# FUSARIUM FOOT ROT OF KENAF (*Hibiscus cannabinus* L.) IN IRAN

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## INTRODUCTION

Kenaf (*Hibiscus cannabinus* L.) is a fiber crop which is cultivated from very old times in Iran, especially, in Caspian Sea area (Guilan and Mazandaran), and to a small amount in the south of the country (Dezfool, Darab, Kazeroon). It is cultivated usually as a second crop in low lands or at the border of plots and its fiber is used by farmers for making strings , rugs, fishing nets, etc ...

The importance of the Kenaf fiber is mostly for manufacturing coarse sacking materials for transporting cereals, as well as, war munitions (gunny-bags). There are four factories in Iran working with Kenaf fiber for making such materials, being able to use 14000 tons raw fibers each year. Because of Fusarium foot rot and some other factors the Kenaf fiber crop is decreased to 2000-2500 tons yearly, so that these factories are obliged to import a large part of their needs from abroad.

The factors involved in the decrease of the Kenaf fiber crop and its low quality in Iran are as follows:

1. The decrease of cultivated surface of Kenaf due to the loss of the crop because of the disease occurrence, as well as, the loss of the crop itself, sometimes up to 80% in actually remaining cultivated lands.
2. The low quality of the indigenous variety.
3. The primitive agricultural methods using the old style iranian plow and broadcast sowing .
4. Not using fertilizers.
5. Successive use of the same land for growing Kenaf.
6. Late harvesting of crop using the plants for both seed and fiber production which makes fibers to become too hard and fragile.
7. The primitive methods of drawing and preparation of fibers.

## HISTORY OF THE DISEASE

The origin of the Fusarium foot rot of Kenaf and its first appearance in Iran is not exactly known. It was probably in 1958 that the growers of Kenaf in the Caspian Sea areas observed for the first time the occurrence of the disease in their fields .

As the disease was increasing from year to year there came complaints from the farmers to the Kenaf office in Mazandaran and to the Fiber Factories Association in Tehran. These complaints were forwarded to the Plant Protection Research Department (Now: Plant Pests & Diseases Research Institute) of the Ministry of Agriculture for help. Following these complaints, **Scharif**, after a visit of the infected areas in 1960, declared the cause of the disease to. be a species of *Fusarium*.

Behdad (1962), student of the College of Agriculture, University of Tehran, worked on this Fusarium as a subject of his thesis for Degree of Agriculture. Meanwhile, Venning, expert for horticulture of point 4 office, ( U.S.A. ), wrote an article about the Kenaf foot rot disease in Iran and explained the cause of the disease being *Phytophthora parasitica* Dast. This brought a doubt about the causal agent of the disease which was supposed to be a species of *Fusarium*. As the problem was of importance a research project was prepared by Plant Pests & Diseases Research Institute to clarify the idendity of the causal agent of the disease and to bring a remedy for the trouble.

The laboratory works were carried out in the centre of the Institute at Evin and the field experiments in the Caspian Sea area at Shahi, all by Engineer Akhavizadegan and under the supervision of Dr. G. Scharif chief of pathology Section of the Institute and Dr. E. Niemann, german plant pathology research advisor in the Institute.

It is to thank here Mr . James . M . Demsey, Fiber expert of the Technical Assistance of the U.S.A., Engineer A. Razeghi, Director General of Agriculture in Mazandaran and Engineer K. Abdollahi, chief of the Agricultural Station of Shahi for their kind cooperations in this work.

## IMPORTANCE OF THE DISEASE

As it is known no other materials so strong and cheap, can take the place of gunny-bags as containers for transportation of grains and many other agricultural and industrial production. It is estimated by James M. Dempsey, expert of fibers that Iran needs yearly 15 millions of Kenaf bags for containing and storing of cereals and other grains of which only a small part is produced in the country.

