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Improved Efficiency of P Fertilization with Bio and Organic additives on Growth, Seed Quality and Soybean Yield

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ABSTRACT

Two field experiments were conducted at Experimental Farm of Tag El-Ezz, Agricultural Research Station, Dakahlia Governorate, Egypt, during two successive summer seasons of 2019 and 2020 to study the improving efficiency of different P mineral sources with bio, and organic additives as combined treatments on growth performance, quantitative and qualitative productivity of soybean plants (Glycine max L., cv. Giza 111). A split-plot design with three replicates was used, representing three sources of P fertilizers (control, Ordinary superphosphate OSP, and Mono ammonium phosphate MAP as the main plots, six bio and organic treatments (control, arbuscular mycorrhizal fungi AM, vermicompost V, potassium humate KH, AM+V, and AM+KH as the subplots. The results were collected briefly as follows: MAP gave the highest values of vegetative growth, yield, its components, and seed quality compared to (OSP) or control. AM+KH had the best-aforementioned adjectives compared to other bio and organic additives, where the plants fertilized with AM+V came in the second-order followed by KH then V, and lately AM alone. The combination of MAP and AM+KH was the superior treatment effect on all studied traits compared to the other treatments, the highest P use efficiencies values and (benefit: cost) ratio were achieved from this reaction. The available N, P, K and pH value of soil after the harvest of soybean were improved significantly due to the integration of inorganic fertilizers with bio and organic fertilizers.

Keywords:Mono ammonium phosphate, Mycorrhiza, vermicompost, potassium humate and soybean.

INTRODUCTION

Soybean (*Glycine max* L.) is among the most important protein and oil crops, where it contains about 40% of protein and 18-22% of cholesterol-free oil as well all some vitamins (Mahrous *et al*., 2016, Morokhovets, 2016 and Ghaly *et al*., 2020). In the year 2019, according to the Ministry of Agriculture and Land Reclamation (MALR), the total production of soybeans reached 25000 Mg in Egypt from an area of 9000 hectares.

The phosphorus (P) element is an essential nutrient for all plants, especially legumes e.g., soybean, where its uptake by soybean plants is essential for proper The majority of oil supplies in Egypt is imported; thus, the Egyptian government strategy aims to duplicate the areas for soybeans cultivation. The phosphorus (P) element is an essential nutrient for all plants, especially legumes e.g., soybean, where its uptake by soybean plants is essential for proper nodule formation (Ghaly *et al*., 2020). In addition, phosphorus plays an essential role in several vital functions such as photosynthesis, transformation of sugar to starch, protein synthesis, nucleic acid production, nitrogen fixation, and oil formation. It is also, part of all biochemical cycles in the plant (Mehrvarz and Chaichi, 2008). And despite that, its availability for plants is limited due to different chemical reactions, especially in arid and semi-arid soils. Plants absorb phosphorus from soil solution as phosphate anion. It is the least moving element in the plant and soil, unlike other macronutrients. precipitated form i.e. orthophosphate is absorbed by Fe^{+2}, Ca^{+2}, and Mg^{+2} in the soil through legend exchange. A large quantity of P applied as a fertilizer becomes immobile through a precipitation reaction with highly reactive Fe^{+2}, Ca^{+2} and Mg^{+2} in the acidic and calcareous, alkaline , or neutral soils (Awasthi *et al*., 2011). Therefore, the efficiency of P fertilization throughout the world is around 10-25%. Phosphorus availability in soil depends on soil pH were, recorded the highest availability within the range of 6 to 7 of soil pH (Gulmezoglu and Dughan, 2017) Phosphorus availability depends also on other factors like soil physicochemical properties, dominant climate and soil organic matter content and phosphorus fertilizers (Ghoname *et al*., 2012) . Phosphorus fertilizers are the main input of inorganic phosphorus in agricultural soils. The most commonly used phosphatic fertilizers are ordinary superphosphate (OSP), diammonium phosphate (DAP), mono ammonium phosphate (MAP) and NPK. OSP is manufactured from reactions between rock phosphate and sulfuric acid, while MAP is the product of reactions between phosphoric acid and ammonia (Green, 2015).

Potassium humate (KH) is a humic acid potassium salt, completely water-soluble (Taha *et al.*,2016).Fulvic (FA) and humic (HA) acids are the major parts of humic materials, where they lead to an increase in soil fertility as well as nutrients availability by increasing the activity of soil organisms and reducing soil pH value, therefore enhancement of plant growth (Taha, 2018 and Samie *et al.*, 2018). Hemida *et al.*,(2017) illustrated that KH improved N,

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P, K, Ca, and vitamin C of snap bean plants compared to untreated plants.

Vermicompost is nutrient-rich organic fertilizer, where the vermicomposting can be defined as a process through which earthworms converts organic residues into compost which can be very beneficial for plant growth (Blouin *et al.,* 20 19). The microbiologically active organic decomposition due to interactions during the breakdown of organic matter (O.M) between micro-organisms and earthworms positively affects soil properties e.g., porosity available water capacity, bulk density, porosity and hydraulic conductivity (Demir, 2019) Moghadam1 and coworkers (Moghadam1 *et al.*,2014) found that vermicompost increased the growth performance and seeds development of soybean relative to the control treatment.

Mycorrhiza inoculant plays an essential role in improving osmotic regulation and photosynthetic rate, enhancing nutrients uptake and water use efficiency as well as improving the growth of plants grown on soil containing low phosphorous levels (Khatab, 2016). Rahmawat *et al*., (2014) revealed that soybean plants inoculated with mycorrhiza fungi have chlorophyll a, b and total chlorophyll contents in leaves more compared to non-mycorrhiza-inoculated plants. The presence of mycorrhizae in the cultivation of plants can increase the inorganic P uptake by plants because the hyphae of mycorrhizal fungi that live in the root zone also emit phosphatase enzymes that are capable of transforming organic P into inorganic P thereby increasing P availability for plants. (Sasongko *et al.,* 2019).

The integrated supply of nutrients via the bio, organic and mineral sources could be an effective practice to optimize crop productivity. (El-Sheshtawy *et al.,*2019) concluded that the integrated between the mycorrhiza fungi and humic acid under different sources of phosphorus gave the maximize yield and reduced the need for phosphorous fertilization.

Due to the food gap existing in Egypt, maximizing crop production became necessary. So this current study aims at assessing the influence of different P mineral sources, bio and different organic fertilizers as combined treatments on the performance of soybean plants, maximize the benefit of phosphate fertilizers, and find out the superior treatment. This will help the growers in Egypt to maximize their yield productivity and profitability.

MATERIALS AND METHODS

Two field experiments were carried out at Experimental Farm of Tag El-Ezz, Agricultural Research Station (30°95' 60.19'' N latitude and 31°61' 07.71'' E longitude), Dakahlia Governorate, Egypt, during two successive summer seasons of 2019 and 2020 to study the effect of different P mineral sources, bio and organic fertilizers as combined treatments on growth performance, quantitative and qualitative productivity of soybean plants (*Glycine max* L., cv. Giza 111).

Soil Sampling and Analysis.

Surface soil sample of the experimental site before cultivation (Table 1) as well as representative soil samples of each experimental unit at the harvest stage of the soybean plants was analyzed according to (Estefan *et al.*, 2013), where all soil samples at both start and end of the field experiment were taken at a depth of 0-25cm.

Table 1. Average physical and chemical properties of the experimental soil (combined seasons).

Particle size distribution , %				Soil moisture constants,%			
Sand		**Silt**	**Clay**	**FC**	**SP**		**WP**
15.73		38.39	45.88	36.24	72.48		18.12
Textural class is Clayey				Chemical properties			
Soluble cations, $meqL^{-1}$				EC, dSm^{-1}	pH	$CaCO_3$,%	O.M,%
Ca^{2+}	Mg^{2+}	Na^+	K^+	1.80	8.10	3.90	1.58
3.18	6.7	5.62	2.5				
Soluble anions, $meqL^{-1}$							
CO_3^{2-}	HCO_3^-	Cl^-	SO_4^{2-}				
N.D.	5.43	10.74	1.83				
Available element, mg kg^{-1}							
N	P		K				
50.39	7.350		215.5				

- Soil Electrical Conductivity (EC) and soluble ions were determined in saturated soil paste extract.
- Soil pH was determined in soil suspension (1: 2.5).
- N.D. means not detected.

