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Effects of Humic Acid Application on Yield and Quality of Cotton (*Gossypium hirsutum* L.)

SEMA BASBAG
Department of Field Crops, Faculty of Agriculture, Dicle University
Diyarbakir 21280, Turkey
E-mail: sbasbag@dicle.edu.tr

Humic acid are referred to as humic substances and are used as soil conditioners, soil supplements and fertilizer amendments. This research was conducted to determine the effects of different humic acid treatments (seed soaking, foliar spray, seed soaking + foliar spray) on yield and technological characteristics of cotton in 2004-2005 at Diyarbakir, Turkey. Plant height, first hand cotton seed yield, number of bolls and sympodial branches and total cotton seed yield affected by humic acid applications. Humic acid applications had no significant effect on ginning percentage and quality properties such as fiber length, fiber fineness and fiber strength.

Key Words: cotton, *Gossypium hirsutum* L., Humic acid, Yield and Quality characters.

INTRODUCTION

Cotton fields constitute 87.3 % of fiber plants all over the world. This rate is 98.5 % for Turkey. Utilization rate of products made from cotton has been increasing gradually compared to other fiber plants due to economical and market demands reosons. Almost 60-61 % of yarns used in Turkey textile industry are made of cotton[1]. To improve the organic contents of soils for growing industrial crops there are some applications such as planting rotation, various plough techniques, green fertilizer application and animal fertilizer application. In addition to these practices, utilization of organic-mineral fertilizers (such as potassium humanate) in agriculture has increased in recent years[2]. Humic acid affect plant growth directly or indirectly[3]. Humin and fulvous acids play an important part in absorption of micro elements in soil by plant roots due to nitrogen and phosphorus given through artificial fertilizers applied especially for the plants grown in limy soils[4,5]. Marschner[6] reported that phosphorus increased plant nitrogen content due to its positive effect on root growth and that there was a synergistic interaction between nitrogen and phosphorus. Benedetti *et al.*[7] and Rubinchik *et al.*[8] reported that P was more useful for plants when it is applied with humic acid. Studies on the positive effects of humic substances on plant growth, with fully available mineral nutrition requirements, have resulted in improved effects on growth independent of nutrition[9]. Mylonas and Mccants[10], Lee and Bartlett[11] and Albuzio *et al.*[12] reported that humic acid increased numbers and lengths of tobacco roots; dry matter yields of corn and oat seedlings, respectively. The aim of this study is to determine the effects of humic acid (given to cotton through different application methods) on yield and technological characteristics.

EXPERIMENTAL

This research was conducted in Experimental Field of Dicle University, Faculty of Agriculture, in 2004 and 2005 years. The altitude of the research location is 660 m and it is located on 37º 54' N and 40º 14' E. The soils of the experimental area were thinly structured alluvial material or limestone. The soil is low in organic material (1.67%) and phosphorus (0.42) has adequate calcium (49 %) and high clay content (67 %) in the 0-150 cm profile (Southeastern Anatolia Agric. Res. Ins.-Soil Analysis Lab., Diyarbakir, 2005). The average of long term temperature is 21.5 ºC, rainfall is 208.6 mm and the average relative humidity is about 44.6 %. The average temperature can reach up to 31 ºC in July and August. The lowest average temperature of growing season can be 9.6 ºC in November. The earliest frost in the region is usually at the end of October and the last frost around end of April. Most rain falls of growing season in April and there is almost no rainfall from July to September. The highest humidity (67 %) occurred in November, lowest (27 %) in July and August (Meteor. Direc., Diyarbakir, 2004, 2005). Two cotton varieties (GW Teks and DP Opal) and liquid form of humic acid were used. Humic acid were applied by three different treatments (seed soaking, foliar spray, seed soaking + foliar spray with humic acid) and a control. Treatments were applied with 150 cm^3 humic acid/100 kg seed + 1000 cm^3 water for seed before sowing and 200 cm^3 humic acid/m^2 + 2000 cm^3 water for foliar spray in initial flowering. In control plots, only the water was sprayed to the seeds and plants. Humic acid used contained humic acid 15 %, fulvic acid 2.4 % and organic matter 16 % and carbon 9.8 %. Experiment was designed as a randomized completely blocks design with two factor and three replications. Plots were formed by 32 rows at 12 m length with inter-row spaces 70 cm and intra-row spaces 20 cm. Fertilization were at sowing 70 kg N ha^{-1} and 70 kg P ha^{-1} and 70 kg N ha^{-1} at the first irrigation. The plots irrigated eight times (100 mm at each application). The harvest was made with hand and at 2 different times.

