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Effect of Soil Applied Humic Acid at Different Sowing Times on Some Yield Components in Wheat (*Triticum* spp.) Hybrids

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Abstract: The objective of this field experiment was to evaluate the effect of humic acid application (2.5 kg ha^{-1} per plot) on yield components of 18F_3 wheat hybrids (*Triticum* spp.) at four sowing times (St_1, St_2, St_3 and St_4) on clay soils of Central Anatolian field conditions in a randomized complete block design with four replications in 1999 and 2001. Genotypes were evaluated for plant height (PH-cm), spike number (SN-no), spikelet number (NSL-no), grain number (GN-no) and 1000-Grain weight (TKW-g). Humic acid (HA) decreased in all yield components in the St_2, St_3 and St_4 dramatically by more than 33.0, 75.0 and 45.0%, respectively. It was observed that separation among the genotypes on the basis of mean values was better under normal than under in any stress factor in this region. Comparison of mean performance under these conditions revealed that the grain number, plant height and spike number were the most sensitive traits followed by rest of them. But, mentioned yield components not always sufficient. They must be supported any kind of soil conditioners such as HA in such regions. Moreover, correlation coefficients findings are being verified that sowing times are crucial importance (esp. first time) and it is being indicated that the most important trait was GN and TKW on the basis of their relationships with other traits. To be able to get higher wheat grain yield under Central Anatolian conditions, all sowing procedures must be done in time, different and soil conditioners (example HA) must be used and proper agronomical precautions must be taken in time and adequately.

Key words: Humic Acid (HA), wheat species (*Triticum* spp.), hybrids, sowing times, yield components

INTRODUCTION

The oldest archaeological evidence for the wheat cultivation comes from Syria, Jordan, Turkey and Iraq showed that wheat is one of the first grains domesticated by human and it is known to have been grown in the Nile Valley by 5000 BC and it is believed that the Fertile Crescent was the centre of domestication. Common wheat (*Triticum aestivum* L.) plant is the world's most widely adapted crop and supplying one-third of the world population with more than half of their calories and nearly half of their protein requirement. It is mainly grown on rainfed land and about 37% of the area of developing countries consists of semiarid environments in which available moisture constitutes a primary constraint on wheat production. Climatic variability in these marginal environments causes large annual fluctuations in yield. On the other hand, as known, yield level, is a major selection criterion in any plant breeding programmes. This trait (yield) is a very complex as governed by several physiological, biochemical and metabolic plant processes, whose (genetics, environmental or genetic × environmental interaction(s) and amongst of them) associations are largely unclear. As mentioned earlier, high grain yield, elevated grain protein content and early maturity are important traits in global bread wheat breeding programmes. Improving three traits simultaneously is difficult due to the negative association between grain yield and grain protein content and the positive association between maturity and grain yield. Improvement in yield should therefore combine a reasonably high yield potential with a specific plant factor which would buffer the yield against a severe reduction under stress (Blum *et al*., 1994).

All humic substances are composed of chemically complex, non-biochemical organic components, which are largely hydrophilic, amorphous, dark colored, liquid, or powder and resistant to chemical and biological degradation (Mackowiak *et al*., 2001; Adani *et al*., 2006). Possible mechanisms involved in the stimulation of plant growth include the assimilation of major and minor elements, bio-chemical effects (enzyme activation and/or inhibition, changes in membrane permeability, protein synthesis) and finally the activation of biomass production. Theirs' activity in promoting plant growth is not completely known, but several explanations have been proposed by some researchers such as increasing cell membrane permeability, important for the transport and availability of micro-nutrients, nutrient uptake stimulates seed germination and viability, oxygen uptake, respiration (esp. in roots) and photosynthesis, phosphate and nutrient uptake and root cell elongation (Mishra and Srivastava, 1988; Ahmad and Tan, 1991; Thangavelu and Ramabadran, 1992; Chen *et al*., 1994; Böhme and Thi Lua, 1997). Studies of the positive effects of them on the plant growth have demonstrated the importance of optimum mineral supply, independent of nutrition (Aydın *et al*., 1999; Dursun *et al*., 2002). Experiments conducted on various crops have shown that HA enhances plant growth both directly and indirectly and they have yield increasive effect at different values in different crops (Ulukan, 2007). Mishra and Srivastava (1988) concluded from his experiments that fresh and dry weight yields of 20 day old oats (*Avena sativa* L.) seedlings increased significantly with an application of 100 mg of HA per pot. It was observed that in controlled experiments, humic substances increased dry matter yields in maize (*Zea mays* L.) corn and oat (*Avena sativa* L.) seedlings by Shariff (2002) and numbers and length in tobacco roots by Mylonas and Mccants (1980). HA acid had a direct effect on the growth processes of wheat (Vaughan and Linehan, 2004) pea (*Pisum sativum* L.) (Vaughan, 1974) and chicory plant (*Cichorium intybus* L.) (Valdrighi *et al*., 1996). The typical growth response curves that have been reported to result from treating plants with humic substances show progressively increased growth with increasing concentrations, but usually there was a decrease in growth at higher concentrations (Chen and Aviad, 1990). Some studies show different findings. For instances, according to studies conducted in Kansas; humate had not significantly improved corn grain yield over a 3-year period (Bauder, 1976; Lawless *et al*., 1984). Similarly, studies in Illinois (Egli and Pendleton, 1984), North Dakota (Bauder, 1976) and Canada (Elegba and Rennie, 1984) also showed no significant improvement in yields of corn grain, corn silage, wheat, barley and field beans when various soil conditioners were applied alone or in combination with commercial fertilizer. However, temperature is very important for the HA and plant-soil system. It was very known that both plant growth and development are affected by temperature (Porter and Moot, 1998). Investigations of the effects of changes in mean annual temperature on agricultural crops (Houghton *et al*., 1996). These substances can either have a direct effect absorption of the humic compounds by the plant, affecting certain enzymatic activities, membrane permeability, etc. (Chen and Aviad, 1990; Pinton *et al*., 1992) or an indirect (changes in the soil structure, increased cationic exchange capacity, stimulation of microbiological activity, the capacity to solubilize or complex certain soil ions) effect on the plant (Alianiello *et al*., 1991; Cimrin and Yılmaz, 2005).