1.Description of the search experience and treatments.

The experimental design was a split-plot design aiming at evaluating the impact of different phosphorus fertilizers as main plots [control, ordinary superphosphate (OSP) and mono ammonium phosphate (MAP)], bio and organic treatments (control, arbuscular mycorrhizal fungi (AM), vermicompost (V), potassium humate (KH), (AM+V) and (AM+KH) as the sub-plots on the performance of soybean plants. Each treatment was replicated three times. The sub-plot size was 10.5 m^2 (3.5 m × 3.0 m). Seeds of soybean (*Glycine max* L. Giza 111) were obtained from ARC, Giza, Egypt. The Seeds were sown manually (3-4 seeds $hill^{-1}$) at a rate of 30 kg fed^{-1} using one side of the ridge in hills 15 cm apart on the 5^{th} of May in both seasons. Nitrogen in a form of urea (46% N) was applied at a rate of 55 kg N fed^{-1} in two equal doses after 21 and 42 days from sowing before the first and second irrigations, respectively. While potassium sulfate, (48 % K_2O) was added with the second irrigation at a rate of 50 kg fed^{-1}. Other recommended agriculture practices for soybean as well as irrigation process (flooding system) were done according to the recommendations of MALR. At period of 20 days from sowing, plants were thinned to obtain one soybean plant $hill^{-1}$.

The experimental treatments were as follows:

The first factor (main plots):

P_0: Control (without addition).

P_1: Ordinary superphosphate (OSP).

P_2: Mono ammonium phosphate (MAP).

The second factor (sub plots):

F_1: Control (without addition).

F_2: Mycorrhiza (AM) as a single treatment.

F_3: Vermicompost (V) as a single treatment.

F_4: Potassium humate (KH) as a single treatment.
F_5: AM+V together.
F_6: AM+KH together.

Potassium humate was added at a rate of 2 kg fed^{-1}before and after 21 days from sowing, while plots received vermicompost at a rate of 500 kg fed^{-1} during soil preparation. Regarding mycorrhiza treatments, soybean seeds were inoculated with mycorrhiza before sowing at a rate of 1.0 kg fed^{-1} (using sugar solution for 10 minutes until all soybean seeds were thoroughly coated). Calcium superphosphate (15.5 % P_2O_5) was added once during soil preparation at a rate of 150 kg fed^{-1} (equivalent to 23.25kg P_2O_5 fed^{-1}), while mono ammonium phosphate (62.0 % P_2O_5 and 11.0 % N) was added at a rate of 37.50 kg fed^{-1}(equivalent to 23.25kg P_2O_5 fed^{-1}) in three equal doses; the first one was at sowing while the 2nd and 3rd one were added at 21 and 42 days from sowing. All these fertilizers were provided by MALR, Egypt. Data of both vermicompost and potassium humate analyses are shown in Table 2.

Table 2. Some characteristics of vermicompost and potassium humate.

Vermicompost characteristics										
	%			mg kg-1			%		pH	EC (1:10),
Organic matter	**Total carbon**	**Total N**	**C/N**	**Fe**	**Mn**	**Total P**	**Total K**	**Saturation**	**(1:10)**	**dSm^{-1}**
33.62	35.62	2.45	14.53	61.2	26.3	2.12	1.31	162.00	7.50	2.72

Potassium humate characteristics							
Moisture	FA	HA	Solubility	N	P_2O_5	K_2O	pH
		(%)					
5.87	3.10	60.5	100	0.48	1.12	11	8.50

2.Measurement traits.

A- Vegetative growth and chemical traits.

At the period of 65 days after sowing of soybean seeds, a random sample of five plants was taken from each sub plot to determine the following criteria:

- **Vegetative growth criteria**: shoot fresh and dry weights as well as roots fresh weight.
- **Photosynthetic pigments:** chlorophyll a, b, total and carotenoids were determined using a method described by (sumanta *et al.*, 2014).
- **Chemical constituents of leaves**: the samples of soybean leaves were digested with a mixture of H_2SO_4 and $HClO_4$ to determined total N, total P and K percentages according to the methods described by (Kalra, 1997).

B- Yield and seeds quality.

The following traits were done at a period of 120 days from sowing soybean (harvesting stage).

- **Yield measurements:** Pods, seeds and stover weights (g/plant), the weight of 100 seeds, seed and stover yield (kg/fed) were measured. In addition, plant height was measured as an indicator of treatments effect at harvest stage .
- **Chemical constituents of seeds:** digestion of soybean seeds was done as formerly mentioned in leaves for N, P and K and their determinations were done as formerly mentioned in leaves. While, digestion of seed samples for Mg, Zn and Fe determination was done by a mixture of nitric acid, H_2O_2 and hydrofluoric acid (Gotteni *et al.* 1982), where they were determined according to (Chapman and Pratt, 1961) using apparatus of Atomic Absorption Spectrophotometer**.**

P- uptake was determined according to the following formula:

P- uptake= Nutrient concentration× yield/100

- **Bio constituents of seeds:** Total lipid and protein content of samples were determined according to (A.O.A.C. 2016).
- **Fatty acid analysis:** Saturated and unsaturated fatty acids were determined in the oil by using methyl esters boron trifluoride method (A.O.A.C. 2000).
- **Phytic acid analysis:** Phytic acid was determined based on precipitation of phytate according to the procedure of (Wheeler and Ferrel 1971), using Iron (III) nitrate calibration curve.

C- Phosphorus -use efficiencies.

It was calculated as the following equation according to (Naeem *et al.*, 2017).

$$\text{Agronomic use efficiency AUE}(\textbf{kg yield/ P2O5 applied}) = \frac{\textit{Seed yield of treated}(kgfed^{-1}) - \textit{Seed yield of control}(kgfed^{-1})}{P_2O_5\ \ applied(23.25\ kgfed^{-1})}$$

$$\text{P- recovery efficiency PRE(\%)} = \frac{\textit{Total P uptake of treated}\ (kgfed^{-1}) - \textit{Total P uptake of control}(kgfed^{-1})}{P_2O_5\ \ applied\ (23.25\ kgfed^{-1})} \times 100$$

Partial Factor Productivity PFP (Kg/Kg) = Seed yield (Kg fed^{-1}) / P_2O_5 applied (23.25 Kg fed^{-1}).

D-Soil estimates:

After harvest of soybean, soil samples were randomly taken to determine the following residues (available N and K) and P forms in soil:

- Available N and K were determined according to (Reeuwijk, 2002). Available P form was determined according to (Olsen and Sommers, 1982). Total P form was determined as described by (Hesse 1971). Other Inorganic P forms *i.e.*Ca-P, Al-P and Fe-P were determined according to (Murphy and Riley, 1962). All P forms were determined using spectrophotometer apparatus.
- Also, soil pH and electrical conductivity values (EC) were determined using a Gallen Kamp pH-meter and electrical conductivity meter (EC meter Model TDScan 3), respectively (Richards, 1954).

3.Economic profitability.

It was done through an account of the total cost, gross return, net return and B: C ratio was calculated as below.

Benefit Cost Ratio (BCR) = Gross return/Total Cost of cultivation

4.Statistical Analysis.

Results from convergent experiments of the 2 years were combined for analysis. Data of the present study were statistically analyzed using CoSTATE Computer Software, The significant differences among the mean of various treatments were established by the Least Significant Differences method (LSD) and Duncan's Multiple Comparisons Test according to (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

1.Performance at period of 65 days.

