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Article

Effect of Humic Acid and Compost with Mineral Fertilizers on Soil Fertility and Productivity of *Phaseolus vulgaris* L.

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Abstract: To mitigate the extensive use of costly mineral fertilizers and promote the adoption of organic alternatives, the current study was used to enhance the efficiency of organic fertilizers, specifically humic acid (HA) and compost (Com) while reducing the reliance on ammonium sulphate (AS) as a mineral fertilizer in common bean cultivation. Consequently, an experiment comprising 27 treatments with three replications was established in a split-split plot design incorporating (3 levels of AS, 3 levels of Com, and 3 levels of HA). This experiment was carried out at a farm located in El-Masharqa village, Fayoum, Egypt, during the agricultural seasons of 2021 and 2022. Humic acid was added as follows: 0, 2, and 4 kg feddan (fed^{-1}), Com was added at levels of 0, 3, and 6 t fed^{-1} and AS was added to the soil surface a rate of 100, 150 and 200 kg fed^{-1}. Some factors were measured, like some plant growth parameters and some chemical soil properties. The results showed that the treatment (AS at rate 200 or 150 kg fed^{-1} with Com 6 t fed^{-1} and 4 kg HA fed^{-1}) gave the highest values, but there was no noticeable difference when AS at a rate of 100 kg fed^{-1} was used. The study recommended using 4 kg HA fed^{-1} with 6 t Com fed^{-1} and 100 or 150 kg AS fed^{-1} which reduced about 25 to 50% of mineral nitrogen fertilizer, which preserved the surrounding environment, increased bean productivity, and soil fertility.

Keywords: Common bean, Organic fertilizers, Nitrogen, Fertilization management.

1. Introduction

Phaseolus vulgaris L. is one of the most ancient and most significant legume crops farmed in Egypt, not only for local consumption but also for export purposes. It's mainly grown for its green pods and dry seeds, which is a good source of proteins that is essential for human nutrition. **FAOSTAT (2020)** reports that 144800 tons of dry beans were produced from 36700 hectares of total cultivated land.

Humic acid is organic molecule that play important role in enhancing soil properties, in turn led to improving plant growth, and agronomic parameters **(Ampong et al., 2022)**. In soil, HA work to increasing the physical and biochemical characteristics by improving texture, structure, water holding capacity (WHC), in addition to microbial population **(Nardi *et al.*, 2021)**. In addition, **Meganid et al. (2015)** reported that HA has both direct and indirect benefits for common bean plant growth and development include changes to enzyme activities, better protein synthesis, increased microbial population, reduced active levels of toxic minerals, enhanced mineral transport, plant hormone-like activity, as well as photosynthesis. **Vikram et al. (2022)** proved that humic compounds have a positive impact on soil quality and fertility by enhancing soil's

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capacity to hold water, establishing soil structure, encouraging soil microbial activity, and modifying plant physiology. Furthermore, it affects nutrient uptake and root architecture, which function as phytohormones for phosphate acquisition and enhance plant tolerance to salinity. Humus is their major microhabitat for microorganisms like dictyostelids, myxomycetes, some species of protostelids, and members of the genus copromyxella. **Ampong et al. (2022)** reported that the physical, chemical, and biological characteristics of the soil may be improved by HA. These characteristics include the ability of the soil to store water, the cation exchange capacity (CEC), pH, carbon content in the soil, enzyme activity, nutrient cycling, and availability.

Li et al. (2019) illustrated that HA enhanced the amount of available nitrogen, available phosphate, available potassium, and organic matter in the soil as well as the total nitrogen, phosphorus, and potassium in the soil. After being treated with HA, the urease enzyme sucrose, and phosphatase activities in the soil all greatly increased, with the maturity period increasing the greatest in peanut planting.

The organic additions and chemical fertilizers had a statistically comparable and impactful significance on the studied parameters of wheat plant **(Hossain et al., 2021)**, who reported that some yield-related metrics, including as spike length, spikeletspike, grainspike, grainspike weight, and 1000-grain weight, were significantly impacted by organic additions. Additionally, compared to control, the combined use of poultry manure boosted grain yield by 73% and straw yield by 27%. Additionally, **Mohamed et al. (2019)** investigated the effects of sludge and compost in combination with bio-fertilizers on wheat grain nutritional content, yield, and yield components. The findings demonstrated that the majority of yield parameters, including spike length, spike weight, and the quantity and weight of grains per spike, were raised by applying sludge or compost as organic fertilizers. When compared to chemical fertilizers, sludge or compost increased grain and straw production as well as biological yield. Further, **Ayneband et al. (2021)** reported that rice 30% compost had the highest grain yield (698.2g .m^{-2}) and grain protein percentage (12.78%). From an agro-ecological perspective, it was discovered that it's important to focus on the quantity, quality, and types of initial organic matter if we want to cut consumption and substitute artificial fertilizer with compost.

