

Research Article

The potential of *Tithonia diversifolia* green manure for improving soil quality for cauliflower (*Brassica oleracea* var. *Brotrytis* L.)

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Abstract: This study aimed to analyze the effect of *Tithonia diversifolia* green manure and cow manure on soil quality and yield of cauliflower. A field experiment was conducted in the village of Tegalondo, Karangploso District of Malang Regency. Eight treatments tested were control (no added manures), *T.diversifolia* 8.15 t/ha, cow manure 25.85 t/ha, NPK fertilizer 1.35 t/ha, *T.diversifolia* 4.08 t/ha + cow manure 12.93 t/ha, *T.diversifolia* 4.08 t/ha + NPK fertilizer 676 kg/ha, cow manure 12.93 t/ha + NPK 676 kg/ha and *T.diversifolia* 2.69 t/ha + cow manure 8.53 t/ha + NPK fertilizer 446 kg/ha. Soil quality was monitored at top soil (0-20 cm) at planting time and 30 days after planting. Soil samples were collected and analyzed for chemical and physical properties. Yield of cauliflower was observed at the time of harvest or 44 days after planting. The results showed that application of green manure could significantly change the physical and chemical properties of the soil. The decrease of bulk density of about 27.47%, increase of organic carbon of about 12.60%, increase of total N of about 53.87%, increase of available P of about 64.24 mg/kg, and exchangeable K of about 8.34 cmol/kg were observed in *T. diversifolia* treatment. The increase of pH of about 1.75%, and total porosity of about 17.73% was found in cow manure treatments. The increased water holding capacity of about 10.70% was found in *T. diversifolia* + cow manure treatments and increased stability aggregate about 23.54% was found in *T. diversifolia* + cow manure + NPK treatments. There was a significant increase of fresh weight of flower about 666.67 g/plant in *T. diversifolia* + NPK treatment.

Keywords: cauliflower, cow manure, soil quality, *Tithonia diversifolia*

Introduction

Cauliflower is one of the important vegetable crops and has high nutritional and good commercial value. Various efforts have been made to improve cauliflower production through extensification. However, the present decline or stagnation of major crop yields is the cumulative effect related of soil constraints. Inceptisol is a soil with a clayey texture, crumb to blocky angular structure and crumbly consistency in all parts of the soil profile. However, chemical properties of this soil are slightly acidic with low organic matter content, wet saturation more than

35%, the cation exchange capacity are 24 me/100 g and nutrient content is low to moderate (Handayanto, 1998). Depleted levels of organic matter have significant negative impacts on water use efficiency and water holding capacity due to poor porosity and infiltration (Wani et al., 2003), soil compaction, inhibit plant root to take up nutrients from the soil and leading to inhibit plant growth (Bonari et al., 1994; Bonini and Alves, 2010). Therefore, management practices to increase soil organic matter, and maintaining it at the level of the threshold was needed to reduce further degradation and to have better soil

fertility. Utilization of organic fertilizers that are locally found in vegetable production areas can increase yields by reducing the use of chemical fertilizers. Organic fertilizers have been known to improve soil fertility in this case also increase crop yields by providing macro and micronutrients needed to grow crops in order to improve results. The addition of organic fertilizers greatly affect micro flora activity and micro faunal organisms in the soil, improving soil good structure, aeration, moisture retention, increase the buffering and exchange capacity of soil.

Traditional organic materials such as animal manure are not usually available in sufficient quantities, have a low nutrients, their processing and their application are labor requires (Palm *et al.*, 1997). Therefore, it is important to use alternative sources of organic fertilizers such as green manure for enrichment of soil organic carbon stocks, improve the health of the soil and agronomic production. According to Chukwuka and Omotayo (2008) and Crespo *et al.* (2011) that the influence of *Tithonia diversifolia* can improve the physical and chemical properties of soil and increase nutrients in the soil, have also been shown to increase soil microbial communities and the benefit of certain agricultural techniques (Bossio *et al.*, 1998). Further, Igua and Huasi (2009) reported residues of *T.diversifolia* increases N in the soil and increase crop yields of maize. Sustainable land productivity can be achieved through the concepts of land conservation. One of the concepts is the use of land maintenance implementation of organic material acting as a soil amendment followed by monitoring the quality of the soil. Larson and Pierce (1996) revealed that the content of organic matter in the soil is one of the attributes of land that has a major influence on the productivity of the land.