Data of Table 3 show the impact of different P fertilizers, bio and organic additives and their interactions on growth criteria i.e. shoot fresh and dry weights, roots fresh weight (g plant^{-1}), the photosynthetic pigment in fresh weight of leaves i.e. chlorophyll a, chlorophyll b, total chlorophyll a + b and carotenoids contents (mg g^{-1} F.W) and chemical constituents of leaves i.e., N, P and K percentages of soybean plants at a period of 65 days from sowing.

Table 3. Impact of P fertilizers, bio with organic additives and their interactions on performance of soybean plants at period of 65 days from sowing (combined data over both seasons).

Treatments		Growth criteria			Photosynthetic pigment in fresh weight of leaves				Chemical constituents of leaves		
		Shoot fresh weight	Shoot dry weight	Roots fresh weight	*Chl.* a	*Chl.* B	Total *chl*a+b	Carotenoids	N	P	K
		(g plant^{-1})			(mg g^{-1} F.W)				(%)		
P fertilizers											
P_0		38.87b	10.92c	6.58c	0.438b	0.235b	0.673b	0.148c	4.20c	0.320c	2.42b
P_1		42.61a	11.90b	6.88b	0.454a	0.251a	0.705a	0.157b	4.31b	0.342b	2.56a
P_2		44.46a	12.30a	6.96a	0.460a	0.263a	0.723a	0.162a	4.37a	0.356a	2.62a
Bio and organic additives											
F_1		27.51f	8.72e	5.61e	0.391f	0.190f	0.581e	0.118f	3.95e	0.265d	1.88f
F_2		34.63e	10.50d	6.14d	0.412e	0.211ae	0.623d	0.136e	4.05de	0.338b	2.33e
F_3		39.15d	11.63c	6.70c	0.455d	0.236d	0.691c	0.152d	4.16cd	0.316c	2.48d
F_4		43.42c	11.87c	6.80c	0.468c	0.255c	0.723b	0.160c	4.27c	0.328bc	2.70c
F_5		51.21b	13.32b	7.74b	0.483b	0.288b	0.771a	0.180b	4.58b	0.389a	2.82b
F_6		55.97a	14.19a	7.86a	0.496a	0.318a	0.814a	0.187a	4.75a	0.399a	2.99a
Interaction											
P_0	F_1	25.00j	8.22k	4.91i	0.380j	0.185j	0.565l	0.112m	3.90j	0.252i	1.76m
	F_2	33.47h	10.24i	6.07g	0.402hi	0.196ij	0.598jkl	0.130j	4.02hij	0.290gh	2.07k
	F_3	37.50fg	11.12g	6.50f	0.432f	0.225fgh	0.657ghi	0.146gh	4.10g-j	0.306fgh	2.30j
	F_4	39.35ef	11.26fg	6.68ef	0.457e	0.237e-h	0.694fgh	0.149g	4.14ghi	0.299fgh	2.66fgh
	F_5	46.67d	12.27de	7.61c	0.477bc	0.278cd	0.755bcd	0.172d	4.46cde	0.382ab	2.79c-f
	F_6	51.25c	12.40d	7.73bc	0.480bc	0.290c	0.77bcd	0.178c	4.59bcd	0.388ab	2.93abc
P_1	F_1	27.64i	8.85j	5.87h	0.392i	0.192j	0.584l	0.119l	3.96ij	0.255i	1.92l
	F_2	35.00h	10.38hi	6.13g	0.413gh	0.217hi	0.63ijk	0.137i	4.05g-j	0.349cd	2.44ij
	F_3	39.80ef	11.77ef	6.80de	0.462de	0.240efg	0.702fg	0.154f	4.19fgh	0.318efg	2.55hi
	F_4	45.25d	12.16de	6.82de	0.470cd	0.259de	0.729def	0.163e	4.26efg	0.340de	2.70e-h
	F_5	51.33c	13.81c	7.75abc	0.485b	0.271cd	0.756abc	0.181c	4.63bcd	0.391ab	2.82b-e
	F_6	56.65b	14.44b	7.93a	0.500a	0.327ab	0.827a	0.190b	4.77ab	0.400ab	2.95ab
P_2	F_1	29.89i	9.08j	6.05gh	0.400i	0.194j	0.594kl	0.124k	3.99hij	0.287h	1.96kl
	F_2	35.41gh	10.89gh	6.23g	0.420g	0.220gh	0.64hij	0.141hi	4.07g-j	0.375bc	2.49i
	F_3	40.14e	12.00de	6.81de	0.470cd	0.244ef	0.714ef	0.157f	4.20fgh	0.325def	2.59ghi
	F_4	45.67d	12.20de	6.89d	0.475bc	0.267d	0.742cde	0.170d	4.41def	0..345de	2.73d-g
	F_5	55.64b	13.88c	7.85ab	0.486b	0.315b	0.801ab	0.186b	4.65bc	0.394cd	2.86bcd
	F_6	60.00a	15.73a	7.93a	0.507a	0.338a	0.845a	0.195a	4.88a	0.409a	3.08a

P_0: Control (without addition); P_1: Ordinary superphosphate (OSP) and P_2: Mono ammonium phosphate (MAP); F_1: Control (without addition); F_2: Mycorrhiza (AM) as a single treatments; F_3: Vermicompost (V) as a single treatment; F_4: Potassium humate (KH) as a single treatments; F_5: AM+V together and F_6: AM+KH together.

The soybean plants fertilized with MAP have the highest values of fresh and dry weights, chlorophyll and carotenoids contents, N, P and K percentages followed by the plants fertilized with OSP; however, plants untreated with P fertilizers possessed the lowest values of all aforementioned traits. The superiority of MAP compared to OSP is due to that MAP fertilizer contains 11.0 % nitrogen as well as other essential plant nutrients. This finding is in agreement with (Ragab *et al.,* 2015) who illustrated that MAP fertilizer gave the best growth parameters compared to the other phosphorus fertilizers.

Soybean plants fertilized with AM+ KH have the highest values of all aforementioned traits compared to other bio and organic additives. The plants fertilized with AM+V came in the second-order followed by those fertilized with KH alone then V alone and lately AM alone, while the plants untreated with bio and organic applications recorded the lowest values of all the aforementioned traits.

This primitive influence of studied bio and organic fertilizers may be due to that these additives supply soybean plants with nutrients and improve soil properties and fertility. AM+ KH as combined treatment is superior more than all other studied bio and organic fertilizers and this may be to the benefit of the combination of both KH and AM, where KH contains high contents from N (0.48 %), K_2O (11%), HA (60.5%), FA (3.1%), P_2O_5 (1.12%) as well as mycorrhiza plays an important role in facilitating phosphorus element availability, where it increases the uptake of poorly soluble P sources. Generally, the beneficial influences of mycorrhiza on soybean plant growth have been related to the raising in the absorption of immobile nutrients, especially phosphorus (P). This effect due to the large surface area of fungal hyphae, which are much longer and finer than plant root hairs, and partly because some such fungi can mobilize soil minerals unavailable to the plants' roots. Which improve the plant's mineral absorption capabilities. While AM+V is superior treatment compared to all studied bio and organic fertilizers in sole applications due to the aforementioned role of AM in addition with the role of V that is rich in nutrients status. These results are in harmony with these obtained by Rahmawati *et al.* (2014); Hemida *et al.* (2017) and Blouin *et al.* (2019).

Concerning interaction effect, the combination of AM+ KH as organic fertilizer and MAP was the superior treatment for all aforementioned parameters, while the lowest values were realized with soybean plants untreated with investigated fertilizers ($P_{0\times}$ F_1).