Before the appearance of the Fusarium foot rot the surface of cultivated lands of Kenaf in the Caspian Sea areas has been about 10,000 hectares each year. But because of the damage of the disease evaluated to 10-60% loss of the crop in Mazandaran and 10-35% in Guilan, the surface of cultivated lands of Kenaf has decreased considerably, namely to 2000-2500 hectares in the last years.

If we count the yield of one hectare of Kenaf 1200 kilos dry fibers, as it is the average actually produced in the Caspian Sea areas with all unsuitable agricultural methods used, and the average loss of the yield due to the existence of the disease 30% there will be almost 100 american dollars decrease in the income of farmers per hectare.

## DISTRIBUTION OF THE DISEASE

The Fusarium foot rot of Kenaf is spread over the whole areas of Mazandaran and Guilan. In Mazandaran the regions Shirgah, Sorkhrood and Mahmoodabad, and in Guilan the region Hassan-Kiadeh, are more infected. However, the disease is prevailing in all Kenaf cultivated areas of the north of Iran. In the south of the country Kenaf is not widely cultivated. However, it seems to be free of the disease.

## SYMPTOMS OF THE DISEASE

On seedlings the symptoms of the Fusarium foot rot are rotting and blackening of roots and the base of the plants, which results in wilting and dying-back of the infected plants. On more grown and developed plants necrotic lesions appear on the base of the plant (Fig.1). The lesions increase in size and sometimes girdle the plant so that the infected plants may break from the base or wilt and die suddenly. The necrotic spots may also appear on the stem, petioles and occasionally on leaves. The lesions on the stem are usually elongated (up to 5 cm. long), being dark brown in the middle and purple in the border. In general the fungus attacks all the outer parts of the stem and roots, but not the woody tissue, and so it does not produce any tracheomycosis. On leaves the necrotic spots are only produced in very humid conditions, especially in artificial inoculations when the plants are sprayed with a suspension of conidia and put in a moist chamber.

## LABORATORY WORK AND PROOF OF PATHOGENICITY OF THE CAUSAL FUNGUS

The frequent presence of minute pink cushions of fructification of a *Fusarium* on lesions of the disease, especially on lesions placed on the aerial parts of the plant, shows that the causal agent of the disease may be this *Fusarium*. But as in the paper prepared by Dr. Venning the causal agent of the disease is mentioned *Phytophthora* this point of view must be also taken under attention.

### *A.* Tentatives to isolate *Phytophthora*

To isolate *Phythophthora* from the lesions of the disease the usual methods for this purpose were used. Among them one method was to use apples, surface sterilized with alcohol, pierced with a sterile needle and then a piece of a diseased lesion to be placed in each hole. No *Phytophthora* was grown in the apples, though several times this trial was repeated. However, all tentatives to isolate a *Phytopthora* from diseased lesions of Kenaf failed.

### *B.* Isolation of *Fusarium*

For this purpose portions of young lesions were surface sterilized with 1 per 1000 solution of mercuric chloride for 2 minutes, washed with sterile water and placed in PDA plates. In each trial a *Fusarium* was grown from the diseased portions. Single spore cultures were prepared from this *Fusarium* by using a diluted suspension of conidia in plates provided with medium, and from colonies grown in the

plates from single spores cultures of the fungus were prepared on sterilized wheat grains. To prepare wheat grains medium, grains were previously put in water for several hours, then two times sterilized for 15 minutes at 120° C.

**Artificial inoculation with isolated *Fusarium***

Clean pots were provided with heat sterilized soil (90° C. for 1/2 hour). Kenaf seeds were also surface sterilized with formalin solution (3gr. pure formalin in 1 litre of water) and planted in the pots. In different stages of the growth of Kenaf in the pots inoculum consisting of the fungus grown on sterilized wheat grains were added at the base of plants, a few grains used for each plant. Some pots were saved as checks, where only sterile wheat grains were used. After a few days some plants in the inoculated pots started to wilt and die. On the roots and the base of these wilted plants symptoms similar to the symptoms of the disease were observed from which the same *Fusarium* fungus was reisolated and used for further artificial inoculations.

