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# Combined Effect of Silica Applications and Nitrogen Fertilizers on Two Rice Cultivars and Infestation Rate by Stem Borer, *Chilo agamemnon* Bles

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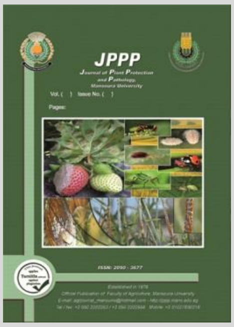

## ABSTRACT

Field experiments were conducted at Sakha, Kafr El-Sheikh, Egypt; to investigate the effect silica combined with mineral nitrogen on rice yield, and stem borer *Chilo agamemnon* Bles. Applying potassium ore combined with 92 kg N/fed. Produced the highest panicles/$m^2$ (814.31) compared to other silica applications or lower nitrogen levels. The same trend was observed with panicle weight. One-thousand grain weight was higher in Egyptian hybrid 1 than in Giza 178. The grain yields were also highest with potassium ore for both cultivars at the rate of 92 kg N/fed. Rice stem borer infestation was higher in hybrid than in inbred cultivar. Both dead hearts and white heads gradually increased by the increase of nitrogenous applications; from 2.65 to 4.14 % dead hearts, and from 3.77 to 5.59 % white heads due to nitrogenous increase from 23 to 92 kg/fed., respectively. The highest dead hearts (4.92 & 5.28) and white heads (9.42 & 7.06 %) were detected in plots without silica. From the data of this experiment, it could be concluded that Egyptian hybrid 1 yielded more than Giza 178, particularly with using 92 kg N/fed., combined with potassium ore at 500 kg/fed.. It was found that silica applications reduced the stem borer infestation, regardless of the cultivar and nitrogen rates.

***Keywords***: rice, hybrid, inbred, nitrogen levels, silica materials, rice stem borer infestation.

## INTRODUCTION

Rice (*Oryza sativa L*.,) is the most important cereal crop after wheat. Also, it is a staple food for nearly one half of the world population most of them live in developing countries. It shares wheat in Egypt to fulfill the requirements of the population for cereals. The total cultivated area with this crop in Egypt every year, in average, is 1.35 million feddans, which produces about 5.3 million tons of rough rice (Anonymous, 2018).

Hybrid rice technology is an innovative breakthrough that can further increase rice production, leading to food security in Egypt. Hybrid rice varieties can out-yield conventional modern varieties by 15-30 % at the same input levels (Abo-Youssef *et al*., 2005).

Nitrogen plays a key role in rice production. It is the essential component of cell molecules including chlorophyll, nucleic acids, amino acids, ATP and a number of plant hormones. It is an important regulator involved in many biochemical processes such as protein synthesis, carbon metabolism and amino acid metabolism (Cai *et al*., 2012).

Application of inorganic fertilizers is costly and gradually leads to environmental problems. Thus, organic residue recycling is becoming an increasingly important aspect of environmentally sound sustainable agriculture (Metwally, 2015). Nowadays, agricultural production based on organic applications is growing in interest and the demands for the resulting products are increasing. Therefore, the effective use of organic materials in rice farming, such as rice compost, is also likely to be promoted (Myint, *et al.* 2010).

Silicon is not considered an essential element for plant development and growth, but its absorption brings several benefits to some crops, especially rice, by increasing cellular wall thickness, providing mechanical resistance to the penetration of fungi and insects, improving the opening angle of leaves and making them more erect, reducing self-shading and increasing resistance to lodging, especially under high nitrogen rates (Jafari *et al.*, 2013). In the absence of natural heritable resistance in rice varieties, resistance could be induced by alternate strategies to suppress certain insect pests. One such strategy is enrichment of silicon in plants ( Jawahar *et al*. 2015).

Insect infestations are considered important biotic factors which negatively affect yield. Rice plants are liable to be attacked by several insect pests. In Egypt, the rice stem borer (*Chilo agamemnon* Bles.) is the most important insect that attacks rice plants throughout the growing season. The damage of the insect appears as dead hearts in the vegetative stage and as white heads in the reproductive stage (Sherif, 2002).

