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Effect of Organic and Bio Fertilization and Magnesium foliar Application on Soybean Production

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EGYPT has paid great attention to expanding the cultivation of oil crops such as soybean by developing plans and strategies, including the research plans, which were developed by the Agricultural Research Center. These plans aim to increase the areas cultivated with oil crops and simultaneously raise the productivity of the cultivated unit. To improve soybean production, a field experiment was carried out in a split-plot design for two successive years (2021 and 2022) where the six treatments of organic and bio fertilization were found in the main plots [$\mathbf{T_1}$: Control (without), $\mathbf{T_2}$: Rhizobium inoculation (RH) , $\mathbf{T_3}$: Farmyard manure FYM at rate of 36.0 m^3 ha^{-1}, $\mathbf{T_4}$: Plant compost PC (sugar cane and banana residues at ratio of 50:50) at rate of 36.0 m^3 ha^{-1}, $\mathbf{T_5}$: T_2+ T_3 (RH+ FYM) and $\mathbf{T_6}$: T_2+ T_4 (RH+ PC)]. The sub-main plots were assigned for foliar application of magnesium (Mg) [$\mathbf{F_1}$: Control (without foliar application) and $\mathbf{F_2}$: Mg sprayed at rate of 1440 g ha^{-1} using magnesium sulphate ($MgSO_4$, consisting of 20.19 Mg % by mass)].The main results showed that the superior treatment for obtaining the maximum values of growth performance *e.g.,* plant height (87.16 and 88.12 cm, for 1st and 2nd seasons, respectively), dry weight(14.99 and 15.18g, for 1st and 2nd seasons, respectively)and chlorophyll(46.22 and 47.41 SPAD, for 1st and 2nd seasons, respectively) wasthe $\mathbf{T_6}$ treatment (combination of RH and PC) followed by $\mathbf{T_5}$ treatment (combination of RH and FYM) then $\mathbf{T_4}$, $\mathbf{T_3}$, $\mathbf{T_2}$ and $\mathbf{T_1}$, respectively. The same trend was found also for all parameters which expressed quantitative and qualitative yield of soybean *e.g.,*number of pods $plant^{-1}$, seed yields, oil, protein and carbohydrates in seeds, where the $\mathbf{T_6}$ treatment came in the first order, while the$\mathbf{T_1}$ treatment came in the last order. Regarding the Mg treatments, the plant growth performance, quantitative and qualitative yield significantly increased with Mg foliar application **($\mathbf{F_2}$)**compared to the corresponding soybean plants grown without Mg addition**($\mathbf{F_1}$)**. Generally, it can be concluded that the combined treatment (rhizobium inoculant + plant compost+ magnesium) will achieve the highest plant growth performance, quantitative and qualitative yield of soybean. Thus, can meet people's needs for strategic oil crops.

Keywords: Rhizobium, PC, FYM,co-enzyme andoil crops.

1. Introduction

Egypt is suffering from a weakness in the production and cultivation of oil crops, as the percentage of self-sufficiency from oils did not exceed 3%, according to official reports**(EAS).** This made the government import the rest of its needs from several countries, in conjunction with farmers retreating from cultivating oil crops due to the low net return, as they believe**(Barghash*et al.* 2014).** Soybean (*Glycine max*) is a main ingredient in many food industries, in addition to being one of the sources of oil production, which is a common denominator and a basic commodity for the majority of Egyptian families. In other words, soybean is one of the strategy oil crops in Egypt, as its total production reached 25000 metric tons from an area of 9000 hectares in the year 2019 **(El-Mahdy and Anwar 2020).** Soybean has high nutritional benefits, as it contains protein (about 40%) and cholesterol-

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free oil (about 30%) and vitamins*e.g.,* V.C and V.E **(Elmahdy *et al.* 2022).**Moreover, the residues of pressing the seeds of soybean are mixed with maize residues to be one of the main components of diet and fodder for cattle, sheep and poultry, and for all animal and poultry production projects **Dei (2011).**Thus, the vertical and horizontal expansion of soybean cultivation is necessary to achieve self-sufficiency from it.

Bio-fertilization and an integrated supply of nutrients via organic sources for oil crops *e.g.,* soybean could be an effective practice to raise soybean productivity**(Mekki and Ahmed 2005; Kravchenko *et al.* 2013; Ghaly*et al.* 2020).**

Bio-fertilizers, which areknown as microbial inoculants, are preparations that contain cells of microorganisms (either live or latent) of highly efficient strains in nitrogen fixation or solubility of soil phosphorus and potassium. Bio-fertilizers areadded either with the seeds or to the soil in order to increase the number of microorganisms and accelerate certain microbial processes that increase the availability of nutrients to plants (**Mahdi *et al.* 2010; Taha *et al.* 2018; Kumar *et al.* 2018).** Rhizobium inoculants have ability to atmospheric nitrogen fixation (symbiotic) in nodules found on the roots of the legumes **(Baddour*et al.* 2021).**

Organic fertilizers are substances that contain organic matter. Their benefits come from the functions and positive effects of their organic matter content on the physical, chemical and biological properties of the soil, which are ultimately reflected in the grown plant. Most of the positive effects of organic fertilizers are due to their effective components produced after the decomposition of organic waste, which is known as humus**(Mian*et al.* 2021; Sarhan *et al.* 2021; Abdrabou *et al.* 2022; Awwad *et al.* 2022; Hussein *et al.* 2022).**

One of the options that can help with optimizing soybean productivity is the foliar application of the magnesium element**(El-Dissoky*et al.* 2017).**Magnesium is a component of chlorophyll. Also, it is responsible in one way or another for building cell walls through magnesium pectates **(Guo *et al.* 2016).** Magnesium is the only nutrient that activates all enzymes that build oils and fats in plants **(Chen *et al.* 2018).**There is an antagonism between potassium and magnesium. So, the usage of potassium fertilizer may lead to the emergence of the need to spray magnesium on the vegetative foliage of the plant **(Xie*et al.* 2021).**

Few papers have focused on the joint influence of organic and bio fertilization and magnesium foliar application on soybean production. So, the aim of this research work was to evaluate the effect of inoculationof soybean seeds with rhizobium, soil addition of different organic sources and foliar application of magnesium sulphate on quantitative and qualitative seed yield of soybean.

2. Material and Methods

- Experimental location

A field research trial was conducted during two summer seasons of 2021 and 2022 at the Tag-Elezz Experimental Farm, Agricultural Research Center (ARC), El-Dakahlia governorate, Egypt, which located at 31°31' 47.64" N latitude and 30°56' 12.88" E longitude.

- Soil Samplingand the studied substances

Table 1 points out the characteristics of the soil before soybean cultivation as well as the properties of the organic fertilization sources (the combined data over both studied seasons).

