Research Article

Foliar Application of Humic Acid Improves Growth and Yield of Chilli (*Capsicum annum* L.) Varieties

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Abstract | Chilli is an important agricultural crop, cultivated all over the world. It has high nutritional value and mostly used as a spice in the food. Nutrients are applied to the crop plants in different farms to improve its production and nutritional value. This experiment was conducted at Agriculture Research Institute (ARI) Tarnab, Peshawar during summer 2016. Two factors i.e. Chilli varieties (Magma and High fly) and humic acid levels (0, 25, 50, 75 and 100 g L^{-1}) were applied in the field during experiment. The results of the experiment showed that High fly variety took minimum days to produce flowering (33 days), maximum numbers of leaves $plant^{-1}$ (208.93), plant height (42.27 cm), stem diameter (1.60 cm), number of fruit $plant^{-1}$ (52.53), yield $plant^{-1}$ (184.61 g) and total yield (3.69 t ha^{-1}), while maximum fruit weight (3.65 g), fruit volume (9.47 cm^3) and fruit diameter (12.0 mm) were noted in variety Magma. In case of humic acid levels, maximum number of leaves $plant^{-1}$ (243.67), branches $plant^{-1}$ (5.50), plant height (47.33 cm), stem diameter (1.83 cm), number of fruit $plant^{-1}$ (57.50), yield $plant^{-1}$ (204.50 g) and total yield (3.93 t ha^{-1}) were recorded in 50 g humic acid L^{-1} as a foliar spray. Whereas early flowering (33 days), fruit weight (3.81 g), fruit diameter (13.82 mm), fruit volume (11.33 cm^3) were found in plants treated with 100 g humic acid L^{-1}. It can be concluded that aerial application of humic acid at 50 g L^{-1} and variety High fly variety give best results under the climatic conditions of Peshawar.

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Introduction

Chilli, botanically known as *Capsicum annuum* L. is a key agricultural crop. It is an important vegetable crop having high nutritional value. It is a very good source of natural colors and anti-oxidant combinations important for human health (Howard et al., 2000). The most important and common specie s of capsicum is pepper which is cultivated throughout the world among domesticated species of capsicums. There are different species of pepper with respect to size and shape in the world (mild and hot), which ranges from chilli peppers to bell peppers. Worldwide, *C. annuum* is vastly cultured and economically significant species which contains both sweetened and spicy fruits in different size and shapes (Bosland, 1992). Chilli originated at America, many important chilli pepper cultivars were spread all over the world, After Columbian Exchange which is used in both food and medicine. The world chilli production in 2004 reached go 1.7 million hectares (FAO, 2008). It is a small variety of capsicum available in various colors such as yellow, orange, green, black and red. They have a straight,

woody stem and single, star-shaped, white flower in the axils of the leaves. The flowers are followed by juiceless berries or pods. World's largest producer of chilli is China. Which produce about 50 % Chilli of the world and covered about 33% of the world area of production of chilli (FAO, 2005). Chilli is cultivated on 652.5 thousand hectares area in Pakistan with a production of 139.9 thousand tons. The Sindh province had shown a very high production of chilli and had produce of 1238.8 thousand tons production. While Punjab, Khyber Pakthunkhwa and Balochistan produced 9.4, 6.2 and 0.5 thousand tons chilli respectively (ASP, 2014-2015). In Pakistan, dehydrated chilli peppers are grown on an area of 66 thousand hectares with 130 thousand tons of production. In Pakistan, yield per hectare is 1.96 tones as compared to 6.25 tons in other dry chilli pepper growing countries like china (FAO, 2007).

Humic acid is recognized as dark gold of agriculture. It is a major constituent of Humic materials contributed the main essential elements of peat, coal and soil. It is extremely soluble in water and simply absorbed up by a plant as related to fertilizer because it has frequent vigorous locations which mark it soluble in water. There is a rising attention in the use of Humic acid as organic manures or soil tonic. El-Ghamry et al. (2009) showed that the use of humic constituents as foliar use increase growth and mineral content as well as reduce the injury of chocolate spot and rust infections of Faba bean. Humic ingredients comprise three types of organic acid; humin, humic acid and fulvic acid. They have been well-defined in humic science in harmony with their solubility features (IHSS, 2004). Humic acid has three types of effect (Physical, Chemical, and Biological) on soil and plants, Physical Effect; enhance water holding capability, Increase ventilation of soil, improve soil workability, assistances in drought resistance, make soil further friable or crumbly, reduce soil corrosion. Chemical effect; chelates nutrients for endorsement by plants, holds high ion-exchange ability and rises buffering traits of soils. Increase nitrogen levels the in soil and biological effect, hastens plant cell division and stimulates growth, increase germination of seed and viability (Shiva et al., 2015). Humic substances encourage plant growth by the integration of major and minor elements, activator and inhibitor of several enzymes, changes in membrane penetrability, important for protein synthesis and increase of biomass production (Mackowiak et al., 2001). Humic acid deficiency is a significant nutritional problem in soils worldwide; therefore, improving the humic acid nutritional status to plants could greatly improve the production of vegetable crops like chilli (Aktafi et al., 2006). Keeping in view that the above review about the importance of Chilli and humic acid, the present research study was conducted to identify the optimum dose of Humic Acid on quantitative attributes to chilli production and to evaluate the growth and yield of chilli varieties.

Materials and Methods

A field experiment on the "Effect of foliar application of Humic acid on development and yield of chilli (*Capsicum annuum* L.) Varieties" was conducted at Agriculture Research Institute (ARI) Tarnab Peshawar during 2016. The research was laid out in Randomized Complete Block Design (RCBD) with three replicates having two factors, factor A was two varieties of chilli i.e., Magma and High fly. Factor B was five different levels of Humic acid i.e., 0, 25, 50, 75, 100 g L^{-1}. The seedlings of both varieties were provided by ARI Tarnab, Peshawar vegetable section. The plot was prepared by using cultivator and rotavator. The plot was leveled and divided in three blocks. The seedlings were planted with row to row distance 60 cm and plant to plant distance 50 cm. In each replication, there were 10 treatments. Total of 300 numbers of seedlings were used in the experiment. The total area of each replication was 42 m^2 having 2.5 m^2 plot size, whereas the total experimental area was 126 m^2. The recommended dose of NPK was applied as a basal dose at the rate of 30:60:30 kg ha^{-1} just before the sowing. The Source of NPK was Urea, Diammonium Phosphate and murate of Potash. The Humic Acid was applied by foliar method on chilli plants, at 0, 25, 50, 75 and 100 g dissolved in one liter volume of water. All other cultural practices were applied uniformly in the field. The following parameters were recorded. Plant Height (cm), Six plants were randomly selected from individual plots and their plant tallness was measured with the help of measuring tape from top of the soil to the tip of the plant and then average was calculated for further statistical analysis. Number of leaves $plant^{-1}$ was calculated randomly in the selected plants in each treatment and each replication of the experiment and their average was calculated for further analysis. For the number of branches $plant^{-1}$, six sample plants were designated in every treatment

