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# Evaluation of the Effect of Amino Acids, Sulphur and Farmyard Manure Along with Phosphorus Fertilization on Wheat Production, Nutrient Status and Soil Properties

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## ABSTRACT

Two field experiments were conducted in the Field of Agricultural Farm of Sids Agricultural Research Station to evaluate the effect of phosphorus rates (0.0, 7.5 and 15 kg $P_2O_5$/fed) and some stimulators, i.e.; without, 2% foliar spraying of amino acids twice, 100 kg elemental sulphur and 10 ton FYM/fed) on growth (plant height and dry weight/plant), yield components (number of spikes/m$^2$, number of grains/spike and 1000-grain weight), yields (grain and straw yields) and N, P and K concentrations and uptake in grains and straw as well as some soil properties after harvesting, i.e.; soil available N, P and K as well as pH, EC and soil organic matter. The results showed that increasing phosphorus rates increased plant height, dry weight/plant, number of spikes/m$^2$, number of grains/spike, 1000-grain weight, grain and straw yields, nitrogen and phosphorus content in grains and straw, protein percentage in grains, and NPK uptake in grains and/or straw as well as soil available P in soil after harvesting. Applied amino acids, sulphur or FYM significantly increased all studied growth parameters, yield and its components and nutrient content and uptake in grains and straw over untreated control. FYM improved the N, P and K availability and soil pH and organic matter, while soil salinity was increased due to FYM application. However, sulphur improved soil available P and K and soil pH.

**Keywords:** Wheat, phosphorus, sulphur, FYM, amino acids, growth, yield and yield components, nutrient status and soil properties.

## INTRODUCTION

Wheat is the third cereal crop in the world after maize and rice, but considering of dietary intake, it is currently second to rice as the main food crop, while in Egypt it is considered the strategic food crop. About 70% of wheat production is used for food, 19% for animal feed and the remaining 11% is used in industrial application, including biofuels. The importance of this crop is mainly attributed to the fact that its grains can be ground into flour, semolina, etc., which from the basic ingredients of bread and other bakery products and pastas, thus it represents the main source of nutrients for the most of world population.

Phosphorus (P) after N is the most important limiting agricultural production in the tropics and sub tropics regions. Many of the agricultural soils in the tropics and subtropics are low in both total and available P when compared with other major nutrients (Chien and Menon, 1995). Deficiency of P is usually associated with low supply of available P, soil mineralogical properties and some chemical reactions which lead to fixed P in unavailable form. Some studies had been performed on how to increase soil P level through fertilizer, sulphur, organic or bio-fertilization in order to improve significant agronomic yield response (Gala *et al.,* 2000).

Sulphur is the fourth major nutrient for plant growth. Elemental sulphur has been used in reclamation and improvement of sodic and calcareous soil (Wassif *et al*., 1993). More attention has been given to sulphur application due to its favorable effects in enhancing nutrient availability in soil (Saleh, 2001). Due to the high cost and adverse effects of commercial fertilizers, especially P fertilizer, use of sulphur may be as a nutrient and soil acidifier and S fertilizer has recently gained importance in agricultural production (Atilgan *et al.*, 2008). Sulphur interacts with phosphorus as phosphate ion is more strongly bound than sulphate (Hedge and Murthy, 2005). Phosphorus application results in increased of anion adsorption sites by phosphate, which releases sulphate ions into the soil solution (Tiwari and Gupta, 2006). Studies have indicated both synergistic and antagonistic relationship between sulphur and phosphorus, but it depends on their application rate and crop species (Marok and Dev, 1980). The interaction of these nutrients may affect the critical levels of available P and S below which response to their application could be observed (Yadav, 2011). Many workers reported that the oxidation of sulphur and sulphuric acid production cause reducing the acidity of soil increasing P and micro-nutrients in the soil (Dawood *et al.*, 1985). Rate of sulphur oxidation in soil vary and depend on population of thiobacillus bacteria in soil, particle size and environmental conditions. With increasing soil sulphur, and sulphur oxidation bacteria population will large and it require more nutrients to bacteria therefore, oxidation of sulphur in soil can be productive more quickly (Agrifacts, 2003).

Amino acids can directly or indirectly improve the physiological activities of plant. It involved the enzymes responsible for the structural photosynthesis process. Also, it act as chelating agent of some nutrients, when it applied together with them, where it absorption and transportation inside the plant is easier (Ibrahim *et al.* 2007). The requirement of amino acids in essential quantities is well known as a mean to increase yield of crops. Also, amino acids are fundamental ingredients in the process of protein synthesis (Ewais *et al*., 2005). Azimi *et al*. (2013) reported that amino acids application reduced the negative effects of water deficit on wheat plants.

Application of farmyard manure is traditionally used by many workers as soil conditioners and fertilizers for increasing growth and yield of crops (Awad *et al*., 2002 and Atta Allah and Mohamed, 2003). In addition to playing important role in improving the physical and chemical soil properties, farmyard manure are valuable resources rich in P, N and micronutrients essential for plant growth, that are slowly released through degradation by micro-organisms. Attia and El-Dosuky (1996) showed that the application of 15 and 30 m$^3$ FYM/fed increased the total grain yield, N and S contents of wheat, they found a synergistic effect between FYM and sulphur which may be due to the increasing in organic matter degradation by heterotrophic sulphur oxidizing micro-organisms and uptake of mineral nutrients released.

The present work aimed to evaluate the effect of phosphorus application along with some activators such as amino acids, sulphur and farmyard manure on wheat productivity and soil properties.

# MATERIALS AND METHODS

Two field experiments were conducted on wheat (*Triticum aestivum* L.) during the two successive seasons of 2014/2015 and 2015/2016 at Sids Agricultural Research Farm, ARC, Beni-Suef Governorate to evaluate the effect of phosphorus fertilizer along with some stimulators, i.e., amino acids, elemental sulphur and farmyard manure (FYM) on, growth, yield and its components and nutrient content in both wheat grain and straw as well as some soil properties after harvesting. The design of the experiment was factorial in complete randomized blocks in two factors in four replicates . The treatments were: phosphorus fertilizer (0.0 ,7.5 and 15 kg $P_2O_5$/fed) and stimulators, namely, without, 2% foliar spraying of amino acids twice at rate of 400 L/fed for each at 30 and 45 days after sowing, 100 kg elemental sulphur/fed and 10 ton FYM/fed. Particle size distribution and some chemical properties of the experimental sites were determined in surface soil sample (0.0-30 cm) according to Klute (1986) and Page *et al.* (1982), respectively and listed in Table 1. Also, the chemical composition of (FYM) was determined according to Klute (1986) and listed in Table 2.

