DF-588
[1-17]

RESEARCH ARTICLE Agricultural Science Digest

Response of Some Soybean Genotypes to Insect Infestation under Three Mineral Nitrogen Fertilizer Rates

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10.18805/ag.DF-588

ABSTRACT

Background: A two-year study was conducted at Giza Agricultural Research Station, Agricultural Research Center (ARC), Egypt, to evaluate the productivity of six genotypes of soybeans under three mineral nitrogen (N) fertilizer rates, as well as their resistance to insects, in comparison to four check varieties.

Methods: The study took place during the 2021 and 2022 summer seasons. The treatments included three mineral N fertilizer rates (N1=67% of N fertilizer rate "71.4 kg N/ha", N2=33% of N fertilizer rate "35.7 kg N/ha" with seed inoculation by *Bradyrhizobium japonicum* and N3=100% of N fertilizer rate of the recommended rate "107.1 kg N/ha") and ten soybean genotypes (H_4L_4, H_6L_{198}, $H_{18}L_{54}$, H_29L_{115}, H_{129}, Misr 10, along with Dr101 and Giza 111 "resistant" and Giza 82 and Crawford "susceptible"). The experiment used a split plot design with three replications. The main plots were assigned the mineral N fertilizer rates, while the subplots, were assigned the soybean genotypes.

Result: Fewer cotton leaf worms, whiteflies and leaf miners were found after applying N1 or N2. In the 6th week from sowing, Misr 10 and Dr 101 had fewer cotton leaf worms and whiteflies. In contrast, throughout the 7th, 8th and 9th weeks from sowing, Misr 10 and H6L198 had fewer cotton leaf worms. Misr 10 had fewer leaf miners in every week and fewer whiteflies in the 7th, 8th and 9th weeks from sowing. In the 6th week of the first season, Misr 10, Dr101, H18L54 and Giza 111 that received N1 or N2 had fewer cotton leaf worms; in the 7th and 9th weeks from sowing, Misr 10, Dr101 and H6L198 harbored fewer whiteflies. The lowest pod weight/plant, seed yield/plant, 100-seed weight, seed yield/ha and HI were obtained by using N3. Higher biological yield/ha, seed yield/plant, 100-seed weight, seed yield/ha and HI were attained by Misr 10. In the second season, seed yield per plant and seed yield per hectare were significantly affected by the interaction between soybean genotypes and mineral N fertilizer rates. Growing Misr 10 with 67 per cent N of the recommended rate increased seed yield/plant and seed yield/ha, along with fewer cotton leaf worm, whiteflies and leaf miners compared to the commercial cultivar Giza 111 receiving the recommended mineral N fertilizer rate.

Key words: Insect infestation, Leaf N content, Mineral N fertilizer rates, Seed yield, Soybean genotypes.

INTRODUCTION

On a local and worldwide scale, soybeans are regarded as one of the most significant industrial and food crops. It serves as a source of oils, human food and animal feed. It has a significant nutritional value due to its approximately 40% protein content. Its protein content is comparable to that of animal sources and its seeds have a 20% oil content. It is thought to have numerous health advantages over other legume varieties because it includes all of the essential amino acids required by the human body, as well as minerals, vitamins, dietary fiber and omega-3 fatty acids. It also aids in the treatment of numerous illnesses. Due to local feed and oil shortages, particularly in the wake of the Russian-Ukrainian crisis, soybean acreage increased to over 63 thousand hectares in 2022, with productivity per hectare of roughly 3.60 tons. Expanding soybean cultivation in Egypt faces several challenges, primarily biotic stresses such as insect infestations. Crop fertilization is one agricultural activity that can impact a plant's vulnerability to insect infestation (Altier and Nicholls, 2003). A significant amount of harm can be done to soybean (*Glycine max* L.) productivity by insects. The Middle East is susceptible to attacks by the cotton leaf worm (*Spodoptera littoralis* 'Boisd.'), which can result in a large reduction in the yields of soybean plants (Kandil *et al*., 2003; Capinera, 2008). Furthermore, in the Mediterranean region, whiteflies (*Bemisia tabaci*) have been found to reduce soybean yields by up to 80 per cent (Gulluoglu *et al*., 2010; Murgianto and Hidaya, 2017). Soybean leaves provide a food source for whiteflies and

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How to cite this article: Abdel-Wahab, E.I., Mohamed, M.K.A, Baheeg, M.A., Abdel-Rahman, S.F. and Naroz, M.H. (2024). Response of Some Soybean Genotypes to Insect Infestation under Three Mineral Nitrogen Fertilizer Rates. Agricultural Science Digest. DOI: 10.18805/ag.DF-588.

Submitted: 12-10-2023 **Accepted:** 19-12-2023 **Online:** 15-01-2024

yellow mosaic virus infection is possible (Harish *et al*., 2023 a and b).

Meanwhile, leaf miners (*Liriomyza trifolii*) that cause serpentine on the leaves can have a detrimental effect on soybean productivity (Viraktamath *et al*., 1993; Higley and Boethel, 1994). In particular, research by Bayoumy *et al*. (2018) demonstrated that serpentine leaf miners are a harmful pest that mostly targets leguminous crops in Egypt and the Mediterranean region. Regarding this, Abolfadel *et al*. (2023) found that various leaf miners attacked the legume crops, severely damaging the leaves. However, mineral fertilizers that enhance the growth and development of various plant tissues-which are thought to be strongly related to herbivorous insect assaults like sucking pests-are what determine crop productivity (Bi *et al*., 2003). Insect populations may rise in response to increased nitrogen (N) fertilizer, suggesting a decline in plant defenses against insect damage (Way *et al*., 2006).

Whitefly attacks have increased with increased N application (Bi *et al*., 2000). Furthermore, using the mineral N fertilizer led to a rise in the quantity of piercing-sucking pests, such as leaf miners (Elsayed *et al*., 2021). Soil-fixing bacteria (*Bradyrhizobium* spp.) that are involved in biological N fixation (BNF) are found in the roots of soybeans. In soybean plants, 50-60% of the N requirements are met by the BNF (Salvagiotti *et al*., 2008). However, to stimulate the growth of these rhizobia that are inoculated with soybean seeds, a starting dose of chemical N fertilizer for soybean seedlings should be applied. A starting fertilizer of 50 kg N per ha can increase root activity, which improves leaf photosynthetic processes and increases soybean output (Gai *et al*., 2017). Due to the difficulty of balancing soil N mineralization with BNF during crop growth, N control in soybean production can be challenging, even though using BNF with a low level of starter N fertilizer to activate the bacteria may not supply an adequate amount of N that is required for achieving high productivity under certain edaphic conditions (Ciampitti and Salvagiotti, 2018; Głowacka *et al*., 2023).

According to Vieira *et al*. (2011), soybean genotypes resistant to whitefly assaults can be a crucial tactic in an integrated pest management program when it comes to genotypes linked to insect infestation resistance. They also mentioned that Barreiras, a soybean genotype, was resistant to whiteflies. According to a recent study, Giza 35 leaves exhibited more resistance against attacks by whiteflies and leaf miners than did Crawford leaves, which were known for having a lower leaf N content. In the meantime, soybean genotypes $H_{15}L_{17}$, H_4L_4 and Giza 111 were found to be resistant to infestation by cotton leaf worms by Abdel-Wahab and Naroz (2023). Even while soybean breeders work very hard to boost crop productivity, certain soybean genotypes are vulnerable to insect re-attacks, which can lower productivity, particularly when mineral N fertilizer is applied. Therefore, this study aimed to evaluate the productivity of six genotypes of soybeans under three mineral N fertilizer rates, as well as their resistance to insects, in comparison to four check varieties.

MATERIALS AND METHODS

A two-year study was conducted at Giza Agricultural Research Station, ARC, in Egypt (Lat. 30°00′30″N, Long. 31°12′43″E, 26 m a.s.l) during the 2021 and 2022 summer seasons. The treatments consisted of three mineral N fertilizer rates N_1 (67% of the recommended rate, equivalent to 71.4 kg N/ha), N_2 (33% of the recommended rate, equivalent to 35.7 kg N/ha) with seed inoculation using *Bradyrhizobium japonicum* and N3 (100% of the recommended rate, equivalent to 107.1 kg N/ha). Ten soybean genotypes were included in the study: H_4L_4, H_6L_{198}, $H_{18}L_{54}$, $H_{29}L_{115}$, H_{129} and Misr 10, along with four check varieties (Dr101 and Giza 111, resistant to insect infestation and Giza 82 and Crawford, susceptible to insect infestation), based on the recommendation of Food Legumes Res. Dept., Field Crops Res. Inst., ARC). (Table 1) provides information on the common names, pedigree, maturity, origin and susceptibility of the soybean genotypes to insect infestation. Meteorological data including maximum

Table 1: The common names, pedigree, maturity (day), origin and susceptibility of soybean genotypes to insect infestation.

