# STUDIES ON LOOSE SMUT OF WHEAT


**BY**

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# INTRODUCTION

# INTRODUCTION

Wheat (*Triticum aestivum L.*) has been considered the first strategic food crop for more than 7000 years in Egypt. It has maintained its position during that time as the basic stable food in urban areas and mixed with maize in rural areas for bread making.

During the past 20 years, wheat cultivation in Egypt has changed out of recognition. Wheat grain yield per unit area and total wheat production has been triggered since 1987 where, wheat area increased from 600.0 hectares in 1987 to 1.0 million hectares in 1999 in the old land with total production reached 5.6 million tons as compared with 2.8 million tons in 1987. In addition to 131000 hectares in the newly reclaimed desert area which produced 694000 tons in 1999*.

Wheat has attacked with many destructive diseases such as rusts, smuts, mildews and some other diseases of minor importance (**Abd-El-Hak** *et al.*, 1972). Wheat loose smut caused by *Ustilago tritici* ranked the second serious disease following rusts. In Egypt, the first record of wheat loose smut caused by *Ustilago tritici* was in 1888 as a result to exchange of seed between countries. In 1949, the losses of wheat yield ranged between trace to 5% on the local and Indian cultivars. Since that date, the disease disappeared for long time due to realizing the resistant cultivars Giza-139, Giza-144 and Giza-155 (**Abd-El-Hak, 1952**). **Then, it was recorded at 1984/1985 on the** cultivars Sakha-61, Sakha-69 and Giza-163. During the period from 1985–1989, annual loose smut survey was performed in 16 Governorates, revealed that disease incidence was about 0.1 % on the commercial cultivars Sakha-61 and Sakha-69 (**Ikhlas Shafik** *et al.* 1990)

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- Agricultural Statistics, Economic Affairs Sector, 1999, Ministry of Agriculture and land Reclamation, MOALR, Egypt.

Loose smut causes damage by destroying the infected plants and reducing the quality of grain of the non-infected plants up on harvest (**Agrious,** 1969). Wheat quality can be defined in terms of physiological characteristics of the grain including size, weight and hardness and intrinsic properties i.e., protein and carbohydrate content (**Vamshidhar**, *et al.*, 1998). Much interest has been associated with the nitrogen metabolism of infected plants particularly in relation to the differences between resistant and susceptible cultivars **Heitefuss** *et al.*, 1959 and **Uritani,** 1971).

Resistant cultivars and seed dressing fungicides are considered the most effective methods for successful prophylaxis against loose smut disease. These resistant cultivars has been usually selected from introductions and regionally collected germplasm. While, seed treatment with effective systemic fungicides provide the most effective control and minimize losses from seed decay (**Vyas**, 1993).

This study was planned to investigate the following points:

1- Determining the efficacy of some fungicides in controlling loose smut.
2- Evaluation of some old and advanced Egyptian bread wheat cultivars
3- Histological studies aiming to detect the dormant smut mycelium in the grain embryo.
4- Studying the biochemical changes in the grain protein of the tested cultivars expressed as disease incidence and the effect of artificial inoculation on some agronomic traits.
5- Studying the inheritance of resistance to loose smut and detecting the resistance gene (s) in four Egyptian wheat cultivars and the monogenic line Lr19 and Sr26.

# REVIEW OF LITERATURE

## RI VIEW OF LITERATURE

### Chemical control

**Effect of systemic fungicides on teleutospores germination of *U. tritici*.**

**Chatrath and Sastry** (1989) reported that benomyl at 1 ppm, inhibited the growth of *Ustilago nuda tritici* to 62% of the control and inhibited completely the same fungal growth at 5 ppm.

**Srivastava** *et al*, (1997) mentioned that Raxil at 200 ppm reduced the germination of chlamydospores of *Ustilago segetum* var *tritici* in vivo to 100% comparing with the control. They added also that Raxil in synthetic medium significantly suppressed mycelium growth of the same fungus (51.0-mg) comparing with control (90.80 mg).

**Phytotoxicity of systemic fungicides on wheat seedlings.**

Many investigators studied the phytotoxicity of pesticides on treated plants and concluded that chemical compounds may be phytotoxic to the treated plants by its single action or by joint action when combined with other chemicals and/or plant extracts which may be used in the pest management. Some of them Many others verified that the treated plants with fungicides revealed phytotoxic effects (**Lepedev** *et al*, **1998** and Some others mentioned that the root system might be more sensitive than the shoot system (**Khaleeq & Klatt**, 1986 , **Ismail & Aly,** 1997 and **Zein** *et al.*, 1999).

**Smiley,** *et al*, (1990) found that tolclofos-methyl, exhibited phytotoxic effects on wheat plants.

**Hamdy,** *et al.* (1996) found that methanolic extract from *Lantana. camara* was moderate phytotoxic on wheat seedlings.

**Zein,** *et al.*, (1999) reported that the insecticides namely, Metachlor, Profenofos, Oxyfluorofen and Deltamethrin were the most phytotoxic to shoot system of wheat seedlings but Mancoper as a fungicide was the least effective one. On the other hand, Metalachlor, Profenofos, Oxyflourofen, Triazophos, Deltamethrin and Carboxin/Captan were the most phytotoxic to the root system of wheat seedlings but Diproptryn was the least phytotoxic.

**Effect of systemic fungicides on seed germination**

**Gothowal** *et al.*, (1972) found that Vitavax, Benlate and Thiram at 2, 0.1 and 0.2% conc. respectively, have not any adverse effect on seed germination of wheat when used for controlling loose smut.

**Gorshkova,** (1974) reported that soaking seeds of wheat in 0.05% Benomyl or 0.01% Orthonitrophenol solution revealed an increment in seed germination percentages, plant growth and yield grain of wheat plants.

**Effect of systemic fungicides on disease incidence of loose smut**

Many investigators have extensively studied chemical control of loose smut. In this regard, the first report of chemical exhibited fungicidal activity toward wheat loose smut was Carboxins (**Vanshemeling & kulta** 1996). Since 1970, a large number of broad-spectrum systemic fungicides, including the triazols, triadimenol, flutriafol and tebuconazole have been introduced as seed treatments for cereal diseases including loose smut.

**Shrivastava & Yadav** (1985) found that treating infected seeds of sonalika wheat with Bavistin (carbendazim), Benlate (benomyl) and Vitavax (carboxin) resulted in a good control of loose smut. They added that Vitavax was the best one.

**Attaud-Din**, *et al.*, (1987) mentioned that the best control of *Ustilago* [*segetum* var.] *tritici* was given by seed treatment with Panoram [fenfuram] at 2g/Kg seed.

**El-Daoudi**, *et al.*, (1989) tested eight systemic fungicides in controlling wheat loose smut and found that Raxil proved to be the most effective one followed by Vincit-P.

**Arora**, *et al*, (1990) tested 5 fungicides as seed dressings against *Ustilago nuda* during 1984/85 and 85/86 seasons. They found that Baytan (Triadimenol) at 0.2% gave 100% disease control while, Vitavax and Bavistin WP also gave excellent results at 0.25%.

**Mehiar**, *et al*, (1990) tested eight systemic fungicides against loose smut in Egypt during 1987/88 and 88/89. The results indicated that Raxil and Bavistin were excellent in controlling the disease, while, Vincit-P occupied the third rank. Meanwhile, Topsin-M70, Bayleton and Sicrol have an intermediate effect in reducing disease incidence whereas, Vitavax-300 and Vitavax-200 proved to be the least effective ones.

**Ikhlas shafik**, *et al*, (1990) evaluated 7 systemic fungicides at three locations (Gemmeiza, Sakha and Giza) and found that the fungicides namely, Vincit-P, Raxil and Vincit-F were superior in 1987/88 respectively. While, the fungicides Sumi-eight, Vincit-F, Baytan and Vincit-P were the best in 1988/89 respectively. Meanwhile, Vitavax-200 FF and Vitavax-200 were the least in controlling loose smut during the two seasons.

**Sherif**, *et al*, (1991) evaluated 9 systemic fungicides for controlling loose smut at two locations in Egypt. Raxil-FS (0.25 Tebuconazole) was the best one, providing 96-100% disease control followed by Sumi-eight (Dinoconazale) and Raxil-SWS (Tebuconazole) respectively. They added also that no significant differences were found between Raxil-WS and Vincit-F, while Vitavax-200 FF and Vitavax-200 (Carboxin + Thiram) were the least effective ones.

**Hussain**, *et al*, (1991) tested 5 systemic fungicides as seed dressings against *Ustilago tritici* and found that Raxil-ZDS (Tebuconazole) at 2g/kg seed gave 100% efficacy compared with Vitavax-200 (87.77% efficacy) during two growing seasons (1988/89 and 89/90).

**Beniwal**, *et al*, (1991) compared between the systemic fungicides Carboxin, Carbendazim and Metsulfovax as dry seed treatments at 1.5 2, 2.5 and 3 g/kg for each one in controlling *Ustilago nuda* var. *tritici* during 1988-1991 at 4 locations. Carboxin and Metsulfovax gave > 90% control at all locations and even at the lowest concentration were superior to carbendazim at the highest.

**Dudhe** *et al.*, (1995) evaluated the ability of Vitavax, Bavistin, Plantavax (oxycarboxin) and Benlate (benomyl) to control wheat loose smut during 1987-1988 at Akola, India. Vitavax was the most efficient followed by Plantavax, Benlate and Bavistin.

**Goel** *et al.*, (1995) compared between 3 systemic fungicides namely, G-696 (provax), carboxin and carbendazim at 0.2, 0.25 and 0.3% for each one. They found that G-696 at 0.25 and 0.3% was significantly superior in controlling the disease compared with the other treatments, except carboxin at 0.3% which was equally effective.

**Sinha & Singh** (1996) evaluated the efficacy of tebuconazole for the control of loose smut, caused by *Ustilago nuda f.sp. tritici* (*U. segetum* var. *tritici*), of wheat. They found that seed treatment with tebuconazole at all the concentrations tested was more effective than the recommended fungicides, carboxin and carbendazim in controlling the smut.

**Khan** *et al.*, (1996) found that carboxin, triadimefon and triadimenol gave significant disease control of wheat loose smut caused by *U. tritici.*

**Paul,** (1996) evaluated the efficacy of carbendazim, carboxin and triadimenol as seed treatments for the control of loose smut, caused by *Ustilago segetum var. tritici* of wheat during 1985-88. He treated seeds of wheat cv. Sonalika with different levels of *U. segetum var. tritici* infection with carbendazim or carboxin at 2g/kg or triadimenol at 1g/Kg before sowing in the field. The disease incidence and infection percentage indicated that when seed infection was low (1.0), all the fungicide treatments gave complete disease control but as the level of seed infection increased loose smut incidence also increased despite fungicidal treatment. Triadimenol (as Baytan) was the most effective fungicide at high levels of seed infection.

**Lebedev,** *et al.*, (1998) reported that in Russia,the mixture of Flutriafol+Thiabendazole (as Vincit),tested for seed treatment on spring wheat and barley.gave good control of root rots and loose smut [*Ustilago nuda*[*U.segetum* var.*nuda*] at 1.5 and 2 litre/t seed.

**Effect of systemic fungicides on grain yield and quality**

**Gorshkova** (1974) reported that soaking of wheat seed in 0.05% benomyl and 0.01% Orthonitrophenol solution revealed an increment in seed germination percentages, plant growth and yield grain.

**Uble,** (1977) found that using 2g / kg seed of Carboxin (Vitavax or Quinolate VUX), or 50%, Benomyl 50% and 25% Triadimefon for controlling loose smut on wheat cv. Lely, gave good control and increased grain yield but not significantly.

**Polyakov** *et al.*, (1979) found that Vitavax was most effective as a seed treatment against *U. tritici.* Maximum yield was obtained after seed treatment at 2 - 4 g / kg seed and there were no injurious effects.

**Sahi** *et al.*, (1985) found that Bavistin (Carbendazim) was better than Vitavax in increasing germination and yield, giving almost double the net profits compared with the control.

**Bhardwaj & Thakur** (1992) evaluated the stability of fungicides (carboxin, carbendazim, triadimefon and biloxazol) used for the control of loose smut, caused by *Ustilago segetum var. tritici* in wheat and their relationships with yield losses. All of the tested fungicides gave effective control of loose smut and increased yield and grain weight than with biloxazol. It is concluded that triadimefon are stable and effective fungicides for the control of primary loose smut infection.

**Varietal resistance for wheat loose-smut**

Breeding for resistance to wheat loose smut may be one of the most effective methods for controlling the disease. An extensive work has been done in many countries of the world for identifying sources of resistance to that disease (**Gothowal & Pathak** 1986, **Bassiouni** *et al.*, 1988, **El-Daoudi** *et al.*, 1989 and **Sherif** *et al.*, 1991).

**Detecting loose smut mycelium in embryos**

Embryo test for detecting the dormant mycelium in the infected seeds has extensive importance by many workers.

**Morton,** (1960) showed that the mycelium of the loose smut fungus *U. nuda* is radish-brown and can be detected with Q15X dissecting microscope.

**Morton,** (1961) found that trypan blue at 0.05 – 0.1% was effective in staining *U. nuda* mycelium in barley embryos when added to 5% NaOH used to extract embryos from kernels. He mentioned also that it could be added at 0.01 – 0.05% to lactophenol for clearing tissue.

**Rewal & Jhooty,** (1982) found a direct correlation between embryos and seedlings having 50 % of tissue invaded by mycelium of *U. nuda* and field expression of the disease. Seedling with < 50% infection become free from loose smut mycelium.

**Verma,** *et al.*, (1985) found that the ratio between seed infection and adult plants infection was lowest in Kalyonsona and highest in Sonalika among the 8 cultivars tested.

**Bhutta & Ahmed** (1991) using the embryo count technique, found that of 104 wheat seed samples, 15 contained dormant mycelium of *Ustilago tritici*.

**Effect of loose smut on grain protein and total carbohydrate content.**

Generally, there is an extensive work has been carried out on the biochemistry of the host-parasite relationship in plant diseases. While, there is a lack-published information regarding the relation between wheat grain protein or sugar content and the infection of loose smut (**El-Shamy** *et al.*, under publication)

**Nilova & Ksendzova** (1966) inoculated pea plants, 25 days old with *E. polygoni* and found that in leaves of diseased plants, the sugar level was considerably less in comparison to the control.

**Uritani**, (1971) stated that in fungus-infected plants, the total nitrogen and protein content of the host-pathogen complex generally increased during the early stage of disease.

**Omar**, (1977) found that there was no clear relationship between the amino acid contents and changes occurring in the susceptible and resistant wheat cultivars to powdery mildew disease caused by *E. graminis tritici*.

**Farahat**, (1980) found in most cases that infection with powdery mildew, increased amino acid content in pea leaves and stems. The magnitude of increase was more pronounced in the highly susceptible variety.

**Dube**, *et al.*, (1988) found a general decrease of insoluble sugar in wheat seeds infected with *A. niger* and *A. tamarii*, while, an increase in seeds infested with *A. flavus* and *A. parasiticus* was recorded. On the contrary, the total soluble sugar decreased in seeds infested with *A. flavus* and *A. niger* and *A. tamarii*. On the other hand, the total insoluble nitrogen and protein increased in seeds infested with *A. flavus* and *A. parasiticus*, while decreased in seeds infested with *A. tamari*.

**Brien**, *et al.*, (1990) studied the effect of stripe rust on the processing quality of Australian wheat varieties over 4- years period.
They found that changes in grain quality were observed with susceptible varieties when subjected to an epiphytotic of the disease. Stripe rust caused grains to be shrinked, which resulted in reduced test weight and flour milling yield and increased grain protein content.

**Farag**, (1990) found that amylase, lipase and protease activities were higher in the infected wheat, sesame and soybean seeds comparing with healthy seeds.

**Drijepondt,** *et al.*, (1990) indicated that leaf rust infection of Thatcher cv. reduced the total grain yield per plot by 25.40 % and 100-grain weight by 5.6% Evaluation of milling and backing quality characteristics revealed that, compared to Thatcher, RL-6058 had a higher flour protein content but inferior milling, dough development and backing properties.

**Schmid,** *et al.*, (1994) studied the effect of leaf rust disease susceptibility on quality characters of protein content, in two year field trial. They found that the tested quality characters showed a negative heterosis effect resulting in protein level.

**Mostafa**, (1995) reported that the infestation of stored grains of durum and soft wheat with *A. flavus*, *A. niger*, *Alternaria alternata* and *Fusarium moniliforme* reduced total soluble sugar and total crude protein content and increased fat acidity values, especially in grain with a high moisture content (17%).

