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THESIS

EFFECTS OF ETHEPHON AND COW DUNG IN COMBINATION WITH CHEMICAL FERTILIZER APPLICATION ON GROWTH AND YIELD OF CORN

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Two experiments were carried out under two irrigation water regimens, weekly irrigated without water withdrawal and with irrigation water withdrawal for 3 weeks, starting from 50% flowering stage of corn. The objectives were 1) to assess the effects of cow dung and ethephon on growth and yield of SW4452 corn hybrid and 2) to evaluate the effects of cow dung in combination with chemical fertilizer on growth and yield of two corn hybrids, SW4452 and SW4901. The experiments were conducted at the National Corn and Sorghum Research Center, Pakchong District, Nakhon Ratchasima province during December 2011 to March 2012. For both experiments, a split plot in RCBD was used with 4 replications. In the first experiment, the main plots were 2 levels of cow dung (C) rates (0 and 1 ton/rai) and the sub plots were ethephon (3%) (E) rates (0, 1.5 and 3.0 l/rai). And in the second experiment, the main plots were SW4452 and SW4901 and the sub plots were cowdung (C) in combination with chemical fertilizer (N) (16-20-0), CN1 (0 ton/rai + 20 kg/rai), CN2 (1 ton/rai + 20kg/rai) and CN3 (1ton/rai + 10kg/rai).

The results revealed that, for experiment I, under stress condition, all parameters measured were not affected by cowdung (C) but ear diameter. Ethephon (E) reduced plant height at 50% flowering (F), 3 weeks after 50% flowering (3F) and at harvest (HV). Moreover, E also reduced leaf area index (LAI) at F and 3F. However, grain yield was not affected by C and E and no interaction was observed. Under non stress condition, C affected plant height at F, LAI at V6 and seed number/ear while E affected plant height at F, 3F and HV, ear height, days to tasselling, days to silking and LAI at F and 3F. Considering experiment II, under stress condition, hybrids exhibited different plant height at 3F and HV, ear length, ear length to the top most seeds, ear diameter and grain yield. SW4452 yielded greater than SW4901 (1,068 VS 922 kg/rai). CN did not affect all parameters measured in this study. Under non stress condition, SW4452 also yielded greater than SW4901 (1,197 VS 1,002 kg/rai). CN affected plant height at V6, days to tasselling and silking and ear diameter. No interaction was observed both under stress and non-stress conditions. Although cow dung, ethephon and CN failed statistically to maintain corn yield under drought condition, the increasing trends were also noticed as compared with control.

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Student's signature Thesis Advisor's signature

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EFFECTS OF ETHEPHON AND COW DUNG IN COMBINATION WITH CHEMICAL FERTILIZER APPLICATION ON GROWTH AND YIELD OF CORN

INTRODUCTION

Corn is an economic crop that is very important to animal feed industry in Thailand. About 94% of total corn production is used domestically and the demand is increasing every year (Agriculture Department, 2010). One of the crucial problems in corn production is lower grain yield especially caused by drought (Agriculture Department, 2010). Like many other environmental stresses, drought has adverse effects on crop yield and is the most potent limiting factor in crop production (Sharp and Davies, 1979, 1985; Netting, 2000; Bruce *et al*., 2002). Fischer *et al*. (1982) indicated that drought resistance in an evolutionary context, however, would normally be the ability of a plant or species to survive and eventually reproduce under limited moisture. Moreover, it is clear that the most effective means of reducing the effect of drought on corn would be to escape the periods of low moisture availability through the manipulation of genotype maturity (Fischer *et al*., 1982) and agronomic management.

Drought caused by limited rainfall or soil moisture shortage may be mitigated by reducing water uptake or improving water availability to plants. One way to slow the rate of soil water uptake would be to reduce the size of the evaporative surface or leaf area index (LAI) (Rosenberg *et al*., 1983; Kasele *et al*., 1994) before water stress occurs. Another important method of improving water availability to plants, in a field, is to apply organic fertilizer (Wong *et al*., 2002).A plant growth retardant, Ethephon (2-chloroethyl phosphonic acid), has been used primarily as anti-lodging agents in field grown corn under optimum condition (Cox and Andrade, 1988; Gaska and Oplinger, 1988). It can also be used to reduce LAI of corn in a field so as to reduce the evaporative surface (Norberg *et al*., 1988). The rate of absorption of water often is impeded by low soil moisture content. The soil dries down from field capacity then the rate of absorption of water is reduced because of increased resistance to water movement in the soil (Kozlowski, 1987). Maintaining and improving soil quality is crucial if agricultural productivity and environmental quality are to be sustained for future generations.

Emerging evidence indicates that integrated soil fertility management involving the judicious use of combinations of organic and inorganic resources is a feasible approach to overcome soil fertility constraints (Abedi *et al*., 2010; Kazemeini *et al*., 2010; Mugwe *et al*., 2009). The addition of organic material of various origins (e.g. manure, green manures) to soil has been one of the most common practices to improve soil properties (Bulluck *et al*., 2002; Celik *et al*., 2004; Edmeades, 2003; Li *et al*., 2008; Sankakkara *et al*., 2004). Cow dung increased aggregate stability, pore space, bulk density and available water range. Inadequate soil moisture considered to be a major constraint for stabilizing the yield of rain fed crops. The application of ethephon and cow dung may help corn escape drought period by reducing LAI and maintaining soil moisture contents under water stress condition. And also, this method could reduce losses of yield and yield components or maintaining yield and yield components higher than untreated corn plants. It is very essential to adopt agronomic management and practice to maximize available soil moisture at the critical phases of plant growth. Combined organic/inorganic fertilization both enhanced carbon storage in soils, and reduced emissions from nitrogen (N) fertilizer use, while contributing to high crop productivity in agriculture (Pan *et al*., 2009).

Moreover, Zhao *et al.* (2009) reported that farmyard manure combined with chemical fertilizer management increase higher maize yield, soil organic matter, available nitrogen and available phosphorus (P) compared with those found under straw manure combined with chemical fertilizer management. The amount of fertilizer required was different from one soil to another as well as with crop type and crop variety. Each treatments in different rate of chemical fertilizer combined with cow dung in this research may help farmer to use the optimum rate of chemical fertilizer combined with cow dung and save production cost to get highest yield of corn.

OBJECTIVES

1. To evaluate if cow dung and ethephon application in different rates can maintain growth and yield of corn under drought condition.

2. To investigate if cow dung in combination with chemical fertilizer can improve corn yield under drought condition.

This thesis therefore examines the levels of technology application that may be useful in the reduction of soil water extraction by the use of ethephon, improving soil water holding capacity by cow dung and improving corn grain yield by cow dung in combination with chemical fertilizer treatments. The suggested application level where the duration of moisture is limited would assist corn plant to escape water stress. When moisture availability is predictably not enough for growing corn, the alternatives should be taken for securing additional moisture which may help to reduce the effects of drought stress in corn.

LITERATURE REVIEW

Corn (*Zea mays*) originates in the Andean region of Central America. For western civilization, the story of corn began in 1492 when Columbus's men discovered this new grain in Cuba (Gibson and Benson, 2002). Currently, the five main producers in the world are the United States of America (USA), China, Brazil, India and Mexico. The USA is the major producer of corn in the world. The tendency in the production of corn in the last three decades, which grows at a rate of about 1.8% annually and this linear-growth production is relatively constant for the major cereals, sustaining production parallel to population increase. This indicates an increase in the consumption but not in the production of corn, due to new uses found for the crop (Agriculture and Agri-Food Canada, 2009). Corn is one of the most important cereals both for human and animal consumption and is grown for grain and forage. Present world production is about 818 million tons grain from about 159 million ha (FAOSTAT, 2009). World corn production decreased by about 1% but its consumption is projected to rise by about 3% to a record high as the sharp increase in food and industrial use more than offsets the decline in feeding (Agriculture and Agri-Food Canada, 2009). Globally, 65 percent of total world corn production is used for feed purposes while around 15 percent is used for food and the remaining mainly is destined for various types of industrial uses. Corn is an essential ingredient in animal feed because it is rich in energy (FAO, 2006).

Impact of Drought on Corn Yield

Corn is very susceptible to drought damage due to the water requirement for cell elongation. Therefore, there is always the danger of yield loss regardless of the timing of dry weather . The golden rule of corn production is that highest yields will be obtained only where environmental conditions are favorable at all stages of growth. The amount of yield loss that occurs during dry weather depends on what growth stage the corn is in and how severe the dry conditions become (Heinigre, 2000). Yield is reduced when evapotranspiration demand exceeds water supply from the soil at any time during the corn life cycle. Evapotranspiration is both the water lost from the soil surface through evaporation and water used by plant during transpiration. Soil evaporation is the major loss of water from the soil during early stages of growth. As corn leaf area increases, transpiration gradually becomes the major pathway through which water moves from the soil through the plant to the atmosphere. Corn yield is most sensitive to water stress during flowering and pollination, followed by grain filling, and physiological maturity stages (Lauer, 2003). Plant growth from emergence to V8 (eight leaf fully emerged or about 4 weeks after planting) determines the size that plant achieves and the size of individual leaves. Dry weather during this period will reduce plant and leaf size. Impact on yield will be based on the reduction in leaf area available for photosynthesis. Minor reductions in leaf size will have little impact on yield while major reductions could reduce potential yields as much as 20 percent. Yield reduction due to continuous drought just before tasselling/silking stage, plant growth from V8 to V16 (all leaves emerged, start of tasselling; from 4 weeks to 66 days after plant emergence) determines ear size and the number of kernels set. From V8 to V14, ear size is set. Drought during this period will reduce ear size and potential yield. Potential yield losses could range from 10 percent to 30 percent. From V14 to tasselling, the number of kernels that can be fertilized are determined. Drought during this period can reduce corn yields 10 to 50 percent. Thoughtout the V8 to V16 period the key question is how long the drought stress is present (Heinigre, 2000).

Water stress around flowering and pollination delays silking, reduces silk length, and inhibits embryo development after pollination. Moisture stress during this time reduces corn grain yield 3 to 8 percent for each day of stress. Moisture or heat stress interfaces with synchronization of pollen shed and silk emergence. Drought stress may delay silk emergence until pollen shed is nearly or completely finished. During periods of high temperatures, low relative humidity, and inadequate soil moisture, exposed silks may dessicate and become non receptive to pollen germination (Lauer, 2003). If soil moisture become depleted during the milk and dough stages of grain fill, then grain abortion may occur, resulting in shrunken and light bushel-weight grain. Maximum grain yields are obtained when soil moisture is available through physiological maturity, or black layer formation (Coffman, 1998).

Corn Cultural Practices and Management Adaptation to Climate and Soil Fertility Requirements

FAO (2011) indicates that the crop is grown in climates ranging from temperate to tropic during the period when daily mean temperatures are above 15°C and frost-free. Adaptability of varieties in different climates varies widely. It tolerates hot and dry atmospheric conditions so long as sufficient water is available to the plant and temperatures are below 45°C. Corn is an efficient user of water in terms of total dry matter production and among cereals it is potentially the highest yielding grain crop. For maximum production a medium maturity grain crop requires between 500 and 800 mm of water depending on climate.

The fertility demands for grain corn are relatively high and amount, for high-yielding varieties, up to about 200 kg/ha N, 50 to 80 kg/ha P and 60 to 100 kg/ha K. In general the crop can be grown continuously as long as soil fertility is maintained. Under irrigation a good commercial grain yield is 6 to 9 ton/ha (10 to 13 percent moisture). The water utilization efficiency for harvested yield (Ey) for grain varies then between 0.8 and 1.6 kg/m^3 (FAO, 2011).

