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Original Research Article

Effect of Concentrations and Time of Kaolin Spraying on Wheat Aphid

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ABSTRACT

Common wheat aphid *(Schizaphis graminum* Rondani) is the cereal key pest. To study the effectiveness of different concentrations and times of kaolin spraying on the reduction of S. *Graminum* damage, a field experiment was arranged based on randomized block design with 4 replicates. Treatments were kaolin concentrations at four levels [0, 1.25 %, 2.5 % and 3.75 %, k1, K2, k3, and k4, respectively], times of kaolin spraying at three levels (concurrently with the stem forming, coincides with the first appearance of spikelets, coincides with dough development, T1, T2 and T3 respectively. The results indicated that the maximum (9914.81 kg ha^{-1}) and minimum (6277.76 kg ha^{-1}) grain yield were found in plots received 3.75 % kaolin at T2 time and untreated control, respectively. The highest (22666.66 kg ha^{-1}) and lowest (16465.92 kg ha$^{-1)}$ biological yield were detected in plots exposed to kaolin 1.25 % at T3 time and control treatment, respectively. The present study showed that Kaolin could reduce wheat aphid damage and had positive effect of grain and biological yields. Therefore, Kaolin can be an important and effective tool to mitigate wheat aphid damage, and could be a good alternative to chemical products.

Key Words: Pest repellent, green wheat aphid, yield and yield components

INTRODUCTION

Wheat (*Triticum aestivum* L.) with a wide range of cultivation worldwide is one of the most important cereals crops comprising the principal source of food of human beings worldwide (Rauf *et al*., 2007).

Common wheat aphid *(Schizaphis germanium*) is one of the most main cereals pests in the world and induces harmful effects on crop yield. This aphid is found on wheat and rice in Ahvaz, on phragmites in Tehran, on wheat in Karaj, Shiraz and Masjedsoleiman in Iran (Amirnazari, 2000). According to Khodabandeh (2007) barley, some wheat varieties, grain sorghum and some maize varieties are good hosts for growth and reproduction of aphids. Growth and development, longevity and fecundity of wheat aphid are considerably affected by host plant. Food is one of the major factors affecting insects growth and development food kind and quality and has large effects on aphids growth and reproduction, so that the rate of aphid reproduction depends on the quality of its host (Razmjou *et al*., 2006). Hagvar *et al*. (2000) reported that *Schizaphis graminum* and *Sitobion avenae* are the most critical pests in the USA and the degree of damage caused by these two aphids in addition to species, population density, duration of storage period and variety, is very dependent on the developmental stage of wheat.

There are many pest control methods which chemical pest control method is the most harmful type. To reduce pesticide use, other methods which have no risks to human health, have been developed by scientists. Use of kaolin clay (Sourround) is one of the innovations that have been developed in the last 10 years and was used in apple orchards of USA for the first time. Kaolin is a white, non-abrasive matter that protects the plant against pests including lepidoptera, sucking insects and small larvae (Alavo and Abagli, 2011).

Kaolin powder is easily dissolved in water. The product must be properly agitated or mixed with water to provide the uniform plant coverage to ensure that the protective properties of the product are fully utilized. The powdery film remains on the plant and fruit as the water evaporates, and provides protection by acting as a physical barrier. Once the insect land on the plant, clay particles from the coating may stick to the insects forcing them to repel from plant host.

Kaolin is applied to suppress diseases, to decrease negative impacts of environmental stresses on crop plants and to protect crops against pests **(**Glenn and Puterka, 2005). The effectiveness of kaolin against *Cacopsylla pyrocpla* (Pasqualini *et al*., 2002), *Bactrocer aoleae (*Saour and Makee, 2003), *Agonoscena targionii* (Saour, 2005) and *Ceratitis capitata* on peach, apple and Date plum (Mazor and Erez, 2004) has been confirmed.

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Kaolin powder are effective against many pests including leafhoppers on grape vines , cucumber bettles on cucurbits such as, cucumber, melon, pumpkin, squash, watermelon. Kaolin is used for reduction of damage from various species of mites, apple maggot, leafhoppers, apple weevil, apple fly, stink bug and thrips. This product applied successfully worldwide against many pests such as pear psylla, trips, cicada and fruit fly, used as a crop protectant in agriculture, with promising results. In Greece, Surround powder was tested on pear psylla and grape trips (Glenn and Puterka, 2005). In a study which set out to assess the effectiveness of kaolin, spinosad and malathion against the Mediterranean fruit fly Lo verde *et al.* (2011) found that in fruit treated by kaolin showed lower damage than ones treated by spinosad and malathion treatments.

