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Effect of Sesbania green manure on availability of some nutrients in calcareous soil

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Abstract
A pot incubation experiment was conducted during the 2012-2013 season at Agricultural Research Directorate / Baghdad - Iraq. Sesbania plant residues were applied with three levels (0%, 1%, 1.5% and 2% w/w) while maintaining the soil moisture at field capacity limits to control the degree of decomposition and nutrient level at two periods (first period 2 months and the second period 4 months after added the Sesbania plant residues). The following season 2013-2014, a field experiment was carried out at Al-Latifia research station using randomized complete block design (RCBD). Sesbania plant residues incorporated into un up layer of soil at levels (0%, 1%, 1.5% and 2% w/w), barley crop was planted. The results of the incubation experiment showed an increase in organic carbon content by 45% and 50% at the treatment of 2% in the 1st and 2nd period respectively, compared to control treatment. As well as all of the available nutrients content in the soil increased at period one, while in the second period of incubation the same trend occurred, except for N, Cu and Zn the soil content of these nutrients decreased. The results of the field experiment showed an increase in grain yield of barley crop from 19% to 30% when adding of sesbania plant residues compared to control treatment. The results suggest the importance of using sesbania plants as green manure to enhance soil properties and increasing its productivity.

Keywords: Incubation, nutrients content, organic carbon, sesbania residues, grain yield, barley

Introduction
As it is known to most soil scientists and researchers in Iraq and the world that phosphorus fertilizers and micro- nutrients added to calcareous soils, including Iraqi soils, are subject to adsorption and fixation processes due to the presence of carbonate minerals, especially calcium carbonate (Lindsay, 1979; Taalab *et al*., 2019) [13, 26], or what is known as lime, whose percentage in Iraqi soils ranges from 20 to 30% or more (Buringh, 1960) [4], where affect distinctly the soil properties related to plant growth, whether they are physical, such as soil–water relations, and soil crusting, or chemicals such as the availability of plant nutrients.So in calcareous soils where pH is high and CaCO3 is dominated, plants suffer low availability of P and K and other nutrients would cause problems more serious than their deficiencies. The increasing availability of these nutrients is one of the important objectives in plant nutrition (Khalefa, 2007) [10]. And due to the importance of phosphorus and the micronutrients in the growth and yield of various plants, especially in calcareous soils and the lack of their availability, it was necessary to think about finding some suitable techniques for fertilization in calcareous soils, including green fertilization, which is expected to reflect positively on the efficiency of absorption of phosphorus, iron, zinc, manganese and copper nutrients, in addition to nitrogen and potassium, which reduces its loss in calcareous soils, and thus improves the growth and yield of plants. (Cakmak, 2008; Marschner, 1995; Malakouti and Tehrani, 2005; Sanchez and Swaminathan, 2005) [5, 15, 14, 24].
Sesbania plant (*Sesbania SP*.) belongs to the leguminosae family, a leaf is a major compound, stamens in a flower are many and fruit is horn contains many of seeds, it is used as low windbreaks and in improving soil properties (Biag *et al*., 2005). The sesbania plant is considered one of the plants that highly fixing of atmospheric nitrogen, some countries of the world have great interest this plant. It has been used as a green fertilizer in the fields of rice in Philippines because the ability of this plant to tolerate salinity, increase biomass, organic carbon content and nitrogen fixation (Biag *et al*., 2005).

