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THE DYNAMICS OF SESAME (*Sesamum indicum* L.) GROWTH TYPE

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ABSTRACT

(*Sesamum indicum* L.) is one of important vegetable oil crops in the world. Indonesian local sesame cultivars in use today still have indeterminate growth types that cause simultaneous harvest, narrow adaptability and lower yield. Stage of the research is to see dynamics growth type of sesame due to environmental change and to find morphological and biochemical selection criteria of determinate growth cultivar. This study uses a factorial completely randomized design consisting of three replications. The first factor is six cultivars of sesame, two types of determinate growth type cultivar introduced from Turkey III Det 23, III Det 36 and four indeterminate growth type cultivars Sbr 3, Sbr 4, white local and black local. The second factor is six environments that combine various combinations of temperature and several concentrations of NaCl as salinity stress. The results showed that the environment combined heat stress temperature and salinity affect growth type of sesame. Heat stress makes longer vegetative phase and salinity stress causes black local genotype changed to determinate growth type. III det 23 and III det 36 were considered as stable determinate cultivar and best used as a parent crossing in sesame breeding program.

Key words: *sesame, growth type, temperature, salinity*

INTRODUCTION

The sesame (*Sesamum indicum* L.) plant is one of important vegetable oil crops in the world. Sesame seeds contain 35-75% oil, 19-25% water, fiber and ash. Sesame consumption tends to increase due to the health benefits (Barnejee and Kole, 2010). Sesame as a source of vegetable oil is still considered low yield (Sanwar and Haq, 2006). According to Sumathi and Murhidharan (2010), sesame with indeterminate growth type have a narrow adaptability and difference maturity pods. Flowering growth of indeterminate sesame can reach 2 months continuously causing pods age variations (Day, 2000). Earlier harvest will produce low quality seeds while the

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late harvest reduces grain yield due to pods burst (Cagirgan, 2006). One way to overcome these problems is to develop improve cultivars of sesame which have a determinate type, a stability of yield and wide adaptability to environment. Uzun and Cagirgan (2006) managed to assemble determinate type sesame cultivars with mutation techniques.

Performance of plants are affected by genetic background and cultivated environment (Falconer and Mackay, 1996). Abiotic stresses, such as drought, salinity, extreme temperatures, chemical toxicity, and oxidative stress are serious threat to agriculture and the environment. Abiotic stresses can change the conditions of morphology, physiology, biochemistry and molecular plant (Wang et al., 2003). Langham (2007) reported that sesame has determinate and indeterminate growth type, these growth type stability of some cultivar is affected by environmental change. Therefore, the stability of growth type will be studied by changing the environment high temperature and salinity treatments. Stable growth type line will be used as parent material for breeding program.

MATERIALS AND METHODS

This research uses 6 x 6 factorial completely randomized design, so there are 36 combinations of treatments with each treatment consisted of three replications and data were variance and correlation analyzed. The first factor are six of sesame cultivars, two determinate growth types sesame cultivars introduced from Turkey, i.e. III Det 23 (G1), III Det 36 (G2) and four indeterminate growth type, i.e. Sbr 3 (G3), Sbr 4 (G4), white local sesame (G5), and black local sesame (G6). The second factor are environments that combine high temperature and several concentrations of NaCl with a combination treatment of E1 (temperatures average 25-30^0 C + 0 g NaCl), E2 (temperatures average 25-30^0 C + 4 g NaCl), E3 (temperatures average 25-30^0 C + 8 g NaCl), E4 (average temperature 45^0 C + 0 g NaCl), E5 (average temperature 45^oC + 4 g NaCl), and E6 (average temperature 45^oC + 8 g NaCl).

Observation included vegetative length phase count starts at planting until the end of flowering while generative growth phase which is calculated at the time when 50% of flowers bloom until harvest, age of flowering, harvest, plant height, number of pods/plant, seed weight/plant, and root length. Biochemical properties include the content of proline and total protein. Determination of proline content (μmol/g FW) refers to the method of *Bates* et al., (1973), while the determination of the total amount of protein made by the method of *Lowry* or *Follin-Ciocalteus Test*.

