Association of Crop Production Practices on the Incidence of Wilt and Root Rot Diseases of Chickpea in the Sudan

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Abstract

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Chickpea is an important cool-season food legume in Sudan but its productivity suffers from various biotic factors including wilt and root rot diseases. A field survey was conducted during 2011/2012 cropping season to determine the importance and distribution of chickpea wilt and root rot diseases in the Sudan. During the survey, chickpea cultivars, agronomic practices and cropping systems used by farmers were evaluated to determine their impact on wilt and root rot disease incidence in farmers' fields. The majority of fungal isolates recovered from diseased chickpea plants (80%) belonged to the genus *Fusarium*, whereas *Rhizoctonia* spp. and *Macrophomina* spp. constituted 20% of the recovered fungi. The majority (72%) of the farmers planted local chickpea landraces, whereas 19% planted improved Kabuli chickpea cultivars. High seed rate and early sowing significantly increased mean wilt and root rot disease incidence. Moreover, mono-cropped fields with chickpea showed high mean disease incidence, unlike chickpea in rotation with other crops. Since the chickpea area in the country is increasing due to attractive market value and increased demand for household consumption, high yielding, disease resistant varieties with suitable agronomic practices should be developed to reduce the impact of wilt and root rot diseases.

Keywords: Chickpea cultivars, agronomic practices, cropping systems, fungal diseases.

Introduction

Chickpea (*Cicer arietinum*) is an important source of protein that plays a significant role in the diets of the people and the economy of the Sudan. Fusarium wilt and root rot diseases caused by *Fusarium oxysporum* f. sp. *ciceris*, *F. solani*, *Rhizoctonia* spp. and *Macrophomina phaseolina* are the major constraints to chickpea production and productivity in the Sudan (4, 10, 13, 17). Wilt and root rot (WRR) causing pathogens are soil-borne organisms that persist for many years in the soil. These pathogens can attack a wide range of plant species in the absence of chickpea which makes the management practices less effective. The most realistic and rewarding management approach to the diseases is through developing resistant cultivars and integrated crop management practices (2, 12, 15, 16, 19). Recent findings showed the existence of races of the fungus *F. oxysporum* f. sp. *ciceris* that can limit wide use of resistant chickpea cultivars in the Sudan (17).

Chickpea cultivars grown in the Sudan are small seeded Kabuli landraces (*Baladi*) traditionally produced in the northern part of the country. Although many high yielding Kabuli chickpea cultivars with associated agronomic practices are developed by the Agricultural Research Corporation, they are not widely adopted by farmers. The high yield losses caused by WRR led most farmers to abandon chickpea cultivation especially in the northern states (Northern State and River Nile State) and currently the area expanded to the central states (Khartoum and Gezira) where cultivated areas reached more than 12000 ha (9). Currently, chickpea area reached more than 100,000 ha in Gezira State during the cropping season 2016/2017 (Gezira Scheme Board, personal communication). Though chickpea is a new crop to the central states, WRR remain the major challenge to farmers. In these states, the extent of disease incidence and role of crop cultivars, cropping system and management practices on disease epidemics are not documented. The objectives of this study were to determine the distribution and importance of WRR disease in the major chickpea growing areas of the Sudan and relate crop management practices with disease incidence.

Materials and methods

A field survey was carried out during 2011/2012 cropping season in different chickpea growing areas of the Sudan covering the northern and central States (Figure 1). These areas are located between 13.77 and 19.62 N and 30.40 to 33.57 E with elevations ranging from 217 to 428 m.a.s.l. Chickpea fields were inspected after every 20-22 km intervals. Chickpea farmers were interviewed on the cropping systems and agronomic practices they follow. These include crop cultivars, seeding rate, sowing date, irrigation frequency, fertilizers and preceding crops. During the survey, 43 fields were covered in the four States. In each field, data on chickpea cultivar, growth stage of the crop, sowing date, seeding rate, preceding crops, irrigation frequency, and type of fertilizers used were recorded. Geo-informatics data using GPS (longitude, latitude and altitude using high sensitivity etrex GARMIN device) were recorded for each field to develop a disease distribution map. Moreover, soil types were classified based on soil classification by the Soil and Water Resources Center at the Agricultural Research Corporation, Sudan (7). WRR

