Inorganic Fertilization of Cotton Field-Plants In Relation To Sucking Insects and Yield Production Components of Cotton Plants

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Abstract: In modern agriculture, the most critical problem for increasing yield and developing sustainable agriculture is sufficient fertilizers supply and successful crop protection against herbivores and pathogens. Field experiments were conducted at Sakha Agricultural Research Station, Egypt to investigate the influence of nitrogen (N), phosphorus (P) and potassium (K) fertilizers at their recommended rates per feddan (NPK units ratio of 66:30:24) on the population densities of jassid, *Impoasca* spp.; cotton aphid, *Aphis gossypii* Glover and whitefly, *Bemisia tabaci* Gennadius infesting cotton plants cv. Giza 89 during 2009 and 2010 seasons. Also, the effect of tested fertilizers on cotton plants growth was studied. Seven fertilizer treatments i.e. N, P, K, NP, NK, PK and NPK were evaluated. Obtained results indicated that nitrogen fertilizer significantly reduced the population density of *Impoasca* spp. whereas, it enhanced the population densities of both *A. gossypii* and *B. tabaci* in the two seasons of study. Plants fertilized with potassium either alone or in combinations with others were significantly infested with the lowest population densities of *Impoasca* spp. and *A. gossypii* and were infested with moderate numbers of *B. tabaci*. Phosphorus fertilizer proved to be very effective in lowering the incidence of *B. tabaci* on treated plants, but it increased the density of *Impoasca* spp. significantly. Plants treated with NPK in combination were infested with moderate population densities of the three insects. In both seasons of our study, the highest average numbers of squares and green bolls per cotton plant were observed on plants treated with NPK. On the contrary, plants which fertilized with K only significantly fruited the lowest means of squares and green bolls per plant. Further studies should be done to limit the adequate combination of N, P and K for cotton maximum production and minimum insects infestation under Egyptian agricultural conditions.

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1. Introduction:

Cotton is still among the most important commercial crops in Egypt and occupies a preeminent place in the Egyptian national economy (**Mesbah *et al*., 2004**). Cotton is an excellent reproductive host with many sucking insects such as whitefly, *Bemisia tabaci*; cotton aphids, *Aphis gossypii*, and jassids, *Impoasca spp.* In the last few decades, these pests became very serious pests of cotton and many other crop plants in tropical and subtropical areas of the world (**Butler *et al*., 1985 and Leclant and Deguine, 1994**).

Cultural control methods are very important component of integrated pest management programs, including adequate inorganic fertilization kinds and amounts. Cotton yield quality and quantity largely depends upon synthetic fertilizers input in modern agriculture, whereas the occurring of insect herbivores is closely related to the nutrient status in plant tissues supplied by the soil fertilization (**Ai *et al*., 2011**). One of the most important factors influencing the performance of herbivorous insects is nitrogen level in their diet (**Douglas, 1993**). The more synthetic fertilizer application, especially nitrogen (N) fertilizer, the more serious insect herbivores occurrence and crop damage from these insects by reducing plant resistance (**Bi *et al*., 2001; Ge *et al*., 2003**). Plant nutritional quality and plant defenses that directly act on herbivores are altered by N fertilization, and herbivorous insects can distinguish between plants receiving different N applications (**Prudic *et al*., 2005 and Chen *et al*., 2008**). Reducing fertilizer applications can reduce production costs for cotton growers, as well as nitrogen (N) leaching into the soil and contamination of surface and ground water, but altered N fertilization may also affect pests and their natural enemies (**Chen and Ruberson, 2008**).

Potassium (K) has been considered a key component of plant nutrition that significantly influences crop growth and some pests infestation. Potassium fertilizer is negatively associated with occurrence of *Aphis glycines* (**Myers and Gratton, 2006**) and leafhoppers and mites (**Parihar and Upadhyay, 2001**). Cotton aphid population density at seedling stage was suppressed by potassium fertilizers in proper rate (**Ai *et al*., 2011**).

Many studies has been done on the effect of nitrogen rates on the population density of sucking pests, but no information are available at present on the effect of combined application of nitrogen, phosphorus and potassium (**Purohit and Deshponde, 1991**).

The objectives of this work were directed to study the effects of nitrogen, phosphorus and potassium fertilizers either alone or in combinations on the population densities of *A. gossypii* Glover, *B. tabaci* Gennadius *and Impoasca* spp. under field conditions. Also, the effects of these fertilization applications on growth of cotton plants were studied in the field.

