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Planting spaces, Humic acid, and NPK fertilizer affect the occurrence of certain insect pests and rust disease on common bean plants and yield

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ABSTRACT

Three planting spaces (7, 10, and 13 cm.) between seeds and the effect of humic acid with the recommended dose (2 kg/feddan) and different rates of NPK fertilizer (humic 100%, NPK 100%, Humic + 25% NPK, Humic + 50% NPK, Humic + 75% NPK, Humic + 100% NPK, and control) were evaluated throughout the 2019 and 2020 seasons at Suez Governorate to determine their combined effect on the population density of certain insect pests, aphids (mainly *Aphis gossypii, Myzus persicae*, and *Aphis craccivora*), whitefly, *Bemisia tabaci* , jassids, *Empasca lybica*, and rust disease severity, *Uromyces appendiculatus* on common bean plants, *Phaseolus vulgaris* (Nepraska cultivar), and pod yield. Common bean plants cultivated in the closest and intermediate planting spaces (7 and 10 cm between hills) harbored the significantly highest infestation of all four pests. The significantly lowest infestation of the three studied insects and rust disease was obtained from common bean plants treated with humic acid plus 50% NPK. The four studied pests and produced yield were significantly affected by both two studied factors together, as the treatment of humic acid + 50% NPK at the three tested spacings (7, 10, and 13 cm) showed the lowest infestation and gave the highest weight of pods. Common bean plants grown in control treatments that did not receive any fertilizers were infested with the least significant numbers of the three studied insects due to the weakness of the plant and the lack of sufficient vegetation while infected by the heaviest rust disease severity.

Keywords: *Phaseolus vulgaris*; aphids; whitefly; jassids; planting spaces; rust disease; *Uromyces appendiculatus*; Humic acid, NPK fertilizer and yield.

INTRODUCTION

Common bean (*Phaseolus vulgaris* L.) is a member of the Fabaceae family and are important food crops both economically and nutritionally. The importance of common beans is that they are a cheap source of protein for poor people in several countries. It is commonly consumed for its delicacy, high protein content, and as a source of certain antioxidants, minerals, and polyphenols. In addition to the superior quality of the protein, the common bean is an excellent source of starch, dietary fiber, vitamins, and minerals (Ernest, *et. al.* 2014). In Egypt, the cultivated area of common bean has increased in recent years, especially in newly reclaimed areas in the open field and under greenhouses to cover needs for local consumption and export to foreign markets. (Shehata *et. al.* 2011). According to the statistics of the Ministry of Agriculture 2018, Egypt occupies the tenth rank in the world in exporting the common bean pod yield and sixth in production, as production reached 270.80 thousand tons.11000 tons are exported, which is equivalent to 4.00 % of the total world export. Because the common bean plant has valuable nutritional properties, it is considered a source for improving food security for poor communities, but it is infested by many insect pests such as aphids (mainly *Aphis gossypii*, (Glover), *Myzus persicae* (Sulzer) and *Aphis craccivora* (Koch) (, whitefly, *Bemisia tabaci* (Genn.) and jassids, *Empasca lybica* (Beg), as well as some fungal diseases such as rust (*Uromyces appendiculate* (Pers: Pers.) (Fatma and Maha 2017).

Aphids and whitefly insect pests are considered two of the most important pets on common bean plants during the three growing periods, seedling, flowering, and fruiting. They can cause several damages to many crops by directly feeding on phloem sap and indirectly by transmitting viral disease. (Satar 2012). These pests cause serious damage leading to a great reduction in both the quantity and quality of the yield (El-Saeidy *et al.,* 2013; Hanafy *et al.,* 2014). Common bean rust disease, *Uromyces appendiculatus* (Pers: Pers.) occurs worldwide but is most common in humid tropical and subtropical areas and can reduce yield and pod quality. Severe epidemics occur periodically in humid temperate climates. Yield losses can reach 100 % and are directly related to earliness and severity of infection (Stavely, 1991; Coyne *et al.* 2003).

Humic acid (HA) is the main fraction of humic substances (HS) and the most active component of soil and compost organic matter. HA can enhance nutrient availability and improve chemical, biological, and physical soil properties The direct and indirect beneficial effects of HA on plant growth and development are their effect on cell membranes which lead to the enhanced transport of minerals, improved protein synthesis, plant hormone-like activity, promoted photosynthesis, modified enzyme activities, the solubility of micro-elements and macro-elements, reduction of active levels of toxic minerals and increased microbial population. (Abeer *et al.* (2015). Humic acid (HA) can be improving soil fertility and increase the availability of nutrients and consequently increase plant growth and yield. It is particularly used to reduce the negative effect of salt stress (Abd El-Al., 2005).

The fertilizers NPK contain three key nutrient elements. Nitrogen promotes vegetative growth and green coloration of foliage, Phosphorus plays a major role in root growth, photosynthesis, respiration, energy storage, cell division, and maturation. Potassium is important in flower and fruit growth, plant metabolism, protein synthesis, and chlorophyll development (Yagoub *et al.,* 2012).