While kaolin has a few adverse side effects than insecticides, it provided long term control effects on pest. Surveys such as that conducted by Cottrell *et al*. (2002) have shown that accumulation of black pecan aphid *(Tinocallis caryaefoliae)* on pecan seedling decreased by kaolin spraying and thus production and longevity of nymphs on seedlings decreased. In addition, kaolin clay suppresses a wide range of pests, it uses for sunburn and heat stress control. The reduction caused by sunburn in Spain pomegranate orchards has been reported by 40 % when summer temperatures reach above 45 ºC. Melgarejo *et al*. (2003) proposed that sunburn damage of fruits was reduced by kaolin spraying over the whole canopy and fruits by four times at 2-3-week intervals from mid-June to early August. To the best of our knowledge, no study has been documented on the effects of Kaolin on wheat performance in the literatures. Therefore, the objectives of this work were to compare concentration and time of kaolin application, to assess kaolin performance on aphis control and thus wheat yield and yield components.

MATERIALS AND METHODS

A field trial was conducted during 2011-2012at Research Field of Faculty of Agriculture and Natural Resources, Islamic Azad University-Karaj Branch, Karaj, Iran (35°45' N, 51°56' E, and 1312.5 m above sea level) with the average annual precipitation of 251.2 mm**.** The experimental design was a randomized complete block with four replications. Treatments included kaolin concentrations at four levels (k1, K2, k3, and k4 [0, 1.25 %, 2.5 % and 3.75 %, respectively], spraying times of kaolin at three levels (T1, T2 AND T3 [8] April concurrently with the stem forming, 30 April coincides with the first appearance of spikelets, 22 May coincides with dough development, respectively. Soil samples were collected from 0-30 cm depth using a tube auger before. Soil samples were mixed thoroughly and the final subsamples were transferred to the laboratory for soil analysis (Table 1).

Table 1. Physicochemical properties of the soil of experiment site.

Depth (cm)	0-30
EC (ds/m)	5.2
pH	7.6
OC	0.6
Lime	10.3
Total N	0.55
P (ppm)	19.6
K (ppm)	314
Clay (%)	14
Silt (%)	30
Sand (%)	56
Soil texture	Sandy loam
Saturation humidity (%)	31

Plots were 4 m long by 1.4 m wide constituting 8 rows of 15 cm apart. Wheat seeds (Pishtaz cultivar) were sown at a depth of 4 cm with a density of 350 plant m^{-2} at 3 November 2011. The first irrigation was done at 5 November 2011. Then plots were furrow irrigated at 15-20 days intervals. The final irrigation was at 6 June

2012. The soil fertility was improved by applying N fertilizer (as urea) at the rate of 200 kg ha^{-1} along with forth irrigation. In order to increase the accuracy of the test, each experimental plot was restricted from all four sides by timbers with a height of 120cm covered by grid 7.5 m long by 4.5 m wide, so that aphids were trapped in grids. Different concentrations of kaolin powder was poured into a hand sprayer and mixed well before application. A mixer was used to avoid powder deposition. Spraying was repeated due to rainfall and strong winds. Harvesting was conducted at 16 June 2012. To determine mean seeds weight and grain yield, plants were harvested from the three inner rows of 3 m long to preclude any edge effects. All data were subjected to ANOVA using the GLM procedure of SAS (SAS Institute, 2002). Treatment means were separated using Duncan test at $P < 0.05$.

RESULTS AND DISCUSSION

Analysis of variance indicated that significant differences exists (at 0.05 levels) between interaction effects K*T in all traits evaluated but plant height (Table 2). Biological yield was affected by interaction effects K*T at the $p = 0.01$ level, so that mean comparison revealed that the highest biological yield (22666.66 kg ha^{-1}) was obtained when 1.25 % rate of kaolin was sprayed at T3 (Table 3). Spiers *et al.* (2008) found that kaolin spraying before fruit set of blueberry increased buds yield from 693.8 g to 1120.2 g. The lowest biological yield was related to control plots at T1 (16465 kg ha^{-1}) and T3 (16576 kg ha^{-1}) (Table 3). Holmes *et al.* (1991) reported that the rate of biological yield decreased under aphid abundance. Reduction in 1000 seed weight and total weight was also confirmed by Royer *et al.* (2005).

Results also indicated that 1.25 % at T3 and T2, 2.5 % at T1 and T2, and 3.75 % at T2 treatments had the highest biomass and were placed in the same group (Table 3). The minimum biomass under control treatment was obtained at T1 and T3. This is may be due to lack of kaolin in control plots. Application of kaolin at T2 had a higher biomass because of less effect of the aphids on this date.