Effects of Cow Dung and Ethephon on Corn

Inadequate moisture during any period of growth can result in reduced grain yield. Nutrient availability, uptake, and transport are impaired without sufficient water.Corn is reported to be relatively tolerant to water stress during the vegetative stage, very sensitive during tasselling, silking and pollination, and moderately sensitive during grain filling period (Shaw, 1977). If a crop is relying heavily on a limited supply of stored soil water, slowing the rate of the soil water extraction prior to anthesis should increase the amount of available water remaining in the soil after anthesis (Kasele *et al*., 1994). One way to slow the rate of soil water extraction would be to reduce the size of the evaporative surface or leaf area index (Rosenberg *et al*., 1983; Kasele *et al*., 1994). The reducing soil evaporation could be one of the most important water-saving measures in this serious water deficit region. Leaf area index (LAI) and moisture in the surface soil greatly affect the ratio of soil evaporation to total evapotranspiration. The relationship between this ratio and surface soil moisture and leaf area index was established, and can help to improve field water utilization efficiency (Wong *et al.*, 2002). Alternatively, plant growth retardants could be used to reduce early season crop water use by reducing LAI, resulting in extended water availability for critical reproductive and grain filling processes and thereby increase in grain yield under drought stress (Shannahan and Nielsen, 1987; Kasele *et al.*, 1994; D' Andria *et al.*, 1997). Another way, total evapotranspiration, transpiration and soil evaporation varies appreciably in the different stages. During the period from heading to grain filling, evaporation reaches a minimum of 17%, and then slightly rises to 18% at maturity. For the summer corn crop, transpiration was less than evaporation at the seedling stage, and then rapidly increased to make up a large proportion of evapotranspiration, when nearly 80% of evapotranspiration was from transpiration. At maturity, the ratio of transpiration to evapotranspiration decreased slightly about 74%. Reduced soil evaporation could help increasing the water use efficiency of summer corn, since the soil evaporation comprises about 30% of total evapotranspiration. Although soil evaporation at the full growth stage is relatively a small percentage of total evapotranspiration, its absolute amount is large because of strong evaporation during this stage (Wong *et al*, 2002).

Some of these factors such as irrigation and manure can be controlled by human. Both of them are essential to increase yield and quality of plants (Singh and Goswami, 2000). Mala (2003) reported that one way to increase organic matter in soil is by applying organic fertilizer for optimizing soil property for crop growth and yield. It improves physical, chemical and biological soil properties to better hold water for coarse soil texture and to easily plow for fine soil texture. This also helps effectively draining air and water in soil. The soil absorbs more nutrients that can be dissolved by water and available for plant growth as long as microorganisms activities in soil are well. For plant, organic fertilizer is directly and indirectly useful to plant growth and yield. Humus in organic fertilizers can improve physical and chemical of soil to be optimal for better crop growth and yield. Whereas phenolic compounds from microorganism's activities can help plant to tolerate unsuitable conditions such as drought escape. Moreover, Mala (2003) indicated that manure contains nitrogen, phosphorus and potassium around 45, 9 and 90 kg, respectively.

Normally, cow dung composed of carbon 12.20-18.60 %, nitrogen 0.86-1.32 %, phosphorus 0.32-0.58 %, potassium 0.80-2.21 % and has pH in a range of 7.40-8.30.

Moreover, Zhao *et al.* (2009) reported that farmyard manure combined with chemical fertilizer management increased higher maize yield, soil organic matter, available N and available P compared with corn under straw manure combined with chemical fertilizer management. Moreover, emerging evidence indicates that integrated soil fertility management involving the judicious use of combinations of organic and inorganic resources is a feasible approach to overcome soil fertility constraints (Abedi et al., 2010; Kazemeini et al., 2010; Mugwe et al., 2009).

Kasele *et al.* (1994) indicated that ethephon, a plant growth regulator, has been used to reduce plant height and lodging of intensively managed corn. However, the impact of ethephon induced changes in vegetative growth on water use and grain yield of corn grown at various densities under drought stress conditions has not been widely studied (Kasele *et al.*, 1994). Currently, ethephon has been used primarily as anti-lodging agents in corn grown under optimum conditions. It could be used to reduce early season crop water use by reducing LAI, resulting in extended water available for critical reproductive stages and grain filling processes and thereby increase grain yield under drought stress. Growth retardant-treated plants are more drought resistant. Finally, plant density affects LAI, which in turn influences the pattern of seasonal water use, as well as grain yield, of corn. Ethephon rates caused reduction in grain yield and had an effect on kernel number, while kernel weight was not affected by ethephon. Shekoofa and Emam (2006) also reported that the rates of folair application of ethephon could play an important role in corn indices. Application of ethephon was associated with a decrease in LAI, Leaf Area Index Duration (LAID) and Crop Growth Rate (CGR). Furthermore, ethephon reduced plant and ear height.

In later decade, Shekoofa and Emam (2006) presented the investigation of growth and yield of corn response to ethephon application under water stress condition of corn in southern Iran. The results of a field experiment 2004-2005, showed that the rate of foliar application of ethephon could play an important role in corn growth indicator and attribute to grain yield components. Ethephons reduced plant and ear height. Increasing the application rates of ethephon showed a significant reduction in early season plant height and LAI. The control plants had lower grain yield than those treated with different rates of ethephon. Under conditions of water stress, the corn plant is able to make better use of available water if vegetative growth is partially restricted early in season.

Effects of Farm Yard Manure on Other Crops

There are some studies about farm yard manure application that affected on plant yield and yield components. Ahmad *et al.* (2011) reported that manure in soil prepares essential elements and increases quality and quantity of plant products. The study of the effects of water stress and manure application on cumin yield components was conducted at the Agricultural Research Station of Zahak, Zabol, south east of Iran. A complete randomized block in factorial design with four replications was used. Treatments including irrigation intervals (I1: two times irrigation, I2: three times irrigation and I3: four times irrigation that are irrigation in germination, seedling, flowering and seed filling stages) and manure application (F1: without manure application, F2: 20 t/ha manure application). Three irrigation times with manure treatment produced the highest number of umbrella per plant, seed and biological yield and the lowest 1000-seed weight and number of seed per umbrella. The results showed that a relationship exist between the main constituents of cumin under water and manure application.

Another research is done on barley, Babaeian et *al*. (2011) reported the study of different proportions of manure and chemical fertilizer and water stress on grain yield and grain nutrient content in barley. An experiment was conducted as split plot in randomized complete block design with three replications in research field of Zabol University, 2009. Water stress treatments consisted of: water stress at grain filling stage and control as the main factor and different proportions of manure and chemical fertilizer treatment consisted of: 100% manure (N1), 100% chemical fertilizer (N2), 50% manure + 50% chemical fertilizer (N3), 75% manure + 25% chemical fertilizer (N4) and control (N5) as sub factor in this experiment. Results illustrated that drought stress at grain filling stage treatment significantly affected all grain yield and yield components with the exception of ear weight. Drought stress at grain filling stage strongly decreased grain yield but its effect was not very strong on another traits. With the exception of grain number/ear and ear weight, fertilizer treatments had significant effect on grain yields and yield components. Grain nutrient content was not affected by water stress but among different proportions of fertilizer treatments, 100% manure (N1) increased these elements in grain.

MATERIALS AND METHODS

Hypothesis

Corn was relatively tolerant to water stress during the vegetative stage, very sensitive during tasselling, silking and pollination. If a crop is relying heavily on a limited supply of stored soil water, slowing the rate of the soil water extraction prior to anthesis should increase the amount of available water remaining in the soil after anthesis that has effect on growth, yield and yield components. One way to slow the rate of soil water extraction would be to reduce the size of leaf area index by using ethephon and increase moisture in soil by cow dung. Additionally, cow dung in combination with chemical fertilizer application levels may help improving yield and yield components of corn under drought condition.

Materials

1. Miaze hybrids: Suwan 4452 and Suwan 4901
2. Cow dung
3. Ethephon 3% (2-chloroethyl phosphonic acid)
4. Tensiometers
5. Ruler
6. Chemical fertilizer (16-20-0 and 46-0-0)
7. Scales
8. Retractable measuring tape
9. Soil auger
10. Irrigated equipments as sprinkler and furrow type
11. Weed control: Atrazine 80% W.P.
12. Polyethylene bags
13. Wood pegs
14. Corn Sheller

Methods

Field Experiment

Field experiments were conducted at the National National Corn and Sorghum Research Center, Pakchong district, Nakhon Ratchasima province. The center lies between latitude 14º30' to 44º00'N and longitude 77º55' to 103º16'E. This location places it in the tropical humid climate. The experiments were conducted during November 2011 to April 2012. The objective was to determine whether ethephon, cow dung and cow dung plus chemical fertilizer have beneficial effects on corn growth and yield under drought condition.

Land Preparation and Cultural practices

Experiment I: Effects of Cow Dung and Ethephon Rates on Growth and Yield of Corn under Drought Condition

The land was plowed twice, once with 3-disk and another with 7-disk plows and, then, harrowed. Ridging was done after cow dung was applied according to the assigned treatments. SW4452 corn hybrid was planted, 0.75 m between row and 0.20 m between plant, with jabber using 2-3 seeds per hill. There were 6 rows of corn per plot with 4.5 x 6.0 m dimension ($27m^2$). Seedlings were thinned out within 2 weeks after emergence to the population of 10,667 plants per rai or 66,662 plants per ha. The border rows were provided to take care of latteral water flow for each plot. Atrazine (80% WP) at 250 cc per rai was sprayed after planting. The 16-20-0 fertilizer was applied at the rate of 30 kg per rai after cow dung was applied, before ridging. At 28 days after emergence, 16-20-0 fertilizer was top-dressed at the rate of 20 kg per rai. Ethephon was sprayed at vegetative 6 (V6) stage, which the 6^{th} leave collar deeply expanded (Heinigre, 2000). In experiment I, there was two sets of identical treatments. One set was tested under water stress condition, another set was non-stress. These two sets were irrigated once a week until the end of the experiment except for under water stress condition where irrigation water was withdrawn for 3 weeks after corn was at 50% flowering stage.

The experiment was laid out in a split plot in Randomized Complete Block Design (RCBD) with 4 replications. Cow dung was used as main plots (C0 and C1 for 0 ton per rai (control) and 1 ton per rai) and 3 rates of ethephon were sub plots as followed:

E0 = ethephon 0 litre per rai
E1.5 = ethephon 1.5 litre per rai
E3.0 = ethephon 3.0 litreper rai

Experiment II: Effect of Variety and Cow Dung in Combination with Chemical on Growth and Yield Components

The experiment II was carried out alongside with the experiment I. Land preparation and cultural practices were done the same way as in the experiment I. A split plot in RCBD was used with 4 replications. Two corn hybrids constituted main plots, SW4452 (S1) and SW4901 (S2). Cow dung (C) in combination with chemical fertilizer (N) (16-20-0) were sub plots as followed:

CN1 = cow dung 0 ton per rai + (16-20-0) 20 kg per rai
CN2 = cow dung 1 ton per rai + (16-20-0) 20 kg per rai
CN3 = cow dung 1 ton per rai + (16-20-0) 10 kg per rai

There were 2 sets of identical treatments, one under water stress and another under non stress conditions. Irrigation management was the same as in the experiment I.

Data Collection and Analysis

Corn sampling and corn analysis were done at the beginning of the experiment. The following data were collected: days to emergence, days to 50%flowering, days to harvest, plant height before and after ethephon application (3 times), plant height at harvest, Leaf area index (LAI), dry matter accumulation, soil moisture tension , and yields per area (rai) were recorded during the course of the experiment.

1. Growth Characteristics

Five plants per sub-plot were randomly selected for data collection

1.1 Corn Height: plant height and ear height

1) Plant height was measured from ground to the latest developed leave.

2) Ear height was measured from ground to the lowest ear.

1.2 Leaf Area Index (LAI): LAI can be calculated from measuring width and length of leaf and multiply by 0.75: LAI = (Leaf area/ ground area)

1.3 Soil moisture tension was measured by the use of tensiometer

2. Development Characteristics

2.1 Days to 50% tasselling was noted when 50% of corn plant tassel.

2.2 Days to 50% silking was noted when 50% of corn plant silk.

2.3 Anthesis to Silking Interval (ASI) = days to silking- days to tasselling

3. Yield& Yield components

3.1 Dry accumulation in plants: corn plants were estimated for final dry matter yield at harvest.

3.2 Harvest Index (HI) = economic yield/biological yield (dry weight)

3.3 Number of seeds per ear: five ears were randomly sampled, threshed, total seeds numbers were counted and averaged per ear.

3.4 Weight of 1000 seeds: 250 seeds per replication were counted for 4 replications and weighed.

3.5 Seed yield at 15% of moisture: corn on 2 middle rows were harvested, air dried and threshed. After that seed yield at 15% of moisture were calculated using the formula: yield = [total seed weight × (100 - % of moisture)] / (100-15)

3.6 Ear length was measured by the use of ruler

3.7 Ear length to top-most seeds was measured by the use of ruler

3.8 Ear diameter was measured by the use of tape measurement

Statistical Analysis

Data will be subjected to analysis of variance (ANOVA) and treatment mean differences were tested by using the least significant difference (LSD) at 95% level of confidence.

