ISSN : 1812-5379 (Print)
ISSN : 1812-5417 (Online)
http://ansijournals.com/ja

JOURNAL OF AGRONOMY

ANSInet
Asian Network for Scientific Information
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan

OPEN ACCESS Journal of Agronomy

ISSN 1812-5379
DOI: 10.3923/ja.2017.154.159

Research Article
Study of *Asystasia gangetica* (L.) T. Anderson as Cover Crop Against Soil Water Content in Mature Oil Palm Plantation

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Abstract

Background and Objective: The study of cover crop in oil palm plantation is more emphasized on its function as soil and water conservation. Cover crop utilization is one of agronomic practice to protect soil surface from any damage caused by rainfall on to the soil surface. Rooting system of the cover crop is able to hold the rain water and in turn maintaining soil water content. This study is aimed to study the effect of *Asystasia gangetica* (*A. gangetica*) as cover crop in mature oil palm plantation toward soil water content. **Materials and Methods:** Research was conducted in mature oil palm plantation. The experiment was conducted by constructing 4×2 m experimental plot between rows of oil palm. The experiment consisted of 2 levels of treatment namely planting cover crop *A. gangetica* and without planting cover crop. It was repeated 3 times. Hydrological parameter data, precipitation, initial soil water content (SWC), SWC during the experiment at specified soil depth (10, 20, 30, 40 and 50 cm) were observed from each trial plot. Soil water content (SWC) was measured using a sensor that connected with GardSens. **Results:** The results showed that *A. gangetica* caused soil water dynamics at the depth 0-20 cm that was at rhizosphere of cover crop. This has a good impact on the water availability of oil palm especially in dry periods when the rate of rainfall less than 60 mm/month. **Conclusion:** It was concluded that cover crop was able to conserve rain water and increased the water infiltration into the soil. This indicates that cover crop was potentially used to maintain and improve the availability of water requirement for the oil palm plantation.

Key words: *Asystasia gangetica*, cover crop, oil palm plantation, water conservation, rooting system

Received: June 06, 2017 Accepted: August 26, 2017 Published: September 15, 2017

Citation: Mira Ariyanti, Syariful Mubarok and Yenni Asbur, 2017. Study of *Asystasia gangetica* (L.) T. anderson as cover crop against soil water content in mature oil palm plantation. J. Agron., 16: 154-159.

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Oil palm plantation often facing significant problem which is water deficit that eventually reducing the oil palm production. This is due to the lack of knowledge of the optimization soil water management, so the availability of water is limited and does not meet[1]. The soil water content (SWC) is influenced by the soil itself, which is related to the soil ability in holding water (water holding capacity). Recently, many techniques have been applied to optimize water holding capacity of the soil, such as by using cover crops, therefore the drought stress of plant can be minimized[2].

Cover crops are the plants that have a benefit value for the cultivated crops. As long as the plant qualifies as cover crop, it can be used as cover crop. Cover crop is able to supply organic matter and carbon stocks in the soil by decomposing the litter, as well as a deterrent to surface erosion during the rainy season. Plant canopy protects the soil from destructive power of the rainfall, whereas the roots can reduce speed and energy of surface runoff and protect the soil against the destructive power of runoff[3].

Weeds grown in oil palm plantations are replanted as cover crops. It is useful to balance the soil water content and nutrient supply. Most of cover crops planted in oil palm plantations in Indonesia is *Mucuna bracteata* or white flower grasses. However, it has several disadvantages such as intolerant in the shade condition, growing very fast and potentially to wrap around the oil palm, so it is harmful if planted in the long term. In the other hand, *A. gangetica* has several advantages such as increasing the availability of N, P, K through creating nutrient and effectively minimizing erosion and reducing the loss of organic C, N, P and K by 95.7, 93.4, 96.0 and 90.0%, respectively[4]. Combination of ridge terrace with *A. gangetica* in mature oil palm plantations was more effective to reduce erosion and loss of organic C, N, P and K, i.e. by 94.1, 99.1, 99.2, 90.0 and 98.5%, respectively[5].