T. diversifolia is family of Asteraceae shrub and is widely distributed along farm boundaries. Green biomass of *T. diversifolia* containing 3.17 to 3.5% N, 0.3 to 0.37% P, 3.22 to 4.1% K, 2.0% Ca and 0.3% Mg (Nyasimi *et al.*, 1997; Jamal *et al.*, 2000). It decomposes rapidly after application

to soil, and incorporation of biomass can be an effective source of N, P and K for maize and vegetable (Nyasimi *et al.*, 1997) and lowland rice (Jamal *et al.*, 2000). Lal (2006) stated that three possible scenarios relating crop yield or agronomic productivity to organic C content of soil are (i) increase in crop yield as a consequence of organic carbon pool enhancement; (ii) no or little decrease in crop yield with reduction in the organic carbon pool, and (iii) increase in crop yield with decrease in the organic carbon pool.

Based on the role and function of *T. diversifolia* biomass as a soil amendment to maintain and improve the physical, chemical and biological properties of soil and increase the availability of nutrients in the soil, the expected utilization of biomass *T. diversifolia* as green manure can replace inorganic fertilizer or cow manure to improve soil productivity and to increase crop yields. The purpose of this study was to analyze the effect of *T. diversifolia* green manure with cow manure and NPK fertilizer in improving of physical and chemical properties soil as well as yield of cauliflower.

Materials and Methods

A field experiment was conducted at Tegalgondo Village, Karang plos District of Malang Regency. Soil samples were analysed at Soil Laboratory, Faculty of Agriculture, Brawijaya University from June to September 2013. Soil of the study site is classified an Inceptisol with physical and chemical properties presented in Table 1. Materials used for this study were fresh green leaf and young stems of *T. diversifolia* biomass collected from vacant lots and roadsides near the study site as green manure, cow manure obtained from small-scale farmer near the study area, "Phonska" NPK fertilizer (15:15:15), and seed of cauliflower of "Bima-45 F-1" purchased from the farm shop. The experiment was arranged in a randomized block design with three replications.

Table 1. The initial physical and chemical properties of soil used for the study

Physical properties	Value	Chemical properties	Value
Bulk density (g/cm ³)	1.30	pH (H ₂ O)	6.30
Total porosity (%)	44.92	C-organic (%)	2.31
Agregat stability (%)	69.13	Total N(%)	0.22
Water hold capacity (%)	38.06	Available P (mg/kg)	23.24
-		Exchangeable K (cmol/kg)	0.39

Eight treatments consisting of control (no added manure), *T. diversifolia* 8.15 t/ha or 7.34 kg/plot, cow manure 25.85 t/ha or 23.27 kg/plot, NPK 1.35 t/ha or 1.22 kg/plot, *T. diversifolia* 4.08 t/ha or 3.67 kg/plot + cow manure 12.927 t/ha or 11.63 kg/plot, *T. diversifolia* 4.08 t/ha or 3.67 kg/plot + NPK 676 kg/ha or 0.608 kg/plot, cow manure 12.93 t/ha or 11.63 kg/plot + NPK 676 kg/ha or 0.608 kg/plot dan *T. diversifolia* 2,72 t/ha or 2.45 kg/plot + cow manure 8,62 t/ha or 7.75 kg/plot + NPK 450 kg/ha or 0.407 kg/plot. The dose was calculated based on the need of N of cauliflower plant using manure, i.e. 202 kg N/ha. The chemical compositions of *T. diversifolia* biomass and cow manure used for this study are presented in Table 2.