Comparing AS to other nitrogen fertilizers like urea and ammonium nitrate (AN), Ammonium sulphate offers essential nutrients for plants, including nitrogen (N) and sulfur (S). Additionally, AS may offer some possible agronomic and environmental advantages as in alkaline soils there is no possible toxicity of aqueous ammonia ($NH_{3)}$ and nitrite (NO_3) to plants, no nitrogen is lost by NH_3 volatilization when applied topically to neutral or acidic soils, no greenhouse gas contribution from CO_2 emissions, less denitrification with AS compared to AN could reduce greenhouse gas emissions and boost N efficiency nitrogen mono oxide (NO) and Nitrose oxide (N_2O) and Positive consequences of soil acidification include increased soil phosphorus (P) availability, phosphate rock application, soil application, and applied micronutrients **(Chien et al., 2011).**

Mineral fertilization has great outcome but the overuse or the high consumption of it destroy the environment and too much expensive. Therefore, this study was conducted to increase the performance of using organic fertilizers (HA and Com) and reducing mineral fertilizers (AS) in common bean productivity and soil fertility.

2. Materials and Methods

2.1 Location, treatments and experimental design

Two field experiments were carried out at farm in El-Masharqa village Fayoum Governorate in Egypt (29° 32' 10.01" N and 30° 91' 87.3" E). Soil was classified sandy loam texture during the two successive seasons of 2021 and 2022, some physical and chemical analyses of experimental site are presented in **Table 1**.

Humic acid was brought from a trading company and treatments were (0, 2 and 4 kg fed^{-1}) was added to the soil after cultivation by dissolution and soaking it in 200 liters of water for 24 to 48 hours then being filtered and adding at two stages on second and fourth irrigation while the stage of root growth and vegetative growth, chemical compositions of the HA are shown in **Table 2**. Compost (Com) was mixed thoroughly with the soil one month before sowing at rate of (0, 3 and 6 t fed^{-1}). Chemical compositions of compost are shown in **Table 3** and chemically analyzed according to **Brunner and Wasmer (1978).**

Ammonium sulphate added to the soil surface at rate (100, 150, and 200 kg fed^{-1}) in three stages first 50 % of the amount with the first irrigation, then 25% of the amount with second irrigation when plant starts flowering and finally 25% of the amount with the third irrigation, common bean needs 40 unit of nitrogen that's equal 200 kg of AS.

An experiment including 27 treatments with 3 replications was set up using a split-split plot design. Ammonium sulphate levels were randomly distributed in the main plots, at three rates (100, 150 and 200 kg fed^{-1}). Each main plot area is about 607.5 m ^{2} and is paved with bridges. Each mean plot has been divided into three sub plots to receive Compost at the rates of (0, 3, and 6 t fed^{-1}) .The sub plots were divided into three sub-sub plots received HA at rates (0, 2, and 4 kg fed^{-1}), each plot has received the P and K in accordance with the recommendations of the Egyptian Ministry of Agriculture. The sub sub-plot area was (3.5 × 2 = 7 m ^{2}) and 3 replicates were used for each there are treatments the total were (81).

Phaseolus vulgaris cv. Nebraska was brought from Egyptian Ministry of Agriculture and the seed used were 50 kg fed^{-1}, using the typical management practices at each site. Common bean was treated with Rhizobium one hour before planting. Common bean was planted by hand from February 20th, the sub sub-plot included 5 ridges each ridge is 0.6 m, seeds planted in 3 cm depth and 5-7 cm space between plants. Common dry bean was harvested 85 to 90 days after planting in each planting season.

Table 1. Some physical and chemical properties of the study soil.

