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EFFECT of SEAWEEDS and ORGANIC FOLIAR FERTILIZERS on the COTTON PESTS, PREDATORS, YIELD and FIBER QUALITY in COTTON

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Abstract

A field experiment was carried out in Aydın region, Turkey during the two successive cotton growing seasons 2010 and 2011. The compounds have did not affect the population amount of *Empoasca* spp., *Bemisia tabaci* Genn., *Frankliniella* spp., whereas they affected *Aphis gossypii* Glov. and *Liriomyza trifolii* Burgess infestation. The highest population of *Aphis gossypii* was observed in Active Black Up treatment. On the other hand, the highest damage caused by *L. trifolii* was in Promina treatment. Among the predators, population in Thysanoptera order was significantly different in the treatments. More thrips populations were observed in Promina. The application of compounds significantly affected on the yield. The highest yield was obtained from Aminoquick treatmetn that has 95% organic matter and produced 28% more yield compared to the control. Treatments had no significant effects on plant height, lint percentage, boll weight, fiber properties, except for number of boll per plant and micronaire. The results showed that these compounds increased the yield, did not enhance the pests' population and not harmful to predators except for Thysanoptera. Thus, containing seaweeds and more organic foliar fertilizer compounds should be considered in integrated management of organic or conservative cotton fields.

Keywords: Seaweeds, organic matter, cotton, pests, yield

INTRODUCTION

About 9,000 macro algae species are classified into three main groups depending on the pigmentation including brown, green and red algae. Seaweeds among the algae are used in the agriculture (Hong *et al.*, 2007).

More than 15 million tons of seaweeds are produced annually (FAO, 2006) and used as biofertilizer in agriculture and also used human food, animal feed and row material for industry. Some chemical analysis revealed that seaweed extracts have all major and minor nutrients, and all trace elements; aliginic, amino acid, vitamins, auxins (Zodape, 2001; Zhang *et al.*, 2003; Zhang and Ervin, 2004; 2008). Seaweeds and their extracts have been used in many countries as soil conditioners, crop growth, and increase the yield, yield components (Verkleij, 1992; Norrie and Keathley, 2006; Chouliaras *et al.*, 2009; Sabir *et al.*, 2014) enhance seed germination, seedling vigor (Kambayashi and Watanabe, 2005; Demir *et al.*, 2006; Economou *et al.*, 2007), increase uptake of nutrients, ripening of fruits, increases shelf-life of the produce, and resistance to fungal diseases such as leaf stripe disease symptoms in grape (Calzarano *et al.*, 2014) and *Alternaria radicine* and *Botrytis cinerea* in carrot (Jayaraj *et al.*, 2008) and shoot length, root length, fresh and dry weights of seedlings were significantly increased in wheat (El-Din, 2015). Many different beneficial effects have been also reported for crops treated with seaweed extract. It increases seed germination, root elongation, hypocotyls and leaf area when applied as foliar spray (Mantri and Chaugule, 2008).

In recent years use of seaweed extracts is popular due to their use in organic and sustainable agriculture (Russo and Beryln, 1990). They are biodegradable, non-toxic, non-polluting and non-hazardous to human, animals and birds (Dhargalkar and Pereira, 2005). Dried, fresh and liquid extract of seaweed have been increasingly used by farmers as a fertilizer and now commercially available on the market (Gandhiyappan and Perumal, 2001; Hong *et al.*, 2007) even the mechanism is not really understood (Fornes *et al.*, 2002). Recently researchers reported that seaweed fertilizer are better than others and are very economical (Gandhiyappan and Perumal, 2001).

Some plant growth regulators and seaweed fertilizers were used in agriculture to improve not the plant yield but also resistance to the pests and disease (Norrie and Hiltz, 1999; Allen *et al.*, 2001; Gencsoylu, 2009). The crop treated with the seaweed develops resistance against red spider mite (Stephenson, 1966; Hankins and Hockey, 1990), aphids (Stephenson, 1966) and reduced the infestation of *Meloidogyne incognita* (Kofoid and White) (Crouch and Staden, 1992; 1993). The aim of this study was to evaluate the effect seaweeds and organic foliar fertilizer compounds on cotton pests, predators, yield and fiber quality in cotton.