(Meena and Majumdar, 2016) [16] found the use of green manure in agriculture lead to increased grain production for agricultural crops and maintaining soil properties. Also (Razaq *et al*., 2016) [23] found that the incorporation of grounded sesbania dry matter in soil markedly enhanced the reclamation process as indicated by the yield of barley and improvement of soil properties. Green manuring can enhance agricultural sustainability by improving nutrient preservation (Dinnes *et al*., 2002) [7]. Mixing leguminous green manure crops into the soil releases organic materials such as organic acids, amino acids, sugars and vitamins during crop growth as well as after decomposition (Shukla *et al*., 2011) [25]. Many crops can be used as green manure; however, the choice of green manure crop depends on several factors such as prevailing climatic conditions, crop cultivation system, the availability of seeds and other factors (Rao, 2014) [22]. The mineral composition of leguminous and its content of elements is different depending on the species, time of crop growth and growth condition (Verma *et al*., 2015) [27]. Mixing leguminous green manure crops in the soil it undergoes to decomposition and mineralization process (Meena *et al*., 2018) [18]. The invert mineralization process of green manure is the transformation of C and N from the mineral to organic form, the most important soil factors that influence this are: soil texture and structure, soil interaction, microbial activity and soil nutrient status (Dhakal *et al*., 2015) [6]. Green manure leads to rapid mineralization compared to grain residues because the low C/N ratio, low lignin content and high amount of easily degradable substances (Gil and Fick, 2001) [9]**.** Besides improving soil properties, green manure help reduce insect pests, disease occurrences and weed management (Kumar *et al*., 2014) [12]. The continued use of green manure leads to the accumulation of OM in soil, which improves the physical properties of soil and amounts of organic and amino acids, sugars and vitamins (Shukla *et al*., 2011) [25]. The green manure has effects on the chemical properties of soil, especially the pH of soil by adding organic acids and generating CO2 during the decomposition of OM which leads to decrease in pH of soil from the proton released by compost (Buragohainet *et al*., 2017). Reducing organic matter leads to decrease iron and fluoride oxides that which lead to high pH in soil, due to the oxidation of Fe and proteins produced during OM decomposition (Meena *et al*., 2017) [17]. The researcher (Pooniya *et al*., 2012) [20] conducted field experiments on summer green manure crops, were found that the highest residues of added green manure resulted in the recycling of 180.5, 22.6 and 267.8 kg/ha-1 of N, P, K respectively.

This research aim to find an appropriate level of green residues for sesbania plants to increase the availability of some nutrients in calcareous soil through conducting of laboratory incubation experiment and then move to field application as a large scale.

Materials and Methods

Incubation experiment

An Incubation experiment was carried out at green house of Soil and Water Resources Center, Agricultural Research Directorate, Ministry of Science and Technology, Iraq during the 2013 season, to an evaluation of the utilization of sesbania plants residues for increasing the availability of nutrients in the soil. Soil samples were collected from Al-Latifia Research Station, 35 km south Baghdad, air dried and grinded to passed through a 2mm sieving and thoroughly mixed and packed in plastic pots 2 kg capacity. Sesbania residues were added after cutting into small pieces at three levels (0%, 1%, 1.5% and 2% w/w), experiment was laid out according to randomized complete block design (RCBD) with three replicates, while maintaining soil moisture at field capacity using river water with EC of 1.50 dS.m-1, observing the degree of decomposition and the chemical analysis of nutrients is conducted after two months of namely the first period, and four months namely the second period from the beginning of incubation experiment. 20 g of urea was added to each treatment when preparing the experiment, as well as the same amount of urea was added to each treatment a month after the incubation period to increase the speed of decomposition. Soil samples were taking from each treatment and dried in an oven for 24 hours at 105 °C. Soil samples were chemically analyzed according to methods in (Page *et al*., 1982) [19], where the EC, pH was measured using 1:1 solution by EC and pH meters. Organic Carbon by (Walkley & Black, 1934) [28] method. Available phosphorous by using a solution of 0.5*M* NaHCO3 and determined it using spectrophotometer. N available (NH4 + NO3) were determined using a 2*M* KCl solution by Kjeldahl instrument. Potassium content determined using ammonium acetate solution NH4CHCO2 by Atomic Absorption. Trace elements Cu, Mn, Zn and Fe were determined using DTPA solution by the Atomic Absorption Spectrometer (AAS) as described in (page *et al*., 1982) [19]. The chemical and Physical properties of soil used in the experiment are presented in Table 1 before adding sesbania plants residues. Some of nutrients content in Sesbania plants as following: total C 27.9%, total N 1.92% and total P 0.12%.

Field experiment

A field experiment was carried out in the 2013-2014 season at Al-Latifia Research Station of Agricultural Research Directorate, Ministry Of Sci. and Technology to study the effect of adding sesbania residues at field scale on the productivity of the barley crop. The experiment was designed according to randomized complete block design (RCBD), with three replications, area of each plot 6 m2. Sesbania plant residues were incorporated with the soil surface at levels (0%, 1%, 1.5% and 2% w/w). All plots received Nitrogen in 40 kg rate per hectare as urea, for increase the rate of organic matter decomposition in soil (Razaq *et al*., 2016) [23]. All experimental units were continuously irrigated within the limits of field capacity for a period of four months to continue the process of decomposing organic waste. Barley planted with seeds rate of 100 kg. ha^{-1} on lines and the distance between them was 30 cm. Urea and phosphate fertilizers were added at the recommended dose. Plants were irrigated with river water as needed. At the maturity stage, plants were harvested, and grain yield was determined.