RESULTS AND DISCUSSIONS

Effect of ethephon and cow dung in combination with chemical fertilizer application on growth and yield of corn were investigated, 2 experiments each having two sets under water stress and non-stress conditions. 1.Effects of cow dung and ethephon on growth and yield of corn, and 2. Effect of cow dung and chemical fertilizer on growth and yield of corn.

Experiment I

Effects of Cow Dung and Ethephon Rates on Growth and Yield of Corn under Drought Condition

Growth and Development Characteristics

Plant Height

The effects of cow dung and ethephon on plant height at different growth stages of corn under water stress condition were shown in Table 1. The results showed that plant height at vegetative 6 stage (V6) (the 6th leave collar deeply expanded, full 50% emerged or about 3.5 weeks after planting) (Heinigre, 2000), 50% flowering, 3 weeks after 50% flowering and at harvest were not affected by cow dung (C) rates and interaction between cow dung and ethephon rates (E). However, Ethephon rates significantly affected plant height at 50% flowering, 3 weeks after 50% flowering and at harvest stages (133.8, 119.5 and 114.6 cm; 176.1, 138.3 and 124.6 cm; 187.3, 163.7 and 150.0 cm for E0, E1.5 and E3, respectively). Under non-stress conditions (Table 1) , cow dung rates did not affect plant height at all stages measured (V6, 50% flowering, 3 weeks after 50% flowering and at harvest stages) . No interaction between cow dung and ethephon rates was observed. Considering ethephon rates, corn plant height was statistically significantly affected by ethephon rates at all stages but V6 (135.6, 113.9 and 110.5 cm; 181.5, 152.3 and 141.7 cm; 195.3 170.5 and 164.0 cm for E0, E1.5 and E3, respectively). The results were similar to corn plant height under stress conditions where increasing ethephon rates decreased plant height.

Table 1 Effects of cow dung and ethephon on plant height of corn hybrid grown at V6, 50% Flowering (F), 3 weeks after 50% flowering (3F) and at harvest stages (HV) under water stress and non-stress conditions.

Cow dung (C)	Eth. Rate (E)	C*E	Stress conditions V6 (cm)	Stress conditions F (cm)	Stress conditions 3F (cm)	Stress conditions HV (cm)	Non-stress conditions V6 (cm)	Non-stress conditions F (cm)	Non-stress conditions 3F (cm)	Non-stress conditions HV (cm)
C0			17.4	117.7	147.8	163.9	18.4	115.9	158.0	174.0
C1			18.2	127.6	144.9	170.0	18.6	124.2	159.3	179.2
F-test			NS	NS	NS	NS	NS	NS	NS	NS
	E0		17.6	133.8[a]	176.1[a]	187.3[a]	18.2	135.6[a]	181.0[a]	195.3[a]
	E1.5		18.2	119.5[b]	138.3[b]	163.7[b]	19.4	113.9[b]	152.8[b]	170.5[b]
	E3		17.7	114.6[b]	124.6[c]	149.8[c]	18.0	110.5[b]	141.7[b]	164.0[b]
	F-test		NS	*	**	**	NS	**	**	**
		C0E0	16.7	129.9	175.6	184.7	17.8	130.1	178.4	193.0
		C0E1.5	18.6	112.0	145.3	160.6	19.1	110.0	150.1	168.6
		C0E3	16.9	111.3	122.4	146.4	18.3	107.6	145.4	160.5
		C1E0	18.4	137.8	176.5	190.0	18.5	141.2	184.5	197.6
		C1E1.5	17.7	126.9	131.3	166.8	19.7	117.8	155.4	172.4
		C1E3	18.5	117.9	126.8	153.3	17.6	113.5	138.0	167.5
		F-test	NS	NS	NS	NS	NS	NS	NS	NS

Table 1 (Continued)

Cow dung (C)	Eth. Rate (E)	C*E	Stress conditions V6 (cm)	Stress conditions F (cm)	Stress conditions 3F (cm)	Stress conditions HV (cm)	Non-stress conditions V6 (cm)	Non-stress conditions F (cm)	Non-stress conditions 3F (cm)	Non-stress conditions HV (cm)
	CV%	C	8.3	10.7	19.9	11.7	8.8	12.0	14.2	10.9
		E	10.3	10.7	8.2	4.7	7.9	5.7	6.9	5.3
		C*E	8.1	7.7	8.5	3.4	8.6	4.3	6.2	6.4
	LSD	C	1.3	11.4	25.2	17.0	1.4	12.5	19.5	16.6
		E	1.9	14.3	12.6	8.5	1.5	7.4	11.5	10.2
		C*E	2.2	14.6	19.2	8.8	2.5	7.9	15.2	17.4

NS = not significant
* = significantly difference at 95% level of confidence
** = highly significant difference at 99% level of confidence

Ear Height

The effects of cow dung and ethephon on ear height of corn under water stress and non-stress conditions were shown in Table 2. The results showed that ear height was not affected by cow dung rates, ethephon rates and interaction between cow dung and ethephon. Under non- stress conditions, cow dung rates did not affect ear height. No interaction between cow dung and ethephon rates was observed. Considering ethephon rates, corn ear height was significantly affected by ethephon (107.2, 89.7 and 85.8 cm for E0, E1.5 and E3, respectively). The results were that corn ear height under stress conditions was not different while increasing ethephon rates decreased ear height under non-stress conditions.

Days to Tasselling

The effects of cow dung and ethephon on days to tasselling of corn under water stress and non-stress conditions were shown in Table 2. The results showed that days to tasselling was not affected by cow dung rates and interaction between cow dung and ethephon. Considering E rates, days to tasselling was significantly affected by ethephon (64.5, 65.9 and 66.4 days for E0, E1.5 and E3, respectively). Under non-stress conditions, cow dung rates did not affect days to tasselling. No interaction between cow dung and ethephon rates was observed. Considering ethephon rates, days to tasselling was significantly affected by E (63.8, 64.9 and 65.9 days for E0, E1.5 and E3, respectively). The results were similar to days to tasselling under stress conditions where increasing ethephon rates increased days to tasselling.

Days to Silking

The effects of cow dung and ethephon on days to silking of corn under water stress and non-stress conditions were shown in Table 2. The results showed that days to silking was not affected by cow dung rates but affected by ethephon rates and interaction between cow dung and ethephon. Considering ethephon rates, days to silking was significantly affected by ethephon rates (68.0, 69.3 and 70.0 days for E0, E1.5 and E3, respectively). No interaction between cow dung and ethephon. Under non stress conditions, cow dung rates did not affect days to silking. No interaction between cow dung and ethephon rates was observed. Considering ethephon rates, days to silking was significantly affected by ethephon (66.9, 68.0 and 69.0 days for E0, E1.5 and E3, respectively). The results were similar to days to silking under stress conditions where increasing ethephon rates increased days to silkling. However there was interaction between cow dung and ethephon only in stress conditions where ethephon 3.0 litre per rai without cow dung (C0E3) delayed days to silking, the longest, up to 70 days.

Anthesis to Silking Interval (ASI)

The effects of cow dung and ethephon on anthesis to silking interval (ASI) of corn under water stress and non-stress conditions were shown in Table 2. The results showed that ASI was not affected by cow dung rates, ethephon rates and interaction between cow dung and ethephon. Under non- stress conditions, cow dung rates and ethephon rates did not affect ASI. No interaction between cow dung and ethephon rates was observed. The results were that corn ASI under stress conditions was not different from under non-stress conditions.

Table 2 Effects of cow dung and ethephon on ear height, days to taselling (DTT) and days to silking (DTS) of corn hybrid grown under water stress and non-stress conditions.

Cow dung (C)	Eth. Rate (E)	C*E	Stress conditions				Non-stress conditions			
			Ear height (cm)	DTT (days)	DTS (days)	ASI	Ear height (cm)	DTT (days)	DTS (days)	ASI
C0			91.0	65.9	69.5	3.6	95.6	65.3	68.5	3.3
C1			97.4	65.3	68.7	3.4	100.7	64.4	67.4	3.0
F-test			NS	NS	NS	NS	NS	NS	NS	NS
	E0		107.2	64.5[b]	68.0[ab]	3.5	108.3[a]	63.8[b]	66.9[b]	3.1
	E1.5		89.7	65.9[ab]	69.3[ab]	3.4	94.9[b]	64.9[ab]	68.0[ab]	3.1
	E3		85.8	66.4[a]	70.0[a]	3.6	91.3[b]	65.9[a]	69.0[a]	3.1
	F-test		NS	*	*	NS	*	*	*	NS
		C0E0	104.1	65.3	68.8	3.5	106.7	64.0	67.3	3.3
		C0E1.5	86.3	66.0	69.5	3.5	91.1	65.8	69.0	3.3
		C0E3	82.8	66.5	70.3	3.8	89.0	66.0	69.3	3.3
		C1E0	110.4	63.8	67.3	3.5	110.0	63.5	66.5	3.0
		C1E1.5	93.2	65.8	69.0	3.3	98.7	64.0	67.0	3.0
		C1E3	88.8	66.3	69.8	3.5	93.6	65.8	68.8	3.0
		F-test	NS	NS	*	NS	NS	NS	NS	NS

Table 2 (Continued)

Cow dung (C)	Eth. Rate (E)	C*E	Stress conditions				Non-stress conditions			
			Ear height (cm)	DTT (days)	DTS (days)	ASI	Ear height (cm)	DTT (days)	DTS (days)	ASI
	CV%	C	16.3	2.0	1.8	14.3	12.0	2.5	2.5	15.5
		E	13.2	2.0	1.8	15.8	8.5	2.0	2.0	15.5
		C*E	12.5	1.4	1.2	15.8	9.0	2.0	2.1	15.1
	LSD	C	13.3	1.1	1.1	0.4	10.2	1.4	1.5	0.4
		E	13.1	1.4	1.3	0.6	8.7	1.4	1.4	0.5
		C*E	18.2	1.5	1.3	0.9	13.6	2.0	2.2	0.7

NS = not significant
 * = significantly difference at 95% level of confidence
** = highly significant difference at 99% level of confidence

Drought Stress

Leaf Area Index (LAI)

The effects of ethephon and cow dung on leaf area index (LAI) at different growth stages of corn under water stress and non-stress conditions were shown in Table 3. The results showed that plant height at V6, F and 3 weeks after 50% flowering stages were not affected by cow dung rates and interaction between cow dung and ethephon rates. However, ethephon rates affected LAI at F and 3 weeks after 50% flowering (3.2, 2.6 and 2.4; 3.4, 2.8 and 2.6 for E0, E1.5 and E3, respectively). Under non- stress conditions, C rates did not affect LAI at all stages measured (V6, 50% flowering, 3 weeks after 50% flowering and at harvest) . No interaction between cow dung and ethephon rates was observed. Considering ethephon rates, LAI was significantly affected by ethephon rates at F and 3 weeks after 50% flowering stages (3.6, 2.8 and 2.6; 3.8, 3.3 and 2.8 for E0, E1.5 and E3, respectively). The results were similar to LAI under stress conditions which has adverse effect by the more ethephon rates the less value on LAI.

Table 3 Effects of cow dung and ethephon on LAI at V6, 50% flowering (F) and 3 weeks after 50% flowering stages (3F) of hybrid corn grown under stress \ and non-stress conditions.