The Rhizobium inoculant was obtained from the bio-fertilizer production unit of Soil, Water and Environment Research Institute, ARC, Giza, Egypt. Egyptian strains of bean nodulating rhizobia such as *A. tumefaciens*,*Bradyrhizobium japonicum*and *R. leguminosarum*sv. *viciae* were used in this study, as all strains were grown in yeast extract-mannitol medium. Plant compost PC (sugar cane and banana residues at ratio of 50:50) was prepared according to the method described by **Inckel*et al.* (2005)** at the experimental site. Farmyard manure was obtained from a private animal farm near the experimental site. Magnesium sulphate fertilizer was purchased from Agro Egypt for agricultural developmentcompany.

Magnesium sulphate ($MgSO_4$) consisted of 20.19 Mg^{2+} % by mass. Its molecular mass was 120.366 g mol^{-1} with a purity percentage of 99%, melting point of 1.124 °C and density value of 2.66 g cm^3.

- Soybean seeds

Seeds "***Glycine* max L. Cv Giza 111**" were obtained from Food Legumes Dep., ARS, Egypt.

- Experimental design and treatments

The current research trial was executed under a split-plot design (as shown in Table 2) with three replicates. Six treatments of organic and bio fertilization [**T_1:** Control (without), **T_2:** Rhizobium (RH) alone at rat of 10 g per 1.0 kgseeds, **T_3:** Farmyard manure (FYM as cow wastes) alone at rate of 36 m^3 ha^{-1}, **T_4:** Plant compost PC (sugar cane and banana residues at ratio of 50:50) alone at rate of 36 m^3 ha^{-1}, **T_5:** T_2+ T_3 (RH+ FYM) and **T_6:** T_2+ T_4 (RH+ PC)] were evaluated as main plots. While the sub-main plots were assigned for foliar application of Mg [**F_1:** Control (without foliar application) and **F_2:** Mg sprayed at rate of 1440 g ha^{-1}using magnesium sulphate ($MgSO_4$, consisting of 20.19 Mg^{2+} % by mass)].

- Experimental Setup

The experimental area was 250 m^2.The sub plot size was 18.0 m^2 (4.0 m × 4.5 m). Seeds sown manually on 13th of May in both studied seasons at rate of 84.0 kg ha^{-1} (2-3 seeds $hill^{-1}$). After 20 days from sowing, the grown plants were thinned to obtain one soybeanplant only in each hill. The studied substances were applied according to the above treatments mentioned. **Bio-fertilization treatments:** Before the cultivation directly, the seeds were inoculated with rhizobium inoculant using 40% Arabic gum as a sticker at rate of 10 g inoculant per 1.0 kg seeds. **Organic-fertilization treatments:** One month before the cultivation, the plots received the organic sources depending on the studied treatments. **Magnesium treatments:** It was sprayed according to the studied treatments by hand sprayer four-time (after 35, 50, 65 and 80 days from sowing) during the experiment with a volume of 1000 L ha^{-1}.

Effective nitrogen dose(30kg urea ha^{-1}, 46% N) was applied for all plots. Potassium sulfate (48 % K_2O) was added in two equal doses at a rate of 120 kg ha^{-1} (1/2 as basal, while the other 1/2after two months after sowing).Calcium superphosphate (6.6%P) was applied before ploughing at 360 kg ha^{-1}.

Other traditional agricultural practices as well as irrigation and mineral fertilization process were implemented according to the Field Crop Research Institute recommendations, ARS, Egypt. Harvest process was doneafter 120 days from sowing.

- Measurement traits

1. Growth criteria *i.e.,*
   - Plant height (before ten days from harvest)
   - Stover fresh and dry weights at period of 85 days from sowing
   - Chlorophyll in F.W (SPAD-502, Minolta Camera, Osaka, Japan)at the period of 85 days from sowing according to **Yan *et al.* (2007)**.
   - The samples of soybean stover were digested according to the stander method described by **Peterburgski (1968),** by the mixture of $HClO_4$ and H_2SO_4 (1:1)**.**
   - Chemical content in soybean tissues (stover, D.W) *i.e.,* N, P and K were determinedat the period of 85 days from sowingaccording to the stander methods reported by **Walinga *et al*. (2013)** using Kjeldahl method, spectrophotometric method and flame photometer for N,P, and K, respectively
   - Nodulation parameters i.e., No. of nodules $plant^{-1}$, fresh and dry weights of nodules at period of 85 days from sowing

2. Yield and its components *i.e.,*No. of pods $plant^{-1}$, pods weight $plant^{-1}$, seeds weight $plant^{-1}$, stover weight $plant^{-1}$, 1000 seeds weight, seeds and stover yieldwere measured at the harvest stage. Also, some chemical and biochemical traits *i.e.,*in milled grains were estimated at the harvest stage. Chemical traits of seeds (N, P and K) were determined as formerly mentioned in stovers. Biochemical traits of seeds (carbohydrates, protein and oil) were determined depending on the stander methods described in **AOAC (2000).**

3. Soil available nutrients(N, P and K) were determined after soybean harvest as the average of both the studied seasons as formerly mentioned in the initial soil using Kjeldahl method, spectrophotometric method and flame photometer for N,P, and K, respectively.

- Statistical Analyses

Data were statistically analyzed using the technique reported by **Gomez and Gomez (1984) [**using **CoStat version 6.303 copyright (1998-2004)]**. Treatment means were compared by utilization of the least significant difference (LSD) at a level of 0.05 probability.

Table 1. Characteristics of the initial soil before soybean cultivation as well as the properties of the organic fertilization sources (the combined data over bothstudied seasons).

Soil used		Organic fertilizers		
Parameters	**Values**	**Parameters**	**Values**	
			Plant compost	**FYM**
Chemical characteristics				
$CaCO_3$, g kg^{-1}	15.3	C:N ratio	11.69	12.77
pH	8.200	Zn, mg kg^{-1}	0.29	0.26
EC, dSm^{-1}	3.870	K, mg kg^{-1}	5.99	0.87
O.M, g kg^{-1}	17.0	P, mg kg^{-1}	0.62	0.49
N, mg kg^{-1}	38.19	Mn, mg kg^{-1}	29.0	24.0
P, mg kg^{-1}	8.02	pH	6.16	6.45
K, mg kg^{-1}	200.63	EC, dSm^{-1}	3.44	3.65
Particle size distribution (%), using pipette method		Total C, %	19.41	20.44
Sand	20.0	Total N, %	1.66	1.60
Silt	29.0			
Clay	51.0			
Textural class is clayey (using soil texture triangle)				
Notes				
Calcium carbonate was measured by calcimeter. Soil pH was measured in soil suspension (1: 2.5) by pH–meter. EC was measured in saturated soil paste extract by EC-meter. O.M was determined by Walkly and Balck method. N, P and K of soil and fertilizers were determined using Kjeldahl method, spectrophotometric method and flame photometer, respectively. Fertilizer pH and EC were measured in soil suspension (1: 10) by pH –meter and EC-meter, respectively. Mn and Zn of fertilizers were determined by atomic absorption spectrophotometer. The samples of the initial soil were taken at depth of 0-25 cm.				
References used				
Dewis and Freitas, (1970);Hesse, (1971);Gee and Baudet (1986); Tandon (2005).				

Table 2. Theexperiment layout.