Planting distances play an important role in infesting common bean plants with insects and diseases, as competition between plants increases by increasing the number of plants per unit area. i.e. close plant spacing reduced plant growth and yield components but increased yield per unit area (Wanns, *et al.* 1986; Osman, *et al.* (2010).

So, the present study aims to study the combined effect of planting spaces and adding humic acid with the recommended dose (2 kg/feddan) into the soil with different rates of NPK fertilizer on the population density of the above-mentioned insect pests and the severity of rust disease on common bean plants and their effect on the resulted yield.

MATERIAL AND METHODS

This experiment was conducted in Shandra village, Sues Governorate, during two successive seasons in 2019 and 2020 to determine the combined effect of three different planting spaces (7, 10, and 13 cm between hills) and adding humic acid, which consists of potassium humate at 85%. potassium 10% and vulvic acid 5%) (Black Earth, Canada Company) with the recommended dose (2 kg/Fadden) and different levels of NPK 19-19-19 (5.00, 3.75, 2.50, and 1.25 kg/Feddan) and compared with the control treatment, which did not receive any fertilizers on common bean plants (Nebraska cultivar). The total area of about 756 m2 was divided into 84 plots, each about 9 m2. All studied treatments were arranged in a split-plot design with three replicates; planting spaces of 7, 10, and 13 cm between seeds were arranged in the main plots, whereas fertilizer application (humic acid and NPK fertilizer) served in sub-plots. The plot area included five ridges, each 0.6 m in width and 4 m in length. Seeds of common bean were sown on September 1st in both seasons in hills on one side of the ridge. The experiment with Humic and NPK fertilizer included seven treatments as follows: (1) Humic (HA) 100%, (2) NPK 100%, (3) (HA+25%NPK), (4) HA+ 50%NPK, (5) HA+ 75%NPK, (6) HA+ 100%NPK, and (7) control (untreated) with three plants spacing 7, 10, and 13 cm between hills. Humic acid and NPK fertilizers were added at 21-day intervals twice, the first time after 21 days from sowing and the second time after 42 days of sowing. All the experimental plots received the normal agricultural practices of mechanical weed control and irrigation and were kept free from any pesticidal application. After 15 days of sowing, samples of 10 leaves representing all plant levels were picked weekly from each replicate (30 leaves for treatment). The collected leaves were placed directly into paper bags and taken to the laboratory. All stages of aphids (mainly *Aphis gossypii, Myzus persicae*, and *Aphis craccivora*) and nymphal stages of *Bemisia tabaci* were counted using a stereomicroscope. Jassids were inspected in the field due to their great speed and the difficulty of keeping them in a paper bag to transport them to the laboratory.

Disease severity (D S) was estimated in leaf samples randomly taken after 60, 70, and 80 days from sowing. The plants were rated for Disease symptoms, as the severity percentage according to Hanounik (1986). Twelve categories were suggested to estimate the severity of rusted leaves using the scale in which 0,1,2,3,4,4,5,6,7,8,9,10,11 and 12 signified 0, 1-3, 3-6, 6-12, 12-25,25-50,50-75,75-88,88-92,92-96,96-100, and 100 % of the leaf surface was covered with pustules

$$Disease\ severity\ \% = \frac{\sum(NPC\ x\ CR)}{(NIP\ x\ MSC)}\ x\ 100$$

W here N P C = N o. of plants in each class rate
C R = class rate
N IP = N o. of infected plants.
M SC = M maximum severity class rate.
To clarify the relative susceptibility of the tested common bean cultivar to infection with rust disease.

Statistical analysis:
The statistical analysis of the obtained data of the effect of the plant spacing, Humic acid, and NPK fertilizers on the population density of the studied insect pests and rust disease severity, was analyzed by using the SAS program computer, Including F-test and calculated L.S.D (Least significant difference) to find differences between seasonal mean numbers of the three studied insect pests and rust disease severity on the studied common bean cultivars. (SAS Institute, 2003).

RESULTS

This study aims to investigate the effects of planting spaces, NPK fertilizer rates, and Humic acid on the infestation rates of common bean plants with aphids (especially *A. gossypii*, *A. craccivora*, and *M. persicae*), whitefly *(Bemisia tabaci*) and jassids (*Empoasca lybica*) as well as the effect on the severity of infection with rust disease (*Uromyces appendiculatus*) and finally their effect on the resulted yield. The obtained results can be summarized as follow:

1- Effect of planting spaces of common bean plants on the population densities of certain insect pests and rust Disease:

Table 1. seasonal mean numbers of certain insect pests and rust disease on common bean plants planted on three spacing.

