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Nitrogen Fertilizer Application in Maize and Its Impact on the Development of *Chilo partellus* (Lepidoptera: Pyralidae)

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Abstract.- The current experiment was conducted to check the efficacy of different nitrogen doses on the bionomics of maize stem borer *Chilo partellus* (Lepidoptera: Pyrlidae) under laboratory and field conditions applied on three maize hybrids *i.e.*, KK-8711, KWS-55 and KS-85. The results revealed that the body weight (mg) and frass weight (mg) of larvae positively correlated with nitrogen levels. There was a significant difference in weight gained by larval instars at various nitrogen applications with highest weight (0.085mg/l) at N4 (150KgN/ha) and minimum (0.078mg/l) at N0 (0KgN/ha). Identical results were observed for the frass weight of different larval instars while maximum frass weight i.e., 0.018 mg was recorded for fifth instar fed on KWS-55 with the application of N4, while minimum frass weight of fifth instar i.e., 0.012 mg fed on KK-8711 applied with N0 and N1. Significant difference for weight gained by the larvae on all three hybrids was recorded but 5^{th} instar maximum larval weight 0.078 mg was recorded by feeding on KWS-55 while minimum 0.066 mg on KK-8711. Cumulative field data analysis showed significant difference among the average maize borer/plant at different nitrogen doses (N0-N4). Maximum number of *C. partellus* (2 larvae/ plant) was found on KWS-55 at (N4) while minimum (0 larvae / plant) was found on KK-8711. The results suggest that the population development of maize borer is dependent on the application of nitrogen doses.

Keywords: Maize, nitrogen, maize borer, pest scouting, development, fertilizers.

INTRODUCTION

Maize accounts for 4.8% of the total cropped area and is the third high yielding major food crop among cereals after wheat and rice in Pakistan, especially in the eastern regions. Maize crop contains genetic diversity and it can be grown in various ecological zones (Ferdu *et al.*, 2002), moreover it is gaining importance owing to being a commercial/industrial crop, where a number of products are being manufactured out of its grains (Chaudhary, 1993).

Maize crop has high yield potential and responds to various agro-management practices. Low yield of maize is owing to many constraints but imbalanced use of fertilizers, traditional sowing methods and insect pests attack are more important. Significant contribution in low yield has been due to the insect pests attack (Rehman and Rehman, 1986). Insects and pathogens out break may possibly reduce yield up to 75% and even total crop failure might happen in case of severe infestation (Kumar and Mihm, 1995; Kumar, 2002; Moyal, 1998). Maize is being attacked by a number of insect pest species and in Pakistan maize is attacked by nearly one hundred insect species. It is accounted that most notorious maize pests are mostly lepidopteron stem borers (Songa *et al.*, 2000; Singh and Sharma, 1984). Several species of maize stem borer have been reported as most damaging pest of maize crop, but spotted stem borer, *Chilo partellus* (Swinhoe) (Lepidoptera: Pyralidae) is most notorious for its damage (Jotwani *et al*., 1971).

Numerous factors enhance the insect pest problem in field either by manipulating the environment, favorable for growth, reproduction and development of insects including traditional cultural methods, unrestricted use of chemicals (insecticides) and imbalanced use of fertilizers (Karimullah, 1986; Mathews, 1983). Nitrogen, phosphorus and potassium are fundamental nutrients for plant growth and development which play a basic role in metabolism and energy production in plants and significantly enhance the grain yield. Leaf area duration, leaf area index (LAI), and crop photosynthetic rate reduces under nitrogen stress (Uhart and Andrade, 1995), but its excessive use not only causes wastage of resources yet can also lead

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to pest problems by increasing the reproduction, longevity and overall fitness of definite pests. Damage to crops by insect pests amplifies with the application of fertilizers (Setamou *et al.*, 1993, 1995). On the other hand crop growth rate reduces under nitrogen stress that leads to decrease in kernel number and grain yield (Uhart and Andrade, 1995). Millet crop grown on high rates of nitrogen survives and following crop damages due to increased borer population amplified as compared to low rates of nitrogen fertilizer (Tanzubil *et al.*, 2006). It has been observed that the application of high doses of nitrogen fertilizer notably increases the number of egg masses deposited by Asian corn borer, *Ostrinia furnacalis* on maize leaves, which ultimately becomes a serious threat for the production.

The present study explicate the prevalence and preferences of *C. partellus* on different maize hybrids being used in the Punjab with different nitrogen applications under field conditions and in addition to check the effects of different nitrogen doses on larval development of *C. partellus* under laboratory conditions.