Cow dung (C)	Eth. Rate (E)	C*E	Stress conditions V6 (cm)	Stress conditions F (cm)	Stress conditions 3F (cm)	Non-stress conditions V6 (cm)	Non-stress conditions F (cm)	Non-stress conditions 3F (cm)
C0			0.6	2.7	2.9	0.3	2.9	3.1
C1			0.6	2.9	3.0	0.4	3.1	3.5
F-test			NS	NS	NS	NS	NS	NS
	E0		0.6	3.2[a]	3.4[a]	0.3	3.6[a]	3.8[a]
	E1.5		0.6	2.6[b]	2.8[b]	0.3	2.8[b]	3.3[ab]
	E3		0.6	2.4[b]	2.6[b]	0.3	2.6[b]	2.8[b]
	F-test		NS	**	*	NS	*	*
		C0E0	0.5	3.2	3.3	0.3	3.3	3.5
		C0E1.5	0.6	2.5	2.8	0.3	2.8	3.3
		C0E3	0.6	2.3	2.5	0.3	2.5	2.6
		C1E0	0.6	3.3	3.4	0.4	3.9	4.1
		C1E1.5	0.5	2.8	2.8	0.4	2.7	3.3
		C1E3	0.6	2.6	2.7	0.3	2.7	3.0
		F-test	NS	NS	NS	NS	NS	NS

Table 3 (Continued)

Cow dung (C)	Eth. Rate (E)	C*E	Stress conditions V6 (cm)	Stress conditions F (cm)	Stress conditions 3F (cm)	Non-stress conditions V6 (cm)	Non-stress conditions F (cm)	Non-stress conditions 3F (cm)
	CV%	C	9.8	17.4	17.1	17.8	27.5	24.9
		E	12.7	10.4	11.6	17.9	16.9	17.2
		C*E	10.5	8.3	12.5	17.8	23.2	21.6
	LSD	C	0.0	0.4	0.4	0.1	1.4	0.7
		E	0.0	0.3	0.4	0.1	0.6	0.6
		C*E	0.0	0.4	0.6	0.1	2.9	3.1

NS = not significant

* = significantly difference at 95% level of confidence

** = highly significant difference at 99% level of confidence

Soil Water Tension

The effects of cow dung and ethephon on water tension at different growth stages of corn under water stress and non-stress conditions were shown in Table 4. The results showed that water tension at V6, 50% flowering, 3 weeks after 50% flowering and at harvest stages were not affected by cow dung and ethephon rates and no interaction between cow dung and ethephon rates was observed. Under non-stress conditions, cow dung and ethephon rates did not affect water tension at all stages measured (V6, F and 3 weeks after 50% flowering at harvest stages) . No interaction between cow dung and ethephon rates was observed. The results were similar to water tension in soil under stress conditions where it was not affected by ethephon treatment and cow dung application.

Yield and Yield Components

Ear Length

The effects of cow dung and ethephon on ear length of corn under water stress and non-stress conditions were shown in Table 5. The results showed that ear length was not affected by cow dung and ethephon rates and no interaction between cow dung and ethephon rates was observed. Under non-stress conditions, cow dung and ethephon rates did not affect ear length. There was no interaction between cow dung and ethephon rates was observed. The results were similar to ear length under stress conditions where it was not affected by ethephon and cow dung rates.

Ear length to the top-most seed

The effects of cow dung and ethephon on Ear length to the top-most seed of corn under water stress and non-stress conditions were shown in Table 5. The results showed that ear length to the top-most seed was not affected by cow dung and ethephon rates and no interaction between cow dung and ethephon rates was observed. Under non-stress conditions, cow dung and ethephon rates did not affect ear length to the top-most seed. There was no interaction between cow dung and ethephon rates was observed. The results were similar to ear length to the top-most seed under stress conditions which was not affected by ethephon and cow dung rates.

Ear Diameter

The effects of cow dung and ethephon on ear diameter corn under water stress and non-stress conditions were shown in Table 5. The results showed that ear diameter was affected by cow dung rates but not affected by ethephon rates and interaction between cow dung and ethephon. Under non- stress conditions, cow dung rates did not affect ear diameter. No interaction between cow dung and ethephon rates was observed. Considering ethephon rates under non-stress, corn ear diameter was significantly affected by ethephon (15.2, 14.8 and 14.6 cm for E0, E1.5 and E3, respectively). The results were that corn ear diameter under stress conditions was not affected by ethephon rates, however, under non-stress conditions, ear diameter decreased with increasing ethephon rates.

Table 4 Effects of cow dung and ethephon on soil water tension at V6, 50% flowering (F), 3 weeks after 50% flowering (3F) and at harvest stages (HV) of hybrid corn grown under water stress and non-stress conditions.

Cow dung (C)	Eth. Rate (E)	C*E	Stress conditions				Non-stress conditions			
			V6 (cm)	F (cm)	3F (cm)	HV (cm)	V6 (cm)	F (cm)	3F (cm)	HV (cm)
C0			11.3	22.0	55.3	26.7	11.5	24.0	25.8	25.7
C1			11.7	22.7	52.2	25.7	10.8	23.7	25.2	24.0
F-test			NS	NS	NS	NS	NS	NS	NS	NS
	E0		12.5	22.0	55.7	25.5	11.5	22.5	26.3	24.8
	E1.5		10.5	21.0	53.3	24.5	10.8	24.0	25.3	24.0
	E3		11.5	24.0	52.5	28.5	11.3	25.0	24.8	25.8
	F-test		NS	NS	NS	NS	NS	NS	NS	NS
		C0E0	13.0	21.0	55.8	26.0	12.5	23.0	26.7	25.5
		C0E1.5	10.0	20.0	53.2	25.0	10.5	24.0	26.3	23.5
		C0E3	11.0	25.0	57.0	29.0	11.5	25.0	24.5	28.0
		C1E0	12.0	23.0	55.3	25.0	10.5	22.0	26.0	24.0
		C1E1.5	11.0	22.0	53.3	24.0	11.0	24.0	24.3	24.5
		C1E3	12.0	23.0	48.0	28.0	11.0	25.0	25.2	23.5
		F-test	NS	NS	NS	NS	NS	NS	NS	NS

Table 4 (Continued)

Cow dung (C)	Eth. Rate (E)	C*E	Stress conditions V6 (cm)	Stress conditions F (cm)	Stress conditions 3F (cm)	Stress conditions HV (cm)	Non-stress conditions V6 (cm)	Non-stress conditions F (cm)	Non-stress conditions 3F (cm)	Non-stress conditions HV (cm)
	CV%	C	13.7	11.8	8.2	11.3	10.0	10.6	7.6	8.5
		E	14.2	11.6	10.8	10.6	9.0	13.5	6.5	9.6
		C*E	13.3	11.6	8.4	11.3	10.7	12.8	7.2	7.7
	LSD	C	2.1	3.5	5.8	3.9	1.5	3.4	2.2	2.8
		E	2.8	4.5	10.1	4.8	1.7	5.6	3.3	4.1
		C*E	4.2	7.2	12.5	8.2	3.3	8.5	5.1	5.3

NS = not significant

* = significantly difference at 95% level of confidence

** = highly significant difference at 99% level of confidence

Table 5 Effects of cow dung and ethephon on ear length, ear length to the top-most seed and ear diameter of corn hybrid grown under water stress and non-stress conditions.

			Stress conditions			Non-stress conditions		
Cow dung (C)	Eth. Rate (E)	C*E	Ear length (cm)	Ear length to the top-most seed (cm)	Ear diameter (cm)	Ear length (cm)	Ear length to the top-most seed (cm)	Ear diameter (cm)
C0			16.1	14.3	14.7	16.5	14.8	14.8
C1			16.2	14.5	15.0	16.6	14.8	15.0
F-test			NS	NS	*	NS	NS	NS
	E0		16.1	14.6	15.1	16.9	15.3	15.2[a]
	E1.5		16.4	14.6	14.8	16.6	14.7	14.8[b]
	E3		15.9	14.0	14.5	16.2	14.3	14.6[b]
	F-test		NS	NS	NS	NS	NS	*
		C0E0	16.1	14.6	15.1	16.7	15.3	15.2
		C0E1.5	16.2	14.4	14.5	16.5	14.8	14.6
		C0E3	16.0	13.9	14.4	16.4	14.2	14.5
		C1E0	16.2	14.6	15.1	17.1	15.3	15.2
		C1E1.5	16.6	14.7	15.2	16.8	14.7	14.9
		C1E3	15.8	14.1	14.7	15.9	14.4	14.8
		F-test	NS	NS	NS	NS	NS	NS

Table 5 (Continued)

Cow dung (C)	Eth. Rate (E)	C*E	Stress conditions			Non-stress conditions		
			Ear length (cm)	Ear length to the top-most seed (cm)	Ear diameter (cm)	Ear length (cm)	Ear length to the top-most seed (cm)	Ear diameter (cm)
	CV%	C	5.2	6.1	4.1	5.6	8.4	2.7
		E	4.9	6.5	3.3	5.5	7.7	2.5
		C*E	5.7	6.5	3.9	5.7	8.7	2.1
	LSD	C	0.7	0.8	1.0	1.6	1.1	0.3
		E	0.8	1.0	0.5	1.0	1.2	0.4
		C*E	1.4	1.5	0.9	1.5	2.0	0.5

NS = not significant

* = significantly difference at 95% level of confidence

** = highly significant difference at 99% level of confidence

Dry accumulation in plant

The effects of cow dung and ethephon on dry accumulation in plant of corn under water stress and non-stress conditions were shown in Table 6. The results showed that dry accumulation in plant was not affected by cow dung, ethephon rates and no interaction between cow dung and ethephon rates was observed. Under non-stress conditions, cow dung and ethephon rates did not affect dry accumulation in plant. There was no interaction between cow dung and ethephon rates was observed. The results were similar to dry accumulation in plant under stress conditions where it was not affected by ethephon and cow dung rates.

Harvest Index (HI)

The effects of cow dung and ethephon on HI of corn under water stress and non-stress conditions were shown in Table 6. The results showed that HI was not affected by cow dung, ethephon rates and no interaction between cow dung and ethephon rates was observed. Under non-stress conditions, cow dung and ethephon rates did not affect HI. There was no interaction between cow dung and ethephon rates was observed. The results were similar to HI under stress conditions where it was not affected by ethephon and cow dung rates.

Table 6 Effects of cow dung and ethephon on dry matter accumulation in plant (DAP) and HI value of corn hybrid grown under water stress and non stress conditions.

Cow dung (C)	Eth. Rate (E)	C*E	Stress conditions DAP (kg)	Stress conditions HI (seed/ plant)	Non-stress conditions DAP (kg)	Non-stress conditions HI (seed/ plant)
C0			2.9	0.4	3.0	0.5
C1			2.9	0.4	3.1	0.5
F-test			NS	NS	NS	NS
	E0		3.2	0.5	3.3	0.5
	E1.5		3.0	0.5	3.0	0.5
	E3		2.6	0.4	2.9	0.4
	F-test		NS	NS	NS	NS
		C0E0	3.3	0.4	3.2	0.5
		C0E1.5	2.9	0.4	2.9	0.5
		C0E3	2.5	0.4	2.8	0.4
		C1E0	3.2	0.5	3.4	0.5
		C1E1.5	3.0	0.5	3.1	0.5
		C1E3	2.6	0.4	3.0	0.5
		F-test	NS	NS	NS	NS

Table 6 (Continued)

Cow dung (C)	Eth. Rate (E)	C*E	Stress conditions		Non-stress conditions	
			DAP (kg)	HI (seed/ plant)	DAP (kg)	HI (seed/ plant)
	CV%	C	13.4	11.2	10.2	10.5
		E	10.4	9.3	9.6	9.9
		C*E	9.2	10.2	10.6	12.0
	LSD	C	0.5	0.1	0.4	0.1
		E	0.5	0.1	0.5	0.1
		C*E	0.7	0.1	0.9	0.2

NS = not significant
 * = significantly difference at 95% level of confidence
** = highly significant difference at 99% level of confidence

Number of Seeds/Ear

The effects of cow dung and ethephon on number of seeds/ear of corn under water stress and non-stress conditions were shown in Table 7. The results showed that number of seeds/ear was not affected by cow dung rates and interaction between cow dung and ethephon. However, ethephon rates affected number of seeds/ear (528.9, 524.5 and 487.9 seeds for E0, E1.5 and E3, respectively). Under non-stress conditions, ethephon rates did not affect number of seeds/ear. No interaction between cow dung and ethephon rates was observed. Considering cow dung rates, number of seeds/ear was significantly affected by cow dung (519.5 and 537.4 seeds for C0 and C1, respectively). The results were that number of seeds/ear under stress conditions was affected by ethephon where increasing ethephon rates decreased number of seeds but under non-stress conditions number of seeds/ear was affected by cow dung where increasing cow dung rates increased number of seeds/ear.