Regarding high biomass and the economic costs, 1.25 % concentrations of kaolin is suggested. The results showed that in all kaolin concentrations at T2 biological yield was high because of the efficacy of Kaolin on aphids at this time. According to Zeb *et al.* (2011) wheat yield at high and low densities of aphids was 2243 kg ha^{-1} and 3048 kg ha^{-1}, respectively. Kerns and Tellez (1998) reported that fruit quality of citrus was improved by foliage spraying of kaolin. Negative effects of aphids on grain have been reported in other studies (Wratten and Redhead, 1976; Girma *et al.*, 1993). Yield loss caused by direct feeding of aphids was 35-40 % (Kiechefer and Gellner, 1992). Yield loss induced indirectly by aphids through the transmission of viral or fungal infection was 20-80 % (Marzochi and Nicoli, 1991; Rossing *et al.*, 1994; Trdan and Mileroj, 1999).

Interaction effects K*T on grain yield was significant at the $p = 0.01$ level (Table 2). Mean comparison of interaction effects of kaolin concentrations and time of kaolin application on grain yield indicated that the greatest grain yield (9914.81 kg ha^{-1}) was produced by 3.75 % spraying kaolin at T2 (a 36.69 % increase compared to untreated control). Connel (2009) reported that walnut yield was improved compared to control by application of kaolin. According to Loverde *et al.* (2011) total fruit yield under kaolin treatment was higher than control fruits (1314 kg vs. 1075 kg, respectively). The least grain yields were detected in control plots at T1, T2 and T3 (6277, 6980 and 6572 kg ha^{-1}, respectively). Application of 1.25 % kaolin at all times, 2.75 % at T2 and 3.75 % t T2 had the best performance on grain yield.

Results also showed that the maximum grain yield at 2.5 % and 3.75 % concentrations of kaolin was detected in T2 (Table 4). General, this reflects, kaolin consumption at a specific time with a specific concentration can increase grain yield, but the concentration of 1.25 % kaolin because of the economy costs is advisable.

Interaction effects K*T on harvest index (HI) was significant at the $p = 0.01$ level (Table 2). Mean comparison of K*T on HI revealed that highest HI (48.03%) was related to 1.25 % kaolin at T1 (Table 4). AT 2.5 % and 3.75 % kaolin, the maximum HI (45%) was produced at T2. Results also indicated that all kaolin rates and control treatment at three times were into a statistically same group. However, the lowest HI was related to control plots at T1 and T2 (36.96 % and 37.13 %, respectively) (Table 4).

Therefore, kaolin spraying at 1.25 % rate in T1 can be proposed as the best treatment. At 2.5 % and 3.75 % kaolin the maximum HI was obtained in T2. This may be attributed to kaolin efficacy at these rates in T2. Nevertheless, 1.25 % rate is better due to less consumption of kaolin.

Spike yield was affected by interaction effects K*T at the p = 0.01 level (Table 2). As Table 4 shows application of 2.5 % kaolin at T2 had the highest spike weight (134444.44 kg ha^{-1}), nevertheless**,** this treatment along with treatments 1.25 % at all times, 2.5 % at T1 and 3.75 % at T2 were in the same group. The lowest spike yield was detected in control plots at three times of kaolin application, 2.5 % rate at T3 and 3.75 % rate at T1 and T3. However, reduction in spike yield under 3.75 % and 2.5 % concentrations of kaolin may be attributed to wheat sensitive to high concentrations of kaolin at flowering and grain filling stages.

There is a direct relationship between grain yield and spike yield. When the grain yield is high, spike weight is too high. Application of 1.25 % kaolin is suggested. The increase in spike weight at T1 may be due to grain filling at this time.

Number of grain per spike was affected by interaction effects K*T at the p = 0.01 level (Table 2), so that the best performance was obtained by application of 3.75 % kaolin under T2 and application of 2.5 % kaolin under T1 (26.15) (Table 4). Other treatments were places in the same statistically group but 3.75 % rate at T1. Number of grain per spike for control treatment at all times was similar (25). The minimum number of grain per spike was related to plots received 3.75 % kaolin at T1 (20.43). Unlike other traits, the minimum number of grains per spike was not observed in the control treatment.

Analysis of variance indicated that number of spike per unit area was affected by different concentrations of kaolin at the p = 0.05 level (Table 2). The minimum number of spike was detected in control plots at three times of kaolin application (1298, 1308 and 1293, respectively). Other rates of kaolin at three times of kaolin application were also placed in the same group. The highest number of spike per unit area (1541) was produced when kaolin 1.25 % sprayed at T3. This highlights that application of kaolin at the rate to 1.25 % was the best.