Table 1: Some chemical and physical properties of the soil before adding Sesbania plants residues

EC1:1 (dS.m-1)	**2.14**
pH	7.68
OC %	0.93
CaCO3 (gm kg-1soil)	230.0
CEC (cmol.kg-1)	25.40
Available nutrients (mg kg^{-1} soil)	
N	228.0
P	12.30
K	213.0
Fe	8.36
Zn	1.23
Mn	8.67
Cu	1.73
Soil Texture	Clay
F.C %	30

Statistical analysis

Variance analysis was conducted using the MSTAT-C program (Department of Crop and Soil Science, Michigan State University, version 1.2) according to randomized complete block design (RCBD), (LSD) test was applied to determine the differences among the mean of three replication at $p<0.05$.

Results and Discussion

Effect of incubating Sesbania residues on organic carbon content and availability of some nutrients

The results of tables 2 and 3 show that, the incubation of Sesbania plants residues led to a statistically significant ($p<0.05$) increase of organic carbon content in soil and the highest value in treatment 2% level of residues, for the first and the secend periods after incubation, the lowest value was at the control treatment (0%), and the increase rate was 45% and 50% for the level 2% in comparison to control for the 1st and 2nd period after sesbania residues applied respectively. This is consistent with (Fageria, 2007, and Razaq *et al*., 2016) [8, 23], who indicated that green manure from leguminous plants plays a major role in improving and accumulating organic carbon in the soil after plant residues addition. Also in the same tables show, the effect of incubation of sesbania residues on the available nutrients content in the soil after two and four months of incubation periods, in the table 2, after two month an available nutrients content in the soil increased statistically significant at ($p<0.05$), and in the 2% level of residue, gave the highest rate, this increase was 24%, 35%, 54%, 33%, 99%, 95% and 222% of nitrogen, phosphorous, potassium, iron, copper, manganese and zinc respectively compared with the control treatment. As in period two (Table 3), Also the results show a statistically significant increased at ($p<0.05$), in the treatment 2% level of residue, gave the highest rate of nutrients content in the soil, this increase was 50%, 39%, 33%, 114%, 77%, 18%,165% and 115% of nitrogen, phosphorous, potassium, iron, copper, manganese and zinc, respectively over control treatment. This is consistent with (Krishnaprabu, S., 2019) [11] where he found an increase in the nutrients of the rice plant by 59% N, 47% P and 8% K, when fertilizing with a green manure of the sesbania plant compared to non-fertilizer. In addition to the content of N and C, a green manure crops may also contain a large number of nutrients and other trace nutrients (Meena, 2018) [18].

In general, the results show that, with increasing the time or period of incubation of sesbania plant green residues up to four months, there were increased soil organic-C content, and soil available nutrients content of N, P, K, Fe, Cu, Mn, and Zn. On other hand, at the 2nd period N content was decreased strongly, while the copper and zinc content decreased slightly. This may be due to don't added a second activator dose of nitrogen fertilizer during the second period to increase the efficiency of decomposition of organic matter to improve the content of available nitrogen and other nutrients.

The behavioral of organic carbon content and availability of some nutrients gives an indication that the decomposition of organic materials added after two and four months has passed leading to release of organic carbon and release most of the available nutrients content to the soil. This is confirmed by many researchers about the role of sesbania plant in improving soil properties (Biag and Zia, 2006; Qadir and Oster, 2002; Razaq *et al*., 2016) [1, 22, 24].