T_1: Control (without), **T_2:**Rhizobium (RH) alone at rat of 1.0 g per 1.0 kgseeds, **T_3:** Farmyard manure FYM (cow waste) alone at rate of 36.0 m^3 ha^{-1}, **T_4:** Plant compost PC (sugar cane and banana residues at ratio of 50:50) alone at rate of 36.0 m^3 ha^{-1}, **T_5:** T_2+ T_3 (RH+ FYM), **T_6:** T_2+ T_4 (RH+ PC), **F_1:**Without Mg and **F_2:** Mg sprayed at rate of 1440 g fed^{-1}

Treatments		**Replicates**		
T_1	**F_1**	R_1	R_2	R_3
	F_2	R_2	R_3	R_1
T_2	**F_1**	R_2	R_3	R_1
	F_2	R_2	R_3	R_1
T_3	**F_1**	R_3	R_2	R_1
	F_2	R_1	R_2	R_3
T_4	**F_1**	R_2	R_1	R_3
	F_2	R_3	R_2	R_1
T_5	**F_1**	R_3	R_1	R_1
	F_2	R_1	R_3	R_2
T_6	**F_1**	R_1	R_3	R_2
	F_2	R_1	R_2	R_3

3. Results

Growth criteria, leaves chemical constituents and photosynthetic pigments

Data regarding growth criteria *i.e.*, plant height (cm), stover fresh and dry weights (g $plant^{-1}$) as influenced by organic and bio fertilization treatments and magnesium foliar application treatments are presented in Table 3. While Table 4 shows the effect of the studied treatments on leaves' chemical constituents *i.e.*, N, P and K (%) and chlorophyll content (as SPAD reading). Table 5 also illustrates the studied treatments on nodulation parameters *i.e.*, No. of nodules $plant^{-1}$, fresh and dry weights of nodules (g $plant^{-1}$).

The findings show that the superior treatment for obtaining the maximum values of growth performance *e.g.*, plant height (87.16 and 88.12 cm, for 1^{st} and 2^{nd} seasons, respectively), fresh weight (62.38 and 63.2 g $plant^{-1}$, for 1^{st} and 2^{nd} seasons, respectively), dry weight (14.99 and 15.18 g $plant^{-1}$, for 1^{st} and 2^{nd} seasons, respectively), leaves N content (4.21 and 4.26%, for 1^{st} and 2^{nd} seasons, respectively) and chlorophyll content (46.22 and 47.41, for 1^{st} and 2^{nd} seasons, respectively) was the **T_6** treatment (combination of RH and PC) followed by T_5 treatment (combination of RH and FYM) then T_4, T_3, T_2 and T_1, respectively. The same trend was found for thenodulation parameters *i.e.*, No. of nodules plant^{-1}, fresh and dry weights of nodules (g plant^{-1}) and chemical composition of the leaf during both seasons of study.

Regarding the magnesium treatments, all parameters which expressed growth criteria, nodulation parameters, leaves chemical constituents and photosynthetic pigments significantly increased with Mg foliar application **(F_2)** compared to the corresponding ones without Mg addition **(F_1)**. For example, in the first season, the highest values of plant height (83.19, cm) fresh weight (58.39, g plant^{-1}), dry weight (13.96, g plant^{-1}), leaves N content (3.88, %), leaves P content (0.358, %), leaves K content (2.72, %) and chlorophyll content (44.82) were recorded when soybean plants were sprayed with magnesium. Similar trend was found in the second season.Where the increasing rate was 2.5, 3.6, 3.6, 5.15, 3.76, 3.8 and 1.58% for plant height, fresh weight, dry weight, leaves N content, leaves P content, leaves K content and chlorophyll content, respectively for the first season. While the increasing rate under the second season for the same traits, respectively, was 2.7, 3.8, 3.5, 5.36, 3.40, 4.1 and 1.33%.

Generally, it can be noticed that the inoculation of soybean seeds with rhizobium inoculant before cultivation with the soil addition of plant compost (sugar cane and banana residues at a ratio of 50:50) and simultaneously treating the grown plants through their life period with magnesium improved soy bean growth performance, nodulation parameters, leaves chemical constituents and photosynthetic pigments.

Yield and its components

Tables 6, 7 and 8 point out the effect of organic and bio fertilization treatments and magnesium foliar applicationon soybean quantitative and qualitative yieldparameters such asNo. of pods plant^{-1}, pods weight (g plant^{-1}), seeds weight (g plant^{-1}), stover weight (g plant^{-1}), 1000 seeds weight (g), seeds and stover yield(Mg ha^{-1}), seeds chemical constituents (N, P and K,%) and seeds biochemical traits (carbohydrates, protein and oil,%).

Regarding the organic and bio fertilization treatments, the sequence order from more effective to less was $T_6 > T_5 > T_4 > T_3 > T_2 > T_1$. In other words,the combined treatment of rhizobium and plant compost **(T_6)** recorded the highest increases in all parameters which expressed soybean quantitative and qualitative yield, and the combined treatment of rhizobium and FYM **(T_5)** came in the second order followed by treatment of plant compost alone **(T_4)** then FYM treatment alone **(T_3)** then rhizobium treatment alone **(T_2)** and lately control treatment **(T_1).**

Concerning the magnesium treatments, all parameters which expressed soybean quantitative and qualitative yield (especially oil percentage*)* significantly increased with Mg foliar application **(F_2)** compared to the corresponding soybean plants grown without Mg addition **(F_1)**. For example, the highest values of seed yield (4.36 Mg ha^{-1}in the first season) and oil seeds (22.41%in the first season) were recorded when soybean plants were sprayed with magnesium. Similar trend was found in the second season.Therefore, it can be said that the combined treatment of rhizobium inoculant plus plant compost plus magnesium was the best for optimizing soybean productivity. The same trend was found during both seasons.

Post-harvest soil analyses

Available soil nutrients *i.e.*, N, P and K (mg kg^{-1}) at harvest stage as affected by organic and bio fertilization and magnesium foliar application are showed in Figs 1, 2 and 3 (combined data over both seasons).

a- Available N

Fig 1 illustrates that available soil N at harvest stage exceeded the initial content in soil due to applications of the studied organic and bio additions.Available N due to T_6 treatment (combination of RH and PC) was the highest among treatments during both seasons of study. The soil fertilized with T_5 treatment (combination of RH and FYM) came in the second order followed by that fertilized with T_4treatment (PC alone) then by FYM treatment alone **(T_3)** then rhizobium treatment alone **(T_2)** and all treatments exceeded the control one **(T_1).**

On the other hand, magnesium treatment led to considerable decline in the values of soil available nitrogen after soybean harvest after both seasons of study. This may be due to the role of Mg in improving general plant status and thereby the plants absorb more N with foliar application of Mg.

b- Available P

Fig 2 points out to the soil available P contents after harvesting which were generally higher than the corresponding one prior to cultivation for all treatments. The effect of rhizobium on soil available