Particle size distribution				Texture	OM (%)	CaCo$_3$ (%)	
Coarse sand (%)	Fine sand (%)	Silt (%)	Clay (%)	Sandy Loam			
11.4	42.7	35.3	10.6		0.41	5.76	

EC (dS m^{-1})	pH (1:2.5)	Cations (meq L^{-1})				Anions (meq L^{-1})			
		Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	CO_3^{2-}	HCO_3^{-}	Cl^{-}	SO_4^{2-}
1.81	7.8	7.2	3.4	6.6	0.8	-	3.8	5.4	8.8

Available macronutrients (mg kg^{-1})	N	P	K
	44.0	4.1	127

Table 2. Chemical composition of humic acid (HA) used in the experiment

Characteristic	Organic carbon (%)	N (%)	C:N ratio	pH	EC (dS m^{-1})	P (%)	K (%)
HA	30.25	2.14	1: 14.14	3.13	1.28	0.21	2.85

Table 3. Chemical composition of the compost used in the experiment

Characteristics	Organic carbon (%)	N (%)	C:N ratio	pH	EC (dS m^{-1})	CaCO$_3$ (%)
Compost	46.5	1.30	1: 35.76	7.76	3.15	1.50

EC: Electric Conductivity, O.M: Organic Matter, pH: Power of Hydrogen or measure of acidity.

2.2 Sampling and measurements

Soil samples from the experimental field were collected at depths of 0 to 30 cm from each site examined during the 2021 and 2022 planting seasons and before the application of compost and irrigation and after performing these treatments. Each plot has 160 plants and 30 plants from each plot were taken for examination. Soluble cations and anions were estimated in the 1:2.5 soil water extract, soluble SO_4 was taken as the difference between the summation of soluble cations and anions, pH values were measured in the soil water suspensions (1:2.5), organic matter was determined by using method as described by **Jackson (1967),** available nitrogen with a solution of potassium sulfate was determined at 1.0%, and the ratio of soil to solution was 1:20 nitrogen in vertat was determined using kjeldahl method **(Jackson 1967)**, Electrical conductivity EC (ds m^{-1}) was determined in 1:2.5 soil water extract by using electrical conductivity bridge according to **Jackson (1967),** available phosphorus was extracted by sodium bicarbonate and then determined by colorimetric method and available potassium was extracted by ammonium acetate, and then measured by a flame photometer as described by **Jackson (1967).** Measurements and calculations of some soil properties were made on the soil samples collected according to **Klute and Dirksen (1986)** for physical analysis, **Jackson (1967), Olsen and Dean (1965) and Chapman and Pratt (1961)** for chemical analysis.

2.2.1. Growth parameters

The fresh and dry weight of common bean plant was recorded by collecting 25 plants from each sub sub-plot in the flowering stage (45 days after planting) and weight of fresh pods when harvesting stage. Common bean plants were cut and dried in the oven at 70 °C for 48 hours.

2.2.2. Yield and yield components

The following harvest parameters were determined weight of 100 seeds (g), seed yield t fed^{-1}, straw yield t fed^{-1} , harvest index and seed nutritional status (i.e. N %, P %, K % and protein) in seeds.

2.2.3. Harvest index:

It was calculated according to the following equation: HI = (EY/BY) × 100, where: HI = harvest index, EY = economic yield (seeds yield), BY = biological yield (seeds+ straw) or (weight of dry plant)

$$\text{Harvest index (\%)} = \frac{\text{Seeds yield}}{\text{(Yield of seeds + Yield of straw) or (plant dry weight)}} \times 100.$$

2.3. Statistical and data analysis

The complete randomized block (spilt-split plot) design with three replicates was used and the collected data were statistically analyzed using the procedures outlined by **Snedecor and Cochran (1982).** Data of the two seasons were subjected to statistical analysis of variance at 5% level according to Duncan multiple range test.

3. Results

3.1. Soil properties

The data in **Table 4** show the effect of used HA, compost and ammonium sulphate on soil pH, EC and organic matter (OM) in the average of both 2021 and 2022 growing seasons. The pH values been significantly reduced due to the effect of HA and compost into the soil. It was observed that the use of HA increased soil acidity that improved the availability and the uptake of N, HA is a chelating compound and when added to the soil and decay it improves soil salinity by chelating some of cations and anions which is responsible for soil salinity like Cl^- and Na^+, which in turn caused a drop in EC. The organic matter content generally increased during the planting seasons that raise in organic matter in the soil achieved highest values upon applying different rates of HA and compost.