2. Performance at period of 120 days (harvest stage).

Data in Table 4 demonstrated yield and its components i.e. pods, seeds, and stover weights (g plant^{-1}), the weight of 100 seed (g plant^{-1}), seed and stover yield (Kg fed^{-1}) and plant height (cm). In addition seed quality traits i.e. N, K, Mg (%), Zn, Fe (mg kg^{-1}), protein and oil contents (%) of soybean plants are shown in (Table 5). Regarding P fertilization treatments, results illustrated pronounced differences among all P sources, where the sequence of treatments from top to less was MAP> OSP > control. The features mentioned above were significantly affected as a result of studied bio and organic additives, where the sequence of treatments from top to less was AM + KH >AM+V > KH > V > AM > control.

Concerning the interaction effect, the combination of AM+KH as organic fertilizer and MAP ($P_2\times F_6$) was the superior treatment as for all studied parameters, while the lowest values were realized with soybean plants untreated with investigated fertilizers ($P_0\times F_1$).

The reason for the difference between the studied treatments were explained above. From another explanations, it may be attributed to the content of MAP from N element that improves root activity and biological processes in the root zone which reflects on soil pH value that declines as activity increases. This increases the viability of the nutrients in the soil, with the exception of molybdenum. On the other hand, it is known that the presence of N and P in the root zone stimulates Mg uptake by plants, so it can be said that the combination of MAP and AM+KH provided more N and P into the root zone of soybean plants compared to other combined treatments, thus led to increasing Mg uptake which reflected on Mg content in the seeds. Generally, the Mg element is involved as a Co-enzyme with enzymes responsible for synthesis of oils and fats in oil-producing plants such as soybean plants.

Data enclosed in Table (6) clearly reveal that P %,P uptake in seed and stover yield, total P uptake, agronomic P use efficiency (AUE), P recovery efficiency (PRE) and partial factor productivity (PFP) of soybean plant under P fertilizers, bio and organic additives and their interactions.

From this previous data, it is shown that MAP showed significantly enhancement in the studied parameters compared to OSP which became the second-order and lately control treatment, these might come back to one or more the following, MAP fertilizer high content (61% as P_2O_5, 27%P), the highest water solubility (365g/L. at 20 ^{O}C) and/or pH value (4.0 to 4.5). The pH of the solution surrounding is moderately acidic, making MAP an especially desirable fertilizer in alkaline soil. In addition, the nitrogen in the ammonium form (NH^{4+}) in MAP, which resists leaching and a slower release form of nitrogen (Youssef *et al.*, 2017). As well as improves root activity and biological processes in the root zone which reflects on soil pH value that declines as activity increases.

Table 4. Impact of P fertilizers, bio with organic additives and their interactions on yield and its components of soybean plants and (plant height) at harvest stage (combined data over both seasons).

Treatments		pods weight (g plant^{-1})	Seeds weight (g plant^{-1})	Stover weight (g plant^{-1})	Weight of 100 seed (g)	Seeds yield (Kg fed^{-1})	Stover yield (Kg fed^{-1})	Plant height (cm)
					P fertilizers			
P_0		42.40c	22.66a	47.61c	18.42c	1510.74Cc	2421.82cc	79.05a
P_1		46.45b	23.35a	50.06b	18.77b	1556.35b	2481.57b	80.68a
P_2		48.15a	23.91a	51.24a	18.98a	1593.75a	2527.08a	81.75a
					Bio and organic additives			
F_1		30.25f	19.75e	42.28f	17.57f	1415.0f	2173.22f	74.33d
F_2		39.18e	21.85d	45.21e	17.92e	1476.18e	2346.94e	78.99c
F_3		42.62d	22.78cd	47.68d	18.13d	1538.77d	2511.58d	80.47b
F_4		48.13c	23.30c	50.23c	18.34c	1553.48c	2525.30c	81.12b
F_5		54.95b	25.39b	53.94b	19.81b	1692.79b	2619.21b	83.39a
F_6		58.89a	26.77a	58.49a	20.57a	1784.26a	2684.69a	84.65a
					Interaction			
P_0	F_1	27.75n	19.19h	39.73g	17.47k	1379.84m	2045.83n	70.50l
	F_2	37.85l	21.45efg	44.50e	17.87ij	1429.6k	2300.09k	78.33ij
	F_3	40.11jk	22.41de	47.30e	18.00hij	1494.67i	2486.48i	79.76hij
	F_4	41.55i	22.71de	47.37e	18.08hi	1514.11h	2491.37i	80.37f-i
	F_5	53.01e	24.97bc	52.40d	19.30e	1664.86e	2593.45e	82.33c-f
	F_6	54.16d	25.23bc	54.37c	19.77d	1681.3d	2613.66d	83.00b-e
P_1	F_1	31.13m	20.00gh	43.12f	17.50k	1448.0l	2208.16m	75.00k
	F_2	39.03k	21.98def	44.63f	17.89hij	1466.19j	2307.81k	79.00hij
	F_3	42.63h	22.95de	47.83e	18.18ghi	1530.0g	2522.70h	80.80e-h
	F_4	49.99f	23.55cd	50.96d	18.41fg	1570.24f	2542.74f	81.00e-h
	F_5	55.61c	25.33bc	54.56c	19.99cd	1688.13d	2622.94d	83.33bcd
	F_6	60.30b	26.30b	59.27b	20.67b	1752.44b	2685.06b	84.95ab
P_2	F_1	31.86m	20.05fgh	43.99f	17.75jk	1450.0l	2265.67l	77.50j
	F_2	40.66ij	22.13de	46.50e	17.99hij	1574.67j	2432.90j	79.66hij
	F_3	45.11g	22.97de	47.90e	18.21fgh	1631.63g	2525.55gh	80.85e-h
	F_4	52.84e	23.65cd	52.35d	18.53f	1676.1f	2541.78fg	82.00d-g
	F_5	56.22c	25.88b	54.87c	20.13c	1725.39c	2641.23c	84.50abc
	F_6	62.22a	28.79a	61.84a	21.28a	1919.04a	2755.33a	86.00a

P_0: Control (without addition); P_1: Ordinary superphosphate (OSP); P_2: Mono ammonium phosphate (MAP);F_1: Control (without addition); F_2: Mycorrhiza (AM) as a single treatments; F_3: Vermicompost (V) as a single treatment; F_4: Potassium humate (KH) as a single treatments; F_5: AM+V together and F6: AM+KH together.

Table 5. Impact of P fertilizers, bio with organic additives and their interactions on seed quality parameters of soybean plants(combined data over both seasons).

Treatments		N(%)	K(%)	Mg(%)	Zn(mgkg^{-1})	Fe(mgkg^{-1})	Protein(%)	Oil(%)
				P fertilizers				
P_0		5.24c	1.81b	0.70c	14.40b	35.85b	32.76c	21.50b
P_1		5.32b	1.84a	0.78b	14.82a	36.50a	33.27b	21.66ab
P_2		5.37a	1.86b	0.82a	15.05a	36.78a	33.54a	21.88a
				Bio and organic additives				
F_1		4.94f	1.63f	0.45	13.10d	33.60d	30.85f	20.93f
F_2		5.08e	1.71e	0.58	13.70c	35.17c	31.77e	21.11e
F_3		5.30d	1.81	0.74	14.43b	36.13b	33.14d	21.34d
F_4		5.38c	1.90c	0.79	14.83b	36.80b	33.63c	21.69c
F_5		5.55b	1.97b	0.97	16.00a	38.07a	34.71b	22.35b
F_6		5.61a	2.01a	1.03	16.47a	38.50a	35.04a	22.66a
				Interaction				
P_0	F_1	4.88m	1.60l	0.40o	12.90l	33.00j	30.50m	20.68k
	F_2	5.04k	1.67jk	0.55l	13.50jkl	34.90ghi	31.50k	21.06ij
	F_3	5.20i	1.78gh	0.67j	14.20g-j	35.60e-h	32.50i	21.26ghi
	F_4	5.26h	1.87ef	0.70j	14.30g-j	36.10d-g	32.88h	21.75f
	F_5	5.52de	1.96bcd	0.91f	15.60cde	37.50a-d	34.50de	22.00ef
	F_6	5.55cd	1.99abc	0.94e	15.90bcd	38.00abc	34.69cd	22.25de
P_1	F_1	4.95l	1.63kl	0.45n	13.10kl	33.60ij	30.94l	20.90jk
	F_2	5.07k	1.71ij	0.58l	13.70i-l	35.20fgh	31.69k	21.12hij
	F_3	5.35g	1.82fg	0.76i	14.50f-i	36.30d-g	33.42g	21.32ghi
	F_4	5.40f	1.90de	0.82h	14.90efg	37.00cde	33.75f	21.38gh
	F_5	5.56cd	1.97bc	0.99d	16.10a-d	38.20abc	34.75cd	22.45cd
	F_6	5.61b	2.01ab	1.06b	16.60ab	38.70ab	35.06b	22.80ab
P_2	F_1	4.98l	1.65jkl	0.51m	13.30kl	34.20hij	31.13l	21.22ghi
	F_2	5.14j	1.75hi	0.63k	13.90h-k	35.40fgh	32.13j	21.15hij
	F_3	5.36fg	1.84fg	0.79i	14.60fgh	36.50def	33.50fg	21.44g
	F_4	5.48e	1.93cde	0.86g	15.30def	37.30bcd	34.25e	21.95f
	F_5	5.58bc	1.98abc	1.02c	16.30abc	38.50ab	34.88bc	22.59bc
	F_6	5.66a	2.04a	1.10a	16.90a	38.80a	35.38a	22.94a