Genotypes	Pedigree	Maturity (day)			Origin	Susceptibility
		1st season	2nd season	MG		
H_4L_4	Dr101 × Lamar	140	138	V	ARC	-
H_6L_{198}	Toano × Nena	122	124	IV	ARC	-
$H_{18}L_{54}$	Crawford × Dekabig	127	128	IV	ARC	-
$H_{29}L_{115}$	HZ73 × H5L23	117	119	IV	ARC	-
H_{129}	Giza 35 × D76-8070	118	121	IV	ARC	-
Crawford	Williams × Columbus	120	122	IV	U.S.A.	Susceptible
Dr101	Selected from Elgin	146	150	IV	ARC	Resistance
Giza 82	Crawford × Maple Presto	95	97	III	ARC	Susceptible
Giza 111	Crawford × Celeste	125	124	IV	ARC	Resistance
Misr 10	N92-831 × Giza 111	126	128	IV	ARC	-

Susceptibility of soybean genotypes to insect infestation was based on recommendations of Food Legumes Res. Dept., ARC, Egypt.

Table 2: The meteorological data of maximum and minimum temperatures and relative humidity during the two summer seasons.

Season / Month	2021			2022		
	Temperature (°C)		Relative humidity	Temperature (°C)		Relative humidity
	Max.	Min.	(Rh %)	Max.	Min.	(Rh %)
June	36.17	19.02	41.18	37.31	20.92	42.19
July	39.27	22.48	41.15	38.18	21.42	42.23
August	39.73	22.90	42.80	39.73	22.90	42.80
September	35.92	20.83	50.99	36.37	21.24	49.95
October	31.52	17.72	55.18	30.52	17.75	57.45
Average	36.52	20.59	46.26	36.42	20.84	46.92

and minimum temperatures and relative humidity for the two summer seasons were obtained from POWER Docs (2023) and are presented in Table 2. Furrow irrigation was the irrigation system for the region. Soil samples were collected from each site in the top 0-30 cm layer of arable soil (Table 3). The soil analysis followed the methods outlined by Jackson (1965). Table 2 and 3. The preceding winter crop was wheat in both seasons. During soil preparation in the two summer seasons, calcium super phosphate (15.5% P_2O_5) was applied at a rate of 357 kg/ha. The soybean genotypes were planted at a density of 20 plants/m in a single row on the ridge. The soybean seeds were sown on June 13th and May 31st in the 2021 and 2022 seasons, respectively. The experiment used a split plot design with three replications. The main plots were assigned the mineral N fertilizer rates, while the subplots, were assigned the soybean genotypes. All regular agricultural practices were applied to the experimental plots and chemical control was completely avoided. Each plot had an area of 10.8 m^2, consisting of six ridges with each ridge measuring 3.0 m in length and 0.6 m in width.

Table 3: Mechanical and chemical properties of the soil at the experimental site.

Properties	Soil depth (0-30 cm)	
	First season	Second season
Coarse sand (%)	3.07	3.24
Fine sand (%)	31.26	30.89
Silt (%)	29.79	29.71
Clay (%)	35.88	36.16
Texture class	Clay loamy	Clay loamy
pH	7.72	7.87
N (mg/kg)	26.22	27.71
P (mg/kg)	9.33	10.46
K (mg/kg)	187.00	227.00

The studied data

Leaf N content

After 60 days from sowing, the leaves (blade only) from three plants were separated. They were then oven-dried at 75°C until a constant mass was achieved (approximately 48 hours). The dried leaves were ground, thoroughly mixed and stored in closed containers. The leaf N content was analyzed using Kjeldahal digestion (Jackson, 1965) by the General Organization for Agricultural Equalization Fund, ARC, Giza, Egypt.

Population of certain insects attack soybean genotypes

The susceptibility of ten soybean genotypes to infestation by cotton leaf worms, whiteflies and leaf miners was investigated at the 6th, 7th, 8th and 9th weeks from sowing in both seasons. Ten plants were randomly collected from each plot to determine the population density of these insects. Whiteflies were monitored by randomly selecting three leaves per plant and transferring them to the laboratory in paper bags. The leaves were then examined under a stereomicroscope to count the number of whiteflies. The population of cotton leaf worms and leaf miners were estimated by examining the plants in the field. The resistance status of each soybean genotype was determined based on the mean number of pests (X) and the standard deviation (SD) as reported by Chiang and Talekar (1980). Genotypes with mean numbers greater than X+2SD, were considered highly susceptible (HS), those between X and X+2SD were considered susceptible (S), those between X and X-1SD were considered low resistant (LR), those between X-1SD and X-2SD were considered moderately resistant (MR) and those with numbers less than X-2SD, were considered highly resistant (HR).

Seed yield and yield components

Ten plants were randomly chosen from each plot during harvest to estimate the following characters: plant height (cm), number of branches/plant, pod weight/plant (g), seed yield/plant (g) and 100-seed weight (g). The biological, straw and seed yields/plot (kg) were recorded based on the experimental plot and expressed as t/ha. The yield data were used to calculate the harvest index 'HI' (%) using the method described by Donald (1962).

Statistical analysis

Mean comparisons were conducted using Duncan's multiple range test (1955) and the least significant differences (L.S.D) test at a significance level of 5% (Gomez and Gomez, 1984). The measured variables were analyzed by ANOVA using the MSTATC statistical package (Freed, 1991).

RESULTS AND DISCUSSION

I. Leaf N content at 60 days from sowing

Mineral N fertilizer rates

Rates of mineral N fertilizer had a significant effect on the N content of the leaves of soybean plants in both seasons. Applying of N_3 to soybean plants had higher leaf N content than the others. In the first season, N_1 and N_2 had lower leaf N contents (25.67 and 26.65 mg/g, respectively) than N_3. In the second one, these values were 23.82 and 25.43 mg/g, respectively. The fact that there were no appreciable variations in the leaf N content between N_2 and N_3 is noteworthy. It is evident that N_2 increased the amount of N in leaves in the same way as N_3. According to Albuquerque *et al*. (2017), plants can more easily utilize between 50 and 75 per cent of the symbiotic fixed N when rhizobium-containing bacteria are present in the soil. The N content of soybean leaves was adversely influenced by soybean plants that were given N_1. Leaf N content dropped marginally even though it was still lower after receiving N_1. Low rates of mineral N fertilizer enhanced root activity and leaf photosynthesis (Gai *et al*., 2017), which had a positive effect on leaf N content during growth and development. Rymuza *et al*. (2020), showed that soil reserves, fertilizers and microbes allow soybeans to absorb N from the atmosphere, corroborate their findings.

Soybean genotypes

The leaf N content of soybean genotypes varied significantly in both seasons (Table 4). While $H_{29}L_{115}$ had higher leaf N content in the first season, Crawford and Giza 82 had higher leaf N content in both seasons. In the first season, H_{129}, H_4L_4, $H_{18}L_{54}$ and H_6L_{198} placed second. In the second one, $H_{29}L_{115}$, H_{129} and $H_{18}L_{54}$ ranked second and third, respectively. Misr 10, Dr101 and Giza 111 showed the opposite trend. These findings may be the consequence of the studied soybean genotypes having distinct canopy structures to take advantage of their particular environmental circumstances. When compared to the other cultivars of soybean, Giza 82 had the highest leaf N content (Abdel-Wahab *et al*., 2020). Evidently, the amount of N absorbed from N sources is dependent on a variety of biotic and abiotic elements, including the cultivar and species of rhizobium, as well as meteorological and agricultural conditions (Rymuza *et al*., 2020).

The interaction between mineral N fertilizer rates and soybean genotypes

The interaction between soybean genotypes and mineral N fertilizer rates had a significant effect on leaf N content in both seasons (Table 4). The reduction of mineral N fertilizer from N_3 to N_1 or N_2 did not significantly effect on the leaf N content of Crawford, Giza 82 and $H_{29}L_{115}$ in both seasons. These findings demonstrate that despite variations in mineral N rates, the leaf N content of these genotypes stayed consistent. This biological condition may result from these genotypes' tendency to maximize the use of alternative N sources, allowing their metabolic processes to continue operating at peak efficiency. It is noteworthy that the mechanism was present in only one season for H_{129} and H_4L_4. Conversely, reducing the mineral N fertilizer from N_3 to N_1 or N_3 to N_2 had a significant effect on the leaf N contents of H_6L_{198}, Misr 10, $H_{18}L_{54}$, Dr101 and Giza 111 in both seasons.

II. Insect population on soybean leaves in 6^{th},7^{th}, 8^{th}, 9^{th} weeks from sowing

Variations in maximum and minimum temperatures and relative humidity (Table 2) may contribute to the variation in soybean genotypes' resistance or susceptibility to insect infestation from season to season. These variations impact plant physiology, which alters the host's response and thus influence branches' capacity to withstand insect attacks.