RESULT AND DISCUSSION

Germplasm of sesame has high diversity. Langham (2007) suggested that the different sesame genotypes may evolve differently in the similar environment, otherwise similar genotypes can evolve very differently in different environmental conditions. Type of plant growth may change depending on the environment. Environmental factors such as temperature, humidity, and light change morphology, physiology, phenology, and proteins can cause variability in the nature of plant growth.

High temperature, salinity and drought are the main limiting factors that prevent the plant express its genetic potential. Among the three factors, temperature stress is a factor that most pervasive and damaging plant growth (Nagesh et al., 2008). High temperatures reduce plant dry weight, growth and net assimilation rate of plants (Wahid and close, 2007) while the salinity stress inhibits seed germination, vegetative growth and pod formation (Sairam and Tyagi, 2004).

Habit of growth properties in various types of crops such as cucumbers, roses, tomatoes, legumes, and sesame are genetically controlled. On *Phaseolus vulgaris*, a single gene difference separating determinate and indeterminate growth type (Yarnell, 1965), while the three properties of soybean determinate, semi-determinate, and indeterminate controlled by two major genes. Determinate growth type is a recessive trait, while the nature of indeterminate type is a dominant trait. Growth type is qualitative character and controlled by major genes either monogenic until oligogenic genes. On sesame, determinate growth type was monogenic recessive (Cagirgan, 2006).

According to Pham (2011), sesame has 2 types of growth, i.e. determinate and indeterminate growth type. On the determinate growth type, plants turn apical meristem to flowering and stop vegetative growth. On the other hand, indeterminate growth type plant will continued vegetative growth (Sato et al., 2008). However, the changes to determinate growth type can occur naturally because mutations (Fong et al., 1995; Kunze et al., 1997).

Figure 1 shows two different growth types of sesame and development in different environments. Genotype III det 36 as determinate type stop vegetative growth when the pods are grown on top primarily stem but on the stress environment although it remains on determinate growth type but have slower vegetative length phase. Sbr 4 genotype (indeterminate growth type) has overlap between vegetative phase and generative phase growth. Although it has already entered generative phase but plants continues vegetative phase. Indeterminate growth type causing time shift between the vegetative to generative phase. First seed pods mature on top while still having flowering. Sesame with indeterminate growth types has diversity in the vegetative phase, reproductive, ripening pods and drying (Langham, 2007).

Many leguminous species are known to be morphologically unstable (Summerfield and Wien, 1980). Temperature effects on controlling the stem determinate growth habit in *Glycine max* were reported by Inouye et al. (1979). Some plants shifted from the determinate growth habit at a constant temperature of 20°C to become indeterminate at 30°C and 35°C under a daylength of between 13.5 hours and 14.3 hours. Determinate cowpea *(Vigna unguiculuta)* elongated and became indeterminate at a night temperature of

24°C as compared with 19°C under a 12 hours photoperiod (Summerfield and Wien, 1980). Summerfield and Wien (1980) suggested that the rate at which nodes, leaf initials and branches are differentiated and expand, the pattern of branching and the height of the plants depends on temperature. The shift of growth habit from determinate to indeterminate in the lablab bean (*Lablab purpureus)* plant was affected by photoperiod as well as temperature (Kim et al., 1992).

Figure 1: III det 36 (G2) genotypes with determinate growth type on the environment E1 (average temperature of 25-30^{0}C + 0 g NaCl), E2 (average temperature 25-30^{0}C + 4 g NaCl), E3 (the average temperature of 25-30^{0} C + 8 g NaCl), E4 (average temperature of 45^{0}C + 0 g NaCl), E5 (average temperature of 45^{0}C + 4 g NaCl) and E6 (average temperature of 45^{0}C + 8 g NaCl). Picture show the pods located on the top of stem refers to determinate growth type.