**Field response to wheat loose smut**

**Gothwal & Pathak** (1983) evaluated 168 cultivars using artificial inoculation with a teliospore mixture of 103 isolates of *U. tritici*. No one of them was immune, the least infection was ( 3.2 – 5%) in WG-430, , H-102, NP-818, CPAN-722 and C-217.

**Sharma** *et al.*, (1985) evaluated 439 *Triticum aestivum* lines and 13 *T. durum* against a mixture of Indian field races of *U. tritici*. The commonly cultivated HD-2009, WH-147, WL-711, Sonalika, Kalyonsona and WL-1562 of the bread wheat lines were susceptible. Meanwhile, 10 of the 13-*T. durum* lines were resistant.

**Kiseleva**, (1990) examined accessions of spring bread wheat, spring durum wheat and oats for resistance to *Ustilago tritici* in wheat and avenae (in oat) under field and greenhouse conditions during 1983-88. He found that inoculation in the greenhouse promoted better manifestation of the disease than field infection. The least disease incidence was shown by Leucurum-120 among durum wheat and Biryasinka x Omshaya-3889 among bread wheat. Wherever, Dula x 24h-263, Narymshil x frazer and falenski x 20/1268 were the least infected oats.

**Sherif** *et al.*, (1991) tested 96-wheat entries as well as 10 Egyptian wheat cultivars to loose smut and found fourteen of 96 entries were highly resistant. The Egyptian wheat cvs. Giza-155, 160 and 162 were resistant (0-5%), while Sakha-61 and Sakha 92 were susceptible. Giza-157 and Sakha-69 cvs. were moderately susceptible (11-20%), while, Giza-163, Gize-164 and Sakha-8 were moderately **resistant** (6-10%).

**Anil-Gupta** *et al.*, (1991) evaluated 938 *T.aestivum,T. durum* and_Triticale lines for resistance to loose smut (*Ustilage segetum var nuda*) from 1982 – 1989. Twenty- two lines of *T. aestivum* and 19 of *T. durum* showed complete freedom from loose smut for 3 or more years.

**Effect of loose smut infection on some agronomic traits.**

**Beniwal** *et al.*, (1990) studied the effect of *U. tritici* on tiller height, number of tillers, number of smutted tillers, ear length and flag leaf in 8 cultivars. Maximum reduction in tiller heights occurred in cv. Kalyansona and the maximum reduction in length of ears occurred in WH-291. While, the total numbers of tillers were reduced in all the cultivars and incidence of smutted tillers ranged from 17.7 – 61.7% according to the cultivar.

**Lal & Siddiqui** (1990) stated that infection of wheat by *U. nuda f. sp. tritici* reduced the average number of tillers/plant to be 6.3 compared with 11.3 on healthy plants. All tillers were affected by smut 21 of the 51 cvs. showed infected plants.

**Rewal** (1992) suggested that the suppression of tillering associated with smut infection should be used as a supplement to ear infection in estimating the disease.

**Inheritance of wheat resistance to loose smut**

Wheat loose smut had been reported to be a genetic inherited trait controlled by one, two or few major gene pairs.

**Caloves**, (1978) reported that the performance of $F_3$ progenies of crosses between the wheat varieties El-Gauche-FA that was resistant in 12 tests and Klein-32 which exhibited susceptibility in the same tests, resulted in the presence of a single recessive gene controlling resistance to loose smut. However, 25% of the progenies proved to be immune.

**Ahmed,** *et al*, (1980) reported that the field tests of crosses involving K-309 and Chris (resistant to loose smut) and Kalam and C-271 (susceptible), resulted in the dominance of resistance over susceptibility. On the other hand, $F_2$ segregation data indicated that resistance was monogenic in K-309 while in Chris, two dominant genes controlled it.

**Gothwal & Pathak** (1982) evaluated wheat cvs as Florence/ Aurora known as resistant to loose smut subculture 24 / VII and exhibited good grain characters in addition to Rewared and Vilmorin 29 that were considered to be highly susceptible to the subculture. The first cv. served as a female parent while the other two served as male. The study gave evidence for the existence of two duplicate dominant genes governing the inheritance of resistance in Florence/ Aurora and that resistance is dominant over susceptibility.

**Tikhomirov,** (1983) concluded that the differential spring wheat reward, Diamont, Runkers, Dickkop and Kota have one dominant gene for resistance to 31 races of loose smut, while Moskovka, Preston, Narodnage, Mindum and Akmolinkas each have two such genes.

**Krivchenko, and Bakharea,** (1984) crossed between 6 varieties resistant *to U. nuda,* and 2 slightly susceptible varieties with 5 varieties showing susceptibility. Analysis of the $F_1$ – $F_3$ and $F_1BC_1$ indicated that in most cases, resistance was dominant.

**Saini** *et al.*, (1989) crossed between 3 resistant varieties to *U. tritici* and the susceptible variety Sharbatisonona, in all possible combinations. The segregation for disease incidence after inoculation of $F_2$ and $F_3$ generations with a mixture of loose smut races indicated that CCL-222, NP-824 and Sonop each possess one dominant gene controlling resistance.

**Pandey & Gautam** (1992) evaluated the parental, $F_1$, $F_2$ and backcross generations from crossing between 7 varieties resistant to *U.tritici* (HD-2236, WL-208, WL-2053, WL-1804, WL-1798, WL-1567 and WL-711) for disease reaction after inoculated with a mixture of field races. Segregation ratios indicated that a single dominant gene controls the resistance to *U. tritici* in each of the resistant varieties.

**Gulerria,** *et al.*, (1994) studied the inheritance to loose smut (*Ustilago tritici* {*segetum var ritici*) pathotype prevalent in Himachal Pradesh in 4 wheat cultivars and their hybrids from crosses with susceptible cultivar WL-711. The F1 generation from crosses CPAN-2016 x WL-711, CPAN-2099 x WL-711 and PBW-65 x WL-711 were all resistant, but the F1 hybrids of CPAN-2059 x WL-711 were susceptible. The segregation patterns of the F2 and backcrossed generations suggest that smut resistance is a dominant trait in CPAN-2016, CPAN-2099 and PBW-65 and a recessive trait in CPAN-2059.

**Shehab El-Din,** *et al,* (1996) determined resistance gene(s) in 4 Egyptian bread wheat cvs. variable in their reaction to loose smut, i.e., Hindi-62 (resistant), Sakha-61 and Giza-163 (susceptible) and Sakha 8 (Moderate). Four crosses and their reciprocal were made among these parents. The results revealed that wheat resistance to loose smut in the first two crosses was controlled by three major gene pairs. Moreover, the reciprocal crosses of the resistant parent, Hindi-62 and each of the susceptible ones, Sakha-61 and Giza-163 showed remarkable lower smut percentage in $F_2$ plants, when resistant cultivar was used as a female parent. On the other hand, resistance in the last two crosses and their reciprocals was governed by four functioning gene pairs indicated that resistance in attributed to embryogenic constitution rather than the genetic make-up of the female parent.

**Grewal,** *et al.*, (1997) studied inheritance of loose smut (*Ustilago segetum* var. *tritici*) resistance in 11 bread wheat genotypes (9 resistance and 2 susceptible). $F_1$, $F_2$, $BC_1$ and $BC_2$ were evaluated by artificial inoculation for 36 direct and reciprocal crosses. No evidence of cytoplasmic effects was observed from the comparison between reciprocal crosses, and resistance was dominant to susceptibility. Segregation ratios indicate that ML-521, WG-2455, WG-2753 and W-2942 carry 1 dominant resistance gene whereas WL-3203, WL-3914, W-972, WG-3069 and W-3902 have 2 epistatic genes for loose smut resistance.

# MATERIALS AND METHODS

# MATERIALS & METHODS

**I- Chemical control**

**A- Laboratory Experiments**

**1-Effect of certain systemic fungicides on germination of loose smut teleutospores under lab conditions:**

This experiment was performed to determine the efficiency of different systemic fungicides (Table 1) at concentrations of 5, 10, 25, 50, 100, 150, 250, 200 and 750 ppm on teleutospore germination under laboratory condition. The appropriate amount of each concentration was added to autoclaved plain agar media. Plain agar media without fungicide was served as control. The treated and untreated agar was poured in 9 Φ-cm plates. Teleutospores used in this experiment were obtained from newly infected spikes collected from naturally infected plants, kept in paper envelops and left 10-14 days to dry at room temperature then teleutospores were extracted by breaking-off a piece of infected spike (**Nielsen,** 1987). The obtained spores were suspended in distilled water (o.25 g of spores per one liter of distilled water). Spore suspension was then spread over the surface of solidified plain agar, (in Petri-dishes), using a sterilized smooth brush (**Popp,** 1958) and incubated for 48 hrs. at $20\pm 1^{\circ}C$. Three replicates were used for each concentration. Percentage of germinated teleutospores as affected by different treatments was estimated by counting germinated and un-germinated spores in 10 fields of each plate.

**2-Phytotoxicity of certain fungicides on plant shoot and root system**

The main objective of this experiment is to study the effect of certain systemic fungicides as illustrated in Table

(1) on the development of shoot and root of wheat seedlings. According to the method described by El-**Nawawy** ***et al.***, (1972). Seeds of Giza-163 cv. were dipped in water for 6 hrs. then put in cotton cloth for 24 hrs for rapid emergence of seedlings. The tested fungicides at 5, 10, 25, 50, 100, 250,500,750 and 1000-ppm concentrations were added to autoclaved plain agar media. When seeds begin to germinate they were transferred aseptically on the surface of the plain agar containing fungicides, (in the test tube 1.2 x 20-cm). Tubes with plain agar medium without fungicides were used as control treatment. Three replicates for each fungicide at different concentrations in randomized complete design were used. All tubes were incubated at room temperature. The length of shoots and roots was measured after the complete development of root system of the control seedling. Inhibition percentage of both roots and shoots were estimated according to the following equation adopted by **Mansour** ***et al.***, (1966).

$$\text{Inhibition } \% = \frac{A - B}{A} \times 100$$

Where A = length of shoot or root in the control.
B = length of shoot or root in the treatment.

Results were statistically analyzed according to Finney's probit analysis. Then regression lines were drawn on probit-log paper and the medium inhibition concentrate ($IC_{50}$) is estimated.

### 3-Effect of certain systemic fungicides on seed germination

Seeds of Giza-163 (150 seeds in three replicates for each treatment) were treated with the tested fungicides at recommended doses (Table 1). The treated and untreated (control) seeds were placed on moistened filter paper in Petri dishes (each one contains 50 seeds). After 7-days, the number of germinated seeds were counted in both control and treated ones. The germination percentage was calculated for each treatment according to the formula of **Rewal & Jhooty** (1985) as following:

$$\text{Germination \%} = \frac{\text{No. of germinated seeds intreament}}{\text{No. of germinated seeds in control}} X100$$

**Table (1): List of tested fungicides, their active ingredients, recommended dose and manufactures.**

| Trade name & Producing Company | Common name & Active ingredient | Chemical formula | Dose (ml or g / Kg seed) |
|---|---|---|---|
| Sumi-eight 5 Ec<br>Kafer El-Zayat | Diniconazol | (E)-1-(2,4 Dichlorophemyl )-4,4-dimethyl 1-2 -(1,2,4-triazol -1-yl)-1-penten -3-01. | 1 ml |
| Sumi-eight 2 FL<br>Suomotumo | Diniconazol | (E)-1-(2,4 Dichlorophemyl )-4,4-dimethyl 1-2 -(1,2,4-triazol -1-yl)-1-penten -3-01. | 2 ml |
| Topsin-M70 (Nippon-sada-Japan | Thiophanate-methyl (70%) | Dimethye (1.2 phenylene) bis (iminocarbono-thioye)bis carbonate | 3 g |
| Vincit-P<br>Haslemer England | Flutviafdol 2.5%+thiabemdazo le 2.5% | (p5)-2,4 difluoro-(1 H-1,2 triazol-1-ylmethyl benzhydry alcohol | 2 ml |
| Vitavax -200<br>K-Z | Carboxin- Thiram | 5,6-dihydro-z-methyl-N- Phenyl-1,4-oxathiin-3-carboxamide | 3.5 ml |
| Premis 2.5 F.S Aventis | Triticonazole | 5-[(4,cholorophenyl)methylene]-2,2-dimethyl 1-1-(1H-1,2,4-triazol-1-ylmethyl) cyclopentanol | 2 ml |
| Galbin -Cu<br>K-Z | Benalaxyl | N-[3-(1-ethyl -1-methylpropyl)-5-isoxazolyl]-2,6-dimethoxybenzamide . | 3 g |
| Antracol -Cu<br>K-Z | Propineb | 2-chloro-N-(iso propoxymethyl )-N-(2-ethyl-6 -methylphenyl)-acetamide | 3 g |
| Apron (Novartis) | Metalaxyl (35%) | N- (2,b-dimethyl phenyl) - N(methoxy acetyl)-D1-kg alanine methyl ester (CAS) | 3 g |

**B-Field Experiment**

This study was performed to detect the efficacy of nine systemic fungicides (Table 1) in controlling loose smut disease during 1998/99 and 1999/2000 growing seasons at Gemmeiza Research Station.Twenty spikes of the susceptible wheat cultivar sakha 61 was artificially inoculated at mid–anthesis stage with a mixture of loose smut teleutospores which collected from naturally infected plants .The dry method of **Sharma** *et al* (1985) was used for inoculation during 1997/98 and 1998/99 ,which the tops of the mid spikelets were half–clipped to expose the stigma .The spikes were covered with pyrgamin bags which opened up from the tops ,a fine mist of water was sprayed in the bags to create humidity, then the spikes were dusted with inoculum and the bags closed with clips. At maturity, the inoculated spikes were harvested and its seeds collected for use.

**Seed dressing with fungicides**

In the subsequent seasons 1998/1999 and 1999/2000 seasons, the inoculated seeds were finely atomized by distilled sterile water just before fungicidal treatment **then** treated with the systemic fungicides at the recommended doses 24 hrs before sowing. The treated seeds were planted in three replicates (each one contains single rows, 3m. long/20cm. apart and 30 seeds/row) in Randomized Block Design. At flowering stage, disease incidence was estimated as a percent of smutted spikes to the total number of spikes. Efficacy of fungicides in controlling loose smut disease was estimated according the equation of **Rewal & Jhooty** (1985). Weight of 1000-kernel and yield/row as affected by fungicidal treatments were also estimated. The increment yield due to using the fungicides over the control was determined.

$$\text{Disease incidence} = \frac{\text{No.of smutted spikes/row}}{\text{Total No.of spikes/row}} \times 100$$

Efficacy %=

$$\frac{\text{Disease incid. in control} - \text{Disease incid. in treatment}}{\text{Disease incidence in control}} \text{X } 100$$

**II- Varietal resistance:**

This experiment was conducted to detect the sources of resistance against loose smut disease among different local and new released wheat cultivars. Fifteen Egyptian wheat cultivars obtained from Wheat Res. Dept., Field Crops Res.Instit., ARC.,Giza ,Egypt (Table 2) were used. Evaluation against loose smut disease was carried out at Gemmeiza Research Station during three growing seasons 1997/1998, 1998/1999 and 1999/2000.

Seeds of each cultivar were planted in three replicates (each contains single row, 3m. long/20cm. apart and 30 seeds/row). The dry method of inoculation with telitospores of loose smut pathogen as described by **Sharma *et al.*,** (1985) was used during both 1997/1998 and 1998/1999 seasons. At mid-anthesis for each cultivar, 20 spikes were inoculated as follow: Two upper and lower florets were removed and the rests were half-clipped to expose the stigma. The spikes were then covered with parchment paper-bags. The bags were opened up from the top and air blown in manually. A fine mist of water was sprayed in the bags to create humidity. The spikes were then dusted with inoculum and the bags closed with clips. At the end of the same season, the mature inoculated spikes were harvested then its seeds were used for determining varietal response against artificial inoculation expressed as:

## A- Laboratory Experiments

### 1-Embryo test

In this test, embryos were extracted from the obtained infected seeds and investigated to determine percentage of infection in seeds of different tested wheat cultivars. The method adopted by **Rennie** (1982) was followed for extracting, clearing, staining and examining the inoculated seeds. Seeds were soaked in a 5% NAOH solution containing 0.2 g trypan blue stain for 24 h. at 20°C. The floated embryos were separated using a small brush and washed in tap water several times, then boiled in lactophenol (lactic acid, phenol, glycerin and water (1:1:1:5) for 45 minutes. Embryos from 50 inoculated seeds of each cultivar were examined microscopically for detecting the presence of dormant smut mycelium in the embryos, then the infected and healthy embryos were counted. Percentage of infected embryos was calculated for each cultivar according to **Rewal & Jhooty** (1985).