The *A. gangetica* are growing well on low fertility soils, in open areas and undershading conditions[6]. Due to the reasons, this study aims to determine the role of *A. gangetica* against soil water content in mature oil palm plantation. It is expected that we understand further the water holding capacity of soil within the oil palm plantation. Thus improve the knowledge of soil water management which is crucial for the palm oil production.

MATERIALS AND METHODS

Study area: This research was conducted in Afdelling III block 375, Rejosari Unit, PT Perkebunan Nusantara (PTPN) VII, District of Natar, South Lampung Regency. Soil analysis was conducted in Soil Laboratory, Bogor Agricultural University. The research was conducted from August, 2014 until April, 2015.

Materials: The materials used in this research were mature oil palm and cover crop (*A. gangetica*). The tools were SWC measuring devices (sensors and GardSens), soil sampling tools and stationery.

Experimental research: The experiment was conducted by constructing 4×2 m experimental plot between rows of oil palm. The experiment consisted of 2 levels of treatment namely planting cover crop (*A. gangetica*) and without planting cover crop. It was repeated 3 times. Hydrological parameter data, precipitation, initial SWC, SWC during the experiment at specified soil depth (10, 20, 30, 40 and 50 cm), were observed from each trial plot. Hydrological variables data were observed daily in each plot and lasts for 9 months, starting from August, 2014-April, 2015. Daily change of SWC (ΔSWC) was calculated by the average value of SWC differences between SWC at measurement with the previous day.

Data analysis: Soil water content (SWC) was measured using a sensor (soil moisture sensor SEN0114 of DFRobot Electronic, People's Republic of China) that connected with GardSens (modified by AgungYogaswara). The observed physical property was bulk density required for calculation of SWC with the following equation:

$$\text{SWC} = \text{bulk density} \times \text{SWC read on GardSens}^{7}$$

RESULTS

Profile of soil water content (SWC) on with (T_1) and without *A. gangetica* (T_0) planted plot from August, 2014-April, 2015 is presented in Fig. 1. The value of SWC in *A. gangetica* planted plot was higher than without *A. gangetica* planted plot during dry period from August-November, 2014. Whereas in wet season in February, 2015 with relatively high rainfall (10.77 mm/day), the SWC in *A. gangetica* planted plot was lower than without *A. gangetica* planted plot. This result indicated that *A. gangetica* has a positive effect on SWC value and potentially used as soil cover crop especially during dry season. Based on the data showed that decreasing SWC value was observed during dry period from August-November, 2014, at the depth of soil at 10-20 cm.