2. Material and Methods

2.1. Experimental design:

The experiments were conducted at the Farm of Sakha Agricultural Research Station. An area of approximately 5000 m^2 (1/2 hectare) was selected to be sown with cotton seeds var. Giza 89 on April 15, 2009 and 2010 seasons and divided into plots each of 175 m^2. The fertilizers used in this study were ammonium nitrate 33% N, superphosphate 15% P_2O_5 and potassium sulphate 48% K_2O as sources of nitrogen (N), phosphorus (P) and potassium (K), respectively. The recommended units of each fertilizer kind per feddan representing N:P:K ratio of 66:30:24 were applied. Seven treatments of fertilization named N, P, K, NP, NK, PK and NPK were studied. Each treatment was repeated in four plots (i.e. four replications). Half of nitrogen fertilizer amount was applied with the first irrigation post thinning and the rest applied with the next irrigation. The total amount of phosphorus fertilizer was added to the soil during the preparation steps before sowing. All the amount of potassium fertilizer were applied at once in early square development stage. All others agricultural practices were applied normally without using insecticidal treatments. The complete randomized blocks design with four replicates was adopted.

2.2. Sampling of studied insects:

2.2.1. Representative population densities of jassid, *Impoasca* spp. and cotton aphid, *Aphis gossypii* Glover:

The sampling started immediately after the thinning of cotton seedlings and continued until approximately 80% opening of the green bolls. 25 cotton leaves were sampled weekly from each plot early in the morning from three different levels of the plant (2, 1 and 2 leaves/plant from upper, middle and lower levels, respectively). The upper and lower surfaces of the randomly chosen cotton leaves were carefully examined using lens (5x) to count all individuals of *Impoasca* spp. and *A. gossypii* and the data were recorded (Hassanein *et al*., 1971).

2.2.2. Representative population density of whitefly *Bemisia tabaci* Gennadius:

For scouting the population density of *B. tabaci*, 25 cotton leaves were randomly chosen from each plot and picked up weekly from the levels mentioned above. The chosen leaves were transmitted to the laboratory in paper bags where binocular-microscope was used to count the immature stages of *B. tabaci* (nymphs and pupae). The duration of sampling as mentioned before.

2.3. Effect of fertilization on cotton plant growth:

Weekly samples of 10 cotton plants from each plot (i.e. replicate) were inspected to count the numbers of plant nods, squares and green bolls according to the method adopted by Shaaban and Radwan (1974). Sampling was initiated after the seedlings thinning and continued until nearly 80% opening of green bolls.

2.4. Statistical analysis:

All sampling data of the studied insects populations were presented as numbers per 100 cotton leaves all through the investigation period (18 weeks). The sampling data of cotton plants nods, squares and green bolls were transferred into numbers per one cotton plant and drawn for every fertilization treatment. The means of numbers for each fertilization treatment were calculated and compared with one-way analysis of variance (ANOVA). Duncan's multiple range test was used to determine significant differences ($P<0.05$) between treatments (means of numbers for each fertilization treatment) by CoStat system for Windows, version 6.311, Berkeley, CA, USA, CoStat Program (2006).

3. Results

Field experiments were conducted to study the effects of fertilizer element kind, either alone or in combinations with its recommended rate in N:P:K units ratio of 66:30:24, on the population densities of *Impoasca* spp., *A. gossypii* and *B. tabaci*. Also, the effects on the growth of cotton plants were studied. Seven fertilization treatments named, N, P, K, NP, NK, PK and NPK were tested.

3.1. Effect of fertilization treatments on population densities of *Impoasca* spp., *A. gossypii* and *B. tabaci*:

3.1.1. Effect on population density of *Impoasca* spp.:

The population density of *Impoasca* spp. was higher in 2009 than that in 2010 cotton season and displayed three main peaks on 22 June, 27 July and 24 August in both years (Table 1). From data shown in Table (1), it is obvious that, the fertilizer element kind and the fertilization treatments significantly affected the population densities of *Impoasca* spp. In case of cotton plants treated with fertilization element in a single form, plants fertilized with K were infested with the lowest mean of *Impoasca* spp. population densities (34.56 and 29.33 insects/100 cotton leaves in 2009 and 2010 seasons, respectively). On the contrary, plants fertilized with P infested with the highest mean of *Impoasca* spp. population densities (49.11 and 43.22 insects/100 cotton leaves in 2009 and 2010, respectively). When fertilization elements were applied to cotton plants in combinations, plants fertilized with NP were significantly infested with the highest mean of *Impoasca* spp. population densities per 100 cotton leaves in 2009 and 2010 seasons (57.11 and 51.72 individuals, respectively). The population density at plants treated with NK was significantly the lowest at all with comparison to the different fertilizers combinations used in this study (2009: $f = 43.79$, $P<0.05$; 2010: $f=12.96$, $P<0.05$).

