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Cultural Practices for the Management of Rhizoctonia Disease in Potato

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Abstract. The study was conducted in the glasshouse of the Faculty of Agriculture, University of Khartoum, to evaluate various cultural practices on the development of Rhizoctonia diseases of potato (*Rhizoctonia solani* Kuhn) during the season 1998/1999. Four cultural practices were applied on two commercial cultivars of potato using factorial design. These treatments were: soil amendment with organic manure, soil exposed to sunlight (solarization), soil flooding and then exposed to sunlight and soil flooded and planted when dried. In the first three treatments, soil was left fallow for 12 months before the planting of potato. Yield reduction due to the soil infestation by the pathogen was 63.96%. The influence of two treatments was significant, particularly in disease suppression and subsequently in improvement of the final tuber yield. Cow manure amendment reduced the sclerotia formation in yielded tubers by 17.04-21.48%. The tuber yield was also improved more than twice as much as using this soil amendment. The practice of soil flooding and exposing to direct sunlight also gave significant results. The ineffective treatment was the soil flooding and planting when dried (without fallow and solarazation). These perspectives have a significant value in the implementation of the disease control especially in Sudan.

Keywords: Potato, *Rhizoctonia solani,* Cultural practices, Sudan.

Introduction

Rhizoctonia stem canker and black scurf (caused by *Rhizoctonia solani* Kuhn) are economically important diseases of potato in many parts of the world [1]. The diseases reduce the progeny tubers quality and marketable yield [2]. In the temperate zones, yield reduction was estimated to range between 30-40% [3] and between 19.2-34.0% in the tropical and subtropical regions [4, 5]. Pesticides used for controlling the disease have been reported to involve problematic, i.e. methyl bromide has residual effect that should be take carefully [6]. However, there is an increasing interest in using physical and cultural methods in disease control as alternatives to pesticides. Cultural practices that used alone or as components in the disease management programs are able to suppress the development of the disease based on the selection of suitable soil management regimes [7]. The important category in this regard is that cultural practices are feasible to increase production as well as to suppress pathogens [8].

Recently, the disease became dreadful for the crop production in Sudan, where a considerable loss in potato yield has been reported [9]. Therefore, there is an urgent need to investigate the potential suppression of some cultural practices on the development of Rhizoctonia diseases in potato and this was the main objective of the present study.

Material and Methods

Preparation of potato dextrose broth (PDB)

Two hundred grams of potato were cooked in 500 ml of distilled water for 30 min. The broth was filtered through cheesecloth and 20 g dextrose was added under boiling. The volume was restored to 1000 ml with distilled water and then autoclaved at 15 lb/in^2 for 15 min.

Rhizoctonia inoculum

The original Rhizoctonia inocula confirmed under microscopy was obtained from tuber-borne sclerotia and left to culture in the Potato Dextrose Agar (PDA) media for 7 days. Five discs (7 mm in diameter) of Rhizoctonia mycelium were added to the PDB medium in 250 ml conical flasks. After 15-day incubation, the mycelium was removed by forceps and washed by sterilized distilled water. Then mycelium was macerated by blender and re-suspended in tap water (10 xs) for final concentration. The macerated mycelium was used to infest (20-ml/kg) the sterilized soil (6.2 PH) of the experiment treatments [10, pp. 390-395].

Planting, treatments and experiment design

The study was conducted during the season 1998/1999 in the glasshouse of the Faculty of Agriculture, University of Khartoum. Tuber seeds of two potato cultivars (Alpha & Turbo) were planted in sterilized soil using clay pots (12 inches diameter). Two halves of healthy seed (no visible sclerotia) pieces were planted per pot at a depth of 5 cm. Each pot contained 5 kg of soil, which was infested by *R. solani* inoculum (100 ml/pot). Four cultural practices were applied on the two potato cultivars using factorial design. These treatments were: soil amendment with organic manure (7.5 g cow manure/kg soil) (CM), solarization (soil exposer to direct sunlight for 4 months) (S), soil flooded artificially for 4 months fallowing exposer to direct sunlight for 4 months also (F+S), and soil flooded and planted when dried (F). The first three treatments were left fallow for 12 months before the planting of potato. Two controls were used, healthy (sterilized soil) and infested soil, which were considered as positive (P) and negative (N) controls respectively. Half gram of urea was applied twice as nitrogen fertilization in each pot of the experiment after 28 and 42 days of sowing date.