The present investigation aimed to study the effect of different silica applications and nitrogen fertilizer levels on rice yield, yield components and infestation by stem borer *Chilo agamemnon* Bles, on two rice cultivars; Giza 178 and Egyptian hybrid 1.

## MATERIALS AND METHODS

Field experiments were carried out at the Experimental Farm of Rice Research and Training Center (RRTC), Sakha, Kafr El-Sheikh, Egypt, during 2017 and 2018 rice growing seasons. The objective was to investigate

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effect of the applications of nitrogen and silica on rice yield, yield components and rice stem borer infestation of two rice cultivars; Giza 178 and Egyptian hybrid 1.

**Experimental design and treatments**

Split-split plot design, with three replicates, was adopted. The main plots were devoted to rice cultivars; Giza 178 and Egyptian hybrid 1, while the sub-plots were assigned to four levels of nitrogenous fertilization; 23, 46, 69 and 92 kg N / fed. as urea (46.5 % N). The sub-sub plots were occupied by six silica treatments (Table 1). The experimental plot area was 21 m$^2$ (4.2 x 5m). Normal irrigation, four days on and four days off was followed, Silica materials, with their component percentages, were kindly provided by Al-Ahram Mining Company, 16 Badr Buildings, Round Road, Cairo.

**Table 1. Silica treatments and applications**

| Silica source | % $SiO_2$ | Rate/fed. | Application |
|---|---|---|---|
| Control (without silica) | - | - | - |
| compost straw | 5.00 | 2.1 t | |
| Mixed minerals | 40.00 | 500 kg | basal after last tillage |
| Potassium ore | 70.00 | 500 kg | |
| Bentocide ore | 29.00 | 2 kg | Two sprays, 30 & 45 |
| Magnesium silicate | 60.00 | 2 kg | days after transplanting |

**Nursery preparation and sowing**

The seed bed was ploughed thrice, with adding calcium super phosphate (15.5 % P2O5) at the rate of 4kg / kerat (175m$^2$) on the dry soil before last ploughing. Nitrogen, in the form of urea (46.50%N), was incorporated into the soil at a rate of 3kg /kerat after the last plough prior to dry leveling. Zinc sulphate (24% ZnSO4), at the rate of one kilogram/ kerat was added after wet leveling just before grain broadcasting. Rice seeds the two cultivars were soaked in fresh water for 48 hr., and incubated for additional 48 hr. The seeds were broadcasted at rates of 40 and 10kg/fed., for Giza178 and egyptin cultivars, respectively, on May 2nd in 2015 and 2016 seasons. At the stage of 3-leaf seedlings, thiobercarb (Saturn 50EC) at a rate of two liters /fed., mixed with sand, was broadcasted into the nursery water to control weeds.

**Permanent field preparation and cultivation**

The permanent field was ploughed thrice, with adding calcium super phosphate (15.5 % $P_2 O_5$) at the rate of 100 kg /fed before the last tillage. The nitrogen fertilizer was added in the form of urea (46.5 % N) in three splits according to the nitrogen levels applied; 1/3 as basal (incorporated into the soil before puddling), 1/3 twenty days after transplanting, and the last third was added at forty days after transplanting. Thirty and thirty-five days, after seed sowing, seedlings of Giza 178 and Hybrid1 rice cultivars, respectively were pulled out, distributed in the permanent field, and transplanted at 20 x 20 cm spacing, with 3-4 seedlings/hill. Five days after flooding the permanent field, the experimental area received thiobercarb (Saturn 50%).

**Evaluation of yield and yield components**

After complete maturity, total number of panicles (productive tillers) in five random hills were counted in the field, calculated the number /m$^2$. Also, ten panicles were randomly collected from each plot, air dried and weighed, in the same time, weight of 1000 grains was recorded.

Plants of an area of 6 m$^2$ (150 hills) of each plot were manually harvested according to the harvest time of the cultivar. On basis of 14% moisture content, the weight was adjusted to ton / fed.

**Evaluation of stem borer, *Chilo agamemnon* Bles. infestation**

Forty days after transplanting of the cultivars, the plants were examined to the dead heart symptom. Dead heart tillers are killed due to the rice stem borer larvae tunneling. From each plot, five random hills were cut at the soil surface, Total number of tillers and those of dead hearts were counted, and thus, dead heart percentage was calculated.

