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AGRONOMIC RESPONSE OF SUNFLOWER TO WATERLOGGING

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Introduction

Sunflower (*Helianthus annuus* L.) is one of the most important oilseed crops of the world and adapts well to areas where corn production is successful. It is a well-known drought tolerant crop and is grown in Thailand after corn at the end of rainy season. Sunflower may be also planted as a sequential crop after rice in the paddy field in the dry season during February and June, especially where irrigation is possible. However, waterlogging in the paddy field due to poor drainage of irrigated water or early rain may damage the crop.

Waterlogging was found to adversely affect many field crops such as groundnut (Laosuwan and Anuchan, 1990), mungbean (Laosuwan et al., 1994), soybean (Laosuwan and Thongsomsri,1995), cowpea (Minchin and Summerfield, 1976) and wheat (Huang et al., 1997). Waterlogging resulted in the reduction in the uptake of oxygen and certain nutrients from the soil (Sherard and Leyshon, 1976; Armstrong, 1978). Decrease in soil O_2 content at the root zone can reduce root and shoot growth and final yield of various plant species (Drew, 1991). The accumulation of methane, hydrogen sulfide and carbon dioxide causing root damage or reduction of root elongation is a common symptom (Grable and Danielson, 1965; Hiron and Wright, 1973; Sachs et al., 1980). Oxygen deficiency or hypoxia was found to enhance root ethylene production which hastened the production of crown roots (Huang et al., 1997).

The present study was conducted to determine to effect of waterlogging on the growth, development and yield of sunflower at different durations stages of growth.

Material and Methods

Sunflower hybrid variety Pacific 33 (Hysun 33) was used in this study based on its popularity among farmers. This study was a pot experiment which was conducted and laid out in a split-plot design in four replications. The growth stages of 5, 15, 25, 35 and 45 days after emergence were the main-plots and durations of waterlogging of 0, 3, 6, 9, 12 and 15 days after emergence (DAE) were the sub-plots. The same amount of soils was filled in each pot and fertilizer at the rate 45 kg ha^{-1}N, P_2O_5 and K_2O was applied at planting. Three sunflower seeds were planted in each pot and was thinned to only one plant pot^{-1} five days after emergence. Pots of each treatment (stage of growth) were put into the styrofoam box and the water was filled in each box to have an equal level of about 2 cm above the ground level in each pot. This level was maintained throughout the experiment. After immersing in the water, four pots (4 replications) for each sub-plot were taken from the water on the due dates and put on a plastic sheet to prevent rooting. Characters measured were plant height,

days to first anthesis, head diameter, seed yield and seed size. Plant height was measured at harvest from the ground level to the head.

Results and Discussion

Waterlogging effects were observed on sunflower growth, development, yield and yield components. The results will be presented as follows:

1. Effects on days to anthesis

Table 1 shows number of days to anthesis of sunflower receiving waterlogging at different durations and stages of growth. Waterlogging at the early stages of growth at 5, 15 and 25 DAE treatment resulted in the delay of the anthesis of sunflower to a certain extent. The delay of 15 DAE was as late as 22 days relative to control if the crop was in the water for 15 days. This was due to the effect of waterlogging on growth of the affected plants. Similar effect was found in waterlogging oilseed rape (Cannell and Belford, 1980)

2. Effect on plant height

The effect of waterlogging on plant height was not found except those exposed to waterlogging at 25 days (Table 2). However, waterlogging at 5 and 15 days reduced plant height, but the plant resumed the normal growth and development soon after removing from the water. At 25 days after planting, the plant was permanently affected and unable to attain normal height. Orchard and Jessop (1984 cited by Laosuwan et al., 1994) found that at the 6-leaf stage waterlogged sunflower tended to reduce stem extension, but, at maturity, this was only evident in the plants waterlogged for 9 days. In contrast, in some stages, the plants grew faster at later stages of growth such that final plant height was increased relative to non-waterlogging controls.

3. Yield components

All waterlogged treatments caused a reduction of head size and seed weight of sunflower although this was most evident for head size at the high durations (Tables 3 and 4). Seed weight of waterlogged sunflower at 5 DAE was not affected as the plant was removed from the water before anthesis. Orchard and Jessob (1984) found that the effect on seed size of sunflower waterlogged at 6-leaf stage was not clear but strong evidence was observed at bud initiation and anthesis stages.