In our trials almost all the plants in the inoculated pots were gradually wilting and dying (Fig.2), while the plants in the check pots remained healthy.

The tables 1&2 show the results of two artificial inoculation trials.

Table 1. Results of the lst. artificial inoculation trial of Kenaf with *Fusarium* sp.

| Treatments | Number of Kenaf plants remained healthy after: | | | | |
|---|---|---|---|---|---|
| | 8 | 15 | 23 | 26 | 28days |
| 6 inoculated pots having 32 Kenaf plants | 31 | 16 | 3 | 1 | 0 |
| 6 check pots having 29 Kenaf plants | 29 | 29 | 29 | 29 | 29 |

Characteristics of the first inoculation trial:

1. Inoculum being a 15 days old culture on sterilized wheat grains.
2. Age of Kenaf plants at the time of inoculation being 40 days.
3. Kenaf seeds disinfected with formalin before sowing.
4. Soil used in pots being heat sterilized for $\frac{1}{2}$ hour at 90° C.

Table 2. Results of the 2nd. artificial inoculation of Kenaf with *Fusarium* sp.

| Treatments | Number of Kenaf plants remained healthy after: | | | |
|---|---|---|---|---|
| | 16 | 19 | 23 | 37 days |
| 5 inoculated pots having 22 Kenaf plants | 21 | 19 | 6 | 0 |
| 5 check pots having 23 Kenaf plants | 23 | 23 | 22 | 22 |

Characteristics of the 2nd inoculation trial:

1. Inoculum being a 15 days old culture on sterilized wheat grains.
2. Age of Kenaf plants at the time of inoculation being 84 days.
3. Kenaf seeds disinfected with formalin.
4. Soil used in pots being heat sterilized for $\frac{1}{2}$ hour at 90° C.

**Discussion for pathogenicity of the isolated *Fusarium***

As the results of the 1st & 2nd inoculation trials show, the isolated *Fusarium* is pathogenic to Kenaf and is the cause of the foot rot of this plant. If in the 2nd trial one plant in the check is also infected, this can be because of some occasionally infection brought by the carelessness of the worker, splashing of the spray water, action of insects , for example, aphids going from a pot to another, etc ...

It is to mention that for soil sterilization the temperature must not go higher than 90° c. and the time not longer than $\frac{1}{2}$ hours. This brings some harmful change in the composition of the soil and kills the whole useful micro-organisms. In one trial where the soil was sterilized twice at 90° C. for $\frac{1}{2}$ hour, the edges of leaves showed some necrosis and even some plants shed leaves.

Apart from the two above mentioned trials many other artificial inoculation trials were carried out to prove the pathogenicity of the isolated *Fusarium* to Kenaf. These trials together with trials for resistant varieties, where the indigenous Kenaf was used as check, all proved that the *Fusarium* was pathogen and the cause of the foot rot disease of Kenaf, as it is occurred in the north of Iran.

**Artificial inoculation of the aerial parts of Kenaf plants**

A suspension of conidia of the *Fusarium* was prepared by putting and shaking in sterile water some wheat grains on which the fungus was grown. The suspension was passed through a sieve and used in a hand bottle sprayer. Before inoculation the surface of the soil of the pots were covered with a thick layer of cotton, in order to avoid the base of the plants to become infected . After spraying the aerial parts of Kenaf plants with the suspension of conidia, they were let for a little while to evaporate the water of suspension and then placed for 48 hours in a moist chamber and then on the bench of the greenhouse. Depending on the temperature and humidity of the greenhouse, soon or late, the symptoms of the disease, consisting of dark oval spots and having a purple border, appear on the stem, peduncles and leaves.

On isolating the fungus from spots on the stem or leaves and using it for inoculation of roots and the base of Kenaf plants, symptoms of the disease on these parts of the plant were produced. So it is demonstrated that the fungus is pathogenic to all parts of Kenaf plant

**Macroscopic and microscopic characters of the causal agent**

On the diseased spots on the stem of Kenaf plants the sporodochia of *Fusarium* appear as very small pink dots. The colour of mycelium and sporodochia produced in

the absence of light, for example, on the lesions at the base of the plants, is white. On agar plates, for example on PDA, the mycelium and sporodochia are at first white and becoming rose when exposed to light.