CONCLUSION

The present study demonstrated that kaolin, as a pest repellant, had a good potential at the evaluated concentrations and it can be an excellent insecticide alternative for *Schizaphis graminum* management in wheat. To prevent aphid damage to wheat, Kaolin spraying should be initiated during the primary stages of wheat development and before wheat aphid become numerous. Based on the studied rates, application of kaolin at 1.25 % was the best due to lower costs.

Table 2. Analysis of variance of wheat traits treated by different concentrations and times of kaolin spraying.

SOV	DF	Grain yield	Biological yield	Harvest index	No. Grain per spike	Plant height	Spike weight	No. spike pr area
Rep	3	55223.08 ns	1611868.7 ns	4.809ns	0.35 ns	4.67 ns	369856.87 ns	5458.98 ns
a (kaolin concentration)	3	14569124.48**	34309422.2**	86.52 **	1.10 ns	6.34 ns	5058051.84**	87281.69**
B (time of kaolin spraying)	2	3399483.54**	11790075.3**	3.44 ns	22.96**	5.89 ns	2340596.50**	6362.11 ns
a*b	6	1881197.98**	6386329**	43.52 **	28.88**	7.72 ns	2555645.92**	12356.46*
E	33	179501.39	790439.7	5.11	0.72	4.36	318414.72	3690
CV		5.16	4.48	5.45	3.42	2.89	4.74	4.27

NS, * and **non-significant and significantat1% and 5%, respectively.

Table 3. the simple effects of different concentrations and times of kaolin spraying on the studied traits in wheat.

Treatments	Grain yield (kg/ha)	Biological yield (kg/ha)	Harvest index (%)	No. Grain per spike	Plant height (cm)	Spike weight (kg/ha)	No. spike pr area
Kaolin concentration							
0	6617.8 c	17310.1 b	2.41 a	25.06 a	73.27 a	10963.3 b	1319.17 c
1.25%	9152.3 a	20616.7 a	2.31 a	24.93 a	74.66 a	12455.4 a	1527.86 a
2.50%	8420.3 b	20941 a	2.39 a	24.37 a	73.43 a	12133.7 b	1415.42 b
3.75%	8628.5 b	20441.7 a	2.25 a	24.9 a	74.54 a	12054.9 b	1421.01 b
Time of kaolin spraying							
8 April (T1)	7852.2 b	19068.6 b	2.42 a	24.56 b	73.45 a	11786.5 b	1403.86 a
30 April (T2)	8726.3 a	20759.1 a	2.32 a	26.12 a	74.64 a	12328.7 a	1415.92 a
22 May (T3)	8035.6 b	19654.4 b	2.28 a	23.77 c	73.83 a	11590.3 b	1442.81 a

Table 4. The interaction between different concentrations and times of kaolin spraying on the studied traits in wheat.

Treatment Kaolin	Time	Biological Yield (kg/ha)	Grain Yield (kg/ha)	Harvest Index (%)	Spike per Unit Area	Spike Weight (kg/ha)	Grains per Spike
Control	8 April (T1)	16465.92 b	6277.76 a	36.96 a	1298.5 a	11144.03 a	25.76 a
	30 April (T2)	18851.85 a	6980.81 a	37.13 a	1308 a	10592.59 a	25 a
	22 May (T3)	16576.23 b	6572.37 a	39.53 a	1293 a	11259.25 a	25.11 a
1.25%	8 April (T1)	17807.03 b	8770.37 a	48.03 a	1531 a	12185.18 a	24.83 a
	30 April (T2)	21814.81 a	8931.81 a	40.93 b	1484.5 a	12074.07 a	25.51 a
	22 May (T3)	22666.66 a	9348.14 a	43.87 a	1541 a	13185.18 a	23.53 a
2.50%	8 April (T1)	21592.59 a	7991.35 b	38.32 b	1399.5 a	12740.74 a	26.15 a
	30 April (T2)	21345.67 a	9629.62 a	45.12 a	1382 a	13444.44 a	23.76 b
	22 May (T3)	19604.93 a	7566.66 b	39.38 b	1473 a	10814.81 b	22.31 b
3.75%	8 April (T1)	19308.64 b	8007.29 b	41.46 b	1382.26 a	11135.8 b	20.43 c
	30 April (T2)	21814.81 a	9914.81 a	45.43 a	1451.5 a	13185.18 a	30.15 a
	22 May (T3)	19567.9 b	8248.14 b	41.87 b	1381.5 a	11641.97 b	23.66 b

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