### 2-Determination of total protein content

The total nitrogen in infected seeds compared with healthy seeds (obtained from un-inoculated spikes) was estimated in 0.2 gm samples of whole flour of each cultivar using the Micro–Kjeldahl method as follow:

1-Weight 0.2 gm of fine grounded sample of each cultivar seeds and transfer to 30 ml digestion flask.

2- Add 5 ml conc. Sulphuric acid and digest the sample on a hot plate till the solution becomes colourless then cooled and completed to a known volume.

3- An aliqout of the digested solution is transferred to microkjeldanl unit .

4- Distill and collect the ammonia on boric acid solution (4%) with a few drops of mixed indicator ( bromocrysol green and methyl red.)

5- Titrate the solution against the standard sulphuric acid until the first appearance of violet colour .

6- Nitrogen percentage can be calculated using the following formula .

$$\% N = \frac{V1 \times N \times 14 \times V2}{1000 \times V3 \times W} X100$$

Where : V1 = Volume of $H_2SO_4$ used for titration (ml)

N = Normality of $H_2SO_4$

V2 = Volume of total digested solution (ml)

V3 = Volume of digested solution which used in distillation (ml)

W = Weight of digested sample (g ).

Percentage of crud protein was calculated by multiplying N % x 5.75 as constant value.

**3-Determination of total carbohydrate content**

Total carbohydrate was determined as glucose using anthrone method adopted by **Megneteski** ***et al.***, (1959) as follow: From each of tested cultivars, 0.2g of grounded sample was digested in a test tube contained 0.8N $H_2SO_4$ on water bath at 70-80°C for 16 hours. 2ml of the previous digested solution added to 4 ml of anthrone reagent (0.2g anthrone in 100 ml of concentrated Sulphoric acid ) in another test tube then heated indirectly in water bath at 100°C for 3 min then cooled under tap water. The developed color was measured at 620 nm using Spectrophotometer (Spectronic-20). Total carbohydrate was calculated using glucose standard curve.

## B-Field Experiments

### 1- Varietal response to artificial inoculation with wheat loose smut

In 1998/99 and 1999/2000 growing seasons, thirty inoculated seeds of each cultivar were sown in 3 m. rows with three replicates as well as the uninoculated seeds in Split Plot Design. The main plots were inoculated seeds and sub plots were the cultivars .At the end of each season, number of smutted and healthy spikes were counted and percentage of disease incidence was estimated as previous mentioned . Varietal resistance against loose smut was evaluated according to the scale of **Nielsen,** (1987) as follows: (a) Resistance = 0 - 5 % smutted heads, (b) Moderately resistant = 6 - 10% smutted heads, (c) Moderate susceptible = 11- 20% smutted heads, and (d) Susceptible = more than 20% smutted heads.

### 2-Effect of loose smut on some agronomic traits

Yield and yield components of ten individual plants of each cultivar were determined by estimating, number of tillers/plant, tiller height, spike length, No. of spikelts/spike as wall as 1000 kernel weight and yield/row. Also, yield looses due to artificial inoculation was estimated for each cultivar according to the formula of **Calpouzos, *et al.*,** 1976 as follows:

$$\text{Losses }\% = \frac{Yh - Yd}{Yh} x100$$

Where

Yh = Yd = Diseased yield

Healthy yield

## Statistical analysis

Statistical analysis was performed using the method of **Stell** ***et al*** (1960)

**III-Inheritance of wheat resistance to loose smut**

This study deals with the inheritance of wheat (*Triticum aestivum* L.) against *Ustillago tritici.* This study was done at the Experimental Farm of Gemmeiza Research Station during 1997–2000 growing seasons. In the first season 1997/1998 and on the basis of their previous response against loose smut, two resistant monogenic lines Lr19 and Sr26 were crossed with 4 susceptible Egyptian wheat cultivars namely, Sakha-61, 69, Giza-162 and Giza-163 as testers to produce 8 crosses. The response, origin and pedigree of these parents are presented in Table (3).

In 1998/1999 growing season, the six parents and eight hybrid seeds were sown (in 3-m. rows and 20-cm apart). At flowering stage, 20 spikes of each parent and hybrid were artificially inoculated at mid–anthesis stage (**Rewal & Jhooty**, 1985) by teleutospores of *Ustilago tritici* the causal agent of loose smut as described previously according to **Sharma** ***et al.***, (1985). At the end of growing season, the inoculated spikes were picked up and their seeds were kept for the subsequent season.

In 1999/2000, the inoculated wheat grains of $F_2$ generation, with the parental genotypes were sown in three replicates (each one contains 4 rows, 4-m length, 30-cm. apart and 30 grains/rows) in a Randomized Complete Block Design. Data on loose smut incidence of 100 plants/replicate of each cross and parent were recorded at the full emergence of spikes as percentage of smutted spikes to the total number of spikes .

General and specific combining ability as well as additive and dominant gene effects of the obtained data were subjected to the biometrical analysis using the procedures of line x tester analysis, which outlined by **Kempthorne** (1957) in specific computer program.

**Table (2): List of 15 Egyptian wheat cultivars and their pedigree evaluated to loose smut disease.**

| Cultivates | Pedigree |
|---|---|
| **Sakha-8** | Indus/Norteno 's' |
| **Sakha-61** | Inia /RL 4220// 7c /Yr 's' |
| **Sakha-69** | Inia /RL 4220// 7c /Yr 's' |
| **Sakha-92** | Napo 63 /Inia 66 // Wern 's' |
| **Gemmeiza- 1** | May's'/ On//1160- 147/3/Bb/Gall/4/ Chat 's' |
| **Gemmeiza -3** | Bb /7c 2//4504 Kal /3/ 5 Skh 8/4/Rrv/ww/3/Bj's'//on 3 Bon. |
| **Gemmeiza 5** | Vee's' /Swm 6525 |
| **Giza-155** | RG/-G.139 // Mdcd / CI 12441 // Hi. 62 |
| **Giza-160** | Chenab 70 /Giza 155 |
| **Giza-162** | Vcn //Cno 67 / 7C /3 /Ral /Bb = Pavon"s" |
| **Giza-163** | T.aestivum /Bon //Con /3 /7C |
| **Giza-164** | Kvz /Buho 's' //Kal /Bb= Veery # s |
| **Giza-165** | Cno /Mfd// Man 's' |
| **Giza-167** | Au /up 301 //Gll /Sx /3/Pew 's' /4 / Mai's' /Maya's' //Pew. |
| **Giza-168** | MRl/Buc//Seri |

**Table (3): Pedigree and field reaction of 6 wheat cultivars used in line x tester**

| Parents | Pedigree | Disease incidence % |
|---|---|---|
| **Sakha-61** | Inia /RL 4220// 7c /Yr 's' | 51.30 |
| **Sakha-69** | Inia /RL 4220// 7c /Yr 's' | 32.27 |
| **Giza-162** | Vcn //Cno 67 / 7C /3 /Ral /Bb = Pavon"s" | 15.56 |
| **Giza-163** | *T.aestivum* /Bon //Con /3 /7C | 22.28 |
| **Lr19** | | 1.80 |
| **Sr 26** | | 2.25 |

# RESULTS AND DISCUSSION

# RESULTS

## I-Chemical control

### A- Laboratory Experiments

#### 1-Effect of certain systemic fungicides on germination of loose smut teleutospores

Data in Table (4) Show the effect of the tested fungicides at different concentrations, i.e., 5, 10, 25, 50, 100, 250, 500 and 750 ppm added to the media on germination of loose smut teleutospores, expressed as a percentage of inhibition. All tested fungicides gave significant inhibition to loose smut teleutospores germination except at 5-ppm concentration. Meanwhile, Diniconazol- FL at 100 ppm gave 100 % inhibition of teleutospores germination followed by Diniconazol- 5EC, Caroxin-Thiram, Triticonazol and Flutviadol-Thiabemazold where the inhibition percentages were 83.33, 83.33, 81.67 and 80.0 % respectively. Therefore, Diniconazol- 5EC, Diniconazol- 2FL, Triticonazol and Caroxin-Thiram at 250 ppm resulted in 100% inhibition followed by Metalaxyl (95%) and Flutviadol-Thiabemazold (86.67%). On the other hand, all the tested fungicides at 500 ppm gave 100 % inhibition except Thiophante-methyl; Benalaxyl and Propineb while, the inhibition percentages at 750 ppm were 100% for all tested fungicides.

#### 2-Phytotoxicity of certain systemic fungicides on plant shoot and root systems

The presented data in Table (5) and illustrated in Figs (1& 3) clearly showed the effect of 9 systemic fungicides on the shoot length of wheat seedlings. Most of tested fungicides showed phytotoxic effect on the shoot system at 5 ppm except Tritcoazol. While , Caroxin-Thiram, Thiophante-methyl

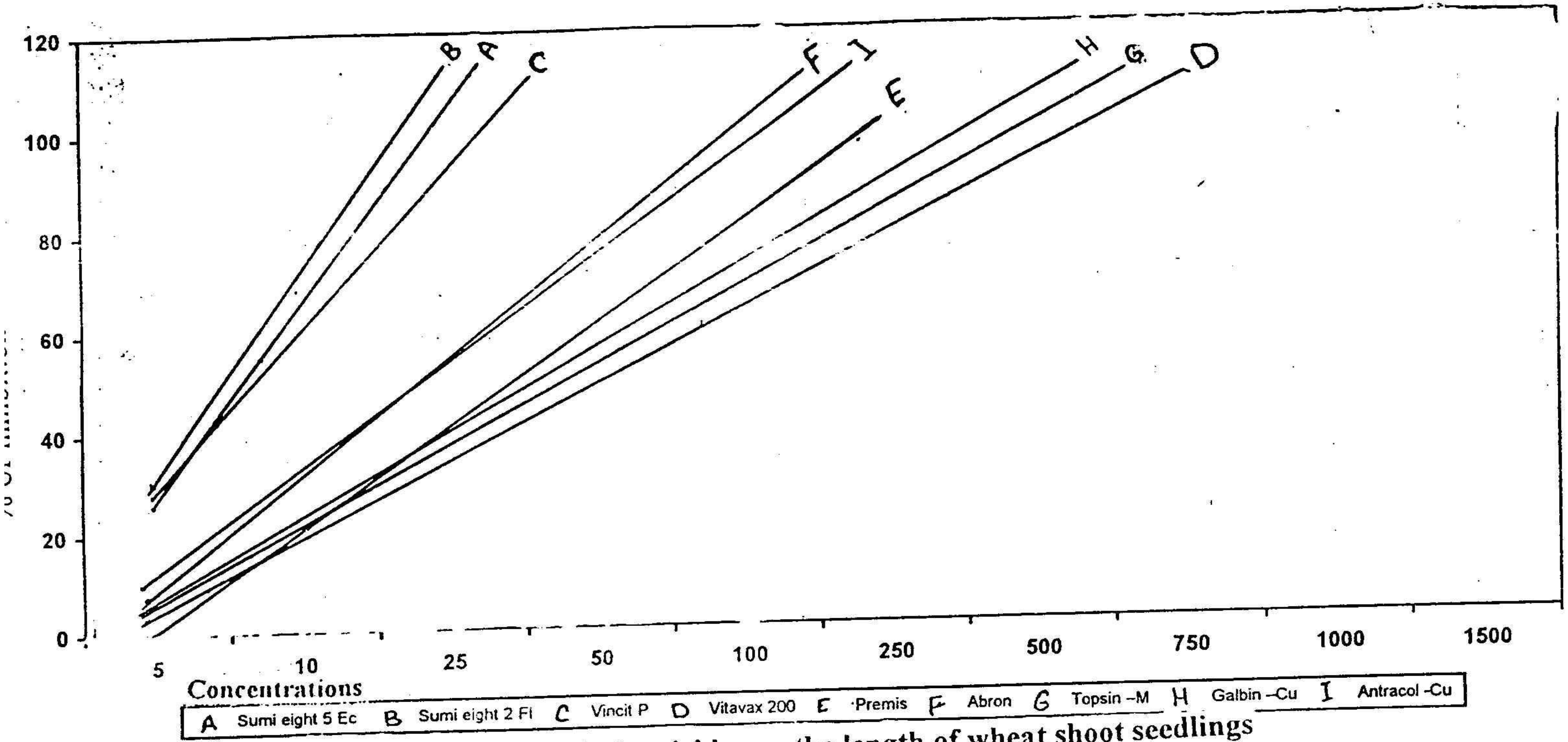
**Table (4): Effect of 9 systemic fungicides on germination percentage of loose smut teleutospores expressed as % of inhibition**

| Fungicides / ppm. | Common name & Active ingredient | % inhibition of teleutospores at concentrations (ppm) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 5 | 10 | 25 | 50 | 100 | 250 | 500 | 750 |
| Sumi eight 5 EC | Diniconazol | 23.33 | 31.67 | 51.67 | 61.67 | 83.33 | 100.0 | 100.0 | 100.0 |
| Sumi eight 2 FL | Diniconazol | 26.67 | 41.67 | 58.33 | 81.67 | 100.0 | 100.0 | 100.0 | 100.0 |
| Vincit-P | Thiophanate-methyl (70%) | 25.0 | 33.33 | 41.67 | 61.67 | 80.0 | 86.67 | 100.0 | 100.0 |
| Vitavax-200 | Flutviafdol 2.5% + thiabemdazole 2.5% | 28.33 | 46.67 | 61.67 | 71.67 | 83.33 | 100.0 | 100.0 | 100.0 |
| Premis | Carboxin- Thiram | 28.33 | 41.67 | 58.33 | 71.67 | 81.67 | 100.0 | 100.0 | 100.0 |
| Apron | Triticonazole | 26.67 | 43.33 | 53.33 | 63.33 | 70.0 | 95.0 | 100.0 | 100.0 |
| Topsin–M | Benalaxyl | 25.0 | 31.67 | 43.33 | 50.0 | 61.67 | 75.0 | 83.33 | 100.0 |
| Galbin–Cu | Propineb | 25.0 | 30.0 | 41.67 | 51.67 | 61.67 | 76.67 | 85.0 | 100.0 |
| Antracol–Cu | Metalaxyl (35%) | 23.33 | 30.0 | 38.33 | 50.0 | 61.67 | 75.0 | 83.33 | 100.0 |
| Control | | 21.67 | 21.67 | 21.67 | 21.67 | 21.67 | 21.67 | 21.67 | 21.67 |
| L.S.D. at 5% | | 5.941 | 3.764 | 3.175 | 4.009 | 3.423 | 2.712 | 2.811 | 2.145 |

**Table (5): Phytotoxicity of 9 systemic fungicides on shoot length of wheat seedlings**

| ppm. / Fungicides | Common name & Active ingredient | % of reduction in shoot length at concentrations (ppm) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 5 | 10 | 25 | 50 | 100 | 250 | 500 | 750 | 1000 | 1500 | $IC_{50}$ ppm |
| Sumi eight 5EC | Diniconazol | 22.9 | 55 | 90 | 98 | 100 | 100 | 100 | 100 | 100 | 100 | 9 |
| Sumi eight 2 Fl | Diniconazol | 30.8 | 67.21 | 94 | 99 | 100 | 100 | 100 | 100 | 100 | 100 | 7.5 |
| Vincit-P | Thiophanate-methyl (70%) | 28 | 60 | 92 | 98.5 | 100 | 100 | 100 | 100 | 100 | 100 | 8 |
| Vitavax-200 | Flutviafdol 2.5% + thiabemdazole 2.5% | 0.55 | 1.50 | 7.5 | 18 | 33 | 58 | 78 | 85 | 93 | 100 | 190 |
| Premis | Carboxin- Thiram | 0 | 2 | 28 | 70 | 95 | 100 | 100 | 100 | 100 | 100 | 35 |
| Apron | Triticonazole | 4.11 | 15.5 | 48 | 58 | 93 | 97 | 99 | 105 | 100 | 100 | 27 |
| Topsin–M70 | Benalaxyl | 0.8 | 3.5 | 17 | 39 | 75 | 89 | 96 | 98 | 99 | 100 | 65 |
| Galbin–Cu | Propineb | 2.8 | 9 | 19 | 51 | 74 | 92 | 97 | 98 | 100 | 100 | 45 |
| Antracol-Cu | Metalaxyl (35%) | 13 | 28 | 51 | 72 | 86 | 96 | 98 | 100 | 100 | 100 | 23 |

**IC 50 = % of fungicide concentration which inhibit 50% of shoot length**



Effect of nine systemic fungicides on the length of wheat shoot seedlings followed by Benalaxyl and Propineb showed the lowest effect of phytotoxicity at 5 ppm where the inhibition percentage of shoot length were 0.55, 0.8, 2.8 and 4.11 % respectively. On the other hand, the phytotoxicity of all tested fungicides increased gradually with increasing their concentration. The fungicides, i.e., Diniconazol- 5EC, Diniconazol- 2FL and Flutviadol-Thiabemazold revealed 100% inhibition of wheat shoot length at 100 ppm followed by Triticonazol at 250 ppm, Benalaxyl and Propineb at 750 ppm and Benalaxyat 1000 ppm. Meanwhile, Vitavax–200 and Topsin–M70 gave 100 % inhibition at 1500 ppm.