Seasons	2019				2020				Mean of two seasons			
Pests / Spacing	Aphids	B tabaci	Jassids	Rust%	Aphids	B tabaci	Jassids	Rust%	Aphids	B tabaci	Jassids	Rust%
7cm	15.09^{a}	10.51a	5.69^{a}	71.84^{a}	21.29^{a}	18.69^{a}	4.39^{a}	73.73^{a}	18.19^{a}	14.60^{a}	5.04	72.79^{a}
10cm	9.20^{b}	7.53b	5.44^{a}	66.29^{b}	10.95^{b}	12.93^{b}	3.07^{b}	68.77^{ab}	10.08^{b}	10.23^{b}	4.26	67.53^{b}
13cm	6.76^{c}	4.69c	4.55^{a}	59.28^{c}	6.81^{c}	9.41^{b}	2.14^{b}	61.73^{b}	6.79^{c}	7.05^{c}	3.35	61.51^{c}
F	12.72	9.20	1.30	7.65	28.31	10.63	6.82	3.06	31.05	15.07	0.98	9.49
L.S.D	2.10	2.71	1.49	5.31	3.96	4.06	1.23	5.75	2.20	1.84	2.30	4.23

2- Effect of Humic acid and different rates of NPK fertilizers on the infestation rates of certain insect pests and rust: disease on common bean plants.

The obtained data in Table (2) show the effect of applying humic acid at the recommended dose (2 kg/feddan) and different rates of NPK fertilizers on the infestation rates of common bean plants with aphids, whiteflies, and jassids, as well as rust disease, during the two studied seasons of 2019 and 2020. Results indicated that the population densities of the three studied insect pests and rust disease were significantly affected by the application rates of Humic and NPK fertilizer, where the lowest seasonal mean number of aphids, whiteflies, and jassids was obtained from common bean plants treated with Humic + 50% NPK, being 6.85, 4.80, and 4.38 individuals per leaf in the first season and 10.47, 11.22, and 2.17 individuals per leaf, respectively. Also, the lowest rust disease severity was recorded on common bean plants that received the same fertilizer rate (Humic + 50% NPK), showing 50.70% and 57.84% in the two studied seasons, respectively. On the other extreme, the highest seasonal mean numbers of the three studied insects were recorded on common bean plants treated with Humic+100%NPK, being 16.82, 10.65, 7.52, 19.53, 23.00, and 6.25 individuals per leaf in the studied seasons, respectively. The heaviest severity of rust disease was obtained from common bean plants in the control treatment, which did not receive any fertilizer levels in the two studied seasons, 92.53 and 95.47%, respectively. Results of the statistical analysis showed that there were highly significant differences between the average numbers of insects in all tested treatments as well as between the severity of rust disease, as L.S.D. values were 2.05, 1.05, 1.65, and 8.59 and 3.41, 2.46, 1.05, and 7.95

for aphids, whiteflies, jassids, and severity of rust disease in the two study seasons, respectively. Also, the results of the statistical analysis of the studied seasons together indicated that there were significant differences between the seasonal mean number of the three studied insects within different treatments as well as between the severity of infection with rust disease, as L.S.D. values were 2.00, 0.95, 1.09, and 6.65, respectively.

From the obtained results in Table 2, it was found that the use of Humic acid at the recommended dose (2 kg/Fadden) + 50% NPK led to infesting common bean plants with the lowest significant number of the three studied insect pests and rust disease, followed significantly by the common bean plants treated with Humic + 25% NPK, and in third place came the common bean plants that received Humic + 75% NPK. On the contrary, the application of Humic + 100% led to the infesting of common bean plants with the largest significant number of the three tested insects and rust disease and occupied the highest rank in the infection. According to L.S.D. values, the treatments of Humic and NPK fertilizers could be arranged discerningly according to their infestation with aphids, whiteflies, jassids, and rust disease as follows: H+100% NPK>NPK 100%> Humic 100%>Humic +75% NPK> Humic +25%NPK > Humic +50%NPK. Finally, it could be stated that the application of Humic + 50% NPK on common bean plants led to a decrease in the infestation of aphids, whiteflies, jassids, and rust disease.

Table 2. Mean numbers of certain insect pests and disease severity on common bean treated with different rates of humic acids and NPK fertilizers during two seasons

