Effects of water stress on yield and some yield components of three selected oil crops; Groundnut (*Arachis hypogea L.*), Sunflower (Helianthus annus L.) and Sesame (*Sesamum indicum L.*)

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Abstract- Groundnut variety Tissa (*Arachis hypogea* L.), Sunflower variety Terkey (*Helianthus annus* L.) and Sesame variety MI3 (*Sesamum indicum* L.) are sensitive to both excessive and deficit water which leads to decrease yield. We studied the growth and reproduction of above oil crops due to 10 day water stress at different growth stages; vegetative (T2), flowering (T3) and at maturity (T4). The study consisted with a control (T1), with daily water supply throughout all growth stages. Experiments were arranged in Complete Randomized Design (CRD) with five replicates and the experiment was repeated two times.

All measured characters; Plant shoot length, Plant root length, Seed weight, Number of flowers and head diameter of flowers were significantly affected by the water stress. Results showed that water stress was highly significant for seed yield and Biological yield. The highest seed yield was obtained in T1 Groundnut (14.1g/plant), Sunflower (9.79g /plant) and Sesame (9.5g/plant) whereas least seed yield belonged in T3 Groundnut (1.9g/plant), Sunflower 5.75g/plant) and Sesame (3.4g/plant). The mean root length was significantly higher in T2 Groundnut (27.58cm), Sunflower (19 cm) and Sesame (14.5cm) compare to all other treatments. Water stress at vegetative stage induced early flowering than other treatments. The highest shoot length Groundnut (80.15cm), Sunflower (163cm) and Sesame (130cm) was recorded in control whereas least height was recorded in T2 Groundnut (54.1cm), Sunflower (130cm) and Sesame (84cm). Water stress at vegetative stage in Sunflower was significantly increased the number of flowers (8.4 flowers/plant) comparing to the water stress at flowering stage (2.4 flowers/plant) which observed with least number of flowers. Furthermore in Sunflower water stress at flowering stage significantly affected to reduce the head diameter of flowers (11.2cm) and highest head diameter (17.9cm) was recorded in control compared to all other treatments. Finally we confirm that water stress at different growth stages; vegetative, flowering and maturity stage significantly affected to the growth and reproduction of Groundnut, Sunflower and Sesame. Our results indicated that drought at flowering stage should be avoided to increase seed yield of Groundnut, Sunflower and Sesame.

Index Terms- Groundnut (Arachis hypogea L.), Sunflower (Helianthus annus L.), Sesame (Sesamum indicum L.), water stress, vegetative stage, flowering stage, maturity stage

I. INTRODUCTION

Groundnut (*Arachis hypogea* L; Fabaceae**),** Sunflower (*Helianthus annus* L; Asteraceae) and Sesame (*Sesamum indicum* L. Pedaliaceae) are some major oilseed crop in the world. They are cultivated in highlands under rain fed condition in Maha season and in paddy lands under irrigation during yala season in dry and intermediate zones of Sri Lanka.

The main objective in agriculture production, so far, focused mostly on the increasing of yield and production (Ulusoy, E. 2001). Water stress may be more severe at certain growth stages and if this is known, planting can be timed on the basis of weather forecast. This is important in determining the priority of water supply to the plants during the growing season.

Trung B.C *et al* 1985 found that both mung bean and adzuki bean maintained relatively high yield even under severe water stress whereas for groundnut yield was reduced. The water deficit conditions during the Sunflower growing season, adversely affect its vegetative as well as reproductive growth in addition to deterioration the quality of its oil content (Jones,1984). Drought stress during the yield formation period of sunflower reduced yields when compared to full irrigation but the reduction was much less than when stress occurred during flowering period (Stone *et al*, 1996; Tolga and Lokman, 2003). Sunflower is the most susceptible to soil water deficiency at flowering, fertilization and grain fill, whereas at the start and end of the growing period the sensitivity is not so evident (Jana *et al*, 1982; Unger,1986; Stone *et al*, 1996; Erdem and Delibas, 2002). Hong *et al* (1985) indicated that drought stress during vegetative growth reduced seed yield of sesame from 8.5 to 4.3 t ha^{-1}.

Water deficit elicits several morphological responses in crop plants (Jones HG, 2004). Most of these responses are adaptive mechanisms to withstand water deficit or drought and to ensure both survival and reproduction under conditions of water deficit stress. There are three main aspects of plant morphological behaviour in relation to drought: the modulation of root growth (Jackson RB *et al*, 2000), the modulation of leaf size and changes in leaf orientation (Chaves *et al* 2003). A fundamental problem with these adaptive responses is that most are aimed at reducing water use and consequently affect plant function and productivity through reduction in photosynthesis (Ribaut J, 2006).