per replication and their numbers of branches were calculated and then their average was considered for further statistical analysis. Similarly, for Days to flowering, six plants were randomly selected and their days were calculated from the date of transplanting to the 50% plants flowered in each replication and their average was considered for further analysis. For fruit weight six randomly samples were selected in each treatment and 10 fruits were randomly selected and weight was calculated by using a digital scale. Vernier caliper was used to determine the fruit diameter of chilli. For this purpose, 10 randomly fruits were collected from every treatment of the experiment and their fruit diameters were measured and the average was considered for further statistical analysis. For the number of fruits plant^{-1}, six random plants were chosen in each treatment of the experiment and fruits were calculated. Thereafter average was calculated for further statistical analysis. Stem diameter was recorded by using Vernier caliper. Six sample plants were designated in each treatment of the trial and their stem diameter was calculated in the lower, middle and upper portion of the stem and the average was calculated. After that their average was considered for further analysis. Fruit volume was measured by means of water displacement method. For this purpose, a beaker was taken and put 100ml of water in it, and it was considered as initial reading. Thereafter a chilli fruit was dipped in that beaker. The level of water was rose up and the reading was recorded as final reading. The volume of each fruit was determined with following formula. This process was repeated for all fruits which was selected randomly and then their average was calculated.

$$Volume\ of\ fruit\ (cm3) = Final\ reading - Initial\ reading$$

Yield plant^{-1} was measured with the help of digital scale. For this purpose, all the fruits were assumed from six randomly selected samples in each treatment of the experiment and their weight was measured and then their average was considered for supplementary analysis. To determine the Total Yield (tons ha^{-1}), All the fruits were harvested from the experimental unit and their weight was measured with the help of a digital scale. This process was repeated for all experimental units and converted into tons ha^{-1} by using the following formula.

$$\text{Total yield (tons ha}^{-1}) = \frac{\text{Yield per plot in (kg)} \times 10000\text{m}^2}{\text{Area of the plot m}^2 \times 1000}$$

Statistical analysis

For statistical analysis statistix software 8.1 was used. Furthermore, LSD test was performed for mean comparison (Steel et al., 1997).

Results and Discussion

Number of leaves plant^{-1}

Leaf is the important organ of the plant which is the main source of food for the plant as the photosynthesis occurred in it. The variety high fly produce maximum number of leaves plant^{-1} (208.93) as compared with variety Magma (184.67) (Table 1). In terms of humic acid concentration maximum number of leaves plant^{-1} (243.67) was found in those plants treated with 50 g L^{-1} humic acid while minimum number of leaves plant^{-1} (129.50) was found in control plot (Table 1). Significant variation was observed among chilli varieties in number of leaves plant^{-1}. This variation might be due to genetic reasons. Mehraj et al. (2014) also recorded a significant variation in chilli varieties. Humic acid levels also showed a significant variation in number of leaves plant^{-1}. It is due to the capability of humic acid to stimulate the hormonal activities in plants and also increase plant growth, plant height, uptake of nutrients and tolerance to stresses (Serenella et al., 2002). The same finding was noted by Dursun et al. (2002) in tomato and eggplant treated with various humic acid concentrations.

Number of branches plant^{-1}

Results showed that number of branches plant^{-1} was significantly affected by humic acid levels. While, chilli varieties and interaction of treatments was non-significant. In case of humic acid, maximum number of branches plant^{-1} (5.50) were recorded in plants treated with 50 g L^{-1} humic acid as foliar spray followed by 4.50 branches which were recorded in 25g L^{-1} humic acid. Humic acid treatments i.e. 25 g L^{-1}, 75 g L^{-1} and 100 g L^{-1} were statistically similar. However, minimum number of branches plant^{-1} (3.0) was noted in Control (Table 2). Humic acid levels also affected number of branches plant^{-1} significantly. Humic acid is very important for root and shoot growth of the plant. It increases the uptake of nutrients in vegetables crop (Cimrin and Yilmaz, 2005). Studies showed that the foliar application of humic acid increase vegetative growth of the plant. Brownell et al. (1987) reported that foliar application of humic acid significantly increased number of branches palnt^{-1} in tomato. It has been reported that the application of

humic acid increased the soil fertility and enhanced the availability of nutrients (Yildirim, 2007). The results are similar with the findings of Dod et al. (1989) who reported that humic acid can significantly affect number of branches plant^{-1}. The similar results were also reported by Fathima and Denesh (2013).

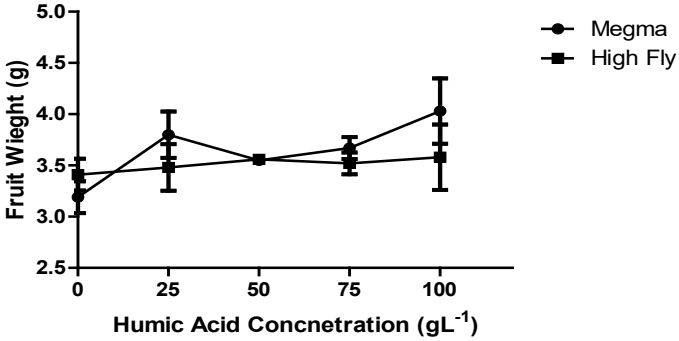

Figure 1: *Present the effect of humic acid concentrations and chilli varieties on fruit weight (g).*

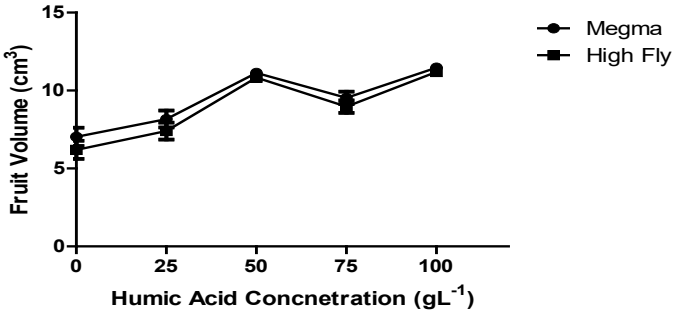

Figure 2: *Present the effect of humic acid concentrations and chilli varieties on fruit volume (cm^3).*