MATERIAL and METHODS

Plant material and experimental design

Cotton (*Gossypium hirsutum*, cv. Carmen) was planted on 8 May 2010 and 15 May 2011, respectively at the Agricultural Experimental Station, Adnan Menderes University, Faculty of Agriculture, Aydin. The experiment was conducted to a randomized complete block design with 3 replications in each year.

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Each plot consists of 8 rows and 10 m in long with 2 m spaces between the plots. Spacing between rows 0.70 m.

Fertilizers and application time

A variety of organic materials that have different amount of organic matter with amino acid and seaweeds are used as foliar fertilizers including Active Black Up (Ege Agriculture Products Co, Izmir), AlgiPlus (ERA Group Ltd, Ankara), Aminoquick (Ege Agriculture Products Co, Izmir), Nutrifol (Orkim Chemical, Izmir), Promina (Akdeniz Agriculture Pesticides, Industrial Products Co, Antalaya) Seafert (Ege Agriculture Products Co, Izmir) under the trade name that were sprayed with a CO2-pressurized backpack sprayer in water (Table1). The treatment was applied on June 18, July 8, July 29 in 2010, and June 30, July 21 and August 11 in 2011 at the recommended rates. The cotton plants were not sprayed with chemicals and cultural practices were conducted as needed.

Sampling of agronomic parameters

Cotton yield was determined by the hand harvesting in 4 m of the four rows in each plot on 5 November 2010 and 20 October 2011 and 25 November 2011. The total seed cotton yield of each plot was converted to total yield in kg ha-1. Ten plants in each plot were randomly checked during the harvest for the measurement of the number of open boll and plant height. The mean number of open bolls and height per plant were recorded by checking 10 plants per replication at harvest. Twenty-five open bolls were picked from each plot and used to determine open boll seed weight (g) per boll and bolls were ginned to determine ginning lint percentage, yield, and fiber quality. Fiber tests were made at the laboratories of Soke Trade Chamber in HVI.

Sampling of pests and predators

The sampling of insects was randomly sampled from 10 plants for each plot. For the each treatment 30 leaves for each plot and totally 60 leaves were checked by the visual technique. Predators were counted by using 50 net sweeps for each treatment and total amounts were given under the order in Table 6.

Analysis of data

Data were analyzed by one-way analysis of variance (ANOVA) and separated by Duncan's multiple range test ($p<0.05$) using the SAS computer program (SAS Institute 1999).

Table 1. Trade names, compounds and recommended rates of seaweed extracts and organic compounds

Trade Names	Compounds (active ingredient/L)	Recommended rates
Active Black Up	Organic matter: 8% Humic acid+ Fulvic acid: 15% K_2O: %1.5	400 ml/100 l
AlgiPlus	Total organic matter: 35% K_2O: 10% Alginic acid: 10% Cytokine and Gibberellins: 600 ppm Free amino acid: 2% *Sorgossum* spp., *Ascophyllum nodusum*, *Laminaria* spp.	50 g/da
Aminoquick	Total organic matter: 95% Free amino acid: 40% Total N: 7.5%	35 g/da
Nutrifol	Organic matter: 18% Free amino acid: 34.1 ppm *Ascophyllum nodosum*	150 ml/100 l
Promina	Total organic matter: 50% Free amino acid: 38% Total N: 18% Organic N: 6%	60 g/da
Seafert	Organic matter: 30% Free amino acid: 1% Alginic acid: 10% K_2O: 12%	100 g/da

N: Nitrogen, K_2O: Potassium

RESULTS

The seed cotton yields treated with seaweeds and organic foliar fertilizer compounds were presented in Table 2. The interaction was found between the years (df:1, F=4.50, p<0.05). Effects of seaweeds (AlgiPlus and Nutrifol) and organic compounds (Active Black Up, Aminoquick, Promina, Seafert) were statistically significant on the yield in 2010 (df:6, F=7.21, p<0.05). Maximum seed cotton yield ha-1 was obtained with 4436.0±223.4 from the treatment with Aminoquick and followed by AlgiPlus, Seafert and Promina. On the other hand, the yield was not statistically affected from the treatment in 2011 (df:6, F=0.47, p>0.05) and more yields were obtained with 3536.3±220.3 from the Aminoquick-treated plot and followed by Seafert, AlgiPlus, Active Black Up, Nutrifol, Promina and control plot. During the study in the over two years the average yield was the highest with 3986.1±245.3 in Aminoquick-treated plot and statistically important (df:6, F=4.48, p<0.05).