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incidence (%) was estimated by randomly selecting 3spots/field by throwing a $1m^2$ quadrat in each spot. Disease incidence was calculated as percentage of diseased plants from the total number of plants of the three spots per field. Infected chickpea roots and stems (5-7 cm above collar region) showing distinct wilt symptoms were washed under running water and cut into small pieces (3-5 mm). The pieces were surface disinfected with 1% aqueous solution of sodium hypochlorite for one minute, rinsed in sterilized distilled water, blotted on filter papers and plated on potato dextrose agar (PDA) in 9 cm Petri dishes. The plates were incubated at 25±2˚C for 5 days. The isolates were identified on the bases of their morphological features.

Data analysis

Most of the plot characteristics or factors observed (genotype, soil type, seeding rate etc.,) were qualitative. Their association, one factor at a time, with the WRR incidence evaluated using variance ratio and the associated p-values based on F-distribution in the analysis of variance of the angular transformation of percent disease incidence. Means of percent WRR were estimated along with their standard errors for individual factors level.

Results

Association of wilt and root rot disease with biophysical factors

Mean wilt and root rot incidence varied from one state to another and from one farm to another as affected by biophysical factors like chickpea cultivars, growth stages, soil types, seeding rate, sowing date, fertilizer, irrigation interval and preceding crops. Pathogens isolated from infected chickpea plants were *F. oxysporum* (70%), *F. solani* (10%), *Rhizoctonia* spp. (5%) and *Macrophomina* spp. (15%).

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Chickpea cultivars, growth stages and soil types

The majority of the chickpea cultivars planted during the survey were local landraces (72%) and 19% improved cultivars namely Shendi (ILC-1335), Atmour (ICCV-89509), Wad Hamid (ICCV-2), and Jebel Marra (ILC-915). Mixed genotypes were grown in only 9% of the total surveyed fields (Table 1). The mixed chickpea genotypes exhibited 25% disease incidence. Local landraces, cvs. Shendi and Jebel Marra showed an average of 20% WRR incidence. Wad Hamid and Atmour cultivars showed mean disease incidence of 12.5 and 11.2%, respectively.

The growth stages of the crop recorded during the survey varied from vegetative (9%), flowering (33%) and podding/flowering (58%) (Table1). The lowest mean disease incidence was found at the flowering stage (13.9 %), whereas the highest was at podding/flowering stage (23.8%) (Table 1). Chickpea crops at the vegetative stage showed slightly lower disease incidence (20%) than those at the podding stage.

The majority of the crop fields (49%) was planted on heavy clay soils of Gezira State while 25% were grown on sandy loam soils mainly in Northern State. The remaining chickpea area (26%) was sandy clay, clay and light clay soils (Table 1). No obvious differences in disease incidence were observed between sandy loam soils of the Northern State (21.4%) and the clay soils of Khartoum State (20%). Disease incidence on sandy clay soils of River Nile State (11.5%) and the light clay soils of the northern parts of Gezira State (11%) was the lowest compared to all other soil types. The heavy clay soils of central and southern Gezira State showed the highest mean disease incidence (23.6%). No significant differences in mean percent WRR disease incidence were observed among chickpea genotypes, growth stages and soil types.