MATERIALS AND METHODS

Collection and rearing of C. partellus

C. partellus were collected from infested maize fields from Multan, Punjab, Pakistan. Rearing was done in the laboratory by providing fresh maize leaves as diet for larvae while adults were fed on 10% honey solution. The insect culture was maintained at 28±1°C, and 70±5% relative humidity.

Land preparation

The experiment was conducted at the research area of Department of Entomology, Bahauddin Zakariya University, Multan. All agronomic practices including weeding, ploughing etc. were performed on the land prior to seed beds preparation. The field measuring 51.22m × 16.5 m was divided into fifteen plots with dimensions of 4.2×3ft while a distance of 45cm was kept between the plots. The three maize hybrids *viz.*, KK-8711(H1), KWS-55(H2) and KS-85(H3) treated with fungicides were sown with row to row spacing 75cm, while a distance of 22 cm was retained between adjoining plots using a seed rate of 30 $kgha^{-1}$. Each plot received one of five levels of nitrogen 0, 60, 90, 120, 150 kg N/ha (N0, N1, N2, N3, N4) in split dosages. First split at the time of sowing, then at 2nd and 3rd week after emergence. Full dose of phosphorous and potassium was applied at the time of sowing. Seedlings were later on thinned to one plant per place. Weeds were controlled through manual weeding to decrease competition for space, light, water and nutrients among the crops and weeds. All other agronomic practices except those under study were kept common and uniform for all the treatment combinations. The field borders were kept clean to lessen the encroachment with insects and rodents.

Data collection and statistical analysis

Scouting for the presence of *C. partellus* larvae started two weeks after emergence of maize and sampling was done weekly in the morning hours when the insects were less active and easier to spot. Larvae were counted per plant on randomly selected ten plants per plot. The experiment was laid out in a Randomized Complete Block Design (RCBD) with fifteen plots. The data was recorded weekly and the means were analyzed and compared by Duncan’s Multiple Range Test (DMRT) by using SAS (SAS, 2002).

For the laboratory studies, five randomly selected four weeks old plants from each plot (with different nitrogen doses) were uprooted and brought into the laboratory, washed with tap water and air dried. These plants were then cut into small pieces and provided to *C. partellus* larvae for feeding. There were five treatments including control containing five larvae of each instar per treatment and each treatment was replicated thrice. The diet was changed daily, feaces were separated and dried individually by placing into the drier. The larvae were observed continuously and the larval weight was recorded at each instar individually. The data were subjected to statistical analysis by using one way analysis of variance under Completely Randomized Design (CRD) by using SAS (SAS, 2002) and the means were compared by DMRT.

RESULTS

Effect of different nitrogen doses on the average number of maize borer per plants

The prevalence of *C. partellus* was recorded on maize hybrids with different nitrogen fertilizer applications under field conditions. The results showed significant difference among the average maize borer/ plant at various nitrogen doses (N0-N4). Maximum number of *C. partellus* (2 larvae/ plant) was found on KWS-55 (Fig. 3) while minimum (1.3 larvae/ plant) was recorded on KK-8711 at (N4) (Fig. 1). The maize hybrid KWS-55 was found to be more susceptible to maize borer attack as compared to other hybrids tested in the experiment (Figs. 1-3).

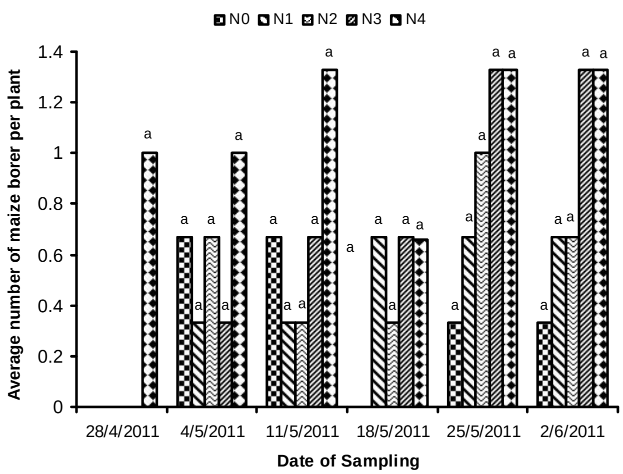

Fig. 1. Average number of maize borer per plant of KK-8711 on different sampling dates. For each date means sharing same letters are not significantly different (P < 0.0001) according to Duncan's Multiple Range Test (DMRT).

