http://www.pjbs.org

PJBS

ISSN 1028-8880

Pakistan Journal of Biological Sciences

ANSInet
Asian Network for Scientific Information
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan

Pakistan Journal of Biological Sciences 15 (4): 203-207, 2012
ISSN 1028-8880 / DOI: 10.3923/pjbs.2012.203.207

Agronomic Importance of First Development of Chickpea (*Cicer arietinum* L.) Under Semi-arid Conditions: I. Effect of Powder Humic Acid

H. Ulukan, N. Bayraktar and N. Koçak
Department of Field Crops, Faculty of Agriculture, University of Ankara,
06110, Ankara, Turkey

Abstract: Due to slow growth and weakness of the first development of chickpea (*Cicer arietinum* L.) plant could not combatted with weeds and easily get caught up by Ascochyta blight (*Ascochyta rabiei* (Pass) Labr.) disease; esp. under the late sowing and semi-arid conditions, due to effect of biotic and abiotic stress factors, significant yield losses could be arised. To be able to avoid from them is only possible to accelerate the first development of this crop. So, one of the best solutions is to use of "*soil conditioner*" chemical compounds such as HA at optimum dose. With this aim, it was established in order to find out the optimum dose range of HA. Three doses (D_0 = 0 g, D_1 = 100 g and D_2 = 200 g), four varieties (V_1 = Er–99, V_2 = Gökçe, V_3 = ILC-482 and V_4 = Australia) and five yield components Plant Height (PH), First pod height (FPH), Number of Branches per Plant (NBP), Number of Pods per Plant (NPP) and Number of seeds per pod (NSP) were investigated. Obtained results are: Recommended (Optimum) HA doses and interactions were ranged and found as ($V_4>V_2=V_3>V_1$); ($D_2>D_0=D_1$); (D_1xV_4) for the PH and FPH, (D_2xV_3) for the NBP and (D_1xV_3) for the NPP, respectively. It was concluded that when the recommended HA dose applied, it was seen that the first development has been clearly accelerated and increased under the semi-arid conditions in terms of investigated traits and cultivars.

Key words: Chickpea (*Cicer arietinum* L.), optimum dose, powder ha, yield and yield components

INTRODUCTION

Chickpea (*Cicer arietinum* L.) is one of the most cultivated and consumed legume crop in the world. It is the second most important pulse crop in the world (used in human and animal feed), in at least 33 countries in South Asia, West Asia, North Africa, East Africa, Southern Europe, North and South America and Australia (Siddique *et al*., 1999) and account for 6.4% (11.6 mil ha) for the area and 7.0% (8.8 mil ton) of global production of pulses (Anonymous, 2008). Seeds have 3.0% fiber; 16.4-31.2% protein; 38.1-73.3% carbohydrate; 3.0-6.0% oil; 1.6-9.0% cellulose; 0.2% calcium; 0.3% phosphorus and 3.0% ash per grain, Ca, P, Mn, Fe and B vitamins (Huda *et al*., 2003; Ozer *et al*., 2010). Findings were shown that humic substances have a positive effect on plant growth, physiologic events increases in root and shot lengths, stimulate the germination and increase in grain yield of soybean (*Glycine max.* Merrill), sunflower (*Helianthus annuus* L.), rapeseed (*Brassica napus* L.), maize (*Zea mays* L.), barley (*Hordeum vulgare* L.), durum (*Triticum durum* Desf.) and common wheat (*Triticum aestivum* L.), common bean (*Phaseolus vulgaris* L.), Pea (*Pisum sativum* L.) and chickpea (*Cicer arietinum* L.) (Vaughan and Malcolm, 1985; Xudan, 1986; Chen and Avaid, 1990; Senesi *et al*., 1990; Valdrighi *et al*., 1996; Lobartini *et al*., 1997; Chen *et al*., 2004; Kaya *et al*., 2005; Kolsarici *et al*., 2005; Ulukan, 2008a, b). The main aim of this research was to fill this scientific information gap via determine or to find out the optimum dose application of powder HA on the yield components of chickpea (*Cicer arietinum* L.) varieties during (2008/2009) and (2009/2010) under the semi-arid conditions.