**Table 1. Some physical and chemical characteristics of the experimental soil.**

| Soil properties | First season | Second season |
|---|---|---|
| Physical properties: | | |
| Particle size distribution: | | |
| Clay (%) | 53.46 | 51.01 |
| Silt (%) | 32.11 | 32.69 |
| Fine sand (%) | 14.18 | 15.76 |
| Coarse sand (%) | 0.25 | 0.54 |
| Texture grade | Clay | Clay |
| Chemical properties: | | |
| pH (1:2.5 soil-water uspension) | 8.1 | 8.2 |
| EC, soil paste (dS $m^{-1}$) | 1.13 | 1.25 |
| Organic matter (%) | 1.75 | 1.69 |
| CaCO3 (%) | 1.89 | 2.21 |
| Available N ($ugg^{-1}$) | 21.0 | 19.5 |
| Available P ($ugg^{-1}$) | 11.3 | 10.9 |
| Available K ($ugg^{-1}$) | 213.0 | 197.0 |

**Table 2. The chemical composition of the farmyard manure which was used in the two growth seasons.**

| Chemical composition | First season | Second season |
|---|---|---|
| pH | 7.96 | 7.88 |
| EC (dS $m^{-1}$) | 5.11 | 5.25 |
| Organic carbon (%) | 15.37 | 16.41 |
| Organic matter (%) | 26.50 | 28.30 |
| Total nitrogen (%) | 0.97 | 0.81 |
| Total phosphorus (%) | 0.24 | 0.21 |
| Total potassium (%) | 1.11 | 1.05 |
| C/N ratio | 15.85 | 20.26 |

Phosphorus fertilizer and farmyard manure were added before wheat sowing during land preparation. However, sulphur and thiobacillus bacteria were concurrently mixed with each other to thirty centimeters in depth of soil plots in the same day of sowing. The thiobacillus microorganism was obtained from the Department of Agricultural Microbiology, Soil; Water and Environment Research Institute, (ARC), Giza, Egypt.

Wheat grains, C.V. Sids 12 were planted in plots (3 x 3.5 m: 10.5 $m^2$) in November 15 and 20 in two growing seasons, respectively. Potassium at rate of 24 kg $K_2O$/fed was added before sowing during land preparation, while nitrogen at rate of 75 kg/fed was added at two equal doses, before the first irrigation and before the second one as ammonium nitrate (33.5% N). The preceding crop in the two seasons was maize. All other cultural practices were done for wheat production in the district. At 75 days age, ten plants were randomly chosen from each plot to measure some wheat growth character, namely, plant height (cm) and dry weight/plant (g). At maturity (in May), some yield components, i.e., number of spikes/$m^2$, number of grains/spike and 1000-grain weight (g) were determined . Also, grain and straw yields were determined for each plot and converted to ardab and ton/fed. N, P and K concentration were determined in both grains and straw according to Chapman and Pratt (1978) and N, P and K uptake in grains and/or straw were calculated. Surface soil samples were taken from each plot after harvesting to determine soil available N, P and K as well as soil pH, EC and organic matter according to Klute (1986).

The data were statistically analyzed according the method described by Snedecor and Cochran (1980). The means of treatments were compared by L.S.D. at 5% probability level.

# RESULTS AND DISCUSSION

## Growth and yield component parameters

The data in Table 3 represent the response of wheat plant height, dry weight, number of spike/$m^2$, number of grains/spike and 1000-grain weight to phosphorus levels and some natural activators. The main effect reveal that increasing phosphorus levels were significantly increased these studied parameters in both seasons. The plant treated with 15.0 kg P2O5 exhibited the highest values of growth and yield components of plant, while the plants not be fed with phosphorus recorded the lowest ones. The positive effect of phosphorus fertilization is mainly explained by the fact that phosphorus had a very important role in energy storage and transfer in plant. It also plays a fundamental role in large number of enzymatic reactions that depends on phosphorylations. These results are in line with those obtained by Galal (2007) and Ismail *et al.* (2015).

Concerning the effect of natural additives, namely amino acids, sulphur mixed with thiobacillus bacteria and farmyard manure; it could be arranged the response of growth and yield components of wheat to these natural activators to the descending order as follow: FYM > S > amino acids > without. The superiority of farmyard manure may be due to its effect on improving physical and chemical properties of soil. Also, FYM consider a rich source for N, P and micronutrients needed for plants (Atta Allah and Mohamed, 2003). These results are similar to those obtained by Attia and El-Dosuky (1996) and Ali *et al.* (2009). It could be observed that elemental sulphur enhanced growth and yield components of wheat than control or amino acids, which mainly due to the beneficial effect on reducing the soil reaction near the plant root, consequently increasing nutrient availability and its absorption (Saleh, 2001). These results agree with those obtained by Badawy *et al.* (2011). Moreover, foliar application of amino acids was significantly increased growth and yield components of wheat plants than control. In this concern, Kowalczyk and Zielony (2008) mentioned that amino acids are a well-known biostimulant which has positive effects on the plant and root growth, the yield and significantly mitigates injuries caused by abiotic stress. These results are agreed with the results obtained by Azimi *et al*. (2013).