Vaughan and Malcolm (1985) concluded that doses of 5-25 mg L^{-1} were optimal for root growth, while 60-100 mg L^{-1} were better for overall the plant growth. HA's activity in promoting plant growth is not completely known, but several explanations proposed by some researchers such as increasing cell membrane permeability, important for the transport and availability of micro-nutrients, nutrient uptake stimulates seed germination and viability, oxygen uptake, respiration (esp. in roots) and photosynthesis, phosphate uptake and root cell elongation (Böhme and Thi Lua, 1997; Nardi *et al*., 2002). Studies of the positive effects of these humic substances on plant growth have demonstrated the importance of optimum mineral supply, independent of nutrition (Dursun *et al*., 1999, 2002; Aydın *et al*., 1999; Dursun *et al*., 2002; Yıldırım, 2007). Experiments conducted on various crops have shown that hümic acid (HA) enhances plant growth both directly and indirectly (Mishra and Srivastava, 1988; Nisar and Mir, 1989; Ahmad and Tan, 1991; Thangavelu and Ramabadran, 1992; Liu *et al*., 1988). Mishra and Srivastava (1988) concluded from his experiments that fresh and dry weight yields of 20 day old oats (*Avena sativa* L.) seedlings increased significantly with an application of 100 mg of HA per pot. For instance, in controlled experiments, humic substances increased dry matter yields of maize (*Zea mays* L.) corn and oat (*Avena sativa* L.) seedlings (Albuzio *et al*., 1994; Shariff, 2002) and numbers and length of tobacco roots (Mylonas and Mccants, 1980). The typical growth response curves that have been reported to result from treating plants with humic substances show progressively increased growth with increasing concentrations, but usually there was a decrease in growth at higher concentrations (Chen and Aviad, 1990). Hypotheses which account for this stimulatory effect at low concentrations are numerous, the most convincing of which is a direct action on the plant which is hormonal in nature, together with an indirect action on the metabolism of soil microorganisms, the dynamics of uptake of soil nutrients and soil physical conditions (Malcolm and MacCarthy, 1986; Nardi *et al*., 1988; Chen and Aviad, 1990; Muscolo *et al*., 1999; Shariff, 2002). Studies conducted in Kansas showed that humate did not significantly improve corn grain yields over a 3- year period (Lawless *et al*., 1984). Similar results were observed in research on a related material called leonardite, an organic, coal-like deposit reportedly high in humic acid (Bauder, 1976). Research in Illinois (Egli and Pendleton, 1984), North Dakota (Bauder, 1976) and

Canada (Elegba and Rennie, 1984) showed no significant improvement in yields of corn grain, corn silage, wheat, barley and field beans when various soil conditioners were applied alone or in combination with commercial fertilizer. Humic acid had a direct effect on the growth processes of wheat plant (Vaughan and Linehan, 2004). Wheat, very well know a field crop, has received far or less scientific attention for the HA yield increasive effect but few reports it on the yield components' increasing at the different sowing times with different genotypes in the literature. The aim of this study was to investigate increasive effect of the humic acid in 18 wheat (*Triticum* spp.) hybrids at 4 sowing times under the Central Anatolian field conditions.

MATERIALS AND METHODS

The experiment was carried out during the winter season of 1998-1999 and 1999-2000 under the Central Anatolian field conditions at the University of Ankara, Faculty of Agriculture, Research and Application Farm of Haymana County (39°-36° N, 32°-40° E, asl 925 m), Ankara, Turkey on the silty clay loam soil. Soil properties of the experimental site are clay structure, dark brown, pH = 6.1, lime 25.4%, organic matter 1.08% and changeable potassium level is 0.022% (Anonymous, 1999). 9 females (7 common *Triticum aestivum* (L.) Em. Thell); P_5 = Aköz 867; P_7 = Köse 220/39; P_9 = Penjamo 62; P_{10} = Sivas 111/33; P_{11} = Sürak 1593/51; P_{12} = Sertak 52 and P_{13} = Yektay 406 and 2 durum *Triticum durum* Desf.; P_1 = Kunduru 414/44 and P_4 = Kunduru 1149) and 4 semi wild males (P_2 = *T. dicoccum*, 2n = 28; P_3 = *T. carthlicum*; P_6 = *T. vavilovii* and P_8 = *T. spelta*) were crossed without reciprocals and derived 180 F_3s (Table 1). Average temperature, rainfall and relative humidity parameters during the growing seasons are presented in (Table 2). The experiment was laid out in randomized complete block design. All sowing procedures were repeated and adjusted to 450 viable seeds per m^2. The plot size was 1.4 m^2 (eight rows, 0.20 cm apart and 1 m length). Sowing time was allocated to main plots, when the planting procedure done by as mentioned above with the 2.5 t ha^{-1} per plot HA application. Related agronomic practices as recommended for the growers were followed through out the growing seasons. Except first and last rows and 15 cm from upper and below parts all remain area in each plot was harvested on July 13-17 in both years. Randomly selected 10 competitive plants from the each plots and data were recorded on the following parameters during the course of study.

