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Effect of Duration of Water-logging on Crop Stand and Yield of Sesame

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ABSTRACT: Sesame was grown for two successive Khari-1 seasons (2008-2009 and 2009-2010) at the research field of Irrigation and Water Management Division, BARI, Gazipur. Two varieties namely **BARI Til 2** and **BARI Til 3** were used as test crop. The aim of the study was to assess the physiological reaction and yield reduction of the two varieties to water logging stress. A significant response of the crop in respect of water logging and its duration was observed for both the varieties. Seed yields were rapidly decreased as duration of logging increased. The trend of decrease in yield and deterioration of crop stand with water-logging was almost similar for both the varieties. Maximum yield decreases of 51.67% and 58.24% for a continuous 36 hours of water logging were observed for BARI Til 2 and BARI Til 3, respectively. Significant effect of duration of water logging on other agronomic parameters of the two varieties was also observed in the study. So farmers are suggested to remove the standing water from the field as early as possible to avoid drastic yield loss from water logging.

KEYWORDS: Sesame, oil crop, water-logging, drainage, seed yield.

INTRODUCTION

Sesame (*Sesamum indicum*) is an important and ancient oil yielding crop. It is the second major oil seed crop in respect of area and production. Now-a-days, more emphasis has been given to develop new high yielding varieties with production technologies (Ahmed, 1994). The sesame seed is a rich source of edible oil. Its oil content generally varies from 42 to 45 percent (Hussain *et al* 2006). It is a rich source of protein, carbohydrate and mineral nutrients such as calcium and phosphorus.

Sesame is probably one of the most ancient oilseed crop known and used by man (Weiss, 1983). Sesame is grown as a rain fed crop in Bangladesh. The total area of production varies from one year to another, mainly due to fluctuation of rainfall and market value. Literature on the influence of soil moisture on the growth of sesame seem to be ambiguous, it is agreed that water logging is harmful. Sesame is very sensitive to excess moisture (Van Rheenen, 1973, Khidir, 1997). Hence, lack of proper drainage system caused major reduction in sesame yield in areas where rain water stands for long periods of time (Osman, 1985).

Sesame seed are unusually high in oil, around 50% at the seed weight, compared to 20% seed oil in soybeans and in protein (up to 25%). It is a fairly high value crop being harvested both for whole seed used in baking and for the cooking oil extracted from the seed (Amend *et. el*., 2009). Poor soil aeration associated with excessive moisture usually influences plants growth in a negative way (Boru *et al*., 2001). In waterlogged soils carbon dioxide, ethylene, manganese and iron may accumulate in concentrations potentially toxic to plants. However, oxygen deficiency is the most important cause of flooding injury (Kozolwski, 1984). In rainy and humid regions, sesame yield is limited by waterlogged soils resulting from excessive rainfall. Water logging commonly damages sesame during seedling establishment and generally it occurs due to poor drainage.

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Inadequate soil aeration affects photosynthesis and activities of metabolizing enzymes. The degree of stress on sesame in water logging soils depends on the crop stage, during of flooding, soil type, growth conditions and genotypes. Previously, some authors observed significant genotypic differences among wheat cultivars in response to flooding stress and suggested that trials associated with flooding tolerance are simply inherited. As an important economic crop, sesame has been cultivated for a long time. However, studies on the inheritance of water logging tolerance in sesame are also limited.

It is suitable to cultivate in a range of soil types, but performs best on well drained moderately texture soils of light to medium texture land neutral reaction. The crop is extremely sensitive to water logging even short periods of water logging will result in significant reductions in plant numbers and seed yield. Hence lack of proper drainage system caused major reduction in sesame yield in areas where rain water stands for long periods of time (Van Rheenen, H. A.1973, Khidir M.O.1997, Osman H. E. 1985). Sesame normally requires temperatures greater them 25^0C for rapid germination growth and flower formation, a temperature of less than 18^0C after emergence severely retards growth. Influence of soil moisture on the growth of sesame seems to be ambiguous. The crop is fairly drought tolerant and once established is capable of withstanding a higher degree of moisture stress then many field crops. The crop grown generally in areas that are too dry to ground nuts with rainfall ranging 300-600 mm (Ahmed and Mahmod, 2010).

