CHAPTER 5

DISCUSSION

5.1 Establishing the effect of water stress on maize

The growth of maize variety (888) had strong effect on all parameters by water stress at 6 weeks compared to those at 3 weeks and strong effect by water level at 33%FC compared to those at 50%FC, 67%FC and 100%FC. In this experiment water stress was found to depressed plant height, leaf area, root length, shoot dry weight root dry weight and total dry weight. 888 maize variety had strong effect on total dry weight when this variety had effect of water stress on plant height, leaf area and root length. This means that the effect of water stress on plant height, leaf area and root length, we can predict the effect on dry weight. The effect of water stress on 888 maize variety at 3 weeks seemed to be strong affected by water stress at 33%FC based on degree on reduction of plant height (49%), leaf area (83%), root length (72%), shoot dry weight (87%), root dry weight (64%) and total dry weight (77%) compared to the other water levels and most pronounced at 6 weeks by water stress at 33%FC based on degree on reduction of plant height (64%), leaf area (91%), root length (47%), shoot dry weight (86%), root dry weight (88%) and total dry weight (87%) compared to the other water levels (Table 4.1.1). This result is similar with the report of Sullivan and Eastin (1974) and Hsio and Acevedo (1974). These authors found effects of water stress on plant growth and yield depend upon degree of stress and developmental stages at which stress occurs. Based on the result, I reduce a water level at 33%FC and time harvest at 3 weeks, because the rate

33%FC of water level used at 3 and 6 weeks have strong effect on plant growth (nearly die) and at 3 weeks after planted, the 888 maize variety had slight reduced on all parameters at 2 water levels (67%FC and 50%FC) compared with 100%FC. So, I choose two water levels (67%FC and 50%FC) and time harvest at 6 weeks after planting for next experiment with 11 maize varieties.

5.2 Exploration of drought tolerance in 11 maize varieties

In this experiment, I found that the Dragon 8 Rows was most tolerance, followed by NS72, moderately tolerance were Sainampeung, Pumpui, Pioneer A33, 888, Super sweet, Loeung Mongkul and Semi-sweet maize while CM and Sor Chey were sensitive to water stress. Water stress was found to depressed plant height, leaf area, root length, shoot dry weight, root dry weight and total dry weight of 11 maize varieties were significant affected by interaction between varieties and water levels. This result is similar with (Bohnert *et al.* 1995; Bray 1997; Jia *et al.* 2006; Ludlow and Muchow 1990; Shinozaki and Yamaguchi-Shinozaki 1997) reported that, drought tolerance is believed to be the result of cooperative interactions among multiple morphological, physiological and biochemical characters. Moreover, different genotypes may have different responses to drought stress. Base on reduction (%) of all parameters of maize varieties at 50%FC relative to those at 67%FC of water levels were shown that Dragon 8 Rows was compared, small ranking mean of reduction of studied parameters (3 ±1.80) than ten maize varieties, followed by NS72 (4 ±2.71). Sainampeung (5 ±1.89), Pumpui (5 ±2.81), Pioneer A33 (6 ±2.52), 888 (6 ±2.87), Super sweet (6 ±2.98), Semi-sweet maize (7 ±3.24) and Loeung Mongkul maize varieties (7 ±1.70) were considered as moderately

ranking mean of reduction of studied parameters while the most sensitive ranking mean of reduction of all parameters and were shown by CM (9 ±3.30) and Sor Chey (9 ±3.04) maize varieties (Table 4.2.7). It means that in water stress condition some maize varieties have a slight reduction on all parameters, we can predict those varieties are tolerant varieties to water stress. This results agreed with Nesmith and Ritchie (1992) found that, water deficit is one of the most important constraints in maize production. Water stress given at the vegetative stage reduces the plant height, leaf area, root length and dry weight production, and that given at reproductive stage reduces grain yield. Therefore the four maize varieties as Thai local variety Dragon 8 Rows (sweet maize), CP group 888 (hybrid maize), CARDI Loeung Mongkul (Open pollinated maize) and private company CM (hybrid maize) should be use for a next experiment.