Plant height (cm)

Mean data shows that plant height was significantly affected by chilli varieties and humic acid levels, while the interaction was found non-significant. In case of varieties, maximum plant height (42.27 cm) was observed in variety High fly while minimum plant height (41.20 cm) was noted in variety Magma (Table 1). Furthermore, In case of humic acid levels, maximum plant height (47.33 cm) was recorded in plants treated with 50 g L^{-1} humic acid as foliar spray followed by 75 g L^{-1} of humic acid (42.67 cm). However, minimum plant height (38.17 cm) was noted in control (Table 2). The variation in plant height among chilli varieties may be due to genetic reasons. The similar finding was noted by Ganefianti et al. (2017) who reported that significant variation was recorded in plant height by different chilli genotypes. In case of humic acid a significant difference was observed in plant height. Humic acid is a type of fertilizers which contain several elements due to which soil fertility increase. It also increases the availability of nutrients in the soil. As a result, growth and yield of the plants, especially, vegetables crops increased and it also reduce the damages caused by stresses (Doran et al., 2003). It has been reported that nitrogen use efficiency increased with the application of humic acid which enhanced plant shoot and root growth (Adani et al., 1998). Our results are similar with the finding of Fathima and Denesh (2013) who reported that humic acid levels significantly affect plant height of chilli. Yildirim (2007) has also similar findings in tomato crop.

Stem diameter (cm)

Results regarding stem diameter showed that, it is significantly affected by chilli varieties and humic acid levels, whereas the interaction of the treatments was found non-significant. In varieties, Variety High fly have maximum stem diameter (1.60 cm) as compared to variety Magma (1.47 cm) (Table 1). In terms of humic acid levels 50 g L^{-1} foliar application produced maximum stem diameter (1.83 cm) which was statistically similar with 75 g L^{-1} humic acid level which produce (1.77 cm) stem diameter. While, minimum stem diameter (1.08 cm) was observed in control plots (Table 1). The variation in stem diameter among chilli varieties is may be genetic combination. Chowdhury et al. (2015) reported that different stem diameter produced by chilli varieties in similar environmental condition was might be due to genetic makeup of the varieties. In terms of humic acid levels, there was a significant variation in humic acid levels regarding stem diameter. The physical, chemical and biological properties of the soil were increased with the application of humic acid. As a result of which the plant growth also improved (Nardi et al., 2005). Trevisan et al. (2009) reported that humic acid substances are the major source of soil fertility and soil properties due to which all the growth and yield components of the plant increased. Studies concluded that there is a direct relationship between nutrients uptake such as N, P, S and micro nutrients such as Fe, Zn, Cu, and Mn with the application of humic acid (Chen et al., 2001).

Days to flowering

Results show that there is a significant effect by chilli varieties and humic acid levels on days to flowering (Table 1), while interaction was non-significant. In terms of varieties, high fly variety produced early flowering (33.07 days) as compared to Magma variety (35.87 days) which produced late flowering. In case of humic acid, the early flowering (33.33 days) was observed in

Table 1: *Present data regarding number of leaves, number of branches, plant height, stem diameter, days to flowering, number of fruits, fruit diameter, yield per plant and total yield as affected by Humic acid concentrations.*

Cultivar	No. of Leaves	No. of branches	Plant height cm	Stem diameter	days to flowering	No. of fruit	fruit diameter	Yield per plant	total yield
Magma	184.67 b	4.27	41.20 b	1.47 b	35.87 a	47.40 b	12.00 a	173.34 b	3.56 b
High fly	208.93 a	4.47	42.27 a	1.60 a	33.07 b	52.53 a	11.53 b	184.61 a	3.69 a
LSD 5%	14.18	ns	0.84	0.06	0.77	1.05	0.27	4.6	0.026

Table 2: *Present data regarding number of leaves, number of branches, plant height, stem diameter, days to flowering, number of fruits, fruit diameter, yield per plant and total yield as affected by Chili cultivars.*

Humic Acid	No. of Leaves	No. of branches	Plant height cm	Stem diameter	days to flowering	No. of fruit	fruit diameter	Yield per plant	total yield
Control	169.50 d	3.00 c	38.17 e	1.08 c	37.33 a	40.50 d	9.18 d	158.80 c	3.30 e
25	195.17 c	4.50 b	39.50 d	1.45 b	34.67 b	48.83 c	10.12 c	177.17 b	3.54 d
50	243.67 a	5.50 a	47.33 a	1.83 a	33.50 bc	57.50 a	13.53 a	204.50 a	3.93 a
75	195.00 c	4.33 b	42.67 b	1.77 a	33.50 bc	55.00 b	12.18 b	197.76 a	3.71 b
100	220.67 b	4.50 b	41.00 c	1.53 b	33.33 c	48.00 c	13.82 a	181.67 b	3.62 c
LSD 5%	22.42	0.8	1.33	0.1	1.23	1.66	0.43	7.28	0.025

plots which were treated with 100 g L^{-1} of humic acid. Maximum days to flowering (37.33 days) were noted in Control plots (Table 2). Variation among chilli varieties may be due to genetic makeup.

Genetic estimation of Days to flowering for hot pepers was 45% (Fitriani et al., 2013). Syukur et al. (2010) proposed that early flowering is a good character in chilli genetic breeding. It has been confirmed by Tesfaw et al. (2013) that every chilli variety needs specific days to flowering. Humic acid levels significantly affected days to flowering of chilli. Humic acid is a substance which can affect plants in two ways such as directly and indirectly. In direct way it improves chlorophyll content, fasten the respiration of plants and also improve the response of hormonal growth which lead early flowering of plants. The indirect effect is improving all the properties of the soil which also increase the plant performance (Salt et al., 2001). Our results are similar with the results of Fathima and Denesh (2013) whos reported that the days to flowering of chilli was significantly affected by humic acid levels.