Little or no literature are available on morphological responses of groundnut variety Tissa, Sunflower variety Terkey and Sesame variety MI3 to short periods of water stress imposed

at different growth and development stages or on the recuperative ability of the species from drought stress. Information on the response pattern of morphological traits to drought imposed at different growth stages might provide a basis for development of strategies to stabilize yields of Groundnut, Sunflower and Sesame in semi- arid environments. Therefore, the objective of this study was to evaluate the effect of water stress imposed at different developmental stages on morphological traits and yield of Groundnut, Sunflower and Sesame.

II. MATERIALS AND METHODS

Experiment was carried out in a research field of faculty of Agriculture, University of Ruhuna, Mapalana, Kamburupitiya, Sri Lanka in 2012. It belongs to Low country wet zone (WL_2); the average annual rainfall, temperature and relative humidity (during the growing season) were >1900 mm, 27.5^{0}C and 72% respectively. Some selected oil crops; Groundnut variety Tissa, Sunflower variety Terkey and Sesame variety MI3 were used as the test varieties.

Nursery media was sterilized by fungicide (Bathione) to prevent pests and diseases incidence. Seeds were germinated in plastic pots (1.5 ft^3) containing coir dust/topsoil/cow dung/compost (1:1:1:1) under greenhouse condition for 3 weeks. Thinning was done to maintain two plants per each pot until harvest. Basal dressing for Groundnut (35 kg/ha Urea, 100 kg/ha TSP and 75 kg/ha MOP and 30 kg/ha of urea at 4 weeks after planting), Sunflower (60 kg/ha Urea, 40 kg/ha TSP, 60 kg/ha MOP) and Sesame ((50 kg/ha Urea, 120 kg/ha TSP, 60 kg/ha MOP and Top dressing Urea 60 kg/ha was applied at 4 weeks after planting) was applied before sowing of seeds on pots/beds according to the recommended by the Department of Agriculture, Sri Lanka.

There were four treatments arranged in Complete Randomized Design (CRD) with five replicates. Experiment was repeated twice. The control (T_1) was full irrigated daily at all growth stages. The other treatments were; water stress at vegetative growth stage (T_2), water stress at flowering stage (T_3), water stress at maturity stage (T_4). Soil water content was measured before giving the water stress at vegetative stage (80%) and at the end of the vegetative stage (60%). That water percentage difference (20%) maintain in other two stages flowering and maturity. It was observed approximately 10 days and then water cut/stress was done for 10 days period in each stage. After that plants were continuously re-watered until collect the yield. Other all management practices had practiced to the plants according to the recommendations of Department of Agriculture, Sri Lanka. After maturity stage plants from each pot were harvested and measured plant height (shoot length and root length), number of pods/flowers per plant, wet and dry weight of seeds for each treatment at each replicate.

Analysis of variance was carried out with the use of Statistical Analysis Systems (SAS version 9.2) software and Duncan's multiple range tests were applied to compare the treatment means.

III. RESULTS AND DISCUSSION

In present study water stress at three different growth stages; vegetative, flowering, mature and the control; continuously watered one time in each day during every growth stages, were used to examine the effects of drought stress on Groundnut variety Tissa (*Arachis hypogea* L.), Sunflower variety Terkey (*Helianthus annus*L.) and Sesame variety MI3 (*Sesamum indicum* L) (Fig. 1). Six different parameters were measured and analysis of variance show traits influenced water stress significantly at different growth stages.

Water stress had a highly significant impact on seed yield and biological yield. The highest seed yield was obtained by T1 Groundnut (14.1g/plant), Sunflower (9.79 g /plant) and Sesame (9.5 g/plant) whereas least seed yield belonged in T3 Groundnut (1.9g/plant), Sunflower 5.75g/plant) and Sesame (3.4g/plant) (Table 1a,b,c) (Fig. 2a,b,c). It seems that Groundnut, Sunflower and Sesame are very sensitive for water stress conditions resulting decreases of yield. Effect of water stress on number of pods per plant was highly significant. The highest number of pods per plant was obtained in T1 Groundnut (12/plant), Sesame (17.9/plant) and the least number of pods per plant was obtained in T3 Groundnut (5.2 /plant) and Sesame (11.2/plant) (Fig. 2a,c). Water stress in Groundnut during flowering period may have resulted in death of pegs before pod initiation. After re-watering, the plants resumed flowering reaching physiological maturity with small pods without mature seeds. Plants stressed during maturity stage had a higher number of seeds per plant compared to other stressed treatments. The plants stressed during the vegetative stage also reduced pod number and seed yield. The reduction in seed yield agrees with previous findings on legumes under water stress such as black beans (Nielson *et al*, 1998); faba beans and bambara groundnuts (Mwale SS *et al*, 2007, European Union FP-5 INCO-DC, 2002) and cereals like oats (Sandha BS *et al*, 1977) and maize (Kamara AY *et al*, 2003).