Weight of 1,000 seeds

The effects of cow dung and ethephon on weight of 1,000 seeds of corn under water stress and non-stress conditions were shown in Table 7. The results showed that weight of 1,000 seeds was not affected by cow dung, ethephon rates and no interaction between cow dung and ethephon rates was observed. Under non- stress conditions, cow dung and ethephon rates did not affect weight of 1,000 seeds. There was no interaction between cow dung and ethephon rates was observed. The results were similar to weight of 1,000 seeds under stress conditions where it was not affected by ethephon and cow dung rates.

Seed Yield at 15% of Moisture

The effects of cow dung and ethephon on seed yield at 15% moisture content of corn under water stress and non-stress conditions were shown in Table 7. The results showed that seed yield at 15% moisture was not affected by cow dung, ethephon rates and no interaction between cow dung and ethephon rates was observed. Under non- stress conditions, cow dung rates did not affect seed yield at 15% moisture. No interaction between cow dung and ethephon rates was observed. Considering ethephon rates, corn seed yield at 15% moisture was significantly affected by ethephon (1,164.4, 1,151.0 and 998.2 kg for E0, E1.5 and E3, respectively). The results were that under stress conditions was not affected on seed yield at 15% moisture whereas under non-stress conditions seed yield at 15% moisture was affected by ethephon where increasing ethephon rates decreased seed yield at 15% moisture.

Table 7 Effects of cow dung and ethephon on yield components and grain yield of corn hybrid grown under water stress and non-stress conditions.

Cow dung (C)	Eth. Rate (E)	C*E	Stress conditions			Non-stress conditions		
			Number of seeds / ear (seeds)	Weight of 1000 seeds (g)	Seed yield at 15% of moisture (kg)	Number of seeds / ear (seeds)	Weight of 1000 seeds (g)	Seed yield at 15% of moisture (kg)
C0			509.2	309.1	876.1	519.5[b]	312.7	1044.4
C1			518.4	317.7	996.5	537.4[a]	315.6	1164.8
F-test			NS	NS	NS	*	NS	NS
	E0		528.9[a]	317.8	997.8	536.7	321.0	1164.6
	E1.5		524.5[a]	314.3	972.0	528.8	316.6	1151.0
	E3		487.9[b]	308.1	839.0	520.0	304.8	998.2
	F-test		*	NS	NS	NS	NS	NS
		C0E0	525.0	315.3	950.1	531.4	317.0	1026.0
		C0E1.5	512.3	306.5	871.1	518.5	315.3	1114.3
		C0E3	490.1	305.5	807.1	508.7	305.8	992.8
		C1E0	532.8	320.3	1045.5	542.1	325.0	1303.2
		C1E1.5	536.7	322.0	1073.0	539.0	318.0	1187.7
		C1E3	485.7	310.8	870.9	531.2	303.8	1003.7
		F-test	NS	NS	NS	NS	NS	NS

Table 7 (Continued)

Cow dung (C)	Eth. Rate (E)	C*E	Stress conditions: Number of seeds / ear (seeds)	Stress conditions: Weight of 1000 seeds (g)	Stress conditions: Seed yield at 15% of moisture (kg)	Non-stress conditions: Number of seeds / ear (seeds)	Non-stress conditions: Weight of 1000 seeds (g)	Non-stress conditions: Seed yield at 15% of moisture (kg)
	CV%	C	6.4	7.8	15.1	3.4	4.5	14.3
		E	4.8	7.8	15.8	2.9	4.9	12.1
		C*E	5.1	8.7	13.2	3.4	4.1	11.2
	LSD	C	28.4	21.0	122.6	15.5	12.3	136.5
		E	26.0	23.9	161.4	15.9	16.1	197.8
		C*E	40.4	42.0	190.7	27.6	19.9	1044.4

NS = not significant

* = significantly difference at 95% level of confidence

** = highly significant difference at 99% level of confidence

Discussions of Experiment I

This research aimed at investigating the effects of cow dung with different ethephon rates on growth and yield of corn under drought condition in the dry season. SW 4452 was grown in a split plot in randomized complete block design (RCBD) with 4 replications. The main plots were cow dung rates (C0= cow dung 0 ton/ rai and C1 = cow dung 1 ton/ rai). The sub plots were 3 rates of ethephon (3%) (E0 = ethephon 0 l/rai, E1.5 = ethephon 1.5 l/ rai and E_3 = ethephon 3.0 l/ rai). Ethephon was foliar-applied at V6 stage of corn. There were 2 identical experiments under different water regimens. One in which corn received irrigation water at 7 day interval throughout the course of the experiment and another in which corn was weekly irrigated and irrigation water was withdrawn for 3 weeks beginning from 50% flowering.

The Cow dung effects

The results revealed that under stress conditions growth characteristics of SW4452 corn, The corn with cow dung was larger ear diameter. This result was consistent with Efthimiadou *et al.* (2010) who reported that organic soil amendments (poultry, cow manure and barley) increased the level of soil organic matter and total nitrogen. The highest height, dry weight, leaf area index and yield were recorded with the cow manure treatments (with or without chemical fertilizer).

For under non stress condition, the effects of cow dung on corn SW4452, plant height was significantly different ear diameter that corn with cow dung at harvest (179.2 cm) was larger than corn without cow dung (174.0 cm) as the same result with Efthimiadou *et al.* (2010) which reported the most significant impact was observed when cow manure was applied to soil.

The Ethephon Effects

For the study of the effects of ethephon on SW4452 corn growth under stress condition, greater ethephon rates significantly reduced plant height since 50%

flowering, 3 F and at harvest stages. After ethephon was sprayed, at 50% flowering LAI was highly significantly different. This meant the greater ethephon reduced LAI. For yield and yield components, corn with non-ethephon maintained most ear diameter which had the same result with Norberg *et al*. (1986), who reported grain yield was not strongly decreased by using lower rate of ethephon. The results showed that greater ethephon significantly reduced number of seed. This result was consist with Cox *et al.* (1988) who reported that ethephon reduced plant height, ear height and grain yield of corn.

For under non stress condition, the study the effects of ethephon on corn SW4452 growth, greater ethephon rates significantly reduced plant height since 50% flowering. Moreover, greater ethephon rates significantly reduced ear height. The result showed that greater ethehon significantly reduced LAI. Similar results have conducted by Kasele *et al*. (1994) which the results revealed that increasing ethephon rates produced either a linear or curvilinear reduction in plant height, LAI and dry matter yield. For development characteristics, the effect of ethephon under non-stress condition. It showed that corn with non ethephon was significantly lowest days to tasselling and days to silking but ASI was not different. This meant the greater ethephon had more days to tasselling and days to silking. Moreover, ear diameter, it showed that greater ethephon significantly reduced ear diameter which the result was consist to Frederick *et al*. (1990) who reported yield reduction in corn due to drought stress depends upon numerous factors, such as the stage of plant development, the severity and duration of water deficiency and susceptibility of the hybrids.

The result was non-significant for stressed condition but the trend was that greater ethephon rates reduced corn grain yields from control. Non-ethephon had the most seed yield at 15% of moisture (997.8 kg/rai) followed by ethephon 1.5 liter/rai (972.0 kg/rai) and ethephon 3 liters/rai (839.0 kg/rai) respectively. This results were different to Kasele *et al.* (1994) who reported that ethephon could be used to reduce early season crop water use by reducing LAI, resulting in extended water available for critical reproductive and gain filling processes and thereby increase gain under drought stress. For non-stressed condition, the result was significant especially for E3 (3.0 l/rai) with E0 had the most seed yield at 15% of moisture followed by E1.5 and

E3 respectively (E0 = 1,154.6 kg, E1.5 = 1,150.9 kg, E3 = 998.2 kg). Finally, greater ethephon rates shorten corn plant height (E0 vs E1.5 vs E3 = 187.3 vs 163.7 vs 124.6 cm under stressed and 195.3 vs 170.5 vs 164.0 cm under non-stressed conditions). and reduced LAI (E0 vs E1.5 vs E3 = 3.4 vs 2.8 vs 2.6 under stressed and 3.8 vs 3.3 vs 2.8 under non-stressed conditions), thus, reducing crop water use (E0 vs E1.5 vs E3 = 55.7 vs 53.3 vs 52.5 cbar under stressed and 26.3 vs 25.3 vs 24.8 cbar under non-stressed conditions). As a consequence, soil water was saved for corn use at later stages of growth, when stressed was subsided.

The Ethephon and Cow dung Effects

For the study of the effects of cow dung and ethephon on corn SW4452, there was no interaction between cow dung and ethephon rates. There still was tendency that under stress that cow dung combination with ethephon rate 1.5 liter/rai (1,073.0 kg/rai) increased grain yield of corn as compared with control (1,045.5 kg/rai) and more than cow dung with ethephon rate 3 liter/rai (870.9kg/rai) the other treatments. This result was consistent with Sarobol *et al*. (2002) reported that ethephon rate 1.5 liter/rai interaction with plant spacing under drought stress for 2 weeks during flowering increased grain yield of corn SW3851 as compared with control and the other treatments. Considering the interaction between cow dung and ethephon, although it was not significantly different but the trend was that under non stress condition cow dung with non ethephon increased most grain yield of corn (1303.2 kg/rai). This result was consistent with Sarobol *et al*. (2002) reported that greater ethephon decreased grain yield of corn from the reduction of kernel weight or kernel number.

Experiment II

Effect of Variety and Cow Dung
in Combination with Chemical Fertilizer on Growth and Yield Components

Effects of variety and cow dung (C) in combination with chemical fertilizer (N) on growth and yield of corn were examined. Two corn hybrids, SW4452 (S1) and SW4901 (S2), were main plots and 3 rates of cow dung and chemical fertilizer combinations were sub plots (CN1=C0+N20 , CN2=C1+N20 and CN3=C1+N10).

Growth and Growth Characteristics

Plant Height

The effects of corn hybrid and cow dung in combination with chemical fertilizer on plant height at different growth stages of corn under water stress and non-stress conditions were shown in Table 8. The results showed that plant height at V6, 50% flowering, 3 weeks after 50% flowering and at harvest stages were affected by corn hybrid (SW4452 andSW4901) at 3 weeks after 50% flowering and at harvest (174.4 and 181.9 cm; 185.3 and 194.3 cm for 3 weeks after 50% flowering and at harvest, respectively).

There were no effect of cow dung in combination with chemical fertilizer on plant height at all stages measured (V6, 50% flowering, 3 weeks after 50% flowering and at harvest stages) . No interaction between corn hybrid and cow dung combined with chemical fertilizer rates was observed (Table 8). Under non- stress conditions (Table 8), two corn hybrid affected on plant height at V6 (21.6 and 23.5 cm for SW4452 and SW4901 and N also affected on plant height at V6 (21.7, 23.8 and 22.11 cm for cow dung 0 ton per rai + (16-20-0) 20 kg per rai; CN1, cow dung 1 ton per rai + (16-20-0) 20 kg per rai; CN2 and cow dung 1 ton per rai+ (16-20-0) 10 kg per rai; CN3, respectively). No interaction between corn hybrid and cow dung combined with chemical fertilizer rates was observed (Table 8). The results of corn plant height under stressed conditions were affected by corn hybrid at 3 weeks after 50%

flowering and at harvest stages whereas non-stressed conditions were affected in V6 only ,where SW4901 were higher than SW4452.

Table 8 The effects of corn hybrid and chemical fertilizer in combination with cow dung on plant height of corn grown at V6, 50% flowering (F), 3 weeks after 50% flowering (3F) and at harvest stages (HV) under water stressed and non-stress conditions.