Mean values for the agronomic characteristics in the treatment was presented Table 3. During the study there were not interaction between the years (df:1, F=0.74, p>0.05), therefore, the data were combined. The plant height (df:6, F=0.14, p>0.05), lint percentage (df:6, F=1.23, p>0.05) and seed cotton weight per boll (df:6, F=0.93, p>0.05) was not affected by the treatment and statistically not important compared to the control. On the other hand, mean number of boll per plant was significantly affected from the treatment (df:6, F=4.32, p<0.05) and more boll numbers were observed with 17.4±1.2 in Aminoquick-treated plot.

Interaction was not noted on the fiber properties between the years. The treatment did not significantly affect the fiber length (df:6, F=0.47, p>0.05), uniformity ratio (df:6, F=0.94, p>0.05), strength (df:6, F=0.74, p>0.05), uniformity ration (df:6, F=1.24, p>0.05) and elongation (df:6, F=0.24, p>0.05) whereas it affected micronaire (df:6, F=4.64, p<0.05) and ranged from 5.1 to 4.4 mc/index and the highest micronaire value was observed with 5.1±0.1 in AlgiPlus-treated plot (Table 4).

Table 2. Yields of cotton treated with seaweeds and organic foliar fertilizer compounds in 2010 and 2011

	Yields kg ha^{-1}		
Treatments	2010	2011	Average
Active Black Up	3060.0±16.7b	3296.7±250.2a	3178.4±124.3b
AlgiPlus	4041.3±235.1ab	3509.3±383.9a	3775.3±233.8ab
Aminoquick	4436.0±223.4a	3536.3±220.3a	3986.1±245.3a
Nutrifol	3299.0±511.0b	3203.0±88.6a	3251.0±232.9b
Promina	3538.0±582.3ab	3166.7±212.8a	3352.3± 289.4ab
Seafert	3818.6±138.4ab	3512.0±233.8a	3665.3±139.5ab
Control	3058.7±252.4b	3166.7±278.9a	3112.6±169.9b

Lower case letters designate the differences among the treatments within each year (P<0.05).

Table 3. Mean values for agronomic characteristics of cotton treated with seaweeds and organic foliar fertilizer compounds over 2010 and 2011

Treatments	Plant height (cm)	Lint percentage (%)	Seed cotton weight per boll (g)	Number of bolls per plant
Active Black Up	98.2±12.6a	40.5±4.1a	6.0±0.0a	13.8±1.4b
AlgiPlus	98.4±10.8a	39.5±4.2a	6.0±0.6a	15.2±1.5ab
Aminoquick	93.9±11.3a	40.0±4.5a	6.4±0.3a	17.4±1.2a
Nutrifol	96.5±10.2a	39.7±4.3a	6.3±0.3a	14.0±1.1b
Promina	96.5±10.9a	39.1±4.3a	6.3±0.7a	14.7±1.3ab
Seafert	97.5±11.9a	39.5±4.1a	6.0±0.0a	15.1±1.1ab
Control	91.9±9.6a	39.7±4.3a	6.0±0.7a	13.7±1.4b

Lower case letters designate the differences among the treatments (P<0.05).

Table 4. Mean values for fiber properties of cotton treated with seaweeds and organic foliar fertilizer compounds over the years 2010 and 2011

Treatments	Micronaire (mc/index)	Fiber length (mm)	Uniformity ratio (%)	Strength (1000 lb inch $^{-2}$)	Elongation (%)
Active Black Up	4.7±0.2ab	28.7±0.5a	83.3±0.6a	33.1±0.8a	6.0±0.4a
AlgiPlus	5.1±0.1a	29.8±0.5a	85.4±0.6a	33.6±0.9a	6.1±0.3a
Aminoquick	4.9±0.2ab	29.3±0.4a	84.7±0.4a	34.2±0.7a	5.7±0.3a
Nutrifol	4.6±0.2ab	28.6±0.6a	84.8±0.2a	34.2±0.5a	5.8±0.2a
Promina	4.5±0.3b	29.3±0.7a	84.7±0.4a	32.6±1.3a	6.0±0.4a
Seafert	4.4±0.1b	28.8±0.5a	84.7±0.3a	33.8±0.8a	5.9±0.3a
Control	4.4±0.1b	29.3±0.5a	83.1±0.9a	33.9±0.6a	5.8±0.2a

Lower case letters designate the differences among the treatments (P<0.05).

