Journal of Soil Sciences and Agricultural Engineering

Journal homepage & Available online at: www.jssae.journals.ekb.eg

Effect of Biofertilization , Potassium Humate and Rates of NPK Fertilization on Growth, Yield and Economic Indicators of Soybean.

Hayam A. El-Shaboury[1*] and E. A. E. Elnefili[2]

[1]Soils, Water and Environment Res. Inst., Agric. Res. Centre, Giza, Egypt
[2]Agricultural Economics Res. Inst., Agric. Res. Centre, Giza, Egypt

Cross Mark

ABSTRACT

Land pollution due to the use of chemical fertilizers, and trying to use materials that do not have harmful effects on the environment, so this present study was conducted to evaluate the effect of biofertilization as arbuscular mycorrhiza fungi (MF) , potassium humate (KH) and rates of N, P and K fertilization on the growth , yield and economic indicators of soybean plants,in a private farm during the summer seasons 2021 and 2022. In randomized complete block design, the experimental was consisted of 3 replicates. The treatments were control treatment (100 % NPK of the recommended) , 75 % NPK , 75% NPK + MF, 75% NPK+ KH , 75 % NPK+ MF + KH , 50 % NPK , 50 % NPK+ MF, 50% NPK+ KH, 50 % NPK+ MF + KH . The obtained results indicated that, The addition of 75 % NPK+ MF + KH attained the highest values of plant growth , yield , nutrients uptake and net return compared to Control treatment100 % NPK. In this treatment increases of 13.93 , 17.57 , 36.71% were reached for seed N, P and K uptake, respectively. While seed yield and net return the increases were 9.44 , 64.96 % , respectively. Generally, the application of mycorrhiza fungi (MF) and potassium humate (KH) with 75 % NPK recommended dose attained the best results for all aforementioned characteristics in both seasons as well as saved 25 % of NPK requirement and maximize the net return for soybean plants by safe natural sources .

Keywords: Mycorrhiza fungi , potassium humate , NPK fertilization , soybean yield and economic indicators.

INTRODUCTION

The soybean crop is one of the important agricultural crops, as it is classified as one of the most important sources of vegetable protein because it contains the essential amino acids necessary for human growth. Egypt suffers from a large gap in the availability of soybeans, as the annual average available for local consumption reached about 3,852 thousand tons, as an average for the period 2018-2020, local production contributed about 39.7 thousand tons, representing about 1% of the available, while imports amounted to about 3812 thousand tons, representing About 99% (Central Agency for Public Mobilization and Statistics), which constitutes a major challenge to Egyptian food security in light of rapid international changes that impose random restrictions on international trade, recently represented by the Covid-19 pandemic and the Russian-Ukrainian crisis. As for the current production situation of soybeans in Egypt, the cultivated area has decreased from about 36.2 thousand feddans with a production of about 43.3 thousand tons in 2010 to about 30 thousand feddans with a production of about 36.0 thousand tons in 2020, a decrease of about 17.3% (Ministry of Agricultural and Land Reclamation). Data on the production of biofertilizers indicate that the annual average production of biofertilizers in Egypt amounted to about 86.7 thousand bags of powdered fertilizers, in which microbene, biohumin, potassium, risobactrin, phosphorine, tropin, ceraline and eugen contributed by about 58.1% , 12.3% , 10.0% , 7.7% , 5.0 % , 2.5% , 2.3% , and 2.1% , respectively, and about 10.6 thousand liters of liquid fertilizers, to which the microbial and eugen fertilizers contributed about 63.8% and 36.2% , respectively (Ministry of Agricultural and Land Reclamation).

The mineral fertilizers play pivotal roles in plants growth and productivity. Nitrogen plays an important role to synthesis of chlorophyll, enzymes and proteins . Phosphorous plays a vital role in the process of photosynthesis, and it can enhance the leaf area, cell division, nitrogen fixation, and chlorophyll formation. It can also increase the number of nodules and cell divisions, and it can improve the nitrogen fixation capacity of legumes and Potassium plays essential role in controlling the stomatal guard cells of leaves, enhancing the translocation of assimilates and the promotion of enzymes activity (Fouda *et al.*, 2017).

Mycorrhiza fungi extraradical hyphae can cross the nutrient depletion zone adjacent, to the plant root and thus improve the immobile elements availability as P, Zn and Cu by translocating them from remote locations through MF hyphae to the plant roots, besides mobile elements as N (Grant *et al.*, 2005). The widespread symbiosis between MF and the roots of the hosted plants has several positive effects, including an improvement in nutrition and an increase in nitrogen fixation (Antunes *et al.*, 2006).

Mycorrhiza colonisation improves nutrient uptake, especially when NPK fertiliser concentrations are low (Abdel-Fattah *et al.*, 2016).The inoculation with mycorrhiza of plants significantly contribute to a sustainable production of crops (Eulenstein *et al.*, 2017). Sasongko *et al.*, (2019) suggested that colonization of soybean plants with MF improved biomass, growth and increas P uptake in plant roots because the hyphae of MF that dwell in the root zone also

*** Corresponding author.**
E-mail address: hayamelshaboury123@gmail.com
DOI: 10.21608/jssae.2023.182034.1123

produce phosphatase enzymes capable of converting organic P into inorganic P, hence boosting P availability for plants.

Potassium Humate is organic compound when sprayed that can improve crop growth and seed quality characteristics and saved 25 % of N requirement for soybean plants (Nassar *et al.,* 2021) . Verlindern *et al.,* (2009) indicated that humic substances enhance enzyme activities, hormonal activity in plant and water holding capacity, therefore increasing plant yield and nutrient uptake. combining organic and mineral inputs is most cost-effective for soybean crops (Vanlauwe and Zingore, 2011). However, Gad El-Hak *et al.,* (2012) revealed that foliar spraying of humate substances promote the penetration of nutritive ions in the leaves, stimulated the creation of some physiologically active metabolic chemicals, and increased the capacity of plants for root absorption. Further, Mohajerani *et al.,* (2016) and Yousif *et al.,* (2019) reported that foliar spraying with humic acid considerably enhanced all morphological characteristics, yield components, and nutrients content .