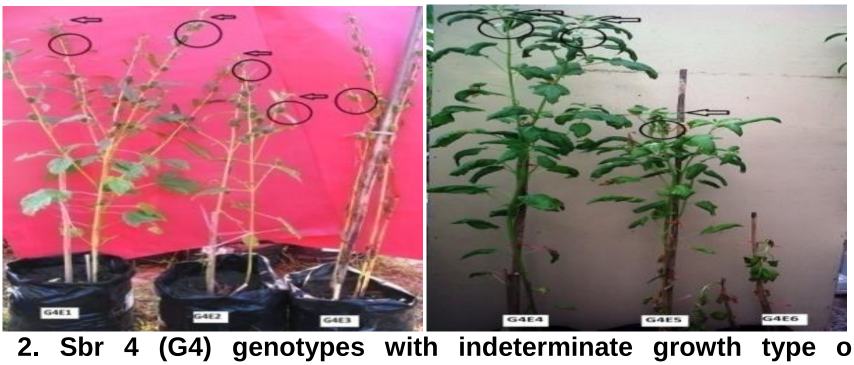

Figure 2. Sbr 4 (G4) genotypes with indeterminate growth type on the environment E1 (average temperature of 25-30^{0}C + 0 g NaCl), E2 (average temperature 25-30^{0}C + 4 g NaCl), E3 (the average temperature of 25-30^{0}C + 8 g NaCl), E4 (average temperature of 45^{0}C + 0 g NaCl), E5 (average temperature of 45^{0}C + 4 g NaCl) and E6 (average temperature of 45^{0}C + 8 g NaCl). The arrow on the right picture shows continued growth despite the plant has entered the generative phase.

Results of analysis variance showed there is an interaction between environmental factors, namely temperature and salinity with cultivar on the length of the vegetative phase and generative phase. Environmental plays a greater role than the cultivars. Environment provides different range and duration of growth vegetative and generative phase at various sesame genotypes (Table 1).

The highest vegetative phase was observed length is highest in indeterminate growth type of Sbr 4 and white local genotype in high temperature environment while the lowest in III det 23 genotypes to saline environmental. III det 23 and III det 36 genotypes, which have determinate growth type indicate the length of the vegetative phase longer on the high temperature environment than low temperature environments. It is influenced by environmental factors primarily elevated temperatures. Growth phase is strongly influenced by the state of the environment, such as the duration of irradiation, temperature and humidity. Temperature is a limiting factor in plant growth and determine the length of the growth phase. Effect of temperature on plant growth varies depending on the stage of plant growth (Fewless, 2006).

Bey (1991) suggested that the high radiation will affect the exchange of heat (temperature) on the plant tissue and environment, the process of transpiration, respiration, photosynthesis and biochemical reactions in morphogenetic and act as regulators and stimulants in the various processes of plant growth and development (germination, flowering and maturation). High temperature environment with an average temperature of 45 ^{0} C causes plants to form proteins as a form of resistance mechanisms. According to Heddy (2001), the production of excessive protein will encourage vegetative growth phase resulting in longer life of flowering and harvest delays.

Table 1. Range and Duration of Growth Phase of Sesame at Different Temperature and Salinity Combination Treatments.