Although a major world oilseed crop, sesame is primarily grown by small farmers in developing countries. Crop development programs in these countries are either small or nonexistent, and little progress has been made during the past 20 years. A revitalization of sesame research using modern plant breeding knowledge and new technology could be of great value in improving the crop. Amend *et al*., (2009) reported that sesame will perform best on fertile and well-drained soils. It is considered drought tolerant, due in part to an extensive root system. However, it requires adequate moisture for germination and early growth. Moisture levels before planting and flowering have the greatest impact on yield. Sesame is intolerant to water-logging. Rainfall late in the season prolongs growth and increases shattering losses. Sesame can provide some improvement in soil structure due to extensive rooting.

Usually there is no need to irrigate the crop but it is very susceptible to drought in respect of various physiological growth stages. Sesame grows best on well drained soil of moderate fertility. Damage of water logging is an important factor of yield loss in sesame. Good drainage is crucial as sesame is very susceptible to short periods of water logging (Bennet, 1995). The crop requires about 50 cm of water during the entire growing period. It is considered essential to irrigate at or just after maximum flowering in order that capsules may develop fully. Sesame is extremely susceptible to water logging and heavy continuous rain. Considering the importance of proper drainage of sesame cultivation, the study was undertaken with the objectives: (i) to investigate the impact of different water logging durations on the growth of sesame cultivars and (ii) to assess the yield loss by different levels of water logging.

MATERIALS AND METHODS

The study was conducted during the 'Kharif 1' seasons of 200-2009 and 2009-2010 years at the experimental field of Irrigation and Water Management Division, BARI, Gazipur, Bangladesh. The experiments on sesame (cv. BARI Til-2 and BARI Til-3) were laid out with three replications. Water logging was imposed at two stages. The stages were vegetative (25-30 days after sowing) and flowering (55-60 days after sowing) stages. The water logging sequence contained four treatments. The experimental set-up was as below.

V_1: BARI Til-2
V_2: BARI Til-3

T_1: Normal drainage practice (flat land drainage)
T_2: Continuous water logging up to 12 hours
T_3: Continuous water logging up to 24 hours
T_4: Continuous water logging up to 36 hours

Sesame seeds were sown continuously on lines with a spacing of 30 cm. The unit plot size was 4 m × 4 m. The fertilizer application rates were N_{125} P_{150} K_{50} S_{100} Zn_{45}. Half of N in the form of urea and full of P, K, S and Zn in the form of TSP, MP, Gypsum and Zinc sulphate were applied during final land preparation. The remaining half of N was top dressed at 30 days after sowing. After plant establishment, excess seedlings were taken off keeping approximate plant to plant spacing of 5 cm. An irrigation was applied at 20 DAS in general to all plots for proper plant establishment and to avoid probable water stress during the drought period. Water logging was imposed as per schedule at 30 and 60 days after sowing. The crop was harvested during the first week of July each year. All necessary agronomic data were collected and analyzed statistically.

RESULTS AND DISCUSSION

The results on the effect of duration of water logging on the two sesame varieties (BARI till 2 and BARI till 3) during the 2008-2009 cropping season are presented in Table 1. Among agronomic parameters plant height was found more susceptible to water logging.

Table 1 Yield and yield contributing parameters of sesame as affected by water logging during 2008-2009.