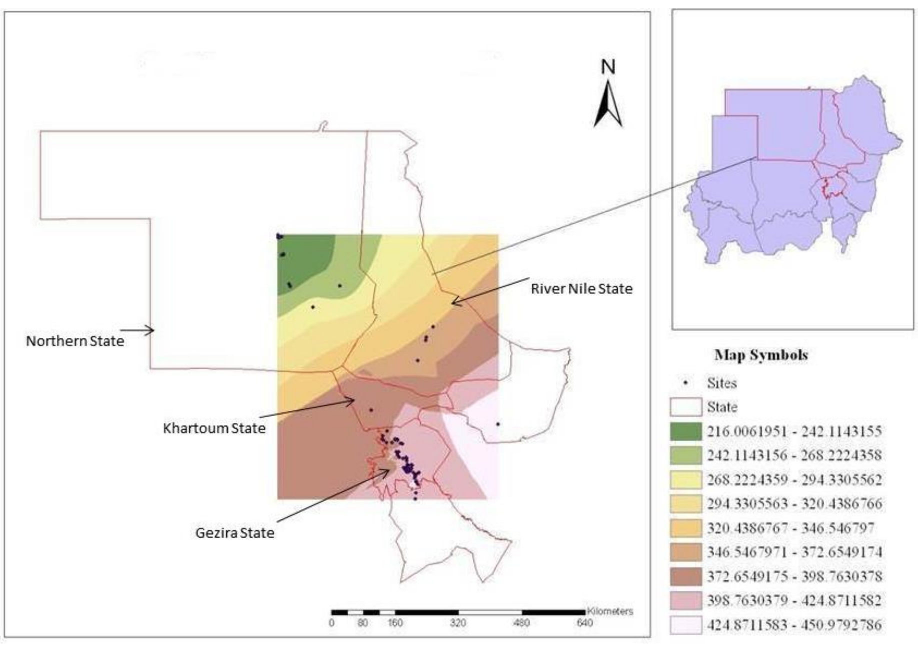

Figure 1. Surveyed locations for chickpea wilt and root rot diseases in different states of the Sudan.

Table 1. Effects of chickpea cultivars, growth stages and soil types on mean percent wilt and root rot incidence, during the 2011/12 cropping season.

Variable	Number of fields	Mean disease incidence (%)*
Chickpea cultivars		
Landraces	31	19.7
Shendi	1	20.0
Atmour	4	11.2
Wad Hamdi	2	12.5
Jebel Marra	1	20.0
Mixed (improved and local)	4	25.0
Chickpea growth stages		
Vegetative	4	20.0
Flowering	14	13.9
Podding/flowering	25	23.8
Soil types		
Sandy loam	11	21.4
Sandy clay	4	11.5
Clay	2	20.0
Light clay	5	11.0
Heavy clay	21	23.6

* Non-trasformed values (angular transformation was used for data analysis)

Seeding rate, sowing date, fertilizer and irrigation interval

Survey data indicated that seeding rates used by farmers ranged from 15 to 125 kg/ha. The majority of the farmers (67%) used 31-70 kg seeds/ha and 23% used less than 30 kg/ha, and only 4% used more than 90 kg/ha (Table 2). Disease incidence was significantly ($P \leq 0.05$) influenced by seeding rate. The highest incidence (50%) was recorded when more than 90kg/ha seed was used. Therefore, 90% of farmers used seeding rates of 15-70kg seeds/ha and disease incidence did not exceed more than 20% (Table 2).

Sowing date of chickpea in the surveyed areas extended from early to mid-November (72% of farmers) until early to late December (28%) (Table2). Disease incidence was significantly ($P \leq 0.003$) influenced by sowing date where the highest incidence (34.3%) was recorded for early sown (November) fields and the lowest (10.6%) was in the late sown (December) fields.

Fertilizer application was not a common practice among chickpea farmers, but over 50% of the interviewed farmers applied urea to their chickpea crops. There was no big difference in WRR disease incidence between fertilized and non-fertilized chickpea (Table 2). Farmers irrigated their crops every 7 to 21days, with the 15-day interval was the most commonly used by farmers. The disease incidence increased (not significantly) by 8 and 6% when the crop was irrigated every 2 and 3 weeks, respectively, as compared to weekly interval.

Table 2. Effects of seeding rate, sowing date, fertilizer and irrigation on mean wilt/root rot incidence.

Variable	Number of fields	Mean disease incidence (%)*
Seeding rate (kg/ha)		
15-30	10	16.6
31-50	16	18.8
51-70	13	19.6
71-90	2	25.0
>90	2	50.0
Sowing date		
Early November	14	34.3
Mid November	17	16.8
Early-late December	12	10.6
Fertilizer application		
Urea Application	20	21.0
No Urea application	23	22.2
Irrigation interval		
Every week	11	15.9
Every two weeks	22	23.7
Every three weeks	10	21.6

* Non-trasformed values (angular transformation was used for data analysis)

Preceding crops

The crops grown in the rotation with chickpea were cereals (wheat, maize and sorghum), vegetables, cotton, fallow, food and forage legumes (chickpea, peanut, pigeon pea and alfalfa). The major preceding crops recorded during the survey, were cereals (49%) followed by food and forage legumes (19%) and vegetables (16%) (data not shown). Most of the chickpea crops were grown after sorghum crops. Significant differences ($P \leq 0.005$) in mean WRR incidence were observed among different preceding crops. The highest mean incidence of WRR (43%) was found in mono-cropped fields followed by chickpea preceded by cereals (24%). Chickpea preceded by fallow, other legumes or crops other than cereals or chickpea had similar and lower disease incidence (12%) (Figure 2).