MATERIALS AND METHODS

This study was carried out at the University of Ankara, Faculty of Agriculture, Department of Field Crops, Ankara, Turkey during the (2008/2009) and (2009/2010) years. Geographical coordinates of experimental site's are (39° 57'N and 32° 51'E) and asl is 848 m, soil structure is clayed, light alkaline with 1.78% organic matter content and lime content between 0.34 and 0.66%, pH : 6.34–6.54. Available P_2O_5 content is 57.2%, K_2O content is 162.0%. All plots were fertilized 60 kg P_2O_5 kg ha^{-1} in triple superphosphate form and 40 kg N kg ha^{-1} in ammonium before sowing. Climatic data for the experimental site are shown as monthly averages were

Corresponding Author: H. Ulukan, Department of Field Crops, Faculty of Agriculture, University of Ankara, 06110, Ankara, Turkey

Table 1: Meteorological data of the experimental site (monthly average)

	Average Temperature (°C)				Average Rainfall (mm)				Average Relative Humidity (%)			
Months	2008	2009	2010	LTA[1] 1926-10	2008	2009	2010	LTA 1926-10	2008	2009	2010	LTA 1926-10
January	-5.5	-4.0	-1.8	-2.3	16.3	24.4	25.0	26.0	72.7	73.6	76.3	78.3
February	-1.4	0.1	1.5	0.4	9.5	12.7	19.5	22.6	60.5	69.4	68.9	76.2
March	4.9	5.8	3.2	3.0	11.6	25.8	26.9	55.3	64.8	73.2	57.7	73.0
April	13.3	13.7	10.6	9.3	33.9	42.4	33.5	32.9	77.7	71.2	54.8	67.2
May	14.1	15.5	12.7	13.3	48.8	55.7	46.8	50.3	60.5	63.7	51.0	62.4
June	21.8	20.3	20.0	16.7	8.1	9.7	10.9	11.2	64.2	52.0	41.1	56.2
July	22.9	21.5	21.7	20.5	0.0	0.0	0.0	0.0	16.7	25.4	35.7	55.6
August	20.7	26.6	25.8	26.1	1.0	1.6	3.1	0.6	23.3	25.8	34.6	57.9
September	14.5	19.9	17.4	17.7	53.2	38.7	45.1	60.4	33.6	23.9	50.2	67.4
October	10.7	13.3	12.5	9.8	26.7	15.5	17.4	18.2	45.1	55.0	63.8	77.2
November	9.5	9.1	9.7	9.4	17.9	16.4	5.8	12.6	65.6	57.7	67.0	70.0
December	3.1	2.4	1.0	2.3	16.5	15.8	16.0	17.4	53.2	50.8	62.3	78.0

[1] LTA: Long term averages (Source: General Directorate of Meteorology)

presented in Table 1. In the research, four chickpea (*Cicer arietinum* L.) varieties (V_1 = Er–99, V_2 = Gökçe, V_3 = ILC–482 and V_4 = Australia) and three doses (D_0 = 0 g, D_1 = 100 g and D_2 = 200 g) were used. HA was applied as powder by hand at the sowing on the beginning of April. The sowing procedure was done by hand (on the date of 2nd April, 2009 and on the date of 3rd April, 2010) in six row plots of 6 m length with 20 cm between row distances as to give 40 viable seeds per m^2. The experimental design was laid out based on Randomized Complete Block Design (RCBD) consisted of three blocks with varieties as main plots and doses as sub–plots. Data were recorded for examined trase components based on five randomly selected plants which were selected from two central rows of each plot. All calculations and sampling procedures were done according to Biçer *et al.* (2004) and Biçer (2005).