P was unclear however, the available P content in soil treated with **T_6**treatment (combination of RH and PC) was the highest among treatments in both seasons.On the other hand, magnesium treatment led to significant reductions in soil available phosphorus after soybean harvest and this may be due to the role of Mg in improving general plant status and thereby the plants absorb more P with foliar application of Mg more than the plants grown without Mg.

c- Available K

Regarding organic and bio fertilization treatments, Fig 3 shows that the available K of soil treated with **T_6** treatment (combination of RH and PC) was higher than that detected in soils treated with other studied additions. The soil fertilized with **T_5** treatment (combination of RH and FYM) came in the second order followed by that fertilized with **T_4**treatment (PC alone) then FYM treatment alone **(T_3)** followed by rhizobium treatment alone **(T_2)** and lately the control treatment **(T_1).** Perhaps the inclusion of banana tree residues in compost formation has a positive effect in increasing the soil available potassium concentration in the soil, due to which treatment **T_6** is superior**.**Concerning foliar applications, magnesium treatment might lead to significant decreases in value of soil available potassium after soybean harvest in the two seasons of study and this may be due to the role of Mg in improving general plant status and thereby the plants absorb more potassium with foliar application of Mg more than the plants grown without Mg.

Table 3. Effect of the organic and bio fertilization and magnesium foliar application on growth criteria of soybean plants during seasons of 2021and 2022.

Treatments		Plant height (cm)		Fresh weight (g plant^{-1})		Dry weight (g plant^{-1})	
		1st	2nd	1st	2nd	1st	2nd
Organic and bio fertilization treatments							
T_1: Control (without)		75.71d	76.82d	50.88e	51.31d	12.30f	12.46f
T_2: RH		78.80c	79.80c	53.97d	54.39c	12.75e	12.90e
T_3: FYM		81.88b	82.56b	57.07c	57.86b	13.58d	13.78d
T_4: PC		83.16b	83.78b	58.44b	59.06b	13.99c	14.16c
T_5: T_2+ T_3 (RH+ FYM)		86.29a	87.33a	61.48a	62.30a	14.69b	14.90b
T_6: T_2+ T_4 (RH+ PC)		87.16a	88.12a	62.38a	63.20a	14.99a	15.18a
LSD 5%		**1.57**	**1.48**	**0.96**	**1.56**	**0.19**	**0.06**
Magnesium treatments							
F_1: Without Mg		81.14b	81.95b	56.35b	56.93b	13.47b	13.66b
F_2: With Mg		83.19a	84.19a	58.39a	59.11a	13.96a	14.14a
LSD 5%		**0.43**	**0.60**	**0.60**	**0.75**	**0.13**	**0.05**
Interactions							
T x F	**LSD 5%**	**1.05**	**1.47**	**1.47**	**1.83**	**0.33**	**0.11**
T_1	**F_1**	74.86i	75.92h	49.96i	50.36i	12.18i	12.34l
	F_2	76.55h	77.73g	51.80h	52.25h	12.42hi	12.58k
T_2	**F_1**	77.49h	78.40g	52.66h	53.07h	12.59gh	12.74j
	F_2	80.11g	81.20f	55.28g	55.71g	12.91fg	13.07i
T_3	**F_1**	80.96fg	81.69f	56.18fg	56.79fg	13.16f	13.36h
	F_2	82.80e	83.43e	57.96e	58.93de	14.00de	14.20f
T_4	**F_1**	81.86ef	82.36ef	57.13ef	57.69ef	13.77e	13.95g
	F_2	84.45d	85.20d	59.74d	60.42cd	14.20cd	14.38e
T_5	**F_1**	85.42cd	86.20cd	60.58cd	61.49bc	14.38c	14.60d
	F_2	87.15ab	88.45ab	62.37ab	63.10ab	14.99ab	15.21b
T_6	**F_1**	86.26bc	87.13bc	61.56bc	62.17bc	14.76b	14.96c
	F_2	88.06a	89.11a	63.21a	64.22a	15.23a	15.40a

Means within a row followed by a different letter (s) are statistically different at a 0.05 level

T_1: Control (without), **T_2:** Rhizobium (RH) alone at rat of 1.0 g per 1.0 kgseeds, **T_3:** Farmyard manure FYM (cow waste) alone at rate of 36.0 m^3 ha^{-1}, **T_4:** Plant compost PC (sugar cane and banana residues at ratio of 50:50) alone at rate of 36.0 m^3 ha^{-1}, **T_5:** T_2+ T_3 (RH+ FYM), **T_6:** T_2+ T_4 (RH+ PC), **F_1:**Without Mg and **F_2:** Mg sprayed at rate of 1440 g ha^{-1}

Table 4. Effect of the organic and bio fertilization and magnesium foliar application on chemical constituents and photosynthetic pigmentsof soybean plants during seasons of 2021and 2022.

Treatments		Nitrogen		Phosphorus		Potassium		Chlorophyll	
		(%)						(SDAP value)	
		1st	2nd	1st	2nd	1st	2nd	1st	2nd
Organic and bio fertilization treatments									
T_1: Control (without)		3.25f	3.30f	0.320f	0.326e	2.35d	2.39f	42.32d	43.15e
T_2: RH		3.52e	3.56e	0.330e	0.335d	2.44c	2.47e	43.22c	44.09d
T_3: FYM		3.74d	3.79d	0.344d	0.351c	2.67b	2.71d	44.37b	44.86c
T_4: PC		3.86c	3.90c	0.348c	0.355c	2.71b	2.74c	44.82b	45.73b
T_5: T_2+ T_3 (RH+ FYM)		4.13b	4.18b	0.378b	0.382b	2.91a	2.94b	45.90a	46.91a
T_6: T_2+ T_4 (RH+ PC)		4.21a	4.26a	0.390a	0.398a	2.96a	2.99a	46.22a	47.41a
LSD 5%		**0.04**	**0.01**	**0.04**	**0.004**	**0.08**	**0.02**	**0.67**	**0.56**
Magnesium treatments									
F_1: Without Mg		3.69b	3.73b	0.345b	0.352b	2.62b	2.65b	44.12b	45.06b
F_2: With Mg		3.88a	3.93a	0.358a	0.364a	2.72a	2.76a	44.82a	45.66a
LSD 5%		**0.04**	**0.01**	**0.004**	**0.005**	**0.03**	**0.04**	**0.51**	**0.46**
Interactions									
T x F		LSD 5%							
		0.10	**0.01**	**0.011**	**0.011**	**0.07**	**0.09**	**1.24**	**1.13**
T_1	**F_1**	3.07h	3.11h	0.316f	0.322g	2.34i	2.38f	42.02f	42.89e
	F_2	3.44g	3	0.324ef	0.330fg	2.37hi	2.40f	42.61ef	43.41e
T_2	**F_1**	3.48g	3.51j	0.328ef	0.335efg	2.41gh	2.44f	42.76ef	43.81de
	F_2	3.56fg	3.60i	0.333e	0.336efg	2.47g	2.50f	43.68def	44.36cde
T_3	**F_1**	3.62f	3.67h	0.336e	0.343ef	2.58f	2.62e	44.05cde	44.47cde
	F_2	3.86e	3.91f	0.351d	0.359d	2.75e	2.79d	44.68ad	45.26bcd
T_4	**F_1**	3.75e	3.80g	0.340e	0.347e	2.62f	2.64e	44.39be	45.46bcd
	F_2	3.97d	4.01e	0.356d	0.363d	2.80de	2.83cd	45.24ad	45.99abc
T_5	**F_1**	4.06cd	4.12d	0.371c	0.375c	2.86cd	2.90bcd	45.64abc	46.49ab
	F_2	4.19ab	4.25b	0.386b	0.390b	2.95ab	2.99ab	46.16ab	47.33a
T_6	**F_1**	4.14bc	4.19c	0.379bc	0.387b	2.90bc	2.93bc	45.86abc	47.21a
	F_2	4.28a	4.33a	0.401a	0.409a	3.01a	3.06a	46.57a	47.62a