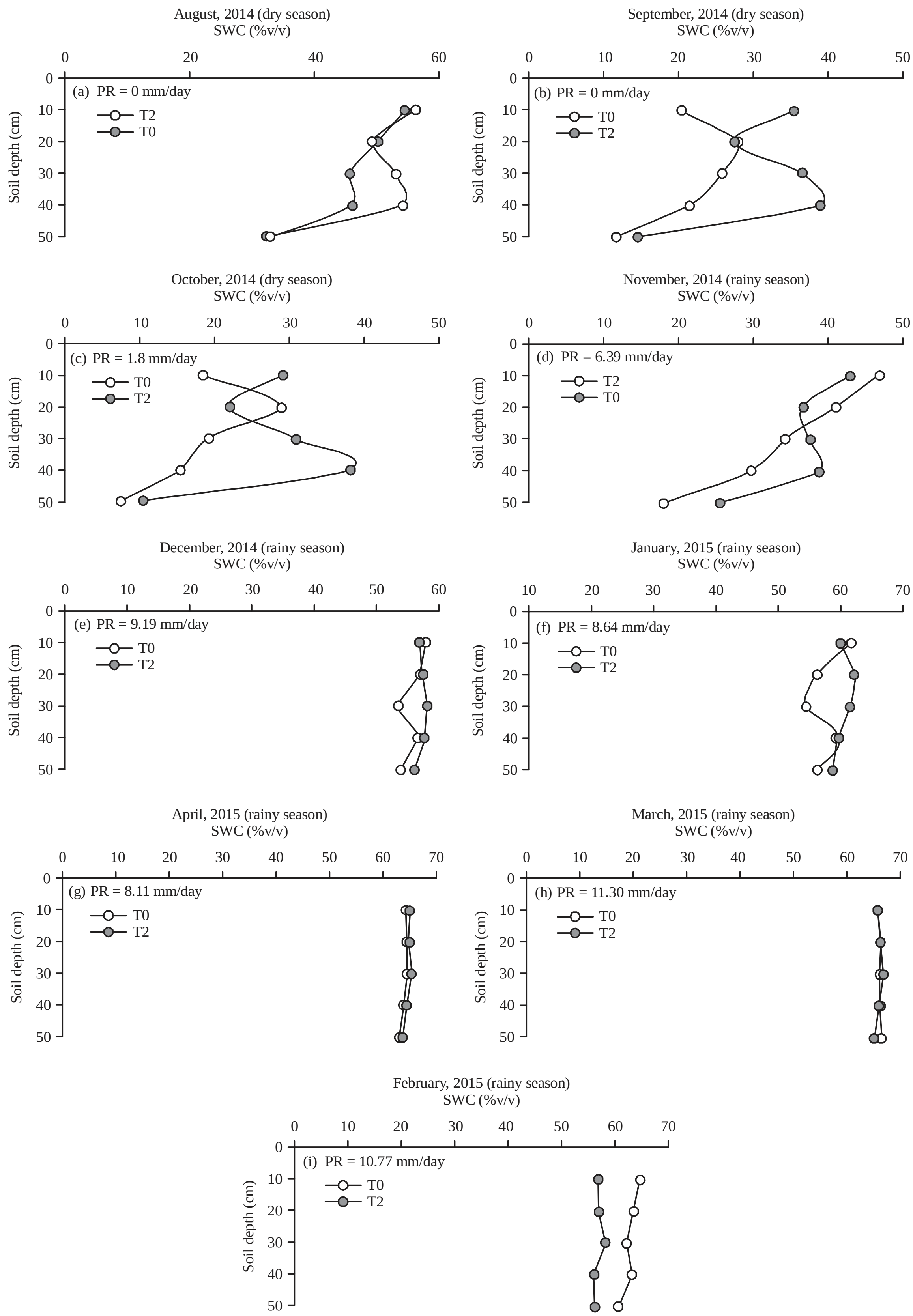

Fig. 1(a-i): Monthly profile of soil water content (SWC) without (T_0) and with (T_2) cover crop planted plot in oil palm plantation

Table 1: Effects of *A. gangetica* on the changes of daily average of ground water content (ΔSWC) on different plots with different soil depths in oil palm plantation PTPN VII Rejosari, South Lampung, from August, 2014-April, 2015

	Soil depth (cm)					
Months/Treatments	0-10 (mm)	10-20 (mm)	20-30 (mm)	30-40 (mm)	40-50 (mm)	The average of rainfall (mm/day)
August, 2014						
T_0	-1.10	-0.85	-0.57	-0.79	-1.46	0
T_2	-0.72	-0.77	-0.60	-0.60	-0.37	
September, 2014						
T_0	-0.71	-0.68	-0.43	-0.60	-0.30	0
T_2	-0.56	-0.29	-0.38	-0.22	-0.44	
October, 2014						
T_0	1.17	0.70	0.21	-0.01	0.03	1.80
T_2	0.84	0.53	0.24	-0.02	-0.07	
November, 2014						
T_0	-0.11	-0.32	0.90	0.95	1.25	6.39
T_2	0.21	0.97	-0.12	0.11	1.01	
December, 2014						
T_0	0.76	0.52	0.47	0.41	0.50	9.19
T_2	0.36	0.71	0.24	0.65	0.77	
January, 2015						
T_0	-0.12	0.13	0.03	0.47	0.18	8.64
T_2	-0.13	-0.03	0.08	0.28	0.46	
February, 2015						
T_0	-2.34	-1.97	-2.17	-2.16	-1.98	10.77
T_2	0.17	0.04	0.00	0.26	0.27	
March, 2015						
T_0	0.02	-0.03	-0.05	-0.18	0.02	11.30
T_2	-0.05	-0.05	-0.09	-0.02	0.08	
April, 2015						
T_0	0.04	0.11	-0.01	-0.04	0.01	8.11
T_2	0.03	0.02	0.02	-0.07	-0.02	