Genotype	Env.	Vegetative Phase		Generative Phase	
		Range (days)	phase Length (days)	Range (days)	Phase Length (days)
III DET 23 (G1) *(determinate growth type)*	E1	0-25	25,33 op	26-56	30,00 jk
	E2	0-25	25,00 p	26-64	20,67 n
	E3	0-27	27,00 o	28-65	37,00 h
	E4	0-48	47,67 k	49-102	52,67 a
	E5	0-44	44,00 l	45-70	25,00 m
	E6	0-36	36,33 n	37-71	33,67 i
III DET 36 (G2) *(determinate growth type)*	E1	0-27	26,67 op	28-66	37,67 h
	E2	0-26	26,00 op	27-64	37,00 h
	E3	0-26	25,67 op	27-66	39,33 g
	E4	0-48	48,33 k	49-101	52,33 a
	E5	0-48	47,67 k	49-71	21,67 n
	E6	0-47	47,33 k	48-75	27,33 l
SBR 3 (G3) *(indeterminate growth type)*	E1	0-60	60,00 i	(28)*-70	42,33 f
	E2	0-57	57,00 j	(27)*-72	45,33 de
	E3	0-55	55,33 j	(27)*-67	40,33 g
	E4	0-120	120,00 b	(89)*-139	50,33 b
	E5	0-98	98,00 c	(91)*-105	14,00 o
	E6	0-92	92,33 f	(89)*-97	8,33 qr
SBR 4 (G4) *(indeterminate growth type)*	E1	0-67	66,67 gh	(28)*-73	45,00 e
	E2	0-65	65,33 h	(28)*-75	46,67 cd
	E3	0-60	60,00 i	(28)*-75	47,00 c
	E4	0-137	136,67 a	(91)*-141	49,67 b
	E5	0-97	97,00 c	(92)*-100	8,00 r
	E6	0-94	94,00 ef	(90)*-98	8,00 r
Black Local (G5) *(indeterminate growth type)*	E1	0-68	67,67 g	(30)*-79	49,33 b
	E2	0-26	26,00 op	27-57	30,00 jk
	E3	0-26	26,33 op	27-58	30,33 j
	E4	0-97	97,33 c	(92)*-105	13,00 o
	E5	0-95	95,00 de	(91)*-97	6,00 s
	E6	0-92	92,33 f	(91)*-94	3,33 t
White Local (G6) *(indeterminate growth type)*	E1	0-68	67,67 g	(31)*-74	42,67 f
	E2	0-41	40,67 m	(30)*-59	28,67 kl
	E3	0-38	37,67 n	(27)*-58	30,67 j
	E4	0-137	136,67 a	(92)*-140	47,67 c
	E5	0-97	96,67 cd	(91)*-102	10,67 p
	E6	0-95	94,67 c	(89)*-99	9,67 pq

1. E1 (average temperature of 25-30^{0}C + 0 g NaCl), E2 (average temperature of 25-30^{0}C + 4 g NaCl), E3 (the average temperature of 25-30^{0}C + 8 g NaCl), E4 (average temperature average 45^{0}C + 0 g NaCl), E5 (average temperature of 45^{0}C + 4 g NaCl), E6 (average temperature of 45^{0}C + 8 g NaCl).
2. The numbers are followed by letters in the same column and row means a different unreal in $DMRT_{\alpha=0,05}$
3. (*) Plant has entered the vegetative phase while generative phase still continuing

Generative phase length was highest in genotypes that have determinate growth type such us III det 23 genotype to high temperature with an average of 52.67 while the lowest phase present in black local genotypes to E6 environment (average temperature of 45 ^{0} C + 8 g NaCl) with an average length of phase 3.33 days (Table 1). III det 23 and III det 36 genotype tend to be more tolerance to temperature and salinity stress on the generative phase so phase length higher than indeterminate growth type.

Combination high temperature and saline environment cause Sbr 3, Sbr 4, black local and white local genotype has a low phase length. This is due to the effects of temperature and salinity are high that adversely affected the development of the plant. Combination high temperature and saline environment causes Sbr 3, Sbr 4, black local and white local genotype are not able to resolve the generative phase of the cycle. Growing interest began to fall under the influence of temperature and salinity stress so the plants are not able to proceed to the next phase. Salinity or high salt concentration will cause stress on the plant and put pressure on plant growth. According to Maas and Nieman (1978), salinity can inhibit plant growth by damaging growth of cells so plant growth disturbed and limit the amount of supplies essential for the metabolism of cell growths.