- **Plant height:** Measured from the base of the plant to the top peduncle on the main branch
- **First pod height:** Measured as the distance (cm) between the first pod and the soil surface.
- **Number of branches per plant:** Found by individually counting the mature plants which are partitioned into branches
- **Number of pods per plant:** Fixed by individually counting the pods of the sampled plants
- **Number of seeds per pod:** Found by harvesting, counting and averaging the pods of the ten sample plants

Statistical analysis: All data were subjected to one-way analysis of variance (one way ANOVA) using MSTAT-C statistical software (MSTAT-C, 1998). Differences among mean values of the treatments were tested using the Least Significant Difference (LSD) range test at 0.05 and 0.01 statistically significance levels (Steel and Torrie, 1984).

RESULTS AND DISCUSSION

According to mean of two yearly data, statistically significant differences were found among the examined five seed yield components (Tables 2, 3).

Plant height: Statistically significant variations were found for (V), (D) and (D×V) Table 2. Powder HA doses were fixed as 28.89 cm in the D_0, 33.20 cm in D_1 and 28.67 cm in D_2 for V_1; 30.89 cm in the D_0, 32.13 cm in the D_1 and 29.07 cm in the D_2 for V_2; 32.03 cm in the D_0, 33.27 cm in the D_1 and 33.00 cm in the D_2 for V_3; 31.33 cm in the D_0, 33.87 cm in the D_1 and 33.20 cm in D_2 for the V_4; and, variety averages were realized as 30.25 cm in the V_1, 30.69 cm in the V_2, 32.76 cm in the V_3 and 32.80 cm in the V_4; (D×V) was determined as 28.67 cm (min.) in (D_2×V_1) and 33.87 cm (max.) in (D_1xV_4) Table 3. It was found that the longest plant height for the powder HA application occurred in the D_1, V_4 and that the longest plant height was produced by the (D_1xV_4). Therefore, obtained results support previous findings showing that HA has an additive and cumulative effects on increasing of the plant height (Fig. 1), reported by Pundir and Rajagophan (1988), Chen and Aviad (1990), Senesi *et al.* (1990), De Sanfilippo *et al.* (1990), Sandhu and Gumber (1991) and Turk *et al.* (1999). It was also observed that applied the powder HA doses increased the height of plants and resulted of the averages this trait in varieties.

First pod height: ANOVA results revealed that statistically significant variations were calculated among the (D), (V) and (DxV) Table 2. The average first pod heights were 15.93 cm in the D_0, 17.57 cm in the D_1 and 14.40 cm in the D_2 for the V_1; 16.53 cm in the D_0, 18.00 cm in the D_1 and 14.40 cm in the D_2 for the V_2; 16.40 cm in the D_0, 17.77 in the D_1 and 16.47 in the D_2 for the V_3; 17.50 cm

Table 2: Variance analysis results of the examined yield components

SV	Df	F-value C_1	C_2	C_3	C_4	C_5
Blocks	2	5.039	0.015	0.241	6.910	4.113
Doses (D)	2	36.582^{**}	788.072^{**}	1.928^{ns}	4.493^{ns}	1.826^{ns}
Error $_1$	4					
Varieties (V)	3	11.201^{**}	188.484^{**}	92.145^{**}	89.145^{**}	161.222^{**}
Int. (D×V)	6	3.016^{*}	52.917^{**}	16.447^{**}	25.508^{**}	20.139^{**}
Error $_2$	18					
General	35					

SOV: Source of variation. Df: Degree of freedom, C_1: Plant height (cm), C_2: First pod height (cm), C_3: No. of branches per plant (No.), C_4: No. of pods per plant (No.), C_5: No. of seeds per pod (No.), (*Significant at p<0.05, **Significant at p<0.01, ns: non-significant)

Table 3: Mean values with their standard errors of the investigated yield components according to cultivars and doses