The objectives of this study are to determine the impact of arbuscular mycorrhiza fungi (MF) and potassium humate (KH) on growth, yield and economic indicators of Soybean and to gives best combination of bio and organic with mineral fertilizers .

MATERIALS AND METHODS

This investigation was conducted at a special farm on the village of Tanboul El-Kobra , Al-Senbilawin , Dakahlia Governorate , Egypt , (31º 11' 33.43' E , 30º 1' 36.16' N) during summer seasons of 2021 and 2022 to study the effect of Mycorrhizal fungi (MF) , potassium humate (KH) and different rates of N, P and K fertilization doeses on growth, some chemical constituents, yield and economic indicators of Soybean plants . The experimental design was randomized complete block design (RCBD) with three replications. The experimental area consisted of 27 plots. The plot area was 10.5 m^2 (3m ×3.5m). The treatments were Control treatment(100 % NPK of the recommended), 75 % NPK , 75% NPK + MF, 75%NPK+ KH , 75 % NPK+ MF + KH , 50 % NPK , 50 % NPK+ MF, 50 % NPK+ KH , 50 % NPK+ MF + KH .

Soil physical and chemical status of the experimental site were determined according to Haluschak (2006) and Reeuwijk (2002) as shown in Table (1).

Soybean seeds (*Glycine max* L., cv. Giza 111)were obtained from Field Crops Research Institute, ARC, Giza, Egypt and were planted in the mid of May for the two successive growing seasons under investigation.

Mineral fertilizers application, 100 % of the recommended dose of NPK application rates (30 kg N fed^{-1} , 23.25 kg P_2O_5 fed^{-1} and 24 kg K_2O fed^{-1}) according to recommendation by the Ministry of Agriculture and Soil Reclamation . The fertilizers source and a broadcast were ammonium sulphate before the first and second irrigations (20.6% N) , calcium superphosphate during the soil preparation (15.5% P_2O_5) and potassium sulphate with the second irrigation (48% K_2O). The other customary soy agronomic practises were used.

Mycorrhizal fungi vaccine was brought from Microbiology Department of Soil, Water and Environment Research Institute , ARC, where inoculated with soybean seeds at rate of 2 bags per acre before sowing .

Table 1. Some experimental soil characteristics before planting for the two studied seasons.

Soil characters		Growing Season	
		1^{st}	2^{nd}
Practical size distribution (%)	Coarse sand	3.68	3.59
	Fine sand	22.25	22.06
	Silt	44.59	44.70
	Clay	29.48	29.65
	Texture class	Clay loam	Clay loam
EC (dSm^{1}) (1:5)		0.95	0.93
pH (1:2.5)		7.91	7.89
S.P %		63.1	62.7
O.M %		1.45	1.37
$CaCO_3$ %		2.09	1.98
Soluble ions meq L^{-1} (1:5 soil : water extract)			
Cations			
Na^+		3.18	3.21
K^+		0.61	0.65
Ca^{++}		3.93	3.76
Mg^{++}		1.82	1.72
Anions			
CO_3^{--}		0	0
HCO_3^-		1.91	1.82
Cl^-		3.58	3.45
SO_4^{--}		4.05	4.08
Available macro and micro-nutrients ($mg\ kg^{-1}$)	N	52.4	51.9
	P	5.95	5.89
	K	181.9	182.6
	Fe	2.96	2.88
	Zn	0.90	0.87
	Mn	1.34	1.30

Potassium hamate solution containing 10 % K_2O was obtained from Plant Nutrition and Soil Fertility Res. Depart., ARC, it was added as foliar spray with 1 % KH solution in a 200 L fed^{-1} volume at 30 and 45 days after sowing .

After 60 days from planting, ten plants were randomly chosen from each plot to measure plant height (cm), number of branches/plant, and chlorophyll a , b and carotenoids in the fourth leaves (mg g^{-1} fresh weight) was measured by spectrophotometric method of (Gavrilenko and Zigalova 2003) . The samples were oven dried at 70 °C till constant weight to calculate fresh and dry weights of the whole plants.

At maturity, the soybean plants were harvested in the middle September of the two seasons. Random plant samples were taken from each plot to record pods weight (g $plant^{-1}$),100 seed weight (g) , concentrations of NPK (%) in soybean seeds and stover were determined in wet digested extract using the methods described by Mertens (2005 a and b). Then , nutrients uptake was calculated as the following:

$$\text{Nutrients uptake} = \textit{Nutrient concentration} \times \text{dry weight} / 100$$

In addition, seed protein and oil percentages were estimated according to A.O.A.C. (2000) . Seed and stover yields (Kg fed^{-1}) and harvest index ,which was determined according to the following equation :

$$\text{Harvest index (\%)} = \frac{\textit{Seed yield}}{\textit{Biological yield (Seed yield + Stover yield)}} \times 100$$

The study relied on the statistical comparison between the treatments under study during the summer seasons 2021 and 2022 to show the reality of the changes occurring in the productivity indicators of the soybean crop, by testing the significant differences between the estimates of those indicators, for this purpose, the least significant difference LSD test was used at a significant level (0.05).

The least significant difference (LSD) test is used in the context of the analysis of variance, The test consists in a pairwise comparison of the means. In general terms, the standard deviation of the difference between the mean of group i and the mean of group j, for $i \neq j$, is equal to

$$\sqrt{s_i^2\left(\frac{1}{n_j}+\frac{1}{n_j}\right)}$$

where s_i^2 is the estimation of the variance inside the groups

$$s_i^2=\frac{SCI}{N-K}=\frac{\sum_{i-1}^{K}\sum_{j-1}^{ni}\left(Y_{ij}-Y_i\right)}{N-K}$$

where SCI is the sum of squares inside the groups, N is the total number of observations, k is the number of groups, Y_{ij} is the jth observation of group i, $\overline{Yi}$ is the mean of group i, n_i is the number of observations in group i, and n_j is the number of observations in group j.