P_0: Control (without addition); P_1: Ordinary superphosphate (OSP); P_2: Mono ammonium phosphate (MAP);F_1: Control (without addition); F_2: Mycorrhiza (AM) as a single treatments; F_3: Vermicompost (V) as a single treatment; F_4: Potassium humate (KH) as a single treatments; F_5: AM+V together and F_6:AM+KH together.

Table 6. Impact of P fertilizers, bio with organic additives and their interactions on P %,P uptake in seed and stover, total P uptake, P use efficiencies and partial factor productivity of soybean plants(combined data over both seasons).

Treatments		P(%)		P uptake (Kg fed^{-1})			AUE	PRE	PFP
		Seed	Stover	Seed	Stover	Total	Kg Kg^{-1}	%	Kg Kg^{-1}
					P fertilizers				
P_0		0.302b	0.218c	4.60b	5.33c	9.94c	0	0	0
P_1		0.322a	0.234b	5.05a	5.86b	10.90b	7.59b	17.94b	66.94b
P_2		0.328a	0.246a	5.27a	6.27a	11.54a	9.20a	20.69a	68.55a
					Bio and organic additives				
F_1		0.272d	0.178f	3.58e	3.87e	7.46f	1.51f	3.14c	56.61f
F_2		0.315b	0.237c	4.60cd	5.58c	10.17d	4.14e	14.80b	62.63e
F_3		0.301c	0.204e	4.57d	5.12d	9.69e	6.84d	12.73bc	65.32d
F_4		0.309bc	0.223d	4.80c	5.63c	10.43c	7.47c	15.91a	66.82c
F_5		0.349a	0.270b	5.90b	7.07b	12.97b	13.46b	26.84a	72.81b
F_6		0.357a	0.285a	6.38a	7.65a	14.03a	17.39a	31.40a	76.74a
					Interaction				
P_0	F_1	0.266l	0.163l	3.40j	3.33p	6.73o	0	0	0
	F_2	0.283jkl	0.212g	4.05hi	4.88m	8.93l	0	0	0
	F_3	0.290ijk	0.199ij	4.34gh	4.95lm	9.28kl	0	0	0
	F_4	0.287i-l	0.203hi	4.35gh	5.06kl	9.40jk	0	0	0
	F_5	0.340b-f	0.257d	5.66d	6.67e	12.33d	0	0	0
	F_6	0.346a-e	0.272c	5.82cd	7.12d	12.93c	0	0	0
P_1	F_1	0.272kl	0.176k	3.63j	3.89o	7.52n	2.93k	3.40f	57.34k
	F_2	0.328d-g	0.243e	4.80ef	5.62i	10.42gh	3.71j	15.87de	62.98j
	F_3	0.303hij	0.205h	4.64fg	5.16jk	9.80ij	6.46h	13.20ef	65.81h
	F_4	0.317fgh	0.227f	4.98ef	5.76h	10.74fg	8.19f	17.25cd	67.54f
	F_5	0.351a-d	0.267c	5.93bcd	7.00d	12.93c	13.26d	26.67cd	72.61d
	F_6	0.360ab	0.287b	6.31b	7.72b	14.02b	16.03b	31.35ab	75.37b
P_2	F_1	0.278kl	0.194j	3.71ij	4.40n	8.12m	3.02l	5.98f	57.45l
	F_2	0.335c-f	0.256d	4.94ef	6.24f	11.18e	8.38i	19.14cd	63.43i
	F_3	0.310ghi	0.208gh	4.75ef	5.25j	10.00hi	10.83g	14.07ef	65.88g
	F_4	0.323e-h	0.239e	5.09e	6.07g	11.16ef	12.74e	19.05cd	67.79e
	F_5	0.355abc	0.285b	6.13bc	7.52c	13.64b	14.86c	29.72bc	74.21c
	F_6	0.365a	0.295a	7.00a	8.12a	15.12a	23.19a	36.09a	82.54a

P_0: Control (without addition); P_1: Ordinary superphosphate (OSP); P_2: Mono ammonium phosphate (MAP);F_1: Control (without addition); F_2: Mycorrhiza (AM) as a single treatments; F_3: Vermicompost (V) as a single treatment; F_4: Potassium humate (KH) as a single treatments; F_5: AM+V together and F_6:AM+KH together.

Concerning bio-organic fertilization of soybean with AM+ KH has the highest values for all the parameters mentioned above in qualities compared to other bio and organic additives because the hyphae of mycorrhizal fungi that live in the root zone emit phosphatase enzymes that were able to convert organic P into inorganic P Subsequently increasing P availability for plants. Plants fertilized with AM+V came in the second-order followed by those fertilized with KH only then V only and lately AM only, while the plants untreated with bio and organic additives recorded the lowest values of all the aforementioned traits. As regards P%, fertilizing with (AM) gave a higher value than adding (KH), (VC) and control, respectively. This is because, , mycorrhizal fungi could increase the production of hormones such as auxin and cytokinin, which can increase cell wall elasticity also prevent and slow down the aging process of roots therefore, it increase the phosphorous in the plant this reported by (Sasongko *et al*.,2019).

The highest interaction effect was produced from MAP fertilization and (AM+KH). The mean values were 0.365 P%, 0.295 P%, 7.00, 8.12 Kg P fed^{-1}, P-uptake, 15. 12 Kg P fed^{-1} total uptake for seed and stover, respectively. while the lowest values were realized with soybean plants untreated with investigated fertilizers (P0 ×F1).Highest agronomical P-use efficiencies PUE 23.19 Kg fed^{-1} ,PFP 82.54, % P- recovery(36.09 %) were achieved with MAP and (AM+KH) because of the total P uptake from organic and inorganic was highest 15.12 Kg fed^{-1} than other treatments. Soybean plants treated with humic substances as soil application gave the highest phosphorus uptake due to the increase in total dry matter plant^{-1} and nutrient content in plant parts including seeds. that were studied by (Savita *et al.*, 2018).

Fatty and phytic acids content

1- Fatty acids content

The studied fatty acids composition studies are important for accessing the quality and stability of soybean oil. Treated plants with different sources of P fertilizers showed variation in the fatty acid composition of their seeds (Table7).

Table 7. Impact the interactions between P fertilizers, bio with organic additives on fatty acids content of soybean seeds (combined data over both seasons).