Means within a row followed by a different letter (s) are statistically different at a 0.05 level

T_1: Control (without), **T_2:** Rhizobium (RH) alone at rat of 1.0 g per 1.0 kgseeds, **T_3:** Farmyard manure FYM (cow waste) alone at rate of 36.0 m^3 ha^{-1}, **T_4:** Plant compost PC (sugar cane and banana residues at ratio of 50:50) alone at rate of 36.0 m^3 ha^{-1}, **T_5:** T_2+ T_3 (RH+ FYM), **T_6:** T_2+ T_4 (RH+ PC), **F_1:**Without Mg and **F_2:** Mg sprayed at rate of 1440 g ha^{-1}

Table 5. Effect of the organic and bio fertilization and magnesium foliar application on nodulation parametersduring seasons of 2021and 2022.

Treatments		Number of nodules plant^{-1}		Nodules fresh weight (g plant^{-1})		Nodules dry weight	
		1st	2nd	1st	2nd	1st	2nd
Organic and bio fertilization treatments							
T$_1$: Control (without)		11.50f	12.33f	1.77d	1.84d	0.55d	0.57f
T$_2$: RH		13.83e	15.83e	1.92c	1.98c	0.63c	0.65e
T$_3$: FYM		16.50d	18.00d	2.05b	2.13b	0.74b	0.77d
T$_4$: PC		17.83c	19.00c	2.13b	2.18b	0.78b	0.81c
T$_5$: T$_2$+ T$_3$ (RH+ FYM)		19.33b	20.83b	2.28a	2.35a	0.94a	0.96b
T$_6$: T$_2$+ T$_4$ (RH+ PC)		20.33a	21.83a	2.33a	2.40a	0.97a	1.00a
LSD 5%		**0.99**	**0.87**	**0.09**	**0.09**	**0.05**	**0.03**
Magnesium treatments							
F$_2$:without Mg		15.56b	17.17b	2.03b	2.10b	0.73b	0.76b
F$_2$: With Mg		17.56a	18.78a	2.13a	2.20a	0.80a	0.83a
LSD 5%		**0.67**	**0.62**	**0.05**	**0.08**	**0.02**	**0.02**
Interactions							
T x F		**LSD 5%**					
		1.65	**1.54**	**0.17**	**0.20**	**0.06**	**0.05**
T$_1$	**F$_1$**	10.67i	11.00j	1.74g	1.81h	0.54i	0.56h
	F$_2$	12.33h	13.67i	1.80fg	1.87gh	0.56hi	0.58gh
T$_2$	**F$_1$**	13.00h	15.33h	1.89efg	1.95fgh	0.61gh	0.63fg
	F$_2$	14.67g	16.33gh	1.96def	2.01eh	0.64fg	0.66f
T$_3$	**F$_1$**	15.33fg	17.00fg	1.97de	2.04d-g	0.70ef	0.73e
	F$_2$	17.67de	19.00de	2.12cd	2.21be	0.78cd	0.82cd
T$_4$	**F$_1$**	16.33ef	18.33ef	2.08cd	2.13cf	0.75de	0.77de
	F$_2$	19.33bc	19.67cde	2.17bc	2.22bcd	0.82c	0.84c
T$_5$	**F$_1$**	18.33cd	20.33bcd	2.22abc	2.29abc	0.89b	0.91b
	F$_2$	20.33ab	21.33ab	2.34a	2.41ab	0.98a	1.01a
T$_6$	**F$_1$**	19.67abc	21.00bc	2.28ab	2.35ab	0.92b	0.95b
	F$_2$	21.00a	22.67a	2.38a	2.46a	1.03a	1.06a

Means within a row followed by a different letter (s) are statistically different at a 0.05 level

T$_1$: Control (without), **T$_2$:** Rhizobium (RH) alone at rat of 1.0 g per 1.0 kgseeds, **T$_3$:** Farmyard manure FYM (cow waste) alone at rate of 36.0 m^3 ha^{-1}, **T$_4$:** Plant compost PC (sugar cane and banana residues at ratio of 50:50) alone at rate of 36.0 m^3 ha^{-1}, **T$_5$:** T$_2$+ T$_3$ (RH+ FYM), **T$_6$:** T$_2$+ T$_4$ (RH+ PC), **F$_1$:**Without Mg and **F$_2$:** Mg sprayed at rate of 1440 g ha^{-1}

Table 6. Effect of the organic and bio fertilization and magnesium foliar application on some soybean physical traits at harvest stage during seasons of 2021and 2022.