Table 1: Parents and hybrids, theirs scientific name, genome formulae and chromosome number

Parents and hybrids	Scientific name	Genome formula	Chromosome number (2n)
P_5 = Aköz 867	*Triticum aestivum* L. Em Thell	AABBDD	42
P_7 = Köse 220/39	*Triticum aestivum* L. Em Thell	AABBDD	42
P_4 = Kunduru 1149	*Triticum durum* Desf.	AABB	28
P_1 = Kunduru 414/44	*Triticum durum* Desf.	AABB	28
P_9 = Penjamo 62	*Triticum aestivum* L. Em Thell	AABBDD	42
P_{12} = Sertak 52	*Triticum aestivum* L. Em Thell	AABBDD	42
P_{10} = Sivas 111/33	*Triticum aestivum* L. Em Thell	AABBDD	42
P_{11} = Sürak 1593/51	*Triticum aestivum* L. Em Thell	AABBDD	42
P_{13} = Yektay 406	*Triticum aestivum* L. Em Thell	AABBDD	42
P_3 = *Triticum carthlicum*	*Triticum durum* Desf.	AABB	28
P_2 = *Triticum dicoccum*	*Triticum durum* Desf.	AABB	28
P_8 = *Triticum spelta*	*Triticum aestivum* spp. *spelta*	AABBDD	42
P_6 = *Triticum vavilovii*	*Triticum aestivum* spp. *vavilovii*	AABBDD	42
$1F_3$ = ($P_1 \times P_2$)		AABB	28
$2F_3$ = ($P_1 \times P_3$)		AABB	28
$3F_3$ = ($P_4 \times P_3$)		AABB	28
$4F_3$ = ($P_4 \times P_2$)		AABB	28
$5F_3$ = ($P_5 \times P_3$)		AABBDD	42
$6F_3$ = ($P_5 \times P_6$)		AABBDD	42
$7F_3$ = ($P_7 \times P_6$)		AABBDD	42
$8F_3$ = ($P_7 \times P_8$)		AABBDD	42
$9F_3$ = ($P_9 \times P_8$)		AABBDD	42
$10F_3$ = ($P_9 \times P_6$)		AABBDD	42
$11F_3$ = ($P_{10} \times P_6$)		AABBDD	42
$12F_3$ = ($P_{10} \times P_8$)		AABBDD	42
$13F_3$ = ($P_{11} \times P_3$)		AABBDD	42
$14F_3$ = ($P_{11} \times P_6$)		AABBDD	42
$15F_3$ = ($P_{12} \times P_6$)		AABBDD	42
$16F_3$ = ($P_{12} \times P_8$)		AABBDD	42
$17F_3$ = ($P_{13} \times P_8$)		AABBDD	42
$18F_3$ = ($P_{13} \times P_6$)		AABBDD	42

Table 2: Meteorological data and their fluctuations during the 1999-2001 growing seasons (monthly average)

	Average temperature (°C)						Average rainfall (mm)					
Months	1996	1997	1998	1999	2000	LTA[§] 1926-96	1996	1997	1998	1999	2000	LTA[§] 1926-96
January	0.5	1.7	2.8	1.3	-5.4	1.6	45.8	60.5	59.6	32.9	78.2	57.0
February	2.4	3.1	-1.1	1.2	-4.1	3.5	37.6	65.4	54.2	91.4	45.5	33.1
March	3.0	3.4	2.9	4.5	1.7	6.0	38.8	47.6	54.3	62.9	51.3	54.5
April	9.7	10.5	9.9	10.1	11.3	12.5	41.5	54.9	66.7	38.0	76.6	66.4
May	12.2	15.3	10.6	14.8	17.4	14.6	30.0	14.9	25.8	13.5	5.4	20.6
June	18.4	20.1	19.5	18.0	23.9	21.1	40.5	34.6	20.0	28.9	48.2	50.3
July	19.7	23.4	21.4	22.1	20.8	22.5	25.7	32.1	45.8	63.9	67.4	75.8
August	18.4	20.1	21.6	17.3	23.6	13.4	9.7	8.6	8.1	8.2	32.7	33.4
September	14.4	13.8	20.5	17.1	16.4	18.2	32.3	26.5	10.1	19.8	6.6	21.5
October	10.5	9.6	13.4	12.5	11.7	12.0	27.2	18.4	52.7	43.4	35.8	37.6
November	6.2	3.5	4.7	5.5	4.9	6.7	46.9	27.5	33.7	30.2	29.7	69.8
December	3.0	2.2	3.1	3.9	2.7	2.0	50.8	34.1	20.4	26.0	39.9	47.6

	Average humidity (%)					
Months	1996	1997	1998	1999	2000	LTA[§] 1926-96
January	75.1	82.8	50.3	83.1	78.0	73.4
February	75.7	68.6	85.1	83.0	79.7	76.7
March	67.5	75.0	80.0	82.1	77.9	70.0
April	54.0	65.6	78.2	78.3	81.5	62.7
May	52.5	68.3	73.5	74.0	76.7	65.3
June	38.9	45.4	70.0	77.6	74.0	60.1
July	31.6	47.5	42.9	42.0	66.9	58.5
August	33.4	35.8	40.7	41.6	68.4	63.6
September	66.6	59.8	80.1	74.9	68.9	61.7
October	55.1	64.4	70.2	78.1	72.4	71.5
November	78.8	69.9	78.4	79.1	66.1	79.9
December	52.3	55.7	58.9	50.0	59.5	52.1

[§] LTA : Long term averages; source: Republic of the Turkey, Environment and Forest Ministry, General Directorate of Meteorology, Ankara

Plant height (PH-cm): Determined at the maturity by measuring of the length between soil surface and top of the ear (awns excluded) of the tallest spikes at the 10 sample plants from the each plot.