Mineral N fertilizer rates

The 6^{th}, 7^{th}, 8^{th} and 9^{th} weeks from sowing showed a significant effect on insect population due to mineral N fertilizer rates in both seasons (Table 5 and 6). In the first season, N_1 and N_2 harbored fewer cotton leaf worms (2.55 and 2.82 in the 6^{th} week and 3.60 and 4.67 in the 7^{th} week, respectively) than N_3. In the second one, these populations were 2.38 and 2.54 in the 6^{th} week and 2.92 and 4.20 in the 7^{th} week, respectively. In the first season, N_1 and N_2 harbored fewer cotton leaf worms (3.90 and 4.95 in the 8^{th} week and 5.91 and 7.27 in the 9^{th} week, respectively) than N_3. In the second one, these populations were 3.36 and 4.76 in the 8^{th} week and 5.57 and 6.93 in the 9^{th} week, respectively. The number and weight of cotton leafworm larvae on the leaves of plants that received N_3 are predicted to rise in proportion to those that fed on the leaves of plants that received N_2, while the increase is predicted to be stable. On the other hand, when the amount of N_1 in the leaves drops, so will the quantity and mass of cotton leafworm larvae on the leaves of those plants (Table 4).

In the first season, N_1 and N_2 harbored fewer whiteflies in the 6^{th} week (2.45 and 3.06) and 7^{th} week (7.16 and 8.89), respectively, than N_3. In the second one, these populations were 1.77 and 2.26 in the 6^{th} week and 4.33 and 6.41 in the 7^{th} week, respectively. In contrast to N_3, N_1 and N_2 had fewer whiteflies in the first season (7.96 and 9.66 in the 8^{th} week and 8.66 and 10.54 in the 9^{th} week, respectively). In the second one, these populations were 5.03 and 7.03 in the 8^{th} week and 8.21 and 10.11 in the 9^{th} week, respectively. There is no doubt that in both seasons, N_3 or N_2 contributed to a rise in whitefly populations relative to N_1. Saleh *et al*. (2016) found that whitefly rates were greater in soil that had received a high N fertilization.

In the first season, N_1 and N_2 had fewer leaf miners (6.66 and 8.40 in the 6^{th} week and 7.21 and 8.90 in the 7^{th} week, respectively) than N_3. In the second one, these numbers were 4.96 and 5.43 in the 6^{th} week and 6.79 and 8.30 in the 7^{th} week, respectively. In the first season, respectively, N_1 and N_2 hosted less leaf miners (11.20 and

12.33 in the 8th week and 12.27 and 13.41 in the 9th week, respectively, than N_3. In the second one, these populations were 9.66 and 11.56 in the 8th week and 11.70 and 12.88 in the 9th week, respectively. These findings demonstrate that the mean number of leaf miners in soybean leaves increases with increasing mineral N fertilizer rate. An increased occurrence of pea leaf miners may be associated with fertilization (Nestel *et al*., 1994). These findings concur with

Table 4: Leaf N content at 60 days from sowing as affected by mineral N fertilizer rates, soybean genotypes and their interaction.

Treatments		Leaf N content (mg/g)	
		First season	Second season
N_1	H_4L_4	25.17	23.31
	H_6L_{198}	25.21	23.72
	$H_{18}L_{54}$	25.23	24.65
	$H_{29}L_{115}$	27.92	25.52
	H_{129}	26.06	24.45
	Crawford	28.95	26.57
	Dr101	22.81	20.20
	Giza 82	28.64	25.74
	Giza 111	23.37	21.50
	Misr 10	23.38	22.61
Mean of N_1		25.67^{b}	23.82^{b}
N_2	H_4L_4	26.23	24.32
	H_6L_{198}	25.98	24.71
	$H_{18}L_{54}$	26.20	26.16
	$H_{29}L_{115}$	28.98	27.47
	H_{129}	26.99	26.49
	Crawford	29.95	28.01
	Dr101	23.97	22.54
	Giza 82	29.62	27.58
	Giza 111	24.41	23.87
	Misr 10	24.23	23.21
Mean of N_2		26.65^{ab}	25.43^{a}
N_3	H_4L_4	27.42	24.65
	H_6L_{198}	26.63	24.83
	$H_{18}L_{54}$	26.89	26.53
	$H_{29}L_{115}$	29.61	27.56
	H_{129}	27.58	26.88
	Crawford	30.58	28.07
	Dr101	24.51	22.67
	Giza 82	27.23	27.69
	Giza 111	25.11	23.94
	Misr 10	25.40	23.16
Mean of N_3		27.09^{a}	25.60^{a}
Average of soybean genotypes	H_4L_4	26.27^{b}	24.09^{d}
	H_6L_{198}	25.94^{b}	24.42^{d}
	$H_{18}L_{54}$	26.11^{b}	25.78^{c}
	$H_{29}L_{115}$	28.84^{a}	26.85^{b}
	H_{129}	26.87^{b}	25.94^{c}
	Crawford	29.82^{a}	27.55^{a}
	Dr101	23.76^{c}	21.80^{f}
	Giza 82	28.49^{a}	27.00^{ab}
	Giza 111	24.30^{c}	23.10^{e}
	Misr 10	24.33^{c}	22.99^{e}
L.S.D. 0.05 N fertilizer		1.21	0.41
L.S.D. 0.05 Genotypes		1.58	0.66
L.S.D. 0.05 Interaction		3.37	0.73

Table 5: Insect population as affected by mineral N fertilizer rates, soybean genotypes and their interaction at the 6th and 7th weeks from sowing in 2021 and 2022 seasons.

Treatments		Cotton leaf worm/plant (no.)		Whitefly/3 leaves/plant (no.)		Leaf miners/plant (no.)		Cotton leaf worm/plant (no.)		Whitefly/3 leaves/plant (no.)		Leaf miners/plant (no.)	
		6th week						7th week					
		First season											
N_1	H_4L_4	2.50		3.16		8.66		3.16		7.16		9.00	
	H_6L_{198}	2.16		2.33		6.66		1.90		5.66		7.10	
	$H_{18}L_{54}$	3.30		2.16		6.66		4.33		5.83		7.16	
	$H_{29}L_{115}$	2.56		2.83		6.66		3.03		9.66		7.33	
	H_{129}	2.46		2.16		6.33		2.60		5.90		6.90	
	Crawford	2.90		3.66		9.33		6.83		12.16		9.83	
	Dr101	2.23		1.66		6.33		2.66		4.83		6.83	
	Giza 82	3.00		2.16		5.66		6.06		6.90		6.10	
	Giza 111	2.23		2.66		5.33		3.66		8.83		5.83	
	Misr 10	2.16		1.66		5.00		1.80		4.66		6.06	
Mean of N_1		2.55^{c}		2.45^{c}		6.66^{c}		3.60^{c}		7.16^{c}		7.21^{c}	
N_2	H_4L_4	2.80		3.83		10.33		3.83		9.66		10.83	
	H_6L_{198}	2.56		3.16		8.66		3.16		7.83		9.26	
	$H_{18}L_{54}$	4.16		2.83		9.66		4.83		7.83		8.80	
	$H_{29}L_{115}$	2.90		3.33		8.33		4.33		10.16		9.23	
	H_{129}	2.63		2.33		9.33		3.03		8.06		9.66	
	Crawford	3.16		4.33		11.33		8.33		12.83		11.76	
	Dr101	2.06		2.33		8.33		3.83		7.83		9.16	
	Giza 82	3.66		2.66		6.66		7.06		7.73		7.33	
	Giza 111	2.20		3.83		5.66		4.60		9.83		6.66	
	Misr 10	2.10		2.00		5.66		3.66		7.10		6.33	
Mean of N_2		2.82^{b}		3.06^{b}		8.40^{b}		4.67^{b}		8.89^{b}		8.90^{b}	
N_3	H_4L_4	3.33		4.33		13.66		4.60		10.66		14.33	
	H_6L_{198}	3.06		3.50		10.66		4.33		9.06		11.50	
	$H_{18}L_{54}$	5.33		3.16		12.33		5.16		8.83		13.33	
	$H_{29}L_{115}$	3.66		3.83		9.33		6.93		10.66		10.83	
	H_{129}	2.90		3.16		11.00		3.90		8.83		10.66	
	Crawford	3.83		5.00		11.66		8.83		13.66		11.83	
	Dr101	2.66		3.16		11.00		5.10		8.40		11.83	
	Giza 82	4.63		2.83		8.66		8.33		7.66		9.33	
	Giza 111	2.66		4.50		6.66		5.33		9.83		7.33	
	Misr 10	2.16		2.33		6.66		4.06		7.66		7.50	
Mean of N_3		3.42^{a}		3.58^{a}		10.16^{a}		5.66^{a}		9.53^{a}		10.85^{a}	
Average of soybean genotypes	H_4L_4	2.87^{de}	LR	3.77^{b}	S	10.88^{a}	S	3.86^{d}	LR	9.16^{c}	S	11.38^{a}	S
	H_6L_{198}	2.60^{ef}	LR	3.00^{cd}	LR	8.66^{c}	S	3.13^{e}	LR	7.52^{d}	LR	9.28^{bc}	S
	$H_{18}L_{54}$	4.26^{a}	HS	2.72^{de}	LR	9.55^{b}	S	4.77^{c}	S	7.50^{d}	LR	9.76^{b}	S
	$H_{29}L_{115}$	3.04^{cd}	S	3.33^{bc}	S	8.11^{c}	LR	4.76^{c}	S	10.16^{b}	S	9.13^{c}	S
	H_{129}	2.66^{d-f}	LR	2.55^{de}	LR	8.88^{bc}	S	3.17^{e}	LR	7.60^{d}	LR	9.07^{c}	S
	Crawford	3.30^{c}	S	4.33^{a}	S	10.77^{a}	S	8.00^{a}	S	12.88^{a}	HS	11.14^{a}	S
	Dr101	2.32^{fg}	LR	2.38^{ef}	LR	8.55^{c}	S	3.86^{d}	LR	7.02^{e}	LR	9.27^{c}	S
	Giza 82	3.76^{b}	S	2.55^{de}	LR	7.00^{d}	LR	7.15^{b}	S	7.43^{d}	LR	7.58^{d}	LR
	Giza 111	2.36^{fg}	LR	3.66^{b}	S	5.88^{e}	MR	4.53^{c}	LR	9.50^{c}	S	6.61^{e}	MR
	Misr 10	2.14^{g}	MR	2.00^{f}	MR	5.77^{e}	MR	3.17^{e}	LR	6.47^{f}	MR	6.63^{e}	MR

Table 5: Continue....