Table 4. Effect of HA (HA), compost (Com) and ammonium sulphate (AS) on some chemical soil properties

HA × Com × AS	pH	EC	OM
$HA_0 \times Com_0 \times AS_{100}$	7.78 ef	1.34 bc	0.69 h
$HA_0 \times Com_0 \times AS_{150}$	7.78 ef	1.28 b	0.75 g
$HA_0 \times Com_0 \times AS_{200}$	7.72 ab	1.35 bc	0.90 fg
$HA_0 \times Com_3 \times AS_{100}$	7.74 bc	1.39 ef	1.06 f
$HA_0 \times Com_3 \times AS_{150}$	7.71 b	1.36 de	1.10 f
$HA_0 \times Com_3 \times AS_{200}$	7.75 b	1.47 f	1.20 e
$HA_0 \times Com_3 \times AS_{100}$	7.76 c	1.33 bc	1.18 ef
$HA_0 \times Com_6 \times AS_{150}$	7.74 c	1.23 ab	1.20 e
$HA_0 \times Com_6 \times AS_{200}$	7.74 c	1.24 ab	1.28 cd
$HA_2 \times Com_0 \times AS_{100}$	7.72 b	1.37 d	1.15 de
$HA_2 \times Com_0 \times AS_{150}$	7.74 c	1.22 a	1.20 e
$HA_2 \times Com_0 \times AS_{200}$	7.71 ab	1.42 de	1.25 d
$HA_2 \times Com_3 \times AS_{100}$	7.75 e	1.48 f	1.20 e
$HA_2 \times Com_3 \times AS_{150}$	7.69 a	1.26 ab	1.25 d
$HA_2 \times Com_3 \times AS_{200}$	7.77 ef	1.33 bc	1.29 cd
$HA_2 \times Com_6 \times AS_{100}$	7.76 d	1.34 bc	1.24 d
$HA_2 \times Com_6 \times AS_{150}$	7.71 ab	1.33 bc	1.29 cd
$HA_2 \times Com_6 \times AS_{200}$	7.75 e	1.36 c	1.35 bc
$HA_4 \times Com_0 \times AS_{100}$	7.68 a	1.36 c	1.29 cd
$HA_4 \times Com_0 \times AS_{150}$	7.76 e	1.30 b	1.32 c
$HA_4 \times Com_0 \times AS_{200}$	7.71 ab	1.49 f	1.36 b
$HA_4 \times Com_3 \times AS_{100}$	7.75 ef	1.30 b	1.32 c
$HA_4 \times Com_3 \times AS_{150}$	7.68 a	1.38 ef	1.35 bc
$HA_4 \times Com_3 \times AS_{200}$	7.76 e	1.40 ef	1.39 b
$HA_4 \times Com_6 \times AS_{100}$	7.76 e	1.20 a	1.35 bc
$HA_4 \times Com_6 \times AS_{150}$	7.75 d	1.28 ab	1.40 ab
$HA_4 \times Com_6 \times AS_{200}$	7.71 ab	1.44 e	1.45 a
p-value	0.001^{**}	0.0001^{**}	0.0007^{**}

pH: measure of acidity, EC: electric conductivity, and OM: Organic matter. **Significant at $p \leq 0.01$ based on Duncan multiple range test. Mean values in each column followed by adifferent lower-case-letter (a,b,c,..,) are significantly different by Duncan multiple range test. Each value is average of 3 replicates.

3.2 Plant growth parameters

The effect of HA, compost, and ammonium sulphate on fresh and dry weights at 45 days and green pod yield of common bean plants was presented in **Table 5**. The effect of various treatments in both seasons 2021 and 2022 led to increases in the plant dry matter. The highest average of both seasons for dry weight value was achieved upon using HA at a rate of 4 kg fed^{-1} + compost at a rate of 6 t fed^{-1} + ammonium sulphate at rate 200 kg fed^{-1}. Similar trend was observed as the best result to fresh weight and green pods yield. The treatments showed insignificant effects of adding HA with compost on fresh weight values of the common bean plants. This increase of dry matter accumulation is considered a good response of improved soil fertility and productivity due to the addition of HA and compost to the soil.

Table 5. Effect of humic acid (HA), compost (Com) and ammonium sulphate (AS) on fresh and dry weights at 45 days and green pods yield