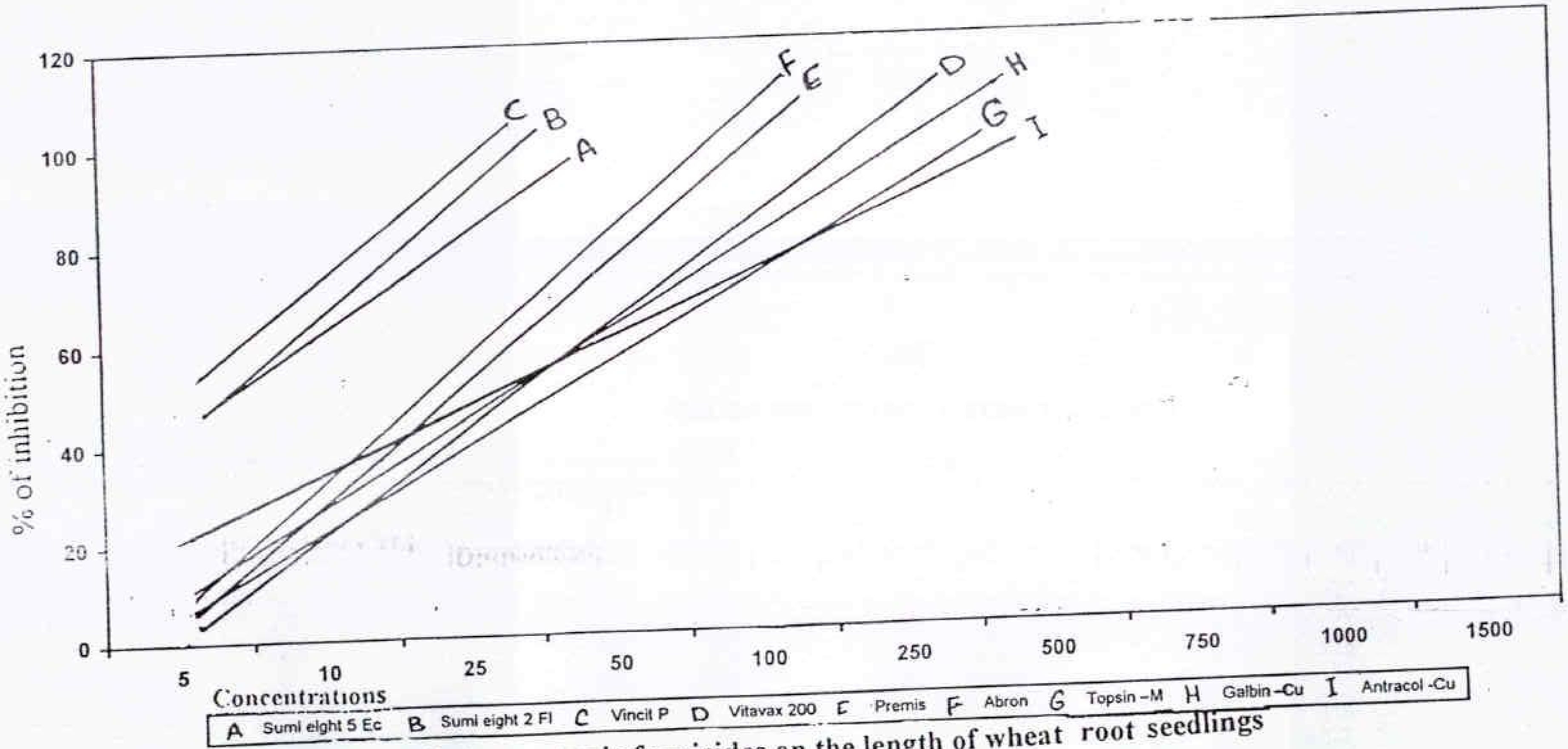
The results indicated also that Carboxin-Thiram exhibited the highest values of $IC_{50}$ (190 ppm.) while, the least values were with Diniconazol- 2FL, (7.5 ppm), Flutviadol-Thiabemazold (8.0 ppm) and Diniconazol- 5EC, (9.0 ppm).

Concerning the phytotoxic effect of the tested fungicides on root length of wheat seedlings, the presented data in Table (6) and illustrated by Figs (2 & 3) revealed that some fungicides showed high phytotoxicity at 5-ppm whereas, Carboxin-Thiram, Triticonazol, Thiophanat-methyl and Metalaxyl respectively revealed low phytotoxicity effect to wheat roots. It was found also that there were clear remarkable increases in inhibition percentages of root length with increasing the fungicide concentrations.Moreover, Diniconazol-5E, Diniconazol-2FL, and Flutviadol-Thiabemazold gave 100% inhibition at 50 ppm, followed by Metalaxyl at 500 ppm, Triticonazol and Propineb at 750 ppm, Benalaxyat and Carboxin-Thiram at 1000 ppm, Then Thiophanat-methyl at 1500 ppm.

Table (6): Phytotoxicity of 9 systemic fungicides on root length of wheat seedlings

| Fungicides / ppm | Common name & Active ingredient | % of reduction in root length at concentrations (ppm) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 5 | 10 | 25 | 50 | 100 | 250 | 500 | 750 | 1000 | 1500 | $IC_{50}$ ppm |
| Sumi eight 5 EC | Diniconazol | 48 | 67 | 98 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 6.5 |
| Sumi eight 2FL | [illegible] | 48 | 74 | 96 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 5.2 |
| Vincit-P | Thiophanate-methyl (70%) | 55 | 76 | 94 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 4.2 |
| Vitavax-200 | Flutviafdol 2.5% + thiabemdazole 2.5% | 1.8 | 7.5 | 28 | 54 | 78 | 95 | 98 | 99 | 100 | 100 | 45 |
| Premis | Carboxin- Thiram | 2 | 8.5 | 44 | 78 | 96 | 98 | 99 | 100 | 100 | 100 | 28 |
| Apron | Triticonazole | 9.3 | 24 | 54 | 78 | 93 | 98 | 100 | 100 | 100 | 100 | 21 |
| Topsin–M | Benalaxyl | 2.4 | 8 | 26 | 50 | 74 | 90 | 96 | 98 | 99 | 100 | 50 |
| Galbin–Cu | Propineb | 13 | 28 | 50 | 72 | 86 | 96 | 97 | 98 | 100 | 100 | 25 |
| Antracol–Cu | Metalaxyl (35%) | 22 | 41 | 71 | 87 | 96 | 98 | 99 | 100 | 100 | 100 | 13 |

IC 50 = % of fungicide concentration which inhibit 50% of root length




Effect of nine systemic fungicides on the length of wheat root seedlings

Fig. (3): Effect of 9 systemic fungicides at different concentrations on shoot and root length of wheat seedlings of Sakha 61 cv.

On the other hand, Carboxin-Thiram showed the highest values of $IC_{50}$ (45 ppm ), while , Flutviadol-Thiabemazold, Dinicoazol- 2 FL and Dinicoazol-5EC, showed the lowest values (4.2, 5.2, 6.5 ppm) respectively.

**3-Effect of certain systemic fungicides on seed germination**

Concerning the effect of the tested fungicides on seed germination, data in Table (7) revealed that seed treatment with the tested fungicides at the recommended doses had no effect on seed germination. Germination percentage of seeds ranged between 98.57 – 100.0 % comparing with the control treatment (water treatment). No significant differences were observed either between the fungicides or the fungicides and the control.

**B- Field Experiments**

**1-Effect of certain systemic fungicides on disease incidence of loose smut**

Influence of nine systemic fungicides as seed treatment namely, Dinicoazol-5EC, Dinicoazol-2Fl, Flutviafdol-thiabemdazole, Carboxin-thiram, Tritconazole, Metalaxyl, Thiophanate-methyl, Benalaxyl and Propineb at the recommended dose on wheat loose smut of Sakha-61 cv. was studied.

Data presented in Table (8) and illustrated in Fig. (4) showed that all tested fungicides have significantly decreased disease incidence percentage. However, highly significant differences were observed between the group of Dinicoazol-2Fl, Dinicoazol-5EC, Tritconazole and Flutviafdol-thiabemdazole and the rest of tested fungicides during 1998/1999 and 1999 / 2000 growing seasons.

Table (7): Effect of 9 systemic fungicides on seed germination

| Fungicides | Common name & Active ingredient | Av. of germinated seeds | % germination |
|---|---|---|---|
| Sumi eight 5EC | Diniconazol | 49.0 | 100 |
| Sumi eight 2FL | Diniconazol | 48.6 | 99.18 |
| Vincit-P | Thiophanate-methyl (70%) | 49.0 | 100 |
| Vitavax-200 | Flutviafdol 2.5%+ thiabemdazole 2.5% | 48.6 | 99.18 |
| Premis | Carboxin- Thiram | 49.0 | 100 |
| Apron | Triticonazole | 48.3 | 98.57 |
| Topsin–M70 | Benalaxyl | 49.0 | 100 |
| Galbin–Cu | Propineb | 48.3 | 98.57 |
| Antracol-Cu | Metalaxyl (35%) | 48.6 | 99.18 |
| Control | | 49.0 | 0 |
| L.S.D. at 5% | | N.S | |

Table (8): Disease incidence and efficacy of 9 systemic fungicides in controlling wheat loose smut in 1998/1999 and 1999/2000 growing seasons

| Fungicides | Common name & Active ingredient | Rate of application | 1998/1999 | | 1999/2000 | |
|---|---|---|---|---|---|---|
| | | | Disease incidence | % efficacy | Disease incidence | % efficacy |
| Sumi eight 5EC | Diniconazol | 1 ml | 2.103 | 96.27 | 2.273 | 95.65 |
| Sumi eight 2FL | Diniconazol | 2 ml | 0 | 100 | 0 | 100 |
| Vincit-P | Thiophanate-methyl (70%) | 3 g | 2.62 | 95.34 | 2.35 | 95.92 |
| Vitavax-200 | Flutviafdol 2.5%+ thiabemdazole 2.5% | 2 ml | 27.26 | 51.6 | 25.13 | 51.91 |
| Premis | Carboxin- Thiram | 3.5 ml | 0.47 | 99.34 | 0.11 | 99.79 |
| Apron | Triticonazole | 2 ml | 23.18 | 58.83 | 22.29 | 57.34 |
| Topsin–M70 | Benalaxyl | 3 g | 14.19 | 74.8 | 15.04 | 71.22 |
| Galbin–Cu | Propineb | 3 g | 24.30 | 56.84 | 22.48 | 56.98 |
| Antracol-Cu | Metalaxyl (35%) | 3 g | 25.21 | 55.44 | 25.30 | 51.58 |
| Control | | | 56.31 | 0 | 52.57 | 0 |
| L.S.D. at 5% | | | 4.260 | | 3.047 | |

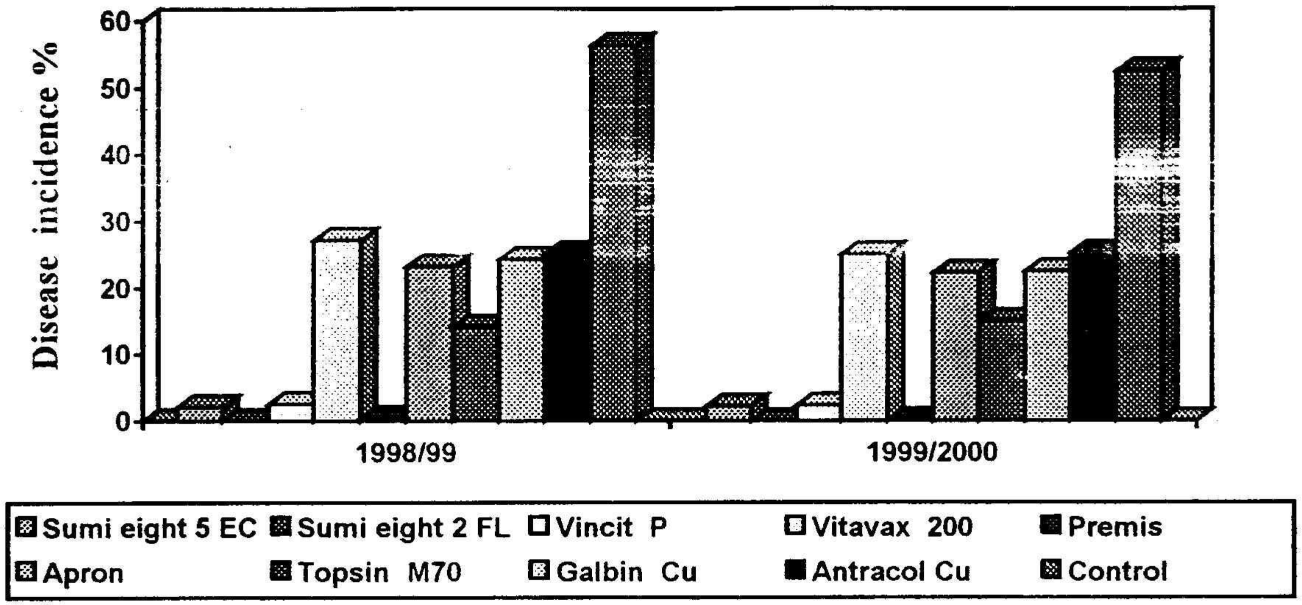



**Fig (4 ) Disease incidence of nine systemic fungicides on infection of loose smut on sakha 61 cv. at 1998/99 and 1999/ 2000**

Dinicoazol 2FL and Flutviafdol-thiabemdazole proved to be the most effective one in suppressing loose smut infection ( 100 , 99.39 % and 100, 99.79 %) during 1998/1999 and 1999 / 2000 growing seasons respectively. No significant difference were recorded between disease readings of Metalayl, Benaalaxyl, Propineb and Carboxin-thiram, respectively which showed low efficiency in reducing disease incidence during the two growing seasons (1998/99 and 1999/2000). Carboxin-thiram was the least effective one in this respect.

**2- Effect of certain systemic fungicides on grain yield/row and 1000 grain weight**

Regarding the effect of tested fungicides on grain yield/row and 1000 grain weight, the presented data in Table (9) show the significant differences in grain yield weight/row between the tested fungicides and the control during 1998/99 and 1999/2000 seasons. Dimiconazol- 2FL, Triticonazole, Dimiconazol- 5EC, and Flutviafdol-thiabemdazole respectively were the best in increasing grain yield weight/row while, no significant differences were recorded between yield of treatments of Metalaxyl, Benalaxyl, Carboxin-thiram and Propineb. Meanwhile, Carboxin-thiram and Propineb gave the lowest yield weight/row respectively during the two growing seasons.

On the other hand, Flutviafdol-thiabemdazole Thiophanate-methyl, and Dimiconazol- 5EC gave the highest values of 1000 grain weight during the two growing seasons (1998 / 99 and 1999/2000). While, Triticonazole and Dimiconazol- 2FL, came in the second rank. Insignificant differences were recorded between treatments of Carboxin-thiram, Metalaxyl, Benalaxyl, Propineb comparing to control gaving the lowest values during the two growing seasons.