Treatment	Plant population #/m^2	Plant height (cm)	Branches/plant	Pods/plant	1000-seed wt. (gm)	Yield kg/ha	Percent decrease over control %
V_1T_1	65	138.00a	5.2 a	31.1a	1.81	1383a	-
V_1T_2	63	114.6bcd	4.8ab	29.2ab	1.63	1048b	24.22
V_1T_3	69	108.7bcd	3.6ab	28.6ab	1.73	857bc	38.03
V_1T_4	66	105.5cd	5.1ab	24.9ab	1.60	838bc	39.41
V_2T_1	66	121.8b	5.0ab	29.4ab	2.50	1389a	-
V_2T_2	67	110.6bcd	4.5ab	28.3ab	2.33	992b	28.58
V_2T_3	62	117.6bc	3.4b	22.3ab	2.33	749bc	46.08
V_2T_4	68	101.4d	3.4ab	17.6b	2.60	650c	53.20
CV (%)	17.83	6.87	12.6	17.22	15.86	18.44	
LSD (0.05)	-	13.81	1.73	12.59	-	319.1	-

As the duration of water logging increased, plant height got more affected. A severe in yield was observed due to water logging in case of both varieties. The rate of yield loss was rapidly increased with the increase of duration of logging. During the first year's study, maximum 39.41 % and 53.20 % of yield in comparison to the control treatment (normal drainage) were lost in case of varieties V_1 and V_2, respectively (Table 1). Based on the first year's result, BARI Til 3 was found more susceptible to water logging in comparison to the BARI till 2.

Relationship of yield versus duration of water logging in respect of different treatment and varieties is graphically shown in Figure 1**.** As observed in Figure 1, yield of both the varieties rapidly decreased with the duration of water logging. Although the trend of yield loss for both the varieties is similar, but comparatively steeper line of the variety V_2 indicates its more susceptibility to water logging.

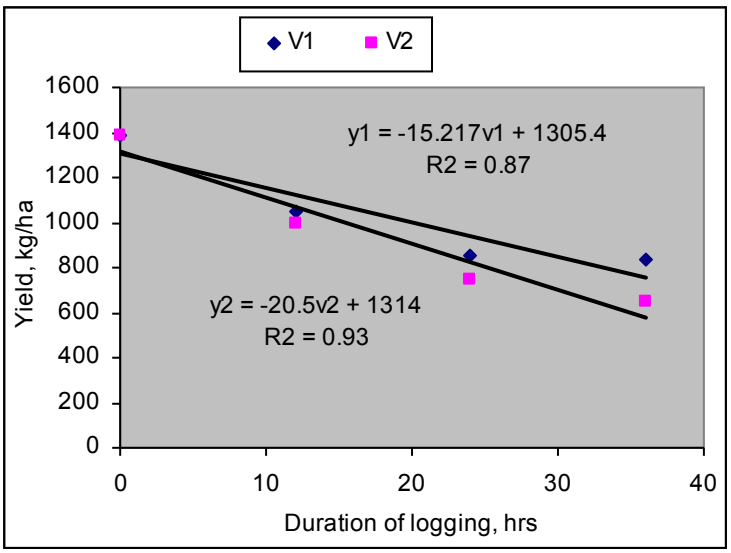

Figure 1 Relationship between yield and duration of water logging during the year 2008-2009.

The results on the effect of duration of water logging on the two sesame varieties during the 2009-2010 cropping season are summarized in Table 2. During the second year's study, all the agronomic parameters differed significantly among the treatments. As the duration of water logging increases, those parameters also got more affected.

A drastic decrease in respect of yield was observed due to water logging in case of both varieties. The rate of yield loss was rapidly increased with the increase of duration of logging. Maximum 67.67 % and 65.61 % of yield loss in comparison to the control treatment (normal drainage) were observed in case of varieties V_1 and V_2, respectively (Table 2). This results also show that, the variety V_1 (BARI Til 2) and V_2 (BARI Til 3) are almost equally susceptible to water logging. However, it was also observed that variety V_1 was more susceptible short duration logging than variety V_2. More than 47% yield loss was occurred in case of variety V_1 only for 12 hours continuous logging at the two stages. Variety V_2 is rather resistant to short duration logging than variety V_1. It lost about 31% yield for 12 hours logging (Table 2).

Table 2 Yield and yield contributing parameters of sesame as affected by water logging during 2009-2010.