Variety	Doses	Yield Components C_1	C_2	C_3	C_4	C_5
V_1	D_O	$28.89\pm6.04^{de*}$	15.93 ± 2.5^{de}	4.00 ± 0.83^{b}	33.33 ± 3.59^{c}	1.13 ± 0.03^{d}
	D_1	33.20 ± 7.05^{ab}	17.57 ± 3.9^{cd}	3.73 ± 1.42^{cd}	30.33 ± 2.48^{cd}	1.00 ± 0.01^{e}
	D_2	28.67 ± 9.30^{e}	14.40 ± 1.6^{f}	3.50 ± 2.36^{de}	22.67 ± 2.01^{f}	1.00 ± 0.02^{e}
Mean		30.25 ± 7.46	15.96 ± 2.6	3.74 ± 1.5	28.77 ± 2.69	1.04 ± 0.02
V_2	D_O	30.89 ± 5.56^{cd}	16.53 ± 0.5^{cd}	3.40 ± 0.85^{e}	24.57 ± 1.23^{ef}	1.50 ± 0.06^{b}
	D_1	32.13 ± 4.67^{abc}	18.00 ± 4.7^{ab}	3.06 ± 0.76^{f}	26.00 ± 2.28^{cf}	1.43 ± 0.08^{b}
	D_2	29.07 ± 3.88^{de}	14.40 ± 1.8^{f}	3.43 ± 1.07^{e}	32.67 ± 2.90^{c}	1.33 ± 0.09^{c}
Mean		30.69 ± 4.70	16.31 ± 2.3	3.29 ± 0.89	27.74 ± 2.13	1.42 ± 0.07
V_3	D_O	32.03 ± 5.94^{abc}	16.40 ± 1.9^{d}	4.33 ± 1.59^{a}	41.57 ± 2.67^{ab}	1.00 ± 0.04^{e}
	D_1	33.27 ± 6.56^{ab}	17.77 ± 2.4^{bc}	3.90 ± 0.13^{bc}	44.67 ± 3.01^{a}	1.30 ± 0.08^{c}
	D_2	33.00 ± 2.92^{ab}	16.47 ± 1.7^{d}	4.43 ± 1.61^{a}	38.33 ± 1.26^{b}	1.30 ± 0.06^{c}
Mean		32.76 ± 5.14	16.88 ± 2.0	4.22 ± 1.11	41.52 ± 2.31	1.20 ± 0.06
V_4	D_O	31.33 ± 1.45^{bc}	17.50 ± 3.8^{c}	3.16 ± 0.92^{ef}	27.57 ± 2.15^{de}	1.50 ± 0.04^{b}
	D_1	33.87 ± 3.27^{a}	18.30 ± 3.1^{a}	3.70 ± 1.2^{cd}	30.00 ± 1.34^{cd}	1.50 ± 0.01^{b}
	D_2	33.20 ± 4.80^{ab}	17.57 ± 2.6^{c}	3.86 ± 0.54^{bd}	40.33 ± 1.67^{b}	1.80 ± 0.02^{a}
Mean		32.80 ± 3.17	17.79 ± 3.1	3.60 ± 0.88	32.63 ± 1.72	1.60 ± 0.02

V_{1-4}: Varieties, D_{0-2}: Doses, C_1: Plant height (cm), C_2: First pod height (cm), C_3: No. of branches per plant (No.), C_4: No. of pods per plant (No.), C_5: No. of seeds per pod (No.), Means followed by the same letter are not different according to least significant difference (LSD) range test (p<0.05 and p<0.01)