Numbers of fruit plant^{-1}

The mean data revealed that number of fruit plant^{-1} was significantly affected by chilli variety and humic acid levels and the interaction was non-significant. maximum number of fruit plant^{-1} (52.53) was recorded in variety High fly while the variety Magma produce less number of fruit plant^{-1} (47.40) (Table 1). In case of humic acid, maximum number of fruit plant^{-1} (57.50) was recorded in plots treated with 50 g L^{-1} foliar application of humic acid, while the minimum number of fruit plant^{-1} (40.50) was recorded in Control (Table 2). The variation was observed among chilli varieties in numbers of fruit plant^{-1} and this variation might be due to genetic reasons. The variation in growth characteristic under similar situations might be due to genetic factors (Kishan and Suryanarayan, 2004). Obidiebube et al. (2012) reported that there is a significant variation among chilli varieties in number of fruits plant^{-1}. With the application of humic acid levels, number of fruits plant^{-1} was significantly increased. It has been reported by Karakurt et al. (2009) that plant growth, quality and yield attributes was increased with the foliar application of humic acid levels. It has reported that the chlorophyll content of plant especially chlorophyll b was increased with the application of humic acid as a result the number of fruit plant^{-1} increased (Fernandez et al., 1996). The similar results were observed by Padem and Ocal (1999) who concluded that different concentration of humic acid application results a significant variation in number of fruits plant^{-1}. Our findings are also same with the finding of Fathima and Denesh (2013) who observed that the number of leaves plant^{-1} was affected on the application of humic acid.

Fruit weight (g)

Chilli is cultivated for its fruit, so its quality and

quantity is very important. The mean data revealed that there is a significant effect of chilli varieties and humic acid levels on fruit weight, while the interaction of these treatments was also observed significant. In case of interaction, the maximum fruit weight (4.03 g) was noted in variety Magma which was treated with 100 g L^{-1} foliar spray of humic acid while the minimum fruit weight (3.19 g) was recorded in variety Magma sown in control plots. In case of varieties, Magma variety gave heavy fruits (3.65 g) as compared to variety High fly (3.51 g). In terms of humic acid levels maximum fruit weight (3.81 g) was recorded in plants which were treated with 100 g L^{-1} humic acid as foliar spray while minimum fruit weight (3.30 g) was recorded in Control plots. The different fruit weight was observed in chilli varieties (Figure 1). Studies showed that the variation among chilli varieties in fruit weight was due to genetic reasons. Fitriani et al. (2013) concluded that there are 86.1 % chances of variation in fruit weight among chilli varieties and these variations was due to genetic makeup. The difference in fruit weight of chilli varieties was also observed by Obidiebube et al. (2012). The significant variation was recorded in humic acid levels in fruit weight. Studies showed that the plant cell metabolism was increased with the application of humic acid and as a result the yield of the plant increased (Turkmen et al., 2004). Kasperbauer (1987) concluded that humic acid can enhanced plant growth, plant canopy due to which plant can intercept light in a good way and as a result fruit weight of plant increased and thus increased yield of the plant. In another experiment Albayrak and Camas (2005) reported that the application of humic acid significantly affect the reproductive growth and yield of the plant. The same results were observed by Celik et al. (2008) in corn and oat and Karakurat et al. (2009) in pepper.

Fruit diameter (mm)

Mean data revealed that fruit diameter of chilli significantly affected by varieties and humic acid levels. However, the interaction of treatments was found non-significant. In varieties, Magma produced fruits having maximum (12.0 mm) diameter as compared to variety High fly (11.53 mm) (Table 1). In terms of humic acid levels maximum fruit diameter (13.82 mm) was produced in plots treated with 100 g L^{-1} of humic acid as foliar spray, while minimum fruit diameter (9.18 mm) was observed in Control (Table 2). The variation among chilli varieties was observed. This variation might be due to genetic makeup of the variety. Widyawati et al. (2014) reported that fruit diameter characters had very heritability estimate. They also added that the differences in fruit diameter of chilli were a genetic controlled character not an environmental controlled. It has reported that there has an about 90.6 % chance of variation in fruit diameter among pepper varieties (Fitriani et al., 2013). Our results are similar with the finding of Wahyudi (2012) who concluded that there is a significant variation in fruit diameter among chilli hybrids. The foliar application of humic acid significantly affected fruit diameter. The application of humic acid significantly increased the rate of photosynthesis, root development and plant nutrients content of the plant and thus increased the fruit weight and diameter Liu et al. (1996). Yildrim (2007) concluded that the addition of humic acid significantly increased the fruit diameter of tomato. In another study it has been noted that the humic acid increased fruit diameter up to 16-17 % as compared to control (Vasilenko, 2002). Similar results were noted by Mehraj et al. (2014) who reported that humic acid significantly affected the fruit diameter of pepper.

Fruit volume (cm^3)

The mean data shows that fruit volume of chilli was significantly affected by varieties and humic acid levels, the interaction of their treatments was also found significant. In terms of interaction, the maximum fruit volume (11.47 cm^3) was noted in variety High fly treated with 100 ml application of humic acid as a foliar spray while the minimum fruit volume (6.20 cm^3) was recorded in variety Magma sown in Control plots. In varieties, the maximum fruit volume (9.47 cm^3) Figure 2 was recorded in variety Magma while the minimum fruit volume (8.92 cm^3) was noted on variety High fly. In case of humic acid the maximum fruit volume (11.33 cm^3) was observed in 100 g L^{-1} application of humic acid and minimum (6.62 cm^3) fruit volume was noted in Control. The significant difference was observed among chilli varieties in fruit volume and these variations might be due to genetic combination of the variety. In a research study Alfian et al. (2014) studied that fruit volume has a high heritability trait and it has been reported that this factor controlled by genetic factors as compared to other factors. Our results are similar with the results of Ganefianti et al. (2017) who concluded that different chilli varieties produced a significant variation in fruit volume. Humic acid application significantly improved the fruit volume of chilli. Humic role is to

increase the health of soil, plant nutrients uptake, and mineral availability as a result of which plant produce fruit having maximum weight, diameter and volume (Mauromicale et al., 2011). Humic acid fertilizers stimulate plant enzymes, improve soil fertility and increase fruit yield by enhancing yield attributes (Mohamed et al., 2009). Asri et al. (2015) also noted that the fruit volume of tomato was significantly affected by humic acid.