Treatment	Plant population (#/m^2)	Plant height (cm)	Branches/plant	Pods/Plant	Seeds/pod	1000-seed wt. (gm)	Yield kg/ha	Percent decrease over T_1 (%)
V_1T_1	68.3bc	122.3a	4.10a	50.2b	53.5a	4.08a	1065a	-
V_1T_2	73.3abc	110.7ab	3.40abc	35.8c	48.1bc	3.69ab	560bc	47.42
V_1T_3	68.0c	100.7bc	2.73bc	26.3def	43.9cd	3.33bc	495cd	53.52
V_1T_4	74.3abc	99.0bc	2.50c	22.3f	39.7d	2.98cd	344d	67.70
V_2T_1	76.3ab	122.0a	4.33a	66.9a	54.1a	3.18bcd	977a	-
V_2T_2	73.3abc	98.0bc	3.57ab	32.3cd	49.0ab	2.92cd	675b	30.91
V_2T_3	73.3abc	97.0c	3.40abc	30.6cde	44.2bcd	2.90cd	406cd	58.44
V_2T_4	78.7a	91.3c	2.80bc	23.6ef	41.5d	2.68d	336d	65.61
CV (%)	6.41	6.90	16.80	12.61	6.29	11.40	15.05	
LSD (0.05)	8.25	12.71	0.986	7.95	5.15	0.64	160.1	

Relationship between yield and duration of water logging of the two sesame varieties is graphically shown in Figure 2. As observed in the figure, yield of both the varieties rapidly decreased with the duration of water logging. The trend of yield loss for both the varieties is almost similar and a very little difference was observed in the two response functions as shown in Figure 2. From the two functions, it may be predicted that, if about 50 hours' continuous water logging is imposed at the two stages, the crop will be totally damaged.

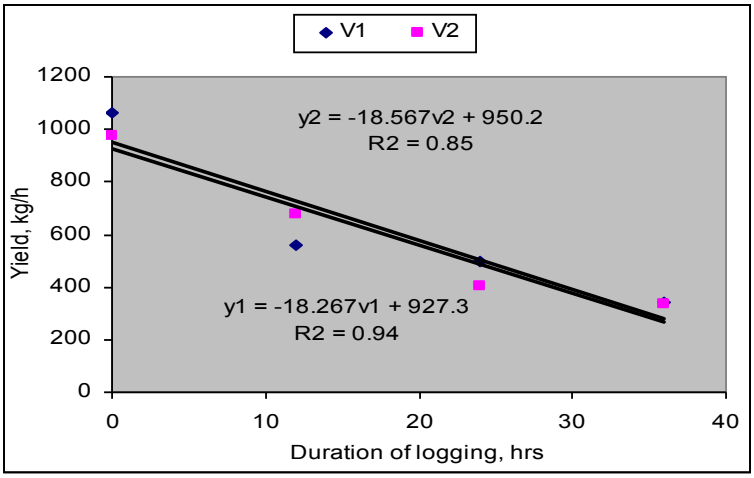

Figure 2 Relationship between yield and duration of water logging during the year 2009-2010.

The combined results on the effect of duration of water logging on the two sesame varieties are summarized in Table 3. Except 1000-grain weight, all important agronomic parameters differed significantly to water logging. As the duration of water logging increased, those attributes also got more affected.

Table 3. Yield and yield contributing parameters of sesame as affected by water logging during 2007-2008 and 2008-2009