Macroconidia of the fungus are curved fusiform, the curvature of two ends being unlike (Fig.3). They have mostly 3 to 5 septa, sometimes 6 or 7 and occasionally more. There seems to exist more or less a foot-cell in macroconidia. Sizes of macroconidia and chlamydospores are given in Table 3.

Table 3. Measuring of *Fusarium* spores from Kenaf
(Single spore cultures from sterilized Kenaf and alfalfa stems)

| | Macroconidia | | | | | | | | Clamydo-spores |
|---|---|---|---|---|---|---|---|---|---|
| Septation | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | |
| No. of spores | 3 | 0 | 15 | 18 | 27 | 8 | 1 | 1 | 10 |
| Extreme L. and W. μ | 16,0–46,2 ×3,5–4,6 | – | 26,2–42,6 ×3,5–5,3 | 32,9–49,7 ×3,9–5,7 | 37,4–65,8 ×4,4–5,7 | 46,3–62,3 ×4,4–5,5 | – | – | 6,1–12,1× 5,6–10,7 |
| Average L. and W. μ | 27,9×4,2 | – | 35,8×4,8 | 43,5×5,1 | 50,5×5,2 | 53,5×5,2 | 44,5× 5,3 | 87,3× 5,3 | 10,2×9,3 |

Chlamydospores of this *Fusarium* are oval or spheric, having a somewhat echinulate epispore and being mostly intercalar. Terminal chlamydospores are less observed. Young chlamydospores are light brown.

Sclerotia are mostly formed in cultures. On PDA they are brown or more or less dark.

Sexual fructification for the fungus was not seen.

**Identification of the species of the kenaf foot rot *Fusarium***

As the macroscopic and microscopic characteristics of the *Fusarium* agent of foot rot of Kenaf, show, according to Snyder & Hansen classification the fungus is probably *Fusarium roseum*. But following the classification of Wollenweber & Reinking nothing can be said at the moment. However, identification of the species needs further investigation.

## EXPERIMENTS FOR THE CONTROL OF KENAF FOOT ROT

### A. Seed disinfection

To prove if seed disinfection is efficient in preventing the disease an experiment was carried out in an infested field at Shahi with Ceresan-dry and Rizoctol-combi, 2 and 3 gr. for one kilo of Kenaf seed respetively. For each treatment there were 24 replications, each consisting of a row of 16m long. The distance betwen two rows was 50 cm. The same number of seeds were sown on each row. The results of this experiment are given in Table 4.

Table 4. Results of seed treatment against Kenaf *Fusarium* foot root.

| | Ceresan | Rhizoctol combi | Check |
|---|---|---|---|
| Number of grown plants 21 days after sowing | 5560 | 5046 | 6448 |
| Number of healthy plants 101 days after sowing | 603 | 518 | 322 |
| percentage of dead plants | 89 | 90 | 95 |

As the results of the above experiment show, seed treatment is not enough effective for controling of the disease.

*B.* **Fungicide spray at the base of Kenaf Plants**

As it was mentioned, the seed treatment is not useful for preventing the *Fusarium* foot rot of Kenaf. So two experiments were carried out to prove if fungicide sprays at the base of Kenaf plants are efficient to bring down the damage of the disease.

*First experiment*

There were used 4 fungicides, namely, Brassicol (PCNB), Captan (Orthocide), Lonacol (Zineb), Arasan (TMTD), in two times, the first one 10 days after sowing and the second one 20 days after the first one. The experiment consisted of nine replications, each being a plot of 5 rows of 5 metres long. The number of seeds used on each row was 70 and the distance between two plots was 1.5 m. The results are given in Table 5.