**Table 3. Mean and significant of growth and yield components of wheat as affected by phosphorus and natural additives.**

| Treatments | | Plant height (cm) | | Dry weight/plant (g) | | Number of spikes/$m^2$ | | Number of grains/spike | | 1000-grains weight (g) | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| A | B | 1st | 2nd | 1st | 2nd | 1st | 2nd | 1st | 2nd | 1st | 2nd |
| 0.0 | 0.0 | 106.5 | 107.3 | 2.25 | 2.27 | 405.0 | 410.2 | 56.25 | 53.59 | 40.40 | 41.23 |
| | Amino acids | 107.3 | 108.1 | 2.30 | 2.31 | 413.2 | 419.3 | 58.60 | 55.85 | 40.65 | 41.58 |
| | Sulphur+ bacteria | 108.6 | 109.4 | 2.40 | 2.42 | 415.5 | 424.0 | 59.88 | 57.40 | 40.80 | 42.86 |
| | FYM | 109.8 | 110.5 | 2.44 | 2.45 | 419.0 | 429.0 | 63.13 | 60.33 | 41.35 | 43.80 |
| Mean | | 108.1 | 108.8 | 2.35 | 2.36 | 413.2 | 420.6 | 59.47 | 56.79 | 40.80 | 42.37 |
| 7.5 kg P2O5/fed | 0.0 | 107.0 | 107.7 | 2.35 | 2.36 | 428.0 | 429.8 | 58.30 | 56.54 | 41.90 | 43.68 |
| | Amino acids | 109.5 | 110.1 | 2.41 | 2.43 | 438.1 | 440.0 | 61.30 | 58.78 | 42.91 | 43.95 |
| | Sulphur+ bacteria | 112.2 | 112.9 | 2.49 | 2.51 | 442.0 | 455.0 | 63.35 | 61.68 | 43.42 | 45.35 |
| | FYM | 113.8 | 114.4 | 2.55 | 2.56 | 452.0 | 462.0 | 65.50 | 63.80 | 44.98 | 45.95 |
| Mean | | 110.6 | 111.3 | 2.45 | 2.47 | 440.0 | 446.7 | 62.11 | 60.20 | 43.30 | 44.73 |
| 15.0 kg P2O5/fed | 0.0 | 109.1 | 109.6 | 2.40 | 2.41 | 435.0 | 445.0 | 60.38 | 59.40 | 43.89 | 46.40 |
| | Amino acids | 112.1 | 112.7 | 2.49 | 2.50 | 450.0 | 469.2 | 65.90 | 62.40 | 46.54 | 47.90 |
| | Sulphur+ bacteria | 112.1 | 112.6 | 2.49 | 2.51 | 450.1 | 470.1 | 65.97 | 64.33 | 46.56 | 47.95 |
| | FYM | 114.0 | 114.5 | 2.55 | 2.55 | 465.0 | 478.0 | 70.05 | 68.50 | 48.20 | 49.56 |
| Mean | | 111.8 | 112.4 | 2.47 | 2.49 | 450.0 | 465.6 | 65.58 | 63.66 | 46.30 | 47.95 |
| Mean | 0.0 | 107.5 | 108.2 | 2.33 | 2.35 | 422.7 | 428.3 | 58.31 | 56.51 | 42.06 | 43.77 |
| | Amino acids | 109.6 | 110.3 | 2.39 | 2.41 | 433.8 | 442.8 | 61.93 | 59.01 | 43.37 | 44.48 |
| | Sulphur+ bacteria | 111.0 | 111.6 | 2.46 | 2.48 | 435.9 | 449.7 | 63.07 | 61.14 | 43.59 | 45.39 |
| | FYM | 112.5 | 113.1 | 2.51 | 2.52 | 445.3 | 456.3 | 66.23 | 64.21 | 44.84 | 46.44 |
| L.S.D. at 5% | | | | | | | | | | | |
| A | | 0.35 | 0.27 | 0.01 | 0.02 | 0.98 | 1.12 | 0.19 | 0.21 | 0.16 | 0.16 |
| B | | 0.23 | 0.20 | 0.01 | 0.02 | 0.85 | 1.08 | 0.16 | 0.19 | 0.14 | 0.15 |
| AB | | 0.42 | 0.40 | 0.02 | 0.03 | 1.11 | 1.34 | 0.25 | 0.24 | 0.20 | 0.21 |

**A: Phosphorus levels (kg P2O5/fed).**
**B: Natural additives.**

As for the interaction between treatments, the results clearly show that all studied growth and yield component parameters were significantly affected by phosphorus levels and the natural stimulators. The effect of sulphur application under 7.5 kg P2O5/fed yielded growth and yield components of wheat equal to those produced under 15.0 kg P2O5/fed. This may be due to the synergistic effect between phosphorus and sulphur, which sulphur application increased the solubility of fixed P in soil, in turn increased soluble P in soil under 7.5 kg P2O5/fed to the recommended rate (15.0 kg P2O5/fed). Similar results were obtained by Yadav (2011). Also, FYM + 7.5 kg P2O5/fed produced growth and yield components similar to those produced under FYM + 15.0 kg P2O5/fed. This mainly due to the phosphorus content in FYM which released slowly in the soil. In general, the highest values of all studied growth and yield components were recorded under the treatment of 15.0 kg P2O5/fed + 10 ton FYM/fed, while the treatment without phosphorus and natural stimulators gave the lowest ones.

**Grain and straw yields**

Data presented in Table 4 showed that the application of 15.0 kg P2O5/fed increased grain yield by 6.1 and 27.4% over 7.5 kg P2O5/fed and control in the first season; respectively. Similar trends were obtained for the second one. The corresponding increasing in straw yield were 4.5 and 12.2% in the first season and 6.7 and 11.6 in the second season, respectively. The increase in grain and straw might be due to phosphorus being the constituent of nucleic acid and different forms of proteins, might have stimulated cell division resulting in increased plant growth and yield components attributes (as discussed before in Table, 3); consequently increased grain and straw yields. These results are in line with those obtained by Ali *et al*. (2009) and Rahman *et al*. (2014).