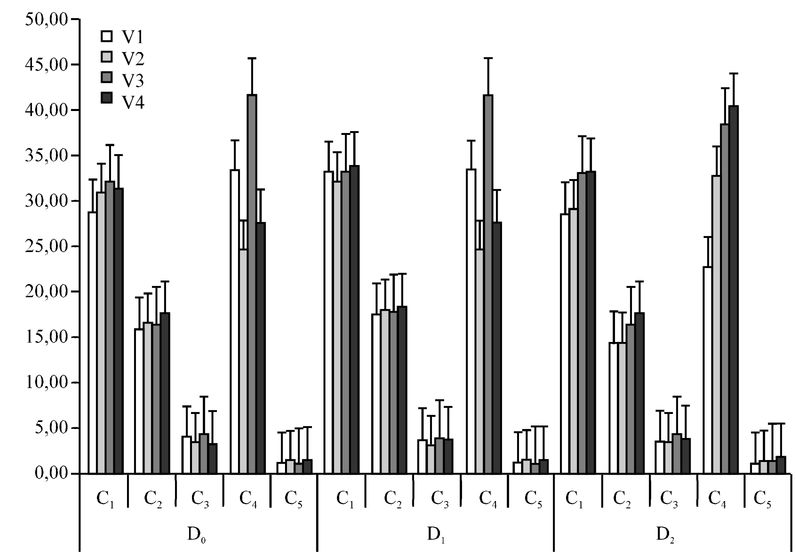

Fig. 1: HA dosages (D_{0-2}) on varieties (V_{1-4}) in terms of examined yield components (Arrows show standard error of the mean value; C_1-C_5: Investigated yield components)

in the D_0, 18.30 cm in the D_1 and 17.57 cm in the D_2 for the V_4; values are recorded as the V_1 = 15.96 cm, the V_2 = 16.31 cm, the V_3 = 16.88 cm and the 17.79 cm in the V_4; (D_2xV_1) and (D_1xV_4) showed a range from 14.40 cm (min.) to 18.30 cm (max.), respectively (Table 3). For the average of first pod height, the highest averages were obtained from the D_1, V_4 and (D_1xV_4) parameters. On the other hand, Observed results were indicate that powder HA application increased the average first pod height of plants Table 3. The findings of our research concerning the effect of powder HA on first pod height support by De Sanfilippo *et al.* (1990), Chen and Aviad (1990), Senesi *et al.* (1990) and Turk *et al.* (1999).

Number of branches per plant: For this trait, statistically significant differences were found between the (V) and (DxV) but not for the (D) Table 2. As show from Table 3, the varieties showed an average number of branches per plant of: 3.74 in the V_1, 3.30 in the V_2, 4.22 in the V_3 and 3.60 in the V_4. Similarly, average figures related to the (DxV) had been taken with a min. of 3.06 from the (D_1xV_2) and max. of 4.43 from the (D_2xV_3). Moreover, the highest number of branches was recorded in the V_3 and (D_2xV_3) (Table 3). Obtained results for this trait are similar to findings reported by De Sanfilippo *et al.* (1990), Chen and Aviad (1990), Sandhu and Gumber (1991) and Turk *et al.* (1999).

Number of pods per plant: It was not found statistically significant difference for the (D) but for the (V) and (DxV) Table 2. As shown in Table 3, values for the number of pods per plant were 28.77 in the V_1, 27.74 in the V_2, 41.52 in the V_3 and 32.63 in the V_4; the averages were found as 22.67 min. (D_2xV_1) and 44.67 max. (D_1xV_3). Thus, for this trait, the highest average values were obtained from the V_3 and (D_1xV_3) Table 3. Observed findings support those of Tekin (1994), Tan and Nopamombodi (1979), Samal (1980), Gupta and Lal (1981), Pundir and Rajagophan (1988), Chen and Aviad (1990), Nardi *et al.* (2002) and Kolsarici *et al.* (2005).

Number of seeds per pod: The (V) and (DxV) were found statistically significant but not for the (D). The min. mean values for this trait were 1.04 in the V_1, 1.42 in the V_2, 1.20 in the V_3 and 1.60 in the V_4; min. value (1.00) was found in the (D_1xV_1) and the max. value (1.80) was fixed in the (D_2xV_4) Table 2. The highest mean values for this trait were obtained from a control dose of D_2 = 200 g, V_2 and (D_0xV_2) Table 3. The current data values are similar to those reported by Virmani *et al.* (1973), Lal (1976), Chen and Aviad (1990), Jirali *et al.* (1994) and Anlarsal *et al.* (1999).