Table 5: Continue....

L.S.D. 0.05 N fertilizer		1.12±0.36		0.25±0.46		0.25±1.42		0.12±1.03		0.35±1.22		0.25±1.82	
L.S.D. 0.05 Genotypes		0.38±0.64		0.53± 0.69		0.88± 1.69		0.41±1.68		0.40±1.93		0.48±1.64	
L.S.D. 0.05 Interaction		0.91±0.77		NS		1.06±2.30		0.49±1.86		0.54±2.17		0.60±2.30	
						Second season							
N_1	H_4L_4	2.06		2.33		6.66		2.83		4.66		8.83	
	H_6L_{198}	2.06		2.16		4.00		1.40		3.83		6.83	
	$H_{18}L_{54}$	3.06		1.33		4.33		4.03		2.83		6.90	
	$H_{29}L_{115}$	2.50		2.60		5.66		2.06		5.66		7.16	
	H_{129}	2.26		1.73		7.00		2.06		3.66		6.40	
	Crawford	2.76		2.66		7.66		5.83		7.66		8.93	
	Dr101	2.06		1.16		3.66		2.13		2.83		6.16	
	Giza 82	2.76		1.10		3.33		4.83		4.66		5.56	
	Giza 111	2.06		1.66		3.66		2.66		4.66		5.43	
	Misr 10	2.16		1.00		3.66		1.40		2.83		5.66	
Mean of N_1		2.38^{b}		1.77^{c}		4.96^{b}		2.92^{c}		4.33^{c}		6.79^{c}	
N_2	H_4L_4	2.43		3.16		7.33		3.83		7.66		10.50	
	H_6L_{198}	2.10		2.83		3.66		2.66		4.83		8.86	
	$H_{18}L_{54}$	3.18		2.33		4.33		5.66		4.80		8.16	
	$H_{29}L_{115}$	2.83		3.00		5.66		4.03		8.66		8.33	
	H_{129}	2.46		1.33		7.66		2.93		5.83		9.16	
	Crawford	2.86		3.33		8.33		7.93		9.50		11.16	
	Dr101	2.10		1.66		5.33		3.06		6.06		8.73	
	Giza 82	3.01		1.33		3.66		5.90		5.83		6.73	
	Giza 111	2.20		2.33		4.00		3.06		7.06		5.66	
	Misr 10	2.23		1.33		4.33		2.93		3.83		5.66	
Mean of N_2		2.54^{ab}		2.26^{b}		5.43^{b}		4.20^{b}		6.41^{b}		8.30^{b}	
N_3	H_4L_4	2.66		3.83		8.66		5.66		8.60		13.60	
	H_6L_{198}	2.22		3.06		5.66		4.13		5.83		10.60	
	$H_{18}L_{54}$	3.52		3.23		6.66		6.80		5.83		12.66	
	$H_{29}L_{115}$	2.78		2.63		6.66		4.83		9.83		10.16	
	H_{129}	2.56		2.16		8.66		3.90		7.06		10.06	
	Crawford	3.08		3.93		9.33		8.70		10.66		11.13	
	Dr101	2.25		2.16		6.33		3.83		5.50		11.06	
	Giza 82	3.23		2.36		5.66		7.66		7.16		8.73	
	Giza 111	2.26		3.66		6.66		3.83		7.86		6.80	
	Misr 10	2.06		2.33		6.66		3.60		4.83		6.56	
Mean of N_3		2.66^{a}		2.94^{a}		7.10^{a}		5.29^{a}		7.32^{a}		10.14^{a}	
Average of soybean genotypes	H_4L_4	2.38^{ef}	LR	3.11^{ab}	S	7.55^{b}	S	4.11^{d}	LR	6.97^{c}	S	10.97^{a}	S
	H_6L_{198}	2.13^{f}	LR	2.68^{bc}	S	4.44^{de}	LR	2.73^{gh}	LR	4.83^{f}	S	8.76^{d}	S
	$H_{18}L_{54}$	3.25^{a}	S	2.10^{cd}	LR	5.11^{d}	LR	5.50^{c}	S	4.48^{f}	S	9.24^{c}	S
	$H_{29}L_{115}$	2.70^{cd}	S	2.94^{ab}	S	6.00^{c}	S	3.64^{e}	LR	8.05^{b}	HS	8.55^{d}	S
	H_{129}	2.43^{de}	LR	1.74^{d}	LR	7.77^{ab}	S	2.96^{f-h}	LR	5.52^{e}	S	8.54^{d}	S
	Crawford	2.90^{bc}	S	3.31^{a}	S	8.44^{a}	S	7.48^{a}	HS	9.27^{a}	HS	10.41^{b}	S
	Dr101	2.13^{f}	LR	1.66^{d}	MR	5.11^{d}	LR	3.01^{fg}	LR	4.80^{f}	S	8.65^{d}	S
	Giza 82	3.00^{ab}	S	1.60^{d}	MR	4.22^{e}	MR	6.13^{b}	S	5.88^{e}	S	7.01^{e}	LR
	Giza 111	2.17^{ef}	LR	2.55^{bc}	S	4.77^{de}	LR	3.18^{f}	LR	6.53^{d}	HS	5.96^{f}	MR
	Misr 10	2.15^{f}	LR	1.55^{d}	MR	4.88^{de}	LR	2.64^{h}	LR	3.83^{g}	S	5.96^{f}	MR
L.S.D. 0.05 N fertilizer		0.24±0.11		0.19±0.4		0.47±0.91		0.17±1.18		0.37±1.53		0.25±1.67	
L.S.D. 0.05 Genotypes		0.27±0.39		70.60±0.64		0.86±1.45		0.32±1.66		0.44±1.70		0.37±1.68	
L.S.D. 0.05 Interaction		NS		NS		1.08±1.75		0.40±1.91		0.59±2.11		0.48±2.25	

Genotypes that had mean numbers more than X+2SD, were considered highly susceptible (HS); between X and X+2SD, susceptible (S); between X and X-1SD, low resistant (LR); between X1SD and X-2SD, moderately resistant (MR) and less than X-2SD, were considered highly resistant (HR).

Table 6: Insect population as affected by mineral N fertilizer rates, soybean genotypes and their interaction at the 8th and 9th weeks from sowing in 2021 and 2022 seasons.