Sbr 3, Sbr 4 and white local sesame shows vegetative phase ranges overlap with the generative phase in all environments (Table 1). Generative phase has been entered, but still there is a development in the vegetative phase. That was characterize of indeterminate growth type, while genotype III det 23 and III det 36 remained in determinate growth type, the cycle of vegetative phase finish first and then proceed to the generative phase. According to Palmer and Kilen (1987), indeterminate growth type have overlap between vegetative phase and reproductive phases, which means that even though the plant has entered the vegetative phase, but generative phase still growing.

The main environmental effect of salinity resulted occur two types of growth on the local black sesame genotypes. Saline environments which lead to determinate growth type. Growth stalled after completing the period of generative, but the conditions of E1 (average temperature of 25-30^{0}C + 0 g NaCl) and E4 (average temperature of 45^{0}C + 0 g NaCl) environmental, although it has entered a period of generative but the vegetative phase is still growing thus leading to indeterminate growth type. There is a large amount of diversity in growth phase primarily on indeterminate growth type sesame. First formed pods will mature while the upper part is still flowering plant later when the pods have begun to dry there are several pods are immature and still developing (Langham, 2007).

The results of variance analysis for flowering time, harvest time, plant height, number of pods/plant, seed weight/plant, root length of six sesame genotypes experimental environment showed that an interaction between environmental factor and cultivars. Environment greatly affects flowering, harvest, plant height, number of pods / plant, seed weight / plant, root length (Table 2, 3, 4, 5, 6 and 7). Type formation is closely related to crop growth stages of a long phase of plant growth. Most types of growth is influenced by environmental factors. Stress environment can change the type of plant growth (Langham, 2007).

Table 2. Flowering Time III Det 23 Det III 36, Sbr 3, Sbr 4, Black Local and White Local Genotypes of Sesame in Various Environment.

Genotype	Environment						Mean
	E1	E2	E3	E4	E5	E6	
III DET 23	25,33 ij	25,00 j	27,00 i	47,67 e	44,00 f	36,33 g	34,22 d
III DET 36	26,67 i	26,00 ij	25,67 ij	48,33 e	47,67 e	47,33 e	36,94 c
Sbr 3	26,67 i	26,33 ij	26,00 ij	88,33 cd	90,33 ab	87,67 d	57,55 b
Sbr 4	27,00 i	27,00 i	27,00 i	90,33 ab	90,67 a	89,00 bcd	58,50 a
B. Loc.	29,33 h	26,00 ij	26,33 ij	91,00 a	90,33 ab	89,67ab	58,77 a
W. Loc.	30,00 h	28,67 h	26,33 ij	90,67 a	89,67 abc	87,67 d	58,83 a
Mean	27,50 d	26,50 e	26,39 e	76,06 a	75,44 b	72,94 c	

Table 3. Harvest Time III Det 23 Det III 36, Sbr 3, Sbr 4, Black Local and White Local Genotypes of Sesame in Various Environment.

Genotype	Environment						Mean
	E1	E2	E3	E4	E5	E6	
III DET 23	85,33 g	85,67 g	85,33 g	136,67 b	105,00 c	100,33 cde	99,72 a
III DET 36	87,33 g	86,33 g	85,67 g	140,00 ab	105,00 c	99,33 de	100,61 a
Sbr 3	88,00 g	86,67 g	85,33 g	142,33 a	105,00 c	97,00 de	100,72 a
Sbr 4	90,00 gf	89,00 gf	87,33 g	141,67 ab	100,00 cde	98,33 de	101,05 a
B. Loc.	90,67 gf	26,00 ij	26,33 ij	105,00 c	97,00 de	95,00 ef	93,72 b
W. Loc.	91,00 gf	88,33 g	85,67 g	141,67 ab	101,67 cd	99,33 de	101,27 a
Mean	88,72 d	87,39 de	85,94 e	134,56 a	102,28 b	98,22 c	

1. E1 (average temperature of 25-30^{0}C + 0 g NaCl), E2 (average temperature of 25-30^{0}C + 4 g NaCl), E3 (the average temperature of 25-30^{0}C + 8 g NaCl), E4 (average temperature average 45^{0}C + 0 g NaCl), E5 (average temperature of 45^{0}C + 4 g NaCl), E6 (average temperature of 45^{0}C + 8 g NaCl).
2. The numbers are followed by letters in the same column and row means a different unreal in DMRT, α=0.05

Table 4. Plant Height III Det 23 Det III 36, Sbr 3, Sbr 4, Black Local and White Local Genotypes of Sesame in Various Environment.