Corn Hybrid (S)	Cow dung with chemical fertilizer Rate (CN)	S* CN	Stress conditions				Non-stress conditions			
			V6 (cm)	F (cm)	3F (cm)	HV (cm)	V6 (cm)	F (cm)	3F (cm)	HV (cm)
S1			20.8	149.5	174.4	185.3	21.6	150.5	183.7	192.9
S2			21.1	155.5	181.9	194.3	23.5	156.5	187.3	199.4
F-test			NS	NS	*	*	*	NS	NS	NS
	CN1		20.1	150.5	178.5	188.2	21.7[b]	151.3	183.3	192.9
	CN2		22.7	156.5	181.7	193.7	23.8[a]	158.2	190.8	202.1
	CN3		20.0	150.4	174.2	187.5	22.1[b]	151.0	182.5	193.5
	F-test		NS	NS	NS	NS	*	NS	NS	NS
		S1CN1	20.0	148.3	173.9	182.6	21.0	148.3	180.8	188.2
		S1CN2	22.5	155.2	177.8	190.9	22.7	158.0	191.3	199.6
		S1CN3	19.8	144.9	171.4	182.4	21.1	145.1	179.1	191.0
		S2CN1	20.1	152.8	183.1	193.8	22.4	154.4	185.7	197.6
		S2CN2	22.9	157.8	185.6	196.6	24.9	158.3	190.3	204.5
		S2CN3	20.2	155.9	176.9	192.5	23.2	156.9	185.9	196.0
		F-test	NS	NS	NS	NS	NS	NS	NS	NS

Table 8 (Continued)

Corn Hybrid (S)	Cow dung with chemical fertilizer Rate (CN)	S* CN	Stress conditions				Non-stress conditions			
			V6 (cm)	F (cm)	3F (cm)	HV (cm)	V6 (cm)	F (cm)	3F (cm)	HV (cm)
	CV%	SW	10.4	5.8	4.2	5.0	6.9	7.6	4.5	4.5
		CN	11.3	5.6	4.3	4.8	5.6	6.8	4.2	4.2
		S*CN	8.4	5.9	4.1	5.3	5.3	8.0	4.1	4.1
	LSD	SW	1.9	7.7	6.4	8.3	1.3	10.2	7.2	7.6
		CN	3.5	8.9	8.1	9.6	1.3	11.0	8.2	8.6
		S*CN	2.7	14.0	11.2	15.6	1.8	18.9	11.8	12.5

NS = not significant

* = significantly difference at 95% level of confidence

** = highly significant difference at 99% level of confidence

Ear Height

The effects of corn hybrid and cow dung combined with chemical fertilizer (CN) rates on ear height of corn under water stressed were shown in Table 9. The results showed that ear height was not affected by corn hybrid, chemical fertilizer rates and no interaction between corn hybrid and cow dung combined with chemical fertilizer. Under non- stress conditions (Table 9), corn hybrid and cow dung combined with chemical fertilizer rates did not affect ear height. No interaction between corn hybrid and cow dung combined with chemical fertilizer rates was observed. The results were that corn ear height under stress conditions was not different from under non-stress conditions

Days to Tasselling

The effects of corn hybrid and cow dung in combination with chemical fertilizer on days to tasselling of corn under water stressed conditions were shown in Table 9. The results showed that days to tasselling was not affected by corn hybrid, cow dung combined with chemical fertilizer (CN) rates and no interaction between corn hybrid and cow dung combined with chemical fertilizer. Under non-stressed conditions (Table 9), corn hybrid did not affect days to tasselling. No interaction between corn hybrid and cow dung combined with chemical fertilizer rates was observed. Considering cow dung combined with chemical fertilizer (CN), days to tasselling was significantly affected by chemical fertilizer (61.9, 60.5 and 61.1 days for CN1, CN2 and CN3, respectively). The results were that days to tasselling under stress conditions were not affected where under non-stressed conditions, CN2 was shortest days to tasselling.

Days to Silking

The effects of corn hybrid and cow dung in combination with chemical fertilizer on days to silking of corn under water stressed conditions were shown in Table 9. The results showed that days to silking was not affected by corn hybrid , chemical fertilizer (CN) rates and no interaction between corn hybrid and cow dung combined with chemical fertilizer (CN) rates. Under non-stressed conditions (Table 9), corn hybrid and cow dung combined with chemical fertilizer rates did not affect days to silking. No interaction between corn hybrid and cow dung combined with chemical fertilizer rates was observed. The results were that days to silking under stressed conditions was not different from under non-stressed conditions.

Anthesis to Silking Interval (ASI)

The effects of corn hybrid and cow dung in combination with chemical fertilizer on ASI of corn under water stress conditions were shown in Table 9. The results showed that ASI was not affected by corn hybrid, cow dung combined with chemical fertilizer (CN) rates and no interaction between corn hybrid and cow dung combined with chemical fertilizer (CN). Under non- stressed conditions (Table 9), corn hybrid and cow dung combined with chemical fertilizer rates did not affect ASI. No interaction between corn hybrid and cow dung combined with chemical fertilizer rates was observed. The results were that ASI under stressed conditions was not different from under non-stressed conditions.

Table 9 The effects of corn hybrid and chemical fertilizer in combination with cow dung on ear height, days to tasselling (DTT) and days to silking (DTS) of corn grown under water stress and non-stressed conditions.

Corn Hybrid (S)	Cow dung with chemical fertilizer Rate (CN)	S* CN	Stress conditions				Non-stress conditions			
			Ear height (cm)	DTT (days)	DTS (days)	ASI	Ear height (cm)	DTT (days)	DTS (days)	ASI
S1			118.2	63.6	67.0	3.4	121.4	61.3	64.4	3.2
S2			118.5	63.0	66.4	3.4	122.9	61.1	64.3	3.2
F-test			NS	NS	NS	NS	NS	NS	NS	NS
	CN1		117.2	63.3	66.8	3.5	121.9	61.9[a]	65.1	3.3
	CN2		121.2	63.0	66.3	3.3	124.2	60.5[b]	63.8	3.3
	CN3		116.7	63.6	67.1	3.5	120.4	61.1[ab]	64.1	3.0
	F-test		NS	NS	NS	NS	NS	*	NS	NS
		S1CN1	118.5	63.5	67.0	3.5	119.4	62.0	65.3	3.3
		S1CN2	120.1	63.3	66.5	3.3	123.3	60.5	63.8	3.3
		S1CN3	116.0	64.0	67.5	3.5	121.5	61.3	64.3	3.0
		S2CN1	116.0	63.0	66.5	3.5	124.4	61.8	65.0	3.3
		S2CN2	122.3	62.8	66.0	3.3	125.1	60.5	63.8	3.3
		S2CN3	117.3	63.3	66.8	3.5	119.2	61.0	64.0	3.0
		F-test	NS	NS	NS	NS	NS	NS	NS	NS

Table 9 (Continued)

Corn Hybrid (S)	Cow dung with chemical fertilizer Rate (CN)	S* CN	Stress conditions				Non-stress conditions			
			Ear height (cm)	DTT (days)	DTS (days)	ASI	Ear height (cm)	DTT (days)	DTS (days)	ASI
	CV%	SW	6.1	1.5	1.8	13.4	5.2	1.7	1.7	9.1
		CN	6.0	1.5	1.9	16.2	5.8	1.5	1.5	12.9
		S*CN	6.5	1.6	1.9	14.6	5.5	1.5	1.5	9.1
	LSD	SW	6.3	0.8	1.0	0.4	0.9	1.0	0.3	0.9
		CN	7.4	1.0	1.4	0.6	1.0	1.0	0.6	1.0
		S*CN	11.9	1.6	1.9	0.8	1.4	1.5	0.4	1.4

NS = not significant

* = significantly difference at 95% level of confidence

** = highly significant difference at 99% level of confidence

Drought Stress

Leaf Area Index (LAI)

The effects of corn hybrid and cow dung in combination with chemical fertilizer on LAI at different growth stages of corn under water stress conditions were shown in Table 10. The results showed that LAI at V6 and 3 weeks after 50% flowering stages were not affected by corn hybrid. Considering cow dung combined with chemical fertilizer (CN) rates, LAI was statistically affected by N rates at 3 weeks after 50% flowering (3.1, 3.3 and 3.5 for CN1, CN2 and CN3, respectively). Under non-stressed conditions (Table 10), LAI was not affected by chemical fertilizer (N) rates. No interaction between corn hybrid and cow dung combined with chemical fertilizer (CN) rates was observed. Considering corn hybrid, LAI was significantly affected by corn hybrid at V6 and 3 weeks after 50% flowering stages (0.5, 0.6 and 3.6 and 3.7 for SW4452 and SW4901, respectively). The results were different from under stressed conditions where SW4901 had more LAI than SW4452 at 50%flowering stage.

Soil Water Tension

The effects of corn hybrid and cow dung in combination with chemical fertilizer on soil water tension at different growth stages of corn under water stress conditions were shown in Table 11. The results showed that water tension at V6, 50% flowering, 3 weeks after 50% flowering and at harvest was not affected by corn hybrid and no interaction between corn hybrid and cow dung combined with chemical fertilizer rates was observed. However, N affected water tension at harvest (32.5, 36.5 and 40.5 cbar for CN1, CN2 and CN3, respectively). Under non-stressed conditions (Table 11), corn hybrid and cow dung combined with chemical fertilizer rates did not affect soil water tension at all stages measured (V6, 50% flowering, 3 weeks after 50% flowering and at harvest stages) . No interaction between corn hybrid and cow dung combined with chemical fertilizer rates was observed . The results were different from under stress conditions where CN1 rate was lowest soil water tension.

Table 10 The effects of corn hybrid and chemical fertilizer in combination with cow dung on LAI at V6, 50% flowering (F) and 3 weeks after 50% flowering stages (3F) of corn grown under water stress and non-stressed conditions.

Corn Hybrid (S)	Cow dung with chemical fertilizer Rate (CN)	S* CN	Stress conditions			Non-stress conditions		
			V6 (cm)	F (cm)	3F (cm)	V6 (cm)	F (cm)	3F (cm)
S1			0.4	3.1	3.2	0.5	3.6	3.6
S2			0.4	3.2	3.4	0.6	3.6	3.8
F-test			NS	NS	NS	NS	NS	NS
	CN1		0.4	3.1	3.1[c]	0.5	3.5	3.6
	CN2		0.5	3.2	3.3[b]	0.5	3.7	3.8
	CN3		0.4	3.1	3.5[a]	0.5	3.6	3.7
	F-test		NS	NS	**	NS	NS	NS
		S1CN1	0.4	3.0	3.1	0.4	3.5	3.5
		S1CN2	0.5	3.2	3.2	0.5	3.6	3.7
		S1CN3	0.4	3.1	3.4	0.5	3.6	3.6
		S2CN1	0.5	3.3	3.2	0.5	3.5	3.8
		S2CN2	0.5	3.3	3.4	0.6	3.7	3.9
		S2CN3	0.4	3.2	3.5	0.5	3.6	3.8
		F-test	NS	NS	NS	NS	NS	NS

Table 10 (Continued)

Corn Hybrid (S)	Cow dung with chemical fertilizer Rate (CN)	S* CN	Stress conditions			Non-stress conditions		
			V6 (cm)	F (cm)	3F (cm)	V6 (cm)	F (cm)	3F (cm)
	CV%	SW	18.2	3.5	6.3	11.4	6.8	5.5
		CN	20.5	3.3	3.9	12.1	8.8	5.1
		S*CN	16.6	2.8	3.8	11.7	7.2	5.7
	LSD	SW	0.1	0.1	0.2	0.1	0.2	0.2
		CN	0.1	0.2	0.1	0.1	0.3	0.2
		S*CN	0.1	0.1	0.2	0.1	0.4	0.3

NS = not significant

* = significantly difference at 95% level of confidence

** = highly significant difference at 99% level of confidence

Table 11 The effects of corn hybrid and chemical fertilizer in combination with cow dung on soil water tension at different growth stages of corn grown at V6, 50% flowering (F), 3 weeks after 50% flowering (3F) and at harvest stages (HV) under water stressed and non-stressed conditions.