Assessment of plant growth and yield parameters

Percentage of emergence was calculated after two weeks of planting by dividing the number of plants emerged on total seeds cultivated. After 4 weeks of the sowing date, the plant height was measured from soil surface to the apex of last the leaf; also the number of stems per pot was recorded. Fresh weight of plant shoots per pot was reported using sensitive balance. The dry weight of plant shoots was estimated after two days of drying in oven at 72°C. The tubers of potato crop were harvested after 81 days from the sowing date and then yield was recorded as the number of tubers, average tuber weight per pot and total tubers weight.

Disease parameters

Plants were evaluated throughout 60 days for stem and tuber disease signs (stem lesion, canker, girdling, pruning, and stolons pruning). A plant is considered infected when one or more than one of these signs appeared. Incidence of the disease was expressed as percentage by dividing infected plant on total plant emergence. The severity of the disease was determined on a zero to 5 scale, with zero indicating no signs, 1, small lesions (0.2 cm long); 2, medium lesion (0.3 cm long); 3, canker (0.5 cm long); 4, girdling of stem; 5, pruning of stem. The percentage of sclerotia formation on tubers surface was estimated at the crop harvest.

Statistical analyses

Data was analyzed using One-way Analyses of Variance. Variations in growth, yield and disease parameters between the four treatments were compared according to Duncan's Multiple Range Test. $P < 0.05$ was considered significant.

Results

Plant growth parameters

The means of plant emergence ranged from 95.85-100% (average, 97.9%). The means of number stems per pot, plant height, fresh and dry weight in the two cultivars of potato were ranged between 2.85 to 4.15/pot, 21.19-35.7 cm 33.39-67.39 g/pot and 2.55 to 4.91 g/pot, respectively. Except the plant height, the parameters of plant growth were statistically not differing significantly between potato cultivars. The interaction between cultivars and treatments was also not significant. Soil amendment with cow manure and soil flooded and solarized were the best treatments in the plant growth parameters. Cow manure treatment gave similar fresh weight (66.7 g/pot) to the positive control, which is differing significantly from negative control (47.31 g/pot). The ineffective treatment in this respect was the soil flooded and planted when dried that gave the lowest fresh weight (33.39 g/pot) below the mean (47.31 g/pot) of the negative control (Table 1).

Disease parameters

The disease incidence, severity and sclerotia (black scurf) on stems and progeny tubers ranged from 0.59 to 0.75, 2.78 to 3.68 and 0.09 to 0.19, respectively. The values of these parameters in the positive control were found zero, whereas in the negative control were 0.84, 5.92 and 0.46, respectively. The interaction between cultivars and

Table 1. Mean of plant growth parameters[1] of two potato cultivars ('Alpha' and 'Turbo') inoculated by *Rhizoctonia solani* as affected by the different cultural practices in the glasshouse

Treatments	Emergence (%)	No. of stems	Plant height (cm)	Fresh weight (g)	Dry weight (g)
N	95.85[a2]	4.15[a]	21.19[b]	47.31[bc]	3.58[ab]
P	100[a]	2.85[bc]	35.71[a]	67.39[a]	4.91[a]
F+S	100[a]	3.00[c]	24.63[b]	59.58[ab]	4.19[a]
F	95.85[a]	3.50[abc]	22.27[b]	33.39[bc]	2.55[b]
Cm	100[a]	4.00[ab]	24.37[b]	66.70[a]	4.87[a]
S	95.85[a]	3.15[bc]	26.16[b]	56.97[ab]	4.30[a]
SE±	3.04	0.30	2.98	5.60	0.50

[1] Means from three replications with tow pots per replication.

[2] Means followed by the same letter(s) are not different significantly according to Duncan's Multiple Range Test (P=0.05).