Gen.	Environment						Mean
	E1	E2	E3	E4	E5	E6	
III DET 23	71,80 hijk	51,77 k	59,63 ijk	213,53 a	113,77 cd	103,98 cdefg	102,41 b
III DET 36	78,10 hijk	59,33 ijk	57,00 jk	204,52 ab	110,32 cdef	123,98 c	105,54 b
Sbr 3	86,67 efghi	80,37 ghij	82,47 ghij	207,38 ab	117,00 cd	85,47 fghi	109,89 ab
Sbr 4	81,00 ghij	66,87 hijk	64,47 ijk	208,82 ab	103,72 cdefg	78,17 hijk	100,50 b
B. Loc.	85,43 fghi	77,47 ghijk	65,37 ijk	183,90 b	119,15 cd	75,65 hijk	101,16 b
W. Loc.	94,97 defgh	74,40 hijk	74,73 hijk	204,02 ab	123,85 c	112,57 cde	114,08 a
Mean	82,99 d	63,36 e	67,27 e	203,694 a	114,63 b	96,63 c	

Table 5. Number of pods/plant III Det 23 Det III 36, Sbr 3, Sbr 4, Black Local and White Local Genotypes of Sesame in Various Environment.

Gen.	Environment						Mean
	E1	E2	E3	E4	E5	E6	
III DET 23	24,67 ab	8,67 ghijk	5,67 ijkl	24,67 ab	7,67 hijkl	7,33 hijkl	13,11 a
III DET 36	16,33 cdefg	11,33 fghij	7,67 hijkl	22,00 bc	12,33 efghijk	5,00 jkl	12,44 a
Sbr 3	20,00 bcde	11,67 fghij	13,33 defghi	21,00 bcde	0,00 l	0,00 l	11,00 a
Sbr 4	14,33 cdefgh	7,33 hijkl	5,67 ijkl	14,00 cdefgh	1,33 kl	0,00 l	7,11 b
B. Loc.	25,33 ab	17.33 bcdef	8,33 ghijkl	20,00 bcde	0,00 l	0,00 l	11,83 a
W. Loc.	31.00 a	19,67 bcde	5,67 ijkl	20,00 bcde	0,00 l	0,00 l	12,72 a
Mean	21,94 a	12,67 b	7,72 c	20,28 a	3,56 d	2,05 d	

Flowering in determinate growth type is marked by the emergence of early flowers and flowering occurs one period while indeterminate growth type will produce flowers simultaneously and emergence slower (Thomas et al., 2003). According to the table (2) indeterminate growth type, Sbr 4 genotype on the high temperature and saline environments provide the longest flowering an average of 90.67 while the shortest life of flowers found in determinate growth type III det 23 genotype on the saline environment. This will affect the harvest (Table 3) which showed III det 23 genotype has the earliest harvest.

Table 6. Seed Weight/Plant III Det 23 Det III 36, Sbr 3, Sbr 4, Black Local and White Local Genotypes of Sesame in Various Environment.

Genotype	Environment						Mean
	E1	E2	E3	E4	E5	E6	
III DET 23	5,04 a	1,18 hijk	1,02 hijklm	2,54 cde	0,26 klm	0,88 ijklm	1,81 a
III DET 36	3,09 bc	2,26 cdef	0,93 ijklm	2,92 bcd	0,49 jklm	0,17 klm	1,64 ab
Sbr 3	3,82 b	2,56 cde	1,06 hijkl	1,38 fghij	0,00 m	0,00 m	1,47 abc
Sbr 4	1,40 fghij	0,64 ijklm	0,26 klm	1,59 efghi	0,07 lm	0,00 m	0,66 d
B. Loc.	3,11 bc	2,10 defg	0,44 jklm	0,96 hijklm	0,00 m	0,00 m	1,10 c
W. Loc.	3,80 b	1,96 defgh	0,61 ijklm	1,33 fghij	0,00 m	0,00 m	1,28 bc
Mean	3,37 a	1,78 b	0,72 c	1,79 b	0,14 d	0,17 d	

Table 7. Long Roots III Det 23 Det III 36, Sbr 3, Sbr 4, Black Local and White Local Genotypes of Sesame in Various Environment.