Corn Hybrid (S)	Cow dung with chemical fertilizer Rate (CN)	S* CN	Stress conditions				Non-stress conditions			
			V6 (cm)	F (cm)	3F (cm)	HV (cm)	V6 (cm)	F (cm)	3F (cm)	HV (cm)
S1			11.7	25.0	68.3	35.7	12.3	23.3	33.8	28.7
S2			12.0	24.7	68.5	37.3	12.5	22.0	31.7	31.7
F-test			NS	NS	NS	NS	NS	NS	NS	NS
	CN1		12.5	22.5	64.6	32.5[b]	12.3	21.5	30.3	27.0
	CN2		11.3	25.0	63.0	36.5[ab]	12.3	22.5	33.8	30.5
	CN3		11.8	27.0	77.7	40.5[b]	12.5	24.0	34.1	33.0
	F-test		NS	NS	NS	*	NS	NS	NS	NS
		S1CN1	12.5	23.0	63.0	32.0	12.0	22.0	31.3	26.0
		S1CN2	11.0	25.0	62.7	35.0	13.0	23.0	34.8	29.0
		S1CN3	11.5	27.0	79.3	40.0	12.0	25.0	35.2	31.0
		S2CN1	12.5	22.0	66.2	33.0	12.5	21.0	29.3	28.0
		S2CN2	11.5	25.0	63.3	38.0	12.0	22.0	32.8	32.0
		S2CN3	12.0	27.0	76.0	41.0	13.0	23.0	33.0	35.0
		F-test	NS	NS	NS	NS	NS	NS	NS	NS

Table 11 (Continued)

Corn Hybrid (S)	Cow dung with chemical fertilizer Rate (CN)	S* CN	Stress conditions V6 (cm)	Stress conditions F (cm)	Stress conditions 3F (cm)	Stress conditions HV (cm)	Non-stress conditions V6 (cm)	Non-stress conditions F (cm)	Non-stress conditions 3F (cm)	Non-stress conditions HV (cm)
	CV%	SW	7.3	14.5	14.6	11.9	10.1	9.9	6.8	12.8
		CN	12.9	13.4	14.6	7.6	10.7	10.2	6.5	10.7
		S*CN	6.9	15.9	11.7	6.3	12.9	11.4	3.5	11.2
	LSD	SW	1.2	4.8	13.3	5.8	1.7	3.0	3.0	5.2
		CN	2.6	5.7	17.2	6.8	2.3	4.0	3.7	5.6
		S*CN	2.3	11.0	22.2	6.4	4.5	7.2	3.2	9.3

NS = not significant

* = significantly difference at 95% level of confidence

** = highly significant difference at 99% level of confidence

Yield and Yield Components

Ear Length

The effects of corn hybrid and cow dung in combination with chemical fertilizer on ear length of corn under water stressed and were shown in Table 12. The results showed that ear length was not affected by cow dung with chemical fertilizer (CN) rates and no interaction between corn hybrid and cow dung combined with chemical fertilizer rates was observed. However, corn hybrid statistically affected ear length (17.0 and 18.4 cm for SW4452 and SW4901, respectively). Under non- stress conditions (Table 12), CN rates did not affect ear length. There was no interaction between corn hybrid and cow dung combined with chemical fertilizer rates was observed. Considering corn hybrid, ear length was statistically affected by corn hybrid (17.5 and 18.9 cm for SW4452 and SW4901, respectively). The results were similar to ear length under stress conditions where ear length of SW4901 was longer.

Ear length to the top-most seed

The effects of corn hybrid and cow dung in combination with chemical fertilizer (CN) rates on ear length to the top-most seed of corn under water stress conditions were shown in Table 12. The results showed that ear length to the top-most seed was not affected by CN rates and no interaction between corn hybrid and cow dung combined with chemical fertilizer (CN) rates was observed. However, corn hybrid statistically affected ear length (15.4 and 16.9 cm for SW4452 and SW4901, respectively). Under non- stressed conditions (Table 12), CN rates did not affect ear length to the top-most seed. There was no interaction between corn hybrid and cow dung combined with chemical fertilizer rates was observed. Considering corn hybrid, Ear length to the top-most seed was affected statistically by corn hybrid (17.7 and 17.3 cm for SW4452 and SW4901, respectively). The results were similar to ear length to the top-most seed under stress conditions where ear length of SW4901 was longer.

Ear Diameter

The effects of corn hybrid and cow dung in combination with chemical fertilizer (CN) rates on ear diameter of corn under water stressed conditions were shown in Table 12. The results showed that ear diameter was not affected by CN rates and interaction between corn hybrid and cow dung combined with chemical fertilizer. However, Corn hybrid ear diameter (15.3 and 14.7 cm for SW4452 and SW4901, respectively). Under non-stressed conditions (Table 12), corn hybrid and cow dung combined with chemical fertilizer rates did not affect ear diameter. No interaction between corn hybrid and cow dung combined with chemical fertilizer rates was observed. The results were that corn ear diameter under stressed conditions was affected by corn hybrid, where ear diameter of SW4901 was longer than SW4452 but it was not affected under non- stressed conditions.

Table 12 The effects of corn hybrid and chemical fertilizer in combination with cow dung on ear length, Ear length to the top-most seed and ear diameter of corn grown under water stress and non-stressed conditions.

Corn Hybrid (S)	Cow dung with chemical fertilizer Rate (CN)	S* CN	Stress conditions			Non-stress conditions		
			Ear length (cm)	Ear length to the top-most seed (cm)	Ear diameter (cm)	Ear length (cm)	Ear length to the top-most seed (cm)	Ear diameter (cm)
S1			17.0	15.4	15.3	17.5	15.7	15.7
S2			18.4	16.9	14.7	18.9	17.3	15.5
F-test			**	**	*	**	**	NS
	CN1		17.7	16.0	15.2	18.0	16.4	15.4
	CN2		17.9	16.3	15.0	18.4	16.7	16.0
	CN3		17.6	16.1	14.8	18.3	16.5	15.2
	F-test		NS	NS	NS	NS	NS	NS
		S1CN1	17.2	15.3	15.5	17.4	15.6	15.5
		S1CN2	17.1	15.6	15.2	17.5	15.9	16.1
		S1CN3	16.8	15.4	15.0	17.6	15.8	15.5
		S2CN1	18.1	16.7	14.9	18.6	17.1	15.4
		S2CN2	18.7	17.1	14.7	19.2	17.5	16.0
		S2CN3	18.5	16.8	14.6	19.0	17.3	15.0
		F-test	NS	NS	NS	NS	NS	NS

Table 12 (Continued)

Corn Hybrid (S)	Cow dung with chemical fertilizer Rate (CN)	S* CN	Stress conditions			Non-stress conditions		
			Ear length (cm)	Ear length to the top-most seed (cm)	Ear diameter (cm)	Ear length (cm)	Ear length to the top-most seed (cm)	Ear diameter (cm)
	CV%	SW	4.4	4.4	2.3	3.6	4.5	3.7
		CN	5.2	5.0	2.2	4.5	5.2	3.2
		S*CN	4.8	4.9	2.1	3.9	5.0	2.9
	LSD	SW	1.0	0.6	0.3	0.6	0.6	0.5
		CN	0.7	0.8	0.3	0.9	0.9	0.5
		S*CN	1.3	1.2	0.5	1.1	1.3	0.7

NS = not significant

* = significantly difference at 95% level of confidence

** = highly significant difference at 99% level of confidence

Dry accumulation in plant

The effects of corn hybrid and cow dung in combination with chemical fertilizer (CN) rates on dry accumulation in plant of corn under water stress conditions were shown in Table 13. The results showed that dry accumulation in plant was not affected by SW, CN rates and no interaction between corn hybrid and cow dung combined with chemical fertilizer rates was observed. Under non-stressed conditions (Table 13), CN rates did not affect dry accumulation in plant. There was no interaction between S and CN rates was observed. Considering corn hybrid, dry accumulation in plant was affected by corn hybrid (3.8 and 4.3 kg for SW4452 and SW4901, respectively). The results were that dry accumulation in plant under stress conditions was not affected where there was affected on dry accumulation in plant under non-stressed conditions that SW4901 was more than SW4452.

Harvest Index (HI)

The effects of corn hybrid (S) and cow dung in combination with chemical fertilizer (CN) rates on HI of corn under water stressed conditions were shown in Table 13. The results showed that HI was not affected by corn hybrid, CN rates and no interaction between corn hybrid and cow dung combined with chemical fertilizer (CN) rates was observed. Under non-stressed conditions (Table 13), CN rates did not affect HI. There was no interaction between corn hybrid and cow dung combined with chemical fertilizer rates was observed. Considering corn hybrid, Harvest Index (HI) was statistically affected by corn hybrid (0.6 and 0.4 for SW4452 and SW4901, respectively). The results were similar to HI under stressed conditions where SW4901 had more HI than SW4452.

Table 13 The effects of corn hybrid and chemical fertilizer in combination with cow dung on dry accumulation in plant (DAP) and HI of corn grown under water stress and non-stress conditions.

Corn Hybrid (S)	Cow dung with chemical fertilizer Rate (CN)	S* CN	Stress conditions		Non-stress conditions	
			DAP (kg)	HI (seed/ plant)	DAP (kg)	HI (seed/ plant)
S1			3.6	0.6	3.7	0.6
S2			3.7	0.5	4.3	0.4
F-test			NS	NS	*	**
	CN1		3.5	0.5	3.8	0.5
	CN2		3.8	0.5	4.2	0.5
	CN3		3.7	0.5	4.0	0.5
	F-test		NS	NS	NS	NS
		S1CN1	3.4	0.5	3.5	0.6
		S1CN2	3.7	0.6	3.8	0.7
		S1CN3	3.7	0.5	3.7	0.6
		S2CN1	3.5	0.5	4.2	0.4
		S2CN2	3.9	0.5	4.5	0.4
		S2CN3	3.8	0.5	4.2	0.4
		F-test	NS	NS	NS	NS

Table 13 (Continued)

Corn Hybrid (S)	Cow dung with chemical fertilizer Rate (CN)	S* CN	Stress conditions		Non-stress conditions	
			DAP (kg)	HI (seed/ plant)	DAP (kg)	HI (seed/ plant)
	CV%	SW	7.4	9.2	5.2	7.2
		CN	6.7	8.9	5.3	7.2
		S*CN	7.5	10.1	4.0	6.2
	LSD	SW	0.4	0.1	4.0	0.1
		CN	0.4	0.1	0.3	0.1
		S*CN	0.8	0.1	0.4	0.1

NS = not significant
* = significantly difference at 95% level of confidence
** = highly significant difference at 99% level of confidence

Number of Seeds/Ear

The effects of corn hybrid and cow dung in combination with chemical fertilizer (CN) rates on number of seeds/ear of corn under water stressed conditions were shown in Table 14. The results showed that number of seeds/ear was not affected by corn hybrid, CN rates and no interaction between corn hybrid and cow dung combined with chemical fertilizer (CN) rates. Under non-stressed conditions (Table 14) , corn hybrid and cow dung combined with chemical fertilizer rates did not affect number of seeds/ear. No interaction between corn hybrid and cow dung combined with chemical fertilizer rates was observed. The results were that number of seeds/ear under stress conditions was not different from under non-stressed conditions.

Weight of 1,000 seeds

The effects of corn hybrid and cow dung in combination with chemical fertilizer (CN) rates on weight of 1,000 seeds of corn under water stressed conditions were shown in Table 14. The results showed that weight of 1,000 seeds was not affected by corn hybrid, CN rates and no interaction between corn hybrid and cow dung combined with chemical fertilizer (CN) rates. Under non-stressed conditions (Table 14), corn hybrid and cow dung combined with chemical fertilizer rates did not affect weight of 1,000 seeds. No interaction between corn hybrid and cow dung combined with chemical fertilizer (CN) rates was observed. The results were similar to under stressed conditions.

Seed Yield at 15% of Moisture

The effects of corn hybrid and chemical fertilizer in combination (CN) rates with cow dung on seed yield at 15% of moisture of corn under water stressed conditions were shown in Table 14. The results showed that seed yield at 15% of moisture was not affected by CN rates and no interaction between corn hybrid and cow dung combined with chemical fertilizer rates was observed. However, seed yield at 15% of moisture was affected by corn hybrid (1,068.4 and 921.6 kg for SW4452 and SW4901, respectively). Under non-stressed conditions (Table 14), corn hybrid and cow dung combined with chemical fertilizer (CN) rates did not affect seed yield at 15% of moisture. No interaction between corn hybrid and cow dung combined with chemical fertilizer (CN) rates was observed. The results were that under stressed conditions was affected by corn hybrid where seed yield at 15% of moisture of SW4452 was more than SW4901 whereas under non-stressed conditions seed yield at 15% of moisture was not affected.

Table 14 The effects of corn hybrid and chemical fertilizer in combination with cow dung on yield of corn grown under water stressed and non-stressed conditions.