Treatments		Cotton leaf worm/plant (no.)		Whitefly/3 leaves/plant (no.)		Leaf miners/plant (no.)		Cotton leaf worm/plant (no.)		Whitefly/3 leaves/plant (no.)		Leaf miners/plant (no.)	
		8th week						9th week					
		First season											
N_1	H_4L_4	3.50		8.33		8.66		5.93		9.16		9.33	
	H_6L_{198}	2.00		6.33		10.66		4.16		6.83		11.33	
	$H_{18}L_{54}$	4.66		6.66		11.66		6.86		6.83		12.16	
	$H_{29}L_{115}$	3.16		10.33		13.66		5.16		11.33		15.33	
	H_{129}	2.83		6.66		14.33		4.86		7.33		16.43	
	Crawford	7.33		13.33		15.66		9.16		13.83		16.40	
	Dr101	2.83		5.66		11.33		5.16		6.66		13.16	
	Giza 82	6.33		7.66		9.66		7.83		8.16		10.23	
	Giza 111	4.16		9.33		8.00		5.83		10.33		9.16	
	Misr 10	2.16		5.33		8.33		4.16		6.16		9.16	
Mean of N_1		3.90^{c}		7.96^{c}		11.20^{b}		5.91^{c}		8.66^{c}		12.27^{c}	
N_2	H_4L_4	4.33		10.66		10.33		7.16		11.33		12.33	
	H_6L_{198}	3.33		8.33		10.33		4.83		9.16		12.16	
	$H_{18}L_{54}$	5.16		8.66		12.33		8.93		9.40		14.33	
	$H_{29}L_{115}$	4.66		11.66		15.66		7.16		12.50		16.16	
	H_{129}	3.16		8.66		14.66		6.10		9.66		16.50	
	Crawford	8.66		14.00		16.66		11.16		14.83		17.43	
	Dr101	4.16		8.33		12.33		6.16		9.16		13.23	
	Giza 82	7.33		8.33		10.66		9.16		9.66		11.23	
	Giza 111	4.83		10.66		9.66		6.20		11.33		10.33	
	Misr 10	3.83		7.33		10.66		5.83		8.33		10.40	
Mean of N_2		4.95^{b}		9.66^{b}		12.33^{a}		7.27^{b}		10.54^{b}		13.41^{b}	
N_3	H_4L_4	4.83		11.33		11.33		9.33		11.83		12.40	
	H_6L_{198}	4.66		9.66		10.33		7.33		10.33		12.36	
	$H_{18}L_{54}$	5.66		9.66		12.33		9.83		10.16		13.56	
	$H_{29}L_{115}$	7.33		11.66		16.33		8.16		12.26		17.16	
	H_{129}	4.33		9.33		14.33		7.00		10.33		15.30	
	Crawford	9.66		14.33		17.33		11.83		15.16		19.16	
	Dr101	5.16		9.33		12.66		6.83		10.16		13.40	
	Giza 82	8.66		8.33		11.33		11.33		9.16		12.16	
	Giza 111	5.66		10.66		10.33		6.93		11.16		12.40	
	Misr 10	4.33		8.33		10.66		6.56		9.16		11.40	
Mean of N_3		6.03^{a}		10.26^{a}		12.70^{a}		8.51^{a}		10.97^{a}		13.93^{a}	
Average of soybean genotypes	H_4L_4	4.22^{de}	LR	10.11^{c}	S	10.11^{de}	LR	7.47^{d}	S	10.77^{c}	S	11.35^{e}	LR
	H_6L_{198}	3.33^{f}	LR	8.11^{d}	LR	10.44^{d}	LR	5.44^{g}	LR	8.77^{de}	LR	11.95^{d}	LR
	$H_{18}L_{54}$	5.16^{c}	S	8.33^{d}	LR	12.11^{c}	S	8.54^{c}	S	8.80^{de}	LR	13.35^{c}	S
	$H_{29}L_{115}$	5.05^{c}	S	11.22^{b}	S	15.22^{b}	S	6.83^{e}	LR	12.03^{b}	S	16.22^{b}	S
	H_{129}	3.44^{f}	LR	8.22^{d}	LR	14.44^{b}	S	5.98^{f}	LR	9.11^{d}	LR	16.07^{b}	S
	Crawford	8.55^{a}	HS	13.88^{a}	HS	16.55^{a}	S	10.72^{a}	S	14.61^{a}	HS	17.66^{a}	S
	Dr101	4.05^{ef}	LR	7.77^{de}	LR	12.11^{c}	S	6.05^{f}	LR	8.66^{e}	LR	13.26^{c}	S
	Giza 82	7.44^{b}	S	8.11^{d}	LR	10.55^{d}	LR	9.44^{b}	S	9.00^{de}	LR	11.21^{e}	LR
	Giza 111	4.88^{cd}	LR	10.22^{c}	S	9.33^{e}	MR	6.32^{f}	LR	10.94^{c}	S	10.63^{f}	LR
	Misr 10	3.44^{f}	LR	7.00^{e}	MR	9.88^{de}	LR	5.52^{g}	LR	7.88^{f}	MR	10.32^{f}	MR

Table 6: Continue...

Table 6: Continue...

L.S.D. 0.05 N fertilizer		0.24±0.86		0.33±0.97		0.43±0.63		0.33±1.30		0.27±1.22		0.18±0.84	
L.S.D. 0.05 Genotypes		0.75±1.66		0.88±1.96		0.85± 2.38		0.41±1.79		0.41±2.05		0.43±2.60	
L.S.D. 0.05 Interaction		NS		1.08±2.24		1.06±2.50		0.55±2.07		0.53±2.27		0.53±2.68	
						Second season							
	H$_4$L$_4$	3.33		5.66		9.00		5.56		8.83		8.83	
N$_1$	H$_6$L$_{198}$	1.66		4.33		9.66		4.20		6.16		10.66	
	H$_{18}$L$_{54}$	4.33		3.33		9.66		6.16		6.33		11.50	
	H$_{29}$L$_{115}$	2.66		6.66		12.00		5.03		11.13		14.66	
	H$_{129}$	2.33		4.33		9.66		4.33		6.96		15.96	
	Crawford	6.66		8.66		13.66		8.66		13.33		16.20	
	Dr101	2.66		3.33		9.66		4.86		6.16		12.56	
	Giza 82	5.33		5.00		8.66		7.16		7.66		9.66	
	Giza 111	3.00		5.33		7.33		5.53		9.83		8.66	
	Misr 10	1.66		3.66		7.33		4.16		5.66		8.33	
Mean of N$_1$		3.36^{c}		5.03^{c}		9.66^{b}		5.57^{c}		8.21^{c}		11.70^{c}	
N$_2$	H$_4$L$_4$	4.66		8.33		10.33		6.66		10.66		11.66	
	H$_6$L$_{198}$	2.66		5.66		13.66		4.60		8.83		12.03	
	H$_{18}$L$_{54}$	6.33		5.66		14.66		8.33		9.16		13.90	
	H$_{29}$L$_{115}$	4.66		9.33		15.66		6.93		12.16		15.53	
	H$_{129}$	3.33		6.33		11.33		5.90		9.16		16.13	
	Crawford	8.66		10.66		10.33		10.66		14.16		16.86	
	Dr101	3.33		6.00		9.66		5.86		8.66		12.63	
	Giza 82	6.66		6.66		9.33		8.80		9.33		10.83	
	Giza 111	3.66		7.33		11.00		6.06		10.83		9.73	
	Misr 10	3.66		4.33		11.33		5.50		8.16		9.50	
Mean of N$_2$		4.76^{b}		7.03^{b}		11.56^{a}		6.93^{b}		10.11^{b}		12.88^{b}	
N$_3$	H$_4$L$_4$	6.66		9.66		10.66		8.80		11.16		12.00	
	H$_6$L$_{198}$	4.66		6.33		13.66		7.23		9.83		11.83	
	H$_{18}$L$_{54}$	7.33		6.66		14.33		9.33		9.83		12.66	
	H$_{29}$L$_{115}$	5.66		10.66		16.00		7.96		11.66		16.70	
	H$_{129}$	4.33		7.33		11.66		6.83		9.90		14.70	
	Crawford	9.66		11.66		11.33		11.60		14.90		18.33	
	Dr101	4.33		6.66		10.33		6.56		10.06		12.73	
	Giza 82	8.66		7.66		9.33		10.83		8.90		11.50	
	Giza 111	4.66		8.66		10.33		6.50		10.80		11.86	
	Misr 10	4.00		5.00		13.66		6.23		8.90		11.06	
Mean of N$_3$		6.00^{a}		8.03^{a}		11.96^{a}		8.19^{a}		10.59^{a}		13.34^{a}	
Average of soybean genotypes	H$_4$L$_4$	4.88^{d}	S	7.88^{c}	S	10.11^{d}	LR	7.01^{d}	S	10.22^{c}	S	10.83^{e}	LR
	H$_6$L$_{198}$	3.00^{f}	LR	5.44^{f}	LR	10.44^{cd}	LR	5.34^{h}	LR	8.27^{e}	LR	11.51^{d}	LR
	H$_{18}$L$_{54}$	6.00^{c}	S	5.22^{f}	LR	10.22^{cd}	LR	7.94^{c}	S	8.44^{de}	LR	12.68^{c}	S
	H$_{29}$L$_{115}$	4.33^{de}	LR	8.88^{b}	S	13.11^{b}	S	6.64^{e}	LR	11.65^{b}	S	15.63^{b}	S
	H$_{129}$	3.33^{f}	LR	6.00^{ef}	LR	12.88^{b}	S	5.68^{g}	LR	8.67^{d}	LR	15.60^{b}	S
	Crawford	8.33^{a}	HS	10.33^{a}	HS	15.11^{a}	HS	10.31^{a}	HS	14.13^{a}	HS	17.13^{a}	S
	Dr101	3.44^{f}	LR	5.33^{f}	LR	10.88^{c}	LR	5.76^{fg}	LR	8.30^{de}	LR	12.64^{c}	S
	Giza 82	6.88^{b}	S	6.44^{de}	LR	10.11^{d}	LR	8.93^{b}	S	8.63^{de}	LR	10.66^{e}	LR
	Giza 111	3.77^{ef}	LR	7.11^{cd}	S	9.11^{e}	MR	6.03^{f}	LR	10.48^{c}	S	10.08^{f}	LR
	Misr 10	3.11^{f}	LR	4.33^{g}	MR	8.66^{e}	MR	5.30^{h}	LR	7.57^{f}	MR	9.63^{g}	MR
L.S.D. 0.05 N fertilizer		0.41±1.07		0.44±1.24		0.64±1.00		0.30±1.31		0.32±1.25		0.19±0.84	
L.S.D. 0.05 Genotypes		0.88± 1.71		0.82± 1.76		0.76± 1.90		0.32±1.68		0.39± 2.01		0.38±2.62	
L.S.D. 0.05 Interaction		NS		1.03±2.19		1.01±2.21		0.44±1.99		0.52±2.26		0.48±2.70	

Genotypes that had mean numbers more than X+2SD, were considered highly susceptible (HS); between X and X+2SD, susceptible (S); between X and X-1SD, low resistant (LR); between X1SD and X-2SD, moderately resistant (MR) and less than X-2SD, were considered highly resistant (HR).

those of Abolfadel *et al*. (2023), who discovered that fertilizers containing ammonium nitrate were followed by urea in terms of leaf miner larvae infestations.