3.1.2. Effect on population density of cotton aphid, *Aphis gossypii*:

Cotton aphid appeared in low numbers at early samples and gradually increased with time elapsing of cotton growing season. Cotton aphid population was differentially influenced by fertilization treatment and formed one main peak time of the population on 10 August in both 2009 and 2010 seasons (Table 2).

The population density of aphid was higher in 2009 than that in 2010 season. Data presented in Table (2) obviously indicated that cotton plants fertilized with N only in a single form were infested with the highest mean of aphid population density in 2009 and 2010 season (397.72 and 316.33 aphid/100 cotton leaves, respectively) and significantly differed from that in plants treated with P and K (2009: $f=58.70$, $P<0.05$; 2010: $f = 64.31$, $P<0.05$). In case of combined fertilization, plants fertilized with NPK in balanced way were infested with the lowest population densities of aphid per 100 cotton leaves in both of 2009 and 2010 seasons (231.56 and 196.17). The aphid densities of plants treated with NP combination were significantly the highest comparing with the other three tested fertilizers combinations (i.e. NK, PK and NPK) recording 330.44 and 277.06 aphids/100 cotton leaves as mean of population densities in 2009 and 2010, respectively.

3.1.3. Effect on population density of cotton whitefly, *Bemisia tabaci*:

Data of population fluctuation of *B. tabaci* immature stages throughout the scouting period (from early June to late September) in 2009 and 2010 seasons were presented in Table (3). It is intelligible that *B. tabaci* population density was more abundant in 2010 than 2009 season and displayed two distinct peaks on 20 July and 24 August in both seasons but the population densities at the peaks time were significantly influenced by the fertilization treatments. Cotton plants fertilized with nitrogen only (N) and did not receive any other fertilizers during the growing season were infested with the highest mean of *B. tabaci* population per 100 cotton plants (156.78 and 240.67 insects in 2009 and 2010, respectively) and significantly differed from that on plants fertilized with P or K (2009: $f=13.14$, $P<0.05$; 2010: $f=23.84$, $P<0.05$). Combined fertilization significantly affected the population densities of *B. tabaci* in both 2009 and 2010 cotton seasons. Plants treated with PK were infested with the lowest mean of the pest per 100 cotton leaves (106.11 and 151.28), followed by that treated with NPK (122.83 and 180.50), NK (125.56 and 186.72) and NP (130.06 and 197.78) in 2009 and 2010 cotton growing seasons, respectively.

3.2. Effect of fertilization treatments on cotton plants:

Growth of cotton plants was significantly affected by different fertilization treatments particularly the presence of nitrogen element in added fertilizers. Cotton plants fertilized with NPK fruited the highest accumulative total of average squares per plant (200.1 and 212.1) followed by that fertilized with NP (177.9 and 183.6), NK (169.8 and 184.9) and N (150.8 and 165.1) in 2009 and 2010 seasons, respectively with significant differences in between (2009: $f=106.56$, $p<0.05$; 2010: $f=195.20$; $P<0.05$) (Fig. 1 a,b). Data presented in Fig. (2 a,b) elucidated that the highest accumulative totals of average green bolls per cotton plant were produced on plants that treated with NPK (126.1 and 142.7) followed with plants fertilized with N (106.7 and 116.7), NP (105.8 and 111.0) and NK (98.1 and 108.9) in 2009 and 2010 seasons, respectively. N fertilizer significantly increased the produced number of green bolls per plant in both seasons (2009: $f=58.75$, $P<0.05$; 2010: $f=178.68$, $P<0.05$). N application significantly affected cotton plant height representing in increase of nodes number in both seasons of study (2009: $f=64.0$, $P<0.05$; 2010: $f=61.04$, $P<0.05$). Significantly the lowest plant growth and number of plant nodes were recorded in plants received fertilization treatments did not include nitrogen element (Fig. 3 a,b).