**Table (9): Effect of 9 systemic fungicides on grain yield/row and 1000- grain weight during 1998/1999 and 1999/2000 growing seasons.**

| Fungicides | Common name & Active ingredient | 1998/1999 | | | | 1999/2000 | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Yield/row (gm) | % increase | 1000-grain weight (gm) | % increase | Yield/row (gm) | % increase | 1000-grain weight (gm) | % increase |
| Sumi eight 5EC | Diniconazol | 385.0 | 120.0 | 47.43 | 6.15 | 356.7 | 109.82 | 46.69 | 7.58 |
| Sumi eight 2FL | Diniconazol | 391.7 | 123.85 | 46.37 | 3.78 | 363.3 | 113.70 | 45.96 | 5.89 |
| Vincit-P | Thiophanate-methyl (70%) | 381.7 | 118.11 | 48.17 | 7.81 | 358.3 | 110.76 | 47.84 | 10.23 |
| Vitavax-200 | Flutviafdol 2.5% + thiabemdazole 2.5% | 285.0 | 62.85 | 44.86 | 0.40 | 270.0 | 58.82 | 43.59 | 0.43 |
| Premis | Carboxin- Thiram | 385.0 | 120.0 | 47.08 | 5.37 | 360.0 | 111.76 | 46.17 | 6.38 |
| Apron | Triticonazole | 295.0 | 68.57 | 44.15 | 0.15 | 285.0 | 67.64 | 43.88 | 1.10 |
| Topsin–M70 | Benalaxyl | 333.3 | 90.45 | 48.40 | 7.68 | 310.0 | 82.35 | 47.62 | 9.72 |
| Galbin–Cu | Propineb | 291.7 | 66.68 | 45.11 | 0.96 | 280.0 | 64.70 | 44.78 | 3.17 |
| Antracol-Cu | Metalaxyl (35%) | 285.0 | 62.85 | 44.73 | 0.11 | 265.0 | 55.88 | 44.26 | 1.98 |
| Control | | 175.0 | 0 | 44.68 | 0 | 170.0 | 0 | 43.40 | 0 |
| L.S.D. at 5% | | 16.20 | | 1.156 | | 15.80 | | 2.475 | |

## II -Varietal Resistance

### A-Laboratory Experiments

This experiment included the effect of artificial inoculation with a mixture of loose smut isolates on 15 old and new Egyptian wheat cultivars namely, Sakha-8, 61, 69, 92, Gemmeiza-1, 3, 5, Giza-155, 160, 162, 163, 164, 165, 167 and 168. The following data includ percentage of embryo infection, grain protein, and total carbohydrate content due to loose smut infection.

### I - Embryo test

As shown in Table (10) and illustrated in fig.(5) the tested seed samples by embryo count technique revealed that infection of embryos ranged from 16-58% and 18-70% in 1998 /1999 and 1999/2000 respectively. The highest infection of embryos was recorded in Sakha-61 cv. to be 58.0 and 70% during the two growing seasons, followed by Gemmeiza-3, Sakha-92, Giza-164 and Sakha-69 during the tested seasons respectively. While Sakha-8 was the least one where infection of embryos was 16 and 18% during the two growing seasons respectively. On the contrary, Giza-155 revealed resistant reaction where infection of the embryo ranged between 4 and 6% during the two growing seasons.

### 2- determination of grain protein, total carbohydrate contents and 1000-grain weight

The presented data in Tables (11 and 12) showed the variation in grain protein, total carbohydrate content and 1000 grain weight due to loose smut infection comparing with healthy grains of the tested cultivars. The obtained results showed that the average of protein content in infected grains of all tested cultivars was increased (12.05

**Table (10): Percentage of infection with loose smut in the embryos of 15 Egyptian wheat cultivars during 1998/1999 and 1999/2000 growing seasons**

| Cultivars | 1998/1999 | | | 1999/2000 | | |
|---|---|---|---|---|---|---|
| | No. of tested embryos | Infected | % Infected embryos | No. of tested embryos | Infected | % Infected embryos |
| Sakha-8 | 50 | 8 | 16 | 50 | 9 | 18 |
| Sakha-[illegible] | 50 | 29 | 58 | 50 | 35 | 70 |
| Sakha-69 | 50 | 19 | 38 | 50 | 20 | 40 |
| Sakha-92 | 50 | 23 | 46 | 50 | 25 | 50 |
| Gemmeiza-1 | 50 | 10 | 20 | 50 | 13 | 26 |
| Gemmeiza-3 | 50 | 24 | 48 | 50 | 30 | 60 |
| Gemmeiza-5 | 50 | 16 | 32 | 50 | 16 | 32 |
| Giza-155 | 50 | 2 | 4 | 50 | 3 | 6 |
| Giza-160 | 50 | 13 | 26 | 50 | 15 | 30 |
| Giza-162 | 50 | 10 | 20 | 50 | 9 | 18 |
| Giza-163 | 50 | 24 | 28 | 50 | 15 | 30 |
| Giza-164 | 50 | 19 | 38 | 50 | 18 | 36 |
| Giza-165 | 50 | 9 | 18 | 50 | 12 | 24 |
| Giza-167 | 50 | 14 | 28 | 50 | 16 | 32 |
| Giza 168 | 50 | 10 | 20 | 50 | 10 | 20 |

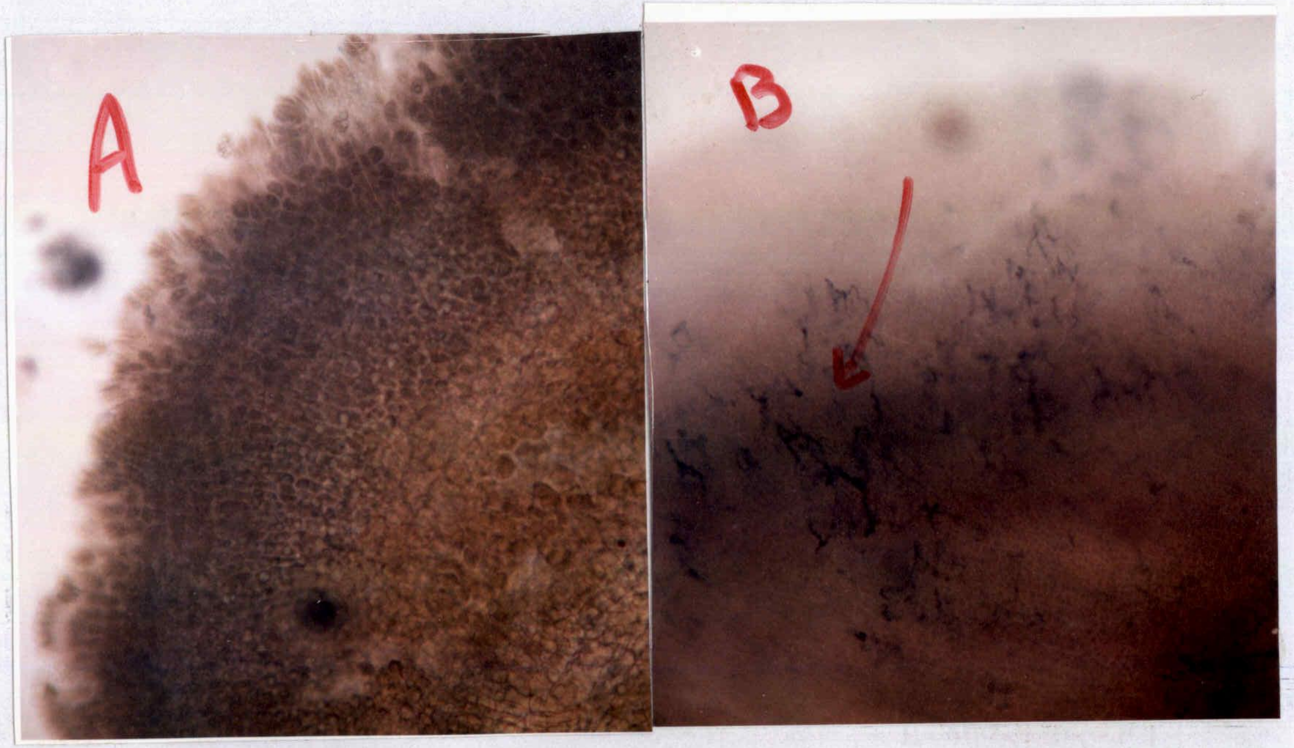



Fig. (5) : Healthy (A) and infected (B) embryos of Sakha-61 with dormant mycelium of *Ustilago tritici*

**Table (11): Grain protein, total carbohydrate content and 1000-grain weight of 15 Egyptian wheat cultivars affected by artificial inoculation with loose smut during 1998 /1999 growing season.**

| Cultivars | Protein % | | | Total carbohydrate % | | | 1000 – grain weight (gm) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Healthy | Inoculated | % increase | Healthy | Inoculated | % reduction | Healthy (gm) | Infected (gm) | % reduction |
| Sakha-8 | 11.30 | 12.01 | 6.28 | 83.80 | 82.11 | 2.16 | 42.30 | 26.70 | 36.42 |
| Sakha-61 | 10.60 | 13.11 | 23.67 | 84.11 | 81.01 | 3.68 | 44.80 | 23.33 | 47.99 |
| Sakha-69 | 10.63 | 12.36 | 16.27 | 85.0 | 82.60 | 2.82 | 43.11 | 30.10 | 30.17 |
| Sakha-92 | 10.13 | 12.54 | 23.79 | 84.31 | 81.33 | 3.53 | 43.11 | 28.88 | 33.03 |
| Gemmeiza-1 | 11.12 | 12.00 | 7.91 | 83.81 | 82.00 | 2.15 | 41.60 | 22.50 | 45.88 |
| Gemmeiza-3 | 11.80 | 13.00 | 10.16 | 83.50 | 80.31 | 3.82 | 62.30 | 39.87 | 36.11 |
| Gemmeiza-5 | 10.90 | 12.10 | 11.00 | 84.31 | 82.11 | 2.62 | 45.0 | 35.73 | 20.66 |
| Giza-155 | 10.80 | 11.20 | 3.70 | 84.0 | 83.60 | 0.47 | 40.29 | 19.50 | 51.60 |
| Giza-160 | 10.11 | 11.50 | 13.74 | 84.33 | 82.80 | 1.81 | 44.27 | 23.47 | 47.10 |
| Giza-162 | 10.80 | 11.35 | 5.09 | 84.10 | 83.0 | 1.30 | 41.8 | 31.07 | 25.69 |
| Giza 163 | 11.21 | 12.11 | 8.02 | 83.11 | 81.33 | 2.14 | 43 | 27.06 | 37.09 |
| Giza-164 | 10.30 | 12.80 | 24.27 | 85.20 | 82.80 | 2.81 | 44 | 31.23 | 29.02 |
| Giza-165 | 10.10 | 12.11 | 19.90 | 84.61 | 83.0 | 1.90 | 40.10 | 29.06 | 27.53 |
| Giza-167 | 10.60 | 11.71 | 10.47 | 85.15 | 83.61 | 1.80 | 41.17 | 28.37 | 31.14 |
| Giza-168 | 9.81 | 10.9 I | 11.21 | 85.81 | 84.00 | 2.1 | 42.60 | 28.67 | 32.86 |
| Av. | 10.68 | 12.05 | | 84.34 | 82.37 | | 43.96 | 28.36 | |

L.S.D. 5% 0.453 1.029 1.771

Table (12): Grain protein, total carbohydrate content and 1000-grain weight of 15 Egyptian wheat cultivar affected by artificial inoculation with loose smut during 1999/2000 growing season.

| Cultivars | Protein % | | | Total carbohydrate % | | | 1000 – grain weight (gm) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Healthy | Inoculated | % increase | Healthy | Inoculated | % reduction | Healthy (gm) | Infected (gm) | % reduction |
| Sakha-8 | 10.4 | 11.24 | 8.07 | 84.14 | 82.44 | 2.20 | 44.13 | 32.24 | 26.94 |
| Sakha-61 | 10.0 | 12.56 | 25.60 | 84.75 | 81.33 | 4.03 | 43.33 | 24.28 | 43.96 |
| Sakha-69 | 10.46 | 12.31 | 17.68 | 84.64 | 82.57 | 2.44 | 42.0 | 29.68 | 29.33 |
| Sakha-92 | 9.20 | 11.84 | 28.69 | 85.13 | 82.0 | 3.67 | 42.80 | 35.46 | 17.14 |
| Gemmeiza-1 | 11.9 | 12.20 | 2.52 | 83.0 | 80.60 | 2.89 | 43.68 | 24.98 | 42.81 |
| Gemmeiza-3 | 10.91 | 12.11 | 10.99 | 84.36 | 81.19 | 3.75 | 60.55 | 38.57 | 36.3 |
| Gemmeiza-5 | 10.66 | 11.55 | 8.34 | 84.82 | 82.60 | 2.61 | 42.60 | 35.37 | 16.97 |
| Giza-155 | 10.91 | 11.28 | 3.39 | 84.17 | 83.8 | 0.43 | 43.0 | 20.91 | 51.37 |
| Giza-160 | 10.0 | 11.50 | 15.00 | 85.0 | 83.88 | 1.83 | 43.85 | 27.13 | 38.12 |
| Giza-162 | 11.14 | 11.71 | 5.11 | 83.1 | 82.0 | 1.32 | 43.11 | 32.95 | 23.56 |
| Giza-163 | 11.0 | 12.0 | 9.09 | 83.42 | 81.6 | 2.18 | 42.24 | 25.13 | 40.5 |
| Giza-164 | 10.91 | 12.86 | 17.87 | 84.88 | 82.41 | 2.9 | 43.50 | 29.08 | 33.14 |
| Giza-165 | 11.18 | 12.84 | 14.84 | 83.17 | 81.5 | 2.0 | 44.52 | 27.39 | 38.47 |
| Giza-167 | 10.84 | 11.95 | 10.23 | 85.0 | 83.38 | 1.90 | 41.44 | 28.20 | 31.94 |
| Giza-168 | 11.14 | 12.21 | 9.60 | 84.58 | 82.73 | 2.18 | 44.30 | 32.33 | 27.02 |
| Av. | 10.71 | 12.01 | | 84.27 | 82.23 | | 44.33 | 25.70 | |
| L.S.D. 5% | 0.045 | | | 0.018 | | | 1.377 | | |

and 12.01 % respectively ) comparing the healthy grains ( 10.68 and 10.71 % ) during two experimental years.

The percentages of increase were varied according to the cultivar and percentage of infected embryos from season to season. Where, the highest increase was recorded with Sakha-61 (23.67%) Giza-164 (24.27%), Sakha-92 (23.79), respectively in 1998/99 while, Sakha-92 (28.69%) Sakha-61 (25.60%), Giza-164 (17.87%) and Sakha-69 (17.68) recorded the highest increase in 1999/2000.

On the other hand, general decrease in the total carbohydrate was observed in the infected grains of all tested wheat cvs where the means of total carbohydrate were 82.37 and 82.23% in 1998/99 and 1999/2000 respectively comparing healthy grains (Av. = 84.34 and 84.27 %). Also, there were a remarkable variation in decrease percentages of total carbohydrate between the tested cvs and seasons. The highest reduction was observed with cvs Gemmeiza-3, Sakha-61 and Sakha-92 (3.82, 3.68 and 3.53%) in 1998/99 respectively, while Sakha-61, Gemmeiza-3 and Sakha-92 were 4.03, 3.75 and 3.67 % in 1999/2000 respectively. Whereas, Giza-155, 162, 167 and 160 were the least affected cvs respectively during the two tested seasons.

Regarding the weight of 1000-grain, significant differences were found between the healthy and Inoculated grains of most tested cvs.(Fig.6) The weight of 1000-grain inoculated with loose smut exhibited significant reduction in weight comparing healthy grains and in between all tested cvs . The highest reduction in weight was found with

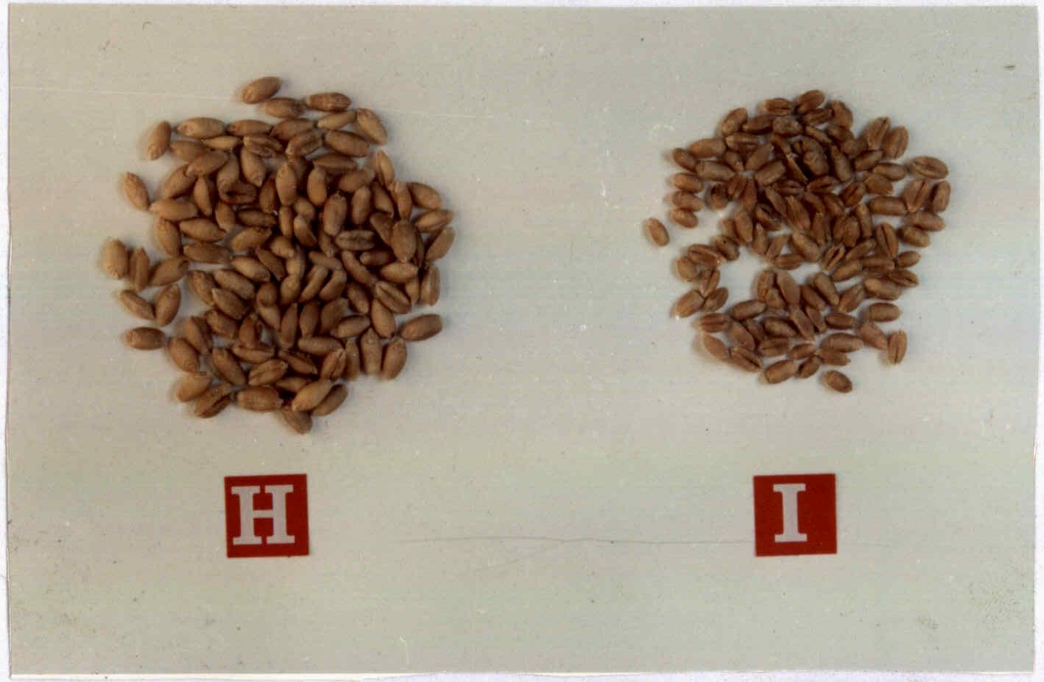



**Fig. (6): Effect of loose smut infection on seeds of Sakha 61**
**(H) healthy (I) inoculated**

cvs, Giza-155 (51.6 –51.37 %), Sakha-61 (47.99– 43.96 %), Giza-160 (47.10–38.12%), Gemmeiza-1 (45.88- 42.81%) and Giza-163 (37.09 –40.5%) during seasons, 1998/99 and 1999/2000, respectively. The rest of the tested cultivars showed reduction in 1000-grain weight ranged between (20.66- 36.42%) in 1998/99 and (16.97– 38.47%) in 99-2000. Briefly, the results indicated that the high reductions in 1000-grain weight are referring to infection with loose smut.