Discussion

Chickpea production was affected by wilt/root rot diseases in all States with varying incidence levels. In this study we found that all chickpea cultivars used in Sudan were susceptible to WRR disease at variable degrees with landraces being the most susceptible. This is in agreement with the finding of Faki *et al.* (8) who found that wilt and root rot incidence was affected by chickpea cultivars, soil types, and agronomic and cropping system practices. Although improved cultivars of chickpea were used by some farmers, the bulk of the area was dominated by chickpea landraces susceptible to WRR disease.

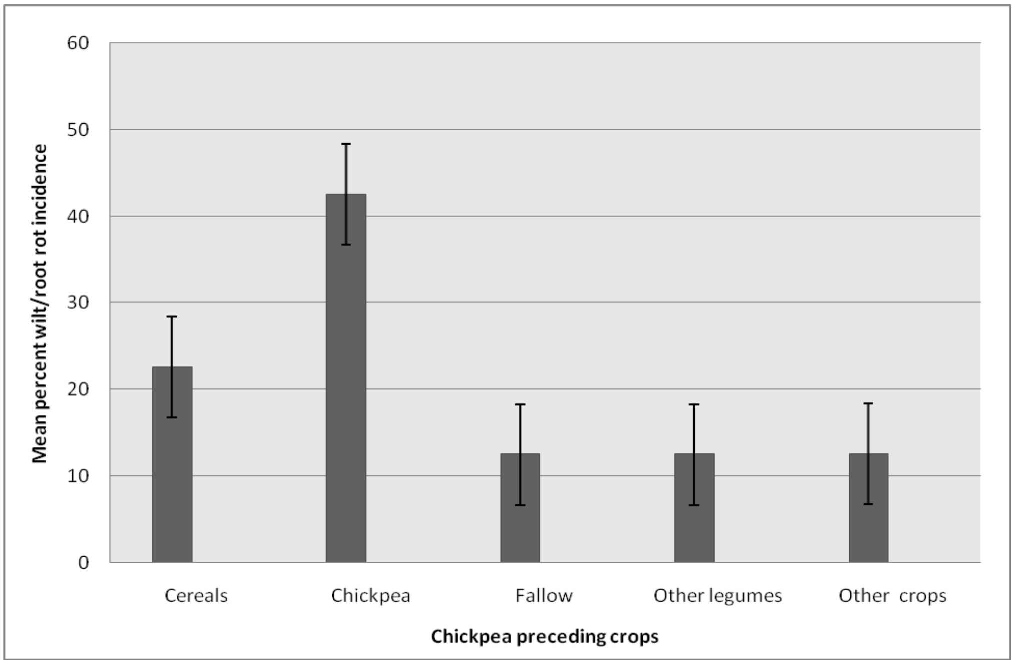

Figure 2. Effects of preceding crops on mean incidence of wilt and root rot diseases on chickpea. Vertical bars represent mean standard errors.

The chickpea breeding program in the Sudan released many high yielding cultivars with varying levels of resistance but they are not widely grown by farmers to reduce the impact of WRR on production and productivity. This makes the use of improved cultivars very limited and only few farmers have access to certified seeds. To maximize chickpea yield, integrated crop management practices like planting on ridges and seeding rate of 60 kg/ha were recommended because fields with higher seeding rates had higher disease incidence (8, 14). However, most farmers did not follow the recommended seeding rate and they used either low or high rates that favored high WRR incidence. The high seed rates resulted in high plant population leading to high competition for nutrients and water. Consequently, the plants became weak and vulnerable to invasion by soil-borne pathogens. Our findings are similar to others, who reported that high plant population density favored high root rot severity in common bean in Iran (18).