Yield plant^{-1} (g)

The mean data shows that there was a significant variation among chilli varieties and humic acid levels regarding yield plant^{-1}. However, the interaction was found non-significant. In varieties, the variety High fly gave maximum (184.61 g) yield plant^{-1} as compared to variety Magma (173.34 g) (Table 1). In humic acid, the maximum yield plant^{-1} (204.50 g) was recorded in 50 g L^{-1} humic acid, while the minimum yield plant^{-1} (133.80 g) was produced in Control (Table 2). Chilli varieties show significant variations in yield plant^{-1} and these variations were presumably due to genetic variations. Mathai et al. (2001) noted that 282 to 334 g weight of fruit plant^{-1} in chilli varieties. The variation yield plant^{-1} in different chilli varieties was due to genetic reasons and big varietal differences (Rajput et al., 1999). Our results was similar with the finding of Sujiprihati et al. (2007) who reported that yield plant^{-1} was different in different chilli varieties. The foliar application of humic acid has significantly affected yield plant^{-1}. It has been studied that the foliar application of humic acid significantly increased number of fruit branch^{-1}, fruit set and number of fruit plant^{-1}. As a result of this plant yield was increased (Zhang and Erwin, 2004). The positive impact of humic acid on plant productivity was due to harmonic activities of humic acid such that improving cell respiration, photosynthesis, formation of protein and activation of several enzymes (Zhang et al., 2003). The similar finding was reported by Delfine et al. (2005) in wheat, Adani et al. (1998) in tomato and Fathima and Denesh (2013) in chilli who concluded that the foliar application of humic acid increased the yield of plant.

Total yield (kg ha^{-1})

A significant increase in yield per plant is recorded; as a result total yield was also significantly affected by chilli varieties and humic acid levels, while the interaction of the treatments was found non-significant. In chilli varieties, the variety High fly produce maximum yield (3.69 t ha^{-1}), as compared to variety Magma (3.56 t ha^{-1}) Table 1. In terms of humic acid, the maximum yield (3.93 t ha^{-1}) was recorded in those plots which were treated with the foliar spray of 50 g L^{-1} humic acid level. However the minimum yield (3.31 t ha^{-1}) of chilli was noted in Control (Table 2). Significantly variation was observed among chilli varieties in total yield. This variation was due to genetic and some other reasons. Genefianti et al. (2008) reported that total yield of the crop was directly proportional to number of fruits plant^{-1}. Fitrini et al. (2013) concluded that total yield of different chilli varieties was controlled by environmental conditions greater than genetic attributes. Total yield of chilli were significantly affected by humic acid levels. Humic acid increase the physiological process of plant. The application of humic acid also increases the micro and macro nutrients availability to plants and thus improves proteins, vitamins and plant growth regulators such as auxine, cytokinines and absasic acid contents of the plant (Yildrim, 2007). In another study Rehman et al. (2007) reported that the application of humic acid significantly increased the tomato yield. Like that Martin and Senn (1997) also noted that the yield of tomato increased with the application of humic acid. Zaky et al. (2006) concluded that the leaf area, number of shoots palnt^{-1}, fruit weight, yield plant^{-1} and total yield of bean plants increased with the application of humic acid. Our results are similar with the finding of Fathima and Denesh (2013) who also noted that the total yield of chilli was increased with the foliar application of humic acid.

Conclusions and Recommendations

From the overall results of the experiment, it is concluded that high fly variety perform better under the climatic conditions of Peshawar. Similarly, foliar application of Humic acid at the rate of 50 gL^{-1} give best results. The application of 50 gL-1 Humic acid to high fly cultivar for the commercial production should be recommended for the climatic conditions of Peshawar valley.

Author's Contribution

Jawad Ali jan designed and performed the experiment. Ghulam Nabi supervised, provide guidance and valuable suggestions. Maqsood Khan helped in designing experiment, data collection analysis and paper writing. Shehzad Ahmad, Peer Sikandar Shah,

Saddam Hussain and Sehrish helped in data collection analysis and constructive discussion. All the authors finally approved submission of paper.

References

Adani, F., P. Gerevini and G. Zocchi. 1998. The effect of commercial humic acid on tomato plant growth and mineral nutrition. J. Plant Nutr. 21: 561-575. https://doi.org/10.1080/01904169809365424

Aksoy, M., O. Türkmen and A. Dursun. 2010. Influences of potassium and humic acid on the seedling performance. Afr. J. Bio. 9(33): 5343-5346.

Aktafi, H., K. Abak, L. Ozturk and S. Cakmak. 2006. The effect of zinc on growth and shoot Concentrations of sodium and potassium in pepper plantsunder salinity stress. Turk. J. Agric., 30: 407-412.

Alfian, D., A. Rasyad, F. Deviona. 2014. Pendugaan parameter genetik populasi cabai (Capsicum annuum L.) melalui pengujian F1 hasil persilangan secara diallel. Makalah Seminar Hasil. Fakultas Pertanian UNRI. Pekanbaru. (In Indonesian language).

Albayrak, S. and N. Çarnas. 2005. Effects of different levels and application times of humic acid on root and leaf yield components of forage turnip. J. Agron. 4(2): 130-133. https://doi.org/10.3923/ja.2005.130.133

Alfian, D., A. Rasyad and F. Deviona. 2014. Pendugaan parameter genetik populasi cabai (*Capsicum annuum* L.) melalui pengujian F1 hasil persilangan secara diallel. Makalah Seminar Hasil. Fakultas Pertanian UNRI. Pekanbaru. (In Indonesian language).

Aman, S. and A. Rab. 2013. Response of tomato to nitrogen levels with and without humic acid. Sarhad J. Agric. 29(2): 181-186.

Aminifard, M.H., H. Aroiee, M. Azizi, H. Nemati and H.E. Jaafar. 2012. Effect of hmic acid on antioxidant activities and fruit qualities of hot pepper (*Capsicum annum* L.). J. Herbs Spices Med. Plants. 18: 360-369. https://doi.org/10.1080/10496475.2012.713905

Arancon, N.Q., S. Lee, C.A. Edwards, R. Byrne. 2006. Effects of humic acids from vermicomposts on plant growth, Eur. J. Soil Biol. (42): S65-S69. https://doi.org/10.1016/j.ejsobi.2006.06.004

Asri, F.O., E.I. Demirtas and N. Ari. 2015. Changes in fruit yield, quality and nutrients concentrations in response to soil humic acid applications in processing tomato. Bulgarian J. Agric. Sci. 21(3): 585-591.

Agriculture State. Pakistan. 2014-15. Chilies, ministry of national food security and research (NFSR). Islamabad. pp. 37.