The quantity $\sqrt{s_i^2\left(\frac{1}{n_j}+\frac{1}{n_j}\right)}.t_{N-K,1-\frac{\infty}{2}}$ is called the LSD.

While for the economic analysis of the results of using the treatments under study, many economic indicators were used as follows:

- Total costs: The sum of the costs of production inputs used in the production of the soybean crop.
- Total revenue: The sum of the return obtained from selling both the primary production (grain) and the secondary production (straw).

Net return: Total return - total costs.

Margin over variable costs = total return - total variable costs.

Benefit Cost Ratio (BCR): total return / total costs.

RESULTS AND DISCUSSION

Soybean growth

Effect of soil application of mineral fertilization at different rats, inoculation with MF and foliar application of potassium humate on soybean during growth stage are present in Table (2) . Plant height , number of branches / plant , fresh weight , dry weight, chlorophyll a , b and carotenoid were significantly affected by all treatments , with increasing NPK fertilization mentioned parameters were increased especially with treatment inoculated with mycorrhiza fungi (MF) and foliar application by potassium humate (KH) . From the data tabulated in Table (2) , it was found that soil application of NPK at 75% and inoculated with MF as well as foliar application with potassium humate significantly recorded the highest mean values of mentioned parameters over other treatments and comparing to the full dose of mineral fertilization (100% NPK).

The availability of micro- and macronutrients to plants during the vegetative stage is crucial, and this availability was made possible by the quicker release of nutrients from chemical fertilizer (Meng *et al.,* 2005). Because of the development of cell elongation in the meristematic area and rapid cell division of the plant, nutrient supply plays a crucial role in vegetative growth of plants. Additionally, proteins, nucleic acids, and co-enzymes all contain a significant amount of nitrogen. Phosphorus also plays a crucial function in the number of enzymatic reactions, the enhancement of nodulation, the expansion of the root system epidermal osmotic adjustment, and the growth of plant photosynthesis. While some enzymes are activated by potassium, and K^+ ions are crucial in controlling the stomatal guard cells of leaves, photosynthesis is also boosted by cell division, elongation, and the metabolism of carbohydrates and protein molecules. This has the support of (Raihan *et al.*, 2021).

Plant vitality is severely impacted by mycorrhizal symbiosis (Patharajan and Raaman, (2012) Table (2) demonstrated that compared to un-inoculated soybeans, applying MF significantly increased plant vegetative growth and pigment content. This may be because the MF application's response causes the roots to grow better, which can boost the intake of water and nutrients used in the plant's body's metabolic process and stimulate plant height growth (Utomo, 2010). In addition, this is because the roots of plants infected with MF can more efficiently utilize phosphorus and nitrogen in the soil, thus promoting the growth and development of plants and increasing the biomass (Alori *et al.,* 2017). MF application to soy-bean plants resulted in a much higher number of leaves than the control treatment, according to study by Yudhiarti *et al.*, (2020). Mycorrhiza can help plants absorb more nutrients, particularly P, which is crucial for the process of photosynthesis. Similar findings were made by Adeyemi *et al.*, (2020), who discovered that employing the commercial MF inoculant could enhance soybean growth and yield in the presence of favourable environmental factors.

The beneficial effects of potassium humate on plant growth parameters and photosynthetic pigments can be explained by the fact that humic substances can influence plant growth physiological processes either directly or indirectly by promoting nutrient uptake, influencing biochemical substances, carrying nutrients and growth regulators, and acting as hormone-like substances (Verlindern *et al.,* 2009). However, (Wang *et al.,* 2015; Ismail *et al.,* 2017 and Dawood *et al.,* 2019) also credited the beneficial effects of potassium on osmoregulation, photosynthesis, transpiration, opening and closing of stomata, protein synthesis, and translating of assimilates into sink organs for the enhancing impact of potassium humate. These findings demonstrated how effective KH is at improving photosynthetic efficiency by raising the concentrations of chlorophylls a, b, and carotenoids. The high-efficiency KH, which activates photosynthesis-related enzymes and improves the Mn and Fe absorption necessary for the formation of chlorophyll (El-Ghamry *et al.*, 2009), may be responsible for this improvement.

Many other reports support our obtained results such as El-Mekawy (2019) indicated that MF are crucial for enhancing common bean yield production and growth while reducing the use of NPK chemical fertilizers. Compared to untreated plants and other treatments, mycorrhiza common bean plants growth characteristics were noticeably greater, especially at 50 % NPK fertilizers. Also, the content of photosynthetic pigments in leaves of common bean treated with soil mycorrhizal plants was significantly higher than other treatments of foliar application under 50 % from NPK. In addition our results agree with El-Mahdy and Anwar (2020) ; Nassar *et al.,* (2021) and Attia and Sary (2021).

Table 2. Mean effect of varying levels of NPK , mycorrhiza and potassium humate on growth of soybean plants.