Our results demonstrated that the highest disease incidence was observed in chickpea planted on heavy clay soils with high moisture holding capacity compared to other soil types. It was apparent that disease incidence was high in Central Gezira State (24%) where heavy clay soils predominate (*data not shown*). Bhatti and Kraft (6) reported that soil moisture plays a key role in wilt and root rot development in chickpea. Similarly, faba bean root rot was associated with water-logged black vertisols in the highlands of Ethiopia (5).

In this study, WRR incidence was significantly influenced by sowing date and this is obviously related to differences in soil temperature that affect the disease. Mid-November is the optimum sowing date for chickpea production in the Sudan. However, the farmers sow their crops earlier in the season to get early harvest and fetches better market prices. However, such shift in planting dates exposed the crop to high WRR incidence and virus attacks. Hamed and Makkouk (11) also found that early sown chickpea was susceptible to *Chickpea chlorotic dwarf virus*. December sowings reduced disease incidence as the optimum root development coincide with low soil temperature that did not favor disease development. However, the crop usually suffers from heat stress at the flowering and pod filling stages and consequently results in very low productivity compared to mid-November sowings.

In the northern states, farmers sow chickpea on residual soil moisture but recently they shifted to irrigation where they applied water every 7 -21 days interval to their chickpea crop. The survey showed that WRR disease increased by 8 and 6% when the crop was irrigated every 2 and 3 weeks, respectively. Previous studies showed that increasing the irrigation intervals of chickpea resulted in increased disease incidence (3). Dry root rot (*R. bataticola*) can develop in epidemic proportion when temperature usually exceeds 30^0C accompanied with low moisture stress during the reproductive stages of the crop (21).

Most farmers adopted 2-3 weeks irrigation interval which increased the disease incidence (23.7% and 21.6%, respectively). Only 25.6% of the farmers adopted one week interval which can reduce WRR disease incidence to only 15.9%. Adoption of this practice will not be sustainable in the current situation where irrigation water is becoming a limiting factor.

Application of urea as a starter fertilizer (43 kg N/ha) was used by half of the visited fields, but no clear impact on WRR disease incidence was observed. Foliar application of nitrogen fertilizer is reported to improve seed yield of chickpea (20), but no information available on its effect on WRR disease of food legumes.

Chickpea is grown in variable rotation and mono-cropping systems where different levels of WRR incidence were recorded. The highest disease incidence was recorded in fields that followed a mono-cropping system, where high pathogen inoculum from the previous season most likely existed during early root system development and caused severe plant mortality. Similar results were reported where chickpea after chickpea planting enhanced soil-borne pathogens inoculum buildup (22). In this survey, chickpea rotation with cereals was not as effective as rotation with vegetables, fallow and other food and forage legumes in reducing WRR disease incidence.

Chickpea after sorghum was the most common crop rotation in the Sudan and its impact on reducing disease pressure was not very high. Planting lentil after sorghum was found to reduce the population of *F. solani* (1). Long term rotation of at least 3 years with non-host crops can be helpful to reduce inoculum levels of soil-borne pathogens affecting chickpea. The results of some previous studies revealed that soil borne fungi affecting lentil increased when lentil followed legumes in the rotation and decreased after cereals like rice or maize (1). Therefore, preceding crops can be an effective component in the management of WRR disease. Our study revealed that chickpea after cereals decreased disease incidence by about 100% compared to mono-cropping.

The management of chickpea WRR disease should be done through integrated crop management approach. These include using high yielding, WRR resistant cultivars with recommended seeding rates, irrigation frequency, sowing dates and appropriate cropping sequences. Multiplication and on-farm demonstration of high yielding, heat tolerant and disease resistant chickpea cultivars with recommended integrated crop management packages will minimize impact of diseases and narrow chickpea yield gaps in the Sudan. In this survey, it was evident that most farmers did not follow the agronomic packages and researchers need to fine-tune the existing recommended chickpea production practices to satisfy farmers' ambition. In order to avoid water-logging problem and reduce WRR, farmers should grow their crops on raised beds which is now expanding in the Sudan. *Chickpea chlorotic dwarf virus* is another production constraint and adoption of multiple disease resistant cultivars is important in order to improve productivity and production of chickpea. The high yield losses caused by WRR disease led most farmers to abandon chickpea cultivation especially in the northern States. The small sample size from northern states in this study reduced precision of the associations of biophysical factors with WRR incidence. Therefore, future surveys should take these into consideration, for better estimation of the variances and hence better detection of the effects of various factors associated with crop varieties and management.