Bagyaraj, D.J. and J.A. Menge. 1978. Interaction between a VA mycorrhiza and *Azotobacter* and their effects on rhizosphere microflora and plant growth. New Phycologist. 80: 567-573. https://doi.org/10.1111/j.1469-8137.1978.tb01588.x

Bosland, P.W. 1992. Chiles: A diverse crop horticulture technology. 2: 6–10. https://doi.org/10.21273/HORTTECH.2.1.6

Brownell, J.R., G. Nordstrom, J. Marihart and G. Jorgensen. 1987. Crop responses from two new leonardite extracts. Sci. Total Environ. 62: 491-499. https://doi.org/10.1016/0048-9697(87)90544-4

Celik, H., A.V. Katkat, B.B. Ayk and M.A. Turan. 2008. Effects of soil application of humus on dry weight and mineral nutrients uptake of maize under calcareous soil conditions. Arch. Agron. Soil Sci., 54(6): 605-614. https://doi.org/10.1080/03650340802294303

Chen, Y., H. Magen and S.E. Clapp. 2001. Plant growth stimulation by humic substances and their complexes with iron. Proc. Int. Fert. Soc., Israel. pp. 14.

Chowdhury, M.S.N., F. Hoque, H. Mehraj and A.F.M.J. Uddin. 2015. Vegetative growth and yield performance of four chilli (*Capsicum frutescens*) Cultivars. Am. -Eurasian J. Agric. Environ. Sci., 15 (4): 514-517.

Cimrin, K.M. and I. Yilmaz. 2005. Humic acid applications to lettuce do not improve yield but do improve phosphorus availability. Acta Agric. Scand., Sect. B, Soil Plant Sci. 55: 58-63. https://doi.org/10.1080/09064710510008559

Delfine, S., R. Tognetti, E. Desiderio and A. Alvino. 2005. Effect of foliar application of N and humic acid on growth and yield of durulm wheat. Agron. Sustain. Dev., 25: 183-191. https://doi.org/10.1051/agro:2005017

Din, Kalim., K.M. Khalequzzaman, M. Rahman, N.A. Siddiquie, and O. Ali. 2003. Yield and yield components of Chilli (*Capsicum annum*) as affected by different levels Nitrogen and Boron. Pak. J. Bio. Sci. 6(6): 605-609. https://

doi.org/10.3923/pjbs.2003.605.609

Dod, V.N., P.B. Kale and R.S. Ranotokar. 1989. Effect of foliar application of auxins and micronutrients on growth and yield of chilli. Punjabrao Krishi Vidyapeeth Res. J., 13: 29-33.

Doran, I., C. Akinci and M. Yildirim. 2003. Effects of delta humate applied with different doses and methods on yield and yield components of diyarbakir-81 wheat cultivar. 5th Field Crops Congress. Diyarbakir. Turkey. 2: 530-534.

Dursun, A., I. Guvenc and M. Turan. 2002. Effects of different levels of humic acid on seedling growth and macro and micronutrient contents of tomato and eggplant. Acta Agrobotanica, 56: 81-88. https://doi.org/10.5586/aa.2002.046

Dursuna, A., T. Metin, E. Mele, G. Adem, A. Nizamettin, E.Aslihan and Y. Ertan. 2010. Effects of Boron Fertilizer on Tomato, Pepper, and Cucumber Yields and Chemical Composition. Commun. Soil Sci. Plant Anal. 13(41): 1576-1593. https://doi.org/10.1080/00103624.2010.485238

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

El-Hak, S.H., A.M. Ahmad and Y.M.M. Mustafa. 2012. Effect of foliar application with two antioxidant and humic acid on growth, yield and yield components of Peas (*Pisum sativum* L.). J. Hortic. Sci. Ornamen. Plants. 4(3): 318-328.

Ertan, A. and M. Yildirim. 2007. Foliar and soil fertilization of humic acid affect productivity and quality of tomato. Acta Agric. Scand. Sect. B. Soil Plant Sci., 57: 182-186. https://doi.org/10.1080/09064710600813107

Fathima, P.S. and G.R. Denesh. 2013. Influence of humic acid spray on growth and yield of chilli. Inter. J. Agric. Sci. 9(2): 542-546.

Fernandez. A., R. Escobar, M. Benlloch, D. Barrmcd, A. Duenas and J.A.G. Ganan. 1996. Response of olive trees to foliar application of humic extracted from leonardite. Sci. Hortic. 4(3-4): 191-200. https://doi.org/10.1016/S0304-4238(96)00914-4

Fitriani, L., Toekidjo and S. Purwanti. 2013. The performance of five cultivated varieties of pepper (*Capsicum annum* L.) at the middle land. Vegetalika. 2(2): 50-63.

FAO. 2005. Food and Agriculture Organization of the United Nations, Agricultural statistics for 2005.

FAO. 2007. Food and Agriculture Organization of the United Nations, Agricultural statistics for 2007.

FAO. 2008. Food and Agriculture Organization of the United Nations, Agricultural statistics for 2008.

Genefianti, D.W., S. Sujiprihati, S.H. Hidayat and M. Syukur. 2008. Metode penularan dan uji ketahanan genotipe cabai (*Capsicum* spp.) terhadap begomovirus. J. Akta Agrosia. 11(2): 162-169.

Ganefianti, D.W., F. Fahrurrozi and Y. Armadi. 2017. Hybrid performance testing of chilli pepper (*Capsicum annum* L.) for resistance to yellow leaf curl begomo virus growth in lowland environment. SABRAO J. Breed. Genet. 49(2): 171-191.

Georgieva, V., T. Christo and S. Georgi. 1997. Growth, yield, lead, zinc and cadmium content of radish, pea and pepper plants as influenced by level of single and multiple contamination of soil. Cadmium. Bulg. J. Plant Physiol. 23: 12–23.

Gomez, A.K. and A.A. Gomez.1984. Statistical procedures for agricultural research. (2nd edition). John Wiley and Sons, New York. Growth and yield of chilli. J. Soils Crops. 13(1): 123-125.

Gulser, F., Sonmez, F. and S. Boysan. 2010. Effects of calcium nitrate and humic acid on pepper seedling growth under saline condition. J. Environ. Bio. 31(5): 873-876.

Guinness Book of World Records. 2006. Hottest Spice. www.guinnessworldrecords.com, Accessed 13 Sept. 2006.

Hakan, A., A. Kazım., O. Levent, and C. İsmail. 2006. The effect of zinc on growth and shoot concentrations of sodium and potassium in pepper plants under salinity stress. Turk. J. Agric. For. 30(6): 407-412.

Hatwar, P., S.U. Gonde, S.M. Urkude and O.V. Gahakar. 2003. Effect of micronutrients on growth and yield of chilli. J. Soils Crops., 13(1): 123-125.