HA × Com × AS	FW (g plant^{-1})	DW (g plant^{-1})	GPY (t fed^{-1})
$HA_0 \times Com_0 \times AS_{100}$	9.76 a	3.34 a	1.32 a
$HA_0 \times Com_0 \times AS_{150}$	10.95 a	3.75 a	2.19 a
$HA_0 \times Com_0 \times AS_{200}$	11.39 a	3.90 a	1.90 a
$HA_0 \times Com_3 \times AS_{100}$	11.97 a	4.10 a	1.70 a
$HA_0 \times Com_3 \times AS_{150}$	12.07 a	4.13 a	2.32 a
$HA_0 \times Com_3 \times AS_{200}$	12.56 a	4.30 a	2.40 a
$HA_0 \times Com_3 \times AS_{100}$	12.26 a	4.20 a	1.67 a
$HA_0 \times Com_6 \times AS_{150}$	12.56 a	4.36 a	2.12 a
$HA_0 \times Com_6 \times AS_{200}$	13.14 a	4.56 a	2.66 a
$HA_2 \times Com_0 \times AS_{100}$	13.04 a	4.47 a	2.16 a
$HA_2 \times Com_0 \times AS_{150}$	14.02 a	4.80 a	2.45 a
$HA_2 \times Com_0 \times AS_{200}$	14.70 a	5.03 a	2.70 a
$HA_2 \times Com_3 \times AS_{100}$	14.41 a	4.93 a	2.12 a
$HA_2 \times Com_3 \times AS_{150}$	15.18 a	5.20 a	2.17 a
$HA_2 \times Com_3 \times AS_{200}$	16.45 a	5.63 a	2.92 a
$HA_2 \times Com_6 \times AS_{100}$	15.18 a	5.20 a	2.75 a
$HA_2 \times Com_6 \times AS_{150}$	16.06 a	5.50 a	3.18 a
$HA_2 \times Com_6 \times AS_{200}$	17.13 a	5.87 a	3.75 a
$HA_4 \times Com_0 \times AS_{100}$	16.94 a	5.80 a	3.20 a
$HA_4 \times Com_0 \times AS_{150}$	16.94 a	5.80 a	3.29 a
$HA_4 \times Com_0 \times AS_{200}$	17.71 a	5.90 a	3.95 a
$HA_4 \times Com_3 \times AS_{100}$	17.23 a	6.02 a	3.31 a
$HA_4 \times Com_3 \times AS_{150}$	18.40 a	6.30 a	3.37 a
$HA_4 \times Com_3 \times AS_{200}$	18.88 a	6.47 a	3.68 a
$HA_4 \times Com_6 \times AS_{100}$	18.40 a	6.03 a	3.99 a
$HA_4 \times Com_6 \times AS_{150}$	19.66 a	6.73 a	3.82 a
$HA_4 \times Com_6 \times AS_{200}$	20.05 a	6.87 a	4.11 a
p-value	NS	NS	NS

FW: fresh weight, DW: Dry weight, and GPY: green pod yield. NS: the values not significant at $p \leq 0.05$. Mean values followed by the same letter are not significantly different according to Duncan's test ($p \leq 0.05$). Each value is average of 3 replicates.

3.3. Yield and yield components

Data in **Table 6** show the 100-seed weight, straw yield, seed yield and harvest index of common bean plants. Using HA, compost and ammonium sulphate treatments caused significant increase by 100-seed weight and harvest index of common bean. The use of HA (4 kg fed^{-1}) and compost 6 t fed^{-1} and ammonium sulphate (200 kg fed^{-1}), produced the highest average value for the weight of 100 seeds of common bean as same as the seed yield and straw yield.

The effect of interactions between HA and compost on bean straw yield was significant. In addition, the application of ammonium sulphate treatments significantly improved bean straw production.

Table 6. Effect of humic acid (HA), compost (Com) and ammonium sulphate (AS) on 100-seed weight, straw and seed yields and harvest index.