Population densities of pests

Some economically important pests were observed during the study in the both years. They were presented in Table 5. There were no interactions between the years in all pests including *Empoasca* spp. (df:1, F=0.48, p>0.05), *Bemisia tabaci* Genn. (df:1, F=0.37, p>0.05), *Aphis gossypii* Glov. (df:1, F=0.65, p>0.05), *Frankliniella* spp. (df:1, F=0.25, p>0.05) and *Liriomyza trifolii* Burgess (df:1, F=0.72, p>0.05). Therefore, the data were combined. The mean number of *Empoasca* spp. (df:6, F=0.58, p>0.05), *B. tabaci*, (df:6, F=0.27, p>0.05), and *Frankliniella* spp. (df:6, F=0.20, p>0.05) were not affected from the treatment whereas the population of *A. gossypii* (df:6, F=3.23, p<0.05) and *L. trifolii* (df:6, F=2.28, p<0.05) was affected compared to the control.

Population of *A. gossypii* was observed with 1.8±0.8 in Active Black Up-treated plot. The lowest population was observed with 0.3±0.2 in Aminoquick, 0.4±0.3 in AlgiPlus and 0.8±0.4 in Nutrifol-treated plot. The highest infestation rate of *L. trifolii* was observed at 9.8±1.5 % in Promina-treated plot.

Population densities of predators

Mean number of predator populations in the treatments was presented in Table 6. There was no interaction between the years with respect to the population density of predators including, Coleoptera (df:1, F=0.67, p>0.05), Hemiptera (df:1, F=0.48, p>0.05), Neuroptera (df:1, F=0.76, p>0.05), and Thysanoptera (df:1, F=0.76, p>0.05). The treatments did not affect the population of Coleoptera (df:6, F=0.44, p>0.05), Hemiptera (df:6, F=0.39, p>0.05) and Neuroptera (df:6, F=0.69, p>0.05). However, the populations of Thysanoptera were different in the treatment. In Thysanoptera the highest population was observed with 1.6±0.6, 1.4±0.5 in Promina and Seafert-treated plot (df:6, F=3.46, p<0.05).

DISCUSSION

The results showed that application of seaweeds and organic foliar fertilizer compounds affected the yield. The effect of the year was more significant. More yields were obtained in 2010 as compared to 2011 due to favorable conditions during the growth period of the plant. Significant differences on the yield were observed in 2010 and more yields were obtained from the Aminoquick-treated plot. The yields were also more in the same plot in 2011. In average the Aminoquick treatment increased the yield about %28 more compared to the control plot. The reason for the increase should be due to more organic matter in Aminoquick compound than that of the other treatments. Since Aminoquick has 95% organic matter and probably produced more bolls that affected the yield and followed by Saefert and Promina. On the other hand, Nutrifol and AlgiPlus as seaweed products were not effective as much as Aminoquick. It is supposed to be related to the low organic matter in seaweed extract. AlgiPlus containing 35% organic matter produced more yield compared to the Promine treated-plot containing 50% organic matter. The reason should be that AlgiPlus has plant 600 ppm cytokines and gibberellins. AlgiPlus also produced more yield compared to other organic compounds such as Promina, Seafert and Active Black Up. Williams *et al.* (1981), Whapham *et al.* (1993) and

Table 5. Mean numbers of *A. gossypii*, *B. tabaci*, *Empoasca* spp., (numbers per leaf ±SE), *Frankliniella* spp. (numbers per flower±SE), *L. trifolii* (infestation rate (%) ±SE) populations in cotton treated with seaweeds and organic foliar fertilizer compounds

Treatments	*A. gossypii*	*B. tabaci*	*Empoasca* spp.	*Frankliniella* spp.	*L. trifolii*
Active Black Up	1.8±0.8a	0.38±0.1a	0.9±0.1a	2.5±1.0a	4.8±1.0b
AlgiPlus	0.4±0.3b	0.4±0.1a	0.9±0.1a	3.0±1.0a	5.7±1.1b
Aminoquick	0.3±0,2b	0.3±0.1a	1.0±0.1a	2.7±0.9a	4.9±1.2b
Nutrifol	0.8±0.4b	0.4±0.1a	0.8±0.1a	2.1±0.7a	6.6±1.4ab
Promina	1.2±1.0ab	0.4±0.1a	1.1±0.1a	2.5±0.9a	9.8±1.5a
Seafert	1.0±0.6ab	0.4±0.1a	1.0±0.1a	2.7±1.1a	4.7±1.1b
Control	1.2±0.9ab	0.3±0.1a	1.0±0.1a	1.9±0.6a	4.1±0.9b

Lower case letters designate the differences among the treatments (P<0.05).