Howard, J., K. Rigo, B. Toth, J. Teren and Z. Kozakiewicz. 2000. Evolutionary relationships among *Aspergillus* species producing economically important mycotoxins. Food Technol. Biotechnol., 41(1): 29-36.

Hussain, S.A., M. Shik, B.V.R. Rao and S. Mohammad. 1989. Response of chilli (*Capsicum annum* L.) to micronutrients. Indian J. Agron. 34: 117-118.

IHSS. 2004. International humic substances society. Isolation of samples, I.H.S.S Vol. 2006. http://www.ihss.gatech.edu, on-line.

Jaisankar, I., S. Singh, R.K. Goutham, A. Velmurugan, A.K. Singh, S.D. Roy, D. Parisa and S. Soan. 2015. Performance of chilli genotypes for green fruit yield in Andaman and Nicobar Island. J. Andaman Sci. Assoc. 20(1): 39-42.

Kalim, M.D.U., K.M. khalequzzaman, M.D.M. Rahman, N.A. Saddiqiue and M.D.O. Ali. 2003. Yield and Yield Components of Winter Chilli as Affected by Different levels of nitrogen and Boron. Pak. J. Biol. Sci. 6(6): 605-609. https://doi.org/10.3923/pjbs.2003.605.609

Kasperbauer, M.J. 1987. Far-red light reflection from green leaves and effects on phyto chrome mediated assimilate partitioning under field conditions. Plant Physiol. 85: 350-354. https://doi.org/10.1104/pp.85.2.350

Karakurta, Y., U. Husnu, U. Halime and P. Huseyin. 2009. The influence of foliar and soil fertilization of humic acid on yield and quality of pepper. Soil and Plant Sci. 59(3): 233-237. https://doi.org/10.1080/09064710802022952

Kazemi, M. 2013. Effect of foliar application of humic acid and potassium nitrate on cucumber growth. Bull. Environ. Pharmacol. Life Sci. 2(11): 3-6.

Kazemi, M. 2014. Effect of foliar application of humic acid and calcium chloride in tomato growth. Bull. Environ. Pharmacol. Life Sci. 3(3): 41-46.

Kishan, K., S. Swaroop and M.A. Surayanarayana. 2004. Response of Chilli Genotypes for Green Fruit Yield and Bacterial Wilt in Bay Islands. Karnataka J. Agric. Sci., 17 (4): 886-890.

Liu, C., R.J. Cooper and D.C. Bowman. 1996. Humic acid application affects photosynthesis, root development, and nutrient content of creeping bentgrass. Hortic. Sci. 33(6): 1023-1025. https://doi.org/10.21273/HORTSCI.33.6.1023

Mackowiaket, G., P.E. Nelson, R.A. Hill and N. Spencer. 2001. Pepper taxonomy and the botanical description of the species. Acta Agron. Hungarica. 54: 151-166. https://doi.org/10.1556/AAgr.54.2006.2.5

Martin, J.A. and T.L. Senn. 1997. The influence of various rates of nitrogen and humic acid derivatives on the growth and yield of greenhouse tomatoes. S. Carolina Ag. Exp. Sta. Res. Ser. 95.

Masud, M., M. Moniruzzaman, M.M. Rahman and S. Noor. 2009. Effect of poultry manure in combination with chemical fertilizers on the yield and nutrient uptake by chilli in the hilly region. J. Soil Nat. 3(2): 24-27.

Mathai, P.J., G.S. Dubey, K.V. Peter, V.D. Sakloni and N.P. Singh, 2001. Pant C-1 and Pant C-2 two new promising selections of chilli. South Indian Hort., 25: 123-125.

Mauromicale, G., M.G.L. Angela and A.L. Monaco. 2011. The effect of organic supplementation of solarized soil on the quality of tomato. Scientia Hort., 129(2): 189-196. https://doi.org/10.1016/j.scienta.2011.03.024

Meena, S., K.D. Ameta, R.A. Kaushik, S.L. Meena and M. Singh. 2017. Performance of cucumber (*Cucucmis sativus* L.) as influenced by humic acid and micro nutrients application under polyhouse condition. Int. J. Curr. Microbial. Appl. Sci. 6(3): 1763-1767. https://doi.org/10.20546/ijcmas.2017.603.202

Mehraj, H., H. Tamima, M.S.N. Chowdhury, M.F. Howlader and A.F.M. Jamal Uddin, 2014. Study on Morpho-physiological and yield performance of four chilli (Capsicum spp.) Lines. J. of Bio Sci. and Agri. Res. 2 (1): 01-07.

Maurya, A.K., M.L. Kushwaha, S.K. Maurya and A. Panchbhaiya. 2017. Estimation of Per se performance of chilli genotypes for yield and quality traits. J. Pharma. Phytochem. 6(1): 333-335.

Mehraj, H., H. Tamima, M.S.N. Chowdhury, M.F. Howlader and A.F.M. Jamal Uddin, 2014. Study on Morpho-physiological and yield performance of four chilli *(Capsicum* spp.) Lines. J. Bio Sci. Agric. Res. 2(1): 01-07. https://doi.org/10.18801/jbar.020114.13

Mohamed, A., A. Bakry, Y.R.A. Soliman and S.A.M. Moussa. 2009. Importance of micronutrients, organic manure and bio-fertilizer for improving maize yield and its components grown in desert sandy soil. Res. J. Agric. Bio. Sci., 5(1): 16-23.

Nardi, S., M. Tosoni, D. Pizzeghello, M.R. Provenzano, A. Cilenti, A. Sturaro, R. Rella and A. Vianello. 2005. Chemical characteristics

and biological activity of organic substances extracted from soils by root exudates. Soil Sci. Soc. Am. J. 69: 2012–2019. https://doi.org/10.2136/sssaj2004.0401

Nisakorn, S., A. Chaiwat, S. Kasem and N. Sarunya. 2012. Evaluation of Streptomyces-bio-fungicide to control chilli anthracnose in pot experiment. J. Agric. Tech. 8(5): 1663-1676.

Obidiebube, E.A., P.G. Eruotor, S.O. Akparobi, S.O. Emosaariue, U.A. Achebe and P.E. Kator. 2012. Response of four cultivars of pepper *(Capsicum frutescens* L.) to different levels of N.P.K. fertilizer in rainforest agro ecological zone. Int. J. Agric. Sci., 2(12): 1143-1150.