**B- Field Experiments**

**1- Varietal response to artificial inoculation with wheat loose smut**

Data in Table (13) showed that the reaction of wheat cvs to loose smut was in the same reaction trend of embryo test. All tested cultivars showed susceptible reaction to loose smut infection ranging between 11.70– 51.3 % in 1998/99 and 12.57- 59.67% in 1999/2000 growing seasons. Meanwhile, Sakha-61 was highly infected followed by Gemmeiza-3, Sakha-92, Giza-164 and Sakha-69 during the two seasons. On the other hand, the lowest disease incidence was recorded with Sakha-8, (11.7 and 12.5%) during the two seasons respectively while, no infection was recorded with Giza-155 during both seasons.

**2-Effect of loose smut infection on certain agronomic traits**

As a result of infection with loose smut, certain yield components i.e.number of tillers and plant height might be affected.

**Table (13): Disease incidence of 15 local wheat cultivars tested against artificial inoculation with *U. tritici* during 1998 /99 and 1999 / 2000**

| Cultivars | 1998/99 | 1999/2000 | Mean |
|---|---|---|---|
| | %Disease incidence | %Disease incidence | |
| **Sakha-8** | 11.7 | 12.57 | 12.13 |
| **Sakha-61** | 51.30 | 59.67 | 55.48 |
| **Sakha-69** | 32.27 | 36.43 | 34.35 |
| **Sakha-92** | 40.11 | 43.90 | 42.00 |
| **Gemmeiza-1** | 17.71 | 19.90 | 18.80 |
| **Gemmeiza-3** | 43.16 | 49.17 | 46.16 |
| **Gemmeiza-5** | 29.3 | 28.87 | 29.08 |
| **Giza-155** | 0 | 0 | 0 |
| **Giza-160** | 21.27 | 25.75 | 23.51 |
| **Giza-162** | 15.56 | 15.80 | 15.68 |
| **Giza-163** | 22.28 | 26.40 | 24.34 |
| **Giza-164** | 37.10 | 28.03 | 31.06 |
| **Giza-165** | 15.30 | 16.93 | 16.11 |
| **Giza-167** | 20.80 | 23.77 | 22.28 |
| **Giza-168** | 16.53 | 16.56 | 16.54 |
| **L.S.D. 5%** | 3.53 | 4.69 | |

### A-Effect of loose smut infection on plant tillering

Data presented in Table (14) show the effect of loose smut infection on plant tillering of 15 local cvs.during 98/99 and 99/2000 seasons. Where, it was clear that all tillers produced from inoculated grains were reduced (Av.= 5.7 – 5.79 tiller/plant) while, they were in healthy (6.62 – 7.37) tiller/plant. In 1998/99 growing season, healthy plants of cvs. Giza-155, 167, Sakha-61, and 92 gave the highest number of tillers/plant (10.67, 8.66, 8.33 and 7.66 tillers/plant respectively). Other cultivars gave tillers ranging from 5-7 tillers/plant while, in case of infected plants the highest tillering number was produced by Giza-155, 167, Sakha-61 and Giza-165 (10.33, 7.66, 6.33 and 6.33 tillers/plant). The rest cvs gave tillers ranging between 4-6 tiller/plant. On the other hand, the highest reduction percentage in tiller numbers was in Sakha-61 (38.33%), Gemmeiza-3 (36.5%), Giza-162 (28.33%) and Gemmeiza-1 (26.33%). Meanwhile, the lowest reduction was recorded with Giza-155 (2.83%).

In 1999/2000 growing season, the highest tillering was given by cvs.Giza-155 (9.33), Sakha-61 (9.0), Giza-167 (8.33), Sakha-69 and Sakha-92 (8.0 tiller / plant ) in the case of healthy plants. While , cvs Giza-155, Sakha-61, Giza-167, Sakha-92 and Giza-164 gave the highest average of tillers in the case of infected plants being 9.33, 6.66, 6.66, 6.33 and 6.33 tillers/plant respectively. The rest cvs gave tillers ranged between 4- 5 tiller/plant.

On the other hand, the highest reduction in tillering was recorded in Gemmeiza-1, Gemmeiza-3 and Sakha-61 (38.57,33.3% and 27.3%). Generally, the reduction in tillering was in a parallel with the disease incidence of the tested cultivars.

**Table (14): Effect of loose smut infection on number of plant tiller of 15 wheat cultivars during 1998/ 99 and 1999 /2000 growing seasons**

| Cultivars | 1998/99 | | | 1999/2000 | | |
|---|---|---|---|---|---|---|
| | Healthy | Inoculated | Reduction % | Healthy | Inoculated | Reduction % |
| Sakha-8 | 7.00 | 5 | 28.00 | 7.33 | 5.33 | 27.3 |
| Sakha-61 | 8.33 | 6.33 | 38.33 | 9 | 6.66 | 26.6 |
| Sakha-69 | 7.00 | 5.33 | 28.00 | 8 | 6 | 25 |
| Sakha-92 | 7.66 | 5.66 | 26.31 | 8 | 6.33 | 21.25 |
| Gemmeiza-1 | 6.00 | 4.33 | 28.33 | 7 | 4.33 | 38.57 |
| Gemmeiza-3 | 6.33 | 4 | 36.50 | 6 | 4 | 33.30 |
| Gemmeiza-5 | 5.00 | 4.33 | 14.00 | 6.33 | 4.66 | 26.98 |
| Giza-155 | 10.67 | 10.33 | 2.83 | 9.33 | 9.33 | 0 |
| Giza-160 | 6.33 | 5.33 | 15.87 | 7 | 5.66 | 20 |
| Giza-162 | 6.00 | 4.33 | 28.33 | 6.33 | 5 | 21.66 |
| Giza-163 | 6.33 | 5 | 20.63 | 6.66 | 5 | 24.24 |
| Giza-164 | 7.00 | 6 | 14.28 | 7.33 | 6.33 | 13.60 |
| Giza-165 | 6.66 | 6.33 | 4.54 | 7 | 6 | 14.28 |
| Giza-167 | 8.66 | 7.66 | 11.62 | 8.33 | 6.66 | 20.48 |
| Giza-168 | 6.66 | 5.66 | 15.15 | 7 | 5.66 | 20 |
| Av. | 6.62 | 5.70 | | 7.37 | 5.79 | |

**L.S.D. 5%** 0.716 0.710

**b-Effect of loose smut infection on wheat plant height**

Data in Table (15) and Fig (7) revealed the effect of loose smut on plant height of 15 local wheat cultivars. Significant differences were found either between the healthy or the smutted plants. Sakha-61 was the most affected by loose smut (26.1%) followed by Giza-164 (25.23%), Giza-160 (24.27%) and Sakha-69 (24%) while Giza-155 was the least affected one (zero %) during 1998/99.

In 1999/2000 the highest reduction was found in Sakha-61 (24.8%), Giza-165 (24.07%), Gemmeiza-5 (22.6%) and Giza-164 (22.1%) while the least in this respect was Giza-155 (0.48%).

**C-Relationship between spike length and number of spikelets /spike on disease incidence of loose smut**

Data presented in Table (16) and Fig.(8) revealed the relationship between spike length, number of spikelets/spike and cultivars infection. The obtained results clearly exhibited that the cultivars with small distance between spikelets showed the lowest appearance of loose smut and the reverse was true. The susceptible cultivars were Sakha-61, 92, Gemmeiza-3 Giza-163 and 164 showed (1.2 cm) between spikelts during 1998/99 and 1.3, 1.3, 1.2, 1.2 and 1.2 cm respectively in 1999/2000.

On the other hand, the moderately susceptible cultivars i.e., Sakha-8, Gemmeiza-1, Giza-162 and 165 showed 1.0-cm distance between spikelts in the two growing seasons. Meanwhile, the resistant cultivar Giza-155 showed 0.9 cm between spikelts during the t wo seasons.

**Table (15): Effect of loose smut infection on average of plant height of 15 wheat cultivars during 1998/ 99 and 1999/2000 growing seasons.**

| Cultivars | 1998/99 | | | 1999/2000 | | |
|---|---|---|---|---|---|---|
| | Healthy (cm) | Inoculated (cm) | % reduction | Healthy (cm) | Inoculated (cm) | % reduction |
| **Sakha-8** | 100 | 79 | 21 | 115.7 | 99.3 | 14.1 |
| **Sakha-61** | 88 | 65 | 25.4 | 95.33I | 71.67 | 24.8 |
| **Sakha-69** | 110 | 86 | 24 | 119.33 | 104.4 | 8.7 |
| **Sakha-92** | 96 | 80 | 16.66 | 98.33 | 83.67 | 14.9 |
| **Gemmeiza-1** | 113 | 87 | 23 | 120. | 101 | 15.8 |
| **Gemmeiza-3** | 114 | 100 | 11.5 | 122.7 | 107.7 | 12.01 |
| **Gemmeiza-5** | 105 | 87 | 17.14 | 112 | 86.67 | 22.6 |
| **Giza-155** | 121.7 | 121.7 | 0 | 125.7 | 125 | 0.48 |
| **Giza-160** | 103 | 78 | 24.27 | 105 | 88.33 | 15.9 |
| **Giza-162** | 95 | 85 | 10.52 | 110.3 | 96.69 | 12.4 |
| **Giza 163** | 104 | 82 | 21.15 | 114.7 | 100 | 12.7 |
| **Giza-164** | 107 | 80 | 25.23 | 111.3 | 86.67 | 22.1 |
| **Giza-165** | 104 | 96 | 7.6 | 116.3 | 88.33 | 24.07 |
| **Giza-167** | 121 | 93 | 23.77 | 112.3 | 95 | 15.4 |
| **Giza-168** | 109 | 88 | 19.26 | 115.3 | 102.3 | 11.27 |
| **Av.** | 106.04 | 93.04 | | 112.61 | 95.8 | |

**L.S.D. 5%** 3.37 4.09

Fig. (7): Effect of loose smut infection on plant height of Sakha-61

**Table (16): Effect of loose smut infection on number of spikelets/spike and spike length of 15 wheat cultivars during 1998/ 99 and 1999 /2000 growing seasons.**

| Cultivars | 1998/99 | | | 1999/2000 | | |
|---|---|---|---|---|---|---|
| | No. of spikelets/ Spike | Spike length (cm) | Distance bet. spikelets (cm) | No. of Spikelets | Spike length (cm) | Distance bet. spikelets (cm) |
| Sakha-8 | 12 | 12 | 1 | 12 | 12 | 1.0 |
| Sakha-61 | 10 | 12 | 1.2 | 10 | 13 | 1.3 |
| Sakha-69 | 10 | 11 | 1.1 | 10 | 11 | 1.1 |
| Sakha-92 | 10 | 12 | 1.2 | 11 | 13 | 1.3 |
| Gemmeiza-1 | 11 | 11 | 1 | 11 | 11 | 1.0 |
| Gemmeiza-3 | 10 | 12 | 1.2 | 11 | 13 | 1.2 |
| Gemmeiza-5 | 11 | 11 | 1 | 10 | 10 | 1.0 |
| Giza-155 | 10 | 9 | 0.9 | 10 | 9 | 0.9 |
| Giza-160 | 10 | 11 | 1.1 | 11 | 11 | 1.0 |
| Giza-162 | 11 | 11 | 1 | 12 | 12 | 1.0 |
| Giza-163 | 10 | 11 | 1.2 | 10 | 12 | 1.2 |
| Giza-164 | 10 | 12 | 1.2 | 10 | 12 | 1.2 |
| Giza-165 | 10 | 10 | 1 | 11 | 11 | 1.0 |
| Giza-167 | 11 | 12 | 1.09 | 11 | 12 | 1.09 |
| Giza-168 | 11 | 11 | 1 | 11 | 12 | 1.09 |
| L.S.D. 5% | 0.864 | 1.13 | | 1.07 | 1.177 | |

**Fig. (8): Spike length of resistance (1), moderately susceptible (2, 3) and susceptible (4, 5) cultivars showing morphological resistance**

1- Giza-155 2- Sakha-8 3- Giza-162
4- Gemmeiza-3 5- Sakha-61

The rest cultivars i.e., Giza-167, 168, 160 and Sakha 69 had 1.09–1.1 cm. distance between spikelets.

**D-Effect of loose smut infection on losses of grain yield/row**

As for losses of grain yield/row of healthy and infected plants of 15 wheat cultivars as shown in Table (17), it is clear that the yield decreased with the increasing of disease incidence with significant differences between either the healthy or infected cultivars referring to cultivar and disease incidence.

In 1998/99 the highest losses in grain yield/row was recorded with cvs, Sakha-61, Gemmeiza-3, Sakha-92, Giza-164 and Sakha-69 (51.61, 43.7, 39.26, 34.8 and 32.14 %) respectively. The moderately susceptible cvs, were Sakha-8 Gemmeiza-1, Giza-165 and 162 where the losses were 11.52, 16.9, 16.12 and 13.97 % respectively. The rest cultivars showed losses ranging between 21.9–27.08 % while the lowest loss in grain yield/row was recorded in Giza-155(0-0.52%).

In 1999/2000 the cvs, Sakha-61, Gemmeiza-3, Sakha-92, 69 and Giza-164 showed the highest losses in grain yield/row where the losses were 59.12, 48.78, 43.42, 37.14 and 31.66% respectively.

On the other hand, no losses in grain yield /row were observed in case of Giza-155 while, the cvs, Sakha-8, Giza-162, Gemmeiza-1, Giza-165 and 168 recorded losses in grain yield/row to be 12.5, 14.11, 19.11, 16.66 and 16.66% respectively.

**Table (17): Losses in grain yield/row of 15 local wheat cvs affected with loose smut infection during 1998/99 and 1999/2000 seasons.**

| Cultivars | 1998/99 | | | 1999/2000 | | |
|---|---|---|---|---|---|---|
| | Healthy (g) | Inoculated (g) | Loss % | Healthy (g) | Inoculated (g) | Loss % |
| Sakha-8 | 303.3 | 268.3 | 11.52 | 320 | 280.0 | 12.5 |
| Sakha-61 | 341.0 | 160.0 | 51.61 | 380 | 155.0 | 59.2 |
| Sakha-69 | 331.7 | 225.0 | 32.14 | 350 | 220.0 | 37.14 |
| Sakha-92 | 365.0 | 221.7 | 39.26 | 380 | 228.0 | 43.42 |
| Gemmeiza-1 | 355.0 | 295.0 | 16.9 | 340 | 275.0 | 19.11 |
| Gemmeiza-3 | 388.3 | 218.3 | 43.7 | 410 | 210.0 | 48.78 |
| Gemmeiza-5 | 356.7 | 260.0 | 27.08 | 370 | 265.0 | 28.37 |
| Giza-155 | 306.7 | 305.0 | 0.52 | 330 | 330.0 | 0 |
| Giza-160 | 325.0 | 255.0 | 21.5 | 310 | 230.0 | 25.8 |
| Giza-162 | 343.3 | 290.0 | 15.5 | 335 | 285.0 | 14.92 |
| Giza-163 | 313.3 | 245.0 | 21.9 | 300 | 218.3 | 26.6 |
| Giza-164 | 301.7 | 196.7 | 34.8 | 300 | 205.0 | 31.66 |
| Giza-165 | 306.7 | 265.0 | 16.12 | 300 | 250.0 | 16.66 |
| Giza-167 | 316.7 | 250.0 | 21.03 | 300 | 230.0 | 23.33 |
| Giza-168 | 310.0 | 260.0 | 13.97 | 300 | 250.0 | 16.66 |
| Av. | 330.96 | 247.66 | | 336.33 | 242.08 | |
| L.S.D. 5% | 14.90 | | | 12.14 | | |

### III- Inheritance of wheat resistance to loose smut

Genetical studies deals with the inheritance of wheat loose smut in two of leaf and stem monogenic lines ( $Lr_{19}$ and $Sr_{26}$ ) and four susceptible commercial wheat cultivars (Sakha 61 , Sakha 69 , Giza 162 and Giza 163 ) as tester were carried out at Gemmeiza Research Station from 1998 – 2000 growing seasons .