Spike length (SL-cm): This trait was found out by counting between the lowest internode and the terminal spikelet as a mean of ten values in the samples at the maturity.

Number of spike (NS-No.): Fixed by counting of the spikelets of the three longest spikes in ten sample wheat plants at maturity.

Number of spikelet (NSL-No.): It was found by weighting of the ten rooted sample wheat plants after harvest and threshing.

Grain number (GN-No.): It was obtained by weighting each of the ten rooted samples after the harvest and threshing.

1000-Grain weight (TKW-g): It was calculated from the equation of Grain Weight × Grain Number in the samples at the maturity.

Statistical analysis: All obtained data from the each plot was statistically analyzed according to RCB design with the analysis of variance (ANOVA) of the MSTAT-C Statistical Software Ver. 2.0 (Freed and Scott, 1998) and upon obtaining significant difference, Duncan's new multiple range test was employed for the comparison (Duncan, 1955). Linear correlation analyses were calculated to determine relationships between measured characteristics, separately, at a significance level of 0.01 and 0.05.

RESULTS AND DISCUSSION

Meteorological data of the experimental site's during the growth season was presented in Table 2 and Fig. 1. Used experimental materials' analysis of variance test results were given in Table 4. Mean values of the agronomical traits' all of the hybrids at separately were given at four different sowing times in Fig. 3 and combined in Fig. 2. In addition, this trend was given in each sowing time was in Fig. 3. On the other hand, (H × St) interaction was given for each sowing time in Fig. 4. Calculated coefficient correlations among the investigated agronomic traits were summarized in Table 5. Statistical analysis of the data revealed that there are

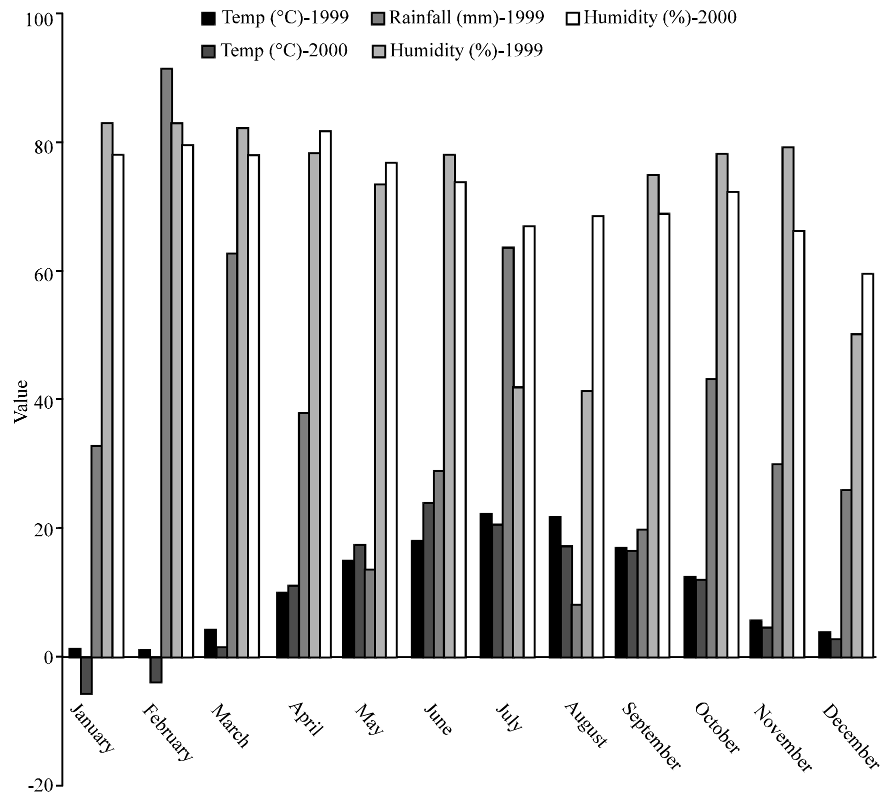

Fig. 1: Meteorological data of the experimental site's during the sowing times.

Table 3: Mean values of the investigated hybrids

Hybrids	PH (cm)	SL (cm)	NS (No.)	NSL (No.)	GN (No.)	TKW (g)
1 F_3	97.006ab	7.219d	7.369a-c	26.500c-e	22.000gh	31.000b-e
2 F_3	101.525ab	7.319cd	6.588a-c	27.313cd	16.125h	30.644b-e
3 F_3	101.308ab	9.069abc	7.931a-c	33.000a	29.938c-e	33.250bc
4 F_3	95.563ab	7.319cd	7.838a-c	33.875a	30.125c-e	30.350c-e
5 F_3	103.175ab	9.462ab	7.181a-c	22.000f	29.125d-f	31.375b-e
6 F_3	158.662a	9.919a	7.012a-c	31.438ab	29.250d-f	32.262b-e
7 F_3	93.094b	9.163ab	7.400a-c	32.688a	33.063b-e	32.837b-d
8 F_3	103.825ab	9.169ab	8.244ab	28.313bc	34.438b-d	38.081a
9 F_3	100.431ab	8.913a-d	7.400a-c	27.000cd	29.125d-f	33.369b
10 F_3	111.725ab	10.119a	8.226ab	24.750c-f	41.125a	35.938a
11 F_3	95.656ab	8.069b-d	6.831a-c	23.813d-f	39.563ab	30.194de
12 F_3	98.063ab	8.594a-d	6.744a-c	26.688cd	22.688fg	31.819b-e
13 F_3	98.131ab	7.269cd	6.288c	24.438c-f	25.875e-g	32.063b-e
14 F_3	93.094ab	7.344cd	6.563bc	22.625ef	30.688c-e	32.319b-e
15 F_3	92.044b	9.800ab	7.356a-c	25.125c-f	27.313d-g	32.950b-d
16 F_3	91.806b	9.331ab	6.287c	22.250f	36.688a-c	29.831e
17 F_3	102.831ab	10.275a	6.825a-c	26.813cd	31.813c-e	31.587b-e
18 F_3	95.019ab	10.306a	8.294a	22.188f	30.750c-e	32.019b-e
Mean	101.816	8.814	7.243	26.712	29.983	32.333
Std. Error	14.62	0.1993	0.3834	0.9405	1.642	0.6595
LSD (0.01)	55.33	1.5930	1.4510	3.5590	6.214	2.496
CV (%)	57.55	19.19	23.07	16.80	23.00	10.91