Table 2: Soil content of organic carbon (%) and available nutrients (mg.kg^{-1}) after two month of Sesbania residues incubation (first period)

Added residues (%)	**OC %**	**N**	**P**	**K**	**Fe**	**Cu**	**Mn**	**Zn**
		mg.kg-1						
%0	1.05 b	837 b	12.1 d	257 b	10.8 d	1.36 c	8.60 d	1.07 c
%1	1.26 ab	939 ab	13.6 c	335 ab	13.3 c	2.48 b	13.4 c	3.16 b
%1.5	1.21 b	870 b	14.3 b	329 ab	13.9 b	2.54 b	15.2 b	3.23 b
%2	1.52 a	1040 a	16.3 a	396 a	14.4 a	2.71 a	16.8 a	3.45 a
LSD0.05	0.27	124	0.4	77	0.16	0.06	0.32	0.10

Table 3: soil content of organic carbon (%) and available nutrients (mg.kg-1) after four month of Sesbania residues incubation (second period)

Added residues (%)	OC %	N	P	K	Fe	Cu	Mn	Zn
		mg.kg-1						
%0	1.09 c	260 c	12.5 c	263 d	9.7 c	1.48 c	9.1 d	1.24 d
%1	1.32 b	304 b	13.1 c	437 c	9.9 c	1.56 bc.	16.6 c	2.65 c
%1.5	1.34 b	260 c	14.7 b	472 b	12.7 b	1.61 b	18.2 b	2.90 b
%2	1.63 a	362 a	16.6 a	564 a	17.2 a	1.74 a	19.6 a	3.28 a
LSD0.05	0.18	39.0	0.8	1.3	1.7	0.10	1.1	0.20

Effect of Sesbania plant residues on barley yield

Table (4) shows the effect of adding Sesbania residues at levels (1%, 1.5% and 2% w/w) in the surface layer of the soil on the grain yield of barley, as it led to an increase in grain yield by 19.00%, 22.86% and 29.47% respectively, compared to the control treatment. The results show, an increase in grain yield with an increase in the level of addition, which is a result of improving soil properties and nutrients, and confirms the results of Tables 2 and 3. This is consistent with (Krishnaprabu, S., 2019) [11], where he indicated an increase of 11% in production of grain yield for the rice with used of Sesbania residues as a green fertilizer added to the soil compared to control treatment without adding the residue.

Table 4: Effect of adding Sesbania residues on grain yield of barley (t.ha-1)

Percentage of added residues (%)	Grain yield	(%)*
0	1.452	-
1	1.728	19.00
1.5	1.784	22.86
2	1.880	29.47

* The percentage increase in grain yield compared to control.

Conclusions and recommendations

Adopting a legume green manure crop such as Sesbania as a green fertilizer is perfect because it is fast-growing, succulent, easy to decompositions and produces a large amount of biomass with low moisture requirements and it is a tolerant plant for salinity. Green manure is considered to ensure environmental sustainability by maintaining soil productivity over a long time by protecting the soil from erosion and nutrient content. The results indicated that the use of 2% of Sesbania plant residues led to an increase in the soil content of organic carbon and other nutrients, as well as an increase in grain yield of barley over to 30%.

Based on the above, we suggest, when the incubation period exceeds more than two months, it is preferable to give a stimulating fertilizer dose of nitrogen to increase the efficiency of decomposition of organic matter and stimulate the micro-organisms responsible for that, and thus improve the content of organic carbon and ready- made nutrients in the soil. This proposal should be applied when moving to a broad field application.

