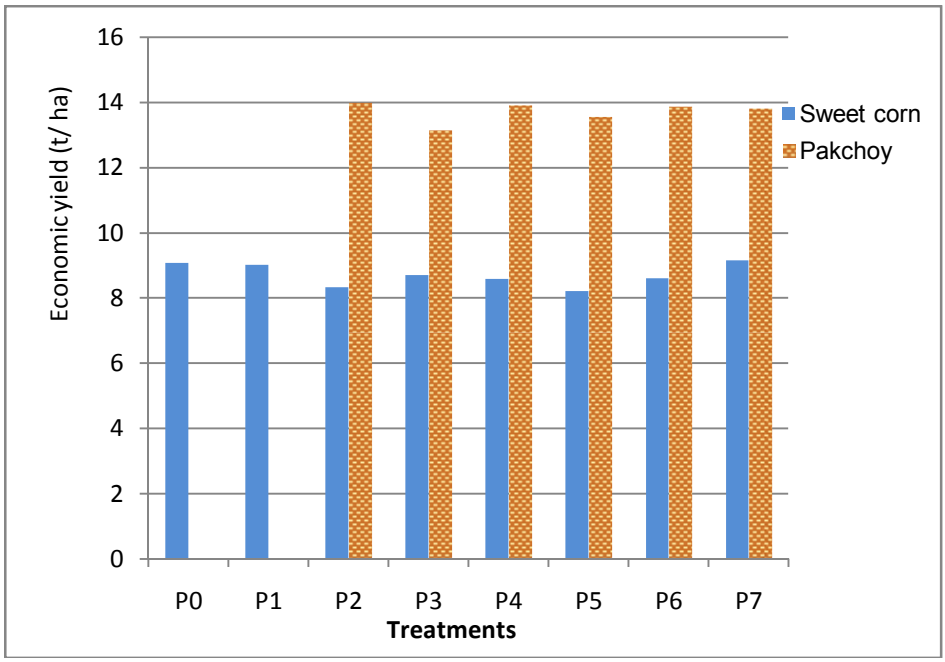

Figure 1 Economic yields at different cropping system and nutrient management: (P0) Sweet corn monocropping system + inorganic fertilizer, (P1) Sweet corn monocropping system + cow manure, (P2) sweet corn intercrop with pakchoy fertlized + inorganic fertilizer, (P3) sweet corn intercropped with pakchoy + cow manure, (P4) sweet corn intercropped with pakchoy + cow manure and *Tithonia diversifolia* (1:1), (P5) sweet corn intercropped with pakchoy + cow manure and *C.juncea* (1:1), (P6) sweet corn intercropped with pakchoy + cow manure and *Tithonia diversifolia (*1:3), (P7) sweet corn intercropped with pakchoy + cow manure and *C. juncea* (1:3)

Economic analysis was done to study the applicability of the treatments. This was done by calculating the Revenue- Cost Ratio (R/C ratio). The result (Table 3) the use of cow manure to sweet corn

yields the same R/C with that of inorganic fertilizer. Intercropped sweet corn with pakchoy increased R/C ratio. The most beneficial treatment was Sweet corn intercropped with pakchoy + cow manure + *C.juncea* (1:3) which had R/C ratio of 1.37.

Table 3 Revenue and cost ratio (R/C) of different cropping systems and nutrient management

Treatments	Revenues (Rp)	Costs (Rp)	R/C
Sweet corn mono crop + inorganic fertilizer	28,905,940	26,350,000	1.10
Sweet corn mono crop + cow manure	27,497,940	26,211,000	1.05
Sweet corn intercropped with pakchoy + inorganic fertilizer	33,554,090	27,700,000	1.21
Sweet corn intercropped with pakchoy + cow manure	32,548,890	27,561,000	1.18
Sweet corn intercropped with pakchoy + cow manure + *T.diforsifolia* (1:1)[*)]	32,955,340	26,297,635	1.25
Sweet corn intercropped with pakchoy + cow manure + *C.juncea* (1:1)	34,519,990	26,383,750	1.31
Sweet corn intercropped with pakchoy + cow manure + *T.diforsifolia*(1:3)	33,268,690	25,665,455	1.30
Sweet corn intercropped with pakchoy + cow manure + *C.juncea* (1:3)	35,228,540	25,795,375	1.37

CONCLUSION

The experimental result discussed here demonstrated that the growth and yield of sweet corn did not significantly by the cropping system and kind of organic matter resources. Kinds of organic resources also did not significantly influenced the growth and yield of pakchoy intercropped with sweet corn. Organic materials used in this experiment had a potential to replace inorganic fertilizer. The use of cow manure to sweet corn yield the same R/C with that of inorganic fertilizer. Intercropped sweet corn with pakchoy increased R/C ratio. The most beneficial treatment was Sweet corn intercropped with pakchoy + cow manure + *C.juncea* (1:3) which had R/C ratio of 1.37.

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