F_3 = Third generation, PH = Plant height, SL = Spike length, NS = Spike number, NSL = Spikelet number, GN = Grain number, TKW = 1000-Grain weight, Means within each column followed by the same letter are not significantly different at the level of $p<0.01$

considerable amount of genetic (hybrids), sowing times and interaction reasoned variability for all the agronomic traits with the HA application under the Central Anatolian conditions (Table 3). As seen from Table 3, all investigated traits for the H, St and (H × St) were found statistically significant ($p<0.01$). This suggested that the choice of humic acid type-dosage, hybrids and the interactions were very appropriate. On the other hand,

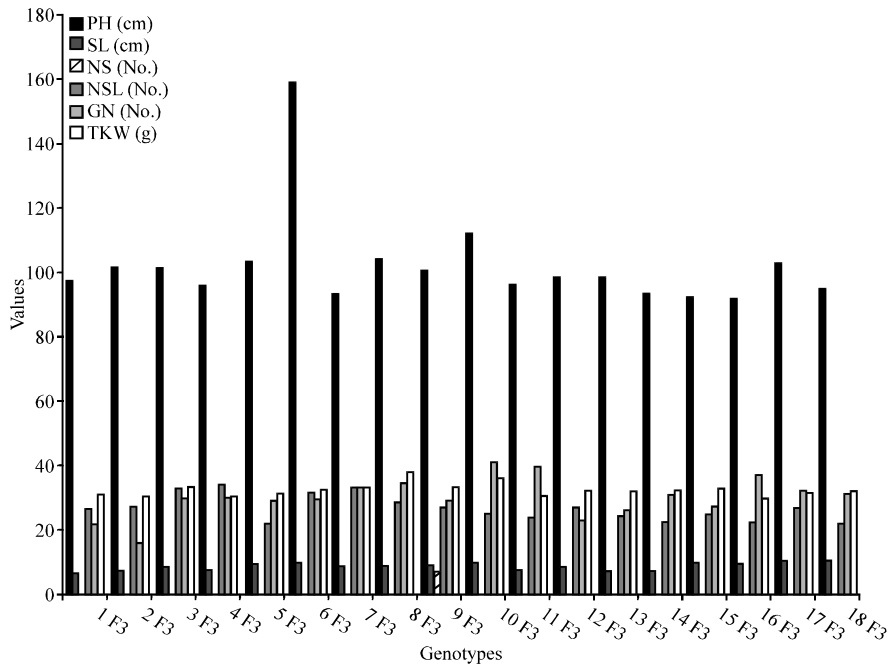

Fig. 2 : Agronomical traits of the genotypes in the four sowing times as mean value
PH = Plant height; SL = Spike length; NS = Spike number; NSL = Spikelet number; GN = Grain number; TKW = 1000-Grain weight

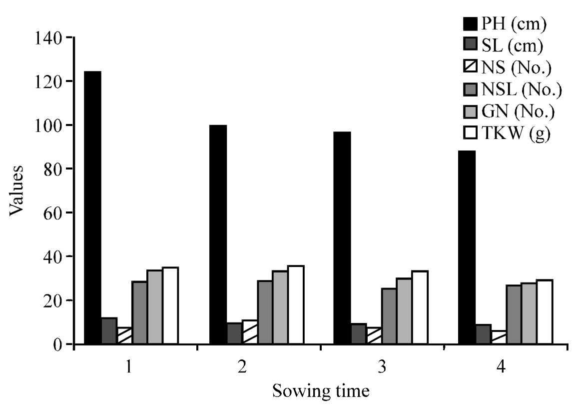

Fig. 3: Means in the St_I = 5/10/1999; St_{II} = 20/10/1999, St_{III} = 4/11/1999 and St_{IV} = 15/11/1999, PH = Plant height, SL = Spike length, NS = Spike number, NSL = Spikelet number, GN = Grain number, TKW = 1000-Grain weight

these results were only for obtained growth period. The lowest value was obtained from the $16F_3$ (91.806) and the highest value from the $6F_3$ (158.662) for PH (Table 3). For SL, the lowest value was taken from the $1F_3$ (7.219) and highest value from the $18F_3$ (10.306) (Table 3). (6.287) is the lowest value which was obtained from the $16F_3$ and (8.924) is the highest value which was taken from $18F_3$ (Table 3). For NSL, the lowest value was observed from the $5F_3$ (22.000) and highest value from the $4F_3$ (33.875) (Table 3). The lowest value was get from the $2F_3$ (16.125) and the highest value from the $11F_3$ (39.563) for GN (Table 3). (29.831) is the lowest value which was obtained from the $16F_3$ and (38.081) is the highest value which was taken from $8F_3$ (Table 3). When the sowing times considered generally, genotypes responses' had not realized very different from each other for the examined agronomical traits and PH parameter had been always realized higher (Fig. 2). Further details will be discussed in discussion section. Similar trend for in terms of the investigated traits can be seen in Fig. 3 and 4. In the Fig. 3, in all sowing times, PH variable was showed highest value. Than, TKW> GN> NSL > SL; except for St_1 and St_4. According to Subhani *et al*. (2000), it was reported that low yield level was as a result of a reduction in the number of grains per ear and TKW per square meter, SL, grain weight per ear and yield level, due to close relationship with the correlation, number of grain per ear, number of spikelet per spike could be recommended a valuable selection criterion such as the Central Anatolian regions. On the other hand, distribution of the introduction of the (H × St) was showed generally a similar pattern with Fig. 3 (Fig. 4).