Treatments	Photosynthetic Pigments (mg g^{-1} F. W)			Plant height (cm)	No. of branches $plant^{-1}$	Plant Weight (g)	
	Chl.(a)	Chl.(b)	Carotenoids			Fresh	Dry
100 % NPK	0.576 d	0.372 d	0.782 d	84.67 ba,bc	6.56 bc	280.03 cb	38.61 dc,db
75 % NPK	0.531 gf	0.327 fg,fh	0.691 h	76.33 ef	5.02 fe,fg	241.17 fe,fg	32.80 fe,fg
75%NPK + MF	0.622 c	0.391 c	0.798 cb	80.85 d	5.68 dc,de	270.40 d	37.07 cb,cd
75%NPK+ KH	0.635 b	0.405 b	0.807 bc,ba	83.93 cb	6.15cb,cd,ce	285.30 bc	39.31 ba,bc,bd
75%NPK+ MF + KH	0.670 a	0.416 a	0.816 ab	85.98 ab	7.43 a	296.47 a	41.37 ab
50 % NPK	0.518 i	0.306 i	0.673 i	67.52 i	3.63 i	215.70 i	27.91 ih
50% NPK+ MF	0.531 hf,hg	0.323 hf	0.74 gf	70.81 h	4.29 hg	227.10 h	29.23 hi
50% NPK+ KH	0.539 fe,fg,fh	0.332 gf	0.749 fg	72.69 g	4.9 gf,gh	236.20 gf	31.98 ge,gf
50%NPK+ MF + KH	0.545 ef	0.342 e	0.76 e	75.03 fe	5.54 ef	244.83 ef	33.51 ef,eg
L.S.D $_{0.05}$	0.007	0.004	0.006	0.837	0.343	3.72	1.32

- **MF: Mycorrhiza fungi and KH: Potassium humate.**
- **The values refer to the average of observed values of measurement variables at different treatments under study to both seasons, while the letters indicate to the order of those averages in descending order from the largest (a) to the smallest (i) ,**
- **The single letters indicates significant of the difference between the treatments, while the correlation between them indicates the insignificant.**

Seed and stover nutrient uptake

Our results of N, P and K nutrient uptake of seed and stover as affected by soil addition of NPK, inoculation with MF and foliar application of potassium humate were recorded in Table (3). The increase of soil fertilization from NPK doses increased N, P and K-uptake by seed and stover. In addition the mycrorohiza soybean plants had higher uptake of nutrient than those of non- mycorhiza plants particularly at 50 and 75% doses of NPK fertilizers. Also, soybean plants foliared with potassium humate increased nutrient uptake by seed and stover comparing to the other treatments. As indicated in the same Table highest N, P and K uptake of seed and stover were recorded in potting mixtures 75 % NPK+ MF + potassium humate, while the lowest mean values with treatment 50 % NPK.

Due to its potential for assimilation, the majority of soil nitrogen produced by mineral fertilizer will take the form of nitrate and be readily available to plants in large quantities. The nutrient P helps the root system grow better, which increases the root's ability to absorb more nutrients. Wile, the involvement of K from K_2So_4 in nutrient uptake and nutritional balance may be attributable to an increase in photosynthesis, but it may also be related to the role of S, which helped to lower soil pH values and consequently made it easier for the roots of soybeans to absorb nutrients (Attia and Sary, 2021).

Nassar *et al.*, (2021) indicated that the superiority effecte of K. humate foliar spraying method may be due to stimulating of leaf area and water retention ,impacting as an activator for physiological respiration, photosynthesis , nutrient uptake, cationic exchange capacity, protein synthesis , antioxidant metabolism and enzyme activities.

Mycorrhiza colonization improves nutrient uptake, especially when NPK fertilizer concentrations are low. Our findings concur with those of Khalil and Yousef (2014). Abdullahi and Sheriff (2013) and Abdel-Fattah *et al.,* (2016) who reported that nutrients were taken up by the hyphae to the plants, leading to a very efficient mobilization and uptake of phosphate, nitrogen, potassium, magnesium, and other elements that were transported to the plant. Mycorrhiza enhances the uptake of P sources that are weakly soluble, which helps to facilitate the availability of this element. In general, mycorrhiza's positive effects on soybean plant growth have been linked to an increase in the absorption of immobile minerals, particularly phosphorus (P). This effect is partially because certain of these fungi may mobilize soil nutrients that are unavailable to the roots of plants, and partly because of the vast surface area of fungal hyphae, which are considerably longer and finer than plant root hairs can enhance the plant's capacity to absorb minerals. These outcomes line up with El-Mahdy and Anwar (2020).

Application of KH can influence soybean plants' nutritional status both directly and indirectly. According to Dawood *et al.* (2019),credited the favourable effects of potassium on osmoregulation, photosynthesis, transpiration, the opening and closing of stomata, protein synthesis, and the translation of assimilates into sink organs for the enhancement effect of KH. In addition, the absorption of nutrients is significantly influenced by humic compounds (Ibrahim and Ali, 2018).

As a result, El-Mekawy(2019) observed that treated common bean plants with mycorrhiza with 50 % NPK fertilizers had much higher nutritional levels (N, P, K, Ca and Mg) than other plants and untreated plants.

Table 3. Mean effect of varying levels of NPK , mycorrhiza and potassium humate on nutrient uptake of seed and stover of soybean crop.

Treatments	uptake (Kg fed^{-1})					
	Seed			Stover		
	N	P	K	N	P	K
100 % NPK	75.15 cb	3.7 db,dc	22.42 c	28.71 cb,cd	4.1 dc	16.26 cd
75 % NPK	59 g	2.7 e	15.95 gf	23.69 fe,fg	3.11 fg,fh	12.57 fe
75%NPK + MF	70.09 d	3.74 cb,cd	20.41 d	27.57 dc	4.41 bc	15.56 dc
75%NPK+ KH	76.95 bc	3.78 db,dc	26.40 b	29.9 bc	4.3 cb	17.57 b
75%NPK+ MF + KH	85.62 a	4.35 a	30.65 a	34.92 a	5.31 a	20.2 a
50 % NPK	47.83 i	1.53 i	10.59 i	17.64 i	2.45 i	7.34 i
50% NPK+ MF	55.37 h	1.99 gh	13.45 h	20.34 h	3 gf,gh	9.06 h
50% NPK+ KH	63.52 fe	1.96 hg	16.47 fg	22.57 gf	2.91 hf,hg	11.19 g
50%NPK+ MF + KH	65.91 ef	2.37 f	18.47 e	24.01 ef	3.52 e	13.19 ef
L.S.D $_{0.05}$	1.597	0.088	0.882	0.761	0.132	0.557

MF: Mycorrhiza fungi and KH: Potassium humate.