Effect of maize hybrids and nitrogen doses (N0-N4) on the weight (mg) gained by different larval instars of C. partellus

The effect of various nitrogen doses applied to maize hybrids was evaluated on the development of *C. partellus*. There was significant difference between the control (N0) and other treatments (N1-N4) on the larval weight gained by different instars of *C. partellus* on maize crop. Larval weight gained by 1st and 2nd instar on all nitrogen doses (N0-N4) for the three maize hybrids, showed no statistical difference (P<0.0001). The results indicated that maximum weight gained by the 3rd, 4th and 5th larval instar was recorded on N4 (150kg/acre), which showed statistically different results (Table I). Maximum weight of 0.03±0.002 for the 3rd instar larvae was obtained in KWS-55 and KK-8711 treated with N4. Parallel results were obtained for 4th and 5th instar larvae in which maximum larval weight of 0.065±0.002 and 0.008±0.002 was obtained from KWS-55 treated with N4.

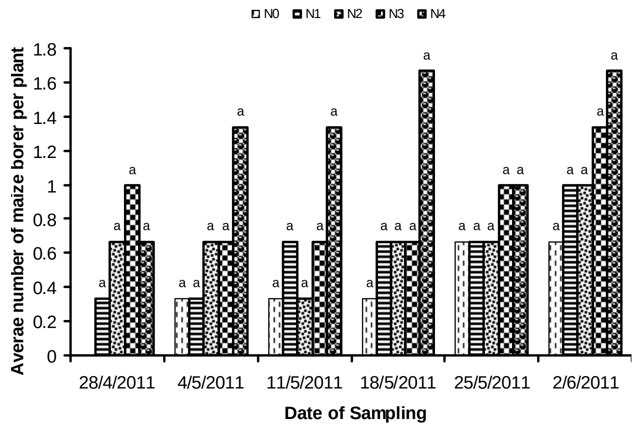

Fig. 2: Average number of maize borer per plant of KS-85 on different sampling dates. For each date means sharing same letters are not significantly different (P < 0.0001) according to Duncan's Multiple Range Test (DMRT).

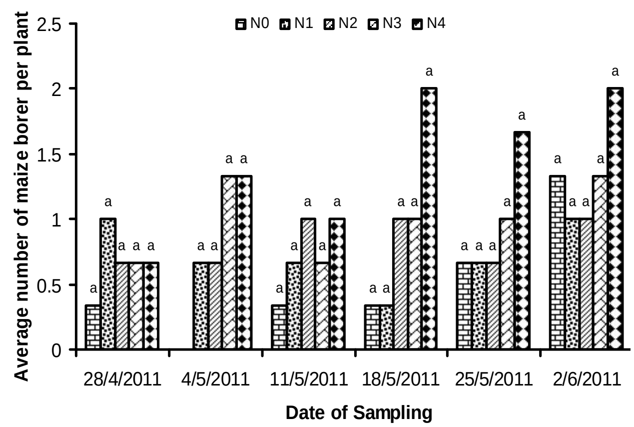

Fig. 3. Average number of maize borer per plant of KWS-55 on different sampling dates. For each date means sharing same letters are not significantly different (P < 0.0001) according to Duncan's Multiple Range Test (DMRT).

Table I.- **Effect of different nitrogen doses on larval weight (mg) gained by *C. partellus.***

Hybrids		1st	2nd	3rd	4th	5th
KK-8711	N0	0.0002±0.00004a	0.0062±0.0007a	0.016±0.0005c	0.047±0.001b	0.058±0.002c
	N1	0.0021±0.00002a	0.0012±0.0001b	0.016±0.0007c	0.048±0.001ab	0.061±0.001c
	N2	0.0002±0.00002a	0.0012±0.0001b	0.017±0.0005bc	0.05±0.002ab	0.068±0.001b
	N3	0.0002±0.00001a	0.0012±0.00007b	0.0185±0.0005b	0.015±0.001ab	0.07±0.002ab
	N4	0.0002±0.00001a	0.0013±0.0001b	0.03±0.001a	0.054±0.002a	0.073±0.001a
KS-85	N0	0.0002±0.00003a	0.0013±0.00008a	0.021±0.0008c	0.051±0.002b	0.072±0.001b
	N1	0.0002±0.00003a	0.0013±0.00008a	0.021±0.0005c	0.052±0.002b	0.072±0.001b
	N2	0.0002±0.00001a	0.0013±0.0001a	0.022±0.0007bc	0.055±0.002ab	0.073±0.001b
	N3	0.0002±0.00001a	0.0014±0.00007a	0.023±0.0002ab	0.056±0.0012ab	0.075±0.002ab
	N4	0.0002±0.00001a	0.0014±0.00007a	0.025±0.0007a	0.06±0.002a	0.078±0.001a
KWS-55	N0	0.0002±0.00003a	0.0014±0.00002b	0.025±0.0001b	0.055±0.002c	0.072±0.001d
	N1	0.0002±0.00003a	0.0014±0.00002b	0.025±0.0007b	0.057±0.001bc	0.075±0.002cd
	N2	0.0002±0.00003a	0.0014±0.00001b	0.026±0.001ab	0.059±0.001bc	0.077±0.001bc
	N3	0.0002±0.00001a	0.0014±0.00001b	0.028±0.001ab	0.062±0.001ab	0.08±0.002b
	N4	0.0025±0.00001a	0.0015±0.00002a	0.030±0.002a	0.065±0.002a	0.08±0.002a