Considering the effect of the natural additives on grain and straw yields of maize the results revealed that all studied natural stimulators increased grain and straw yields than control. It could be arranged the effect of these natural additives on grain and straw yields in the descending order as follow: FYM > sulphur > amino acids > control. Application of elemental sulphur increased grain and straw yields by 17.0 and 12.8% in the first season, respectively. The same trend was obtained in the second season. Application of sulphur may be help in availability of other nutrients which results in better growth (Table, 3) and nutrients uptake, especially in high pH value of the experimental soil (8.1 and 8.2 for the two seasons, respectively), consequently increase leaf cell division, elongation and photosynthesis (El-Sheikh *et al*. (2006) and Mehanna *et al*. (2010). These results are similar to those obtained by Badawy *et al.* 2011 and Duhoky *et al.* 2014). The application of FYM induced the highest increase in wheat grain and straw yields. Compared with the untreated control, the increases in grain and straw yields due to 10 ton FYM/fed reached to 32.7 and 28.2% in the first season and 30.2 and 25.0% in the second one, respectively. These increments in grain and straw yields caused by FYM application may due to supplementation of N and other nutrients from the degradation of organic matter, beside the improvement of the physical soil properties. These results agree with those obtained by Khalil and Aly (2004) and Ali (2007). As for amino acids, the results showed that foliar spray of 4% amino acids to wheat plants twice significantly increased both grain and straw yields compared to control by about 10.3 and 7.7% in the first season, respectively. The corresponding increases for the second season were 8.9 and 10.0% in the abovementioned respect. The positive effect of amino acids are important for growth regulation and modulators of growth and cell differentiation, which may be affecting general metabolism and consequently morphogenesis (Basu *et al*., 1989). In this concern, Glawischnig *et al*. (2000) mentioned that amino acids are not only building bocks of proteins but also precursors for a myriad of other molecules that serve important function in plants. They added that, amino acids are involved in the synthesis of organic compounds such as protein, alkaloids, vitamins, enzymes, terpenoids and plant hormones that control various plant processes. These results are in harmony with those obtained by Eisa *et al*. (2010), Dromantiene *et al*. (2013) and Azimi *et al*. (2013).

**Table 4. Mean and significant of grain and straw yields of wheat as affected by phosphorus and natural additives**

| Treatments | | Grain yield (ardab/fed) | | Straw yield (ton/fed) | |
|---|---|---|---|---|---|
| A | B | 1st | 2nd | 1st | 2nd |
| 0.0 | 0.0 | 14.3 | 14.8 | 3.6 | 3.7 |
| | Amino acids | 15.6 | 16.0 | 3.9 | 4.1 |
| | Sulphur+ bacteria | 16.8 | 17.2 | 4.2 | 4.4 |
| | FYM | 18.7 | 18.9 | 4.7 | 4.8 |
| Mean | | 16.4 | 16.7 | 4.1 | 4.3 |
| 7.5 kg P2O5/fed | 0.0 | 16.4 | 16.6 | 3.9 | 4.1 |
| | Amino acids | 18.6 | 18.9 | 4.2 | 4.3 |
| | Sulphur+ bacteria | 20.5 | 20.8 | 4.5 | 4.4 |
| | FYM | 23.4 | 23.5 | 5.1 | 5.2 |
| Mean | | 19.7 | 20.0 | 4.4 | 4.5 |
| 15.0 kg P2O5/fed | 0.0 | 18.9 | 19.2 | 4.1 | 4.3 |
| | Amino acids | 20.4 | 20.3 | 4.5 | 4.7 |
| | Sulphur+ bacteria | 20.6 | 20.5 | 4.5 | 4.8 |
| | FYM | 23.6 | 23.6 | 5.2 | 5.1 |
| Mean | | 20.9 | 20.9 | 4.6 | 4.8 |
| Mean | 0.0 | 16.5 | 16.9 | 3.9 | 4.0 |
| | Amino acids | 18.2 | 18.4 | 4.2 | 4.4 |
| | Sulphur+ bacteria | 19.3 | 19.5 | 4.4 | 4.5 |
| | FYM | 21.9 | 22.0 | 5.0 | 5.0 |
| L.S.D. at 5% | | | | | |
| A | | 0.56 | 0.73 | 0.12 | 0.10 |
| B | | 0.42 | 0.55 | 0.11 | 0.07 |
| AB | | 0.67 | 0.73 | 0.18 | 0.15 |

**A: Phosphorus levels (kg P2O5/fed).**
**B: Natural additives.**

With regard to the interaction between treatments, the data revealed that grain and straw yields were significantly affected by the interaction between phosphorus levels and sulphur or FYM. Application of 100 kg of elemental sulphur or 10 ton FYM/fed under 7.5 kg P2O5/fed equal to those obtained under the recommended rate of phosphorus (15.0 kg P2O5/fed). The positive effect of FYM and sulphur is mainly due to its promotive action of these fertilizers on enhancing growth and yield components of wheat as discussed before (Table, 3). These results means that it could save about half recommended phosphorus rate by application of 100 kg S/fed or 10 ton FYM/fed to produce high wheat production.

**NPK concentration in grains and straw as well as protein in grains**

Data in Table 5 represent the effect of phosphorus and some natural stimulators application on NPK concentrations in wheat grains and straw. The data revealed that increasing phosphorus levels were significantly increased N and P and protein percentage in grains and N and P content in straw up to 15.0 kg P2O5/fed, while K concentration in both grains and straw did not affect. In this concern, Jones *et al*. (1991) reported that there were no consistent relationships between P and K in plant tissue. These results are in line with those obtained by Dwivedi and Bapat (1998) and Ismail *et al*. (2015) who found that increasing P levels had a positive effect on N and P% in grains and straw.

**Table 5. Mean and significant of NPK concentration in grains and straw and protein in grains as affected by phosphorus and natural additives.**