N: Negative control (infested soil), P: Positive control (healthy soil), F+S: Soil flooded and exposed to sunlight, F: Soil flooded and planted when dried, Cm: Soil treated with cow manure and S: Soil exposed to direct sunlight.

treatments was not significant. Cow manure treatment recorded the lowest disease incidence (0.59), severity (2.99) and sclerotia (0.09). The difference was statistically significant compare to negative control. The percentage of this suppression during the sclerotia formation was 19.3%. Soil flooded and left to solarize was the second best treatment in these respects that recorded 0.7, 3.6 and 0.12 for the disease incidence, severity and sclerotia respectively. The treatment of soil flooded and planted when dried was statistically not effective on the disease incidence (Table 2).

Table 2. Mean of disease parameters[1] of two potato cultivars ('Alpha' and 'Turbo') inoculated by *Rhizoctonia solani* as affected by the different cultural practices in the glasshouse

Treatments	Disease incidence[1]	Disease severity[1]	Sclerotia[1]
N	0.84[a2]	5.92[a]	0.46[a]
P	0.00[bcd]	0.00[bc]	0.00[bcd]
F+S	0.70[bc]	3.60[b]	0.12[bc]
F	0.75[ab]	3.68[b]	0.19[b]
CM	0.59[bc]	2.99[b]	0.09[bc]
S	0.61[bc]	2.78[b]	0.12[bc]
SE±	0.045	1.91	0.03

[1] Means from three replications with tow pots per replication.

[2] Means followed by the same letter(s) are not different significantly according to Duncan's Multiple Range Test (P=0.05).

N: Negative control (infested soil), P: Positive control (healthy soil), F+S: Soil flooded and exposed to sunlight, F: Soil flooded and planted when dried, Cm: Soil treated with cow manure and S: Soil exposed to direct sunlight.

Yield parameters

The means of tuber number, tuber weight and total tubers weight per pot ranged from 7.67 to 6.00 tuber/pot, 12.65 to 9.44 g/pot and 88.95 to 64.04 g/pot, respectively. Yield reduction due to the soil infestation by the pathogen was 63.96%. The interaction between cultivars and treatments was not significant. Soil amendment with cow manure was the best treatment in the final tuber weight that was recorded 88.95 g/pot compared to 112.49 g/pot to the positive control (the difference was statistically not significant). The final tuber yield was improved more than 2.2 times using this treatment in comparison to negative control. Soil flooded and left to solerize also gave good results and the mean of the total tuber weight was 74.35 g/pot. The lowest mean of the final tuber weight (64.04 g/pot) was reported when soil flooded and planted when dried (without fallow and solarization) in which the difference was statistically not significant in comparison to negative control (Table 3).

Table 3. Mean of tuber yield parameters[1] of two potato cultivars ('Alpha' and 'Turbo') inoculated by *Rhizoctonia solani* as affected by different cultural practices in the glasshouse

Treatments	No. of tubers/pot	Average tuber weight (g)	Total tuber weight/pot (g)	Yield reduction %
I	6.17[b2]	6.26[b]	40.54[c]	63.96
H	10.50[a]	11.29[a]	112.49[a]	.,..
F+S	6.00[b]	12.65[a]	74.35[b]	33.91
F	6.00[b]	9.44[ab]	64.04[bc]	43.07
CM	7.67[b]	12.55[a]	88.95[ab]	20.93
S	6.50[b]	10.62[a]	66.09[bc]	41.25
SE±	0.73	1.40	9.08	

[1] Means from three replications with tow pots per replication.
[2] Means followed by the same letter(s) are not different significantly according to Duncan's Multiple Range Test (P=0.05).
N: Negative control (infested soil), P: Positive control (healthy soil), F+S: Soil flooded and exposed to sunlight, F: Soil flooded and planted when dried, Cm: Soil treated with cow manure and S: Soil exposed to direct sunlight.