4. Seed Yield

Waterlogging adversely affected seed yield of sunflower in most durations and stages of growth. The effect was very serious at the durations higher then 3 days (Table 5). This effect was due to the reduction of head size, seed size and increase of barren seeds. There was quite a good relation between duration of waterlogging and subsequent effect on seed yield at all stages of growth. Similar effects were found in most crops affected by waterlogging such as groundnut (Laosuwan and Anuchan, 1990), mungbeans (Laosuwan et al., 1994), soybean (Laosuwan and Thongsomsri,1995).

5. Effect on root

Waterlogged treatments at the early stage of growth (5-15 days), particularly at high durations (6 days or more) killed most lateral root of the crops. This root was replaced by the development of adventitious root, which were very profused. However, at the late stage of

growth, the affected root were permanently damaged and there was no root development to replace damaged rooting system after removal from the water.

Conclusion

The results from this experiment show that sunflower, which usually planted in the upland area, when grown in low land or waterlogged prone area are easily affected and required proper management. The plant was stunted, the root was damaged and the development was retarded. All these effects were subsequently found in low seed yield, seed size and head size. However, the crop may withstand waterlogging at the durations lower than 6 days at which the lateral root was not seriously damaged. If sunflower is planted as second crop after rice, ridging of seed base may be necessary.

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Table 1. Number of days to anthesis of sunflower exposed to waterlogging at different stages of growth and duration.

Duration of	Days after emergnce[1]				
waterlogging	5	15	25	35	45
(days)	----------	----------	(no.)	----------	----------
Control	47 c	47 c	47 b	47	47
3	47 c	52 bc	49 ab	47	47
6	49 b	55 b	51 a	46	47
9	52 b	56 b	52 a	48	47
12	56 a	66 a	53 a	47	48
15	59 a	69 a	54 a	47	48
CV(%)	3.10	4.70	5.80	1.40	1.40

(1) Means in a column followed by different letters are significantly different at 0.05 level of probability

Table 2. Means of plant height.

Duration of	Days after planting[1]				
waterlogging	5	15	25	35	45
(days)	----------	----------	(cm)	----------	----------
Control	122	123	123 a	123	123
3	122	123	125 a	126	128
6	124	122	76 b	130	128
9	125	116	83 b	128	136
12	125	120	79 b	122	124
15	124	121	56 c	126	123
CV(%)	5.8	6.5	6.6	6.8	5.4

[1]Means in a column followed by different letters are significantly different at 0.05 level of probability.

Table 3. Means of head diameter.

Duration of	Days after emergence[1]				
waterlogging	5	15	25	35	45
(days)	----------	----------	(cm)	----------	----------
Control	17 a	17 a	17 a	17 a	17 a
3	15 b	13 b	14 b	14 b	13 b
6	15 b	9 c	13 b	13 b	13 b
9	14 b	10 c	11 bc	12 bc	11 b
12	12 c	8 d	8c	9 c	11 b
15	10 c	8 d	8c	9 c	*
CV(%)	11.80	10.80	8.40	8.60	11.90

[1]Means in a column followed by different letters are significantly different at 0.05 level of probability.

* Treated plants died before harvest

Table 4. Means of seed size

Duration of	Days after emergence[1]				
waterlogging	5	15	25	35	45
(days)	----------	----------	(g/100 seed)	----------	----------
Control	4.79	4.90 a	4.90 a	4.90 a	4.90 a
3	4.65	4.74 a	4.25 b	4.25 ab	4.07 b
6	4.94	4.08 ab	4.16 b	4.07 ab	3.91 b
9	4.69	3.86 ab	3.18 c	3.66 b	4.14 b
12	4.71	3.91 ab	3.42 c	3.10 b	4.20 ab
15	4.70	3.17 b	*	*	*
CV(%)	13.20	17.90	8.49	15.40	11.10

[1]Means in a column followed by different letters are significantly different at 0.05 level of probability.

* Treated plants died before harvest

Table 5. Means of seed yield

Duration of	Days after emergence[1]				
waterlogging	5	15	25	35	45
(days)	----------	----------	(g/head)	----------	----------
Control	35.88 a	35.72 a	35.72 a	35.72 a	35.72 a
3	37.56 a	23.14 b	25.78 b	22.67 b	26.19 b
6	27.09 b	17.89 bc	22.24 b	21.70 b	22.69 b
9	25.32 b	16.16 bc	19.80 b	19.65 b	19.45 b
12	22.90 b	13.37 c	17.07 b	16.64 b	18.86 b
15	18.91 c	15.20 c	*	*	*
CV(%)	18.80	19.70	17.60	35.10	23.00

[1]Means in a column followed by different letters are significantly different at 0.05 level of probability.

* Treated plants died before harvest