T_0: Without cover crop, T_2: With cover crop (*A. gangetica*)

Effects of *A. gangetica* on the changes of daily average of groundwater content (ΔSWC) on different plots with different soil depths in oil palm plantation PTPN VII Rejosari, South Lampung, from August, 2014-April, 2015 is presented in Table 1. During experimental periods, there are 2 periods, from August-September, 2014 was dry period, whereas from October, 2014-April, 2015 was wet period with a relatively high intensity of rainfall. Decreasing SWC level was observed in August and September, but the presence of *A. gangetica* as cover crop could increase the water deficiency during these months. In the depth of 10-20 cm, *A. gangetica* reduced the daily average of ΔSWC by 34.5%. Generally, the mean of daily deficit reduction of ΔSWC from August-September, was 37% and it was occurred in the soil up to 50 cm in the depth. Table 1 shows that in the period of October, 2014-January, 2015, SWC deficit tended to decrease as reflected by the positive ΔSWC value.

DISCUSSION

Decreasing SWC value caused by SWC retained in the roots of cover crop and contributed to the increasing of SWC after passing the root system at a soil depth more than 20 cm. Root of *A. gangetica*is tap root with a depth of approximately 20 cm. Similarly, Basche *et al.* reported on the cover crop treatment to have significantly higher SWC at the 0-30 cm depth[1]. Another study by Chen *et al.*[8] show that cover crops able to increase SWC and water permeability within the depth of 0-20 cm. This situation has positive effect on the water supply in the root areas of oil palm, especially in the dry period with less than 60 mm/month of rainfall. In the soil depth below to 40 cm, SWC was significantly decreased by 37% because the oil palm root through evapotranspiration process has absorbed the water. In previous study it was found that cover crop's water use has been estimated to be between 20-60 mm by simulation models where soil evaporation is predicted to be reduced by a cover crop between 2 and 18%[9,10]. The reduction of soil evaporation between 2 and 18% implying the significant role of over crop in maintaining the SWC in the depth of soil 0-30 cm by suppressing the soil evaporation due to rooting system and sufficient canopy of the cover crop.

The pattern of SWC profile in November, 2014 was almost the same as in the dry period, although during this month the rain started to increase. Soil mechanisms are still adjusting to the previous period, where rainfall is still intended to fill topsoil pores, which previously experienced a drought[1]. Decreasing of SWC along the depth of soil on plots with cover crop was different than plot without cover crops. There is dynamics decreasing and increasing of SWC in plot with cover crop, so that SWC can still be retained at a certain depth in the presence of cover crops. The situation is visible at the beginning of the rainy season.

During February-April, 2015 was occurred a high rainfall with the rate of 10.77, 11.30 and 8.11 mm/day, respectively, so that *A. gangetica* seems to have less influence on SWC during those periods. In February, 2015, the SWC in *A. gangetica* planted plot was lower without *A. gangetica* planted plot for each soil depth, even though the rainfall was lower than in March, 2015. Increased SWC in plot without cover crop caused by the rainfall is not intercepted by cover crop. In the other hand, in plot with *A. gangetica*, the rain water is intercepted by *A. gangetica* caused the SWC become lower[1,11].

Soil condition from March-April, 2015 was more affected by the rainfall, because this period was the peak of rainy season. High rainfall caused the soil pores were fully filled by rain water. Because of that, the role of cover crop did not significantly appear during this period, so with and without cover crop planted plot showed similar SWC profile. Aligh with study of King *et al.*[12] which showed that cover crops affecting SWC more on dry season. In addition, study of Zhang *et al.*[13] showed that on rainy season, cover crops has more impact to the decreament of runoff instead of impacting to SWC.