In the first sowing each hybrid was given to maximum means; in the second sowing time, $10F_3$, $18F_3$ and $4F_3$ were given to maximum means; in the third and fourth (St), each

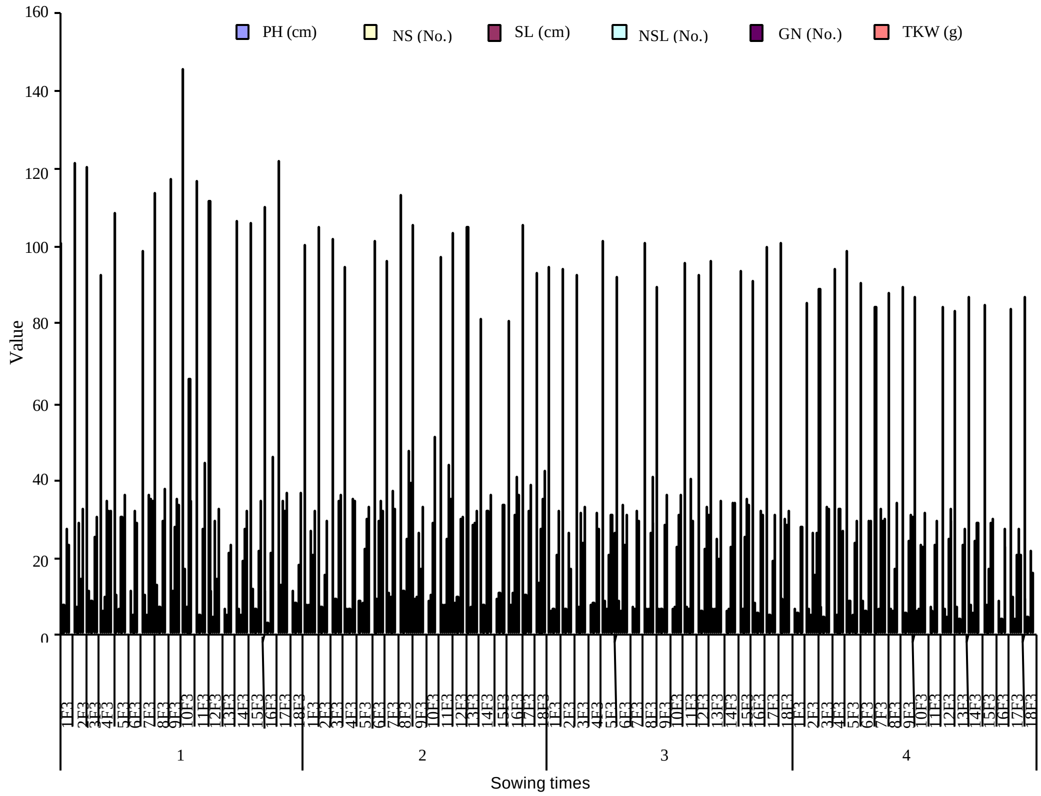

Fig. 4 : (H × St) interaction in each sowing time
PH = Plant height; SL = Spike length; NS = Spike number; NSL = Spikelet number; GN = Grain number; TKW = 1000-Grain weight

hybrid was given to different similar mean values (Fig. 4). The highest mean values for the investigated agronomic traits were taken from the first (St). It was recorded that when the sowing time progressed all related data were diminished clearly. Especially this situation indicates that first sowing time is the crucial importance with the humic acid application and used (H); because, meteorological conditions of the experimental place are getting the limits of the production and effect of the soil conditioner (here is HA) under the Central Anatolian field conditions (Fig. 4). The highest percentage reduction was noted for the plant height (PH) (38%), spike length (SL) (22%), spike number (NS) (32%), spikelet number (NSL) (7.6%) and 1000-grain weight (TKW) (7.9%) at the transition of the sowing times. This effect can be explained with unfavorable meteorological conditions during the St and HA's availability by the plants.

Correlation coefficients among the examined agronomic traits were calculated according to hybrids, sowing times and their interactions' each others and results are given in Table 5. As seen from the Table 5, For all examined traits were not showed statistically significance at the level of H, St and (H × St), but among PH and SL ($r = 0.393$, $p<0.01$), NS and NSL ($r = 0.309$, $p<0.05$), SL and GN ($r = 0.471$, $p<0.01$), NS and TKW ($r = 0.536$, $p<0.01$) and GN and TKW ($r = 0.289$, $p<0.05$) (Table 5). According to some agronomic studies, there is no simple relationship between grain yield and the amount of reserves mobilized during grain filling in wheat. This could be due partly to the large sensitivity of the accumulation of reserves to environmental conditions and source-sink status (Evans and Wardlaw, 1996). This can be when the photosynthetic activity is inhibited by stress conditions after anthesis event, however, grain filling becomes more dependent on mobilized stem reserves, which then may represent 40-60% of the dry matter that accumulates in the grain (Blum *et al*., 1994; Przulj and Mladenov, 1999). Environment strongly affects yield and its components; moreover, correlation studies in barley (*Hordeum vulgare* L.) (Rassmuson and Cannell, 1970) and durum wheat (*Triticum durum* Desf.) (Royo *et al*., 2007) provide additional evidence of the important effect that