4. DISCUSSION

4.1. Effect of fertilization treatments on population densities of *Impoasca* spp., *A. gossypii,* and *B. tabaci*:

The nutrition requirements for cotton growth are mostly from soil supply during growing stages and nitrogen, phosphorus and potassium are very important nutrient elements for crop growth and development. The concentration of each element in the soil affects the absorption of growing plants to the other elements. The obtained results indicated that different fertilization treatments significantly affected the preferability of cotton plants to studied insects infestation and their population densities. Amtmann *et al*. (2008) suggested that potassium ion from soil supply may affect a number of physiological, metabolic and hormonal processes in plant tissues. These processes are likely to be crucial for plants' susceptibility or resistance to pathogens and insects. Ai *et al*. (2011) stated that the occurrence of insect herbivores is closely related to the nutrient status in plant tissues supplied by soil fertility.

Our results revealed that the vital role of fertilizer element either applied alone or in combinations on the population densities of sucking insects. Cotton plants treated with potassium and/or nitrogen fertilizers were less preferable to *Impoasca* spp. infestation, while that treated with phosphorus fertilization were highly infested with *Impoasca* spp. Krausus (2001) reported that high levels of potassium can enhance secondary compound metabolism, reduce carbohydrate accumulation and plant damage from insect pests. Also, potassium fertilizer, in this study, significantly decreased the aphid population density and reduced the infestation level of cotton plants with aphids. On the contrary, plants fertilized with nitrogen either alone or in combinations with other fertilizers were infested with the highest means of aphid population densities in both seasons of study. Cisneros and Godfery (1998) reported that nitrogen affected the population dynamics of naturally occurring aphids with higher densities in plots receiving high N rates. Godfery *et al*. (1999) mentioned that high levels of nitrogen fertilization appear to promote increased cotton aphid reproduction and the build-up of high in-field aphid populations. The results of our study cleared the important role of phosphorus fertilizer in cotton plants infestation with *B. tabaci*. In both seasons of study, cotton plant treated with phosphorus element only were infested with the lowest *B. tabaci* population density and the same direction occurred in case of combination of phosphorus and potassium. *B. tabaci* population density was significantly and positively affected by nitrogen fertilization either alone or in combined treatments. Buttur *et al*. (1996) indicated that soil application of phosphorus at 30 kg/ha considerably reduced the mean population of whitefly nymphs and adults. Bi *et al*. (2003) observed a positive response between N application rates and the numbers of adult and immature whiteflies appearing during population peaks. Ahmed *et al*. (2007) found that the highest rates of nitrogen resulted in the highest per leaf mean population of jassid, whitefly and thrips.

4.2. Effect of fertilization treatments on cotton plant growth:

In modern agriculture, there is urgent need for increase crop yield, thus sufficient nutrient supply and successful crop protection against insects and diseases is the most critical problem faces the agriculturists. Ideal growth of cotton plants required balanced fertilization containing both of nitrogen, potassium and phosphorus elements with adequate amounts of each. Increasing nitrogen fertilizer enhanced cotton foliar photosynthetic rates and altered concentrations of glucose, fructose and sucrose in cotton petioles (Bi *et al*., 2001). Our results indicated that nitrogen fertilizer was the most important in cotton plants growth and green bolls yield, where plants treated with nitrogen either alone or in combinations with other elements (N, NP, NK and NPK) produced higher squares and green bolls than that treated without nitrogen fertilizer (P, K an PK). In our study, plants treated with balanced fertilization (NPK) fruited the highest green bolls at all. Rustamani *et al*. (1999) reported that cotton plants which received recommended doses of nitrogen along with higher doses of phosphorus fertilizer yielded significantly higher seed cotton than other fertilizer levels. El-Tabbakh (2002) found that plants fertilized with 142 kg N/ha gave the highest seed cotton yield, lint percentage and the heaviest bolls and seeds comparing to that fertilized with 71 and 214 kg N/ha. Bauer and Roof (2004) showed that grown cotton plants without nitrogen fertilization tended to have lower yield, fiber length and micronaire than nitrogen fertilized ones. Under rainfed conditions, Tayade and Dhoble (2009) indicated that application of cotton plants with 80:40:40 and 100:50:50 of N:P:K were equally effective in enhancing growth and yield attributes.