| Treatments | | N% | | | | P% | | | | K% | | | | Protein % | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | In grain | | In straw | | In grain | | In straw | | In grain | | In straw | | | |
| A | B | 1st | 2nd | 1st | 2nd | 1st | 2nd | 1st | 2nd | 1st | 2nd | 1st | 2nd | 1st | 2nd |
| 0.0 | 0.0 | 1.20 | 1.22 | 0.42 | 0.40 | 0.34 | 0.35 | 0.12 | 0.11 | 0.53 | 0.45 | 1.50 | 1.45 | 7.50 | 7.63 |
| | Amino acids | 1.38 | 1.38 | 0.50 | 0.48 | 0.37 | 0.36 | 0.12 | 0.12 | 0.55 | 0.49 | 1.52 | 1.47 | 8.63 | 8.63 |
| | Sulphur+ bacteria | 1.30 | 1.31 | 0.43 | 0.41 | 0.44 | 0.45 | 0.13 | 0.14 | 0.58 | 0.51 | 1.54 | 1.50 | 8.13 | 8.19 |
| | FYM | 1.39 | 1.39 | 0.52 | 0.51 | 0.49 | 0.48 | 0.14 | 0.14 | 0.62 | 0.55 | 1.59 | 1.54 | 8.69 | 8.69 |
| Mean | | 1.32 | 1.33 | 0.47 | 0.45 | 0.41 | 0.41 | 0.13 | 0.13 | 0.57 | 0.50 | 1.54 | 1.49 | 8.23 | 8.28 |
| 7.5 kg P2O5/fed | 0.0 | 1.24 | 1.23 | 0.45 | 0.44 | 0.40 | 0.42 | 0.12 | 0.13 | 0.53 | 0.45 | 1.51 | 1.44 | 7.75 | 7.69 |
| | Amino acids | 1.39 | 1.39 | 0.51 | 0.53 | 0.47 | 0.46 | 0.14 | 0.13 | 0.55 | 0.48 | 1.53 | 1.47 | 8.69 | 8.69 |
| | Sulphur+ bacteria | 1.35 | 1.34 | 0.46 | 0.48 | 0.52 | 0.50 | 0.15 | 0.16 | 0.59 | 0.52 | 1.55 | 1.50 | 8.44 | 8.38 |
| | FYM | 1.44 | 1.50 | 0.54 | 0.53 | 0.56 | 0.56 | 0.17 | 0.16 | 0.63 | 0.56 | 1.58 | 1.55 | 9.00 | 9.38 |
| Mean | | 1.36 | 1.37 | 0.49 | 0.50 | 0.49 | 0.49 | 0.15 | 0.15 | 0.58 | 0.50 | 1.54 | 1.49 | 8.47 | 8.53 |
| 15.0 kg P2O5/fed | 0.0 | 1.26 | 1.25 | 0.48 | 0.47 | 0.43 | 0.45 | 0.13 | 0.14 | 0.53 | 0.45 | 1.50 | 1.44 | 7.88 | 7.81 |
| | Amino acids | 1.42 | 1.45 | 0.52 | 0.51 | 0.47 | 0.49 | 0.15 | 0.16 | 0.54 | 0.50 | 1.52 | 1.46 | 8.88 | 9.06 |
| | Sulphur+ bacteria | 1.36 | 1.38 | 0.48 | 0.48 | 0.56 | 0.57 | 0.17 | 0.18 | 0.58 | 0.51 | 1.55 | 1.51 | 8.50 | 8.63 |
| | FYM | 1.50 | 1.55 | 0.56 | 0.60 | 0.56 | 0.58 | 0.20 | 0.19 | 0.62 | 0.56 | 1.58 | 1.55 | 9.38 | 9.69 |
| Mean | | 1.39 | 1.41 | 0.51 | 0.50 | 0.51 | 0.52 | 0.16 | 0.17 | 0.57 | 0.51 | 1.54 | 1.49 | 8.66 | 8.80 |
| Mean | 0.0 | 1.2 | 1.2 | 0.45 | 0.44 | 0.39 | 0.41 | 0.12 | 0.13 | 0.53 | 0.45 | 1.50 | 1.44 | 7.71 | 7.71 |
| | Amino acids | 1.4 | 1.4 | 0.51 | 0.51 | 0.44 | 0.44 | 0.14 | 0.14 | 0.55 | 0.49 | 1.52 | 1.47 | 8.73 | 8.79 |
| | Sulphur+ bacteria | 1.3 | 1.3 | 0.46 | 0.46 | 0.51 | 0.51 | 0.15 | 0.16 | 0.58 | 0.51 | 1.55 | 1.50 | 8.35 | 8.40 |
| | FYM | 1.4 | 1.5 | 0.54 | 0.55 | 0.54 | 0.54 | 0.17 | 0.16 | 0.62 | 0.56 | 1.58 | 1.55 | 9.02 | 9.25 |
| L.S.D. at 5% | | | | | | | | | | | | | | | |
| A | | 0.06 | 0.07 | 0.04 | 0.05 | 0.04 | 0.04 | 0.02 | 0.03 | N.S. | N.S. | N.S. | N.S. | 0.13 | 0.12 |
| B | | 0.05 | 0.06 | 0.02 | 0.02 | 0.03 | 0.02 | 0.02 | 0.02 | 0.01 | 0.01 | 0.01 | 0.01 | 0.10 | 0.10 |
| AB | | N.S. | N.S. | N.S. | N.S. | N.S. | N.S. | N.S. | N.S. | N.S. | N.S. | N.S. | N.S. | N.S. | N.S. |

**A: Phosphorus levels (kg P2O5/fed).**
**B: Natural additives.**

As for the natural additives, the results showed that N, P and K% in grains and straw as well as protein% in wheat were significantly responded to the studied natural stimulators. It could be arranged the effect of natural additives on content in grains and straw in the descending order as follow: FYM > amino acids > sulphur > control .However, as for P and K these effect could be arranged as follow: FYM > sulphur > amino acids > untreated control. It worthy to notice that amino acids was more effective on N content than sulphur, while sulphur application caused more P and K in wheat than amino acids, which mainly due to the oxidation of sulphur by thiobacillus bacteria and sulphuric acid production cause reducing of acidity of soil, consequently increased P and K availability in soil and enhanced its absorption by plants (Dawood *et al*., 1985). On the other hand, foliar spraying of amino acids was directly involved the process of protein synthesis, beside it is consider a source of nitrogen (Ewais *et al.*, 2005). The higher NPK contents were recorded under FYM application, which mainly due to organic manure playing an important role in improving the physical properties of soils, it are valuable resources rich in P, N and K (Table, 2) that are slowly released after degradation by microorganisms (Awad *et al*., 2002 and Atta Allah and Mohamed, 2003).

The results clearly showed that nutrient content and protein percentage did not respond to the interaction between phosphorus fertilization and the natural stimulators application. In general, the highest NPK content in grains and straw and protein percentage in grains were recorded under 15.0 kg P2O5/fed + 10 ton FYM/fed, while the wheat plants without phosphorus and natural stimulators exerted ones.

**NPK uptake by grains and straw**

The data in Table 6 showed the effect of phosphorus fertilization and some natural stimulators application on N, P and K uptake by grains and/or straw. Increasing phosphorus levels were significantly increased N, P and K by grains and straw as well as total uptake. Added 15.0 kg P2O5/fed increased total N, P and K by 28.8, 51.0 and 14.1% over untreated control in the first season, respectively. The corresponding increasing in the second season were 31.0, 57.4 and 13.7% in the abovementioned order. The positive effect of phosphorus on NPK uptake is mainly explained by the effect of phosphorus on grain and straw yields as discussed before in Table 4. These results are similar to those obtained by Ismail *et al*. (2014) and Ismail *et al*. (2015).