Discussion

The total reduction of potato tuber yield caused by *R. solani* investigated in the present study was ranged from 32.4% to 39.6% similar to the finding of Little *et al.* [3]. This result agrees with other observations stating that the black scurf disease of potato caused by *R. solani* is one of the important factors that influence significantly potato yields [10, pp. 390]. However, the influence of most cultural practices in this perspective study was significant, particularly in disease suppression and subsequently in the improvement of the final tuber yield. All treatments except flooding soil without solarization (F) were successful to suppress significantly the incidence and severity of the disease (Table 2). Similar observation has been confirmed that soil remained fallow and exposed to sunlight (solarization), reduced significantly the infection of *Streptomyces scabies, R. solani* and *Colletotrichum atramentarium* (*C. coccodes*) [12]. However, poor stands of potato and the increase in the severity of the disease have been observed in areas planted immediately with potato following crops of red clover and alfalfa [13]. As it is well known that continuous cropping system increased soil borne diseases, i.e. sugar beet caused by *R. solani* [14]. A greater growth suppression of *R. solani* hyphae has been reported in the arable land under rotation in comparison to grassland [7]. Clearly, crop rotation and fallow are a beneficial practice that could be used for reducing the Rhizoctonia and other soil-borne diseases [15, 16].

It is interesting to note that cow manure amendment was the best treatment in both reducing the severity of the disease and improving the final tubers yield of potato (Tables 2 and 3). Similar results have claimed that the suppression of black scurf, scab (caused by *Streptomyces scabies*) and Verticillium wilt of potato as a result of soil amendment with organic manure [14, 16, 17]. Also, the reduction in the stem infection has been observed when oats preceded potato as a green manure crop [18]. In newly cultivated soil, organic material is frequently recommended to prevent the increase of pathogens and this was attributed to the unfavorable condition that produces by organic amendment [19, 20]. However, solarizing soils plus suitable organic materials have been reported to actuate a chain reaction of chemical and microbial degradation, which enhance toxicity against soil flora and fauna, especially soil borne plant pathogens [8]. These probably contributed to the higher nutrient contents, which could be found with organic manure amendment [14].

It can be concluded that leaving fields fallow and exposed to direct sunlight is the significant method in suppressing the development of the soil borne diseases, i.e. black scurf caused by *R. solani*. However, an organic amendment could be used as a beneficial agricultural treatment in controlling the Rhizoctonia disease of potato as well as to improve the final tubers yield.

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استخدام الطرق الزراعية لإدارة مرض الرايزوكتونيا في البطاطس

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(قدم للنشر في ١٠/١٠/١٤٢٥هـ ؛ قبل للنشر في ١٨/١٠/١٤٢٦هـ)

ملخص البحث. أجريت هذه الدراسة فى البيت المحمي بكلية الزراعة، جامعة الخرطوم، لتقييم المعاملات الزراعية، على تطور مرض الرايزكتونيا في البطاطس خلال الموسم ١٩٩٨/١٩٩٩م. طبقت أربعة معاملات زراعية على عينتين تجاريتين من البطاطس باستخدام تصميم التجارب العاملية. هذه المعاملات هي: معاملة التربة بمخلفات الأبقار، تعريض التربة لأشعة الشمس (التشميس)، غمر التربة بالماء ثم تعريضها لأشعة الشمس وغمر التربة بالماء ثم زراعتها مباشرة بعد أن تجف. تركت التربة بور في المعاملات الثلاثة الأولى لمدة ١٢ شهرا قبل زراعة البطاطس. أوضحت النتائج أن النقص في الإنتاجية نتيجة لتلويث التربة بالممرض كان ٦٣,٩٦٪. الأثر كان معنويا لاثنين من المعاملات، تحديدا في تثبيط المرض وتحسين الإنتاجية النهائية للدرنات. أدت معاملة التربة بمخلفات الأبقار لخفض نسبة الأجسام الحجرية في الدرنات بمقدار ١٧,٠٤-٢١,٤٨٪، كما أن الإنتاجية زادت إلى أكثر من الضعف نتيجة لاستخدام هذه المعاملة. أعطت أيضا معاملة التربة بالغمر ثم تعريضها لأشعة الشمس مباشرة نتائج معنوية. كانت المعاملة غير المؤثرة غمر التربة بالماء وزراعتها مباشرة بعد أن تجف (دون تركها بور وتعريضها لضوء الشمس). هذه النتائج يمكن أخذها في الاعتبار في الإطار المستقبلي لحل هذه المشكلة في السودان.