Three weeks prior to harvest, white head percentages, were estimated. "White heads" are empty rice panicles (unfilled grains) due to tunneling of the borer larvae in each plot was represented by random five hills, cut at the soil surface. Total number of tillers and those having white heads were recorded, and thus, white head percentage was calculated.

**Statistical analysis**

Data were subjected to the standard statistical analysis with COSTAT. The significantly differed means were compared using Duncan's Multiple Range Test (1955).

## RESULTS AND DISCUSSION

**1- Number of panicles/m$^2$**:

Data in Table (2) showed that, significant differences, in mean number of panicle/m$^2$, between the two cultivars. Egyptian hybrid 1 exhibited more panicles/m² (673.23 and 708.14) than Giza 178 (626.37 and 666.67) in two respective seasons, The differences between these means are mainly due to the genetic background of the cultivars, similar to those recorded by El-Kassaby *et al.* (2012) and Aamer (2015).

Nitrogenous fertilization induced highly significant differences in this respect in both seasons (Table 2). The highest numbers (758.65 and 798.42) were recorded with the treatment of 92 kg N/fed, followed by those at 69 kg (716.10 and 731.44) in the first and second seasons, respectively. The lowest numbers (511.31 and 540.67/ m$^2$) were found in the plots fertilized with 23 kg N/fed. The effect of nitrogen application on number of panicles/m$^2$ may be attributed mainly to its stimulation effect of nitrogen on effective tiller formation. These findings are consistent with those reported by El-Rewainy (2012).

As for potassium ore, the highest number of panicles were (699.17 and 754.22/m$^2$) (Table2) followed by compost straw (695.64 and 738.31) in the first and second seasons, respectively. The lowest numbers were found in the non-application of silica plots (572.70 and 606.07 panicles/m$^2$). Li *et al.* (2011) found that application of slag based Si fertilizers promoted silicon uptake and enhanced $Si0_2$ content in stems and leaves of rice at harvest.

**2. Panicle weight:**

The result presented in Table (2) showed highly significant differences between the used cultivars in panicle weight (g) in both seasons. Egyptian hybrid 1 recorded heavier panicles weight (4.87 and 5.01g) than Giza 178 (4.22 and 4.29 g) in the seam seasons, respectively. Abou Khalifa *et al.* (2007) found that Hybrid 1 surpassed other inbreds either in growth parameters or yield components

The variable levels of nitrogen induced highly significant differences in the panicle weight (Table 2). The heaviest panicles (5.05 and 5.07 g) were found in plots fertilized with 92 kg N/fed, while the lightest panicles (3.87 and 4.12 g) were in the plots fertilized with 23 kg N/fed. The increase in this weight may be attributed to the increase in number of grains/panicle which was increased with highering rates of nitrogen fertilization. These results are in accordance with those of Yoseftabar *et al.* (2012) yield and yield components increased significantly with increasing nitrogen fertilizer from 100 to 300 kg/ha.

As for silica application, panicle weight (Table 2) took a trend similar to that of the number/m$^2$, the values were greatest at the treatment of potassium ore (500 kg /fed.), followed by those at compost straw (2.1t/fed). The lowest was at the control (without silica) in both seasons. Pati *et al.* (2015) tested effect of recommended fertilizer practice combined with different levels of diatomtic earth as a source of silicon at rates of 150- 600 kg/ha. on rice yield and yield attributes. They clarified that of silicon significantly increased grain and straw yields as well as yield-attributing parameters.

**3- One thousand grain weight:**

Egyptian hybrid 1 cultivar recorded significantly higher weight (24.94 and 24.98 g) than Giza 178 (21.56 and 21.47 g) in the first and second seasons, respectively (Table 2). The results are in accordance with those by Abu Khalifa *et al.* (2007) and El-Kassaby *et al.* (2012).