**Analysis of variance**

The mean squares of genotypes (parents and crosses ) were highly significant for loose smut incidence indicating the presence of considerable variability among then (Table 18 ).

**Table (18): Mean squares from analysis of variance for loose smut.**

| Sources of variance | d.f. | Loose smut |
|---|---|---|
| Replications | 2 | 0.167 |
| Parents | 5 | 1082.622** |
| Crosses | 7 | 24.667** |
| Parents Vs. Crosses | 1 | 2762.698** |
| Lines | 1 | 54.00** |
| Testers | 3 | 35.778** |
| Lines x testers | 3 | 3.77* |
| Error | 26 | 1.064 |
| G.C.A. | 5 | 3.685 |
| S.C.A. | 7 | 1.725 |

**Combining ability**

General combining ability value (G.C.A.) was higher than that of specific combining ability (S.C.A.) for loose smut incidence ( Table 18 ).

**a – General combining ability effects**

General combining ability effects given in Table (19) revealed that the monogenic line Lr 19 and the local cultivars Sakha 61 and Sakha 69 were good general combiner for loose smut resistance .They showed the highest significant negative effects ( -1.500 , -1.833 and –1.500 ), while the cultivar Giza 162 showed the lowest negative effect ( -0.166) .

**Table (19 ) : Estimates of general combining ability effects of the parents for loose smut .**

| Parents | Loose smut |
|---|---|
| **Lines** | |
| Lr. 19 | -1.500** |
| Sr. 26 | 1.500 |
| **Testers** | |
| Sakha-61 | -1.833** |
| Sakha-69 | -1.500** |
| Giza-162 | -0.166 |
| Giza-163 | 3.500 |
| L.S.D. gi- gj for lines 0.05 | 0.506 |
| L.S.D. gi- gj for testers 0.05 | 0.718 |

**b- Specific combining ability effect**

Estimates of specific combining ability effects for loose smut resistance in eight crosses presented in Table (20).The cross Lr19 x Giza-163 expressed the highest negative and significant specific combining ability effects ( -1.166 ), while the crosses Sr26 x Sakha-61 , Sr-26 x Giza-162 and Sr 26 x Sakha 69 were the least in this respect ( -0.500,-0.500 and –0.166 ).

**Table (20): Estimates of specific combining ability effect of the crosses for loose smut**

| Crosses | Loose smut |
|---|---|
| Lr. 19 x Sakha 61 | 0.500 |
| Lr. 19 x Sakha 69 | 0.166 |
| Lr. 19 x Giza 162 | 0.500 |
| Lr. 19 x Giza 163 | -1.166** |
| Sr. 26 x Sakha 61 | -0.500 |
| Sr. 26 x Sakha 69 | -0.166 |
| Sr. 26 x Giza 162 | -0.500 |
| Sr. 26 x Giza 163 | 1.166 |
| L.S.D .Sij-Sik 0.05 | 0.842 |

## DISCUSSION

The present work aimed to clarify some items of wheat loose smut disease caused by *Ustilago tritici* (Pers) Rostrup, i.e., effect of certain systemic fungicides on disease incidence, teleutospore germination and phytotoxicity of these fungicides on shoot and root length of wheat seedlings and grain yield. Also, evaluation of some commercial wheat cultivars against artificial inoculation of loose smut using embryo test technique and field assessment as well as some agronomic traits. Furthermore, inheritances of resistance to wheat loose smut in certain crosses.

The obtained data revealed that, all tested fungicides could significant inhibition to teleutospore germination of loose smut except with 5-ppm concentration. Diniconazol–2FL at 100-ppm followed by Diniconazol–5EC, Triticonazole and Carboxin-Thiram at 250-ppm were the most affected fungicides. These findings are in harmony with the obtained results by **Chatrath and Sastry** (1989) who reported that Benomyl at 5 ppm has completely inhibited teleutospore germination of *U. tritici*. Also, **Sirvastava** ***et al.***, (1997) found that Raxil at 200 ppm gave almost 100% reduction in germination of *U. segetum var. tritici*.

This study indicated that the tested fungicides at the recommended dose had no effect on seed germination, which ranged between 98.57 – 100%. This result is supported by data recorded by **Gothowal** ***et al*** .,(1972), **Gorshkova** (1974), **Sahi** ***et al.,*** (1985) and **El-Shamy & Amer** (2000) Who found that the fungicide Premis gave 95.23% seed germination comparing with the control.

Regarding phytotoxicity effect of tested fungicides on wheat shoot and root length, the obtained data revealed that fungicides, i.e., Flutviadol-Thiabemdazole ; . Diniconazol - 2FL and . Diniconazol-5EC exhibited low ($IC_{50}$ )on shoot and root length of tested wheat cv. This finding proves that these fungicides have high phytotoxic effect on shoot and root length of wheat seedlings and must be used at very low concentrations. While the rest of tested fungicides showed moderate values of $IC_{50}$.On the other hand, Carboxin-Thiram revealed the highest value of $IC_{50,}$ it means that this fungicide is very safe for use at high concentrations than the other fungicides. These results are in agreement with those reported by **Smiley *et al.*,** (1990) who found that tolclofos methyl had phytotoxic effects on wheat plants. While, **Hussain *et al.*,** (1996) found that methanolic extract from *Lantana camara* was moderately phytotoxic of wheat seedlings. Similar results were reported by **Zein *et al.*,** (1999) who found that the pesticides, i.,e., Metolachlor, Profenofos, Oxyfluorafen and Deltamethrin were the most phytotoxic compounds on shoot length of wheat seedlings at $IC_{50}$ values 0.1, 8.8, 9 and 10 ppm respectively. While, Brominal, Methomyl, *Nargs baltim*, Pencycuron, Kocide and Ain El-kot were slightly phytotoxic at $IC_{50}$ values 30, 95, 100, 100 and 110 ppm respectively. Mancoper at $IC_{50}$ 1100 ppm was the least phytotoxic one. These pesticides revealed similar results on root length at lower $IC_{50}$ values.

The obtained results also showed that roots of wheat seedlings were more sensitive to the tested fungicides than shoots, since, the $IC_{50}$ values of tested fungicides were low in case of root length than in case of shoot length. These results are in harmony with those of **Ismail and Aly** (1997) who, found that root systems of cotton seedlings were highly sensitive to Monceren-combi, Rhizolex-T, Vitavax-300 and Gaucho particularly at higher concentrations.

Concerning the application of certain systemic fungicides to control wheat loose smut disease, the present results gave evidence that all the tested fungicides could reduce disease incidence comparing with the control treatment. Diniconazol 2FL proved to be the best fungicide in this respect followed by Triticnazole, Diniconazol –5EC and Flutviadol-Thiabemdazole, respectively, while Thiophanat-methyl, Carboxin-Thiram, Propinep, Metalaxyl and Benalaxyl were the least in this respect. Similar results were obtained by **Imbaby *et al.*,** (1999) who reported that, Sumi-eight 2FL (Diniconazole) and Raxil (Tebuconazol) had the highest control effectiveness followed by Premis (Triticonazole). Regarding Carboxin-Thiram, the present data showed that it was weak in controlling loose smut (51.6 and 51.91 % efficacy) during 1998/99 and 1999/2000 growing seasons. **Rewal and Jhooty** (1985), **Iklas Shafik** *et al.*, (1990), **Mehiar** *et al.*, (1990) and **Sherif** *et al.*, (1991) stated that Vitavax–200 was the least effective in controlling loose smut as compared with the other tested fungicides. Topsin–M70 had intermediate effect in controlling loose smut (74.8 and 71.22% effectiveness) during the tested seasons respectively. Similar results was obtained **Youssef** (1989) . Metalaxyl, Benalaxyl and Propinep, were almost equal to Carboxin-Thiram in their efficiency, since they showed the highest values of disease incidence during the two growing seasons, this efficiency may be attributed to their specificity to Oomycetous fungi. **Anon.** (1978), **Cohen** *et al.*, (1978) and **Stoub** *et al.*, (1979) studied the fungitoxicity of metalaxyl and indicated that it is specific to Oomycetes fungi especially *Perno sporales*. Also, **Reilly**,

(1980) observed that Metalaxyl had longer persistence and more effective comparing to other systemic fungicides against Oomycetes, while, **Kotwal** *et al.*, (1981a) observed downward translocation by seeds after seed treatment of Metalaxyl. Meanwhile, **Smith and Margot** (1988) and **Wilkins and Falconer** (1988) reported that, metalaxyl is an effective residual and systemic fungicide for soil and foliar treatment of many *Phytophthora* crop pathogens.

As for grain yield/row, the presented data indicated that all the tested fungicides caused significant increment comparing to control. The fungicides, Diniconazol 2FL, Triticnazole, Diniconazol-5EC and Flutviadol-Thiabemdazole respectively resulted in the highest increment in grain yield over the other fungicides during the two seasons while, Carboxin-Thiram showed the least percentage of increase.

Concerning 1000-grain weight, Flutviadol-Thiabemdazole, Thiophanat-methyl, Diniconazol-5EC; Triticnazole and Diniconazol-2FL, respectively were significantly differed in increasing 1000-grain weight as compared to the rest of fungicides. These results are in agreement with **Youssef** (1989) who found that, Bavistin, Vincit-P and Topsin–M70 increased significantly 1000-grain weight. On the other hand, no significant differences were found between metalaxyl, Carboxin-Thiram. , Benalaxyl; Propinep and control in 1000-grain weight These results were verified by **Sahi** ***et al.***, (1985) who found that, bavistin was better than Vitavax in improving seed germination and increasing yields, given almost double the net profits compared with control.

As for varietal resistance, the presented data gave clear evident that all tested cultivars showed susceptibility under artificial inoculation either using embryo count technique or under field assessment during the two seasons. Sakha-61, Gemmeiza–3, Sakha-92, Giza-164 and Sakha-69 revealed the highest values of infected embryos and field disease incidence, while Sakha-8 was moderately affected since, it revealed 16- 18% disease incidence. These findings are in harmony with the scale of **Nielsen** (1987) who showed that Giza-155 is considered resistance, while cvs Sakha-8, Gemmeiza–1, Giza-162, 165 and 168 are considered moderately susceptible. However, the cvs Sakha-61, Gemmeiza–3, Sakha-92, 69, Giza-164, Gemmeiza-5, Giza-163, 160, 167 are considered susceptible. Similar results were reported also by **Sherif *et al.*,** (1991) who mentioned that Giza-155, 160, were resistant while Sakha-61, Sakha 92 were susceptible and cvs Giza-157 and Sakha-8 were moderately susceptible.

The obtained data revealed confidently relationship between infected embryos and smutted spikes in adult stage. In this respect, **Verma et al.,** (1985), **Youssef** (1989) and **Rewal and Jhooty** (1982) verified this relationship. On the contrary, the cultivar Giza-155 showed highly resistant reaction under field condition, although it showed 2-4 % embryo infection. This finding was supported by results of **Popp**, (1951), **Ohms & Bever** (1955) and **Batts & Jeater** (1958) who showed that the embryos of some loose smut resistant wheat cultivars were invaded by *U. tritici* although, the mature spikes were free from smut spores. Also, this result could be interpreted in light of the plumular bud of the embryo of such resistant cultivars was not invaded although other structures were invaded as mentioned by

**Popp,** (1959) or in light of **Rewal and Jhooty** (1982) who gave evidence that tissues of embryos with less than 50% infection became free from loose smut mycelium, while, those having more than 50% infection exhibited field persistence of disease.

Concerning the effect of loose smut infection on grain protein and total carbohydrate content, the presented data revealed that grain protein of tested cvs was increased as a result to infection. Actually, there is a lack-published information regarding the relationship of loose smut and grain protein content. However, **Uritani** (1971) mentioned that in fungus infected plants, the total nitrogen and protein content of the host pathogen complex generally increases during the early stage of disease. Also, he reported that this increase might be due to the presence of the pathogen or to newly synthesized protein in the host. While, **Staples *et al.*,** (1958) showed that this protein increase is due principally to protein synthesis of the pathogen rather than in the host. Also, **Dube *et al.*,** (1988) reported that the total insoluble nitrogen and protein content increased in wheat seed infected with *Aspergillus flavus* and *A. parasiticus* while, decrease was observed in seeds infected with *A. tamarii*. **Brien *et al.*,** (1990) reported that stripe rust infection resulted a reduction in flour milling yield and increased grain protein content. These examples indicate a general perturbation in the protein metabolism of the fungal disease plants.

The results revealed that total carbohydrate of inoculated grains was decreased in all the tested cultivars comparing with the healthy grains. This finding is in agreement with **Dube *et al.*,** (1988) who showed that total soluble sugars were decreased in wheat seeds infested with *A. flavus* and *A. parasiticus* while, increased in seeds infested with *A. nigar* and *A. tamarii*. Meanwhile, Mostafa, (1995) reported that the infestation of stored grains of durum and soft wheat with *Aspergillus flavus, A.niger, Alternaria alternata* and *Fusarium moniliforme* reduced total soluble sugar and total crude protein content, especially in grains having high moisture content (17%).

As for 1000-grain weight of inoculated grains, all tested cultivars revealed reduction in 1000-grain weight comparing with healthy grains and significant differences were found between cultivars. Similar results were recorded on stripe rust by **Brien,** (1990) who, mentioned that Giza-155 revealed the highest reduction in 1000-grain weight inspit of the low degree of infested embryos. It could be related to embryogenic resistance of that cultivar.

The present study gave evidece that mean number of tillers per plant was affected by loose smut incidence in 1999 and 2000 growing seasons where it was lower in infected than in healthy. This result agree with **Lal and Siddiqui** (1990) and **Beniwal *et al.*,** (1990) and **Rewal** (1992) who suggested that the suppression of tillering associated with smut infection should be used as a supplement to ear infection in estimating the disease.

Concerning effect of loose smut incidence on plant height, data indicated that average of plant height in infected plants was smaller than healthy ones. This result was supported by **Beniwal *et al.*,** (1990) who stated that the maximum reduction in tiller height occurred in the line WH 291.

The present results indicated that the resistance of cultivars to loose smut could be associated with the spike length and distance between spikelets. The distance between spikelets was 1.2 cm in the susceptible cvs. Sakha-61, 92, Gemmeiza–3, while the moderately susceptible cvs. Sakha-8, Gemmeiza–1, Giza-162 and 165 showed 1.00 cm. On the other hand, Giza-155 exhibited the lowest distance between spikelets (0.9 cm.). This finding was in agreement with the results of **Pandey and Gautam** (1988) who reported that the spikes of the highly susceptible cvs. Sonalika and WL-711 were more lax (1.8 and 1.2 cm.) while the resistant lines WL-1567, WL-2053, WL-2087, WL-1798 and HD-2236 were less lax (0.9–1.1 cm.). It could be concluded that structural changes might have different degree to functioned resistance i.e. smaller lodicules, smaller angle of opening for the palea and lemma during flowering, extrusion of anthers, type of florets and distance of spikelet along the rachis on each spike. This interpretation was confirmed by **Pederson and Jorgensen** (1965) who mentioned that varieties with large lodicules might provide higher infection to loose smut in wheat. Hence, structural changes might give different degree to functional resistance.

Line x tester analysis is an extension of the top cross method in which several testers are used (**Kempthorne** , 1957 ) .This design provides information about general and specific combining ability of parents and at the same time it is helpful in estimating various types of gene effects .The mean squares associated with the parents showed significant values for loose smut incidence and this provide the base of genetic variability for improving loose smut resistance .Concerning the relative importance of G.C.A. with respect to S.C.A., their ratio GCA / SCA was more than a unit .This result indicate that additive type of gene action play a predominant role in the inheritance of loose smut resistance and controlled by minor genes ( polygenic resistance ).It could be concluded that the cross L.r.19 x Giza 163 seemed to be the best among the studied crosses for resistance to loose smut .Similar results were obtained on common smut of maize by **Zeinab ,M. Fahmy** ( 1983 ) and **Abdel – Sabour and Elian** (1993)

# SUMMARY

## SUMMARY

Wheat (*Triticum aestivum L.*) has been considered the first strategic food crop for more than 7000 years in Egypt. It has maintained its position during that time as the basic stable food in urban areas and mixed with maize in rural areas for bread making. Wheat loose smut caused by *Ustilago tritici* ranked the second serious disease following rusts. The losses of wheat yield were ranged between trace to 5% on the local and Indian cultivars.