T. diversifolia green manure and cow manure were incorporated into the soil one week before planting. The experiment plot size were 4.50 m (l) x 2 m (w) with space between plot treatments were 0.4 m and between replicated plots were 0.5 m. The seed of cauliflower were planted with distance between row were 40 cm and between plant in a row were 45 cm. Soil quality was monitored at top soil (0-20 cm) before amended and 30 days after planting. The methods

used for analysis of soil physical and chemical properties were as follows: bulk density (Cylinder), total porosity (calculated from bulk density and particle density), aggregate stability (wet and dry sieve) and calculated formula $\text{Aggregate stability\%} = \{1: (\text{MWDdry} - \text{MWDwet})\} \times 100$, water holding capacity (Gravimetric), pH (pH meter), organic C (Walkey and Black), total N (Kjedhal), available P (Olsen) dan Exchangeable K (extracted with neutral 1M ammonium acetate and K was determined with a flame photometer).

Soil quality parameters measured were bulk density, total porosity, aggregate stability water holding capacity, pH, organic C, total N, available P and exchangeable K. Five plants per plot were randomly selected for eligible data collection. Yield (fresh weight of flowers) began to be observed at 44 days after planting. Data obtained were subjected to statistical analysis using the Analysis of Variance (ANOVA) using Microsoft Office Excel 2007. The different of treatment result was assessed using Least Significant Differences (LSD) Test at 5%.

Table 2. Chemical compositions of *T. diversifolia* biomass and cow manure

Materials	Organic C (%)	Total N (%)	C/N ratio	Organic matter (%)	Total P (%)	Total K (%)
<i>T. diversifolia</i> biomass	31.76	4.46	7.12	54.91	0.61	3.75
Cow manure	8.18	0.98	8.35	14.15	0.86	0.64

Result and Discussion

Soil physical properties

Application of *T. diversifolia* green manure, cow manure and NPK significantly affected soil physical properties (Table 3). The highest decrease in soil bulk density was found in *T. diversifolia* treatment, and the lowest was observed in NPK and control treatments. Compared to the initial soil quality, the soil bulk density decreased 1.23% to 27.47%. It indicated that *T. diversifolia* green manure and cow manure application improved the structure of the soil so that a decreased in soil bulk density. This is in line with the results of research reported by Adekalu and Osunbitan (1995) that *T. diversifolia* decreased bulk density. This is likely attributable to increases in soil organic matter due to decomposition of the plant residue. Organic matter is known to reduce soil compaction. Muddarisna dan Prijono (2014) reported that the

use of *Arachis pintoii* green manure and cow manure decreased soil bulk density. Tejada et al. (2006) investigated the effect of poultry manure and grain cotton compost on the properties of saline soil and concluded that application of these amendments decreased bulk density. Soil total porosity increased significantly except for the NPK and control treatments (Table 3). The highest increased soil total porosity was found in treatment cow manure, the lowest in treatment NPK and control. Compared to the initial soil quality, the soil total porosity increased 11.11% to 17.73%. Application organic matter will be able to create high soil pore space due to increased the formation of crusts and make more pores in the soil and friable (Refliaty et al., 2011). Decomposition of organic matter produces polysaccharide which binding primary particle to become secondary particle and create larger pore space (Brady and Weil, 2002).

Aggregate stability of soil increased significantly (Table 3). The highest increased was found in treatment *T. diversifolia* + cow manure + NPK and the lowest in treatment NPK. Compared to the initial soil quality, the soil aggregate stability increased 0.69% to 23.54%. Improvement aggregate stability of Inceptisol in *T. diversifolia* green manure and cow manure plots could be attributed to an increase soil organic matter which acted as a cementing factor for flocculating soil particles to form stable aggregates. This is similar to the results of research Wiesmeier et al. (2015) reported green manure application to the soil significantly increased macro and micro aggregate

rates. Bandyopadhyay et al. (2010) also reported the application of farmyard manure increased aggregate stability in soils.

Water holding capacity of soil increased at all plots compare to control plot (Table 3). Highest water holding capacity of soil found at plot treatment cow manure + NPK and the lowest in control. Compared to the initial soil quality, the soil water holding capacity increased 1.69% to 10.70%. Increased water-holding capacity after the treatment of organic manure due to increase soil porosity and aeration, It also relating to soil water retention.