Table 5. Results of a fungicides trial, sprayed at the base of Kenaf plants against *Fusarium* foot rot.

| | Brassicol | Captan | Arasan | Lonacol | Check |
|---|---|---|---|---|---|
| Number of plants 18 days after sowing | 1545 | 1550 | 1575 | 1298 | 1425 |
| Number of healthy plants 108 days after sowing | 267 | 240 | 227 | 143 | 113 |
| Percentag of dead plants | 83 | 85 | 86 | 89 | 92 |

As the table 5 shows fungicides sprays at the base of Kenaf plants is not enough efficient.

*Second experiment*

Five fungicides were used in this experiment (table 6). There were 6 replications, each consisting of a plot of 5 rows and each row being 5m. long. The distance between two rows was 50 cm. and the distance between two plots 1.5m. 500 Kenaf seeds were sown in each plot. Fungicides were used 6 times, the first spray applied when seeds were placed in the furrow before being covered with soil and the others at 15 days interval from each other. The amount of fungicide used for each plot was 5 gr. The results are given in Table 6.

Table 6. Results of a fungicides trial, sprayed at the base of Kenaf plants agianst *Fusarium* foot rot.

| | Lonacol | Lanstan | Captan | Arasan | Brassicol | Check |
|---|---|---|---|---|---|---|
| Number of grown plants 16 days after sowing | 3034 | 1995 | 1948 | 2069 | 2086 | 2070 |
| Number of healthy plants 69 days after the sixth spray | 149 | 35 | 98 | 95 | 24 | 21 |
| Percentage of dead plants | 92.7 | 98.3 | 95 | 95.5 | 98.9 | 99 |
| Weight of fibers (in grams) | 1800 | 560 | 1425 | 1450 | 425 | 325 |

As the table 6 shows there is not enough difference between the percentage of dead plants in check and other treatments and the weight of fibers in comparison with the yield of a healthy field is at least 14 times less. For example in Lonacol treatment which has been the most effective only about 7% of the Kenaf plants were saved. So from the above experiments is resulted that fungicides sprays at the base of the Kenaf plants is not useful for preventing *Fusarium* foot rot.

**C. Covering the base of kenaf plants with soil**

To avoid humidity from the base of Kenaf plants dry soil was gradually piled at the base of plants to see if such a practice has any effect on the disease. This experiment was carried out in 9 replications, each being a plot of 5 rows, the length of each row was 5m. and the distance between two rows 50 cm. The results are given in Table 7.

Table 7. Results of covering the base of Kenaf plants with soil in regards to *Fusarium* foot rot.

| | Base covered | not covered |
|---|---|---|
| Number of grown plants 24 days after sowing | 1442 | 1514 |
| Number of healty plants after 55 days | 430 | 394 |
| Percentage of dead plants | 70 | 74 |

As the table 7 shows, piling soil at the base of Kenaf plants is not useful. Moreover, as the fungus attacks invariably any parts of the root and stem, such a practice can not usually be efficient, especially that the humidity lasts more on the stem when it is in contact with the soil, and the soil itself contains the inoculum.

**D. Resistant varieties**

As it is demonstrated, seed treatment, fungicides sprays at the base of plants and covering the foot of Kenaf plants with soil are not useful in preventing the disease.

This *Fusarium* as most species of the genus can survive saprophytically for years in the soil on debris of plants, and as it is able to attack any part of Kenaf plants at any time, these methods usually are not enough efficient for its control. So the only way to control economically the disease is to seek for resistant varieties.

1. Greenhouse Experiments for Resistant Varieties

Experiment No.1

This experiment was carried out using foreign varieties of Kenaf and with the same procedure as was used for proving pathogenicity of the causal fungus. Plants were 45 days old at the time of inoculation. Results of the experiment are given in Table 8.