Soybean genotypes

Insect populations on soybean leaves in the 6^{th}, 7^{th}, 8^{th} and 9^{th} weeks from sowing in both seasons showed substantial differences between soybean genotypes (Table 5 and 6). In the 6^{th} week, Misr 10, Dr101, Giza 111, H_6L_{198} and H_4L_4 in the second season and the others retained fewer cotton leaf worms than the others in both seasons. In contrast, during the 6^{th} week of both seasons, $H_{18}L_{54}$ and Giza 82 had many cotton leaf worms than the other genotypes. In the 7^{th} week of both seasons, Misr 10, H_{129} and H_6L_{198} had fewer cotton leaf worms than the others. In comparison to the others in both seasons, Misr 10, Dr101, H_{129} and H_6L_{198} had fewer cotton leaf worms at the 8^{th} week. Additionally, during the 9^{th} week of both seasons, Misr 10 and H_6L_{198} had fewer cotton leaf worms than the others. In the 7^{th}, 8^{th} and 9^{th} weeks of both seasons, Crawford and Giza 82 had many cotton leaf worms than the others. El-Khayat *et al*. (2019) and Abdel-Wahab and Naroz (2023) had the same results.

In the first season, Misr 10 and Dr101 harbored fewer whiteflies than the others; in the second season, Misr 10, Giza 82, Dr101, H_{129} and $H_{18}L_{54}$ had many whiteflies than the others in the 6^{th} week. On the other hand, in the first season, Crawford, Giza 111 and H_4L_4 harbored many whiteflies than the others in the 6^{th} week. In the second one, Crawford, H_{129} and H_4L_4 had many whiteflies than the others in the 6^{th} week. In the 7^{th} week of both seasons, Misr 10 had fewer whiteflies, whereas Crawford and $H_{29}L_{115}$ had the opposite trend. Misr 10 hosted fewer whiteflies, but Crawford and $H_{29}L_{115}$ harbored many whiteflies in the 8^{th} and 9^{th} weeks in both seasons. The findings of Abdallah *et al*. (2015), Alaa El-Deen (2016) and Mesbah *et al*. (2019) that Giza 111 seems vulnerable to whitefly infestation are consistent with these findings.

In the 6^{th} week, Misr 10 and Giza 111 harbored fewer leaf miners in the first season, meanwhile Misr 10, Giza 111, Giza 82 and H_6L_{198} harbored fewer leaf miners in the second one than the others. Conversely, Crawford, H_4L_4 and H_{129} harbored many leaf miners in both seasons. With regard to 7^{th} week, Misr 10 and Giza 111 harbored fewer leaf miners than the others in both seasons. However, Crawford, H_4L_4, H_6L_{198} and $H_{18}L_{54}$ harbored many leaf miners in the first season, meanwhile H_4L_4 and Crawford harbored many leaf miners in the second one than the others. In 8^{th} and 9^{th} weeks, Misr 10 and Giza 111 harbored fewer leaf miners, meanwhile the converse was true for Crawford, H_{129} and $H_{29}L_{115}$ than the others in both seasons. These findings are consistent with Abou-Attia and Youssef (2007) findings that Giza 82 had the highest level of resistance against leaf miner infestation.

The interaction between mineral N fertilizer rates and soybean genotypes

The number of leaf miners in the 6^{th}, 7^{th}, 8^{th} and 9^{th} weeks from sowing in both seasons was significantly affected by the interaction between mineral N fertilizer rates and soybean genotypes; on the other hand, the number of cotton leaf worms in the 6^{th} week of the first season was significantly affected by the interaction (Tables 5 and 6). Additionally, in the 7^{th}, 8^{th} and 9^{th} weeks in both seasons, the populations of whiteflies were significantly affected by the interaction between soybean genotypes and mineral N fertilizer rates. In the 6^{th} week of the first season, fewer cotton leaf worms were inhabited by Misr 10, Giza 111, Dr101 and H_6L_{198} that got N_1 or N_2, while many were sheltered by $H_{18}L_{54}$ and Giza 82 that received N_3. Cotton leaf worm numbers in H_4L_4, H_6L_{198}, H_{129}, Dr101, Giza 111 and Misr 10 were not substantially affected by reducing N_3 to N_2 or N_1. The consistency of the N content in leaves at varying N fertilizer rates was the cause of these outcomes (Table 4). As a result, the number of cotton leaf worms on the leaves of Dr101, H_4L_4, Giza 111 and Misr 10 did not rise when N_1 or N_2 was increased to the recommended rate (N_3). If the rate of mineral N fertilizer increased, so did the number of cotton leaf worms on the leaves of Giza 82 or Crawford. The lack of certain chemical or mechanical defenses in the leaves may be the cause of the soybean genotypes Crawford and Giza 82's susceptibility to cotton leaf worm infestation (Abdel-Wahab *et al*., 2020).

In both seasons, there were many whiteflies in Crawford, $H_{29}L_{115}$ and H_4L_4 that got N_3. In contrast, throughout the 7^{th} and 9^{th} weeks of both seasons, Misr 10, Dr101 and $H_{18}L_{54}$ had fewer whiteflies under N_1 and N_2. Reducing N_3 to N_2 of the recommended rate had no effect on the number of whiteflies on Dr101 or Misr 10 leaves. On the other hand, in the 7^{th} and 9^{th} weeks of both seasons, reducing the mineral N fertilizer rate from 100% to 67% of the recommended rate reduced the number of whiteflies on Dr101 or Misr 10 leaves. In the 6^{th}, 7^{th}, 8^{th} and 9^{th} weeks of both seasons, there were fewer leaf miners in Misr 10, Giza 111, Giza 82 and H_4L_4 that got N_1. In contrast, a greater number of leaf miners was observed in the 6^{th}, 7^{th}, 8^{th} and 9^{th} weeks of both seasons in Crawford, $H_{29}L_{115}$ and H_{129}, which were given N_3.

III. Seed yield and yield components

Mineral N fertilizer rates

The mineral N fertilizer rates had a significant effect on pod weight/plant, seed yield/plant, 100-seed weight and seed yield/ha in both seasons and The harvest index (HI) in the second one (Table 7). N_3 had higher pod weight/plant, seed yield/plant, 100-seed weight, seed yield/ha and HI compared to the others. Comparing to N_3, N_1 and N_2 decreased seed yield/plant and seed yield per ha. It was expected that reducing the recommended rate of mineral N fertilizer by one third would lead to a corresponding decrease in seed yield. However, the actual yield reduction did not exceed 18 per cent. This could be attributed to low insect infestation as indicated by Tables 5 and 6, or the insufficient amount of N in the leaves, which may have limited the larvae's number and vitality. These findings are consistent with G³owacka *et al*. (2023), who observed

Table 7: Seed yield and yield components as affected by mineral N fertilizer, soybean genotypes and their interaction.

Treatments		Biological yield/ha (t)	Straw yield/ha (t)	Plant height (cm)	Branches/plant (no.)
			First season		
N_1	H_4L_4	15.17	12.31	106.00	3.00
	H_6L_{198}	13.60	11.34	101.00	3.50
	$H_{18}L_{54}$	13.90	11.40	99.00	3.16
	$H_{29}L_{115}$	12.99	10.72	90.00	3.16
	H_{129}	14.28	11.78	94.00	5.33
	Crawford	12.10	10.31	99.33	5.00
	Dr101	14.43	11.69	76.66	3.16
	Giza 82	13.10	10.95	92.66	4.16
	Giza 111	15.68	12.59	103.66	4.33
	Misr 10	18.04	14.11	107.33	4.66
Mean of N_1		14.33	11.72	96.96	3.95
N_2	H_4L_4	15.09	12.00	105.33	2.66
	H_6L_{198}	13.71	11.09	99.33	3.00
	$H_{18}L_{54}$	13.50	10.88	100.00	3.50
	$H_{29}L_{115}$	12.42	10.24	91.66	2.83
	H_{129}	14.81	11.95	93.33	5.16
	Crawford	12.29	10.02	103.33	4.83
	Dr101	13.49	10.75	78.33	3.33
	Giza 82	13.71	10.86	96.00	3.83
	Giza 111	14.58	11.37	105.66	4.83
	Misr 10	17.52	13.36	105.00	4.16
Mean of N_2		14.11	11.25	97.80	3.81
N_3	H_4L_4	15.74	12.53	104.00	3.00
	H_6L_{198}	15.12	12.15	98.00	3.16
	$H_{18}L_{54}$	14.71	11.74	96.33	3.66
	$H_{29}L_{115}$	14.15	11.41	89.66	2.83
	H_{129}	15.59	12.49	92.33	5.33
	Crawford	13.78	11.28	97.66	4.83
	Dr101	15.11	12.14	76.66	3.33
	Giza 82	15.09	12.11	94.33	3.66
	Giza 111	16.39	12.94	103.66	4.66
	Misr 10	18.18	14.02	103.00	4.33
Mean of N_3		15.38	12.28	95.56	3.88
Average of soybean genotypes	H_4L_4	15.33^{bc}	12.28^{b}	105.11^{a}	2.88^{f}
	H_6L_{198}	14.14^{c-e}	11.52^{b-d}	99.44^{a}	3.22^{ef}
	$H_{18}L_{54}$	14.03^{de}	11.34^{b-e}	98.44^{a}	3.44^{e}
	$H_{29}L_{115}$	13.19^{ef}	10.79^{de}	90.44^{ab}	2.94^{f}
	H_{129}	14.89^{b-d}	12.07^{bc}	93.22^{ab}	5.27^{a}
	Crawford	12.72^{f}	10.54^{e}	100.11^{a}	4.88^{ab}
	Dr101	14.34^{c-e}	11.52^{b-d}	77.22^{b}	3.27^{ef}
	Giza 82	13.97^{de}	11.31^{c-e}	94.33^{a}	3.88^{d}
	Giza 111	15.55^{b}	12.30^{b}	104.33^{a}	4.61^{bc}
	Misr 10	17.91^{a}	13.83^{a}	105.11^{a}	4.38^{c}
L.S.D. 0.05 N fertilizer		NS	NS	NS	NS
L.S.D. 0.05 Genotypes		1.20	0.96	16.06	0.4
L.S.D. 0.05 Interaction		NS	NS	NS	2NS