Yield components and quality parameters:

Results in (Table 4) show that the yield components involved pods weight, 100 seed weight, seed yield, stover yield and harvest index as well as different quality parameters include; protein% and oil % of NPK soil doses, inoculation with MF and foliar application by potassium humate were significantly increased. Both of yield components and quality parameters increased gradually with increasing doses of NPK fertilizers up to 75% with plants inoculated with MF comparing to the non-inoculated. Also, foliar application of potassium humate increased all previous parameters especially with plants inoculated with MF under mineral fertilization. In this concept, the highest mean values of mentioned parameters scored with addition of 75 % NPK+ MF + KH in comparing to the full dose of NPK (100 %) which recorded medium values, while the lowest values indicated with 50 % NPK fertilization.

The availability and solubility of mineral fertilizer (NPK), which is easily absorbed by plants, may have contributed to an increase in soybean production. Additionally, the addition of NPK to the soil increases the amount of nutrients that are available in the rooting zone, which increases the capacity of plant roots to absorb additional nutrients into plant tissues (Attia and Sary, 2021).

This is due to the fact that mycorrhizal fungi may boost the synthesis of hormones like auxin and cytokinin, which can increase cell wall flexibility and stop or slow down the ageing process of roots, this was reported by (Sasongko et al., 2019).

In comparison to the control treatments, the application of NPK fertilisers to the infected mycorrhiza plants significantly increased the yield components, especially at 75% of NPK fertilizers. These findings concur with those made by (Millar and Ballhorn 2013 and Parial et al., 2014), who found that plants treated with 75% fertilizer and MF had higher yields than plants treated with 75% fertilizer alone and were nearly comparable to plants treated with 100 % fertilizer alone.

Inoculating seedlings with MF, as demonstrated by Abdel-Fattah et al., (2016), increased yield while using only 25% of the recommended NPK dose. With rising NPK concentrations in the soil, the mycorrhiza colonization of common bean plants rapidly declined. However, compared to other concentrations, a much higher were seen in common bean plants grown in 50% or 75% concentrations of NPK. Mycorrhiza colonization was not seen in the untreated group. Improved nutrient uptake by MF colonization can affect the yield-related factors of common bean plants.

Increased levels of endogenous cytokinins and auxin, which most likely result in improved yield, may be the primary cause of humic acids' beneficial effects on yield components (Moraditochaee, 2012). Moreover, the use foliar spraying of humic acid increased the leaf area and provided more photosynthetic material that helps in packing the grains which can increase the yield (Mohajerani, *et al.* 2016). Also, the increased leaf area, which allows for improved light and air penetration and consequently increases the number of metabolites in the plant tissues, may be to blame for the rise in yield and its constituent parts. These effects had a favourable effect on the growth and yield of soybeans (Hemida *et al.*, 2017). The enhanced output could be attributed to the plants' stimulation by humic acid, which improves plant performance. Utilizing humic acid increases plant metabolism, nutrient uptake, and translocation inside the plant, as well as the efficiency of photosynthetic activities, increasing overall production (Dawood *et al*., 2019).

Table 4. Mean effect of varying levels of NPK , mycorrhiza and potassium humate on quality parameters yield attributes of soybean crop.

Treatments	Yield and its components					Quality parameters (%)	
	pods weight (g plant^{-1})	100 seed weight (g)	Yield (Kg fed^{-1}) Seed	Stover	Harvest index (%)	C. Protein	Oil
100 % NPK	53.07 dc,de	17.76 b	1462 cd,cb,ce	2343 cb,cd,ce	38.42 ca,cb,cd,ce	34.56 ba, bc	19.81 cb
75 % NPK	44.26 hg	16.47 e	1229 gh	2103 hi	36.89 gf	32.38 fd,fe,fg	18.73 fe
75%NPK + MF	55.15 cb,cd	17.08 d	1419 dc,de	2302 eb,ec,ed,ef	38.13 db,dc,de,df	33.06 dc,de,df	19.38 d
75%NPK+ KH	57.00 bc	17.43 c	1500 bc	2360 bc,bd,be	38.86 ba,bc,bd,be	34.06 cb,cd	20.05 bc
75%NPK+ MF + KH	60.85 a	18.21 a	1600 a	2500 a	39.03 ab,ac,ad	35.44 a	20.84 a
50 % NPK	39.07 i	14 i	1090 i	2059 ih	34.61 i	29.63 ih	16.72 i
50% NPK+ MF	47.26 gf,gh	14.39 h	1218 hg	2175 g	35.9 h	30.63 hg,hi	17.31 h
50% NPK+ KH	49.37 fe,fg	14.72 g	1347 f	2264 fd,fe	37.3 fd,fe,fg	31.81 ge,gf, gh	17.95 g
50%NPK+ MF + KH	51.59 ed,ef	15.13 f	1410 ec,ed	2304 db,dc,de,df	37.96 eb,ec,ed,ef	32.56 ef,ed,eg	18.82 ef
L.S.D $_{0.05}$	1.754	0.088	30.667	33.627	0.509	0.646	0.132

MF: Mycorrhiza fungi and KH: Potassium humate.

The economics of soybean production according to a sample field study:

The data in the Table (5) indicate that the total cost of producing soybean was about 7,640 pounds, the variable cost was about 4,940 pounds, which represented about 64.7% of the total cost, included each of, the cost of seeds by about 220 pounds, at about 2.9% of the total cost, the cost of automated work by about 1,320 pounds, about 17.3%, the cost of nitrogen fertilizers by about 600 pounds, about 7.9%, the cost of phosphate fertilizers by about 250 pounds, about 3.3%, the cost of pesticides by about 300 pounds, about 3.9%, the wages of workers by about 2,250 pounds, about 29.5%. While the fixed costs was about 2,700 pounds, which represented about 35.3% of the total cost, included each of the rent, about 2,500 pounds, by about 32.7% of the total cost , and petty cash reached about 200 pounds, about 2.6%. The table also shows that the yield of soybean crop was about 1.26 tons, and the average price per ton of the crop amounted to 8000 pounds, with a return of about 10240 pounds / feddan for the main crop, while the value of the secondary crop reached about 800 pounds / feddan, with a total return of about 11,040 pounds / feddan.