Concerning the natural additives, the results cleared that all studied natural additives improved N, P and K uptake by grains and/or straw when compared with control. Application of 10 ton FYM/fed produced the highest NPK uptake in both seasons. However, amino acids resulted in nitrogen uptake by grains and/or straw significantly equal to those affected by sulphur application. Treated wheat plants with 100 kg sulphur yielded P and K uptake by grains and/or straw higher than produced under amino acids, which mainly due to the effect of sulphur on depressing soil pH, consequently increased P and K solubility in soil. Similar results were obtained by Somani and Kanthaliya (2004) and Duhoky (2014) for sulphur; Vernieri *et al*. (2005) and Nikiforova *et al*. (2006) for amino acid; and Mekail *et al*. (2006) and Ali *et al*. (2009).

**Table 6. Mean and significant of NPK uptake by grains and/or straw as affected by phosphorus and natural additives.**

| Treatments | | N uptake (kg/fed) | | | | | | P uptake (kg/fed) | | | | | | K uptake (kg/fed) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1$^{st}$ | | | 2$^{nd}$ | | | 1$^{st}$ | | | 2$^{nd}$ | | | 1$^{st}$ | | | 2$^{nd}$ | | |
| A | B | Grain | Straw | Total | Grain | Straw | Total | Grain | Straw | Total | Grain | Straw | Total | Grain | Straw | Total | Grain | Straw | Total |
| 0.0 | 0.0 | 26.7 | 15.1 | 41.7 | 27.2 | 14.9 | 42.1 | 7.3 | 4.3 | 11.5 | 7.9 | 4.1 | 12.1 | 11.3 | 54.1 | 65.4 | 9.9 | 53.5 | 63.3 |
| | Amino acids | 32.1 | 19.6 | 51.8 | 33.2 | 19.5 | 52.6 | 8.6 | 4.7 | 13.3 | 8.7 | 4.9 | 13.6 | 13.0 | 59.2 | 72.3 | 11.8 | 60.2 | 72.1 |
| | Sulphur+ bacteria | 32.7 | 18.1 | 50.9 | 33.7 | 18.1 | 51.8 | 11.2 | 4.6 | 15.7 | 9.5 | 6.1 | 15.6 | 14.7 | 64.5 | 79.2 | 13.3 | 66.1 | 79.5 |
| | FYM | 39.1 | 24.3 | 63.4 | 39.3 | 24.4 | 63.6 | 13.8 | 6.7 | 20.5 | 3.6 | 6.8 | 20.5 | 17.3 | 74.8 | 92.1 | 15.6 | 73.8 | 89.5 |
| Mean | | 32.7 | 19.3 | 52.0 | 33.4 | 19.2 | 52.5 | 10.2 | 5.1 | 15.3 | 9.9 | 5.5 | 15.5 | 14.1 | 63.2 | 77.3 | 12.7 | 63.4 | 76.1 |
| 7.5 kg P2O5/fed | 0.0 | 30.6 | 17.5 | 48.0 | 30.5 | 18.0 | 48.6 | 9.7 | 4.7 | 14.3 | 10.4 | 5.2 | 15.6 | 13.1 | 58.7 | 71.7 | 11.3 | 59.1 | 70.4 |
| | Amino acids | 38.7 | 21.3 | 60.0 | 39.2 | 22.7 | 61.9 | 13.2 | 5.8 | 19.1 | 13.1 | 5.5 | 18.7 | 15.4 | 64.1 | 79.5 | 13.7 | 63.3 | 77.1 |
| | Sulphur+ bacteria | 41.4 | 20.8 | 62.2 | 41.7 | 21.2 | 62.8 | 16.1 | 6.7 | 22.7 | 15.7 | 7.0 | 22.7 | 18.0 | 69.6 | 87.5 | 16.1 | 66.1 | 82.3 |
| | FYM | 50.6 | 27.4 | 78.1 | 52.8 | 27.5 | 80.3 | 19.5 | 8.5 | 28.0 | 19.8 | 8.3 | 28.4 | 22.0 | 80.4 | 102.4 | 19.8 | 80.5 | 100.2 |
| Mean | | 40.3 | 21.8 | 62.1 | 41.1 | 22.4 | 63.4 | 14.6 | 6.4 | 21.0 | 14.8 | 6.5 | 21.4 | 17.1 | 68.2 | 85.3 | 15.2 | 67.3 | 82.5 |
| 15.0 kg P2O5/fed | 0.0 | 35.7 | 19.6 | 55.2 | 35.9 | 20.3 | 56.2 | 12.1 | 5.2 | 17.4 | 12.9 | 6.1 | 19.1 | 14.9 | 61.4 | 76.3 | 13.0 | 61.8 | 74.9 |
| | Amino acids | 43.3 | 23.5 | 66.7 | 44.2 | 24.0 | 68.1 | 14.3 | 6.8 | 21.2 | 14.9 | 7.4 | 22.2 | 16.5 | 68.3 | 84.8 | 15.2 | 68.5 | 83.6 |
| | Sulphur+ bacteria | 42.1 | 21.7 | 63.8 | 42.2 | 23.1 | 65.3 | 17.2 | 6.7 | 23.8 | 17.4 | 8.5 | 25.9 | 18.0 | 69.6 | 87.6 | 15.8 | 72.4 | 88.2 |
| | FYM | 53.0 | 29.2 | 82.1 | 54.9 | 30.5 | 85.4 | 19.9 | 10.3 | 30.1 | 20.6 | 9.6 | 30.2 | 21.9 | 82.1 | 104.1 | 19.9 | 79.1 | 99.1 |
| Mean | | 43.5 | 23.5 | 67.0 | 44.3 | 24.5 | 68.8 | 15.9 | 7.3 | 23.1 | 16.5 | 7.9 | 24.4 | 17.8 | 70.4 | 88.2 | 16.0 | 70.5 | 86.5 |
| Mean | 0.0 | 31.0 | 17.4 | 48.3 | 31.2 | 17.7 | 49.0 | 9.7 | 4.7 | 14.4 | 10.4 | 5.1 | 15.6 | 13.1 | 58.0 | 71.1 | 11.4 | 58.1 | 69.5 |
| | Amino acids | 38.0 | 21.5 | 59.5 | 38.9 | 22.1 | 60.9 | 12.0 | 5.8 | 17.9 | 12.2 | 6.0 | 18.2 | 15.0 | 63.9 | 78.9 | 13.6 | 64.0 | 77.6 |
| | Sulphur+ bacteria | 38.7 | 20.2 | 59.0 | 39.2 | 20.8 | 60.0 | 14.8 | 6.0 | 20.7 | 14.2 | 7.2 | 21.4 | 16.9 | 67.9 | 84.8 | 15.1 | 68.2 | 83.3 |
| | FYM | 47.6 | 27.0 | 74.5 | 49.0 | 27.5 | 76.4 | 17.7 | 8.5 | 26.2 | 18.0 | 8.2 | 26.4 | 20.4 | 79.1 | 99.5 | 18.4 | 77.8 | 96.3 |
| L.S.D. at 5% | | | | | | | | | | | | | | | | | | | |
| A | | 0.62 | 0.45 | 2.11 | 0.58 | 0.38 | 1.98 | 0.33 | 0.27 | 0.95 | 0.37 | 0.28 | 1.02 | 1.10 | 1.42 | 2.59 | 1.01 | 1.15 | 2.25 |
| B | | 0.41 | 0.33 | 1.05 | 0.37 | 0.30 | 1.16 | 0.31 | 0.29 | 0.77 | 0.28 | 0.24 | 0.78 | 0.32 | 0.66 | 1.21 | 0.37 | 0.69 | 1.62 |
| AB | | N.S. | N.S. | N.S. | N.S. | N.S. | N.S. | N.S. | N.S. | N.S. | N.S. | N.S. | N.S. | N.S. | N.S. | N.S. | N.S. | N.S. | N.S. |