Table (1): Population density of *Impoasca* spp./100 cotton leaves as influenced by fertilizer treatments during 2009 and 2010 seasons

Fertilizer Treat.	Number of *Impoasca* spp./100 cotton leaves at indicated dates of scouting																			
	Season 2009																			
	1/6	8/6	15/6	22/6	29/6	6/7	13/7	20/7	27/7	3/8	10/8	17/8	24/8	31/8	7/9	14/9	21/9	28/9	Total	Mean
N	45	39	46	55	44	34	33	40	67	45	37	33	49	36	23	31	24	20	701	38.94 d
P	49	68	85	109	76	55	44	42	60	46	35	29	52	30	26	25	28	25	884	49.11 b
K	42	44	49	72	37	29	26	29	51	27	25	27	51	34	22	20	19	18	622	34.56 e
NP	45	50	70	115	74	60	48	53	78	52	48	59	85	57	37	34	33	30	1028	57.11 a
NK	44	46	51	63	38	31	42	42	60	36	21	41	67	33	26	29	23	32	725	40.28 d
PK	37	40	60	94	53	35	36	65	77	45	29	49	82	48	36	26	27	25	864	48.00 b
NPK	42	50	58	75	55	46	43	57	71	46	38	27	54	26	34	28	21	31	802	44.56 c
	Season 2010																			
N	42	36	41	47	39	28	27	35	59	42	31	28	39	31	19	25	20	16	605	33.61 cd
P	44	66	83	99	71	48	39	35	50	41	28	23	43	25	21	21	23	18	778	43.22 b
K	39	41	44	65	32	24	21	25	42	22	19	22	45	29	17	15	14	12	528	29.33 d
NP	40	47	71	109	69	54	43	48	68	47	42	54	75	51	32	29	28	24	931	51.72 a
NK	41	44	45	53	33	27	37	36	53	31	15	37	59	28	21	24	18	17	619	34.39 cd
PK	34	37	56	83	48	29	30	59	67	41	23	44	73	42	30	20	25	19	760	42.22 b
NPK	37	48	53	68	50	42	39	53	62	41	32	22	44	21	28	22	15	25	702	39.00 bc

Within a column in the same season, means followed by the same letter are not significantly different using DMRT (2009: f=43.79, P<0.05; 2010: f=12.96, P<0.05)

Table (2): Population density of *Aphis gosspyii*./100 cotton leaves as influenced by fertilizer treatments during 2009 and 2010 seasons

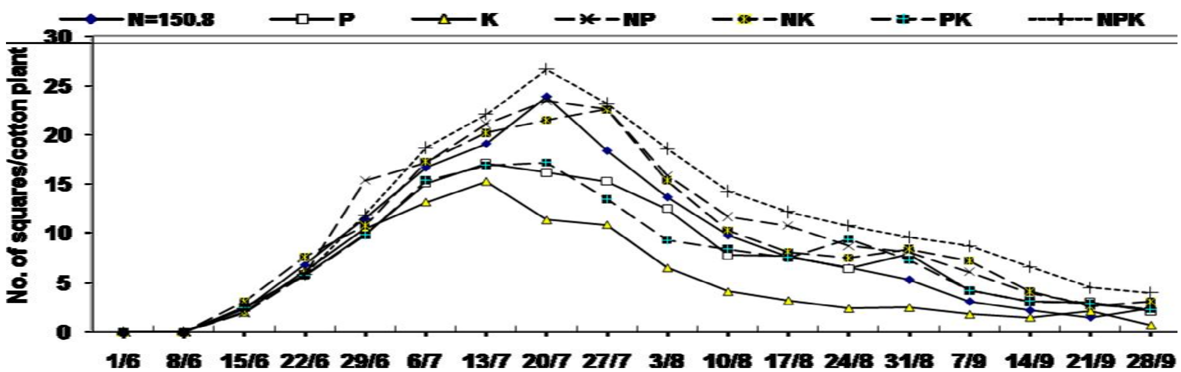
Fertilizer Treat.	Number of *Aphis gossypii*/100 cotton leaves at indicated dates of scouting																			
	Season 2009																			
	1/6	8/6	15/6	22/6	29/6	6/7	13/7	20/7	27/7	3/8	10/8	17/8	24/8	31/8	7/9	14/9	21/9	28/9	Total	Mean
N	6	18	21	35	42	65	83	319	554	849	1690	1271	692	540	508	131	155	180	7159	397.72 a
P	5	10	14	25	39	50	70	215	490	670	1260	980	640	470	305	150	85	37	5515	306.39 c
K	9	15	17	23	30	42	50	207	465	616	1173	1060	766	592	178	75	78	50	5446	302.56 c
NP	2	6	10	15	35	58	66	270	470	713	1390	1116	520	490	380	204	105	98	5948	330.44 b
NK	8	10	21	19	32	41	52	130	520	809	1230	1090	615	320	219	131	87	61	5395	299.72 c
PK	1	9	15	30	43	60	80	190	315	670	1111	994	691	470	312	110	95	72	5268	292.67 c
NPK	7	9	13	25	39	52	69	210	320	512	942	716	520	314	191	121	65	43	4168	231.56 d
	Season 2010																			
N	8	9	10	15	27	47	103	339	584	779	1291	622	548	431	315	220	161	185	5694	316.33 a
P	5	8	12	20	16	53	66	196	512	699	1035	595	459	222	135	105	73	51	4262	236.78 c
K	4	6	9	14	14	39	80	217	492	636	873	432	341	201	121	85	78	37	3679	204.39 d
NP	2	5	9	16	22	53	100	296	528	591	1123	550	558	411	298	221	134	70	4987	277.06 b
NK	6	9	15	21	25	34	94	251	430	630	1043	495	410	315	210	152	109	86	4335	240.83 c
PK	3	6	10	18	22	40	83	221	483	570	915	410	367	291	182	121	51	16	3809	211.61 d
NPK	5	7	11	14	17	35	85	201	471	592	830	421	312	198	151	94	62	25	3531	196.17 d