Mean no. of insect pests and rust/ leaf												
Seasons	**First season (2019)**				**Second season (2020)**				**Mean of two seasons**			
Pests	**Aphids**	***B tabaci***	**Jassids**	**Rust%**	**Aphids**	***B tabaci***	**Jassids**	**Rust %**	**Aphids**	***B tabaci***	**Jassids**	**Rust %**
Humic 100%	12.92 b	9.73 b	5.75 bc	50.58 d	14.07b	14.43c	3.22bc	47.50 d	13.50c	12.08c	4.49c	49.04e
NPK 100%	13.77 b	13.48 a	6.68 ab	61.14c	17.76 a	15.53bc	4.17b	62.56c	15.77b	14.51 b	5.43bc	61.85c
H+25 % NPK	8.50d	4.88 d	4.05 d	59.49c	13.90b	11.25d	2.55cd	61.80c	11.20d	8.07d	3.30d	60.65cd
H+50 % NPK	6.85d	4.80 d	4.38 cd	50.70 d	10.47c	11.22d	2.17d	57.84c	8.66e	8.01d	3.28d	54.27d
H+75 % NPK	10.65c	7.52 c	6.87 ab	72.08 b	14.00b	17.10b	3.73b	75.01 b	12.33cd	12.31c	5.63ab	73.55b
H+100 % NPK	16.82 a	10.65 b	7.52 a	74.10 b	19.53 a	23.00a	6.25a	76.33 b	18.18a	16.83a	6.56a	75.22b
Control	2.97e	1.98 e	1.35	92.53a	1.38d	3.20e	0.32e	95.47a	2.18f	2.59e	0.84e	94.00a
F value	18.40	10.65	4.10	23.98	17.80	25.50	10.51	29.65	21.25	9.58	7.05	24.45
LSD	2.05	1.05	1.65	8.59	3.41	2.46	1.05	7.95	2.00	0.95	1.09	6.65

3- Combined effect of planting spaces and fertilizers treatments on the infestation of certain insect pests and rust disease on common bean plants:

From the obtained results in Table (3), aphids, whitefly, and jassid & rust disease were significantly affected by both planting distances and fertilizers. The obtained results were as follow:

Regarding aphid infestation, a clear and significant difference was observed between seasonal mean numbers in the two studied seasons within the different spaces and fertilizer treatments, as L.S.D. values were 2.29 and 2.74, respectively. Common bean plants grown on the three tested planting spaces (7, 10, and 13 cm between hills) and treated with H+50%NPK were exposed to the lowest significant numbers of aphids in the two studied seasons, as the seasonal mean numbers were 5.65, 4.25, and 4.05 and 18.10, 7.25, and 6.05 individuals per leaf, respectively. On the contrary, the significantly highest infestation of aphids was recorded on common bean plants planted at the narrowest distance (7 cm) and treated with H+100%NPK, NPK 100%, and 100% Humic during the first season, with a seasonal mean number of 25.65, 22.25, and 18.50 individuals per leaf, respectively. The obtained results in the second season were like the results of the first one, where common bean plants planted at the closest space (7 cm) and treated with NPK 100% and H + NPK 100% occupied the first infestation group (a), showing 30.30 and 29.05 individuals per leaf, respectively, followed significantly by group (b), which presented by applying 100% Humic (24.60 individuals per leaf). Common bean plants grown in the control treatment did not receive any fertilizers and were infested with the least significant numbers of aphids due to the weakness of the plant and the lack of sufficient vegetation to feed the aphids.

Table 3. Mean numbers of certain insect pests and rust disease on common bean plants in three planting spaces and treated with different rates of humic acids and NPK fertilizers during two seasons