Table 4: Variance analysis results

Source	Df.	PH (cm)	SL (cm)	NS (No.)	NSL (No.)	NG (No.)	TKW (g)
Blocks	3	1.1479	0.1785	0.7521	0.2875	0.9843	0.4474
Hybrids (H)	17	1.0624**	7.1138**	2.9400**	16.7052**	13.7332**	9.4167**
Error	51						
Sowing times (St)	3	5.5294**	39.6635**	68.4375**	11.0509**	11.7601**	56.9138**
H × St	51	0.9944**	2.7436**	2.2332**	2.2000**	4.8113**	4.1268**
Error	162						

Df: Degree of freedoms; PH: Plant height; SL: Spike length; NS: Spike number; NSL: Spikelet number; GN: Grain number; TKW: 1000-Grain weight; *,** are statistically significant at the level of p<0.05 and 0.01, respectively

Table 5: Correlation coefficients of the examined agronomical traits

Sources	SL (cm)	NS (No.)	NSL (No.)	GN (No.)	TKW (g)
H					
PH (cm)	0.319	0.042	0.302	0.016	0.175
SL (cm)		0.394	-0.084	0.460	0.360
NS (No.)			0.314	0.303	0.613
NSL (No.)				-0.131	0.143
GN (No.)					0.308
St					
PH (cm)	0.957	0.102	0.594	0.794	0.597
SL (cm)		0.174	0.716	0.822	0.584
NS (No.)			0.670	0.683	0.803
NSL (No.)				0.869	0.659
GN (No.)					0.911
H×St					
PH (cm)	0.393**	-0.035	0.171	0.116	0.221
SL (cm)		0.101	0.073	0.471**	0.179
NS (No.)			0.309*	0.199	0.536**
NSL (No.)				-0.050	0.252
GN (No.)					0.289*

H = Hybrids, St = Sowing times, (H × St) = Interaction, PH = Plant height, SL = Spike length, NS = Spike number, NSL = Spikelet number, GN = Grain number, TKW = 1000-Grain weight; *, **; are statistically significant at the level of p<0.05 and p<0.01, respectively

environmental variation has on the relationships among yield components. Obtained results can be summarized as follows:

Plant height (PH-cm): As know this trait is a key factor for the wheat production. Hence, this yield component must be realized between certain limits. Especially, for the field condition of the Central Anatolia, soil water is very limited and related meteorological parameters getting lower by the sowing time. Even, adding the humic acid, its usefulness and availability by the plants is limited till to spring or to again earning the water's viscosity for the transition. Maximum value was taken from the $6F_3$ (158.662) and lowest value was observed at the $16F_3$ (91.806) (Table 3). Eighteen F_3 genotypes were collected under three different statistically significance groups. This formation supports that genotypic variation for the used hybrids' plant height in not so wide and HA and environmental conditions (inc. climatologically) were not very much effected as expected but after the 3rd (St) increasive effect was came to seen obviously (Table 3).

Spike length (SL-cm): This is very important because it carries another important yield components such as spikelets, grains etc. Its desired as possible as long due to this superiority and its length directly reflects to the other yield components such as number of spikelet, number of grain, 1000-grain weight etc. As seen from the Table 3, humic acid's positive effect was not clearly realized in that trait for all sowing times but commonly in plant height. For this trait, maximum value was recorded in $18F_3$ (10.306) and lowest value was found at $1F_3$ (7.219) (Table 3). $18F_3$ hybrid genotypes were formed six statistically significance groups. That reality verifies that spike length agronomic trait has larger genetic base than the plant height and genetic variation is much more. According to this information, trait's behavior in the effect of HA and environmental conditions under the Central Anatolian field condition was happened plasticity and adaptation flexibility within the certain limits.

Spike number (NS-No.): Agronomically, this trait is important for the number of viable plant per meter square, consequently grain yield. Due to sharing of the plant nutrition elements, grain yield level relatively will be decrease if spike number increases. On the other hand, this trait closely related to previously investigated yield component (spike length). Just as, recorded max. value is $18F_3$ (8.294) is supported to this idea and min. value was taken from the $16F_3$ (6.287) (Table 3). All experimental materials were constructed five different statistically significance groups in terms of this trait. That classification means that there were similar genetic variations for this trait. HA applications' positive effects were observed in three sowing times but in the last one all obtained data was clearly reduced.

Spikelet number (NSL-No.): Due to the spike number in the plant, its agronomical effect on the yield level is important. It plays determinative roles during the maturity as fertile or sterile counterpart(s). If plants have higher the number of fertile spikelets the yield level higher but if they not fertile spikelets or high sterile spikelets the yield level reduces. Especially dry seasons, stress conditions or high temperatures causes the sterile spikelets in the plants. Same trend was happened in all (St) for this study. On the other hand, humic acid applications were effected superficially and it was not clearly effected in each sowing times. For the spikelet number; max. value was get in $4F_3$ (33.875) and min. value was calculated from the $5F_3$ (22.000) (Table 3). Used all genotypes were formed 9 different and significant classes. This is showed that there was a wider genetic variation in this trait than the spike number but humic acid's positive effect was not realized not profoundly especially in the last sowing time all recorded data was clearly and negatively effected.