Table 7: Continue...

Table 7: Continue...

			Second season		
N_1	H_4L_4	12.42	9.73	101.66	3.50
	H_6L_{198}	10.40	8.32	97.66	3.50
	$H_{18}L_{54}$	11.22	8.91	99.66	4.00
	$H_{29}L_{115}$	10.36	8.29	87.33	3.50
	H_{129}	11.08	8.78	90.66	5.16
	Crawford	8.79	7.18	97.00	5.16
	Dr101	11.63	9.10	79.33	3.33
	Giza 82	9.90	8.00	91.66	4.16
	Giza 111	13.40	10.51	101.66	4.83
	Misr 10	16.09	12.38	103.00	4.33
Mean of N_1		11.53	9.12	94.96	4.15
N_2	H_4L_4	12.34	9.38	100.00	3.66
	H_6L_{198}	10.65	8.16	99.00	3.50
	$H_{18}L_{54}$	10.68	8.20	98.33	3.83
	$H_{29}L_{115}$	9.11	7.08	86.33	3.33
	H_{129}	11.51	8.76	91.00	5.16
	Crawford	9.40	7.27	97.33	5.33
	Dr101	11.02	8.41	79.66	3.50
	Giza 82	11.33	8.63	92.33	4.16
	Giza 111	12.76	9.70	104.00	4.83
	Misr 10	15.89	11.90	103.66	4.16
Mean of N_2		11.47	8.75	95.16	4.15
N_3	H_4L_4	12.48	9.50	98.33	3.33
	H_6L_{198}	11.69	8.92	96.33	3.16
	$H_{18}L_{54}$	11.89	9.10	97.33	3.66
	$H_{29}L_{115}$	10.95	8.40	86.00	3.00
	H_{129}	12.06	9.19	89.00	5.16
	Crawford	10.05	7.73	95.33	5.16
	Dr101	12.04	9.17	78.33	3.33
	Giza 82	11.63	8.87	90.66	4.00
	Giza 111	13.78	10.39	102.33	4.66
	Misr 10	15.90	11.91	102.66	4.00
Mean of N_3		12.25	9.32	93.63	3.95
Average of soybean genotypes	H_4L_4	12.41^{bc}	9.53^{bc}	100.00^{a}	3.50^{de}
	H_6L_{198}	10.91^{d}	8.47^{d}	97.66^{a}	3.38^{e}
	$H_{18}L_{54}$	11.26^{cd}	8.73^{cd}	98.44^{a}	3.83^{cd}
	$H_{29}L_{115}$	10.14^{de}	7.92^{de}	86.55^{ab}	3.27^{e}
	H_{129}	11.55^{cd}	8.91^{cd}	90.22^{ab}	5.16^{a}
	Crawford	9.41^{e}	7.39^{e}	96.55^{ab}	5.22^{a}
	Dr101	11.56^{cd}	8.89^{cd}	79.11^{b}	3.38^{e}
	Giza 82	10.95^{d}	8.50^{cd}	91.55^{ab}	4.11^{c}
	Giza 111	13.31^{b}	10.20^{b}	102.66^{a}	4.77^{b}
	Misr 10	15.96^{a}	12.06^{a}	103.11^{a}	4.16^{c}
L.S.D. 0.05 N Fertilizer		NS	NS	NS	NS
L.S.D. 0.05 Genotypes		1.46	1.04	18.44	0.36
L.S.D. 0.05 Interaction		NS	NS	NS	NS

Table 7: Continue...

Table 7: Continue...

Treatments		Pod weight/plant (g)	Seed yield/plant (g)	100-seed weight (g)	Seed yield/ha (t)	HI (%)
				First season		
	H_4L_4	14.04	12.13	15.61	2.85	23.37
N_1	H_6L_{198}	11.77	10.11	15.03	2.26	21.32
	$H_{18}L_{54}$	12.93	10.92	13.26	2.49	22.88
	$H_{29}L_{115}$	12.04	10.04	14.00	2.25	22.57
	H_{129}	14.16	10.99	15.03	2.49	22.12
	Crawford	9.70	8.43	12.25	1.78	19.56
	Dr101	13.49	11.68	14.16	2.73	23.90
	Giza 82	11.45	9.83	13.05	2.14	21.21
	Giza 111	15.09	12.94	17.47	3.09	24.14
	Misr 10	19.01	15.99	17.71	3.92	26.07
Mean of N_1		13.37^{b}	11.30^{b}	14.76^{b}	2.60^{b}	22.71
	H_4L_4	16.17	13.01	17.27	3.09	25.58
N_2	H_6L_{198}	14.02	11.20	14.85	2.61	24.44
	$H_{18}L_{54}$	14.67	11.43	15.13	2.61	24.98
	$H_{29}L_{115}$	12.36	9.78	15.40	2.17	23.05
	H_{129}	15.28	12.22	16.90	2.85	24.21
	Crawford	13.17	10.13	14.73	2.26	24.35
	Dr101	15.06	11.82	17.23	2.73	26.02
	Giza 82	15.16	12.17	15.36	2.85	26.53
	Giza 111	16.60	13.41	19.20	3.20	27.47
	Misr 10	20.52	16.74	19.20	4.16	28.84
Mean of N_2		15.30^{a}	12.19^{ab}	16.52^{a}	2.85^{ab}	25.55
N_3	H_4L_4	15.53	13.33	17.19	3.21	25.22
	H_6L_{198}	14.88	12.55	15.76	2.97	24.53
	$H_{18}L_{54}$	14.44	12.34	15.11	2.97	25.48
	$H_{29}L_{115}$	13.75	11.61	14.92	2.73	24.59
	H_{129}	15.11	12.89	16.80	3.09	24.56
	Crawford	12.97	10.91	14.37	2.49	23.22
	Dr101	14.98	12.58	16.82	2.97	24.60
	Giza 82	14.59	12.56	15.25	2.97	24.65
	Giza 111	16.59	14.21	18.82	3.45	25.83
	Misr 10	19.53	16.74	19.24	4.16	27.53
Mean of N_3		15.24^{a}	12.97^{a}	16.43^{a}	3.10^{a}	25.02
Average of	H_4L_4	15.24^{bc}	12.82^{bc}	16.69^{b}	3.05^{bc}	24.72^{bc}
soybean	H_6L_{198}	13.55^{c-e}	11.29^{de}	15.21^{d}	2.61^{de}	23.43^{bc}
genotypes bc	$H_{18}L_{54}$	14.01^{cd}	11.56^{c-e}	14.50^{e}	2.69^{c-e}	24.45
	$H_{29}L_{115}$	12.71^{de}	10.47^{ef}	14.77^{de}	2.38^{ef}	23.41^{bc}
	H_{129}	14.85^{bc}	12.03^{cd}	16.24^{bc}	2.81^{cd}	23.63^{bc}
	Crawford	11.95^{e}	9.82^{f}	13.78^{f}	2.17^{f}	22.37^{c}
	Dr101	14.51^{b-d}	12.02^{cd}	16.07^{c}	2.81^{cd}	24.84^{bc}
	Giza 82	13.73^{c-e}	11.52^{c-e}	14.55^{e}	2.65^{c-e}	24.13^{bc}
	Giza 111	16.09^{b}	13.52^{b}	18.50^{a}	3.24^{b}	25.81^{ab}
	Misr 10	19.69^{a}	16.49^{a}	18.72^{a}	4.08^{a}	27.48^{a}
L.S.D. 0.05 N Fertilizer		0.54	1.18	0.30	0.34	NS
L.S.D. 0.05 Genotypes		1.88	1.18	0.47	0.40	2.52
L.S.D. 0.05 Interaction		NS	NS	NS	NS	NS

Table 7: Continue...