Table 5. The most important items of costs and return for the soybean crop in the sample of the field study in 2021and 2022.

Item		value	% of total
variable cost	seeds	220	2.9
	automated work	1320	17.3
	nitrogen fertilizers	600	7.9
	phosphate fertilizers	250	3.3
	pesticides	300	3.9
	wages of workers	2250	29.5
	Total	4940	64.7
fixed costs	rent	2500	32.7
	petty cash	200	2.6
	Total	2700	35.3
total cost		7640	100
the yield (ton)		1.26	
Price		8000	
Value of production	main crop	10240	
	secondary crop	800	
Total return		11040	

Source: collected and calculated from the questionnaire conducted in Dakahlia Governorate in 2021and 2022.

Economic Analysis:

The analysis of the effect of using the applications under study on the economics of soybean production was relied on a set of economic criteria represented in the total costs per acre, the total per-acre yield, the net per-acre yield, the margin above the variable costs, and the ratio of return to costs. As for the total costs, the rise of which is a negative indicator when compared, table No. (6) indicates that the application (100% NPK) achieved the highest value by about 9815 pounds / feddan, while the application (50% NPK + MF) achieved the lowest cost by about 8004 pounds. For the total yield of acres, which It includes the value obtained from the crop and therefore its height is a positive indicator, the table indicates that the application (75 % NPK + MF + KH) achieved the highest value by about 13655 pounds / feddan, while the application (50 % NPK) achieved the lowest return by about 9424 pounds. As for the net return, which is obtained by excluding the total costs from the total return, which is the most common criterion in comparison, the application (75 % NPK + MF + KH) achieved the highest value by about 4396.3 pounds / feddan, while the application (50 % NPK) achieved the lowest value by about 1122 pounds. For the criterion of the margin above the variable costs, which is calculated in the variable costs as being the most affected by the change of any of the inputs or the output, the application (75 % NPK + MF + KH) achieved the highest value by about 7096.3 pounds / acres, while the application (50 % NPK) achieved the lowest value by about 3821.5 pounds. As for the criterion of return to costs, which calculates the rate of return coverage for production costs, the two applications (75 % NPK + MF + KH) , (50 % NPK + MF + KH) achieved a very close result at 1.48 % , while the application (50 % NPK) achieved the lowest value by about 1.14 %.

Table 6. Profitability per fedan of soybean crop under varying levels of NPK, mycorrhiza and Potassium humate.

Treatments	Total cost (E.P)	yield (ton /feddan)	Price (E.P / ton)	Total Return	Straw Crop Value	Total Return (E.P)	Net Return	Margin over variable cost	Benefit Cost Ratio (BCR)
100 % NPK	9815	1.46	8000	11680	800	12480	2665	5365	1.72
75 % NPK	9079	1.23	8000	9840	719	10559	1480	4180.3	1.16
75%NPK + MF	9138.8	1.42	8000	11360	787	12147	3008.3	5708.3	1.33
75%NPK+ KH	9178.75	1.50	8000	12000	807	12807	3628.25	6328.3	1.40
75%NPK+ MF + KH	9258.75	1.60	8000	12800	855	13655	4396.3	7096.3	1.48
50 % NPK	8303	1.09	8000	8720	704	9424	1122	3821.5	1.14
50% NPK+ MF	8004	1.22	8000	9760	744	10504	2500	5199.6	1.31
50% NPK+ KH	8044	1.35	8000	10800	774	11574	3530	6229.6	1.44
50%NPK+ MF + KH	8124	1.41	8000	11280	788	12068	3944	6643.6	1.49

MF: Mycorrhiza fungi and KH: Potassium humate.

CONCLUSION

At the end of the current study for two consecutive seasons, it is recommended to inoculate seeds with mycorrhiza at a rate of two bags per feddan, and spray potassium humate at a rate of 2 liters per feddan at 30 and 45 days after sowing with 75% of NPK mineral fertilizer to increase yield, quality, profits and reduce the damage of mineral fertilizers in a safe and environmentally friendly way.

REFERENCES

A.O.A.C., (2000). Association of Official Analytical Chemists, 17th ed. of A.O.A.C. international published by A.O.A.C. international Maryland, U.S.A., 1250 pp.

Abdel-Fattah, G. M. ; Shukry, W. M. ; Shokr, M. M. B. and Ahmed, M. A. (2016). Application of mycorrhizal technology for improving yield production of common bean plants. International Journal of Applied Sciences and Biotechnology, 4(2): 191-197.

Abdullahi, R. and Sheriff, H. H. (2013). Effect of Arbuscular Mycorrhizal Fungi and Chemical Fertilizer on Growth and shoot nutrients content of Onion under Field Condition in Northern Sudan Savanna of Nigeria. IOSR-JAVS. 5 (3): 85-90.

Adeyemi, N. O. ; Atayese, M. O. ; Olubode, A. A. and Akan, M. E. (2020). Effect of commercial *arbuscular mycorrhizal* fungi inoculant on growth and yield of soybean under controlled and natural field conditions. J. Plant Nutr., 43: 487–499.

Alori, E. T. ; Dare, M. O. and Babalola, O. O. (2017). Microbial Inoculants for Soil Quality and Plant Health; Lichtfouse, E., Ed.; Sustainable agriculture reviews; Springer International Publishing: Cham, Switzerland, 281–307.

Antunes, P. M. ; de Varennes A. ; Zhang T. and Goss M. J. (2006). The tripartite symbiosis formed by indigenous arbuscular mycorrhizal fungi, *Bradyrhizobium japonicum* and soybean under field conditions. J. Agron. Crop Sci., 19: 373-378.