Means (± SE) within column followed by the same letter are not significantly different at (P < 0.0001) according to Duncan's Multiple Range Test (DMRT)

Table II.- **Effect of different varieties of maize on the weight (mg) gained by different larval instars of *C. partellus***

Hybrids	1^{st} instar	2^{nd} instar	3^{rd} instar	4^{th} instar	5^{th} instar
KK-8711	0.0002±0.00001a	0.0022±0.0012a	0.0195±0.0005b	0.0503±0.0008c	0.0662±0.002c
KS-85	0.0002±0.000008a	0.0013±0.00003a	0.0223±0.0007b	0.0555±0.001b	0.0742±0.0005b
KWS-55	0.0002±0.000005a	0.0014±0.00001a	0.0269±0.0007a	0.0596±0.001a	0.078±0.001a

Means (± SE) within column followed by the same letter are not significantly different at (P < 0.0001) according to Duncan's Multiple Range Test (DMRT)

Table III.- **Effect of different varieties and nitrogen doses (N_0-N_4) on frass weight produced by different instars of *C. partellus.***

		N0	N1	N2	N3	N4
KK-8711	L1	0.001±0.0001b	0.001±0.0001b	0.001±0.0001c	0.001±0.0001c	0.001±0.0001c
	L2	0.002±0.0001b	0.002±0.0001b	0.002±0.0001bc	0.002±0.0001bc	0.002±0.00004bc
	L3	0.004±0.0005b	0.004±0.0005b	0.004±0.0004b	0.004±0.0003b	0.005±0.00008b
	L4	0.013±0.002a	0.136±0.002a	0.014±0.002a	0.014±0.002a	0.016±0.001a
	L5	0.012±0.001a	0.012±0.001a	0.012±0.001a	0.013±0.001a	0.014±0.001a
KS-85	L1	0.004±0.0003b	0.004±0.0003b	0.001±0.0001c	0.001±0.0001c	0.001±0.0001c
	L2	0.006±0.0002b	0.006±0.0002b	0.006±0.0002b	0.007±0.0002b	0.007±0.0002b
	L3	0.005±0.0001b	0.005±0.0001b	0.005±0.0002b	0.005±0.0004b	0.006±0.0003b
	L4	0.015±0.001a	0.015±0.001a	0.015±0.001a	0.016±0.002a	0.017±0.001a
	L5	0.013±0.0007a	0.013±0.0007a	0.014±0.0003a	0.015±0.0004a	0.016±0.0004a
KWS-55	L1	0.001±0.00002c	0.001±0.00002c	0.001±0.00002c	0.001±0.00002c	0.001±0.00002c
	L2	0.007±0.0001b	0.007±0.0001b	0.007±0.0001b	0.007±0.0001b	0.007±0.0001b
	L3	0.006±0.0001b	0.006±0.0001b	0.006±0.0002b	0.007±0.0004b	0.007±0.0003b
	L4	0.016±0.002a	0.016±0.0002a	0.016±0.002a	0.017±0.002a	0.018±0.002a
	L5	0.014±0.0005a	0.015±0.0004a	0.015±0.0002a	0.016±0.0001a	0.018±0.0001a

Means (± SE) within column followed by the same letter are not significantly different at (P < 0.0001) according to Duncan's Multiple Range Test (DMRT)

Effect of maize hybrids on the weight (mg) gained by different larval instar of C. partellus

The effect of different hybrids viz., KK-8711, KS-85 and KWS-55 was evaluated on the larval instars of *C. partellus*. For the 1st and 2nd instar larvae, statistically similar results were obtained on all hybrids used in the experiment ($P<0.0001$). Significantly different results were obtained for the 3rd, 4th and 5th instar larvae in which 3rd instar maximum larval weight (0.026±0.007) was obtained for KWS-55, while minimum larval weight (0.019±0.0005) was recorded for KK-8711, respectively. In contrast to this similar results for 4th and 5th instar larvae were obtained, wherein maximum larval weight gained by *C. partellus* feeding on KWS-55 with an average weight of 0.059±0.001 and 0.078±0.001 was recorded (Table II).