**A: Phosphorus levels (kg P2O5/fed).**
**B: Natural additives.**

As for the interaction, the results showed that NPK uptake did not respond to the studied treatments. In general, the highest NPK absorbed by grains and/or straw of wheat plants were recorded under the treatment of 15.0 kg P2O5/fed + 10 ton FYM/fed, while the plants without phosphorus and natural additives showed the lowest nutrient uptake.

**Soil properties**

The changes in some soil properties after harvesting, i.e. soil available N, P and K as well as soil pH, EC and organic matter are presented in Table 7.

**Table 7. Some soil properties after harvesting**

| Treatments | | N (ugg$^{-1}$) | | P (ugg$^{-1}$) | | K (ugg$^{-1}$) | | pH | | EC dS m$^{-1}$ | | Soil organic matter% | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A | B | 1$^{st}$ | 2$^{nd}$ | 1$^{st}$ | 2$^{nd}$ | 1$^{st}$ | 2$^{nd}$ | 1$^{st}$ | 2$^{nd}$ | 1$^{st}$ | 2$^{nd}$ | 1$^{st}$ | 2$^{nd}$ |
| 0.0 | 0.0 | 21.0 | 19.4 | 12.2 | 11.8 | 214 | 195 | 8.13 | 8.25 | 1.16 | 1.22 | 1.74 | 1.68 |
| | Amino acids | 21.0 | 19.2 | 12.2 | 11.9 | 217 | 196 | 8.14 | 8.21 | 1.17 | 1.23 | 1.74 | 1.67 |
| | Sulphur+ bacteria | 21.1 | 19.5 | 15.6 | 14.8 | 231 | 215 | 8.00 | 8.10 | 1.15 | 1.21 | 1.75 | 1.68 |
| | FYM | 30.3 | 28.1 | 19.7 | 19.1 | 262 | 250 | 7.92 | 7.99 | 1.36 | 1.46 | 1.91 | 1.85 |
| Mean | | 23.45 | 21.6 | 14.9 | 14.4 | 231 | 214 | 8.05 | 8.14 | 1.21 | 1.28 | 1.79 | 1.72 |
| 7.5 kg P2O5/fed | 0.0 | 21.1 | 19.3 | 14.8 | 14.6 | 215 | 193 | 8.12 | 8.24 | 1.16 | 1.23 | 1.73 | 1.68 |
| | Amino acids | 21.3 | 19.5 | 14.7 | 14.9 | 215 | 195 | 8.14 | 8.23 | 1.15 | 1.22 | 1.74 | 1.69 |
| | Sulphur+ bacteria | 21.4 | 19.4 | 20.1 | 20.3 | 235 | 217 | 8.00 | 8.11 | 1.14 | 1.19 | 1.76 | 1.68 |
| | FYM | 30.4 | 28.2 | 26.3 | 26.1 | 266 | 254 | 7.90 | 7.97 | 1.37 | 1.49 | 1.92 | 1.86 |
| Mean | | 23.6 | 21.6 | 19.0 | 19.0 | 233 | 214 | 8.04 | 8.14 | 1.21 | 1.28 | 1.79 | 1.73 |
| 15.0 kg P2O5/fed | 0.0 | 21.0 | 19.5 | 29.5 | 29.2 | 216 | 197 | 8.13 | 8.24 | 1.17 | 1.23 | 1.74 | 1.76 |
| | Amino acids | 21.2 | 19.4 | 29.3 | 29.4 | 218 | 194 | 8.15 | 8.20 | 1.17 | 1.22 | 1.75 | 1.68 |
| | Sulphur+ bacteria | 21.0 | 19.4 | 33.7 | 33.5 | 233 | 218 | 8.00 | 8.12 | 1.15 | 1.19 | 1.76 | 1.69 |
| | FYM | 30.4 | 28.3 | 38.5 | 38.0 | 267 | 252 | 7.91 | 7.98 | 1.37 | 1.47 | 1.92 | 1.85 |
| Mean | | 23.4 | 21.7 | 32.8 | 32.5 | 233 | 215 | 8.05 | 8.14 | 1.22 | 1.28 | 1.79 | 1.72 |
| Mean | 0.0 | 21.1 | 19.4 | 18.8 | 18.5 | 215 | 195 | 8.13 | 8.24 | 1.16 | 1.23 | 1.74 | 1.68 |
| | Amino acids | 21.2 | 19.4 | 18.7 | 18.7 | 217 | 195 | 8.14 | 8.21 | 1.16 | 1.22 | 1.74 | 1.68 |
| | Sulphur+ bacteria | 21.2 | 19.4 | 23.1 | 22.9 | 228 | 217 | 8.00 | 8.11 | 1.15 | 1.20 | 1.76 | 1.68 |
| | FYM | 30.4 | 28.2 | 28.2 | 27.7 | 265 | 252 | 7.91 | 7.98 | 1.37 | 1.49 | 1.92 | 1.85 |
| L.S.D. at 5% | | | | | | | | | | | | | |
| A | | N.S. | N.S. | 1.25 | 1.20 | N.S. | N.S | N.S. | N.S. | N.S. | N.S. | N.S. | N.S. |
| B | | 1.16 | 1.11 | 1.37 | 1.31 | 5.26 | 4.31 | 0.07 | 0.07 | 0.16 | 0.17 | 0.14 | 0.13 |
| AB | | N.S. | N.S. | N.S. | N.S. | N.S. | N.S. | N.S. | N.S. | N.S. | N.S. | N.S. | N.S. |