Table 3. Effect of *T. diversifolia* green manure, cow manure and NPK on soil physical properties

Treatments	Bulk Density (g/cm ³)	Total Porosity (%)	Aggregate Stability (%)	Water Holding Capacity (%)
Control	1,27 c	45,38 a	69,12 b	37,85 a
<i>T. diversifolia</i>	0,94 a	52,40 cb	74,21 d	39,80 e
Cow manure	1,06 b	52,88 d	69,68 c	39,58 d
NPK	1,28 c	45,31 a	60,00 a	38,16 b
<i>T. diversifolia</i> + Cow manure	1,04 b	50,82 bc	78,60 f	38,70 c
<i>T. diversifolia</i> + NPK	1,00 ab	51,88 cd	75,35 e	41,25 f
Cow manure + NPK	1,05 b	49,91 b	84,10 g	42,13 g
<i>T. diversifolia</i> + Cow manure + NPK	1,04 b	51,00 bc	85,40 h	41,25 f
LSD 5%	0,06	1,71	0,09	0,24

Variables followed by similar letters in the same column indicate not significant in LSD 5 % test. The initial soil characteristics: bulk density 1.30 g/cm³, porosity 44.92%, aggregate stability 69.13%, water-holding capacity 38.06%.

The high organic matter can increase soil water holding capacity. According to the study of Acharya et al. (1988), improvement in water holding capacity of soil due to addition of organic manures compared to only inorganic fertilizer application. In addition to the provision of essential plant nutrients to soils, organic manure improves soil structure through enhanced soil water holding capacity, aeration and drainage which encourage good root formation and plant growth (Cooke, 1975). Bhriguvanshi (1988) reported that application of farmyard manure (FYM) either alone or in combination with nitrogenous fertilizers under conservation tillage played a definite role in improving water-holding capacity of soil which was attributed to the improvement in structural condition of the soil.

Soil chemical properties

Application of *T. diversifolia* green manure and cow manure significantly contributed to changes of pH, of the soil studied pH, organic C, total N, available P and total K of the soil studied (Table

4). Soil pH increased in the treatment of cow manure and *T. diversifolia* + cow manure, while the other treatments decreased. Compared to the initial soil quality, the soil pH increased 0.48% to 1.75% and decreased 5.87% to 15.71%. Increase in pH due to organic matter associated with an exchange reaction between anions of organic decomposition (organic acids) of the OH⁻ free, thus increasing OH⁻ ions in the soil solution. Reported difference organic materials gave difference value of soil pH. The response was in direct relationship to the pH of the materials themselves and type of organic acid that release from decomposition process of organic matter. Results of research Haynes and Mokolobate (2001) reported that application *Gliricidia sepium* after the addition of organic residues to acidic soils, often there is a temporary increase in the pH of the soil, then in case the decomposition process there will be a decline below the initial pH level.

Soil organic carbon changes significantly (Table 4). The highest increased was found in treatment *T. diversifolia* and the lowest in control.

Compared to the initial soil quality, the soil organic carbon increased 1.87% to 12.60% and decreased 4.50% to 32.20%. This case shows that the application *T. diversifolia* green manure and cattle manure through the process of decomposition contribute to improving soil organic matter. According to Okunade et al. (2005), application of *T. diversifolia* increased organic N content by about 10% compared with the control, in the upper 30 cm of soil, after 10 years of compost treatments. This result was complemented by significant increases in organic C, of 22%, indicating that the organic N was tied in organic matter (Hartl and Erhart, 2005) also reported Muddarisna and Prijono (2014) reported that difference organic carbon content of *Arachis pintoi* green manure, chicken dung, cow dung and goat dung gave different effect on soil organic carbon. Soil total N increased significantly except in control decreased (Table 4). The highest increased was found in treatment *T. diversifolia* and the lowest in control. Compared to the initial soil quality, the soil total N increased 5.21% to 53.87% and decreased 45.75%. Akanbi and Ojenyi (2007) reported that *T. diversifolia* contribution in increased N, in other studies conducted using *T. diversifolia*, panicum and chromolaena (Olabode et al., 2007) it was reported that *T. diversifolia* was superior to in N. The increase in total soil N after organic matter incorporation on soil compost, biosolids was closely related to the build up of organic matter in the soil over time and may be attributed to the

direct effect of organic inputs (Mantovi et al., 2005; Ros et al., 2006).