HA × Com × AS	**100-seed weight (g)**	**Seed yield ($t\ fed^{-1}$)**	**Straw yield ($t\ fed^{-1}$)**	**HI (%)**
$HA_0 \times Com_0 \times AS_{100}$	40.40 k	0.70 a	1.28 n	35 a
$HA_0 \times Com_0 \times AS_{150}$	42.8 i-k	1.15 a	1.32 m	46 a
$HA_0 \times Com_0 \times AS_{200}$	44.98 e-j	1.00 a	1.37 l	42 a
$HA_0 \times Com_3 \times AS_{100}$	41.32 jk	0.9 a	1.32 m	40 a
$HA_0 \times Com_3 \times AS_{150}$	43.77 g-k	1.22 a	1.36 l	47 a
$HA_0 \times Com_3 \times AS_{200}$	45.28 d-j	1.26 a	1.43 k	47 a
$HA_0 \times Com_3 \times AS_{100}$	43.33 h-k	0.88 a	1.32 m	40 a
$HA_0 \times Com_6 \times AS_{150}$	45.84 c-j	1.11a	1.43 k	44 a
$HA_0 \times Com_6 \times AS_{200}$	46.55 b-j	1.4 a	1.50 k	48 a
$HA_2 \times Com_0 \times AS_{100}$	44.37 f-k	1.14 a	1.44 j	44 a
$HA_2 \times Com_0 \times AS_{150}$	45.19 d-j	1.29 a	1.53 k	46 a
$HA_2 \times Com_0 \times AS_{200}$	47.42 a-h	1.42 a	1.59 i	47 a
$HA_2 \times Com_3 \times AS_{100}$	45.90 c-i	1.11 a	1.54. fg	42 a
$HA_2 \times Com_3 \times AS_{150}$	47.77 a-g	1.14 a	1.56 i	42 a
$HA_2 \times Com_3 \times AS_{200}$	45.20 d-j	1.54 a	1.63 h	48 a
$HA_2 \times Com_6 \times AS_{100}$	45.50 a-i	1.45 a	1.56 e	48 a
$HA_2 \times Com_6 \times AS_{150}$	48.79 a-f	1.68 a	1.61 h	51 a
$HA_2 \times Com_6 \times AS_{200}$	49.56 a-e	1.75 a	1.63 ef	52 a
$HA_4 \times Com_0 \times AS_{100}$	48.44 a-g	1.68 a	1.57 e	52 a
$HA_4 \times Com_0 \times AS_{150}$	48.21a-g	1.73 a	1.61 gh	52 a
$HA_4 \times Com_0 \times AS_{200}$	49.29 a-e	1.57 a	1.65 e	53 a
$HA_4 \times Com_3 \times AS_{100}$	47.65 a-g	1.74 a	1.62 cd	52 a
$HA_4 \times Com_3 \times AS_{150}$	47.40 a-g	1.77 a	1.63 e	52 a
$HA_4 \times Com_3 \times AS_{200}$	50.86 ab	1.94 a	1.68 e	53 a
$HA_4 \times Com_6 \times AS_{100}$	48.88 a-d	1.89 a	1.65 d	53 a
$HA_4 \times Com_6 \times AS_{150}$	50.01 a-c	1.96 a	1.67 bc	54 a
$HA_4 \times Com_6 \times AS_{200}$	51.40 a	2.01 a	1.70 a	54 a
p-value	0.0001^{**}	NS	0.001^{**}	NS

HI: Harvest index %. **Significant at $p \leq 0.01$ in Duncan multiple range test. Each value is average of 3 replicates. NS: the values not significant at $p \leq 0.05$. Mean values followed by the same letter are not significantly different according to Duncan's test ($p \leq 0.05$ or ≤ 0.01). Mean values in each column followed by different lower-case-letter (a,b,c,..,) are significantly different according to Duncan's test ($p \leq 0.05$ or ≤ 0.01).

3.4 Macronutrients and protein content in seeds

Data in **Table 7** show the effect of HA additives, compost and ammonium sulphate on nitrogen, phosphors, potassium, and protein percent in seeds of the common bean crop.

The treatment of HA (4 kg fed^{-1}) and compost (6 t fed^{-1}) and ammonium sulphate (200 kg fed^{-1}), and the treatment of HA (4 kg fed^{-1}) and compost (3 t fed^{-1}) and ammonium sulphate (200 kg fed^{-1}) produced the highest values of N % and protein % in the average of both season respectively. The increasing of HA enhances plant growth and increases plant efficiency for absorption of Phosphor can be responsible for increasing the P content. The findings indicate that common dry bean maximum K% in the average of both seasons was reached when HA was added at 4 kg fed^{-1}, compost 6 t fed^{-1} and ammonium sulphate at 150 kg fed^{-1}, generally the treatment 150 kg fed^{-1} (75 %) gave the higher values of k% in dry bean seeds.

The highest values of P concentration were realized for the plants received ammonium sulphate(150 kg fed^{-1}) coupled with the addition of (3 or 6 t fed^{-1}) of compost jointly with HA treatments (2 or 4 kg fed^{-1}). Furthermore, it has been proven that the chemical components of plants and their growth are related to the physiological and biochemical qualities of humic compounds.

Table 7. Effect of humic acid (HA), compost (Com) and ammonium sulphate (AS) on N, P, K and protein content in common bean seeds.