Table 6. Mean numbers of predator populations (numbers per 50 sweep net±SE) in cotton treated with seaweeds and organic foliar fertilizer compounds

Treatments	Coleoptera	Hemiptera	Neuroptera	Thysanoptera
Active Black Up	3.0±0.7a	15.6±5.6a	1.4±0.3a	0.4±0.3b
AlgiPlus	2.7±0.9a	15.7±5.2a	1.2±0.2a	1.4±0.4a
Aminoquick	3.1±0.9a	19.6±5.9a	1.3±0.3a	0.8±0.2b
Nutrifol	2.6±0.8a	19.1±5.2a	1.2±0.2a	0.9±0.3b
Promina	3.0±0.9a	17.5±5.5a	1.4±0.4a	1.6±0.6a
Seafert	3.6±1.0a	15.8±4.7a	1.1±0.2a	1.4±0.5a
Control	3.4±0.9a	12.9±4.6a	1.0±0.2a	1.3±0.4ab

Lower case letters designate the differences among the treatments (P<0.05).

Zodape (2001) mentioned that seaweed products containing auxins, cytokines and gibberellins affected cell growth and division cycle nutrition, maturity and yield.

The treatments did not significantly affect the plant height, lint percentage, seed cotton weight. Fiber qualities including length, strength, uniformity and elongation were not also significantly affected except micronaire by the treatments. The reason for the micronaire variability should be due to plant growth regulators in AlgiPlus. Sawan *et al.* (2000) reported that plant growth regulators did not significantly affect fiber parameters, except microanire in 1994. He also mentioned that micronaire was affected from the concentration of plant growth regulators in the year. In contrary, Namken (1984), Abdel-Al *et al.* (1989) and Hofmann & Else (1989) found that cytokinin had no significant effect on the fiber quality.

The treatment did not affect the amount of *Empoasca* spp., *B. tabaci* and *Frankliniella* spp. whereas it influenced the amount of *A. gossypii* and *L. trifolii*. Population amount of *A. gossypii* was the highest in Active Black Up and lower in Aminoquick and AlgiPlus-treated plot as well as in Nutrifol-treated plot. It was thought that humic substance and fulvic acid in Active Black Up increased the plant canopy during the early stage of the cotton. Since humic acid affect the plant height (Basag, 2008). Piccolo *et al.* (1993) and Kaschl & Chen (2005) reported that humic substance enhance root, leaf and shoot growth. Thus, more populations were recorded. The result showed that both seaweed products and more organic compounds in the products reduced the population and the study was supported by Hankins & Hockey (1990). They mentioned that Aphids and some sap feeding insects generally avoid plants treated with seaweed extracts. In the study *T. urticae* population was rarely found. Therefore, it is not counted. However, seaweed extract reduced the population of *T. urticae* in some studies (Terriere and Rajadhyaksha, 1964; Stephenson, 1966; Abetz 1980; Hankins and Hockey, 1990).

The application of seaweed and organic compounds did not affect the population densities of Coleoptera, Hemiptera, and Neuroptera. On the other hand, Thysanoptera populations were significantly different in the treatment and the differences should be due to interaction between predators and pest populations in the plot.

CONCLUSION

Seaweeds and organic foliar fertilizer compounds are increasingly used in Agriculture. However, the mechanisms of action are still unknown. These compounds increase the yield and did not enhance the pests' population and were not harmful to predators. It has been reported that seaweed products have efficiency on growth, yield and quality, and pest resistance and the study was supported by Featonby-Smith & van Staden (1987), Crouch (1990) and Norrie & Hiltz (1999). They are also non-toxic, non-polluting and non-hazardous to human, animals, and birds (Dhargalkar and Pereira, 2005). Thus, containing seaweeds and more organic foliar fertilizer compounds should be considered in integrated management of organic or conservative cotton fields.

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