5.3 Difference in drought tolerance on four maize varieties

In this study, I found that Dragon 8 rows was tolerance to water stress, followed by Loeung Mongkul and CM wile 888 was sensitive to water stress condition. Based on the data of root length and root dry weight seemed to be the better parameter than shoot dry weight and total dry weight for consideration of drought tolerance for short term experiment at 6 weeks. If the reduction of each studied parameters as affected as water stress was considered (Table 4.3.1) shoot dry weight and leaf area were more severely affected than the others. It means that the effect of water stress on plant height, leaf area and root length, we can predict the effect on dry weight. This experiment results agreed with O'Toole and Cruz (1980) showed that, drought stress during the vegetative stage has a large effect on a number of morphological traits of plant, such as leaf rolling,

leaf area, leaf death, plant height and root length. From the performance of this tested maize varieties under different water stress condition, Dragon 8 rows seemed to be less affected by water stress based on degree on reduction of shoot dry weight (23%), root dry weight (19%) and total dry weight (21%) compared to the other maize varieties while the most reduction on shoot dry weight (80%), root dry weight (31%) and total dry weight (61%) were shown by 888 maize variety. Loeung Mongkul was less tolerant to drought than Dragon 8 Rows, followed by CM maize variety. This experiment agree with Kummerow (1980) reported that in general, shoot growth is reduced more by drought then root growth because more severe water deficits develop in the transpiring shoot and probably persist longer.

Tanguilig et al. (1987) reported that, nutrient uptake by plants is decreased under drought stress conditions due to reduced transpiration, impaired active transport and membrane permeability resulting in reduced root absorbing power. The effects of water levels with maize varieties on total NPK content in shoot and root, I found that total N content in shoot and root seemed to be the better parameter than total P and K contents in shoot and root for consideration of drought tolerance for experiment at 6 weeks. All maize varieties had strong effect on total dry weight when they had effect of water stress on total NPK content and concentration in shoot and root. This means that the effect of water stress on total NPK content in shoot and root, we can predict the effect on total dry weight, because maize plant can't growth will without NPK. From the performance of this tested four maize varieties under different water stress condition, Dragon 8 rows seemed to be less affected by water stress based on degree on reduction of total N content

in shoot and root (13%), total P content in shoot and root (35%) and total K content in shoot and root (41%) compared to the other maize varieties. So, Dragon 8 Rows maize variety was most tolerant to drought while the most reduction on total N content in shoot and root (63%), total P content in shoot and root (73%) and total K content in shoot and root (67%) were shown by 888 maize variety. Loeung Mongkul was slightly less tolerant to drought than Dragon 8 Rows, followed by CM maize variety. This result agree with Garg (2003) showed that, plant species and genotypes within a species vary in their response to mineral uptake under drought stress. Also Alam (1999) showed that, the drastic effect of drought stress observed is on the transport of nutrients to the root and on the root growth and extension.

For NPK concentration of this tested four maize varieties under different water stress condition, Dragon 8 rows seemed to be less affected by water stress based on degree on reduction of total P concentration in shoot and root (17%) and total K concentration in shoot and root (24%) compared to the other maize varieties. Except total N concentration in shoot and root did not have any effect by water stress compared to those at 100%FC. So, Dragon 8 Rows maize variety was most tolerant to drought while the most reduction on total N concentration in shoot and root (6%), total P concentration in shoot and root (29%) and total K concentration in shoot and root (17%) were shown by 888 maize variety. Loeung Mongkul was slightly less tolerant to drought than Dragon 8 Rows, followed by CM maize variety. This result agree with (Marschner, 1995; Baligar *et al.*, 2001) showed that, low water availability under drought stress generally results in

reduced total nutrient uptake and frequently reduces the levels of mineral nutrients in crop plants.