The mean root length was significantly higher in T2 Groundnut (27.58cm), Sunflower (19cm) and Sesame (14.5cm) compare to all other treatments (Table 1a,b,c). The reason is when water stress at vegetative stage roots may induce and penetrate the deep soil to absorb much water. Water stress at vegetative stage induced flowering little earlier than other treatments.

There was a significant difference between control plants and water stressed plants for average shoot length and plant height (Table 1a,b,c). The highest shoot length Groundnut (80.15cm), Sunflower (163cm) and Sesame (130cm) was recorded in control whereas least height was recorded in T2 Groundnut (54.1cm), Sunflower (130cm) and Sesame (84cm). Same results were observed Riahi (2003) in his experiment on sunflower, Cotton, bean and maize. Higher plant height was obtained from higher irrigation frequency; meaningful irrigation applied at all growth stages (Kaya and Kolsarici, 2011). Water stress reduced plant height in plants stressed during the vegetative and flowering stages. This was attributed to reduction of stem and leaf expansion. Water deficit did not affect plant height during the maturity stage because the plants had ceased growing vegetatively by this time. After re-watering, the plants stressed during the vegetative and flowering stage increased in plant height. This may be attributed to resumption of stem cell division and elongation plus leaf expansion.

In Sunflower plants water stress at vegetative stage was significantly increased the number of flowers (8.4 flowers/plant) comparing to the water stress at flowering stage (2.4 flowers/plant) which observed least number of flowers. Furthermore in Sunflower water stress at flowering stage significantly affected to reduce the head diameter of flowers (11.2cm) and highest head diameter (17.9cm) was recorded in control compared to all other treatments (Fig3).

IV. CONCLUSIONS

Water stress at flowering stage was observed as a limiting factor for plant height, number of pods per plant, number of flowers per plant, head diameter of the flower and seed weight per plant which caused to significant reduction of seed yield in Groundnut variety Tissa, Sunflower variety Terkey and Sesame variety MI3.

Plant root length is increased when water stress at early vegetative stage, vegetative stage is comparatively drought tolerant than other growth stages.

Water stress at vegetative stage induces early flowering but not increases the final yield.

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TABLE 1a: Effect of water stress on different parameters at different growth stages of Ground nut plant.

	Shoot Length (cm)	Root Length (cm)	Number of pods per plant	Wet weight of pods per plant (g)	Wet weight of seeds per plant (g)	Dry weight of seeds per plant (g)
T1	80.15 a	21.05 b	12.0 a	21.74 a	15.24 a	14.1 a
T2	54.10 b	27.58 a	9.7 b	13.36 b	8.03 b	7.0 b
T3	59.80 b	17.06 b	5.2 c	8.52 c	3.1 0c	1.9 c
T4	75.06 a	20.55 b	7.2 b	15.58 b	9.45 b	8.2 b

TABLE 1b: Effect of water stress on different parameters at different growth stages of Sunflower.

	Shoot Length (cm)	Root Length (cm)	Number of flowers per plant	Average head diameter of flower (cm)	Wet weight seed of per plant (g)	Dry weight of seeds per plant (g)
T1	163 a	13 b	5.4 b	17.9 a	9.79 a	6.8 a
T2	130 b	19 a	8.4 a	17.5 a	7.5 a	4.9 a
T3	129 b	13.5 ab	2.4 c	11.2 b	5.75 b	3.2 b
T4	140 b	12 b	5.0 b	16 a	6.4 ab	4.2 ab

TABLE 1c: Effect of water stress on different parameters at different growth stages of. Sesame plant.

	Shoot Length (cm)	Root Length (cm)	Number of pods per plant	Wet weight of pods per plant (g)	Dry seed weight per plant (g)
T1	130.5a	11.0 b	48.4 a	9.5 a	8.7 a
T2	113.2 a	14.5 a	28.0 b	7.4 b	6.6 b
T3	84.0 b	9.3 b	14.2 c	3.4 d	2.7 c
T4	110.6 a	11.0 b	33.0 b	6.3 c	5.7 b

Note: Column values followed by the same letter are not significantly different as determined by Duncan's multiple range test (P=0.05).Values in same column with same letter denoted non- significant difference

Fig. 1 Field layout a. Groundnut b. Sunflower c. Sesame

a b

Fig. 2 (a) Pods of groundnut per plant (b) Seeds per plant in each treatment.

a b

Fig. 2 (b) Seeds of Sunflower per plant (b) Seed filling of sunflower under water stress condition

a b

Fig. 2 (c) Number of pods of Sesame per plant (b) Number of seeds per replicate

Fig. 3 Head diameter of Sunflower flowers