**A: Phosphorus levels (kg P2O5/fed).**
**B: Natural additives.**

The data clearly showed that phosphorus levels affected only phosphorus availability. Comparing with control added 7.5 or 15.0 kg P2O5/fed increased soil available phosphorus after harvesting by 27.5 and 120.0% in the first season and 31.9 and 125.7% in the second season, respectively. These results may be due to the amount of added P was higher than crop demand (Sharama and Prasad, 2009). Similar results were obtained by Rafique *et al.* (2012) and Islam *et al.* (2013).

The results also showed that amino acids did not affect the availability of NPK as well as soil pH, EC and organic matter. Sulphur application improved the soil available phosphorus and potassium in soil after harvesting. Moreover, 10 ton FYM/fed increased the availability of N, P and K and soil organic matter, beside decreased soil reaction. While, the soil salinity was increased due to FYM application. The promotive effects of sulphur on reducing soil pH and consequently increased the availability of P and K in soil are attributed to with increasing soil sulphur, sulphur oxidation and bacteria population will be increased and requires more nutrients to bacteria. Therefore, oxidation of sulphur in the fertile soil more quickly has done (Agrifacts, 2003). Oxidation of sulphur by thiobacillus bacteria reduced soil pH (Mahler and Maples, 1986). These results agree with those obtained by Habashy and Bishara (2013) and Sabagh *et al*. (2014). On the other hand, the positive effect of FYM on nutrient availability, pH and soil organic matter is due to the composition of FYM resulted in chelated compound enhanced the availability of nutrients. In addition, FYM contains sufficient amounts of nutrients and organic acids which released in soil (Mekail *et al*., 2006). Increasing of soil salinity due to FYM application may be due to used FYM having a relatively high EC value (5.11 and 5.25 dS $m^{-1}$ in the studied seasons, respectively) as mentioned by Ahmed (2009). Similar results were obtained by El-Koumey (1998), Ahmed (2009) and Ahmed (2017)..

As the interaction between treatments, the results clearly showed that the studied soil properties did not affect by the interaction between phosphorus rates and natural additives. This means that the highest available N, P, K, EC and soil organic matter and lowest pH values were recorded under 10 ton FYM/fed application. On the other hand, the plants without sulphur and FYM exhibited the lowest soil available N, P and K and soil organic matter and the highest pH values.

## CONCLUSION

From abovementioned results and under the conditions of this experiments, added 15 kg P2O5/fed + 10 ton FYM/fed significantly improved quality and quantity of wheat. In addition to improving soil fertility and its physical properties after harvesting.

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## تقييم تأثير الاحماض الامينية والكبريت والسماد البلدي والتسميد الفوسفاتي علي انتاجية والحالة الغذائية لنبات القمح وخواص التربة

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أجريت تجربتان حقليتان بالمزرعة البحثية بمحطة البحوث الزراعية بسدس مركز البحوث الزراعية ،محافظة بني سويف بهدف دراسة تأثير استخدام الاحماض الامينية والكبريت والسماد البلدي والتسميد الفوسفاتي علي انتاجية القمح والحالة الغذائية لة وخواص التربة بعد الحصاد علي صفات النمو (طول النبات والوزن الجاف للنبات) ومكونات المحصول (عدد السنابل في المتر مربع ، عدد الحبوب في السنبلة ، وزن الالف حبة) ومحصول الحبوب والقش وتركيز وامتصاص النيتروجين والفوسفور والبوتاسيوم في الحبوب والقش وكذلك بعض صفات التربة بعد الحصاد (صلاحية النيتروجين والفوسفور والبوتاسيوم ودرجة الحموضة والملوحة ونسبة المادة العضوية). وأوضحت النتائج ان زيادة التسميد الفوسفاتي حتي 15 كجم بو2أ5/فدان ادي الي زيادة معنوية في صفات النمو والمحصول ومكوناتة وتركيز النيتروجين والفوسفور وامتصاص النيتروجين والفوسفور والبوتاسيوم في الحبوب والقش ونسبة البروتين في الحبوب ، كما ادي التسميد الفوسفاتي الي زيادة الفوسفور الميسر بالتربة بعد الحصاد. وادي رش نبات القمح بمعدل 2% احماض امينية مرتين او اضافة 100 كجم كبريت معدني/فدان او اضافة 10 طن سماد بلدي/فدان الي زيادة معنوية لصفات النمو والمحصول ومكوناتة وتركيز العناصر وامتصاصة في الحبوب والقش مقارنة بمعاملة الكنترول. كما ادت اضافة المادة العضوية الي تحسين صلاحية النيتروجين والفوسفور والبوتاسيوم ودرجة الحموضة في التربة بعد الحصاد، كما ادت المادة العضوية الي زيادة ملوحة التربة ونسبة المادة العضوية بها. بينما ادي اضافة الكبريت المعدني الي تحسين صلاحية النيتروجين والفوسفور والبوتاسيوم ودرجة الحموضة بالتربة بعد الحصاد. ومن نتائج الدراسة فان اضافة 15 كجم فو2أ5/فدان +10 طن سماد بلدي/فدان ادي الي تحسين محصول القمح وخواص التربة بعد الزراعة.