CONCLUSIONS

The effective doses were varied between the D_1 and D_2. The first one (D_1 = 100 g) was effected on the yield components such as expressed in length, but, the last one (D_2 = 200 g) was effected on the yield components stated in weight. In addition this, the dose effects of powder HA application was showed that (D_2>D_0 = D_1) had the highest mean distribution. On the other hand, in terms of the effect of varieties on examined traits and this ordering was realized as (V_4>V_2=V_3>V_1) according to varieties (Table 2, and Fig. 1). On the other hand, it was seen that HA could be used as the accelerator of the first development in chickpea cultivation under the arid conditions within the determined limits. But, this point is clear that, the internal and external factor(s) with their interactions, growth weakness and slowness, etc., constitute the major handicaps for the first development, growth and further stages. Nearly all of them could be determinative factors in the chickpea cultivation under the arid conditions. But, it is essential that as possible as to accelerate the first development. However, to be able to give more decisive result(s) on this topic, further researches should be carried out with the aid of interdisciplinary studies and more variety/ies, chemical substance's dose/s at the multi locations under the arid conditions. With this context, still researches are being carried out in our department on the chickpea cultivation under the arid conditions.

REFERENCES

Anlarsal, A.E., C. Yucel and D. Ozveren, 1999. A research to determine of yield and yield components on some chickpea (Cicer arietinum L.) lines under the cukurova conditions. Proceedings of the 3rd Congress of Field Crops. November 15-18, 1999, Meadow and Pasture and Edible Pulses, Adana, Turkey, pp: 342-347.

Anonymous, 2008. Preliminary 2009 database. http://faostat.fao.org/site/567/default.aspx#ancor.

Biçer, B.T., 2005. Evaluation of chickpea landraces. Pak. J. Biol. Sci., 8: 510-511.

Biçer, B.T., A.N. Kalender and D. Sakar, 2004. The effect of irrigation on spring-sown chickpea. J. Agron., 3: 154-158.

Chen, Y. and T. Aviad, 1990. Effects of Humic Substances on Plant Growth. In: Humic Substances in Soil and Crop Sciences: Selected Readings, MacCarthy, P., C.E. Clapp, R.L. Malcolm and P.R. Bloom (Eds.). Soil. Sci. Soc. Am., Madison, Wisconsin, USA., pp: 161-186.

Chen, Y., C.E. Clapp and H. Magen, 2004. Mechanisms of plant growth stimulation by humic substances: The role of organo-iron complexes. Soil Sci. Plant Nutr., 50: 1089-1095.

De Sanfilippo, E.C., J.A. Arguello, G. Abdala and G.A. Orioli, 1990. Content of auxin: Inhibitor and gibberellins-like substances in humic acids. Biol. Plant, 32: 346-351.

Gupta, V.P. and S. Lal, 1981. Development allometry and plant type in chickpea. Int. Chickpea Newslett., 4: 8-9.

Huda, S., N.A. Siddique, N. Khatun, M.H. Rahman and M. Morshed, 2003. Regeneration of shoot from cotyledon derived callus of chickpea (*Cicer arietinum* L.). Pak. J. Biol. Sci., 6: 1310-1313.

Jirali, D.I., Y.C. Panchai, B.S. Janagoudar and B.C. Patil, 1994. Studies on the growth pattern and yield in chickpea (*Cicer arietinum* L.) genotypes under receding soil moisture conditions. Indian J. Plnt Physiol., 37: 275-276.

Kaya, M., M. Atak, K. Mahmood, C.Y. Çefçi and S. Ozcan, 2005. Effect of pre-sowing seed treatment with zinc and foliar spray of humic acid on yield of common bean (*Phaseolus vulgaris* L.). Int. J. Agric. Biol., 7: 875-878.

Kolsarici, O., M.D. Kaya, S. Day, A. İpek and S. Uranbey, 2005. Different doses of humic acid sunflower (*Helianthus annuus* L.) seedling growth and its effects on the output. J. Akdeniz Univ. Fac. Agric., 18: 151-155.

Lal, S., 1976. Relationship between seed yield and biological yields in chickpea (*Cicer arietinum* L.). Trop. Grain Legume Bull., 6: 29-31.