The highest 1000-grain weights (Table 2) were recorded in the rice plots fertilized with 23 kg N/fed (23.64 and 23.72 in the two seasons, respectively). The lowest values were obtained from the plots 92 kg N/fed (22.88 and 22.69 g), or of 69 kg N/fed (23.13 and 23.08 g). Application of nitrogen significantly reduced the weight, mainly due to the higher number of spikelets per panicle in the plants that received nitrogen at any rate than those without nitrogen. Similar results were obtained by Metwally (2015).

**Table 2. Effect of nitrogen levels and silica sources on yield, yield components of rice cultivars**

| Treatment | No. Panicles /m$^2$ | | Panicle weight (g) | | 1000-grain weight (g) | | Grain yield t/fed. | |
|---|---|---|---|---|---|---|---|---|
| | 2017 | 2018 | 2017 | 2018 | 2017 | 2018 | 2017 | 2018 |
| Cultivar (A) | | | | | | | | |
| Giza 178 | 626.37 b | 666.67 b | 4.22 b | 4.29 b | 21.56 b | 21.47 b | 4.36 b | 4.73 b |
| Egyptian hybrid1 | 673.23 a | 708.14 a | 4.87 a | 5.01 a | 24.94 a | 24.98 a | 4.85 a | 5.15 a |
| F test | ** | ** | ** | ** | ** | ** | ** | ** |
| Nitrogen level (B) (kg/fed) | | | | | | | | |
| 23 | 511.31 d | 540.67 d | 3.87 d | 4.12 d | 23.64 a | 23.72 a | 3.76 d | 4.09 d |
| 46 | 613.20 c | 678.06 c | 4.43 c | 4.58 c | 23.41 b | 23.51 b | 4.39 c | 4.84 c |
| 69 | 716.10 b | 731.44 b | 4.85 b | 4.83 b | 23.13 c | 23.08 c | 4.95 b | 5.33 b |
| 92 | 758.65 a | 798.42 a | 5.05 a | 5.07 a | 22.88 d | 22.69 d | 5.27 a | 5.51 a |
| F test | ** | ** | ** | ** | ** | ** | ** | ** |
| Silica source (C) | | | | | | | | |
| Control | 572.70 e | 606.07 f | 4.12 e | 4.24 e | 23.02 de | 22.91 d | 4.01 f | 4.74 d |
| Compost straw 2.1 t/fed (basal) | 695.64 a | 738.31ab | 4.94 b | 4.98 b | 23.55 b | 23.59 b | 5.04 b | 5.14 a |
| Mixed mineral 500 kg/fed (basal) | 666.39 b | 697.39 c | 4.48 c | 4.61 c | 23.21 c | 23.15 c | 4.71 c | 4.89 b |
| Potassium ore 500 kg/fed (basal) | 699.17 a | 754.22 a | 5.05 a | 5.12 a | 23.70 a | 23.82 a | 5.11 a | 5.16 a |
| bentocide ore 2 kg /fed (two sprays) | 617.21 d | 653.02 e | 4.25 d | 4.42 d | 22.95 e | 22.92 d | 4.23 e | 4.81 c |
| Magnesium silicate 2 kg /fed (two sprays) | 647.75 c | 685.37 d | 4.44 c | 4.57 c | 23.08 d | 23.13 c | 4.49 d | 4.88 b |
| F test | ** | ** | ** | ** | ** | ** | ** | ** |

**** indicates highly significant differences ( P<0.01) .**
**In same column, means followed by same letter are not significantly different at 5% level of probability according to DMRT.**

Data in the same table revealed that, the highest values of 1000-grain weight (23.70 and 23.82 g) were obtained at potassium ore (500 kg /fed)., followed by those at compost straw (2.1t/fed) (23.55 and 23.59 g). The lowest values were in the control (without silica) rice plots (23.02 and 22.91 g) in 2015 and 2016 seasons, respectively. Increase in 1000-grain weight with silica applications could be due to greater deposition of Si on paleae and lemma., similar results were obtained by Yogendra *et al*. (2014).

**4- Grain yield**

Egyptian hybrid 1 recorded significantly higher grain yield (4.85 and 5.15 t/fed) than Giza 178 (4.36 and 4.73) in two seasons, respectively. The grain yield advantage of hybrid rice cultivars may be due to high physiological efficiency due to their vigorous shoot system, great sink size, large leaf area index during grain filling, and wide adaptability to various environments. These results are in accordance with those reported by Abou Khalifa *et al.* (2007) and El-Kassaby *et al.* (2012).