Treatments	(P_2×F_1)	(P_2×F_5)	(P_2×F_6)
% Lauric acid C12:0	5.41	2.35	4.41
%Myristic acid C14:0	0.13	0.12	0.16
%Palmitic acid C16:0	11.00	11.49	11.82
%Palmitoleic acid C16:1 ω7	0.12	0.13	0.15
%Heptadecanoic acid C17:0	0.11	0.11	0.13
% Stearic C18:0	3.83	3.95	3.96
%Oleic acid C18:1 ω9	24.92	24.97	23.58
%Vaccinic acid C18:1	1.31	1.34	1.34
%Linoleic acid C18:2 ω6	47.44	49.53	48.21
%Linolenic acid C18:3 ω3	4.95	5.21	5.25
% Arachidic acid C20:0	0.30	0.30	0.34
%Gondoic acid C20:1	0.21	0.21	0.35
%Behenic acid C22:0	0.29	0.30	0.32

P_0: Control (without addition); P_1: Ordinary superphosphate (OSP); P_2: Mono ammonium phosphate (MAP); F_1: Control (without addition); F_2: Mycorrhiza (AM) as a single treatments; F_3: Vermicompost (V) as a single treatment; F_4: Potassium humate (KH) as a single treatments; F_5: AM+V together and F_6: AM+KH together.

Maximum Oleic acid (ω9) and Linoleic (ω6) was found in(P_2×F_5) treatment and minimum content was found in Control (P_2×F_1). However, (P_2×F_6) treatment exhibited a higher content of Linolenic (ω3) and some saturated fatty acids such as palmitic, Arachidic acid and Behenic acid as compared to other treatments. Krueger et al. (2013) reported that linolenic acid concentration increased with excessively P fertilization. Linolenic is a key quality attribute in soybean seed for human and animal consumption because it is an important polyunsaturated fatty acid that cannot be synthesized by human or animal (Yin et al., 2016). Therefore, a higher level of linolenic fatty acids in the oil may increase the market value of soybean seeds. These results suggest that linolenic acid concentration in soybean seed may be positively affected by P fertilization.

2-Phytic acid content

As shown in Figure 1, there was a slight difference in the phytate content of soybean seeds; were the contents ranged from 0.83 % to 1.01%. The lowest phytate content was (P_2×F_6) , and the highest was Control (P_2×F_1). (Weaver and Kannan, 2002) reported that Phytic acid chelates calcium, magnesium, potassium, iron, and zinc is rendering them unavailable to non-ruminant animals. Many phytates in diets decrease the availability of these minerals, mainly calcium, phosphorus, and zinc. Phytates also decrease the activity of enzymes (pepsin, trypsin, and amylase) as well as the availability of protein, amino acids, starch, and energy.

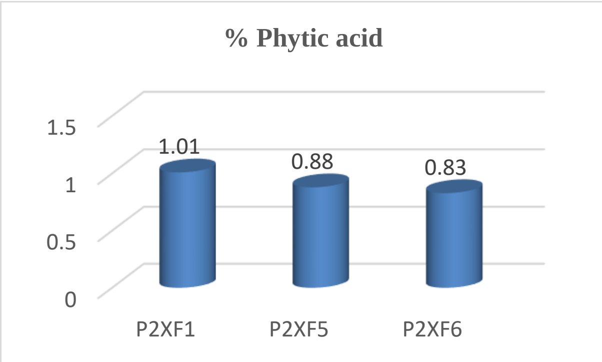

Fig. 1. *Impact the interactions between P fertilizers, bio with organic additives on Phytic acid content of soybean seeds(combined data over both seasons).*

P_0: Control (without addition); P_1: Ordinary superphosphate (OSP); P_2: Mono ammonium phosphate (MAP); F_1: Control (without addition); F_2: Mycorrhiza (AM) as a single treatments; F_3: Vermicompost (V) as a single treatment; F_4: Potassium humate (KH) as a single treatments; F_5: AM+V together and F_6: AM+KH together.

Phytic acid concentration appears to be a function of plant P status during soybean seed development. (Alamu *et al.*, 2019) demonstrated the positive relationship between nutrient P and phytic acid accumulation in rice. Phytic acid is present in soybean and most soybean products at a level of 1–1.5 g/100 g dry matter. The present results showed that the application of bio and organic fertilizers to MAP fertilizer did not significantly increase the phytic acid content in seeds under different treatments.

Soil Properties.

Available nutrients as average *i.e.* N, P and K(mg kg^{-1}), total P and inorganic P forms *i.e.*Ca-P, Al-P and Fe-P (mg kg^{-1}) as average , pH and EC (dSm^{-1}) values as average in the soil at harvest stage of soybean plants as affected by bio and organic additives, different P fertilizers are shown in Figs from 2 to 7.

a- Available N.

Available N in soil (Fig 2) after harvesting soybean plants increased over that before sowing due to all studied bio and organic additives which caused an increase in available N in soil (mg kg^{-1}), where available N of soil fertilized with AM+V was more than other additives. The soil fertilized with V alone came in the second-order followed by that fertilized with AM+KH together then KH alone and AM alone, while the available N of untreated soil slightly differed compared to pre-planting. Although MAP fertilizer contains 11% nitrogen, soils treated with OSP contain more available N than soil treated with MAP. This is may be due to that plants treated with MAP have grown better than plants treated with OSP, thus raising the uptake of N from soil under MAP more than OSP.

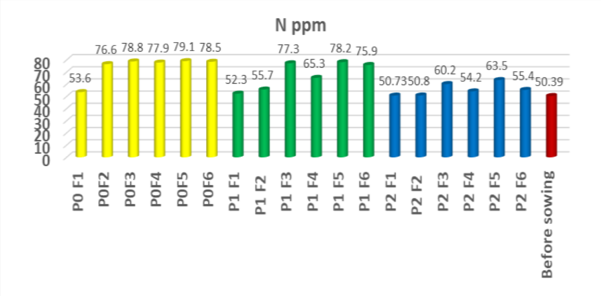

Fig. 2. Impact of P fertilizers, bio with organic additives on soil available N(mg kg^{-1}) after soybean harvest(combined data over both seasons).

IS: Initial soil before sowing; P_0: Control (without addition); P_1: Ordinary superphosphate (OSP); P_2: Mono ammonium phosphate (MAP); F_1: Control (without addition); F_2: Mycorrhiza (AM) as a single treatments; F_3: Vermicompost (V) as a single treatment; F_4: Potassium humate (KH) as a single treatments; F_5: AM+V together and F_6: AM+KH together.

b- Available P.

Available p in soil (Fig 3).after harvesting soybean plants increased over that before sowing due to all treatments, except $P_0 \times F_1$ treatment due to the plants of this treatment did not receive any P source. All studied bio and organic additives caused an increase in available P in soil (mg kg^{-1}), where available P of soil fertilized with AM+V was more than other additives..

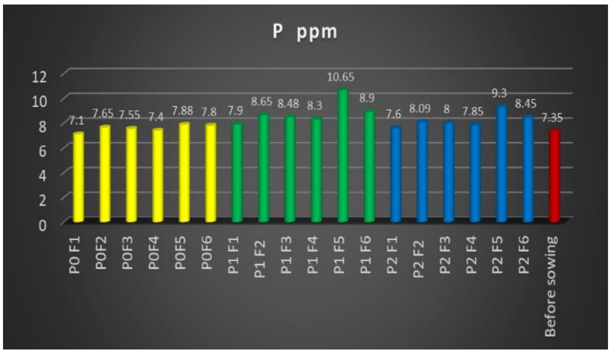

Fig. 3. Impact P fertilizers, bio with organic additives on soil available P(mg kg^{-1}) after soybean harvest(combined data over both seasons).

IS: Initial soil before sowing; P_0: Control (without addition); P_1: Ordinary superphosphate (OSP); P_2: Mono ammonium phosphate (MAP); F_1: Control (without addition); F_2: Mycorrhiza (AM) as a single treatments; F_3: Vermicompost (V) as a single treatment; F_4: Potassium humate (KH) as a single treatments; F_5: AM+V together and F_6: AM+KH together.