Table 8. Results of greenhouse experiment No. 1 for resistance of Kenaf against *Fusarium* foot rot.

| | | Varieties used | | | | |
|---|---|---|---|---|---|---|
| | | Cuba 2032 | Purja | Cuba 108 | Costa Rica | Local |
| Number of inoculated Kenaf plants | | 22 | 34 | 10 | 14 | 32 |
| Number of healthy plants 27 days after artificial ino - culation | | 20 | 26 | 1 | 0 | 0 |
| Percentage of resistance | | 90 | 77 | 10 | 0 | 0 |
| Check | No. of plants (non inoculated) | 23 | 31 | 11 | 15 | 22 |
| | Percentage of healthy plants | 100 | 100 | 100 | 100 | 100 |

As it is seen by the above table, the variety Cuba 2032 shows 90% resistance; while Purja shows 77% resistance, and the two others (Costa Rica & Cuba 108) are susceptible, almost the same as the local Iranian variety.

Experiment No.2

This experiment was carried out with the same varieties as in the experiment No.1. Kenaf plants were inoculated when 124 days old. Results are given in Table 9.

Table 9. Results of greenhouse experiment No. 2 for resistance of Kenaf againt *Fusarium* foot rot.

| | Varieties used | | | | |
|---|---|---|---|---|---|
| | Cuba 2032 | Purja | Cuba 108 | Costa Rica | Local |
| Number of inocula- ted Kenaf plants | 23 | 31 | 11 | 15 | 22 |
| No. of healthy plants 48 days after inoculation | 23 | 29 | 0 | 0 | 0 |
| Percentage of resistance | 100 | 93.6 | 0 | 0 | 0 |

The above experiment shows again that Cuba 2032 and Purja varieties are more or less resistant to *Fusarium* foot rot.

*E*xperiments No. 3 & 4

These experiments were carried out with the same procedure as the two previous ones, except that 3 new varieties were included.

Results are given in tables 10 & 11.

Table 10. Results of greenhouse experiment No.3 for resistance of Kenaf against *Fusarium* foot rot .

| | Varieties used | | | | | | |
|---|---|---|---|---|---|---|---|
| | Cubano | Cuba 108 | Purja | Local | Everglades 71 | Cuba 2032 | Costa Rica |
| No. of inoculated plants | 15 | 39 | 63 | 51 | 32 | 67 | 45 |
| No. of healthy plants 43 days after inoculation | 0 | 0 | 48 | 0 | 11 | 61 | 0 |
| Percentage of resistance | 0 | 0 | 76 | 0 | 31 | 91 | 0 |

Table 11. Results of greenhouse experiment No . 4 for resistance of Kenaf against *Fusarium* foot rot.

| | Varieties used | | | | | | |
|---|---|---|---|---|---|---|---|
| | Cubano | Cuba 108 | Purja | Local | Everglades 71 | Everglades 41 | Cuba 2032 |
| No. of inoculated plants | 17 | 44 | 60 | 58 | 28 | 11 | 72 |
| No. of plants remained healthy | 4 | 5 | 48 | 0 | 22 | 8 | 69 |
| Percentage of resistance | 23 | 11 | 80 | 0 | 78.5 | 72 | 95 |

As it is resulted from the 4 above experiments, the varieties Cuba 2032 & Purja are to a great degree resistant, while the varieties Costa Rica, Cuba 108 and Cubano are more or less susceptible.

2. Field Experiments for Resistance

In 1965 two experiments were carried out in the Agricultural Station at Shahi, using two infected pieces of land which were under Kenaf cultivation the year before. The degree of infection in these two lands was different. In 1966 also two experiments were fulfilled in this regard at the same station.

Experiment No.1 (1965)

For this experiment 4 types of Kenaf seeds were used in 9 replications. The lenght of each row was 16 m. and the distance between rows 50 cm. Results of the experiment are given in Table 12.