Treatments		No. of pods $plant^{-1}$		Pods weight $plant^{-1}$		Seeds weight $plant^{-1}$ (g)		Stover weight $plant^{-1}$		Weight of 1000 seeds	
		1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Organic and bio fertilization treatments											
T_1		48.50f	55.50f	49.48f	54.37f	25.23f	28.12f	51.74f	53.69f	181.77d	188.22d
T_2		52.83e	57.33e	52.84e	59.43e	26.70e	29.51e	53.76e	55.60e	185.31c	191.77c
T_3		60.17d	63.33d	56.28d	62.48d	28.23d	31.48d	57.37d	59.00d	193.40b	200.58b
T_4		62.33c	69.50c	57.69c	64.06c	28.81c	32.12c	58.69c	60.91c	194.96b	201.78b
T_5		76.50b	83.50b	61.08b	67.77b	30.14b	33.91b	61.62b	63.60b	202.48a	209.58a
T_6		81.00a	89.00a	62.11a	69.57a	30.58a	34.25a	62.81a	65.08a	205.27a	211.53a
LSD 5%		**1.63**	**1.77**	**0.35**	**0.58**	**0.23**	**0.26**	**0.79**	**1.22**	**3.06**	**3.00**
Magnesium treatments											
F_1		60.44b	65.94b	55.44b	61.51b	27.82b	31.07b	56.75b	58.78b	191.39b	197.83b
F_2		66.67a	73.44a	57.72a	64.38a	28.74a	32.06a	58.57c	60.51a	196.34a	203.32a
LSD 5%		**1.18**	**1.25**	**0.15**	**0.20**	**0.38**	**0.42**	**0.61**	**0.48**	**1.90**	**2.30**
Interactions											
T x F		**LSD 5%**									
		2.89	**3.07**	**0.36**	**0.49**	**0.93**	**1.03**	**1.50**	**1.19**	**4.67**	**5.63**
T_1	**F_1**	47.00j	56.00g	48.52l	53.25j	24.86f	27.84f	51.25e	53.37f	180.83f	187.20f
	F_2	50.00i	55.00g	50.44k	55.48i	25.59ef	28.39f	52.22e	54.01f	182.71f	189.24ef
T_2	**F_1**	52.00hi	56.00g	51.35j	58.02h	26.04e	28.91f	52.92e	54.75f	184.69ef	190.30ef
	F_2	53.67h	58.67fg	54.32i	60.84g	27.36d	30.10e	54.60d	56.45e	185.93def	193.23def
T_3	**F_1**	57.67g	60.67f	55.35h	61.44f	27.85d	31.20d	56.09d	57.56e	189.68de	196.02de
	F_2	62.67ef	66.00e	57.22f	63.52e	28.60cd	31.75d	58.65bc	60.45d	197.12c	205.13bc
T_4	**F_1**	60.00fg	64.00e	56.24g	61.87f	28.26cd	31.66d	57.89c	60.29d	191.57d	198.43cd
	F_2	64.67e	75.00d	59.14e	66.24d	29.36bc	32.59cd	59.48bc	61.53cd	198.35c	205.12bc
T_5	**F_1**	71.00d	76.00d	60.04d	66.64d	29.75ab	33.32bc	60.39b	62.42c	199.85bc	206.52b
	F_2	82.00b	91.00b	62.12b	68.90b	30.54ab	34.50ab	62.85a	64.78ab	205.11ab	212.65ab
T_6	**F_1**	75.00c	83.00c	61.13c	67.86c	30.18ab	33.50bc	61.98a	64.28b	201.72bc	208.51ab
	F_2	87.00a	95.00a	63.08a	71.29a	30.97a	35.00a	63.63a	65.87a	208.82a	214.55a

Means within a row followed by a different letter (s) are statistically different at a 0.05 level

T_1: Control (without), T_2: Rhizobium (RH) alone at rat of 1.0 g per 1.0 kgseeds, T_3: Farmyard manure FYM (cow waste) alone at rate of 36.0 m^3 ha^{-1}, T_4: Plant compost PC (sugar cane and banana residues at ratio of 50:50) alone at rate of 36.0 m^3 ha^{-1}, T_5: T_2+ T_3 (RH+ FYM), T_6: T_2+ T_4 (RH+ PC), F_1:Without Mgand F_2: Mg sprayed at rate of 1440 g ha^{-1}

Table 7. Effect of the organic and bio fertilization and magnesium foliar application onseed and stover yield at harvest stage during seasons of 2021 and 2022.

Treatments		Seed yields		Stover yield	
		(Mg ha^{-1})			
		1st	2nd	1st	2nd
Organic and bio fertilization treatments					
T_1: Control (without)		3.83f	4.27f	7.85f	8.15f
T_2: RH		4.05e	4.48e	8.16e	8.44e
T_3: FYM		4.28d	4.78d	8.71d	8.96d
T_4: PC		4.37c	4.88c	8.91c	9.25c
T_5: T_2+ T_3 (RH+ FYM)		4.58b	5.15b	9.35b	9.65b
T_6: T_2+ T_4 (RH+ PC)		4.64a	5.20a	9.53a	9.88a
LSD 5%		**0.04**	**0.04**	**0.12**	**0.18**
Magnesium treatments					
F_2:without Mg		4.22b	4.72b	8.62b	8.92b
F_2: With Mg		4.36a	4.87a	8.89a	9.19a
LSD 5%		**0.06**	**0.06**	**0.09**	**0.07**
Interaction					
T x F		**LSD 5%**			
		0.14	**0.16**	**0.23**	**0.18**
T_1	**F_1**	3.77f	4.23f	7.78e	8.10f
	F_2	3.88ef	4.31f	7.93e	8.20f
T_2	**F_1**	3.95e	4.39f	8.03e	8.31f
	F_2	4.15d	4.57e	8.29d	8.57e
T_3	**F_1**	4.23d	4.74d	8.51d	8.74e
	F_2	4.34cd	4.82d	8.90bc	9.18d
T_4	**F_1**	4.29cd	4.81d	8.79c	9.15d
	F_2	4.46bc	4.95cd	9.03bc	9.34cd
T_5	**F_1**	4.52ab	5.06bc	9.17b	9.48c
	F_2	4.64ab	5.24ab	9.54a	9.83ab
T_6	**F_1**	4.58ab	5.09bc	9.41a	9.76b
	F_2	4.70a	5.31a	9.66a	10.00a

Means within a row followed by a different letter (s) are statistically different at a 0.05 level

T_1: Control (without), T_2: Rhizobium (RH) alone at rat of 1.0 g per 1.0 kgseeds, T_3: Farmyard manure FYM (cow waste) alone at rate of 36.0 m^3 ha^{-1}, T_4: Plant compost PC (sugar cane and banana residues at ratio of 50:50) alone at rate of 36.0 m^3 ha^{-1}, T_5: T_2+ T_3 (RH+ FYM), T_6: T_2+ T_4 (RH+ PC), F_1:Without Mg and F_2: Mg sprayed at rate of 1440 g ha^{-1}

Table 8. Effect of the organic and bio fertilization and magnesium foliar application on seed quality parameters at harvest stage during seasons of 2021and 2022.