Reduced the daily average of ΔSWC at the depth of 10-20 cm caused by the holding water process by the rooting system of *A. gangetica*. The role of cover crop was more noticeable especially during the dry months, where SWC on *A. gangetica* planted plot was better than plots without the cover crop. This result corresponds with the result that the using *Nephrolepis biserrata* as cover crop is capable to decrease ΔSWC deficit in the dry months[14]. To maintain SWC during the dry season, it is advisable to improve the vegetation conditions that grow to achieve a shade condition above 80% and cover with 100% of litter[15]. The level of land cover with *A. gangetica* increases ground water availability in the range of 33-66%[7].

From October, 2014-January, 2015, decreased SWC deficit caused by the rainfall during the period increased although the peak was occurred in February-March. The fell of precipitation to the soil surface after reduced by oil palm and cover crop interception in this period more contributed to ΔSWC. In February, 2015 with the rainfall rate of 10.77 mm/day, cover crop reduced the average of SWC deficit by 93% at 10-50 cm of soil depth. Supposed that the overgrown canopy of *A. gangetica* retained the water in the soil by interception that play the reduction of SWC deficits. Interception is retained water by the plant canopy and these the water will be evaporated and up take by the plant stem that indirectly affecting ΔSWC. The dense of oil palm canopy and cover crops increased the water interception.

In March, 2015 the deficit of ΔSWC occurred at 10-40 cm of soil depth, in the other hand, ΔSWC surplus occurred at 50 cm of soil depth. These conditions allowed the soil water still stored in the soil depth of 50 cm due to the presence of soil cover crop. Water stored on deeper soil layers has benefit for the water absorption by oil palm roots. *A. gangetica* as cover crop is capable of storing the ground water up to 300% at 50 cm of soil depth in the peak of rainfall month (Table 1).

Rainfall was decreased in the next month April, 2015 and the effect of cover crop increased ΔSWC by 300% at 30 cm of soil depth. The ΔSWC fluctuation was determined by the amount of rainfall supported by the soil and vegetation in this soil.

Soil water management in oil palm plantations needs to be further studied by observing hydrological aspects and considered not only based on of perceptions like a case in Jambi, Indonesia which according to the local people that water scarcity was due to oil palms plantations. According to Merten *et al.*[16], rather than to high water use of oil palm, local water scarcity seems connected to the redistribution of water after precipitation at the landscape scale. In natural ecosystems, e.g., forest, the largest part of rainfall water is taken up by the soil and contributes to the transpiration of plans and groundwater recharge. Under palm oil plantations, however, precipitated water cannot well penetrate the eroded water and compacted soil. Consequently, a significant amount of water leaves the landscape as runoff and less water is available for groundwater recharge.

CONCLUSION

It can be concluded that *A. gangetica* as cover crop was potential in retaining water by increasing SWC level at 20 cm of soil depth. In dry periods, the presence of *A. gangetica* decreased the daily ΔSWC deficit by 37% at soil depth of 50 cm in the presence of *A. gangetica*. *A. gangetica* as cover crop is able to hold soil water up to 300% at 50 cm of soil depth during the peak rainfall. Cultivation of cover crop is able to conserve rainwater by maximizing the water infiltration that affect the appropriate SWC value for oil palm and preservation of SWC around the palm oil plantations.

SIGNIFICANCE STATEMENTS

This study discovers the potential role of *Asystasia gangetica* as cover crop that can be beneficial for maintaining soil water content in palm oil plantation. This study will help the researcher to uncover the critical areas of soil water balance in palm oil plantation that many researchers were not able to explore. It is expected that a new theory, palm oil does not cause drought (water deficit) in the plantation and surrounding area will be proven by *Asystasia gangetica* as cover crop.

ACKNOWLEDGMENTS

The authors thank to Indonesian Oil Palm Research Institute, Medan, North Sumatera, Indonesia, which has funded the entire research (Grant No. 027/Super/PPKS/III/2014) and PT. Perkebunan Nusantara VII Lampung who has given permit for the research.