The highest grain yields (5.27 and 5.51 t/fed) were found in the plots fertilized by 92 kg N/fed, followed by those at 69 kg N/fed (4.95 and 5.33 t/fed) in 2017 and 2018 seasons, respectively. The lowest value (3.76 t/fed) was recorded in the rice plots fertilized with 23 kg N/fed in 2015 season, (Table2). Nitrogen is one of the most crucial elements required for the growth and yield of rice plants. It is involved in the photosynthesis, a principal constituent of chlorophyll, enzymes, proteins and vitamins (Sara *et al.*, 2013).

Application of silica materials increased grain yield in the two seasons arranged in (Table 2) over control (without silica). Potassium ore (500 kg/fed) recorded the highest values (5.11 and 5.16 t/fed) of grain yield, followed by compost straw at 2.1 t/fed. (5.04 and 5.14) in the first and second seasons, respectively. The lowest value (4.01 t/fed) was found at control (without silica) in the first season. Grain yield is the out-product of its main components.

Any increase in one or more of such components without decrease in the others will lead to an increase in grain yield. Therefore, the increase in grain yield due to potassium ore or compost straw reflected an increase in rice yield components. Similar results were obtained by Myint *et al.* (2010) and Pati *et al*. (2015). Wattanapayapkul *et al.* (2011) reported that silicon enhanced grain yield by 19 – 43% over the control.

**5- Rice stem borer (*C. agamemnon*) infestation:**

Data presented in Table (3) cleared that, the borer infestation, as dead hearts and white heads, affected by rice cultivars, nitrogen, as well as by silica in both seasons.

**1. Dead hearts**

Egyptian hybrid 1 (indica type) had significantly higher dead heart plants (3.84 and 3.71 %) than Giza 178 (indica – japonica type) (2.83 and 3.17 %) in the first and second seasons, respectively (Table 3). These results are in line with the findings of Sherif and Bastawisi (1997), concluded that rice varieties belonging to indica type are more susceptible to stem borer than those belonging to japonica or indica x japonica type.

The highest levels of dead hearts (4.06 and 4.14 %) were found in the plots fertilized with 92 kg N/fed, followed by those in the plots with 69 kg N/fed (3.63 and 3.71 %) in the first and second seasons, respectively (Table 3). The least levels of infestation were detected in the plots fertilized with 23 kg N/fed (2.47 and 2.65 % dead hearts).

Abdalla & Badawi (1990) and Sultan *et al*. (2013) reported that rice stem borer infestation increased with increasing nitrogen fertilization levels. Alll silica materials reduced dead heart % in both seasons, (Table 3) .The highest values (4.92 and 5.28 %) were found at the control (without silica). All silica sources gave lower values of dead heart % ; 2.35 – 3.71 % in 2017 season, and 2.45 – 4.85 % in 2018 season, compared with 4.9 – 5.3 % in the control. Similar results were obtained by Meena *et al.* (2014). Takahashi (1996) found that the mandibles of rice borer larvae when were damaged when fed on plants with a high silicon content. Chau and Heong (2005) concluded that the organic fertilizers induced 2% lower rice stem borer as compared to chemical fertilizers.

The interaction between nitrogen fertilization and silica sources had a significant effect on dead hearts caused by the rice stem borer in 2016 season, (Table 4). The least incidence of dead hearts (1.77 and 1.90 %) was observed under the plots receiving 23 kg N/fed, combined with potassium ore and magnesium silicate, respectively. All treatments having silica materials, whatever nitrogen levels, gave lower dead heart %. The highest value of dead heart (6.65 %) was recorded for the treatment of 92 kg N/fed without silica.

Rice infestation by stem borer was less in plants receiving higher silica than those receiving lower silica (Rajamani *et al.,* 2013). Formation of a physical barrier in epidermal cells by silica deposition contributes to plant resistance against pests (Epstein, 1994).