Treatments	Chemical traits						Biochemical traits					
	Nitrogen		Phosphorus		Potassium		Oil		Protein		Carbohydrates	
	(%)											
	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Organic and bio fertilization treatments												
T_1	2.99f	3.03f	0.313f	0.319f	2.22f	2.25f	20.73f	21.02f	18.68f	18.93f	20.45d	20.80e
T_2	3.16e	3.20e	0.326e	0.331e	2.33e	2.37e	21.41e	21.74e	19.76e	20.02e	21.24c	21.57d
T_3	3.44d	3.51d	0.345d	0.352d	2.48d	2.52d	22.11d	22.45d	21.47d	21.92d	22.10b	22.44c
T_4	3.55c	3.59c	0.351c	0.358c	2.54	2.57c	22.40c	22.78c	22.21c	22.46c	22.42b	22.80b
T_5	3.90b	3.95b	0.373b	0.377b	2.71cb	2.75b	23.11b	23.50b	24.36b	24.67b	23.44a	23.91a
T_6	4.02a	4.07a	0.379a	0.388a	2.77a	2.81a	23.30a	23.78a	25.11a	25.46a	23.78a	24.13a
LSD 5%	**0.08**	**0.06**	**0.004**	**0.004**	**0.05**	**0.03**	**0.20**	**0.27**	**0.52**	**0.36**	**0.44**	**0.25**
Magnesium treatments												
F_1	3.42b	3.47b	0.342b	0.348b	2.46b	2.49b	20.94b	22.30b	21.37b	21.68b	21.96b	22.32b
F_2	3.60a	3.65a	0.354a	0.360a	2.56a	2.59a	22.41a	22.79a	22.49a	22.81a	22.52a	22.90a
LSD 5%	**0.06**	**0.04**	**0.004**	**0.005**	**0.03**	**0.02**	**0.29**	**0.17**	**0.40**	**0.22**	**0.22**	**0.2**
Interactions												
T x F	LSD 5%											
	0.16	**0.09**	**0.011**	**0.011**	**0.06**	**0.06**	**0.72**	**0.43**	**0.98**	**0.54**	**0.55**	**0.56**
T_1 F_1	2.96j	3.00j	0.309i	0.315h	2.18h	2.21h	20.57h	20.85g	18.50j	18.75j	20.25i	20.63h
T_1 F_2	3.02j	3.06j	0.318hi	0.324gh	2.26g	2.29g	20.89gh	21.19fg	18.85j	19.10j	20.66hi	20.96gh
T_2 F_1	3.11ij	3.15i	0.324gh	0.330fg	2.30g	2.33g	21.12fgh	21.49f	19.44ij	19.69i	21.10gh	21.41fg
T_2 F_2	3.21hi	3.26h	0.329gh	0.332fg	2.37f	2.40f	21.69efg	21.99e	20.08hi	20.35h	21.37g	21.73f
T_3 F_1	3.34gh	3.42g	0.336fg	0.343ef	2.43ef	2.47e	21.93def	22.25de	20.85gh	21.35g	21.74fg	22.09ef
T_3 F_2	3.53ef	3.60f	0.353de	0.361cd	2.53d	2.57d	22.29b-e	22.65d	22.08ef	22.48f	22.45de	22.80d
T_4 F_1	3.43fg	3.47g	0.344ef	0.351de	2.47e	2.50e	22.05c-f	22.42de	21.44fg	21.67g	22.13ef	22.46de
T_4 F_2	3.68de	3.72e	0.358d	0.365c	2.60c	2.64c	22.76a-d	23.13c	22.98de	23.25e	22.72de	23.13cd
T_5 F_1	3.78cd	3.83d	0.366cd	0.370bc	2.65c	2.69c	22.90a-d	23.26bc	23.60cd	23.92d	23.09cd	23.53c
T_5 F_2	4.02ab	4.07b	0.380ab	0.384ab	2.76b	2.81ab	23.31ab	23.74ab	25.13ab	25.42b	23.78ab	24.30ab
T_6 F_1	3.90bc	3.95c	0.372bc	0.381b	2.72b	2.75b	23.08abc	23.54abc	24.40bc	24.69c	23.44bc	23.78bc
T_6 F_2	4.13a	4.20a	0.387a	0.395a	2.83a	2.86a	23.53a	24.02a	25.83a	26.23a	24.12a	24.47a

Means within a row followed by a different letter (s) are statistically different at a 0.05 level
T_1: Control (without), T_2: Rhizobium (RH) alone at rat of 1.0 g per 1.0 kgseeds, T_3: Farmyard manure FYM (cow waste) alone at rate of 36.0 m^3 ha^{-1}, T_4: Plant compost PC (sugar cane and banana residues at ratio of 50:50) alone at rate of 36.0 m^3 ha^{-1}, T_5: T_2+ T_3 (RH+ FYM), T_6: T_2+ T_4 (RH+ PC), F_1:Without Mg and F_2: Mg sprayed at rate of 1440 g ha^{-1}

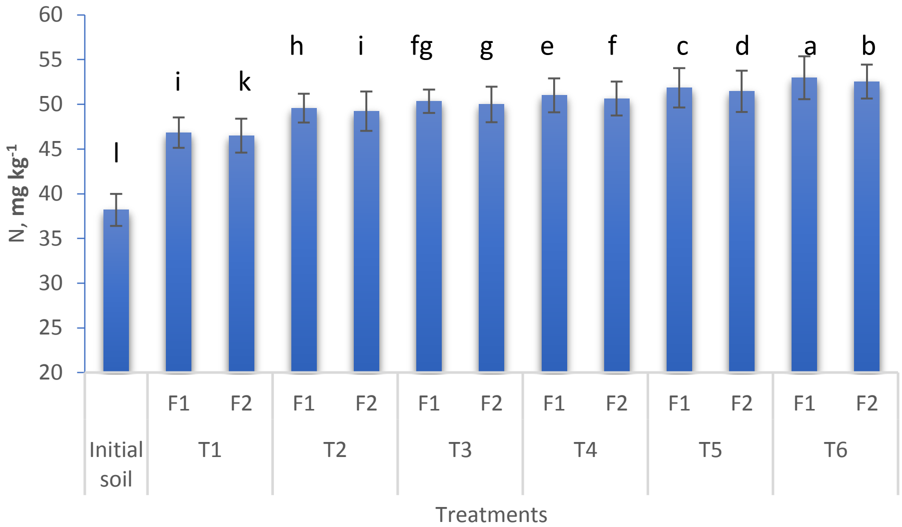

Fig. 1. Effect of the organic and bio fertilization and magnesium foliar application on soil available nitrogen after harvest during seasons of 2021and 2022 (combined data over both seasons). Bars indicates standard error (SE). Different letters indicate significant differences between the treatments at according to the Duncan test (*p* ≤ 0.05).T_1: Control (without), T_2: Rhizobium (RH) alone at rat of 1.0 g per 1.0 kgseeds, T_3: Farmyard manure FYM (cow waste) alone at rate of 36.0 m^3 ha^{-1}, T_4: Plant compost PC (sugar cane and banana residues at ratio of 50:50) alone at rate of 36.0 m^3 ha^{-1}, T_5: T_2+ T_3 (RH+ FYM), T_6: T_2+ T_4 (RH+ PC), F_1:Without Mg and F_2: Mg sprayed at rate of 1440 g ha^{-1}.