REFERENCES

1. Lidon, B., 2015. Water Management in and Around Sustainability of Soil Fertility. In: Sustainable Management of Soil in Oil Palm Plantings, Webb, M.J., P.N. Nelson, C. Bessou, J.P. Caliman and E.S. Sutarta (Eds.). Australian Centre for International Agricultural Research, USA., ISBN: 9781925133639, pp: 18-20.
2. Basche, A.D., T.C. Kaspar, S.V. Archontoulis, D.B. Jaynes, T.J. Sauer, T.B. Parkin and F.E. Miguez, 2016. Soil water improvements with the long-term use of a winter rye cover crop. Agric. Water Manage., 172: 40-50.
3. Yu, Y., W. Loiskandl, H.P. Kaul, M. Himmelbauer, W. Wei, L. Chen and G. Bodner, 2016. Estimation of runoff mitigation by morphologically different cover crop root systems. J. Hydrol., 538: 667-676.
4. Asbur, Y., S. Yahya, K. Murtilaksono, Sudradjat and E.S. Sutarta, 2015. The role of cover crop against nutrient balance at mature oil palm plantation at South Lampung. J. Indonesian Oil Palm Res., 23: 53-60.
5. Asbur, Y., S. Yahya, K. Murtilaksono, Sudradjat and E.S. Sutarta, 2016. The roles of *Asystasia gangetica* (L.) T. Anderson and ridge terrace in reducing soil erosion and nutrient losses in oil palm plantation in south Lampung, Indonesia. J. Trop. Crop Sci., 3: 49-55.
6. Samedani, B., A.S. Juraimi, M.P. Anwar, M.Y. Rafii, S.H.S. Awadz and A.R. Anuar, 2013. Competitive interaction of *Axonopus compressus* and *Asystasia gangetica* under contrasting sunlight intensity. Scient. World J. 10.1155/2013/308646.
7. Ariyanti, M., 2016. The role of *Nephrolepis biserrata* cover crop on water and soil conservation technique against water balance at oil palm plantation. Ph.D. Thesis, Bogor Agricultural University, Indonesia.
8. Chen, G., R.R. Weil and R.L. Hill, 2014. Effects of compaction and cover crops on soil least limiting water range and air permeability. Soil Tillage Res., 136: 61-69.
9. Basche, A.D., S.V. Archontoulis, T.C. Kaspar, D.B. Jaynes, T.B. Parkin and F.E. Miguez, 2016. Simulating long-term impacts of cover crops and climate change on crop production and environmental outcomes in the Midwestern United States. Agric. Ecosyst. Environ., 218: 95-106.
10. Malone, R.W., N. Huth, P.S. Carberry, L. Ma and T.C. Kaspar *et al*., 2007. Evaluating and predicting agricultural management effects under tile drainage using modified APSIM. Geoderma, 140: 310-322.
11. Junaedi, H., 2014. The effect of arasungsang (*Asystasia gangetica* (L.) T. Anders.) against available soil water content and yield of ground nut on Ultisol. Proceedings of the Suboptimal Land Nasional Seminar, September 26-27, 2014, Palembang, Indonesia, pp: 72.1-72.7.
12. King, K.W., M.R. Williams, M.L. Macrae, N.R. Fausey and J. Frankenberger *et al*., 2015. Phosphorus transport in agricultural subsurface drainage: A review. J. Environ. Qual., 44: 467-485.
13. Zhang, T.Q., C.S. Tan, Z.M. Zheng, T. Welacky and Y.T. Wang, 2017. Drainage water management combined with cover crop enhances reduction of soil phosphorus loss. Sci. Total Environ., 586: 362-371.
14. Ariyanti, M., S. Yahya, K. Murtilaksono, Suwarto and H.H. Siregar, 2015. Study of the growth of *Nephrolepis biserrata* Kuntze and its utilization as cover crop under mature oil palm plantation. Int. J. Sci. Basic Applied Res., 19: 325-333.
15. Suhardi, A. Munir, S.N. Faridah and I.S. Tulliza, 2012. Dynamic of soil water content understorey of cacao stand in various condition. Proceedings of the PERTETA National Seminar 2012, November 30-December 2, 2012, Malang, East Java, pp: 441-447.
16. Merten, J., A. Roll, T. Guillaume, A. Meijide and S. Tarigan *et al*., 2016. Water scarcity and oil palm expansion: Social views and environmental processes. Ecol. Scoc., Vol. 21. 10.5751/ES-08214-210205.