Padem, H. and A. Ocal. 1999. Effects of humic acid applications on yield and some characteristics of processing tomato. ISHS 6th International Symposium on the Processing Tomato. Pamplona, Navarra, Spain, 25-28 May 1998. Acta Hort., 487: 159-163. https://doi.org/10.17660/ActaHortic.1999.487.20

Rajput, J.C., S.B. Palwe and P.B. Patil, 1999. Varietal evaluation of red chillies for, yield and quality in Konkan region of Maharastra. Indian Cocoa, Arecanut Spices J., 14: 107-108.

Rehman, M.J., M. N. Mondol, A. Rahman, R.A. Begum and M.K. Alam. 2007. Effect of irrigation and nitrogen on tomato yield in the grey terrace soil of Bangladesh. J. Soil Nat.1: 01-04.

Salt, D.E., R.C. Prince, I.J. Pickering and I. Raskin. 2001. Effect of various levels of humic acid (HA) on the growth and yield of Indian mustard. Plant Physiol., 109: 1427-1433. https://doi.org/10.1104/pp.109.4.1427

Sensoy, S., E. Ocak, S. Demir and S. Tufenkci. 2013. Effects of humic acid, whey and arbuscular mycorrhizal fundi applications on seedling growth and fusarium wilt in zucchini (*Cucurbita pipo* L.). J. Anim. Plant Sci. 23(2): 507-513.

Serenella, N., D. Pizzeghelloa, A. Muscolob and A. Vianello. 2002. Physiological effects of humic substances on higher plants. Soil Bio. Biochemi. 34: 1527-1536. https://doi.org/10.1016/S0038-0717(02)00174-8

Shiva, K.C., M.D. Sharma, D. Dhakal and S.M. Shakya. 2015. Evaluation of heat tolerant chilli (*Capsicum annuum* L.) genotypes in Western terai of Nepal. J. Int. Agric. Anim. Sci., 27: 59-64. https://doi.org/10.3126/jiaas.v27i0.696

Srinivasl, J., K.R. Reddyl, P. Saidaiah, K. Anitha and S.R. Pandravada. 2017. Performance of chilli genotypes for yield and yield attributes of fruit quality in Southern Telangana. Int. J. Pure Appl. Biosci. 5(4): 11630-1170.

Steel, R. G., J. H. Torrie and D. A. Dickey. 1997. Principles and procedures statistics. Biometric approach. 3rd(ed). McGraw Hill companies Inc. New York, USA.

Sujiprihati, S., R. Yunianti and M. Syukur. 2007. Pendugaan nilai heterosis dan daya gabung beberapa komponen hasil pada persilangan dialel penuh enam genotipe cabai (*Capsicum annuum* L). Bul. Agron. 35: 28-35.

Suryanarayana, V. and P. Hariprasad. 1985. Responce of chilli to boron and zinc in combination with farm yard manure. Andhera Agric. J. 32(1): 37-40.

Syukur, M., S. Sujiprihati, R. Yunianti and D.A. Kusumah. 2010. Evaluasi daya hasil cabai hibrida dan daya adaptasinya di empat lokasi dalam dua tahun. J. Agron. Indonesia. 38(1): 43-51.

Tesfaw, A.N. Dechassa and K.W.T. Sadik. 2013. Performance of hot pepper (*Capsicum annum* L.) varieties as influenced by nitrogen and phosphorus fertilizer at Bura, Upper water shed of the blue Nile in north western Ethipia. Int. J. Agric. Sci. 3 (8): 599-608.

Trevisan, S., D. Pizzeghello, B. Ruperti, O. Francioso, A. Sassi, K. Palme, S. Quaggiotti and S. Nardi. 2009. Humic substances induce lateral root formation and expression of the early auxin-responsive IAA19 gene and DR5 synthetic element in Arabidopsis. Plant Biol. 12: 604-614. https://doi.org/10.1111/j.1438-8677.2009.00248.x

Turkmen, O., A. Dursun, M. Turan and C. Erdinc. 2004. Calcium and humic acid effect seed germination, growth and nutrient content of tomato (*Lycopersicon esculentum* L.) seed lings under saline soil conditionspp. Acta Agric. Scand., 7: 168-174. https://doi.org/10.1080/09064710310022014

Unlu, H.O., H. Unlu., Y. Karakurt and H. Padem. 2011. Changes in fruit yield and quality in response to foliar and soil humic acid application in cucumber. Sci. Res. Essays. 6(13): 2800-2803.

Vanitha, K. and S. Mohandass. 2010. Humic acid on plant growth characters and yield of aerobic rice. Bioscan. 9(1): 45-50, 2014.

Velmurugan. A., R.K. Goutham, A.K. Singh, S.D.

Roy, D. Parisa and S. Soan. 2015. Performance of chilli genotypes for green fruit yield in Andaman and Nicobar Island. J. Andaman Sci. Assoc. 20(2): 39-42.

Vasilenko, V., 2002. Hydroponics and Humates: Ancient acids for modern agriculture. The best of the growing edge international, 2000-2005: Select Cream-of-The-Crop articles for soilless growers. New Moon Publ., pp. 373-375.

Wahyudi, M. 2012. Heterosis dan heterobeltiosis cabai dalam persilangan dialel. Skripsi. fakultas pertanian, Universitas Bengkulu, Bengkulu. (In Indonesian language). pp. 123-128.

Widyawati, Z., I. Yulianah and R. Respatijarti. 2014. Heritabilitas dan kemajuan genetik harapan populasi F2 pada tanaman cabai besar (*Capsicum annuum* L.). J. Produksi Tanaman. 2(2): 247-252.

Yildirim, E. 2007. Foliar and soil fertilization of humic acid affect productivity and quality of tomato. Acta Agriculturae Scandinavica Section B-Soil. Plant Sci., 57: 182-186. https://doi.org/10.1080/09064710600813107

Zaky, M.H., E.L. Zoah and M.E. Ahmed. 2006. Effects of humic acids on growth and productivity of bean plants grown under plastic low tunnels and open field. Egypt. J. Appl. Sci., 21(4B): 582-596.

Zhang, X. and E.H. Ervin. 2004. Cytokinin-containing seaweed and humic acid extracts associated with creeping bent grass leaf cytokinins and drought resistance. Crop Sci. 44: 1737-1745. https://doi.org/10.2135/cropsci2004.1737

Zhang, X., E.H. Ervin and R.E. Schmidt. 2003. Plant growth regulators can enhance the recovery of Kentucky bluegrass sod from heat in Jury. Crop Sci. 43: 952-956. https://doi.org/10.2135/cropsci2003.9520