References

1. Baig MB, Zia MS. Rehabilitation of problem soils through environmentally friendly technologies- II: Role of Sesbania (*Sesbania aculeata*) and gypsum. Agricultural Tropical & Subtropical. 2006:38:12-16.
2. Baig MB, Zia MS, Szombathova AN, Zaujec A. Rehabilitation of problem soils through environmentally friendly technologies: Role of Sesbania and farm yard manure. Agricultural Tropical & subtropics. 2005:38:12-16.
3. Buragohain S, Sharma B, Nath JD, Gogaoi N, Meena RS, Lal R. Impact of ten years of bio-fertilizer use on soil quality and rice yield on an inceptsol in Assam, India. Soil Res; c2017. https:// doi.org/10.1071/SR17001.
4. Buringh P. Soils and soil conditions in Iraq. Ministry of agriculture; c1960.
5. Cakmak I. Enrichment of cereal grains with zinc: agronomic or genetic biofortification. Plant and Soil. 2008:302:1-17.
6. Dhakal Y, Meena RS, De N, Verma SK, Singh A. Growth, yield and nutrient content of mungbean (*Vigna radiata* L.) in response to INM in eastern Uttar Pradesh, India. Bangladesh J Bot. 2015:44(3):479-482.
7. Dinnes DL, Karlen DL, Jaynes DB, Kaspar TC, Hatfield JL, Colvin TS, *et al*. Nitrogen management strategies to reduce nitrate leaching in tile-drained Midwestern soils. Agron J. 2002:94:153-171.
8. Fageria NK. Green manuring in crop production. J Plant Nutr. 2007:30(5):691-719.
9. Gil JL, Fick WH. Soil nitrogen mineralization in mixtures of eastern gam grass with alfalfa and red clover. Agron J. 2001:93:902-910.
10. Khalefa AM. Response of maize to application of microbial activator, sulphur and phosphorus to maize grown on a calcareous soil. J Biol. Chem. Sci. 2007:2(2):165-188.
11. Krishnaprabu S. Effect of green manuring and nitrogen levels on soil health and yield of rice. Journal of Pharmacognosy and Phytochemistry. 2019:8(2):1508-1510.
12. Kumar R, Mahajan G, Srivastava S, Sinha A. Green manuring: a boon for sustainable agriculture and pest management-a review. Agric Rev. 2014:35(3):196-206.
13. Lindsay WL. Chemical Equilibria in Soils. John Wiley and Sons, New York; c1979.
14. Malakouti MJ, Tehrani MM. Effects of micronutrient on the yield and quality of agricultural products: Micronutrient with macro-effects. Tarbiat Modares University Press. Tehran, Iran; c2005. p. 445.
15. Marschner H. Mineral nutrition of higher plant. Second ed., Academic Press. New York; c1995. p. 890.
16. Meena BL, Majumdar SP. Improving yield of barley grown on coarse textured soil by compaction and sulphur fertilization. Ecol Env Cons. 2016:22:151-156.

17. Meena BL, Rattan RK, Datta SP. Solubility relationships of iron and evaluation of its fertility status in degraded soils. Commun Soil Sci Plant Anal. 2017:48:1059-1067.
18. Meena BL, Fagodiya RK, Prajapat K, Dotaniya ML, Kaledhonkar MJ, Sharma PC, *et al*. Legume green manuring: an option for soil sustainability. In legumes for soil health and sustainable management. Springer, Singapore; c2018. p. 387-408.
19. Page AL, Miller RH, Keeney DR (Ed). Methods of Soil Analysis part 2, 2nd (ed.) Agron., 9, Publisher, Madison Wisconsin, USA; c1982.
20. Pooniya V, Shivaya YS, Rana A, Lata N, Radha P. Enhancing soil nutrient dynamics and productivity of
21. Basmati rice through residue incorporation and zinc fertilization. Eur. J Agron. 2012:41:28-37.
22. Qadir M, Oster JD. Vegetative bioremediation of calcareous sodic soils: History mechanisms and evaluations. Irrigation Sci. 2002:6:1-18.
23. Rao DLN. Recent advances in biological nitrogen fixation in agricultural systems. Proc Indian Natn Sci Acad. 2014:80:359-378.
24. Razaq IB, Saadi M, Al-Ghrairi Sh, Khudhair A, Al-Obaidi HS, Ali A, *et al*. Role of Sesbania in Increasing Reclamation Efficiency of Chemically Amended Calcareous Soil. Eur. Acad. Research. 2016:4(9):7398-7408.
25. Sanchez PA, Swaminathan MS. Hunger in Africa: The link between unhealthy people and unhealthy soils. Lancet. 2005:365:442-444.
26. Shukla KP, Sharma S, Singh NK, Singh V, Tiwari K, Singh S. Nature and role of root exudates: efficacy in bioremediation. Afr. J Biotechnol. 2011:10(48):9717-9724.
27. Taalab AS, Ageeb GW, Siam HS, Mahmoud SA. Some Characteristics of Calcareous soils. A review AS Taalab1, GW Ageeb2, Hanan S. Siam1 and Safaa A. Mahmoud1. Middle East J. 2019:8(1):96-105.
28. Verma JP, Meena VS, Kumar A, Meena RS. Issues and challenges about sustainable agriculture production for management of natural resources to sustain soil fertility and health: A book review. J Clean Prod. 2015:107:793-794.
29. Walkley A, Black IA. An examination of Degtjareff method for determining soil organic matter and a proposed modification of the chromic acid titration method. Soil Science. 1934:37:29-37.