**2. White head**

Levels of white heads did not differ significantly by the two rice cultivars in 2017 but they varied significantly in 2018. The Egyptian hybrid 1 was higher infested (5.38 %) than Giza 178 (4.19 %), (Table3). These results are in agreement with those of El-Malky *et al* (2013). Anonymous (2018) categorized 55 rice promising lines according to rice stem borer infestation (on basis of white head level) into resistant, moderately resistant, moderately susceptible, susceptible and highly susceptible. Giza 178 was categorized as moderately susceptible while Egyptian hybrid 1 was as susceptible.

The highest white heads (7.44 and 5.89 %) were found in plots fertilized with 92 kg N/fed (Table 3), followed by those in the plots fertilized with 69 kg N/fed (6.56 and 4.94 %) in the first and second seasons, respectively. The least of infestation was detected in the plots fertilized with 23 kg N/fed (4.13 and 3.77 % white heads). The higher rice infestation was gained at the highest nitrogen levels was similar to theat obtained by Jawahar *et al.* (2015). Kulagod *et al* (2011) reported that excessive use of nitrogen fertilizer further aggravated the rice stem borer incidence.

The application of silica materials reduced significantly white head percentage (Table 3). In 2017 season, the lowest percent was recorded for magnesium silicate (3.77 %), followed by that of potassium silicate (3.98 %) with no significant differences between both treatments. In 2018 season, the treatment of potassium cleared the lowest rank (3.59 %), followed by mixed mineral (3.67 %) without significant differences between the two treatments. The highest values of white heads were found in the control (9.42 and 7.06 %) and compost straw (8.81 and 6.44 %) in both seasons, respectively. The low infestation may be due to reduced digestibility and increased hardness and abrasiveness of plant. The number of larvae which bored into the stems and the amount of faeces were negatively correlated with Si content of the stems Meena *et al.* (2014). Chandr Amani *et al.* (2010) concluded that application of silica sources in rice fields reduced the incidence of stem borer by about 58.66 %.

**Table 3. Effect of nitrogen levels and silica sources and their interactions on stem borer infestation in rice cultivars**

| Treatment | Dead heart % | | White head % | |
|---|---|---|---|---|
| | 2017 | 2018 | 2017 | 2018 |
| Cultivar (A) | | | | |
| Giza 178 | 2.83 b | 3.17 b | 5.58 | 4.19 b |
| Egyptian hybrid1 | 3.84 a | 3.71 a | 6.05 | 5.38 a |
| F test | ** | * | NS | * |
| Nitrogen level (kg/fed) (B) | | | | |
| 23 | 2.47 d | 2.65 d | 4.13 d | 3.77 d |
| 46 | 3.16 c | 3.26 c | 5.10 c | 4.53 c |
| 69 | 3.63 b | 3.71 b | 6.56 b | 4.94 b |
| 92 | 4.06 a | 4.14 a | 7.44 a | 5.89 a |
| F test | ** | ** | ** | ** |
| Silica source (C) | | | | |
| Control | 4.92 a | 5.28 a | 9.42 a | 7.06 a |
| Compost 2.1 t/fed (basal) | 3.71 b | 4.85 b | 8.81 b | 6.44 b |
| Mixed mineral 500 kg/fed (basal) | 2.47 c | 2.45 d | 4.43 c | 3.67 cd |
| Potassium silicate 500 kg/fed (basal) | 2.35 c | 2.45 d | 3.98 cd | 3.59 d |
| Biocide ore 2 kg /fed (two sprays) | 3.02 b | 2.93 c | 4.45 c | 3.96 c |
| Magnesium silicate 2 kg /fed (two sprays) | 2.51 c | 2.67 d | 3.77 d | 3.96 c |
| F test | ** | ** | ** | ** |
| Interaction – F test | | | | |
| A X B | NS | NS | NS | NS |
| A X C | NS | NS | NS | NS |
| B X C | NS | * | ** | ** |
| A X B X C | NS | NS | NS | NS |

***, ** and NS indicate P <0.05, P<0.01 and not significant, respectively. In same column, means followed by same letter are not significantly different at 5% level of probability according to DMRT.**