Effect of maize hybrids and nitrogen doses (N0-N4) on frass weight (mg) of different instars of C. partellus

The findings for the frass production showed the same sequence which demonstrated that the nitrogen doses (N0-N4) and maize hybrids had statistically no effect on the frass yield of (L1-L2) ($P<0.0001$) while unlike results were obtained when the larvae reached 3rd instar and frass production enhanced significantly with the applications of different nitrogen doses. Maximum dried frass weight was obtained for N4 *i.e.*, 0.007±0.0003 feeding on KWS-55, while minimum (0.005±0.00008) on KK-8711 treated with N4. For the 4th and 5th larval instars, statistically similar results were obtained and maximum frass weight was recorded on KWS-55 treated with N4 *i.e.*, 0.018±0.002 and 0.018±0.0001 while minimum *i.e.*, 0.016±0.001 and 0.014±0.001 was documented on KK-8711 treated with N4.

DISCUSSION

The current study was carried to out to check the effect of various nitrogen doses on the development and prevalence of *C. partellus*. Nitrogen is a component of amino acids, protein and chlorophyll, and is an imperative component for plants, which is itself vital for phytophagous insects. Present research noticeably expressed that application of nitrogen fertilizer had a significant effect on the development of *C. partellus*, including survivorship of larvae, which illustrated that larval developmental rate was completely associated with increasing nitrogen levels. The current findings are in agreement with the results reported by McNeill and Southwood (1978); Mattson (1980); Hunt *et al.* (1992); Denno and Perfect (1994); Wier and Boethel (1995). Parallel observations were also reported for *Fiorinia externa* (Ferris) fed on hemlock *Tsuga canadensis* and for soyabean looper *Pseudoplusia includens* (Walker) fed on soya bean (Wier and Boethel, 1995).

Development and survival of larvae were lowest in the treatment with zero nitrogen and larvae survived for maximum period of time on higher nitrogen doses, whereas parallel results were reported for *S. calamistis* by Setamou *et al.* (1993). There was also significant difference in weight gained by different larval instars at various nitrogen level applications with highest weight (0.085 mg/L) at N4 and minimum (0.078 mg/L) at zero nitrogen level (Table I). The greater nitrogen supply would amplify protein production and reduce the carbohydrate contents consequential in development of thinner cell wall and softening the tissues, which ultimately attracts the insects and damage by the insects amplifies.

Janssen (1993) noted that nitrogen level of plant was absolutely associated with water contents and other minerals describing that an increase in nitrogen leads to softer tissues, which can direct more stem borer attack and more larval weights. It has been found that the rates of injury, densities, weight and sizes of larval body of *C. suppressalis* amplified significantly with the increase in nitrogen (Cruz *et al.*, 2001; Scriber, 1984).

The current findings are in accordance with Singh *et al.* (1990) who accounted that NPK ratio of 120-60-60 Kg/ha augmented the susceptibility of rice crop to rice stem borers. Saha and Saharia (1970) have also reported the incidence of stem borers from 8.36% in plots without nitrogen fertilizer to 20.12% in those treated with 100 Kg/ha. The results are compatible with Ramzan *et al.* (1992) who stated that high infestation of pest is associated with the high use of nitrogenous fertilizers. Different maize hybrids also affected the weight gained by the larvae with maximum resistance in KK8711 and minimum in KWS55, the resistance factor also declined by increasing nitrogen levels as Cisneros and Godfrey (2001) stated that nitrogen modifies the plant nutrition and decreases the resistance against aphids in cotton.

Frass weight of larvae was also affected by different application levels of nitrogen, maximum 0.018mg/5L at N4 and minimum 0.001mg/5L at N0 was recorded (Table III). Fertilization with high doses of urea, a source of nitrogen, has also been reported to increase the feeding and growth in addition to development of insects (Slansky and Scriber, 1985). Moreover, it is found that maximum mortality occurred in the initial instars as compared to later instars. This could be owing to the nitrogen balance which may be serious to young insects, whereas old larvae and adults could effectively exploit nutrients from a deranged profile (Brodbeck *et al.*, 1999).

The present results suggest that optimum doses of nitrogen fertilizer which are sufficient for proper crop production should be applied for minimum pest damage because increasing the nitrogen application leads to an increase in *C. partellus* population, development and infestation on maize crop. The strongest effect of nitrogen on weight gained and high frass production by the larvae indicates that increasing the nutritional status of the plant by providing high nitrogen doses will increase consumption and attack during the season. The outcomes of the current studies indicate that nitrogen fertilizer can be applied as an integrated pest management tactic in the control of *C. partellus* population, development and infestation on maize crop.

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