Table 12. Results of field experiment No. 1 for resistance of Kenaf against *Fusarium* foot rot

| | Varieties used | | | |
|---|---|---|---|---|
| | Costa Rica | Cuba 108 | Purja | Local |
| No. of plants 11 days after sowing | 2940 | 3491 | 2745 | 3192 |
| No. of healthy plants at the time of harvest (5 months after sowing ) | 245 | 325 | 2340 | 34 |
| percentage of resistance | 8.3 | 9.3 | 86 | 1 |

Experiment No.2 (1965)

This experiment was carried out in 12 replications each being a plot of 4 rows. The lenght of each row was 14 m., the distance between rows 50 cm. On each row 200 Kenaf seeds were sown.

Results are given in Table 13.

Table 13. Results of field experiment No. 2 for resistance of Kenaf against *Fusarium* foot rot.

| | Varieties used | | | |
|---|---|---|---|---|
| | Costa Rica | Cuba 108 | Purja | Local |
| No. of plants 23 days after sowing | 444 | 564 | 684 | 664 |
| No. of healthy plants at the time of harvest (127 days after sowing) | 163 | 217 | 631 | 35 |
| percentage of resistance | 36 | 38 | 92 | 5 |

As it is seen by tables 12 and 13 the variety Purja shows a good resistance to *Fusarium* foot rot of Kenaf while the varieties Costa Rica, Cuba 108 and Local (iranian) are respectively susceptible. The larger numbers for percentage of resistance in the experiment No.2, compared with those in the experiment No.1, is because of less infection of the soil in the experiment No.2 and thinner seeding.

Experiment No. 3 (1966)

This experiment was carried out with 8 types of Kenaf seed and 8 replications, each replication being composed of 16 rows of 12m. long and 50 cm. distance between rows. Of 8 rows in each replication, each row was grown with one type of Kenaf seed and between them 8 other rows were cultivated at intervals with the susceptible local variety. Results of the experiment are given in table 14.

Table 14. Results of field experiment No. 3 for resistance of Kenaf against *Fusarium* foot rot.

| | Varieties used | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Purja | Cuba 2032 | Evergla-des 71 | Soudan late | Everg-lades 41 | Soudan early | Cuba 108 | Local |
| No. of grown plants 20 days after sowing | 1336 | 1056 | 935 | 1539 | 857 | 1325 | 609 | 1320 |
| No. of healthy plants after 5 months | 845 | 805 | 50 | 355 | 40 | 69 | 28 | 0 |
| percentage of resistance | 63 | 76 | 5 | 23 | 4.5 | 5 | 4.5 | 0 |

Observation: The seeds of different types had different degree of power of germination. So the number of grown plants were different.

Experiment No. 4 (1966)

As the power of germination for different types of seeds was different, from each variety 250 seeds were sown on each row and then the number of grown seedlings were reduced on each line to 100 by thinning. This experiment was carried out with 8 types of Kenaf, 7 of them were the same as in experiment No.3. There were 6 replications, each being 16 lines of which 8 were different types of Kenaf used in the experiment and 8 other lines were local variety sown at intervals with them. The length of each row (line) was 11 m. and the distance between two rows was 50 cm. Results are given in Table 15.

Table 15. Results of field experiment No 4 for resistance of Kenaf against *Fusarium* foot rot.

| | Purja | Cuba 2032 | Evergla-des 71 | Soudan late | Evergla-des 41 | Soudan early | BG-52-135 | Local |
|---|---|---|---|---|---|---|---|---|
| No. of germinated seeds after 14 days of sowing | 1085 | 892 | 1024 | 1132 | 974 | 1048 | 717 | 1028 |
| No. of plants after thinning | 600 | 600 | 600 | 600 | 600 | 600 | 600 | 600 |
| No. of healthy plants 134 days after sowing | 429 | 476 | 42 | 176 | 30 | 55 | 154 | 12 |
| percentage of resistance | 71.5 | 79 | 7 | 29 | 5 | 9 | 25 | 2 |
| Weight of dry fibers in gr. | 11200 | 13600 | 1800 | 5600 | 800 | 2000 | 1800 | 170 |

As it is resulted from experiments No. 3 & 4 the variety Cuba 2032 is the most resistant (76-79%), after that is Purja (63–71%) . The variety Soudan-late shows some tolerance (23–29%). Because in this variety most of plants which showed some slight symptoms of the disease and for this reason they were recorded as diseased plants had a natural good growth and did not wilt.