Attia, R. H. and Sary, D. H. (2021). Effect of some soil conditioners on snap bean growth yield and sandy soil properties. Journal of Soil Sciences and Agricultural Engineering 12 (3): 123-129.

Central Agency for Public Mobilization and Statistics, annual bulletin of the movement of production, foreign trade and available for consumption of agricultural commodities, various issues.

Dawood, G. M. ; Abdel-Baky, Y. R. ; El-Awadi, M. E. and Bakhoum, G. S. (2019). Enhancement quality and quantity of faba bean plants grown under sandy soil conditions by nicotinamide and/or humic acid application. Bull. Nat. Res. Cen., 43 (28): 1–8.

El-Ghamry, A. M. ; Abd El-Hai, K. M. and Ghoneem, K. M. (2009). Amino and humic acids promote growth, yield and disease resistance of faba bean cultivated in clayey soil. Aust. J. Basic Appl. Sci., 3: 731–739.

El-Mahdy, R. E. and Anwar, D. A. (2020). Improved Efficiency of P fertilization with bio and organic additives on growth, seed quality and soybean yield. Journal of Soil Sciences and Agricultural Engineering, 11(12): 881-891.

El-Mekawy, D. M. A. (2019). Improvement of growth and productivity of common bean plants by using some biological and organic stimulants. M. Sc. Thesis, Botany Department, Faculty of Science, Mansoura University, Egypt.

Eulenstein, F. ; Tauschke, M. ; Behrendt, A. ; Monk, J. ; Schindler, U. ; Lana, M. A. and Monk, S. (2017) The application of mycorrhizal fungi and organic fertilisers in horticultural potting soils to improve water use efficiency of crops. Horticulturae 3(1):1-8

Fouda, K. F. ; El-Ghamry A. M. ; El-Sirafy Z. M. and Klwet I. H. A. (2017). Integrated effect of fertilizers on Beans cultivated in alluvial soil. Egypt. J. Soil Sci., 57 (3) : pp. 303 – 312

Gad El-Hak, S. H. ; Ahmed, A. M. and Moustafa, Y. M. M. (2012). Effect of Foliar Application with Two Antioxidants and Humic Acid on Growth, Yield and Yield Components of Peas (*Pisum sativum* L.). Journal of Horticultural Science and Ornamental Plants. 4 (3): 318-328.

Gavrilenko, V. F. and Zigalova, T. V. (2003). The Laboratory Manual for the Photosynthesis. Academia, Moscow. 256 стр. (in Russian).

Grant, C., Bittman, S. ; Montreal, M. ; Plenchette, C. and Morel, C. (2005) Soil and fertilizer phosphorus: Effects on plant P supply and mycorrhizal development. Can. J. Plant Sci. 85, 3-14.

Haluschak, P. (2006) Laboratory Methods of Soil Analysis. Canada-Manitoba Soil Survey. April.

Hemida, K. A. ; Eloufey, A. Z. A. ; Seif El-Yazal, M. A. and Rady, M. M. (2017). Integrated effect of potassium humate and α-tocopherol applications on soil characteristics and performance of Phaseolus vulgaris plants grown on a saline soil. Arch. Agron. Soil Sci., 63: 1556–1571.

Ibrahim, S. M. and Ali, M. A. (2018). Effect of potassium humate application on yield and nutrient uptake of maize grown in a calcareous soil. Alex. Sci. Exch. J., 39: 412–418.

Ismail, E. E. M. ; Galal, R. M. and Mahseb, M. E. (2017). Effect of some Potassium sources on productivity and quality of Pea under conditions of saline soil. Journal Plant Production, Mansoura University, 8 (12): 1323 – 1328.

Khalil, S. E. and Yousef, R. M. M. (2014). Interaction Effects of Different Soil Moisture levels, Arbuscular Mycorrhizal Fungi and Three Phosphate Levels on: I-Growth, Yield and Photosynthetic Activity of Garden Cress (Lepidium sativum L.) plant. International Journal of Advanced Research, 2(6):723-737.

Meng, L. ; Ding, W. and Cai, Z. (2005). Long-term application of organic manure and nitrogen fertilizer on N2O emissions, soil quality and crop production in a sandy loam soil. Soil Biology and Biochemistry, 37(11): 2037–2045.

Mertens, D. (2005a). A.O.A.C. Official method 922.02. plants preparation of laboratory sample. Official Methods of Analysis, 18th ed. North Frederick Avenue, Gaitherburg, Maryland, 1-2 pp.

Mertens, D. (2005b). A.O.A.C. Official method 975.03. Metal in plants and pet foods. Official Methods of Analysis, 18th ed. North Frederick Avenue, Gaitherburg, Maryland, 3-4 pp.

Millar, J. A. and Ballhorn, D. J. (2013). Effect of mycorrhizal colonization and light limitation on growth and reproduction of lima bean (*Phaseolus lunatus* L.). Journal of Applied Botany and Food Quality. 86: 172 - 179.

Ministry of Agricultural and Land Reclamation, Economic Affairs Sector, Bulletin of Agricultural Statistics, various issues.

Mohajerani, S. ; Alavi fazel, M. ; Madani, H. ; Lak, S. and Modhej, A. (2016). Effect of the foliar application of humic acid on red bean cultivars (*Phaseolus vulgaris* L.). Journal of Experimental Biology and Agricultural Sciences, 4(5) : 519-524.

Moraditochaee, M. (2012). Effects of humic acid foliar spraying and nitrogen fertilizer management on yield of peanut (*Arachis hypogeae* L.) in Iran. ARPN Journal of Agriculture and Biological Sciences, 7: 289- 293.

Nassar, K. E. M. ; EL-Shaboury, H. A. and EL-Sonbaty, A. E. (2021). Influence of some potassium humate application methods and mineral fertilization of nitrogen and phosphorus on soybean yield and quality. Menoufia Journal of Soil Science, 6(5): 133-145.