Soil available P increased significantly (Table 4). The highest increased was found in treatment *T. diversifolia* and the lowest in control. Compared to the initial soil quality, the soil available P increased 0,37 mg/kg to 64,24 mg/kg. This is similar to the results Akanbi and Ojenyi (2007) that *T. diversifolia* contribution in increased soil P, in other studies conducted using *T. diversifolia*, panicum and *C. odorata* (Olabode et al., 2007) it was reported that *T. diversifolia* was superior to in soil available P. Application organic matter *T. diversifolia* and cow manure tend to increase soil P due to release of organic acids during decomposition organic materials and formed complex metal with Al and Fe and reduce reactivity Al and Fe on P fixation. This mechanism can help in solubilization of P and reduction in P sorption (Weil and Magdoff, 2004). Organic acids also formed complexes with clay minerals and led to the addition of H⁺ ions to surface of clay mineral therefore will have a positive charge. The positive charge on the clay mineral will attract organic anion (R-COO) from organic material and formed organo compound with Al and Fe complexes (Al-chelate). Amount of available P in the soil at chelate mechanism is influenced by soil pH and type of organic acids that release from decomposition process. Chelate formed can increased dissolves inorganic phosphate thereby increasing the available P in the soil (Wahyudi et al., 2010).

Table 4. Effect of *T. diversifolia* green manure, cow manure and NPK on soil chemical properties

Treatment	Soil pH	SOC (%)	Soil total N (%)	Available P mg/kg	Exchangeable K (cmol/kg)
Control	5,80 c	1,57 a	0,12 a	23,61 a	0,27 a
<i>T. diversifolia</i>	5,84 c	2,60 f	0,34 g	87,48 g	8,73 h
Cow manure	6,41 f	2,35 e	0,32 fg	67,93 c	2,98 b
NPK	5,31 a	1,73 b	0,23 b	74,29 d	5,80 f
<i>T. diversifolia</i> + Cow manure	6,33 e	2,14 c	0,26 c	49,48 b	3,89 c
<i>T. diversifolia</i> + NPK	5,62 b	2,21 d	0,29 d	85,58 f	4,39 d
Cow manure + NPK	5,83 c	2,18 cd	0,31 e	78,88 e	6,32 g
<i>T. diversifolia</i> + Cow manure + NPK	5,93 d	2,38 e	0,32 ef	85,54 f	5,29 e
LSD 5%	0,06	0,06	0,01	0,21	0,39

Variables followed by similar letters in the same column indicate not significant in LSD 5 % test.. The initial soil characteristics: pH 6.30, organic C 2.31%, total N 0.22%, available P 23.24% mg/kg, exchangeable K 0.39 cmol/kg, SOC = soil organic matter

Soil exchangeable K increased significantly except in control decreased (Table 4). The highest increased was found in treatment *T. diversifolia* and the lowest in control. Compared to the initial

soil quality, the soil exchangeable K increased 2.59 cmol/kg to 8.34 cmol/kg. Soil K concentrations depended mostly on the K organic matter (Liu et al., 2008). The increase in

exchangeable K on plot treatments with *T. diversifolia* was probably mainly due to a great release of this nutrient by the decomposing residues that contained large amounts of K. This is similar to the results Akanbi and Ojenyi (2007) *T. diversifolia* in increased soil K, in other studies conducted using *T. diversifolia*, panicum and *C. odorata* (Olabode et al., 2007) it was reported that *T. diversifolia* was superior to in soil K. Further reportedly also Kolawole et al. (2014) soil exchangeable K was found to increase with mulch rate up to 20 t/ha.

Cauliflower yield

There were significant differences between treatments, fresh weight masses flower of cauliflower (Figure 1). The highest fresh weight of flowers was found in *T. diversifolia* + NPK treatment, and the lowest was in control. This could be due to the supplying of large quantities of needed nutrients as well as improving the soil physical and chemical properties. The treatment manure with *T. diversifolia* green manure sole or combination with cow manure and NPK had a beneficial effect on cauliflower yield. Green manuring crops like *T. diversifolia* specifically influence soil structural properties by reduce bulk density, increase soil porosity, aggregate stability and water holding capacity, soil pH and nutrient concentrations are the main factor that determined the improved yields in this experiment. Jama et al.