Observations on plant height (cm), number of sympodial branches (per plant), number of bolls (per plant), first hand cotton seed yield (kg ha^{-1}), cotton seed yield (kg ha^{-1}), ginning percentage (%), fiber length (mm), fiber fineness (mic.) and fiber strength (g/tex) were recorded. The fiber quality characters were analyzed *via* HVI. Statistical analyses were made with the MSTAT statistical program (Michigan State University, East Lansing, MI). Comparisons between mean values were made using least significant differences (LSD) at a 0.05 probability level following an analysis of variance.

RESULTS AND DISCUSSION

The effect of humic acid applications on plant height were significant ($p < 0.01$). The plant height was positive respond to different humic acid applications. Plant height were ranged from 74.50 to 79.83 cm. Humic acid applications on seed soakings and foliar spray, separately, were increased plant height. The application on seed soaking + foliar spray had less effect on plant height. Kononova[13] and Chen and Aviad[9] stated that low humic acid doses (0.6-60 ppm) affect plant growth in a positive way and high humic acid doses affect plant growth in a negative way. In other research in barley and wheat, effect of delta humate on plant characteristics was not significant[2]. The effect of humic acid applications on plant height were different among varieties tested, resulted in higher plants in DP Opal than that of GW Teks (Table-1).

The effect of humic acid applications on number of bolls were statistically significant ($p < 0.01$). Number of bolls per plant changed from 13.78 to 15.94. The effect of humic acid applications on number sympodial branches per plant was significant ($p < 0.01$). Number of sympodial branches ranged from 10.28 to 12.13 (Table-1). Humic acid application on foliar spray + seed soaking increased number of boll and sympodial branches. According to the control, applications had positive effects on these characters. Humic acid application increased the vegetative production due to enhancing plants water and nutrition absorption capacity[14].

The effect of humic acid applications on first hand cotton seed yield and total cotton seed yield was significant. The first hand cotton seed yield and total cotton seed yield ranged from 2259 to 2868 kg ha^{-1} and from 3207 to 3889 kg ha^{-1}, respectively. DP Opal was more affected by applications of humic acid on seed soaking than other applications and GW Teks for total cotton seed yield. There were also significant differences between the types of humic acid applications; seed soaking application resulted in higher cotton seed yields than those obtained from other applications (foliar spray, seed soaking + foliar spray) and control (Table-2). The increased yield may be due to hormonal effect of humic acids which also act as a respiratory catalyst and increased cell permeability. Humic acids also contain quinone groups, which act as a growth regulating substances and contributing to the increased yield[15]. However, Buehring *et al.*[16] reported that hydrahume did not increase seed cotton yield. The effect of humic acid applications on

TABLE-1
EFFECTS OF HUMIC ACID (APPLIED IN DIFFERENT PERIODS) ON PLANT HEIGHT AND NUMBER OF BOLLS OVER TWO YEARS (2004-2005)

Humic acid treatments	Plant height (cm)			Boll number (plant^{-1})			Sympodial branch number (plant^{-1})		
	DP Opal	GW Teks	Mean	DP Opal	GW Teks	Mean	DP Opal	GW Teks	Mean
Control	75.57 c	74.00 cd	74.78 bc	13.60	13.97	13.78 b	10.57	10.00	10.28 c
Foliar spray	80.57 ab	74.17 cd	77.37 ab	15.55	14.58	15.07 ab	11.00	10.57	10.78 bc
Seed soaking	82.03 a	77.63 bc	79.83 a	14.10	14.02	14.06 b	11.27	10.37	10.82 b
Seed soaking + foliar spray	77.70 bc	71.30 d	74.50 c	15.21	16.67	15.94 a	12.33	11.92	12.13 a
Means	78.97 a	74.27 b		14.61	14.81		11.29 a	10.72	
LSD (%5)			2.655**			1.603**			0.505**
Treatment × variety Int.			3.755**						