The soil fertilized with AM+KH came in the second order followed by that fertilized with AM then V and KH alone. Although the amount of phosphorus added from both types of P fertilizers is constant, however soils treated with OSP contain more available P than soil treated with MAP. This is may be due to that plants treated with MAP have grown better than plants treated with OSP, thus raising the uptake of P from soil under MAP more than OSP. Also, most of the phosphorus of OSP was fixed due to its addition before sowing, while the fixation under MAP was less due to two-thirds (2/3) of MAP amount were added after sowing. These results are in harmony with the obtained findings of (El-Ghamry *et al*., 2012) who reported that the best time for applying P fertilizer was after sowing of cowpea plants, where fixation of P decrease and phosphorus fertilizer use efficiency enhance

c- Available K.

Available K in soil (Fig 4) after harvesting soybean plants increased over that before sowing due to all studied bio and organic treatments which caused an increase available K in soil (mg kg^{-1}), where available K of soil fertilized with AM+KH was more than other additives.

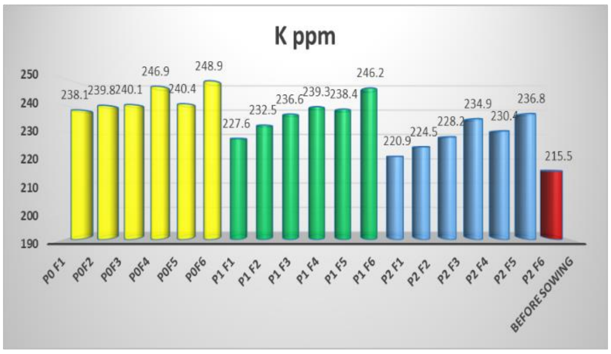

Fig. 4. Impact of P fertilizers, bio with organic additives on soil available K (mg kg^{-1}) after soybean harvest(combined data over both seasons).

IS: Initial soil before sowing; P_0: Control (without addition); P_1: Ordinary superphosphate (OSP); P_2: Mono ammonium phosphate (MAP) F_1: Control (without addition); F_2: Mycorrhiza (AM) as a single treatments; F_3: Vermicompost (V) as a single treatment; F_4: Potassium humate (KH) as a single treatments; F_5: AM+V together and F_6: AM+KH together.

The soil fertilized with KH alone came in the second-order followed by that fertilized with AM+V together then V and AM alone, respectively and lately untreated soil slightly differed. Soils treated with OSP contain more available K than soil treated with MAP. This is may be due to that plants treated with MAP have grown better than plants treated with OSP, thus raising the uptake of K from soil under MAP more than OSP.

d-Total P and its other forms (fractionations).

It is known that most of the phosphorus of soil is in a fixed form unavailable to plants. Total P, inorganic P forms *i.e*. Ca-P, Al-P, and Fe-P (Fig 5) in the soil after harvest took a reverse trend of the values of available phosphorous In other words, the treatment that caused an increase of available phosphorus in the soil at that same time caused a decrease in the values of total P, inorganic P forms *i.e.*Ca-P, Al-P, and Fe-P as a result of the conversion of fixed P to available form. Also, it is also worth noting that amount of fixed P with OSP was more than with MAP (due to the above-mentioned reasons) and this definitely reflected on all aforementioned P forms. Also, the ammonium form lower the pH in the root zone which increases the dissolution of Ca-P precipitated compound and thus enhances phosphourus availability and uptake which consequently increase the efficiency (Chien *et al.*,2011). Mycorrhiza treatments were superior in solubilizing the phosphorus present in fixed form, therefore making P more available to soybean plants..

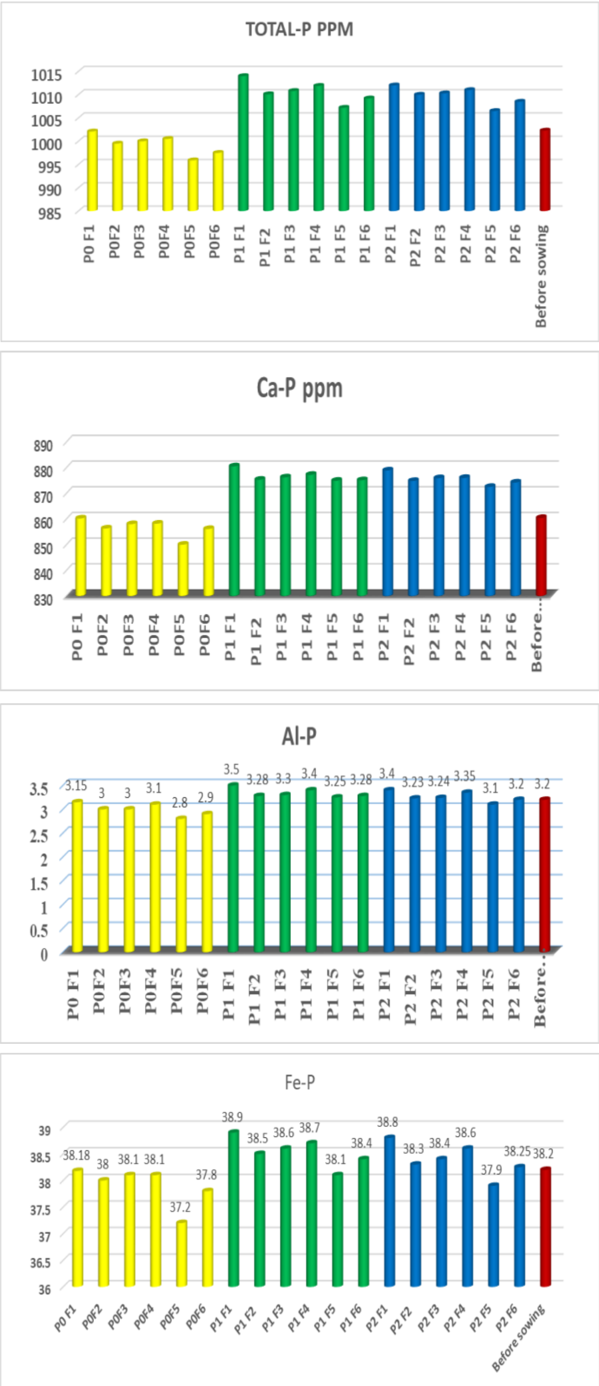

Fig. 5. Impact of P fertilizers, bio with organic additives on Total P and its other forms in soil (mg kg^{-1}) after soybean harvest(combined data over both seasons).

IS: Initial soil before sowing; P_0: Control (without addition); P_1: Ordinary superphosphate (OSP); P_2: Mono ammonium phosphate (MAP); F_1: Control (without addition); F_2: Mycorrhiza (AM) as a single treatments; F_3: Vermicompost (V) as a single treatment; F_4: Potassium humate (KH) as a single treatments; F_5: AM+V together and F_6: AM+KH together.

The addition of organic matter produces organic compounds in the soil that can increase P availability through the formation of organophosphate complexes that are easily assimilated by plants, the replacement of H_2O anions in the adsorption site, and the covering of Fe, Al oxide by humus that forms a protective layer, reduces P adsorption, and increases the amount of organic P mineralized into inorganic P (Tisdale *et al*., 1993).

e- pH value.

The studied bio and organic additives (F_2, F_3, F_4, F_5 and F_6) caused decreasing soil pH value, while control treatment caused an increase in soil pH value (Fig 6). The lowest value of soil pH was realized with AM+KH treatment followed by AM+V treatment, KH treatment, AM treatment, V treatment, control (without bio and organic addition), respectively. On the other hand, MAP fertilizer caused a decrease in soil pH value more than OSP and this may be attributed to the ability of MAP in improving plant growth and increasing activity of microorganisms that produce organic acids that decline the soil pH value.