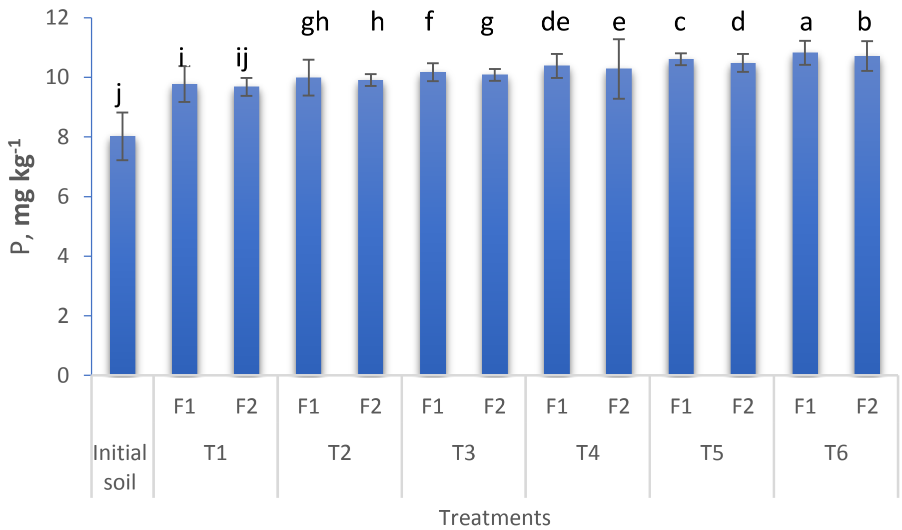

Fig. 2. Effect of the organic and bio fertilization and magnesium foliar application on soil available phosphorus after harvest during seasons of 2021and 2022 (combined data over both seasons). Bars indicates standard error (SE). Different letters indicate significant differences between the treatments at according to the Duncan test (*p* ≤ 0.05).T_1: Control (without), T_2: Rhizobium (RH) alone at rat of 1.0 g per 1.0 kgseeds, T_3: Farmyard manure FYM (cow waste) alone at rate of 36.0 m^3 ha^{-1}, T_4: Plant compost PC (sugar cane and banana residues at ratio of 50:50) alone at rate of 36.0 m^3 ha^{-1}, T_5: T_2+ T_3 (RH+ FYM), T_6: T_2+ T_4 (RH+ PC), F_1:Without Mg and F_2: Mg sprayed at rate of 1440 g ha^{-1}.

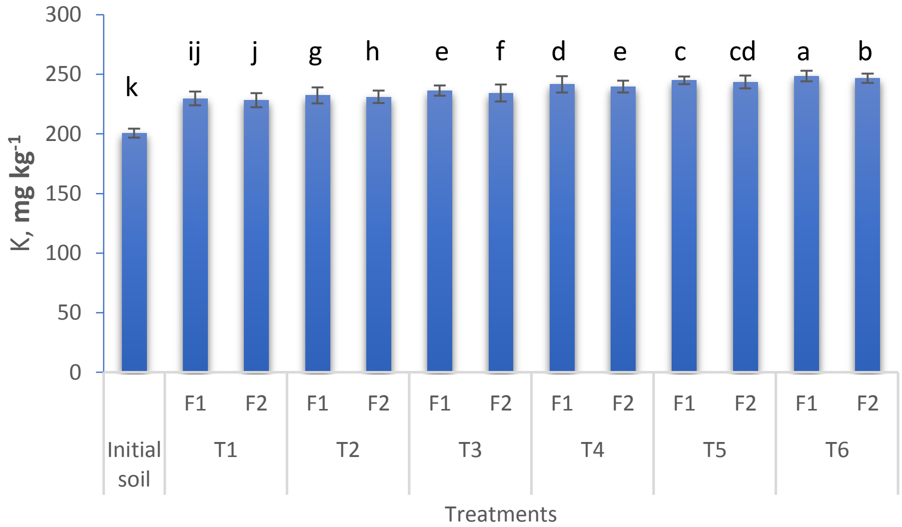

Fig 3. Effect of the organic and bio fertilization and magnesium foliar application on soil available potassium after harvest during seasons of 2021and 2022 (combined data over both seasons). Bars indicates standard error (SE). Different letters indicate significant differences between the treatments at according to the Duncan test (*p* ≤ 0.05).T_1: Control (without), T_2: Rhizobium (RH) alone at rat of 1.0 g per 1.0 kgseeds, T_3: Farmyard manure FYM (cow waste) alone at rate of 36.0 m^3 ha^{-1}, T_4: Plant compost PC (sugar cane and banana residues at ratio of 50:50) alone at rate of 36.0 m^3 ha^{-1}, T_5: T_2+ T_3 (RH+ FYM), T_6: T_2+ T_4 (RH+ PC), F_1:Without Mg and F_2: Mg sprayed at rate of 1440 g ha^{-1}

4. Discussion

Benefits of both organic fertilizers and rhizobium inoculation positively affected soy bean performance under the condition of the current study.The pronounced promotional effect ofcompost may be due to the role of compost in improving soil structure, increasing soil temperature, increasing microbial activity, supplying the soil to many nutrients, increasing soil cation exchange capacity, raising elements availability in soiland protecting the soil surface from erosion.

On the other hand, the pronounced promotional effect ofrhizobiuminoculant due to its role inhelping fix atmospheric nitrogen in a symbiotic way. The rhizobium entered the nodules on the roots of soybeans, either through the islet hairs or directly through the point of root prominence. The nodules are the place of nitrogen fixation, where the nitrogenase enzyme is present, and it is the mediator that turns atmospheric nitrogen into NH_4. Thus, it can be said that rhizobium inoculantprovided nitrogen requirements for soybean.The same role that plant compost plays in improving soil properties is also played by farmyard manure, but with less efficiency**(Mekki and Ahmed 2005; Mahdi *et al.* 2010)**.

The superiority ofplant compost compared to FYMfor all the studied agro parameters may be due to that the residues of the sugar cane and banana tree contain more nutrients (especially potassium as shown it Table 1), vitamins and hormones than FYM (**Kravchenko *et al.* 2013; Taha *et al.* 2018)**.It is known that potassium plays a major role in enhances carbohydrates' movement from foliage to storage organs.**T_2**treatment (rhizobium alone) only outperformed the control treatment **T_1**treatment (without addition) due to its ability in N fixation. Besides its ability in N-fixation, perhaps the superiority of rhizobium is due to its ability to secrete polysaccharides (slime), which help bind soil particles to each other**(Baddour*et al.* 2021).**.These findings are in harmony with the obtained results of **Kumar *et al.* (2018); Ghaly*et al.* (2020); Abdrabou *et al.* (2022).**

The obtained results also help in understanding the vital role of magnesium element in improving plant growth of soybean and quantitative and qualitative yield. Foliar application of magnesium on soybean plants might have improved the photosynthesis process and increased chlorophyll formation. As magnesium is included in the composition of the chlorophyll molecule, with a percentage of 2.7%**(Guo *et al.* 2016).** The superiority of magnesium treatment might be due to the ability of magnesium to assist in the processes of movement of phosphorus into the plant **(Chen *et al.* 2018).**Also, it is known that magnesium helps move carbohydrates from the stem to the leaves. It can be said that magnesium acts as an activator for many important enzymes in the metabolism of carbohydrates**Xie*et al.* 2021).** The role of magnesium, as a co-enzyme, might activate all enzymes that build oils and fats in soybean plants. The reason of improving the nodulation parameters with Mg treatment may be due to the improvement of general plant statu due to the vital role of magnesium, and thus increased activity in the root zone. Similar results were observed by **El-Dissoky*et al.* (2017).**

5. Conclusion

It can be concluded some facts as follows: bio-fertilization has a vital role in improving the performance and productivity of oil crops.Also, plant residues compost and FYM provide nutrients to the grown plants.Magnesium plays an important role in building oils and fats in oil crops.Generally, it can be concluded that the combined treatment (rhizobium inoculant + plant compost+ magnesium) will achieve the highest plant growth performance, quantitative and qualitative yield of soybean. Thus, can meet people's needs for strategic oil crops.

Conflicts of interest

Authors have declared that no competing interests exist.

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