Treatments	Mean no. of insect pests and rust/ leaf											
	First season (2019)											
	Aphids			B tabaci			Jassids			Rust		
	7 cm	10cm	13 cm	7 cm	10cm	13 cm	7 cm	10cm	13 cm	7 cm	10cm	13 cm
Humic 100%	18.50^{c}	12.60^{e}	7.65^{hi}	12.40^{b}	9.15^{c}	7.65^{cde}	5.75^{cdefg}	6.45^{bcd}	5.05^{defg}	58.13^{ghijk}	50.20^{kml}	43.40^{m}
NPK 100%	22.25^{b}	*8.85^{gh}*	10.20^{fg}	18.90^{a}	12.95^{b}	8.60^{cd}	6.25^{cde}	6.85^{bcd}	6.95^{bcd}	67.53^{ef}	61.70^{fghi}	54.20^{hijkl}
H+25 % NPK	12.25^{ef}	9.80^{gh}	10.05^{fg}	6.25^{ef}	5.45^{efg}	2.95^{hi}	3.95^{gh}	4.15^{fg}	4.05^{gh}	63.56^{efgh}	59.60^{fghij}	55.30^{hijk}
H+50 % NPK	5.65^{ij}	4.25^{j}	4.05^{j}	6.40^{def}	4.95^{fgh}	3.05^{hi}	5.05^{defg}	3.95^{gh}	4.15^{fg}	56.12^{hijk}	50.71^{jklm}	45.27^{ml}
H+75 % NPK	17.20^{cd}	9.25^{gh}	5.50^{ij}	9.15^{c}	9.65^{c}	3.75^{ghi}	7.55^{abc}	8.85^{ab}	6.15^{cdef}	78.22^{cd}	72.25^{de}	65.77^{efg}
H+100 % NPK	25.65^{a}	16.05^{d}	8.75^{gh}	18.35^{a}	8.60^{cd}	5.00^{fgh}	9.25^{a}	6.85^{bcd}	4.52^{efg}	82.93^{bc}	77.28^{cd}	62.10^{fghi}
Control	4.15^{j}	3.60^{j}	1.15^{k}	2.15^{i}	1.95^{i}	1.85^{i}	2.05^{hi}	1.00^{i}	1.00^{i}	96.40^{a}	92.30^{a}	88.90^{ab}
F	64.80			38.38			9.84			21.75		
L.S.D	2.29			2.25			2.03			9.34		
Second season (2020)												
Humic 100%	24.60^{b}	10.95^{ef}	6.65^{hi}	14.65^{ef}	15.80^{e}	12.85^{f}	4.65^{cde}	2.95^{fgh}	2.05^{ghi}	55.14^{ghi}	49.12^{i}	38.25^{j}
NPK 100%	30.30^{a}	14.95^{d}	8.03^{ghi}	21.20^{c}	13.45^{ef}	11.95^{fgh}	5.85^{bc}	3.10^{fg}	3.55^{def}	68.08^{de}	63.20^{efg}	56.40^{fghi}
H+25 % NPK	20.30^{c}	12.10^{e}	9.30^{fgh}	18.65^{cd}	12.35^{fg}	8.65^{i}	4.05^{def}	2.01^{ghi}	1.60^{hij}	65.40^{ef}	62.10^{efgh}	57.90^{fghi}
H+50 % NPK	18.10^{c}	7.25^{hi}	6.05^{i}	12.75^{f}	9.85^{ghi}	5.15^{j}	3.20^{efg}	2.01^{ghi}	1.30^{ij}	65.13^{efg}	55.95^{fghi}	52.45^{hi}
H+75 % NPK	24.25^{b}	11.10^{ef}	6.65^{hi}	26.05^{b}	16.05^{de}	9.20^{hi}	4.70^{cd}	4.95^{bcd}	1.55^{hij}	80.34^{c}	75.80^{cd}	68.90^{de}
H+100 % NPK	29.05^{a}	19.30^{c}	10.25^{efg}	32.85^{a}	20.05^{c}	16.10^{de}	7.75^{a}	6.25^{b}	4.75^{cd}	83.50^{bc}	79.70^{c}	65.80^{def}
Control	2.40^{j}	1.00^{j}	0.75^{j}	4.65^{jk}	2.95^{jk}	2.00k	0.55^{j}	0.20^{j}	0.20^{j}	98.50^{a}	95.50^{a}	92.40^{ab}
F value	84.60			58.04			16.58			20.17		
LSD	2.74			2.81			1.45			10.02		

Concerning *B. tabaci*, the obtained results were similar to the results of aphids, which showed a significant difference between the seasonal mean number within the different treatments (21 treatments) in the two studied seasons, as L.S.D. values were 2.25 and 2.81, respectively. The significantly least infestation of *B. tabaci* was obtained from common bean plants that received H+50%NPK and H+25% NPK, as the seasonal mean numbers of these two treatments in the first season were 6.40, 4.95 and 3.05 & 6.25, 5,45 and 2.95 individuals/ leaf respectively, and 12.75, 9.85 and 5.15 & 18.65, 12.35 and 8.65 for the two treatments in the second season respectively. The results in the same table indicated that the best treatment to obtain the lowest significant infestation of *B. tabaci* was the common bean plants planted at the widest distance (13cm) for the two previously mentioned treatments. In contrast, the highest infestation of *B. tabaci* was recorded on common bean plants cultivated in the closest distance (7cm) treated with NPK 100% and H+100% NPK in the first season with seasonal mean numbers 18.90 and 18.35 individuals/ leaf, respectively and treated with H+100% NPK and H+75% NPK, 32.85 and 26.05 individuals/ leaf, respectively. As in the case of aphids, very weak numbers of *B. tabaci* were recorded on common bean plants in the control treatment. As happened in the case of aphids and *B. Tabaci,* the obtained results of the examination of jassid insect indicated that there was a significant difference between the average numbers in all treatments, The least significant infestation of jassid was recorded on the same two treatments that were infested with the lowest significant numbers of aphids and whitefly, *i.e.* when planting common bean seeds at any of the three tested spaces (7,10, and 13cm) and applying H+50%NPK and H+ 25%NPK, as the seasonal mean numbers were 5.05,3.95 and 4.15 & 3.95,4.15 and 4.05 individuals/leaf in the first season, respectively and 3.20,2.01and 1.30 & 4.05, 2.01 and 1.60 individuals/ leaf. On the other hand, the significantly highest infestations of jassids were recorded on common bean plants planted at the closest distance (7cm) and received H+100 %NPK, as the seasonal mean numbers were 9.25 and 7.75 individuals/ leaf in the two seasons, respectively. In the first season, the best treatment to reduce jassid infestation was obtained when planting common bean plants at a distance of (7cm) and adding H+25%NPK followed by H+50% NPK in the same space, as the seasonal mean number was 3.95 and 5.05 individuals/leaf. In the second season, the best treatment was common bean plants planted at 13 cm and applying H+50% NPK and H+25% NPK, being 1.30 and 1.60 individuals /leaf, respectively. As for the combined effect of planting spaces and fertilizer rates on the infection of common bean plants with rust disease, the obtained results differed from the three previously mentioned insect pests where common bean plants grown in the control treatment which did not receive any fertilizer rates were infected with the significantly highest infection of rust in the three studied cultivation distances (7,10 and 13cm), as the seasonal mean disease severity of rust were 96.40, 92.30 and 88.90 % in the first season and 98.50, 95.50 and 92.40 % in the second season, respectively. On the contrary, the results were completely similar to the previous insects in terms of infection with rust disease, as the plants in the two treatments H+50%NPK and H+25%NPK which were infested by the lowest numbers of aphids, whitefly and ,jassids had the lightest significant severity of rust disease, being 56.12, 50.71 and 45,27 % & 63.56, 59.60 and 55.30 % for the two treatments in the first season, respectively, and 65.13, 55.95 and 65.13 % & 65.40,62.10 and 57.60% in the second season respectively. The first season results showed that the best treatment to decrease the severity of rust disease on common bean plants is cultivated seeds at widest distance (13cm) and treated them with Humic 100% and H+50% NPK, as the average of rust severities were 43.40 and 45.27 %, respectively without significant difference between these two treatments. In the second season, the best treatment is common bean plants planted at 13 cm between hills and treated with H+100% only, 38.25 % (table 3).