Parial, R.; Mohajan, S. ; Hussain, M. T. ; Hashem, M. A. ; Manisha, D. and andmIslam, M. M. (2014). Isolation of *Arbuscular Mycorrhizal* Fungi and Evaluation its Effect on Plant Growth over Chemical Fertilizers for Better Human Health. SMU Medi Journal. 1(2): 192-206.

Patharajan, S. and Raaman, N. (2012). Influence of *Arbuscular mycorrhizal* fungi on growth and selenium uptake by garlic plants. Arch Phytopathol. Plant Prot., 45: 138–151.

Raihan, S. H.; Islam, M. Sh.; Islam, M.; Khan, R. N. A. and Hossain, B. (2021). Impacts of organic and inorganic fertilizers on growth and yield of country bean (*Lablab purpureus* L.) In summer season. Bangladesh Journal of Multidisciplinary Scientific Res., 3 (1): 1-9.

Reeuwijk, L. P. (2002) Procedures For Soil Analysis. Inter. Soil Ref. and Info. Center. Food and Agric. Organization of the United Nations.

Sasongko, S. R. ; Utami, S. N. H. and Purwanto, B. H. (2019). Effects of NPK and mycorrhizae on the growth, P uptake of soybean, and soil chemist in peat land, Pelalawan, Riau. Inter. Seminar and Congress of Indonesian. Soil. Sci. Soci. 393.

Utomo, B. (2010). Pemanfaatan beberapa bioaktivator terhadap peningkatan laju dekomposisi tanah gambut dan pertumbuhan Gmelina arborea Roxb The Use of Bioactivators to Increase the Decomposition Rate of Peat Soil and the Growth of Gmelina arborea Roxb. Jurnal Penelitian Hutan Tanaman, *7*(1): 33–38.

Vanlauwe, B. and Zingore, S. (2011) Integrated soil fertility management. An operational definition and consequences for implementation and dissemination. Better Crops 95: 4-7.

Verlindern, G. ; Pycke, B. ; Mertens, J. ; Debersaques, F. ; Verheyen, K. ; Baert, G. ; Bries, J. and Saert, G. H. (2009). Application of humic substances results in consistent increases in crop yield and nutrient uptake. Journal of Plant Nutrition 32:1407-1426.

Wang, X. G. ; Zhao, X. H. ; Jiang, C. J. ; Li, C.H. ; Cong, S. ; Chen, Y. Q. ; Yu, H. Q. and Wang, C. Y. (2015). Effects of potassium deficiency on photosynthesis and photoprotection mechanisms in Soybean (*Glycine max* (L.) Merr.). Journal of Integrative Agriculture, 14(5): 856–863.

Yousif, S. H. ; Yousif, K. H. and Salih, S. M. (2019). Effect of bread yeast and humic acid on growth and yield traits on Broad bean (*Vicia faba* L.). Journal of University of Duhok., 22 (1): 98-106.

Yudhiarti, S. ; Sudantha, M. and Fauzi, T. (2020). Effect of Giving Arbuscular Mycorrhizal Fungi (AMF) and Bioactivator Dosage of Trichoderma spp. on the Growth and Products of soybeans (Glycine max L. Merr.). Traektoriâ Nauki Path of Science, 6(9): 6001-6007.

تأثير التسميد الحيوي وهيومات البوتاسيوم ومعدلات تسميد NPK على النمو والإنتاجية والمؤشرات الإقتصادية لفول الصويا

هيام عبد الفتاح الشابورى[1] والحسيني أحمد الحسيني النفيلي [2]

[1]معهد بحوث الأراضى والمياه والبيئة - مركز البحوث الزراعية - الجيزة - مصر

[2]معهد بحوث الإقتصاد الزراعي - مركز البحوث الزراعية - الجيزة – مصر

الملخص

تلوث الأرض بسبب إستخدام الأسمدة الكيماوية ، ومحاولة إستخدام المواد التي ليس لها آثار ضارة على البيئة ، لذلك أجريت هذه الدراسة الحالية لتقييم تأثير الأسمدة الحيوية مثل فطر الميكروريزا (MF) ، و هيومات البوتاسيوم (KH) ومعدلات التسميد بالنيتروجين والفوسفور والبوتاسيوم على النمو والمحصول والمؤشرات الإقتصادية لنبات فول الصويا ، في مزرعة خاصة خلال فصلي صيف 2021 و 2022 في تصميم القطاعات العشوائية الكاملة ، تتكون التجربة من 3 مكررات. كانت المعالجات عبارة عن علاج تحكم (100٪ NPK من الموصى به) ، 75٪ NPK، ميكروريزا + 75 ٪ NPK ، هيومات بوتاسيوم + 75 ٪ NPK ، ميكروريزا + هيومات بوتاسيوم + 75 ٪ NPK، 50 ٪ NPK ، ميكروريزا +50 ٪ NPK ، هيومات بوتاسيوم +50 ٪ NPK ،، ميكروريزا + هيومات بوتاسيوم +50 ٪ NPK. أشارت النتائج المتحصل عليها إلى أن إضافة ميكروريزا + هيومات بوتاسيوم + 75 ٪ NPK حققت أعلى قيم لنمو النبات والمحصول وامتصاص العناصر الغذائية والعائد الصافي مقارنة بمعاملة المقارنة 100٪ NPK . في هذه المعاملة تم تحقيق زيادة 36,71،17,57،13,93٪ في إمتصاص البذور للعناصر N و P و K على التوالي. بينما كانت الزيادة في محصول البذور وصافي العائد 9.44 ، 64.96٪ على التوالي. بشكل عام ، فإن تطبيق فطريات الميكوريزا (MF) وهيومات البوتاسيوم (KH) مع إضافة 75٪ من NPK قد حقق أفضل النتائج لجميع الخصائص المذكورة أعلاه في كلا الموسمين بالإضافة إلى توفير 25٪ من متطلبات NPK وتعظيم العائد الصافي لنبات فول الصويا من مصادر طبيعية آمنة.