5.4 Drought and root growth

According to Blum (1982) plants adapt to water stress by increasing root depth and root density, which enhance the ability of the root system to extract soil water. Early drought can limit leaf area and root growth. In this study, no significant interaction effects of water levels and maize varieties on plant height and root length were found, but the different responses of the tested maize varieties on water stress were more clearly shown on leaf area, shoot dry weight, root dry weight and total dry weight. Thus root dry weight seemed to be the better parameter than root length for consideration of drought tolerance for short term experiment at 6 weeks. If the reduction of each studied parameters as affected as water stress was considered (Table 4.4.7) root dry weight and leaf area were more severely affected than the others. This experiment results agreed with Blum (1982) who reported that early drought could limit leaf area and root growth. Westgate and Boyer (1985); Garg *et al.*, (2004) and Samarah *et al.*, (2004) showed that, all plants growing in drying soil, the development of the root system is usually less prevented than shoot growth. The experiment results shown in table 4.4.7 supported the reports of those authors. Kummerow (1980) reported that in general, shoot growth is reduced more by drought then root growth because more severe water deficits develop in the transpiring shoot and probably persist longer. Root- shoot ratios are generally increased by water stress, although the absolute weight of roots usually decreases. In this study, root dry weight of maize varieties were more affected by water stress than shoot

dry weight and root: shoot ratio decreased when water stress increased particularly at 50%FC. This experiment results did not agree with Kummerow's report (1980) which might be due to differences on growing condition and experimental period used. From the performance of this tested maize varieties under different water stress condition, 888 seemed to be less affected by water stress based on degree on reduction of plant height (21%), root length (21%), shoot dry weight (16%) and root dry weight (36%) compared to the other maize varieties. So, 888 maize variety was most tolerant to drought while the most reduction on root dry weight (57%) and total dry weight (37%) were shown by Loeung Mongkul variety. Dragon 8 Rows was slightly less tolerant to drought than 888, followed by CM maize variety.

5.5 Root distribution and drought tolerance

Data presented in table 4.5.1 showed that, significant interaction effects of water levels and two maize varieties on plant height, leaf area, root length, shoot dry weight, root dry weight and total dry weight were found. Begg (1980) reported that, the most important responses of crop to water stress had marked reduction in leaf area. A reduction in leaf area could result in a reduction of the transpiring surface. Thus root length and root dry weight seemed to be the better parameter than total dry weight and shoot dry weight for consideration of drought tolerance for short term experiment at 4 weeks. If the reduction of each studied parameters as affected as water stress was considered (Table 4.5.1) root dry weight and total dry weight were more severely affected than the others. This experiment results agreed with Hays et al. (1991) and Marcum et al. (1995) reported that, deep rooting and root length density often has been

emphasized in relation to drought resistance. From the performance of this tested maize varieties under different water stress condition, Dragon 8Rows seemed to be less affected by water stress based on degree on reduction of plant height (22%), leaf area (24%), root length (11%), shoot dry weight (44%), root dry weight (40%) and total dry weight (43%) compared to the Loeung Mongkul maize variety while Loeung Mongkul maize was least tolerant to drought on plant height (39%), leaf area (36%), root length (17%), shoot dry weight (55%), root dry weight (59%) and total dry weight (66%). This experiment results, Loeung Mongkul maize had more reduction on root dry weight (59%) than shoot dry weight (55%) did not agree with Kummerow (1980) reported that in general, shoot growth is reduced more by drought then root growth because more severe water deficits develop in the transpiring shoot and probably persist longer.