Lobartini, J.C., G.A. Orioli and K.H. Tan, 1997. Characteristics of soil humic acid fractions separated by ultrafiltration. Com. Soil sci. Plant Anal., 28: 787-796.

Mstat-C., 1998. Michigan State University statistical software manuel handbook. East Lansing, MI 48824, Michigan, USA.

Nardi, S., D. Pizzeghello, A. Muscolo and A. Vianello, 2002. Physiological effects of humic substances on higher plants. Soil Biol. Biochem., 34: 1527-1536.

Ozer, S., T. Karakoy, F. Toklu, S.F. Baloch, B. Kilian and H. Ozkan, 2010. Nutritional and physico?chemical variation in Turkish Kabuli chickpea (*Cicer arietinum* L.) landraces. Euphytica, 175: 237-249.

Pundir, R.P.S. and N.C.K. Rajagophan, 1988. Collection of chickpea germplasm in Tamil Nadu. India. Plnt Breed. Abst., 58: 391-391.

Samal, A.P., 1980. A preliminary study of chickpea varieties at Sambalpur, India. Int. Chickpea Newslett., 3: 9-10.

Sandhu, T.S. and R.K. Gumber, 1991. Genetic divergence in chickpea. Int. Chickpea Newsl., 24: 8-19.

Senesi, N., E. Loffredo and G. Padonava, 1990. Effects of humic acid. Herbicide interactions on the growth of pisum sativum in nutrient solution. Plant Soil, 127: 41-47.

Siddique, K.H.M., S.P. Loss, K.L. Regan and R.L. Jettner, 1999. Adaptation ans seed yield of coo season grain legumes in Mediterranean environments of South-Western Australia. Aust. J. Agric. Res., 50: 375-387.

Steel, R.G.D. and J.H. Torrie, 1984. Principles and Procedures of Statistics: A Biometric Approach. 2nd Edn., McGraw Hill Book Co. Inc., New York, USA., ISBN-13: 9780070610286, Pages: 633.

Tan, K.H. and N. Nopamornbodi, 1979. Effect of different levels of humic acids on nutrient content and growth of corn (*Zea mays* L.). Plant Soil, 51: 283-287.

Tekin, K., 1994. Determination of some foreign originned chickpea *Cicer arietinum* L. agronomic, physiologic and technologic traits. Master's Thesis, University of Cukurova, Adana, Turkey.

Türk, Z., V. Ciftci and N. Atıkyılmaz, 1999. A research on the determination of high yielded chickpea (*Cicer arietinum* L.) varieties in Southeastern Anatolia region. Proceedings of the Congress of Southeastern Anatolian Project GAP, May 26-28, 1999, Sanlýurfa, Turkey, pp: 783-788.

Ulukan, H., 2008a. Effect of soil applied humic acid at different sowing times on some yield components in wheat (*Triticum* spp.) hybrids. Int. J. Bot., 4: 164-175.

Ulukan, H., 2008b. Humic acid application in agricultural crops. J. Sci. Eng. Kahramanmaras Univ., 112: 119-128.

Valdrighi, M.M., A. Pear, M. Agnolucci, S. Frassinetti, D. Lunardi and G. Vallini, 1996. Effects of compost-derived humic acids on vegetable biomass production and microbial growth within a plant (*Cichorium intybus*) soil system: A comparative study. Agric. Ecosyst. Environ., 58: 133-144.

Vaughan, D. and R.E. Malcolm, 1985. Influence of Humic Substances on Growth and Physiological Processes. In: Soil Organic Matter and Biological Activity, Vaughan, D. and R.E. Malcolm (Eds.). Springer, USA., pp: 37-75.

Virmani, S.S., K.B. Sing and J.S. Brar, 1973. Genetic variability for biological yield and harvest index in Bengal gram. Proceedings of the 10th Workshop on Rabi Pulses, September 10-14, 1973, ICAR, New Delhi, India, pp: 48-54.

Xudan, X., 1986. The effect of foliar application of fulvic acid on water use, nutrient uptake and wheat yield. Aust. J. Agric. Res., 37: 343-350.