HA × Com × AS	**N (%)**	**P (%)**	**K (%)**	**Protein (%)**
$HA_0 \times Com_0 \times AS_{100}$	3.35 a	0.70 n	1.66 i	20.94 a
$HA_0 \times Com_0 \times AS_{150}$	3.44 a	0.76 i-l	1.74 de	21.81 a
$HA_0 \times Com_0 \times AS_{200}$	3.52 a	0.71 mn	1.68 hi	22.02 a
$HA_0 \times Com_3 \times AS_{100}$	3.40 a	0.70 mn	1.68 f-h	21.25 a
$HA_0 \times Com_3 \times AS_{150}$	3.44 a	0.81 de	1.82 c	21.79 a
$HA_0 \times Com_3 \times AS_{200}$	3.58 a	0.72 l-n	1.71 e-g	22.38 a
$HA_0 \times Com_3 \times AS_{100}$	3.49 a	0.72 j-m	1.68 gh	21.78 a
$HA_0 \times Com_6 \times AS_{150}$	3.55 a	0.83 b-d	1.81 c	22.19 a
$HA_0 \times Com_6 \times AS_{200}$	3.63 a	0.73 k-n	1.72 e-g	22.69 a
$HA_2 \times Com_0 \times AS_{100}$	3.51 a	0.71 j-m	1.68 gh	21.96 a
$HA_2 \times Com_0 \times AS_{150}$	3.59 a	0.78 ef	1.82 bc	22.46 a
$HA_2 \times Com_0 \times AS_{200}$	3.66 a	0.72 j-n	1.72 f-h	22.88 a
$HA_2 \times Com_3 \times AS_{100}$	3.60 a	0.72 j-m	1.70 e-g	22.48 a
$HA_2 \times Com_3 \times AS_{150}$	3.67 a	0.82 bc	1.83 ab	22.96 a
$HA_2 \times Com_3 \times AS_{200}$	3.74 a	0.74 h-j	1.73 d-f	23.38 a
$HA_2 \times Com_6 \times AS_{100}$	3.62 a	0.73 h-k	1.71 e-g	22.65 a
$HA_2 \times Com_6 \times AS_{150}$	3.73 a	0.82 a	1.84 ab	23.33 a
$HA_2 \times Com_6 \times AS_{200}$	3.81 a	0.76 f-h	1.74 e-g	23.83 a
$HA_4 \times Com_0 \times AS_{100}$	3.74 a	0.72 h-k	1.69 f-h	23.35 a
$HA_4 \times Com_0 \times AS_{150}$	3.80 a	0.79 c-e	1.82 bc	23.77 a
$HA_4 \times Com_0 \times AS_{200}$	3.86 a	0.72 kn	1.73 e-g	24.15 a
$HA_4 \times Com_3 \times AS_{100}$	3.79 a	0.75 g-i	1.71 f-h	23.71 a
$HA_4 \times Com_3 \times AS_{150}$	3.85 a	0.83 a	1.84 ab	24.08 a
$HA_4 \times Com_3 \times AS_{200}$	3.92 a	0.76 f-i	1.75 d	24.44 a
$HA_4 \times Com_6 \times AS_{100}$	3.77 a	0.76 ef	1.72 e-g	23.58 a
$HA_4 \times Com_6 \times AS_{150}$	3.89 a	0.84 ab	1.86 a	24.08 a
$HA_4 \times Com_6 \times AS_{200}$	3.95 a	0.77 e-g	1.76 d	24.71 a
p-value	NS	0.01**	0.02*	NS

**Significant at $p \leq 0.01$ based on Duncan multiple range test. NS: the values not significant at $p \leq 0.05$ or ≤ 0.01. Mean values followed by the same letter are not significantly different according to Duncan's test ($p \leq 0.05$ or ≤ 0.01).Mean values in each column followed by different lower-case-letter (a,b,c,..,) are significantly different according to Duncan's test ($p \leq 0.05$ or ≤ 0.01). Each value is average of 3 replicates.

Discussion

The data in **Table 4** show that compost has been shown to both raise and lower soil pH and have the capacity to buffer soil pH **(Butler et al., 2008).** According to **Ampong et al. (2022)** HA may help to improve the soil's physical, chemical, and biological properties. These attributes consist of the soil's pH, (CEC), and carbon content. When organic matter dissolves CO_2 is released into the atmosphere. This CO_2 reacts in soil moisture to generate H_2CO_3, which increases soil acidity. Additionally, the EC was lowered after applying compost and ammonium sulphate. This could be as a result of the acids created during the decomposition and interaction of organic materials with soil fertilizers. Applications of organic amendments, such as compost, improved biological variety and soil structure, which raised the soil's capacity for cation exchange and organic C in addition to reducing the soil salinity **(Rahman et al., 2020)**. The findings showed that applying HA significantly raised the amount of organic matter in the soil, which this finding is similar to that found by **Mahmoud et al. (2011).**