Within a column in the same season, means followed by the same letter are not significantly different using DMRT (2009: f=58.31, P<0.05; 2010: f=64.31, P<0.05)

Table (3): Population density of *Bemisia tabaci* immature stages/100 cotton leaves as influenced by fertilizer treatments during 2009 and 2010 seasons.

Fertilizer Treat.	Number of *Bemisia tabaci* immature stages/100 cotton leaves at indicated dates of scouting																			
	Season 2009																			
	1/6	8/6	15/6	22/6	29/6	6/7	13/7	20/7	27/7	3/8	10/8	17/8	24/8	31/8	7/9	14/9	21/9	28/9	Total	Mean
N	2	5	7	13	28	56	139	238	217	243	279	285	320	247	222	198	171	152	2822	156.78 a
P	1	3	5	9	12	39	102	160	131	142	203	210	262	207	148	121	105	87	1947	108.17 c
K	1	2	6	10	15	44	111	146	142	159	217	236	283	218	164	139	115	98	2106	117.00bc
NP	2	4	7	12	27	45	149	249	179	190	205	234	294	195	178	150	121	100	2341	130.06 b
NK	2	5	8	15	21	49	160	239	173	185	195	217	264	185	168	131	118	125	2260	125.56 b
PK		5	9	12	18	47	117	168	147	162	184	196	232	167	140	122	105	76	1910	106.11 c
NPK	1	3	6	11	23	58	142	217	165	179	195	239	261	186	160	153	115	97	2211	122.83 b
	Season 2010																			
N	4	10	14	22	30	74	178	376	334	386	458	470	540	394	344	298	219	181	4332	240.67 a
P	2	6	8	10	16	38	104	220	160	184	304	320	424	314	196	171	148	113	2738	152.11 d
K	4	8	10	16	20	48	122	192	184	218	334	372	466	336	228	201	185	145	3089	171.61 c
NP	5	9	13	19	34	52	197	395	258	280	313	369	489	290	256	220	190	171	3560	197.78 b
NK	3	8	11	18	25	38	219	377	246	271	290	354	429	271	236	211	192	162	3361	186.72bc
PK	4	6	9	15	19	51	134	236	195	224	268	313	365	239	194	175	151	125	2723	151.28 d
NPK	2	7	9	11	24	73	181	333	219	252	300	358	431	273	231	205	189	151	3249	180.5 bc

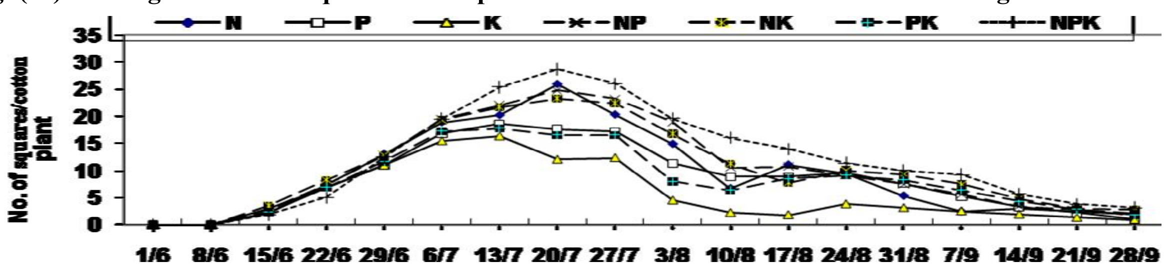
Within a column in the same season, means followed by the same letter are not significantly different using DMRT (2009: f=13.14, P<0.05; 2010: f=23.84, P<0.05)