Treatment	Plant population (#/m^2)	Plant height (cm)	Branches/plant	Pods/plant	Seeds/pod	1000-seed wt. (gm)	Yield kg/ha	Percent decrease over T_1 (%)
V_1T_1	68.3b	130.2a	4.65a	40.7ab	53.1ab	3.007	1225a	-
V_1T_2	75.3ab	112.7bc	4.12ab	32.5bc	48.0bc	2.663	804b	34.69
V_1T_3	68.0b	104.8cd	3.17b	27.5cd	43.9cd	2.383	676bc	44.82
V_1T_4	74.3ab	102.3cd	3.82ab	23.6cd	39.3d	2.290	592cd	51.67
V_2T_1	93.0a	121.8ab	4.67a	48.1a	54.1a	2.838	1183a	-
V_2T_2	91.7a	104.3cd	4.02ab	30.2bcd	48.5bc	2.628	835b	29.42
V_2T_3	78.3a	107.3c	3.40ab	26.4cd	44.0cd	2.615	578cd	51.14
V_2T_4	92.0a	96.3d	3.13b	20.6d	41.25d	2.640	494d	58.24
CV (%)	14.27	6.89	20.83	19.27	6.69	16.65	11.73	
LSD (0.05)	20.03	13.28	1.412	10.52	5.443	NS	166	

Yield of both varieties was decreased drastically due to water logging. The rate of yield loss was rapidly increased with the increase of duration of logging. As much as 67.67 % and 65.61 % of total yield in comparison to the control treatment (normal drainage) were observed in case of varieties V_1 and V_2, respectively (Table 3). This results also show that, the variety V_1 (BARI Til 2) and V_2 (BARI Til 3) are almost equally susceptible to water logging. However, it was also observed that variety V_1 was comparatively less susceptible to water logging than variety V_2. However, for short duration of logging variety V_1 was found slightly more susceptible than variety V_2. More than 34% yield loss was occurred in case of variety V_1 only for 12 hours continuous logging at two stages. Variety V_2 is rather resistant to short duration logging than variety V_1. It lost about 29% yield for 12 hours logging.

Combined relationship of two years' study between yield and duration of water logging of the two varieties is graphically shown in Figure 3. Yield of both varieties rapidly decreased with the duration of water logging. As shown in the graph, the trend of yield loss for both the varieties is almost similar. A very little difference was observed in the two response functions as shown in Figure 3 From the two functions, it may be predicted that, if about **50** hours' continuous water logging is imposed at the two stages, the crop will be totally damaged.

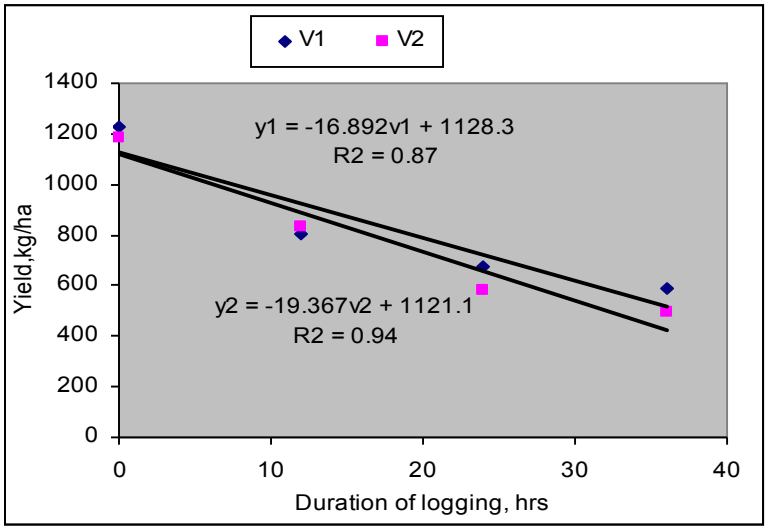

Figure 3 Relationship between yield and duration of water logging during the two study years.

CONCLUSION

Proper drainage is vitally important for almost all upland crops. Sesame is a crop which is exceptionally susceptible to water logging. With a proper management, more than 1200 kg/ha yield of sesame can be obtained. Both the varieties (BARI Til 2 and BARI Til 3) were found very much sensitive to water logging. A reasonable yield may be lost even due to a logging of only 12 hours of water logging. From the results presented here, it was observed that as much as 51.67 percent and 58.24 percent of yields of the two varieties in comparison to that of the well managed treatment were lost for a continuous logging of 36 hours at two (vegetative and flowering) stages. To avoid a severe decrease in yield of sesame due to water logging, standing water from the sesame field must be removed as early as possible.

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