**Table 4. Dead heart percentages as influenced by the interaction between nitrogen and silica during 2018 season**

| Silica source | Nitrogen (kg/fed) 23 | 46 | 69 | 92 |
|---|---|---|---|---|
| Control | 3.90 ef | 4.89 c | 5.68 b | 6.65 a |
| Compost 2.1 t/fed (basal) | 4.18 de | 4.68 cd | 4.99 c | 5.53 b |
| Mixed minerals 500 kg/fed (basal) | 2.07 j-l | 2.30 i-l | 2.63 h-k | 2.80 g-j |
| Potassium ore 500 kg/fed (basal) | 1.77 l | 2.33 i-l | 2.67 h-k | 3.04 g-i |
| Bentocide ore 2 kg /fed (two sprays) | 2.05 j-l | 2.91 g-i | 3.21 gh | 3.54 fg |
| Magnesium silicate 2 kg /fed (two sprays) | 1.90 kl | 2.44 h-l | 3.08 g-i | 3.24 gh |

**Means followed by the same letter are not significantly different at the 1 % level.**

Data arranged in Table (5) showed that, white heads percentage displayed highly significant differences due to the interaction between nitrogen levels and silica sources in both seasons. The highest white heads (12.48 and 8.98 %) were found in the plots fertilized with 92 kg N/fed without silica, followed by those fertilized with 92 kg N/fed (11.85 and 7.59 %) combined with compost straw in the first and second seasons, respectively.

All treatments having 23 kg N/fed. Combined with different silica sources gave lower values of white head %; 2.57 – 3.54 % in 2015 and 2.74 – 3.17 % in 2016 season. Application of silica as basal or spray reduced the white head percentage apart from the increase in nitrogen levels. Yoshida (1981) found that increasing the amount of nitrogen application increases the total uptake of nitrogen and silicon but reduces the silicon content in the straw.

**Table 5. White head percentage as influenced by the interaction between nitrogen levels and silica sources in both seasons**

| Silica source | 2017 | | | | 2018 | | | |
|---|---|---|---|---|---|---|---|---|
| | Nitrogen (kg/fed) | | | | | | | |
| | 23 | 46 | 69 | 92 | 23 | 46 | 69 | 92 |
| Control | 6.07 d | 7.75 c | 11.63 a | 12.48a | 5.73 de | 6.39 c | 7.15 b | 8.98 a |
| Compost 2.1 t/fed (basal) | 6.03 d | 7.55 c | 9.58 b | 11.85 a | 5.42 e | 6.17 cd | 6.58 c | 7.59 b |
| Mixed minerals 500 kg/fed (basal) | 3.36 g-i | 4.00 f-h | 4.85 d-g | 5.51 de | 2.74 k | 3.58 h-j | 3.92 f-j | 4.46 fg |
| Potassium ore 500 kg/fed (basal) | 3.19 hi | 3.73 g-i | 4.14 e-h | 4.85 d-g | 2.84 k | 3.44 ij | 3.69 g-j | 4.41 fg |
| Bentocide ore 2 kg /fed (two sprays) | 3.54 g-i | 4.02 f-h | 4.88 d-g | 5.34 d-f | 2.74 k | 3.82 g-j | 4.04 f-i | 5.28 e |
| Magnesium silicate 2 kg /fed (two sprays) | 2.57 i | 3.56 g-i | 4.30 e-h | 4.64 e-h | 3.17 j-k | 3.79 g-j | 4.28 f-h | 4.62 f |

**Means followed by the same letter are not significantly different at the 1 % level.**

**6. Stem uptake of nitrogen and silica:**

Data presented in Table (6) cleared that, both nitrogen and silica increased in rice stems as a result of applications of silica and nitrogen. Nitrogen levels were highest (0.63 and 0.66%) at the highest level of nitrogen (92 kg/fed) in 2017 and 2018 seasons, respectively compared to the lowest level (23 kg/fed). Bhutto *et al* (2015) indicated that dead heats and white heads, due to rice stem borer, increased by the application of high doses of nitrogen.