## 3. CHARACTERISTICS OF KENAF VARIETIES USED IN EXPERIMENTS

As it is shown, variety Cuba 2032 is the most resistant to *Fusarium* foot rot and it can be replaced with the susceptible local variety. Moreover this variety is not much dependent on day light ( photoperiodism ) and to some extent can produce seeds in the conditions of Caspian Sea areas.

The variety *Purja* shows also good resistance to *Fusarium* foot rot. Its origin is south Africa ( JOHANSBURG ). The stem of this variety is purple, so it is easily distinguished from the other varieties used in the experiments. The plants become very high and under favorable conditions they may reach up to 5m. The fibers are white and soft. This variety is photoperiodic, so that in Capian Sea areas it does not produce seeds, even after being 7 months in the field.

The varieties *Soudan late* (with green stem and simple leaves), *Evergladies 71*, *Evergladies 41* and *BG-52-135* are not enough resistant (5-30%) and the varieties *Costa Rica* aud *Cuba 108* are susceptible.

The variety *BG-52-135* is precocious and like the Iranian variety produces a lot of seeds in Caspian Sea areas.

### *E.* Fallow and rotation

As already mentioned the fungus, agent of the Kenaf foot rot, can survive in the soil saprophytically on debris of plants and transmit the disease from year to year by infected soil. This transmission may occur to some extent by spores transported on seeds.

However the saprophytic life of the fungus can not last long, and gradually the degree of infection of the soil will decrease. In fields where for the first time Kenaf is grown the disease is observed rarely, and that not more than 1 or 2% . Contrarily if in a land Kenaf is successively grown for several years the infection of the soil will increase from year to year.

The texture and composition of the soil and the amount of water may also influence on the degree of infection. Marshy lands and, as it is observed at the Agricultural Station of Shahi, soils containing a large amount of Calcium salts may increase the disease.

## OTHER FUNGI ALREADY SEEN ON KENAF IN IRAN

1. *Cercospora* sp., cause of purple leaf spot, which produces round spots with purple border on the upper surface of Kenaf leaves, especially on foreign varieties ( Fig . 4 ).

2. *Cercospora* sp., cause of leaf sooty blotches which are produced under moist conditions at the end of season, especially on the lower suface of the leaves ( Fig . 5 ).

3 *Botrytis* sp., cause of gray rot of Kenaf, which at the end of summer in rainy weather and under intensive moist conditions attacks the top of the stem and

produces masses of spores around it. If the fungus attacks the capsules, seeds are more or less avorted and to some degree they lose their power of germination. On leaves the symptoms of the disease appear as necrotic spots. The disease may be transmited by seed (Fig . 6&7).

4. ***Colletotrichum*** sp, , cause of Anthracnose. It only was once observed on the ***Soudan*** variety.

5. ***Macrophomina*** sp., observed by G. Scharif on the stem of Kenaf,

6. ***Leveillula taurica***, produces powdery mildew on the lower surface of leaves. Symptoms of the disease are especially seen at the end of season. Specimens are collected only from Dezful, (Kootian) and Varamin (Fig.8).

7. ***Rhizoctonia solani***, cause of damping–off on Kenaf and cotton, as shown by cross inoculations in greenhouse . The fungus is observed for the first time at Varamin on foreign varieties (Fig.9).

8. ***Sclerotium rolfsii***, The fungus is observed on Kenaf on some plants at Shirgah (Caspian Sea area). Mycelium and sclerotia of the fungus are produced at the base of plants.

9 ***Fascination***, cause unknown, may be some genetic or physiological cause ( Fig . 10).

Nematode root–knot (***Meloidogyne*** sp.) is also observed on Kenaf in Caspian Sea areas (Fig. 11). This parasite, although important on Kenaf in foreign countries, does not show itself as yet so dangerous in our country.

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