Genotype	Environment						Mean
	E1	E2	E3	E4	E5	E6	
III DET 23	11,47 bc	6,97 efghijk	5,97 fghijk	11,43 bc	6,53 efghijk	8,67 cdefgh	8,50 a
III DET 36	9,47 bcdef	8,60 cdefgh	8,53 cdefgh	10,57 bcd	9,13 cdefg	6,40 fghijk	8,78 a
Sbr 3	17,80 a	9,40 bcdef	6,80 efghijk	7,27 defghijk	4,13 k	5,67 ghijk	8,51 a
Sbr 4	8,87 cdefg	8,03 cdefghij	7,40 defghijk	4,90 jk	4,23 k	3,90 k	6,22 b
B. Loc.	10,90 bc	11,33 bc	7,03 efghijk	8,47 cdefghi	4,80 jk	5,03 ijk	7,92 a
W. Loc.	12,67 b	9,93 bcde	9,10 cdefg	5,97 fghijk	4,57 jk	5,37 hijk	7,93 a
Mean	11,86 a	9,04 b	7,47 c	8,10 bc	5,57 d	5,84 d	

1. E1 (average temperature of 25-30^{0}C + 0 g NaCl), E2 (average temperature of 25-30^{0}C + 4 g NaCl), E3 (the average temperature of 25-30^{0}C + 8 g NaCl), E4 (average temperature average 45^{0}C + 0 g NaCl), E5 (average temperature of 45^{0}C + 4 g NaCl), E6 (average temperature of 45^{0}C + 8 g NaCl).
2. The numbers are followed by letters in the same column and row means a different unreal in $DMRT_{\alpha=0,05}$

Sesame is a photosensitive and short day plants will flower when the days get long 10 hours. Long exposures of more than 10 hours will cause stunted flowering (Weiss, 1983). On cowpea which is a short day plant, flowering delay up to 2 weeks when planted in heat environments and long day (Patel and Hall, 1990). Early harvesting that occurs in low temperature environment is different from high temperature environments. Visually on an average 25-30^{0}C temperature (low temperature) environments, harvesting leading to determinate growth type while the high temperature environments caused by heat temperature and salinity stress.

Based on the table (4) III det 23 genotype which has determinate growth type on the high temperature showed superior plant height. E4 Environment shows the average of the high value in all genotypes than in other environments, even in III Det 23 and III Det 36 genotype, which have determinate type of plant height to three times higher than the normal environment. III det 23 genotypes on low temperature an saline environment shows the average lowest plant height. Saline Environment showed lower plant height due to the high doses of NaCl to inhibit the development of the stem. Salinity is a major abiotic stress in arid and semi-arid regions. Salinity severely limit crop yield (Gehlot et al., 2005). Salinity lowers water potential and ion induces stress and oxidative stress (Shalata et al., 2001). Resistance to salinity in plants are complex and vary between species and even be ween varieties of plants (Mittova et al., 2002; Gehlot et al., 2005).

Based on Table 7, root length was highest in Sbr 3 genotype to normal environment, but the high temperature and saline environment cause roots cannot develop properly. III Det 36 is a genotype that has long roots that tend to be stable primarily on gripped environments.

Plants that are experiencing stress will do defense mechanisms, one of which is an extension of the root. In general, the roots of plants that accumulate NaCl, is part of an important osmotic adjustment in plant tissue. Greater Inhibition to growth shoots than root because roots more quickly adjust osmotic balance by absorbing water and reduce transpiration (Haryadi and Yahya, 1988).