Turner (1979) reported that, roots are most important for plant adaptation to soil water deficits, which was supposed to take up water and necessary solutes from the soil and also deep root systems increase water absorption. In this study, significant interaction effects of water levels and maize varieties on root dry weight at 50 cm to 75 cm deep soil layer were found that at 67%FC and 50%FC, the Dragon 8 Rows had more root dry weight compared to 100%FC than Loeung Mongkul maize variety. Thus root dry weight at 50 cm to 75 cm deep soil layer seemed to be the better parameter than root dry weight at 0 to 25 cm and 25 cm to 50 cm for consideration of drought tolerance for short term experiment at 4 weeks. This experiment results agree with Taylor's report (1983) that, Water uptake depends on root size (length or mass), activity, and spatial distribution. Extensive, deep rooting often has been emphasized in relation to drought tolerance. And

also White et al. (1993) and Carrow (1996) reported that, drought resistance had been attributed mainly to differences in total root length density and rooting depth.

No significant interaction effects of water levels and maize varieties on total P content in shoot and root was found, but the different responses of the tested maize varieties on water stress were more clearly shown on total N an K contents in shoot and root. Thus total N content in shoot and root seemed to be the better parameter than total P and K contents in shoot and root for consideration of drought tolerance for experiment at 4 weeks. This experiment results agreed with Marschner (1995) and Baligar *et al.* (2001) reported that low water availability under drought stress generally results in reduced total nutrient uptake and frequently reduces the levels of mineral nutrients in crop plants.

5.6 Grain yield responses to drought of the maize varieties in the field

Maize is very sensitive to drought. It is exposed to more hazards and it is a higher risk crop in general (Misovic, 1985). In this study, four maize varieties (Dragon 8 Rows, 888, Loeung Mongkul and CM) were used in this experiment. The results in experiment 2 reported a sensitive maize variety was CM, moderately maize varieties were 888 and Loeung Mongkul and most tolerance to water stress was Dragon 8 Rows maize variety. In experiment 3 reported a sensitive maize variety was 888, moderately maize varieties were CM and Loeung Mongkul and most tolerance to water stress was Dragon 8 Rows maize variety. In experiment 4 reported a sensitive maize variety was Loeung Mongkul, moderately maize varieties were Dragon 8 Rows and CM and most tolerance to water stress was 888 maize variety. In experiment 5 reported a sensitive maize variety was

Loeung Mongkul and most tolerance to water stress was Dragon 8 Rows maize variety. Ritchie (1992) founded that the maize varieties had differed in tolerance of water stress. In experiment 6, when all of those maize varieties were planted at water stress field in the field at Agronomy Department, Chiang Mai University, Thailand, the results showed that CM was the highest grain yield (0.31 kg/m^2) and was significant different ($P<0.05$) with 888 (0.27 kg/m^2), Dragon 8 Rows (0.24 kg/m^2) and Loeung Mongkul (0.23 kg/m^2) respectively. But based on degree of reduction of grain yield, Dragon 8 Rows was compared, small reduction on grain yield (22%) than CM (33%), 888 (43%) and Loeung Mongkul (44%). It means that Dragon 8 Rows was most tolerance to water stress in field condition while Loeung Mongkul was most sensitive maize variety in this case. This result agree with Schussler and Westgate (1994) found that, water stress around flowering and pollination delays silking, reduces silk length, and inhibits embryo development after pollination. Water stress during this time reduces maize grain yield 3 to 8 percent for each day of stress. The water stress at flowering may also decrease maize grain yield even if pollination occurs. Nesmith and Ritchie (1992) found that, water stress given at the reproductive stage delays tassel and silk emergence. But the different responses of the tested maize varieties on water stress were more clearly shown on plant height, biomass dry weight and grain yield. Bolao` os et al. (1993) reported that, the reduction in grain yield of maize caused by drought ranges from 10 to 76%, depending on the severity of the drought and the growth stage at which it occurs. And Heinigre (2000) reported that, the amount of yield loss that occurs during dry weather depends on what growth stage the maize is in and how severe the dry conditions become. Water stress has

been found to reduce leaf area; photosynthesis, leaf chlorophyll contents and consequently grain yield. Senthong and Pandey (1989) found that in medium and late maturity genotypes showed the less value of drought susceptibility index tended to have a higher grain yield and tolerated greater water stress than the short maturity ones.