(2000) reported that the potentials of *T. diversifolia* in supplying and maintaining soil nutrients after periods of decomposition, it has been used as an organic fertilizer for vegetable crops, its use as green manure resulted in an increase in maize (*Zea mays*) yield and it proved as an effective source of nutrients for lowland rice (*Oryza sativa*) (Jama et al., 2000; Nziguheba et al., 2002; Sangakkara et al., 2002), also was found as effective nutrient source for maize, beans and vegetables in Kenya, and yam in Nigeria (Adeniyani et al., 2008). *T. diversifolia* mulch was able to increase tuber weight of cassava at both sites of field of experiments. Further research results (Olabode et al., 2007; Ademiluyi and Omotosho, 2007; Akanbi and Ojeniyi, 2007), who obtained better crop yields by compost *T. diversifolia*. Also, better growth and yield of okra resulted from soil treated with freshly crushed and dried ground *T. diversifolia*. Okra yields were 40 and 43% higher than the ashes treated and the control respectively when treated with crushed *T. diversifolia* 35 and 38% superior when treated with dried *T. diversifolia* (Olabode et al., 2007), that maize yields were even higher with incorporation of *T. diversifolia* biomass than with commercial mineral fertilizer at equivalent rates of N, P and K. In addition to providing nutrients, *T. diversifolia* incorporated at 5 t/ha dry matter can reduce P sorption and increase soil microbial biomass.

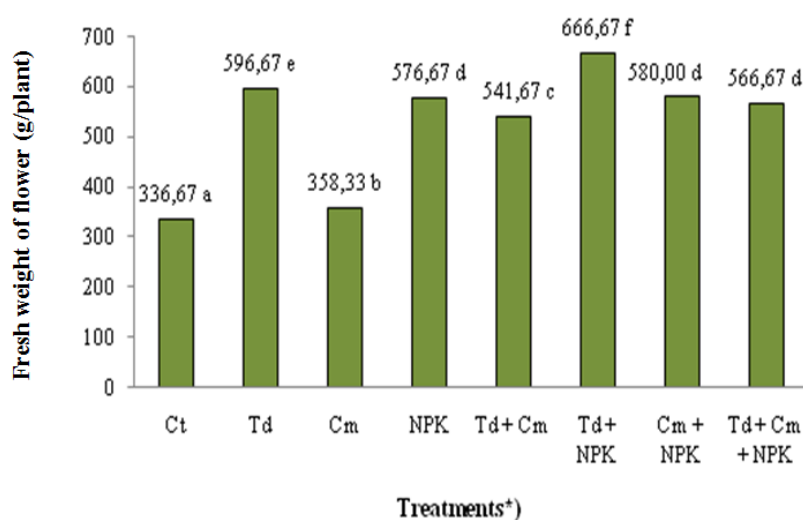


Figure 1. Effect *T. diversifolia* green manure, cow manure and NPK fertilizer on yield (fresh weight of flower) of cauliflower. Bars carrying the same alphabet are not significant in LSD 5 % test. *) Treatments: Ct: Control, Td: *T. diversifolia*, Cm: cow manure, NPK, Td + Cm: *T. diversifolia* + cow manure, Td + NPK: *T. diversifolia* + NPK, Cm +NPK: cow manure + NPK and Td + Cm + NPK: *T. diversifolia* + cow manure + NPK.

Conclusion

Application of *T. diversifolia* green manure and cow manure can improve soil physical and chemical properties as well as increased yield of cauliflower.

Green manure *T. diversifolia* gave contribution better in a decreased in soil bulk density, increased soil organic carbon, the increased total N soil, increased total porosity, increased the soil P availability and increased K exchangeable compared with other treatments either singly or in combination. cow manure gave contribution better in increased porosity total, increased soil pH and increased total N compared with other treatments.

Combination cow manure and NPK gives contribution in increasing water holding capacity soil compared with other treatments. Combination *T. diversifolia* green manure and NPK gives contribution in increased of plant the fresh weight masses flower of about 666.67 g/plant compared with other treatments. Combination *T. diversifolia* green manure, cow manure and NPK gives contribution on increased the soil stability aggregate compared with other treatments.

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