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الملخص

محمد، اميمة الماحي، سعيد أحمد، موراري سينج ونفيسة الماحي أحمد. 2018. ترافق ممارسات الإنتاج الزراعي مع الإصابة بمرضي الذبول وتعفن الجذور التي تصيب الحمص في السودان. مجلة وقاية النبات العربية، 36(1): 21-26.

يعد الحمص من البقوليات الغذائية المهمة في موسم الشتاء في السودان، على أن إنتاجيته تعاني من إجهادات أحيائية مختلفة بما في ذلك مرضي الذبول وتعفن الجذور. تم إجراء مسح ميداني خلال الموسم الزراعي 2012/2011 لتحديد أهمية هذه الأمراض وانتشارها في السودان. تم خلال المسح، تسجيل أصناف الحمص المزروعة والعمليات الفلاحية ونظم الزراعة التي يستخدمها المزارعون لتحديد أثرها في انتشار المرض في حقول المزارعين. كانت معظم العزلات الفطرية من نباتات الحمص المصابة (80%) تنتمي إلى جنس *Fusarium*، بينما شكلت *Rhizoctonia* و *Macrophomina* spp. نسبة 20% من الفطور المعزولة. وبين المسح أن أغلبية المزارعين يزرعون الحمص المحلي (72%) بينما زرع 19% منهم أصناف الحمص المحسنة. كما بينت الدراسة أيضاً أن ارتفاع معدل البذور والتبكير في موعد الزراعة يؤدي إلى زيادة معنوية في معدل ذبول الجذور ونسبة الإصابة. علاوة على ذلك، أظهرت الحقول التي زرعت بالحمص لسنوات متتالية معدلات مرتفعة من المرض، على عكس زراعة الحمص في دورة زراعية مع محاصيل أخرى. وبما أن منطقة الحمص في البلاد آخذة في الازدياد بسبب السوق الجاذبة، وزيادة الطلب على الاستهلاك المحلي للحمص وارتفاع اسعاره.، ينبغي تطوير أصناف مقاومة للأمراض و ذات معاملات فلاحية مناسبة للحد من آثار مرضي الذبول وتعفن الجذور.

كلمات مفتاحية: أصناف الحمص، العمليات الفلاحية، نظم الزراعة، أمراض فطرية.