Fertilizer treatment	N	P	K	NP	NK	PK	NPK
Accumulative total of squares/plant during the season	150.8 c	136.6 d	94.3 e	177.9 b	169.8 b	135.4 d	200.1 a

Different letter following accumulative totals denote significant difference at P<0.05 (f = 106.56, DMRT)

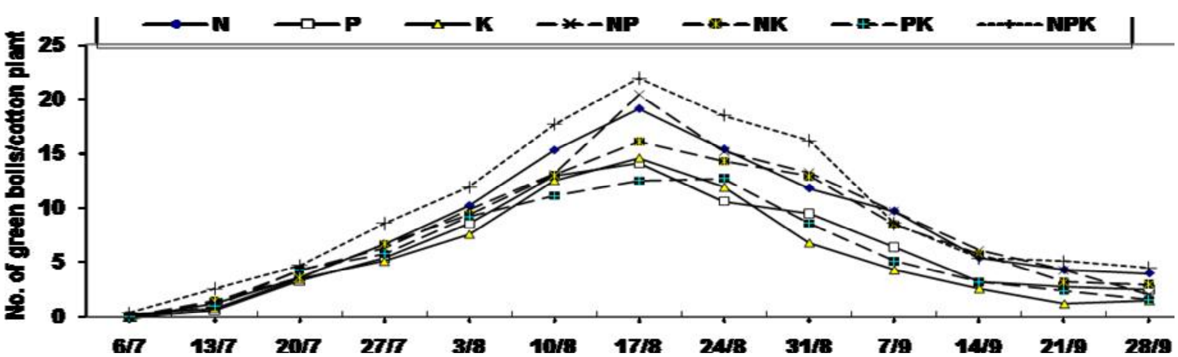
Fig. (1a): Average number of squares/cotton plant in relation to fertilizer treatments during 2009 season.



Fertilizer treatment	N	P	K	NP	NK	PK	NPK
Accumulative total of squares/plant during the season	165.1 c	149.5 d	98.6 e	183.6 b	184.9 b	145.1 d	212.1 a

Different letter following accumulative totals denote significant difference at P<0.05 (f = 195.20, DMRT)

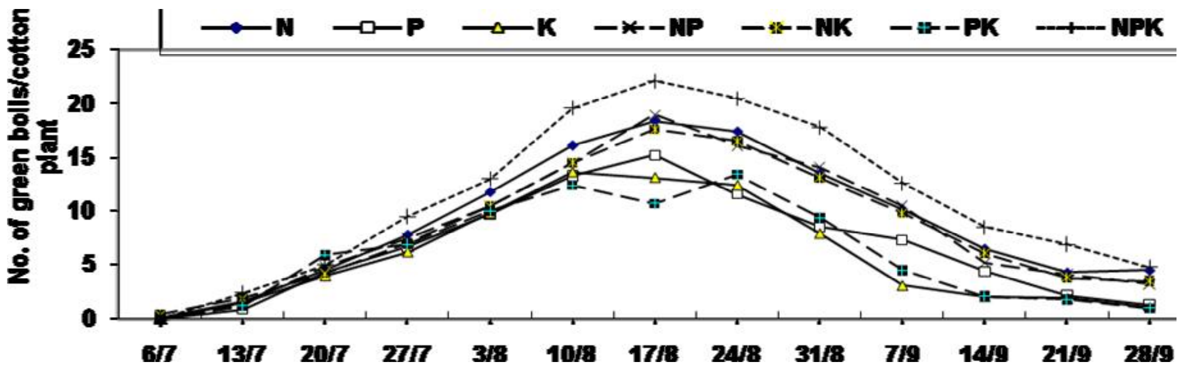
Fig. (1b): Average number of squares/cotton plant in relation to fertilizer treatments during 2010 season.