The pathological studies concerned with chemical, varietal and genetic control of wheat loose smut were carried out at Gemmeiza Research Station during 1998/99 and 1999/2000 growing seasons. The items of the present study included evaluation of certain systemic fungicides on spore germination, its phytotoxicity on root and shoot system of wheat seedlings and the effect of these fungicides on seed germination, disease incidence as well as grain yield. Fifteen of old and new released Egyptian wheat cultivars were evaluated to artificial inoculation to identify those that posses any forms of resistance using embryo test technique, relation between disease incidence and grain protein, total content, field expression and effect of loose smut on some agronomic traits. Genetic study deals with inheritance of wheat loose smut using 4 susceptible Egyptian wheat cultivars and 2 leaf and stem monogenic lines showed resistant reaction .The obtained results could be summarized as follows:

1-All the tested fungicides showed significant inhibition to loose smut teleutospores comparing with the control except with 5 ppm. The fungicide Diniconazole- 2FL gave 100%

inhibition at 100 ppm while, Thiophanate-methyl, Benalaxyl and Propineb showed complete inhibition at 750 ppm.

2-Concerning phytotoxicity of the tested fungicides, the obtained data gave evidence that the fungicides Vitavax-200, Thiophanate-methyl, Benalaxyl and Propineb showed the highest values of $IC_{50}$ and could be used safety at relatively high concentrations. On the contrary, Diniconazole- 2FL, Diniconazole- 5EC and Triticonazole showed the lowest $IC_{50}$ values and must be used at lower concentrations.

3-The obtained data revealed that all the tested fungicides at the recommended dose had no effect on seed germination which percent of germination ranged from 98.57% to 100 % comparing with the control.

4- The results clear that the fungicides Diniconazole- 2FL, Triticonazole, Diniconazole- 5EC and Vincit--P respectively were the best in increasing grain yield/row. While Thiophanate-methyl, Flutviafdol-thiabemdazole, Diniconazole- 5EC and Diniconazole- 2FL respectively gave the highest values of 1000-grain weight.

5-Embryo test technique enabled us to detect the dormant mycelium of *Ustilago tritici* before sowing and this procedure has an important role for saving time and efforts.

a-The obtained results indicated that all the tested cultivars showed susceptible reaction ranged from 16- 58 % and 18-70 % in 1998 / 99 and 1999 /2000 respectively.

b-The cvs Sakha-61, Gemmeiza–3, Sakha-92, Giza-164 and Sakha- 69 showed the highest percentage of infected embryos. While the cultivar Sakha-8 was moderately susceptible since showed 16–18 % during the two seasons.

c-The cultivar Giza-155 is considered to be resistant under artificial inoculation (4–6 %).

6-The results concerning with the effect of loose smut infection on grain protein and total carbohydrate content showed adverse response as follow:

a-Protein content of the inoculated grains of all the tested cultivars increased (Av. = 12.05 and 12.01 %) during the two years over the healthy grains (Av. =10.68 and 10.71%).

b-The percentage of protein increase in the inoculated grains was varied according to the cultivar and disease incidence.

c-The total carbohydrate in the inoculated grains of the tested cultivars was decreased (Av. = 82.37 and 82.23%) in 1998/99 and 1999 /2000 respectively, comparing with the healthy grains (Av. = 84.34 and 84.27%). The highest reduction was noticed in the cultivars Gemmeiza–3, Sakha-61 and Sakha-92.

d-Values of 1000-grain weight showed significant difference between the inoculated and healthy grains of the tested cultivars. The percentage of reduction in the inoculated grains ranged from 20.66 to 51.60% in 1998/99 and 16.97 to 51.37 % in 1999/2000.

7-The obtained results clear that all the tested fungicides decreased percentage of disease incidence. The fungicides Sumi–eight 2FL, Premis, Vincit–P and Sumi–eight 5EC respectively, are considered the most effective in controlling loose smut during the two growing seasons as compared with the other ones.

8-The obtained results gave evidence that the situation of the tested cultivars under artificial inoculation as follow:

a-The cultivar Giza-155 was immune and considered a good source of resistance to loose smut under the Egyptian conditions.

b-The cultivars Sakha-8, Giza-162, 165, 168 and Gemmeiza-1 are considered moderately resistant.

c-The cultivars, Sakha-61, Gemmeiza-3, Sakha-92, 69, Giza 164, Gemmeiza-5, Giza-163, 167 and 160 were susceptible to loose smut.

9-The agronomic traits of the tested cultivars were affected by loose smut infection since showed a reduction as compared with those of the healthy plants i.e., number of tillers/plant, plant height and grain yield/row.

10-The obtained results revealed a high relation between spike length distance between spikelts and loose smut infection. The cultivars with compact spikes were the most resistant and vice versa.

11-The results showed that highly significant differences for loose smut incidence among the studied parents .

12- The GCA /SCA ratio revealed the importance of additive gene action in the inheritance of loose smut resistance .

13- The best general combining for loose smut resistance were Lr 19 , sakha 61 and sakha 69.

14- The cross L.r.19 x Giza 163 was the best among the tested crosses for resistance to loose smut .

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# ARABIC SUMMARY

## الملخص العربي

# دراسات على مرض التفحم السائب فى القمح

يعتبر القمح هو المحصول الإستراتيجي الغذائي الأول فى مصر لاكثر من سبعة آلاف عام . ولقد اكتسب القمح هذه المكانة على أساس انه الغذاء الرئيسي فى المناطق العربية حيث يتم خلطة مع ألا ذرة في المناطق الريفية لصناعة الخبز .يحتل مرض التفحم السائب في القمح المرتبة الثانية بعد الأصداء . تشمل الدراسات المرضية المتعلقة بالمقاومة الكيماوية والصنفية والوراثية لمرض التفحم السائب في القمح والتي أجريت في محطة بحوث الزراعية بالجميزة أثناء موسمى ١٩٩٨/٩٩ ، ١٩٩٩/ ٢٠٠٠ تقييم بعض المبيدات الجهازية على إنبات جراثيم الفطر، تأثير سميتها على جذور وأشطاء بادرات القمح ، إنبات الحبوب وكذلك تأثير هذه المبيدات على الشدة المرضية ومحصول الحبوب .وكذلك تقييم ١٥ صنف من الأقماح المصرية القديمة والحديثة تحت ظروف العدوى الصناعية بهدف تعريف أنواع المقاومة فى هذه الأصناف وذلك باستخدام تكنيك اختبار الأجنة ،والعلاقة بين شدة الإصابة ومحتوى الحبوب من البروتين ، والكربوهيدرات الكلية الذائبة ، وزن الألف حبة .كذلك رد فعل هذه الأصناف تحت ظروف الحقل وتأثير العدوى على بعض الصفات المزرعية للأصناف .وتتعلق الدراسة الوراثية بوراثة المرض للتفحم السائب فى أربع أصناف مصرية قابلة للإصابة ، ٢ من سلالات القمح أحادية الجين ويمكن تلخيص النتائج المتحصل عليها فى الآتي:

الدراسات المعملية :

١- أظهرت جميع المبيدات الفطرية المختبرة معنوية فى تثبيط إنبات الجراثيم التيليتة لفطر التفحم مقارنة بمعاملة الكنترول فيما عدا عند تركيز ٥ جزء فى المليون .ولقد أعطى المبيد سومى ايت 2Fl (دينيكونازول ) تثبيط ١٠٠% عند تركيز ١٠٠ جزء فى المليون بينما اظهر كل من التوبسين –م٧٠ (ثيوفانات ميثيل)، جالبين نحاس (بنالاكسيل)، إنتراكول نحاس(بروبينيب) تثبيط كامل للجراثيم عند ٧٥٠ جزء فى المليون .

٢- بخصوص السمية النباتية للمبيدات الفطرية المختبرة فقد أوضحت النتائج أن المبيدات فينافكس ٢٠٠ (كاربوسين ثيرام) ، توبسين – م٧٠(ثيوفانات ميثيل) ، جالبين نحاس(بنالاكسيل)، إنتراكول نحاس(بروبينيب) أظهرت أعلى قيم من الـ $IC_{50}$ وأنه يمكن استخدامها بتركيزات أعلى نسبيا . على العكس من ذلك أظهرت المبيدات سومى ايت 2FL(دينيكونازول ) سومى أيت 5EC (دينيكونازول )اقل قيمة لـ $IC_{50}$ حيث يجب استخدامها بتركيزات أقل .

٣- أظهرت النتائج أن استخدام المبيدات الفطرية المختبرة بالتركيزات الموصى به ليس له تأثير على إنبات الحبوب، حيث تراوحت نسبة الانبات بين ٨٩,٥٧ إلى ١٠٠% مقارنة بمعاملة الكنترول .

٤- أوضحت النتائج ان المبيدات سومى ايت 2Fl(دينيكونازول ) ، برميس ،سومى ايت 5EC (دينيكونازول )، فنست - P على التوالى كانت الأفضل فى زيادة محصول الحبوب .بينما أعطت

، فنست - P (فلوتفيافدول)، سومى ايت 5EC (دينيكونـــازول ) ، سومى ايت 2F1 (دينيكونازول ) على التوالي أعلي قيم لوزن الالف حبة .

٥- يمكن استخدام تكنيك اختبار الأجنة فى تقدير الميسليوم الساكن لفطر التفحم قبل الزراعة وبذلك يكون لة أهمية فى توفير الوقت والمجهود ولقد اظهر ان :

أ-أظهرت كل الأصناف المختبرة قابليه للإصابة تراوحت بيـن ١٦- ٥٨ % ، ١٨ – ٧٠ % فى موسمى ٩٨ / ٩٩ ، ٩٩ / ٢٠٠٠ على التوالي .

ب- أظهرت الأصناف سخا ٦١ ، جميزة ٣ ، سخا ٩٢ ، جيزة ١٦٤ ، سخا ٦٩ أعلى نسبة من الاجنة المصابة بينما كان الصنـــف سـخا ٨ متوسـط الإصابة حيث اظهر من ١٦ – ١٨ % أثناء الموسمين .

ج-يعتبر الصنف جيزة ١٥٥ مقاوما تحت ظروف العدوى الصناعية حيـث اظهر نسبة اصابة فى الاجنة تتراوح بين ٤- ٦ % .

٦-أظهرت النتائج الخاصة بتأثير الإصابة بالتفحم السـائب علــى محتـوى الحبوب من البروتين ، الكربوهيدرات الكلية الذائبة نتائج متعارضة كمايلى :

أ-أظهرت الحبوب المصابة لكل الأصناف المختبرة زيـــادة فـــى محتـوى البروتين بمتوسط ١٢,٠٥ ، ١٢,٠١% إثنـــاء موســـمى الدراسـة مقارنــة بالحبوب السليمة ١٠,٦٨ ، ١٠,٧١%

ب- اختلفت نسبة زيادة محتوى البروتين فى الحبوب المصابة تبعا للصنـف وشدة الإصابة .

ج- اظهرت الحبوب المصابة لكل الأصناف المختبرة نقصا فـــى محتـوى الكربوهيدرات الكلية الذائبة ( متوسط ٨٢,٣٧ ، ٨٢,٢٣% ) خلال موسـمى

الدراسة مقارنة بالحبوب السليمة ٨٤,٣٤، ٨٤,٢٧٪ وكانت أعلى نسبة نقص فى الأصناف جميزة ٣ ، سخا ٦١ ، سخا ٩٢ .

د- أظهرت قيم وزن الالف حبة فروق معنوية بين الحبوب المصابة والسليمة للأصناف المختبرة وتراوحت نسبة النقص بين ٢٢,٦٦ – ٥١,٦٠ % فى عام ٩٩/١٩٩٨ ، ١٦,٩٧ – ٥١,٣٧ % فى عام ٢٠٠٠/١٩٩٩ .

**التجارب الحقلية :**

٧- أوضحت النتائج ان جميع المبيدات الفطرية المختبرة خفضت نسبة الإصابة بالمرض وتعتبر سومى ايت 2FI(دينيكونازول ) ، برميس (تريتيكونازول)،فنست P- (فلوتفيافدول)، سومى ايت 5EC(دينيكونازول ) اكثر المبيدات فاعلية فى مقاومة التفحم السائب خلال موسمى الدراسة مقارنة بالمبيدات الأخرى .

٨-أوضحت النتائج المتحصل عليها موقف الأصناف المختبرة تحت ظروف العدوى الصناعية كالآتي :

أ-كان الصنف جيزة ١٥٥ منيعا ويعتبر مصدر جيد لمقاومة التفحم السائب تحت الظروف المصرية .

ب- تعتبر الأصناف سخا ٨ ، جيزة ١٦٢ ، جيزة ١٦٥ ، جيزة ١٦٨ ، جميزة ١ على التوالى متوسطة المقاومة .

**ج- كانت الأصناف سخا ٦١ ، جميزة ٣** ، سخا ٩٢ ، **سخا ٦٩ ، جيزة ١٦٤ ، جمبزة ٥** ، جيزة ١٦٣ ، جيزة ١٦٧ ، جيزة ١٦٠ **شديدة الإصابة بالتفحم السائب .**

٩-تأثرت الصفات المزرعية للأصناف المختبرة بالاصابة بالتفحم السائب حيث أظهرت نقصا مقارنة بمثيلتها فى النباتات السليمة مثل عدد الأفرع / نبات ، ارتفاع النبات ، وزن المحصول .

١٠- أوضحت النتائج وجود علاقة كبيرة بين طول السنبلة ،المسافة بين السنيبلات والإصابة بالتفحم السائب . وكانت الأصناف ذات السنابل المدمجة الأكثر مقاومة للتفحم والعكس صحيح .

١١-أوضحت النتائج وجود فروق معنوية عالية بين الاباء المستخدمة من حيث شدة الاصابة بالتفحم السائب .

١٢-اوضحت النسبة بين القدرة العامة على الائتلاف ، والقدرة الخاصة على الائتلاف عن اهمية الفعل الجينى المضيف فى وراثة مقاومة مرض التفحم السائب .

١٣- كانت افضل الاصناف من حيث القدرة العامة على الائتلاف L.r.19 ، سخا ٦١ ، سخا ٦٩ .

١٤-كان الهجين L.r.19 × جيزة ١٦٣ الأفضل بين الهجن المختبرة لمقاومة مرض التفحم السائب

# إهداء

- إلى والدى العزيز.
- إلى والدتى الحنون.
- إلى إخوتى الأعذاء.
- إلى أستاذتى الأفاضل.
- إلى كل من ساعدنى فى إتمام الرسالة

# دراسات على مرض التفحم السائب في القمح

مقدمة من


## محمد عبد القادر حسن

بكالوريوس العلوم الزراعية (شعبة أمراض نبات)١٩٩٦
كلية الزراعة
جامعة الزقازيق


للحصول على درجة
الماجستير في العلوم الزراعية

(أمراض النبات)

وقد تمت مناقشة الرسالة والموافقة عليها

اللجنـــــــــة

.د. فاروق محمد بركات ..............................
أستاذ أمراض النبات – كلية الزراعة - جامعة القاهرة (رئيسا)

.د. عبدالمنعم إبراهيم إسماعيل الفقي ..............................
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. رؤوف نجيب فوزي ..............................
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. جهاد محمد الدسوقي الهباء ..............................
أستاذ أمراض النبات المساعد بزراعة مشتهر – جامعة الزقازيق / فرع بنها

تاريخ الموافقة:الأحد ١١/٢/ ٢٠٠١م

# دراسات على مرض التفحم السائب فى القمح

رسـالة مقدمـــــــــــة من

**محمد عبد القـادر حســــن**
**بكالوريوس في العلوم الزراعية (أمراض النبات)**
**كلية الزراعة - جامعة الزقازيق ١٩٩٦**

للحصـول علي درجـــــة

الماجستير في العلوم الزراعيـــــــة
( أمراض النبات )

لجنة الاشراف العلمى :

**١ - الدكتور/ رؤوف نجيب فوزى**
أستاذ أمراض النبات المساعد - كلية الزراعة بمشتهر - جامعة الزقازيق - فرع بنها

**٢ -الدكتور / جهاد محمد دسوقي الهباء**
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**٣ -الدكتور / مصطفى محمود الشامى**
باحث بمعهد بحوث أمراض النباتات مركز البحوث الزراعية

**كلية الزراعة بمشتهر**
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٢٠٠١