Table 7: Continue...

				Second season		
N_1	H_4L_4	13.62	11.58	13.90	2.68	21.67
	H_6L_{198}	11.13	9.46	16.53	2.08	20.02
	$H_{18}L_{54}$	12.11	10.28	11.83	2.31	20.57
	$H_{29}L_{115}$	11.09	9.43	12.01	2.07	20.11
	H_{129}	12.03	10.24	13.95	2.30	20.84
	Crawford	9.29	7.85	11.38	1.61	18.36
	Dr101	12.56	10.69	13.63	2.53	21.99
	Giza 82	10.45	8.89	11.78	1.90	19.28
	Giza 111	14.88	12.38	15.73	2.88	21.59
	Misr 10	17.81	15.16	17.03	3.71	23.09
Mean of N_1		12.49^{b}	10.60^{b}	13.78^{b}	2.41^{b}	20.75^{b}
	H_4L_4	16.17	12.57	15.17	2.96	24.09
N_2	H_6L_{198}	13.18	10.88	17.72	2.49	23.33
	$H_{18}L_{54}$	13.28	10.91	14.25	2.48	23.27
	$H_{29}L_{115}$	11.06	9.34	14.22	2.03	22.34
	H_{129}	15.19	11.74	14.55	2.75	23.96
	Crawford	11.81	9.70	13.43	2.13	22.63
	Dr101	13.72	11.32	14.83	2.61	23.69
	Giza 82	13.74	11.63	13.28	2.70	23.79
	Giza 111	15.28	12.93	17.53	3.06	23.85
	Misr 10	19.35	16.11	17.93	3.99	25.04
Mean of N_2		14.28^{a}	11.71^{ab}	15.29^{a}	2.72^{ab}	23.60^{a}
N_3	H_4L_4	14.91	12.69	15.60	2.98	23.92
	H_6L_{198}	14.02	11.90	14.80	2.77	23.71
	$H_{18}L_{54}$	14.10	11.99	14.25	2.79	23.56
	$H_{29}L_{115}$	13.16	11.18	14.41	2.55	23.38
	H_{129}	14.43	12.27	14.91	2.87	23.78
	Crawford	12.10	10.27	13.42	2.31	23.13
	Dr101	14.44	12.27	15.16	2.86	23.81
	Giza 82	13.94	11.85	13.63	2.76	23.78
	Giza 111	16.46	14.00	17.63	3.38	24.60
	Misr 10	18.92	16.10	17.98	3.99	25.12
Mean of N_3	14.65^{a}	12.45^{a}	15.18^{a}	2.92^{a}	23.88^{a}	
Average of soybean genotypes	H_4L_4	14.90^{bc}	12.28^{bc}	14.89^{d}	2.87^{bc}	23.22^{b}
	H_6L_{198}	12.78^{c-e}	10.75^{de}	16.35^{c}	2.45^{cd}	22.35^{b-d}
	$H_{18}L_{54}$	13.17^{c-e}	11.06^{cd}	13.44^{e}	2.53^{cd}	22.46^{b-d}
	$H_{29}L_{115}$	11.77^{de}	9.98^{de}	13.55^{e}	2.21^{de}	21.94^{cd}
	H_{129}	13.88^{b-d}	11.42^{cd}	14.47^{d}	2.64^{c}	22.86^{bc}
	Crawford	11.06^{e}	9.27^{e}	12.74^{f}	2.02^{e}	21.37^{d}
	Dr101	13.57^{b-d}	11.42^{cd}	14.54^{d}	2.66^{c}	23.16^{b}
	Giza 82	12.71^{de}	10.79^{cd}	12.90^{f}	2.45^{cd}	22.28^{b-d}
	Giza 111	15.54^{b}	13.10^{b}	16.96^{b}	3.11^{b}	23.34^{ab}
	Misr 10	18.69^{a}	15.79^{a}	17.65^{a}	3.90^{a}	24.41^{a}
L.S.D. 0.05 N Fertilizer		0.67	1.12	0.31	0.38	0.91
L.S.D. 0.05 Genotypes		2.14	1.49	0.42	0.42	1.17
L.S.D. 0.05 Interaction		NS	1.54	NS	0.93	NS

that N fertilization positively affects yield-related factors such as plant height, pod number/plant and seed weight/plant.

Soybean genotypes

Soybean genotypes showed significant differences in seed yield and yield components in both seasons (Table 7). Misr 10 had the highest biological yield compared to the others. Giza 111 and H_4L_4 ranked second. The converse was true for Crawford and $H_{29}L_{115}$. This indicates that Misr 10 has a higher resistance to insect attacks than Giza 111 (Table 5 and 6). This tolerance positively affects the yield potential by maximizing photosynthesis outputs and increasing dry matter accumulation during growth and development. Misr 10 had a higher straw yield compared to the others. Giza 111 and H_4L_4 ranked second. The converse was true for Crawford and $H_{29}L_{115}$. This indicates that Misr 10 has a higher resistance to insect attacks, as shown in Tables 5 and 6. These findings are consistent with the results of Abdel-Wahab and Naroz (2023), who demonstrated that soybean genotypes Giza 111, $H_{15}L_{17}$, H_{129} and H_4L_4 exhibit tolerance to infestation by the cotton leaf worm.

All soybean genotypes, except Dr101, were characterized as tall. The genetic makeup of these genotypes likely contributes to differences in the growth of their internodes. These results align with the findings of Serag *et al*. (2019), who reported significant variations in plant height among soybean genotypes.

Crawford and H_{129} had a higher number of branches/plant compared to the others. Giza 111 ranked second. $H_{29}L_{115}$, H_4L_4, H_6L_{198} and Dr101 had a lower number of branches/plant than the others. Misr 10 had a higher pod weight/plant compared to the others. H_4L_4, Giza 111, Dr101 and H_{129} ranked second. The converse was true for Crawford and Giza 82.

In terms of seed yield/plant, Misr 10 had a higher yield compared to the others. Giza 111 and H_4L_4 ranked second. The converse was true for Crawford and $H_{29}L_{115}$. This indicates that Misr 10 has a higher resistance to insect attacks, as shown in Tables 5 and 6. This resistance allows for increased dry matter accumulation. These findings are consistent with previous studies by Abdel-Wahab *et al.* (2019) and Abdel-Wahab and Naroz (2023), which also reported significant variation among soybean genotypes in terms of seed yield/plant.

In the first season, Misr 10 and Giza 111 had a heavier 100-seed weight compared to the others. In the second season, Misr 10 had the heaviest 100-seed weight, followed by Giza 111. These results suggest that these cultivars have a mechanism to transfer dry matter from their organs to the seeds, even when infested by insects. Crawford had a lighter 100-seed weight than the others in the first season. In the second season, Crawford and Giza 82 had lighter 100-seed weight, which can be attributed to their higher leaf N content allowing insects to feed on their leaves. These findings are in parallel with Serag *et al.* (2019), who showed that there was significant variation among soybean genotypes for 100-seed weight.

Misr 10 had a higher seed yield/ha compared to the others. Giza 111 and H_4L_4 ranked second. The converse was true for Crawford and $H_{29}L_{115}$. This indicates that Misr 10 has a higher resistance to insect attacks, as shown in Tables 5 and 6, which leads to increased dry matter accumulation. Similar results were found by Morsy *et al*. (2011) and Abdel-Wahab *et al*. (2019), who observed significant variation in seed yield among soybean genotypes. El-Khayat *et al*. (2019) identified three genotypes with high yield and low pest infestation. Additionally, Mandiæ *et al*. (2020) suggested that selecting the right genotype with a starter dose of 60 kg N/ha with rhizobial inoculation can contribute to achieving high yields.

Misr 10 and Giza 111 exhibited higher HI compared to the others. The converse was true for Crawford. These results are in parallel with Abdel-Wahab and Naroz (2023), who observed significant variation in HI among soybean genotypes.

The interaction between mineral N fertilizer rates and soybean genotypes

The second season's results revealed significant effects of mineral N fertilizer rates × soybean genotypes on seed yield/plant and seed yield/ha (Table 7). Comparing to N_3, N_1 did not decrease seed yield/plant or seed yield/ha of Misr 10. In fact, growing Misr 10 with N_1 increased seed yield/plant or seed yield/ha compared to Giza 111 with N_3. Comparing to N_3, N_2 did not decrease seed yield/plant or seed yield/ha of Giza 111. Decreasing the mineral N fertilizer rate from 100 to 67% N can maintain a higher yield potential for Misr 10 due to its resistance to insect attack.

CONCLUSION

Based on the results, growing Misr 10 with an application of 71.4 kg N/ha increased soybean productivity. Additionally, this method resisted the insect attack (cotton leaf worms, whiteflies and leaf miners). On the other hand, growing Giza 111 with an application of 35.7 kg N/ha, along with seed inoculation, also increased soybean productivity along with fewer cotton leaf worms and leaf miners.

Conflict of interest

The authors declare no competing interests.

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