**Table 6. Stem contents of nitrogen and silica as affected by applications**

| Treatment | | Silica % 2017 | Silica % 2018 | Nitrogen % 2017 | Nitrogen % 2018 |
|---|---|---|---|---|---|
| Cultivar (A) | Giza 178 | 3.31 b | 3.11 b | 0.50 b | 0.53 b |
| | Egyptian hybrid1 | 3.55 a | 3.47 a | 0.56 a | 0.59 a |
| | F test | ** | * | ** | ** |
| Nitrogen level (kg/fed) (B) | 23 | 2.97 d | 2.81 d | 0.43 d | 0.46 d |
| | 46 | 3.32 c | 3.21 c | 0.49 c | 0.54 c |
| | 69 | 3.77 a | 3.63 a | 0.57 b | 0.59 b |
| | 92 | 3.67 b | 3.52 b | 0.63 a | 0.66 a |
| | F test | ** | ** | ** | ** |
| Silica source (C) | Control | 2.99 f | 2.83 f | 0.57 a | 0.62 a |
| | Compost 2.1 t/fed (basal) | 3.26 d | 3.18 d | 0.55 ab | 0.60 ab |
| | Mixed mineral 500 kg/fed (basal) | 3.66 b | 3.43 b | 0.50 b | 0.53 cd |
| | Potassium ore 500 kg/fed (basal) | 4.10 a | 3.96 a | 0.49 b | 0.51 d |
| | Bentocide ore 2 kg /fed (two sprays) | 3.12 e | 3.08 e | 0.53 ab | 0.54 cd |
| | Magnesium silicate 2 kg /fed (two sprays) | 3.45 c | 3.26 c | 0.55 ab | 0.57 bc |
| | F test | ** | ** | ** | ** |

Also, the applications of silica enhanced silica contents in rice stems, as they were the lowest (2.99 and 2.83%) in the plots untreated with silica in the first and second seasons, respectively compared to any of the silica treatments. However, potassium ore and mixed mineral were superior in accumulation of silica in rice stems. Chandramani *et al.* (2010) recommended application of silica materials to soils of rice. This increases deposits of silica in stems and reduces the ability of insect feeding due to wearing of their mandibles.

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## التأثير المشترك لتطبيقات السيليكا والأسمدة النيتروجينية على صنفين من محصول الأرز ومعدلات الإصابة بحفار الساق *Chilo agamemnon* Bles

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أجريت التجربة بالمزرعة البحثية لمركز البحوث والتدريب في الأرز محطة بحوث سخا – كفر الشيخ خلال موسمي الزراعة ٢٠١٧ – ٢٠١٨ , لدراسة تأثير إضافة مصادر من السيليكا مع التسميد النيتروجيني علي محصول الأرز ومكوناته والإصابة بثاقبة ساق الأرز لصنفي الأرز جيزة ١٧٨ و هجين مصري ١. وأظهرت النتائج أن استخدام خام البوتاسيوم مع التسميد النيتروجيني بمعدل ٩٢ كحم/ فدان أعطى أعلى قيم في عدد السنابل/ م$^2$ ووزن السنبلة بالجرام بالمقارنة مع معاملات السيليكا الأخرى المصحوبة بمعدلات التسميد النيتروجيني الأقل . وقد تفوق الصنف هجين مصري ١ علي الصنف جيزة ١٧٨ في وزن الألف حبه ومحصول الحبوب وتحقق أعلي محصول من الصنفين عند استخدام خام البوتاسيوم بمعدل ٥٠٠ كجم/فدان مع اضافة ٩٢ كجم نيتروجين/ فدان . وبخصوص الإصابة بثاقبة ساق الارز كانت إصابة الصنف هجين مصري١ أعلي منها في الصنف جيزة ١٧٨. كما زادت الإصابة بثاقبة ساق الأرز تدريجيا بزيادة التسميد النيتروجيني . كما أوضحت النتائج أيضا أن الإصابة بثاقبة الساق زادت في غياب السيليكا , حيث كانت أعلي إصابة بالقلوب الميتة هي ٤،٩٢ , ٥،٢٨% , وفي السنابل البيضاء ٩،٤٢ , ٧،٠٦ % علي التوالي خلال موسمي الزراعة , وعند استخدام السيليكا انخفضت الاصابة بالحفار في كل من الصنفين بغض النظر عن معدلات التسميد النيتروجيني .