Grain number (No.): Grain number per ear is a major factor determining the yield of cereals. As known, grain number is an end product. Moreover, yield level varies according to its number, amount and fullness. In addition, environmental conditions, genotypes and applied techniques are effective to this trait. HA applications were evidently effected in a positive way of the grain number in the first sowing time but that effect is not observed for other sowing times. The highest value was obtained from the $16F_3$ (36.688) and the lowest value was taken from the $2F_3$ (16.125) (Table 3). Genotypes were gathered into eleven different significant classes. This formation can be explained that this trait has the widest genotypic variation. Due to this peculiarity, HA was effected each genotype at the various level and this case very clear in the first sowing time.

1000-Grain weight (TKW-g): This is a finger print of any wheat genotypes like other yield and yield components. It can be consider a passport in terms of the agronomic acceptance. In addition, amount of this trait must be as possible as high within the genotypic limits. In view of many earlier reports yield of a grain crop is the net outcome of the synthesis of assimilates by leaves and translocation of these assimilates to the developing seed where they are utilized to synthesize other organic compounds such as starch, proteins and oil, etc. (Egli and Pandleton, 1984; Wardlaw, 1990; Pettigrew and Meredith, 1994; Lawlor, 1995). TKW is a closely related with grain formation period. But, several studies have demonstrated no association between grain fill duration and grain yield in spring wheat (Nass and Reiser 1975; Bruckner and Frohberg 1987; Talbert *et al*., 2001). However, the rate of grain filling has been found to be positively associated with grain weight and hence grain yield (Nass and Reiser, 1975; Bruckner and Frohberg, 1987; Duguid and Brule-Babel, 1994). Przulj and Mladenov (1999) investigated the inheritance of grain fill duration in spring wheat and found an inconsistent association between this trait and maturity. The highest value for this trait was taken from the $8F_3$ (38.081 g) and lowest value was obtained from the $16F_3$(29.831 g). According to this trait, there were formed seven different classes. This case was an evident that there was a diverse genotypic makeup. On the other hand, all obtained values were not expressed great difference. This discrepancy can be take into consider another verified evidence.

Grain yield can be analyzed in terms of three primary yield components (number of spikes per unit land area, product of number of plants per land area and number of spikes per plant, number of grains per spike and mean grain weight). These components develop sequentially, with later-developing components under control of earlier developing ones (Moragues *et al*., 2006). Environment effects contributed the most to the observed variation in the measured traits, followed by H and St and (H × St) effects. All traits exhibited a wide range of variation (Table 3). Yield components in generally exhibited a positive genetic variation with St. But after the first sowing time, examined yield components showed dramatically decreased values (Table 3). From them, one component (NSL) was expressed slightly increasing, two components were showed clearly decreasing (PH and TKW) and one component was indicated decreasing for St_1 and St_2, increasing St_3 and St_4 (Table 3, Fig. 3). This case can be explain as the seedling quality traits (genotype), applied agronomical practices, ecological conditions of the experimental site's, HA's positive effects and their interactions on the dry matter production. On the other hand, it was fixed negatively associations between SL and NSL, NSL and GN traits in terms of the hybrids; between NSL and GN, PH and NS traits in terms of the interaction (Fig. 4, Table 4).

HA application to plant growth media increased the growth of both shoots and roots significantly. Our results were in agreement with Chen and Aviad (1990). HA has the positive influences on plant growth and productivity, which seem to be concentration-related, could be mainly due to hormone-like activities of the humic acids through their involvement in cell respiration, stress tolerance, photosynthesis, oxidative phosphorylation, protein synthesis, antioxidant and various enzymatic reactions (Vaughan and Malcalm, 1985; Chen and Aviad, 1990; Zhang and Schmidt, 1999, 2000; Muscolo *et al*., 1999; Nardi *et al*., 2002; Zhang *et al*., 2003). They are known to evoke plant growth responses similar to those induced by plant hormones, it has not yet been proved conclusively whether humic acids contain hormone like components (Muscolo *et al*., 1999).

Results of the present study suggest the possibility of developing positive effects of the HA's in selected wheat hybrids without negatively affecting during the shorter grain filling period. However, a point of concern is the low heritability of grain fill duration, implying that genetic gain in this trait would require multi-environment testing. HA applied to the plant growth medium at 1 g to 1 kg concentration increased seedling growth and nutrient contents in the plant. However, high levels of HA arrested or decreased plant growth and nutrient contents, respectively. They (HA) are not only increased macronutrient contents, but also enhanced micro-nutrient contents of the plant organs. This apparently puzzling anomaly can be explained partly by their chelating capacity and partly by their hormone-like activity. This is not surprising, considering the complex and differentiated nature of humic acid. We assume that humic substances play a major role in plant nutrient uptake and growth parameters in wheat plats in both vegetative and generative stages.

These traits also varied between sowing dates, as it was expected, due to the ample variability in environmental conditions. During the growing period, drought stress may cause a reduction in all the yield components, but particularly in the number of fertile spikes per unit area and in the number of grains per spike, while kernel weight is negatively influenced by high temperatures and drought during ripening (Moragues *et al*., 2006). During the vegetative stage of the October to May, wheat plant and the grain filling stage of the crop, temperatures could be considered low and any kind of the compensation from the yield components is a result of competition for limited resources (Moragues *et al*., 2006) during this period. But, instead of this parameter, relative humidity level is high. At that stage, due to the different effects of the external factors, mainly ecological, the eighteen hybrids had differed in morphological characteristics and related yield components. In summary, HA applications to the wheat hybrids at different sowing times under the Central Anatolian condition is not increased the yield components clearly but slightly. Moreover, this effect had been appeared much clearer at the first sowing time.

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