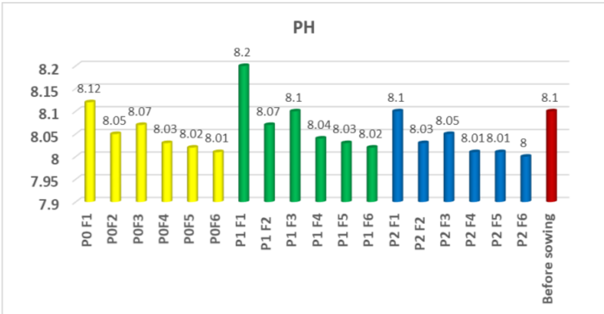

Fig. 6. Impact of P fertilizers, bio with organic additives on soil pH value after soybean harvest(combined data over both seasons).

IS: Initial soil before sowing; P_0: Control (without addition); P_1: Ordinary superphosphate (OSP); P_2: Mono ammonium phosphate (MAP); F_1: Control (without addition); F_2: Mycorrhiza (AM) as a single treatments; F_3: Vermicompost (V) as a single treatment; F_4: Potassium humate (KH) as a single treatments; F_5: AM+V together and F_6: AM+KH together.

f- EC value.

The studied bio and organic additives, except KH treatment alone, caused a decrease in soil EC value (Fig 7). Control treatment (without addition) caused an increase in soil EC value; it may be due to the fertilization process.

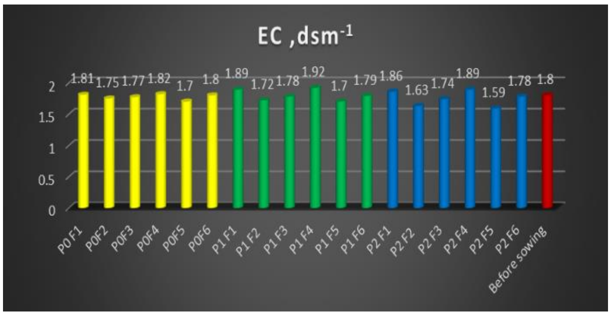

Fig. 7. Impact of P fertilizers, bio with organic additives on soil EC value (dSm^{-1}) after soybean harvest (combined data over both seasons).

IS: Initial soil before sowing; P_0: Control (without addition); P_1: Ordinary superphosphate (OSP) and P_2: Mono ammonium phosphate (MAP); F_1: Control (without addition); F_2: Mycorrhiza (AM) as a single treatments; F_3: Vermicompost (V) as a single treatment; F_4: Potassium humate (KH) as a single treatments; F_5: AM+V together and F_6: AM+KH together.

Although KH treatment alone caused a relative increase in soil EC value compared to control treatment, it has a positive effect on plant performance due to its high content from humic acid. Generally, the lowest value of soil EC was realized with AM+KH treatment. On the other hand, soil addition of both MAP and OSP causes raising soil

EC (dSm^{-1}) compared to no adding P fertilizer, but OSP fertilizer caused increase soil EC value more than MAP.

Economic Feasibility.

The highest net return of L.E. 29830 fed^{-1} was obtained from the application of KH+AM and MAP as combined treatment followed by application of KH+AM and OSP (L.E 26875 fed^{-1}) as combined treatment, while the lowest net return of L.E. 16152 fed^{-1} was obtained from the application of vermicompost alone without P fertilizers (Table 8) and this may be attributed to the high cost of vermicompost (perpetration, transport and labor).

Table 8. Economic profitability of different treatments..

Treatments		Total cost, L.E	Gross return, L.E	Net return, L.E	B:C Ratio
P_0	F_1	9124	25935	16811	1.84
	F_2	9184	27498	18314	1.99
	F_3	11624	27776	16152	1.39
	F_4	9204	30281	21077	2.29
	F_5	11684	30633	18949	1.62
	F_6	9260	31976	22716	2.45
P_1	F_1	9274	30043	20769	2.24
	F_2	9334	31005	21671	2.32
	F_3	11774	31685	19911	1.69
	F_4	9354	32797	23443	2.51
	F_5	11834	34470	22636	1.91
	F_6	9414	36289	26875	2.85
P_2	F_1	9687	32407	22720	2.35
	F_2	9744	33258	23514	2.41
	F_3	12184	34814	22630	1.86
	F_4	9764	35273	25509	2.61
	F_5	12244	36069	23825	1.95
	F_6	9824	39654	29830	3.04

P_0: Control (without addition); P_1: Ordinary superphosphate (OSP) ; P_2: Mono ammonium phosphate (MAP); F_1: Control (without addition); F_2: Mycorrhiza (AM) as a single treatments; F_3: Vermicompost (V) as a single treatment; F_4: Potassium humate (KH) as a single treatments; F_5: AM+V together; F_6:AM+KH together; B: C=benefit : cost.

Also, the gross return to total cost ratio (benefit: cost) was ranged from 1.39 to 3.04 profits fed^{-1}. Therefore, the application of mycorrhiza + potassium humate + MAP was economically feasible and recommended for soybean production in the Nile Delta region, Egypt.

CONCLUSION

Obtained results of the current research illustrate that treating soybean c.v Giza 111' with mycorrhiza + potassium humate as combined treatment under P fertilization with mono ammonium phosphate was economically feasible and recommended to obtain the best growth parameters, yield, and seed quality in the Nile Delta region and other areas with similar agro-climate conditions.

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تحسين كفاءة التسميد الفوسفاتي مع الاضافات الحيوية والعضوية علي النمو وجودة البذور وانتاجيه فول الصويا.

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تم إجراء تجربتين حقليتين بمزرعة تاج العز التجريبية بمحطة البحوث الزراعية بمحافظة الدقهلية ، مصر ، خلال موسمين صيفيين متتاليين لعام 2019و 2020 لدراسة تأثير مصادر الفوسفور المعدنية المختلفة والأسمدة الحيوية والعضوية المختلفة كمعاملات مشتركة على أداء النمو والانتاجيه الكميه والنوعيه لنباتات فول الصويا صنف جيزة 111. تم استخدام تصميم القطعة المنشقة بثلاث مكررات تمثل في ثلاث مصادرمن الاسمدة الفوسفاتيه (االكنترول ، السوبر فوسفات العادي، والمونو امونيوم فوسفات) باعتبارها القطع الرئيسية ، وسته معاملات حيوية وعضوية (الكنترول,فطرالميكروهيزا،الفرميكومبوست،هيومات البوتاسيوم, (الميكروهيزا+الفيرميكبوست) و(الميكروهيزا+هيومات البوتاسيوم)) كمعاملات منشقه. تم جمع النتائج بايجاز علي النحو التالي:- اعطي سماد المونوامونيوم فوسفات اعلي قيم للنمو الخضري والمحصول ومكوناته وجودة البذور مقارنه بـالسوبر فوسفات العادي اوالكنترول. - واعطت اضافه (الميكروهيزا + هيومات البوتاسيوم) افضل الصفات المذكوره اعلاه مقارنه بالاضافات الحيويه والعضويه الاخري حيث جاءت النباتات المخصبة بـ (الميكروهيزا + الفيرمي كمبوست) في المرتبة الثانية تليها (هيومات البوتاسيوم) ثم (الفيرمي كمبوست) ومؤخراً (الميكروهيزا) وحدها. -كان الجمع بين المونوامونيوم فوسفات و(الميكروهيزا + هيومات البوتاسيوم) هو افضل معامله تأثيرا على جميع الصفات المدروسة مقارنة بالمعاملات الاخري وتم تحقيق اعلي قيم كفاءه استخدام الفوسفور وكذلك نسبه (الفائده : التكلفه)عند هذا التفاعل. - تحسنت معنويا صلاحيه العناصر(نيتروجين,فوسفور,بوتاسيوم) في التربه بعد حصاد فول الصويا وكذلك قيم pHالرقم الهيروجيني للتربه نتيجة دمج الأسمدة غير العضوية مع الأسمدة الحيوية والعضوية.