4: combined effect of planting spaces and fertilizers on common bean yield:

The obtained results in Table (4) showed that the production of common bean pods was significantly affected by both two factors (planting spaces and fertilizers). The statistical analysis indicated that there were significant differences between all the studied treatments in the two growing seasons, as L.S.D. values were 0.55 and 0.58 in the two seasons, respectively. Regarding the results of the first season, it was found that the yield of common bean pods increased in all treatments compared with the control treatment which produced the significantly lowest quantity of pod yield. Results revealed that the most productive treatments for common bean pod, which occupied the first group (a), were the common bean grown in the following treatments: (7cmxH+100%NPK), (10cm xH+NPK100%, and NPK100% which produced the same quantity of yield), (10 cm H+50%NPK), (10cmxNPK 100%), (7cmxH+50%NPK and 10cm x H+50%NPK), as they produced 2.10, 2.05, 2.00, 1.98 and 1.95 ton /feddan, respectively. On the other extreme, the lowest quantity of common bean yield was obtained from common bean plants planted at 7,10, and 13cm between hills and treated with Humic 100%, as they yielded 0.45, 0.59, and 0.80 ton/feddan respectively, and occupied the last three groups (ef, fg, and fgh). The results in the second season followed the same trend as the first season. Common bean plants planted at the closest space and medium space (7 cm and 10 cm) and treated with Humic+100% NPK produced the significantly highest quantity of pods, being 2.30 and 2.10 ton /feddan and represented in the first group (a), followed significantly by the second group (ab) which include common bean plants planted at 10 cm and 7 cm and treated with NPK 100% and produced 2.00 and 1.90 ton / feddan, respectively and common bean plants planted at 10 cm space and treated with H+50%NPK produced 1.90 ton/ feddan.

Table 4. Combined effect of planting spaces, NPK fertilizer, and Humic acid on the resulting yield Ton / feddan of common bean plants in two studied seasons 2019 and 2020.

Treatments	2019			2020		
	7 cm	10 cm	13cm	7 cm	10 cm ^{fg}	13cm
Humic 100%	0.45^{fgh}	0.59^{fg}	0.80^{ef}	0.50^{gh}	0.65^{fg}	0.65^{fg}
NPK 100%	2.05^{a}	1.98^{a}	1.65^{abcd}	1.90^{ab}	2.00^{ab}	1.85^{abc}
H+25 % NPK	1.35^{bcde}	1.55^{abcd}	1.30^{cde}	1.30^{cde}	1.46^{bcde}	1.15^{ef}
H+50 % NPK	1.95^{a}	2.00^{a}	1.95^{a}	1.80^{abcd}	1.90^{ab}	1.75^{abcd}
H+75 % NPK	1.19^{de}	1.88^{ab}	1.70^{abcd}	0.95^{efg}	1.22^{def}	1.02^{efg}
H+100 % NPK	2.10^{a}	2.05^{a}	1.80^{abc}	2.30^{a}	2.10^{a}	1.95^{ab}
Control	0.20^{gh}	0.03^{h}	0.02^{h}	0.04^{h}	0.02^{h}	0.03^{h}
F value	13.62			12.72		
LSD	0.55			0.58		

As happened in the first season, the results confirmed that the cultivation of common bean at any distance (7,10, and 13 cm) between hills and applying Humic 100% only led to obtaining the least significant number of resulting pods and occupied the lowest two groups (table 4).