Fertilizer treatment	N	P	K	NP	NK	PK	NPK
Accumulative total of green bolls/plant during the season	106.7 b	79.9 d	72.6 d	105.8 b	98.1 c	77.5 d	126.1 a

Different letter following accumulative totals denote significant difference at P<0.05 (f = 58.75, DMRT)

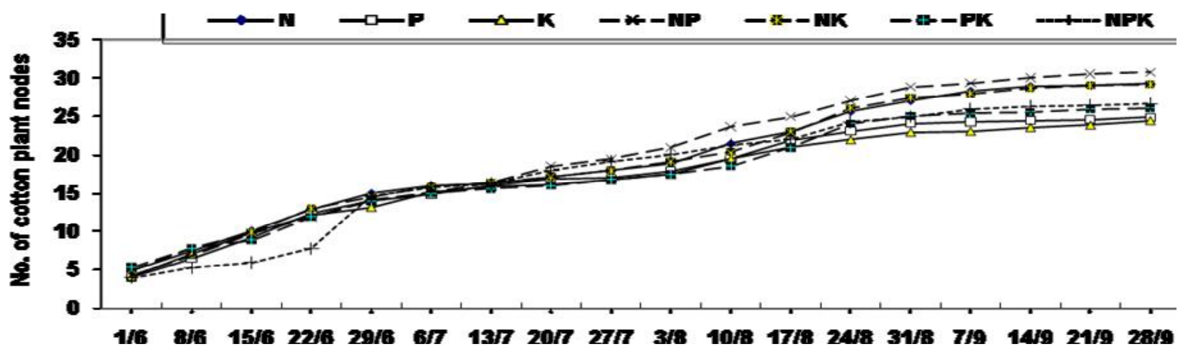
Fig. (2a): Average number of green bolls/cotton plant in relation to fertilizer treatments during 2009 season.



Fertilizer treatment	N	P	K	NP	NK	PK	NPK
Accumulative total of green bolls/plant during the season	116.7 b	85.4 d	76.7 e	111.0 c	108.9 c	79.3 e	142.7 a

Different letter following accumulative totals denote significant difference at P<0.05 (f = 178.68, DMRT)

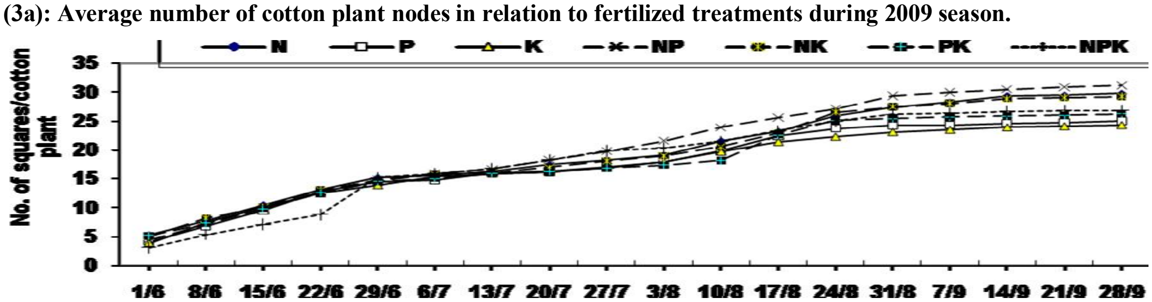
Fig. (2b): Average number of green bolls /cotton plant in relation to fertilizer treatments during 2010 season.



Fertilizer treatment	N	P	K	NP	NK	PK	NPK
Accumulative total of nodes/plant during the season	350.0 b	315.9 de	308.6 e	363.2 a	349.0 b	320.8 cd	325.3 c

Different letter following accumulative totals denote significant difference at P<0.05 (f = 64.00, DMRT)

Fig. (3a): Average number of cotton plant nodes in relation to fertilized treatments during 2009 season.



Fertilizer treatment	N	P	K	NP	NK	PK	NPK
Accumulative total of nodes/plant during the season	353.8 b	318.8 de	312.4 e	370.1 a	350.0 b	326.1 cd	333.8 c

Different letter following accumulative totals denote significant difference at P<0.05 (f = 61.04, DMRT)

Fig. (3b): Average number of cotton plant nodes in relation to fertilizer treatments during 2010 season.

Conclusion

Excessive application of fertilizers in cotton fields, especially nitrogen fertilizers, to increase crop yield and pest management is generally adverse. Majority of Egyptian farmers fertilized cotton plants using nitrogen and phosphorus fertilizers only. Results of our study indicated the importance of these two fertilizers in addition to potassium one in ideal growth of cotton plans to produce the highest yield and reduce the insects population densities. More studies should be done to limit the optimum combination of N, P and K for cotton high production under agricultural conditions of Egypt.

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