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References

1. **Abdel-Monaim, M.F. and K.A.M. Abo-Elyousr.** 2012. Effect of preceding and intercropping crops on suppression of lentil damping-off and root rot disease in New Valley, Egypt. Crop Protection, 32: 41-46.
2. **Ahmed, S.K., M. Abang, M., Imtiaz and A. Nader.** 2015. Effect of Integrated management on Fusarium wilt progression and grain yield of chickpea in Syria, Archives of Agronomy and Soil Science, 61: 1551-1560.
3. **Ali, M.E.K.** 1996. A review of wilt and root-rot diseases of food legumes. Pages 153-168. In: Production and Improvement of Cool-Season Food Legumes in the Sudan. S.H. Salih, O.A. Ageeb, M.C. Saxena, M.B. Solh (eds.), Proceedings of the National Research Review Workshop, Agricultural Research Corporation, Sudan, International Center for Agricultural Research in the Dry Areas, Syria/Directorate General for International Cooperation, The Netherlands.
4. **Ali, M.E.K., S. Inanaga and Y. Sugimoto**. 2002. Sources of resistance to *Fusarium* wilt of chickpea in Sudan. Phytopathologia Mediterranea, 41:163-169.
5. **Belete, E., A. Ayalew and S. Ahmed.** 2013. Associations of biophysical factors with faba bean root rot (*Fusarium solani*) epidemics in the northeastern highlands of Ethiopia. Crop Protection, 52: 39-46.
6. **Bhatti, M.A and J.M. Kraft**. 1992. Influence of soil moisture on root rot and wilt of chickpea. Plant Disease, 76: 1259-1262.
7. **Elmobarak, A.A and F.M. Salih.** 2009. Strategic Priority in Soil Information Package for Better Land Care in East and Southern Africa. Tour Guide. Technical Bulletin, Wad Medani, Sudan. 54 pp.
8. **Faki, H.H., A.I. Sheikh Mohamed and M.E.K. Ali**. 1992. Adaptation of Chickpea in Sudan. Pages 155-169. In: Proceedings of the international workshop on adaptation of Chickpea in the WANA region. 9-12 November, 1992. ICARDA, Syria.
9. **FAOSTAT.** 2012. Food and Agricultural Organization Statistical Database. Rome: FAO (Food and Agricultural Organization) - available at www.faostat.org.
10. **Freigoun, S.O**. 1980. Annual Report of Hudieba Research Station, Agricultural Research Corporation, Sudan. 172 pp.
11. **Hamed, A.A. and K.H.M. Makkouk.** 2002. Occurrence and management of Chickpea chlorotic dwarf virus in chickpea fields in northern Sudan. Phytopathologia Mediterranea, 41: 193-198.
12. **Haware, M.P., Y.L. Nene, R.P.S. Pundir and J. Narayana.** 1992. Screening of world chickpea germplasm for resistance to Fusarium wilt. Field Crops Research, 30: 147-154.
13. **Hussein, M.M**. 1982. Major disease problems of faba bean in the Sudan. Pages 227-232. In: Faba Bean Improvement. G. Hawtin and C. Webb (eds.). Proceedings of the Faba bean Conference, Nile Valley Regional Program, 7-11 March 1981, Cairo, Egypt. Martinus Nijhoff Publishers, The Hague, The Netherlands.
14. **Ibrahim, O.H**. 1996. Review of chickpea agronomic studies. Pp. 87-95 *In:* Production and Improvement of Cool-Season Food Legumes in the Sudan (S.H. Salih, O.A. Ageeb, M.C. Saxena, M.B. Solh, Eds.), Proceedings of the National Research Review Workshop, Agricultural Research Corporation, Sudan/International Centerfor Agricultural Research in the Dry Areas, Syria/Directorate General for International Cooperation, The Netherlands.
15. **Jimenez-Díaz, R.M., P. Castillo, M.M. Jimenez-Gasco, B.B. Landa and J. A. Navas-Cortes.** 2015. Fusarium wilt of chickpeas: Biology, ecology and management. Crop Protection, 73: 16-27.
16. **Landa, B.B., J.A. Navas-Cortés and R. M. Jiménez-Díaz.** 2004. Integrated management of Fusarium wilt of chickpea with sowing date, host resistance, and biological control. Journal of Phytopathology, 94: 946-960.
17. **Mohamed, O.E., A. Hamwieh, S. Ahmed and N.E. Ahmed.** 2015. Genetic Variability of *Fusarium oxysporum* f. sp. *ciceris* Population Affecting Chickpea in the Sudan. Journal of Phytopathology, 163: 941-946.
18. **Naseri, B. and A. Marefat**. 2011. Large-scale assessment of agricultural practices affecting Fusarium root rot and common bean yield. European Journal of Plant Pathology, 131: 179-195.
19. **Navas-Cortés, J.A., B. Hau and R.M. Jiménez Díaz.** 1998. Effect of sowing date, host cultivar, and races of *Fusarium oxysporum* f. sp. *ciceris* on development of Fusarium wilt of chickpea. Journal of Phytopathology, 88: 1338-1346.
20. **Palta, J.A., A.S. Nandwal, S. Kumari and N.C. Turner.** 2005. Foliar nitrogen applications increase the seed yield and protein content in chickpea (*Cicer arietinum* L.) subject to terminal drought. Australian Journal of Agricultural Research, 56:105–112.
21. **Sharma, M., G. Raju and P. Suresh.** 2016. Dry root rot (*Rhizoctonia bataticola* (Taub.) Butler): an emerging disease of chickpea – where do we stand? Archives of Phytopathology and Plant Protection, 48: 1-16.
22. **Yadav, S.S., R. Redden, W. Chen and B. Sharma.** 2007. Chickpea in cropping systems. Pages 193-212. In: Chickpea Breeding and Management. A.F. Berrada, B.G. Shivakumar and N.T. Yaduraju (eds.). CABI, London. UK.

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