The study showed that the use of compost led to high results of organic matter in the soil after planting and it restores the organic matter that intensive farming has drained from the soil, which is the same result with **Tittarelli et al. (2007).** The right addition of ammonium sulphate increases soil acidity by offers N and S when it dissolved and preserves the biological activity, that helps the organic compounds to decay faster which lead to increase the OM **(Chien et al., 2011).**

Table 5 presents that HA stimulate plant growth by the assimilation of major and minor elements, enzyme activation and/or inhibition, changes in membrane permeability, protein synthesis and finally the activation of biomass production **(Ulukon, 2008).** This increment in vegetative growth of bean plants by HA may be due to that HA contains many elements which improve the plant growth. These results are in harmony with those reported by **Kaya et al. (2005),** which indicates the beneficial effect of nitrogen fertilization on plant growth.

The applied treatments in **Table 6** showed that compost and ammonium sulphate significantly enhanced the weight of 100 seeds of common bean in the growing seasons according to **(Tayebeh et al., 2010**). Due to compost treatments in both growing seasons, there has been a significant increase when the second treatment was used (6 t fed^{-1}) in the weight of 100 seeds of common dry bean by more than 5%. The data indicated that the use of compost achieved similar results to **Mohamed et al. (2019)**. The best results were obtained in both seasons due to application of HA, the effect of using this treatment in dry seed yield production could be referred to that humic substance may possibly enhance the uptake of minerals through the stimulation of microbiological activities **(Mayhew, 2004)**. Results showed significant increases in the seed yield weight due to compost applications. These findings are consistent with **(Ayneband et al., 2021)**.

Data in **Table 7** show that plant roots are greatly influenced by humic substances in their growth, HAs have been shown to improve root initiation and promote root growth when added to the soil **(Pettit, 2004)**. Enhancing the uptake of nitrogen has been directly connected to the stimulatory actions of humic compounds **(Chen and Aviad, 1990)**.

The beneficial impact of compost on N% and its uptake could be the result of compost's improvement of the physical characteristics of the soil and the availability of nutrients, which in turn affected root and vegetative growth and, ultimately, N content and plant uptake this result was consistent with the findings of **(Selim et al., 2007)**.

The data observed that protein content was increased with increasing the level of HA. This is consistent with those reported by **Ahmed et al. (2010), EI-Bassiony et al. (2010), and Fawzy et al. (2010).** Results from **Kaya et al. (2005) and Zaki et al. (2006)**, support the beneficial effect of adding the treatment HA+ mineral fertilizers recommendation on N and protein percentage in common bean dry seeds.

Furthermore, **El-Ghamry et al. (2009)** noted that humic substances play an essential role in the carbon cycle because they are a stable fraction of carbon and control the release of nutrients like phosphate and nitrogen, which reduces the need for inorganic fertilizers in plant growth through facilitating absorption of both major and minor nutrients. By increasing compost, there was a slightly increase in P% in dry bean seeds. The highest values of P concentration were realized for the plants received ammonium sulphate(150 kg fed^{-1}) coupled with the addition of (3or 6 t fed^{-1}) of compost jointly with HA treatments (2 or 4 kg fed^{-1}). These results are in agreement with those obtained by **Abd El-Monium and massoud (2009)**.

The superior results of K% were obtained with the addition of compost combined with 75% mineral nitrogen fertilizer and humic components according to **Meshref et al. (2010).** Similar findings observed by **Abd El-Monium and Massoud (2009),** who found that applying compost, increased the amount of K% and increasing in total K content may have resulted from compost's positive reaction as an organic matter amendment which can enhance crop quality and soil properties also promoting soil microbial populations and biological activity.

5. Conclusions

Regarding to the results, it can be concluded that common bean plants fertilized with HA and Com enhanced the vegetative growth and some chemical soil properties. The treatment of HA 4 kg fed^{-1} with Com 6 t fed^{-1} with the use of AS at rate 200 or 150 kg fed^{-1} gave the best value. But there was no big difference when AS at rate 100 kg fed^{-1} was used. There was an ascending relationship between seed yield harvest index % and different rates of HA, Com and AS but using HA effect more in seed yield harvest index %. Otherwise the outcome when AS used at rate 100 or 150 kg fed^{-1} gave a great result when mixed with HA and Com comparing with the average production of common bean in Egypt that's lead us to reduce AS from 200 kg fed^{-1} to 150 or 100 kg fed^{-1} about 25% to 50% of mineral nitrogen fertilizer.

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