DISCUSSION

In the current study, the obtained results indicated that the studied factors (planting distances,7, 10, and 13cm. between common bean seeds), the effect of Humic Acid with recommended dose (2 kg / feddan), and different rates of NPK fertilizer (Humic100%, NPK 100%, Humic + 25% NPK, Humic + 50% NPK, Humic + 75% NPK, Humic +100%NPK, and control) had a direct effect on the population densities of aphids, whitefly, and jassids & rust disease severity on common bean plants, as well as the resulting pod yield. The same results were reported by many authors in different countries.

The results of the effect of planting distances on the four studied pests were in harmony with those recorded by, Emam *et al.* (2006) in Egypt who mentioned that the sweet pea plants were infested by the significantly lowest seasonal mean numbers of *B. tabaci* in the largest distance (40cm between hills) between hills. Manjesh (2018) stated that the higher rust incidence (61.64 %) was recorded on bean plants in closer (45x30cm), while the lower incidence of 33.86% was recorded with wider spacing. (60x75). Getachew *et al.* (2014) in Ethiopia recorded that the narrow distance of common bean plants (40x7cm) had the potential to decrease the rust incidence compared with the widest distance (50cm x 7cm,40x 15cm, and 40x10cm).

Concerning the effect of Humic acid and different rates of NPK fertilizers on the infestation rates of certain insect pests and rust disease on common bean plants, the obtained results were in Agreement with Hanfy (2004) and Ghallab *et al.* (2014) in Egypt they mentioned that the population density of *B, tabaci , T. tabaci*, and aphids increased by increasing the NPK fertilizer level on cucumber and common bean, respectively. Baidoo and Mochiah (2011) on okra plants stated that the increasing of nutrient application enhances plant growth; however, growth can make the plant more attractive to pests attack due to the better growth of plants which supported their survival and reproduction. Fatma Morsy (2021) in Egypt mentioned that the application of Humic acid through fertigation on eggplant lead to reduce the population density of aphids, *Aphis gossypii*, whitefly (*Bemisia tabaci*), and red two-spotted spider mite, *Tetranychus urticae*) on eggplant were recorded compared with foliar application.

Obtained results concern the combined effect of planting distances and fertilizers treatments on the common bean pests and resulting yield were in agreement with discussed results by Singh *et al.* (1992) in China found that close plant distance of faba bean increased the yield of pods. Abubaker (2008) found that the highest early yields (73% and 71%) were obtained at plant densities of 20x30 cm and 30x 30cm, compared with 40 x 40 cm. Osman *et al.* (2010) in Sudan stated that the pod yield of Snap Bean (*Phaseolus vulgaris L*. was increased by increasing row distance. Ayoub *et al.* (2014) In Sudan stated that the yield of snap bean (*Phaseolus vulgaris* L.) mentioned that the maximum pod yield was obtained from the narrowest distance between hills. Manjesh (2018) recorded that significantly higher (15.04 ton/hectare) and lower pod yield (9.19 t/ha) were recorded with closer distances (45x30 cm) and wider distances of 60x75cm, respectively and the higher rust incidence was observed in the closer distance and lower diseases were recorded in the wider distance. Fatma and Maha (2017) in Egypt recorded that the application of Humic acid with recommended dose (2 kg / Fed) + 50% NPK gave the lowest infestation of aphids, *T. tabaci*, and *B. tabaci* as well as reduced the infection of rust disease on common bean plants. While the treatment of Humic acid + 100 % NPK and Humic acid + 75% NPK gave the highest percent of rust disease severity and heaviest infestation of these three insect pests. Masa *et al.* (2017) in Ethiopia mentioned that the grain yield of common beans increased at the closest spacing. Al-Nafei and Maher (2021) in Iraq found that planting safflower at a distance of 20 cm and spraying Humic acid with 500 mg / L. gave the highest rates in most considered qualities and yield of dry petals and seed yield, while treatment of 10 cm distance × 500 mg / L. humic acid produced the highest means on total phenolic compounds and total oxidative activity. In Egypt Fatma Morsy (2021) reported that using of Humic acid through fertigation on eggplant caused a significant enhancement in the number of shoots, stem diameter, and fresh weight of yield (Hayam and Abd Elrahman, 2021). in Egypt mentioned that using potassium Humate + Yeast extract in combination treatment with 75% Nitrogen and Phosphor (NP) improves plant quality and decreases infestation of *B. tabaci*, *Aphis craccivora,* and *Tetranychus urticae.*

CONCLUSION

The result of this study indicated that although common bean plants planted at a narrow distance of 7 cm were subjected to the highest significant infestation of aphids, whiteflies, and jassids, they produced the highest yield of pods. The best fertilizer treatments were Humic + 50% NPK, as its plants were infected with the fewest insects and rust diseases and produced a good crop of pods. The results of insects and rust disease were affected by two factors together, and the most important results were the plants planted at distances of 7, 10 cm, which were treated with H+50%NPK, which was exposed to the least significant infection by pests and produced the highest significant yield.