Based on Table 5 and 6 for the number of pods and seed weight per plant, genotype III det 23 with determinate growth type provides the best average results. III det 23 and III det 36 genotypes that have determinate type has a tendency resistant to salinity stress and heat even in high temperature and saline environments which causes death in plants. III det 23 and III det 36 genotype with determinate growth type able to complete one of life cycle even forming pods and seeds, in other words the determinate growth type of sesame is more efficient in allocating assimilates sesame seeds for growth compared with indeterminate growth type.

Several studies on the effect of the growth type on yield has been carried out on the *Phaseolus vulgaris* (Dawo et al., 2007), soybean (Thomas et al., 2003), and sesame (Uzun and cagirgan, 2005). Results showed that the indeterminate growth type having a better yield than determinate growth type. However, the determinate growth type superior than indeterminate growth type to agronomic traits such as flowering and more uniform flowering, but for the high-yield seeds, sesame with determinate growth type still dominates (Uzun and Cagirgan, 2005).

Environment such as nutrients, toxic substances, salinity, the wavelength of light affect plant growth (Crispeels, 1994). The ability of plants to adapt in stress environmental conditions reflect the ability of the plant to control the action and synthesis of specific proteins (Smith, 1990). Table 8 shows the correlation between the length of the vegetative phase, the generative phase, protein and proline.

Table 8 Correlation coefficient of Vegetative Phase Length, Generative Phase Length, Protein and Prolin of Sesame.

Correlation	Vegetative Phase length	Generative Phase length	Protein	Proline
Vegetative Phase Length	1	- 0,19642 ns	- 0,02100 ns	- 0,45780 **
Generative Phase Length	- 0,19642 ns	1	- 0,42715 **	0,32677 ns
Protein	- 0,02100 ns	- 0,42715**	1	- 0,20879 ns
Proline	- 0,45780 **	0,32677 ns	- 0,20879 ns	1

(*) significant correlation at 5% probability level, (**) significant correlation at 1 % probability level, (ns) = Non-significant

Table 8 shows highly significant negative correlation between vegetative phase length with proline while generative phase length with protein. Responses of plants experiencing stress include changes in salinity and temperature on the cellular and genetic level as changes in osmotic solute accumulation of metabolites, changes in carbon and nitrogen metabolism in response to changes in biochemistry and gene action in response to genetic (Muller and Whitsitt, 1996).

Correlation coefficient results showed that genotype which having a fast vegetative phase primarily sesame with determinate growth type, has a large number of proline in the vegetative phase so as to complete one cycle phase and lead to an increase in yield. Plants able to complete the vegetative phase, but the effect of NaCl would simultaneously reduce yield. Increased levels of proline is mechanism to remain resistant plants seized in condition. Proline acts as an osmotic protectant in plants subject to drought and salinity (Lea, 1999).

Length generative phase and the influence of temperature and salinity stress causes a decrease in the total number of proteins in plants. In the opinion of Irigoyen (1992), that plants experience drought stress, decreased protein levels due to decreased synthesis and increased protein degradation. Similarly, the opinion Hanson and Hitz (1982), that the leaves are experiencing drought stress decreased protein synthesis of proline, while proteolysis of proteins to be fixed so that the last proline in leaf protein content decreased. Chakraborty et al. (2002) reported that decreased levels of protein in the leaves of the tea plant Toklai and Darjeeling cultivars after experiencing drought stress.

CONCLUSION

Environment with an high temperature led to the development of vegetative phase and generative phase was longer in all genotypes nevertheless III Det 23 and III Det 36 genotype who have determinate growth type remained in determinate type. III Det 23 genotype have high yield and tend to be more tolerance to salinity and heat stress in six environments. Black local genotypes in the environment without having salinity stress having a determinate growth type but under conditions of salinity changed to determinate types. Protein and proline is a form of plant resistance to stress marker heat and salinity.

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