*,**Significant at the 0.05 and 0.01 probability level, respectively.
Means in each column followed by the same letter are not significantly different ($p < 0.05$)

TABLE-2
EFFECTS OF HUMIC ACID (APPLIED IN DIFFERENT PERIODS) ON NUMBER OF SYMPODIAL BRANCHES AND FIRST HAND COTTON SEED YIELD OVER TWO YEARS (2004-2005)

Humic acid treatments	First hand cotton seed yield (kg ha^{-1})			Cotton seed yield (kg ha^{-1})			Ginning percentage (%)		
	DP Opal	GW Teks	Mean	DP Opal	GW Teks	Mean	DP Opal	GW Teks	Mean
Control	2270.8	2246.8	2259 b	3349.7 b	3228.8 a	3289 b	41.60	42.27	41.93
Foliar spray	2560.5	2532.7	2547 ab	3759.5 b	3202.8 a	3481 b	41.82	42.18	42.00
Seed soaking	3093.8	2641.5	2868 a	4449.7 a	3328.2 a	3889 a	41.12	42.03	41.57
Seed soaking + foliar spray	2539.0	2379.7	2459 ab	3392.7 b	3020.5 b	3207 b	41.28	41.95	41.62
Means	2616.0	2450.2		3737.9 a	3195.1 b		41.46 b	42.11 a	
LSD (%5)			412.0*			364.5**			
Treatment × variety Int.						447.0**			

*,**Significant at the 0.05 and 0.01 probability level, respectively.
Means in each column followed by the same letter are not significantly different ($p < 0.05$)

ginning percentage was not significant. Similarly, Buehring *et al.*[16] reported that hydrahume did not increase ginning percentage. Differences among varieties were significant and GW Teks had higher ginning percentage (42.11 %). Other applications were lower ginning percentage than control (Table-3).

TABLE-3
EFFECTS OF HUMIC ACID (APPLIED IN DIFFERENT PERIODS) ON FIBER LENGTH, FIBER FINENESS, AND FIBER STRENGTH OVER TWO YEARS (2004-2005)

Humic acid treatments	Fiber length (mm)			Fiber fitness (mic)		
	DP Opal	GW Teks	Mean	DP Opal	GW Teks	Mean
Control	28.53	29.93	28.22	4.00	4.03	4.008
Foliar spray with humic acid	28.60	29.80	29.20	4.17	3.92	4.042
Seed soaking with humic acid	28.57	30.03	29.23	4.02	3.98	4.017
Seed soaking + foliar spray with humic acid	28.95	27.48	29.30	3.98	4.03	4.000
Means	28.66	29.31	–	4.04	3.99	–
	Fiber strength (g/tex)					
Control	31.42	36.90	35.91			
Foliar spray with humic acid	32.30	35.88	34.09			
Seed soaking with humic acid	32.60	35.22	34.16			
Seed soaking + foliar spray with humic acid	33.95	37.87	33.91			
Means	32.57	36.47	–			

Means in each column followed by the same letter are not significantly different ($p < 0.05$)

There were no significant effects of humic acid applications on fibre length, fibre fineness and fibre strength. Earlier studies suggested that humic acid treatments had no significant effects on cotton fiber quality and also had limited promoting effects on wheat quality[17,18].

Conclusion

The current study suggested that humic acid application on seed enhanced plant height, first hand cotton seed yield and total cotton seed yield. Humic acid application through seed soaking + foliar spray increased the number of bolls and sympodial branches. However, humic acid applications had no significant effect on ginning percentage and quality properties of cotton (fibre length, fibre fineness and fibre strength).

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