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تأثير مسافات الزراعة ، حمض الهيوميك ومعدلات سماد NPK على تواجد أهم الآفات الحشرية ومرض الصدأ على نباتات الفاصوليا والمحصول الناتج

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تم إجراء هذه الدراسه بمحافظة السويس بجمهورية مصر العربيه خلال موسمى2019 و 2020 بهدف دراسة تأثير مسافات الزرعه بين بذور الفاصوليا عند زراعتها وكذلك دراسة تأثير حمض الهيوميك بالجرعة الموصى بها (2 كجم / فدان) مع معدلات مختلفه من سماد ال NPK وكذلك التأثير المشترك لهما على معدلات اصابة نباتات الفاصوليا بحشرات المن ، الذبابه البيضاء ،الجاسيد ومرض الصدأ الفطرى وأيضا تأثيرهما على محصول القرون الناتج. حيث تم زراعة بذور الفاصوليا فى العروه النيلى(صنف نبراسكا) على ثلاث مساقات زراعه هى 7 ، 10 ، 13 سم واستخدام ستة معدلات سماديه مختلفه هى هيوميك 100%، NPK100 ، هيوميك + NPK 100 %، هيوميك + NPK 75 %، هيوميك 50% ،هيوميك + NPK25 % ومقارنتها بالكنترول بدون إضافة أى معاملات سماديه . أظهرت نتائج الدراسه أن شدة الإصابه بمرض الصدأ والحشرات المدروسه قد تأثرت معنويا بمسافات الزراعه حيث تبين أن نباتات الفاصوليا التى زرعت بذورها على المسافات الضيقه والمتوسطه (7 و 10 سم) قد تعرضت للإصابه بأعلى عدد معنوى من الحشرات محل الدراسه وكذلك أعلى شدة إصابه بمرض الصدأ فى حين أنها أنتجت أعلى وزن معنوى من القرون الخضراء. سمادNPK وحمض الهيوميك كان لهما تأثير معنوى واضح على شدة الإصابه بمرض الصدأ والكثافه العدديه الثلاث حشرات محل الدراسة حيث تم الحصول على أقل إصابه معنويه من الأربعة أفات لنباتات الفاصوليا المعامله بحمض الهيوميك + NPK 50 %فى حين أن أعلى إنتاج معنوى من القرون تم الحصول عليه خلال موسمى الدراسه من نباتات الفاصوليا التى إستقبلت حمض الهيوميك + NPK 100 %، هيوميك + NPK50 % و NPK. 100 %تأثرت شدة الإصابة بمرض الصدأ والحشرات الثلاثة المدروسه بشكل كبير بالعاملين المدروسين معا (مسافات الزراعة والمستويات المختلفه من التسميد) حيث تم تسجيل أعلى متوسطات للإصابه بالأربعة أفات المدروسه على نباتات الفاصوليا التى زرعت بذورها على أقل مسافه (7 سم2) والتى تم معاملتها بحمض الهيوميك + 100٪ ، هيوميك 100% و NPK100%ومن ناحية أخرى فإن نباتات الفاصوليا الموجوده فى معاملة الكنترول تعرضت لأقل عدد معنوى من الحشرات الثلاثه نتيجة ضعف النبات وعدم تكوين مجموع خضرى كاف لتغذية الحشرات. إختلفت النتائج التى تم الحصول عليها لمرض الصدأ عن الأفات الحشريه الثلاثه المذكوره سابقا حيث تعرضت نبات الفاصوليا الموجوده فى معاملة الكنترول لأعلى شدة إصابه بالصدأ فى الثلاث مسافات المختبره يليها نباتات الفاصوليا المزروعه فى أضيق مسافه (7 سم) وعوملت بالهيوميك + NPK100 % و هيوميك + NPK. 75 %أظهرت معاملة الهيوميك + NPK 50 %فى المسافات الثلاثه المختبره (7،10 و 13 سم)أقل شدة إصابه بمرض الصدأ وأقل عدد معنوى للثلاث حشرات محل الدراسه وأعطت وزن عالى من القرون وكان أفضلها نباتات لفاصوليا التى عوملت بنفس المعدل من التسميدى والتى زرعت على أقل مسافة (7 سم) وهى التى انتجت أعلى إنتاج معنوى من القرون. على العكس من ذلك فقد تم الحصول على أقل إنتاج معنوى من نباتات الفاصوليا الزروعه فى معاملة الكنترول.

الكلمات المفتاحية: الفاصوليا ، المن ، الذبابة البيضاء ، الجاسد ، مسافات الزراعة ، مرض الصدأ ، حمض الهيوميك و سماد NPK و المحصول.