Corn Hybrid (S)	Cow dung with chemical fertilizer Rate (CN)	S* CN	Stress conditions			Non-stress conditions		
			Number of seeds / ear (seeds)	Weight of 1000 seeds (g)	Seed yield at 15% of moisture (kg)	Number of seeds / ear (seeds)	Weight of 1000 seeds (g)	Seed yield at 15% of moisture (kg)
S1			536.8	319.6	1068.4	561.2	333.0	1196.5
S2			529.9	316.3	921.7	557.8	323.4	1002.0
F-test			NS	NS	*	NS	NS	*
	CN1		525.5	317.8	947.3	550.1	321.5	1019.9
	CN2		540.9	320.3	1045.8	569.3	334.3	1170.7
	CN3		533.6	315.9	992.1	559.0	328.9	1107.2
	F-test		NS	NS	NS	NS	NS	NS
		S1CN1	529.9	318.0	1026.2	548.1	324.5	1113.2
		S1CN2	544.7	321.3	1107.3	576.1	340.5	1260.9
		S1CN3	535.7	319.5	1071.8	559.4	334.0	1215.6
		S2CN1	521.2	317.5	868.4	552.1	318.5	926.7
		S2CN2	537.1	319.3	984.3	562.6	328.0	1080.5
		S2CN3	531.5	312.3	912.3	558.6	323.8	998.7
		F-test	NS	NS	NS	NS	NS	NS

Table 14 (Continued)

Corn Hybrid (S)	Cow dung with chemical fertilizer Rate (CN)	S* CN	Stress conditions			Non-stress conditions		
			Number of seeds / ear (seeds)	Weight of 1000 seeds (g)	Seed yield at 15% of moisture (kg)	Number of seeds / ear (seeds)	Weight of 1000 seeds (g)	Seed yield at 15% of moisture (kg)
	CV%	SW	5.1	6.3	11.5	6.1	4.8	13.9
		CN	4.8	7.2	12.6	5.7	7.0	13.9
		S*CN	5.6	7.2	11.9	6.7	5.0	13.7
	LSD	SW	23.6	17.2	99.2	29.4	5.0	13.7
		CN	26.9	24.0	186.4	33.8	13.6	131.4
		S*CN	46.4	35.1	183.0	57.4	24.0	160.9

NS = not significant
* = significantly difference at 95% level of confidence
** = highly significant difference at 99% level of confidence

Discussions of Experiment II

This research aimed at investigating the effects of cow dung (C) with chemical fertilizer application (N) levels on growth and yield of two hybrid of corn under drought condition in dry season. Corn was grown in a split plot in randomized complete block design (RCBD) with 4 replications. The main plots were two hybrid of corn (SW4452 and SW4901). The sub plots were 3 level application rates of cow dung combined with chemical fertilizer (16-20-0) (CN1 = Cow dung 1 ton per rai with N fertilizer 10 kilograms per rai, CN2 = Cow dung 1 ton per rai with N fertilizer 20 kilograms per rai, CN3 = Cow dung 0 ton per rai with N fertilizer 20 kilograms per rai). There were 2 identical experiments under different water regimens. One in which corn received irrigation water at 7 day interval throughout the course of the experiment and another in which corn was weekly irrigated (non-stressed) and irrigation water was withdrawn for 3 weeks during 50% flowering (stressed condition).

The Variety Effects

The effect of corn hybrid on growth and development characteristics under stressed conditions showed that plant height of different corn varieties was not significantly different at V6 and 50% flowering stages but after that they were significant. During 50% flowering 3 weeks, the result showed that SW4901 had significantly less LAI than SW4452. This meant that SW4901 developed faster than SW4452. The results showed that SW4901 had longer ear length and ear length to the top-most seed, but SW4452 had longer ear diameter.

The effect of corn hybrid on growth and development characteristics under non-stressed conditions was studied. It showed significantly different that corn hybrid with SW4901 was higher than SW4452 at V6 stage that ear height of SW4901 was higher than SW4452. This meant that SW4901 developed faster than SW4452. The results showed that corn hybrid with SW4901 had longer ear length and ear length to the top-most seed but shorter ear diameter than SW4452. Moreover, this also showed that corn hybrid SW4901 had more dry accumulation in plant, but SW4452 had more HI than SW4901.

The results revealed that under non-stressed and stressed conditions, corn grain yields were significantly different that SW4452 yielded greater than SW4901 (SW4452 vs SW4901 = 1,068.4 vs 921.7 kg/rai under stressed and 1,196.5 vs 1,002.0 kg/rai under non-stressed conditions) because of higher number of kernel/ear and weight of 1,000 kernels meanwhile SW4901 had more other yield components. This result was consistent with Jampathong *et al.* (2006) reported that SW4452 had more yield than SW4901 in the experiment of 22 pre-commercial hybrids corn from 16 locations of farm testing. Plant height of corn SW4901 was significantly higher than SW4452 (SW4452 vs SW4901 = 185.3 vs 194.3 cm) under stressed condition. Under non-stressed condition, LAI of SW4901 had significantly more than SW4452 (SW4452 vs SW4901 = 3.6 vs 3.8). This result was consistent with Jampathong *et al.* (2006) reported that agronomic data of SW4901 were greater than SW4452 in the cooperative corn hybrid yield trial from 8 environments.

The Effects of Cow dung combined with Chemical Fertilizer in different rates

The effect of cow dung and chemical fertilizer level on growth and development characteristics under stressed conditions was evaluated and found that LAI, after 3 weeks of water withdrawal, of corn with cow dung 1 ton/rai and chemical fertilizer 10 kg/rai had the lowest LAI. The trend was that corn with cow dung 1 ton/rai and chemical fertilizer 20 kg/rai yielded the most number of seeds/ear, weight of 1,000 seeds and seed yield at 15% of moisture. The results were agreed with Zhao *et al.* (2009) reported that farmyard manure combined with chemical fertilizer management resulted in a higher in maize yield.

For growth and development characteristics under non-stressed conditions, the results showed that in V6 corn with cow dung 1 ton/rai and chemical fertilizer 20 kg/rai gave significantly highest plant and shortest days to tasselling. Similarly, Herencia *et al.* (2009) also reported that the use of organic fertilizer resulted in higher soil organic matter, soil N content and available P and K. Combined organic and inorganic fertilization promoted plant growth (height, dry weight and leaf area index) in comparison to the mineral fertilized and control plots.

According to Herencia *et al*. (2009), combined organic and inorganic fertilization promoted plant growth especially in height, dry weight and leaf area index. For the effects of application rates of cow dung combined with chemical fertilizer on plant height and LAI , the results were non-significant for both stressed and non-stressed conditions but the trend was that corn with cow dung 1 ton per rai with chemical fertilizer 20 kilograms per rai tended to increase corn grain yields and the tendency of greater yield components. Seed yield at 15% of moisture of corn under stressed condition with cow dung 1 ton per rai with chemical fertilizer 20 kilograms per rai had the most yield (1,045.8 kg/rai) CN2 had the greatest seed yield at 15% of moisture followed by 3 weeks after 50% flowering and 50% flowering stages respectively (CN1 = 947.3 kg, CN2 = 1,045.8 kg, CN3 = 992.1 kg). For non-stressed condition, seed yield at 15% of moisture of corn with cow dung 1 ton per rai with CN fertilizer 20 kilograms per rai had the greatest yield (1,170.7 kg/rai) had the most seed yield at 15% of moisture followed by CN3 and CN1 respectively (CN1 = 1,019.9 kg, CN2 = 1,170.7 kg, CN3 = 1,107.2 kg). This was consistent with Babaeian *et al.* (2011) who reported that effect of different proportions of manure and chemical fertilizer and water stress on grain yield at grain filling stage of barley strongly decreased grain yield with the exception of grain number/ear and ear weight, where fertilizer treatments had significant effect on grain yields and yield components. Finally, corn with cow dung 1 ton per rai with N fertilizer 20 kilograms per rai increased plant height (CN1 vs CN2 vs CN3 = 188.2 vs 193.7 vs 187.5 cm under stressed and 192.9 vs 202.08 vs 193.5 cm under non-stressed conditions). Cow dung 0 ton per rai with N fertilizer 20 kilograms per rai significantly increased LAI under stressed condition (CN1 vs CN2 vs CN3 = 3.1 vs 3.3 vs 3.5), but cow dung 1 ton per rai with N fertilizer 20 kilograms per rai reduced crop water use CN1 vs CN2 vs CN3 = 64.6 vs 63.3 vs 77.7 cbar under stressed condition. This was consistent with Shen *et al*. (2000) who reported that for balancing fertilizer application, application in chemical fertilizer could increase the net photosynthesis rate under mild or moderate water stress. It was different from non stressed condition that cow dung 1 ton per rai with N fertilizer 20 kilograms per rai increased most LAI (CN1 vs CN2 vs CN3 = 3.8

vs 3.3 vs 2.8), but cow dung 1 ton per rai with N fertilizer 10 kilograms per rai reduced crop water used (CN1 vs CN2 vs CN3 = 30.3 vs 33.8 vs 34.1 cbar). This result was consistent with Wong *et al*. (2002) who reported that important method of increasing water use efficiency in the field is to manage efficiently the fertilizer application.

CONCLUSION

To assess the effects of cow dung and ethephon (Experiment I) and evaluate the effects of cow dung in combination with chemical fertilizer (Experiment II) on growth and yield of corn, two experiments were carried out using SW4452 hybrid in experiment I and SW4452 and SW4901 in experiment II. The results were concluded hereafter.

For experiment I, under stress condition, cow dung had no impact on all parameters evaluated except for ear diameter. Ethephon significantly reduced corn plant height at 50% flowering, 3 weeks after 50% flowering and at harvest. Additionally, ethephon also reduced leaf area index (LAI) at 50% flowering and 3 weeks after 50% flowering. Nevertheless, grain yield was not affected by cow dung, ethephon and their interaction. Under non stress condition, there was an impact of cow dung and ethephon but their interaction. Cow dung affected plant height at 50% flowering, LAI at V6 and seed number/ear. In addition, ethephon reduced plant height at 50% flowering, 3 weeks after 50% flowering and at harvest, ear height, days to tasselling, days to silking and LAI at 50% flowering and 3 weeks after 50% flowering.

For experiment II, under stress condition, hybrids exhibited different plant height at 3 weeks after 50% flowering and at harvest, ear length, ear length to the top most seeds, ear diameter and grain yield. SW4452 yielded greater than SW4901 (1,068 VS 922 kg/rai). Cow dung in combination with chemical fertilizer did not affect all parameters measured in this study. Under non stress condition, SW4452 also yielded greater than SW4901 (1,197 VS 1,002 kg/rai). Cow dung in combination with chemical fertilizer affected plant height at V6, days to tasselling and silking, and ear diameter. No interaction was observed both under stress and non-stress conditions.

Even though, cow dung, ethephon and cow dung in combination with chemical fertilizer unsucceeded statistically in maintaining corn yield under drought condition, the tendency was that yield tended to increase as compared with control.

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APPENDIX

Appendix

Appendix Table 1 Analysis of variance for effects of cow dung and ethephon on plant height of corn hybrid grown under water stress condition.

Source of variation	d.f.	Mean square			
		V6	50% Flowering	3 weeks after 50% flowering	at Harvest
Replication	3	9.32^{NS}	386.32 ^{NS}	169.38 ^{NS}	75.74 ^{NS}
Main plot (A)	1	4.07 ^{NS}	582.63^{NS}	51.77 ^{NS}	228.17 ^{NS}
Error (a)	3	2.63	206.59	5679.64	58.15
Sub plot (B)	2	0.79 ^{NS}	801.29 *	69.718*	2878.24 *
A× B	2	4.23^{NS}	39.542^{NS}	191.77 ^{NS}	58.15 ^{NS}
Error (b)	12	2.09	90.021	154.90	32.81
Total	23	3.26	222.75	624.81	294.91

Appendix Table 2 Analysis of variance for effects of cow dung and ethephon on development characteristics of corn hybrid grown under water stress condition.

Source of variation	d.f.	Mean square			
		Ear Height	Days to Tasselling	Days to Silking	ASI
Replication	3	294.97 ^{NS}	5.39 ^{NS}	4.28 ^{NS}	0.33 ^{NS}
Main plot (A)	1	246.40 ^{NS}	2.67^{NS}	4.17 ^{NS}	0.17 ^{NS}
Error (a)	2	1041.70	1.67	8.17	0.13
Sub plot (B)	3	77.69^{NS}	7.54*	2.28 *	.28 ^{NS}
A× B	2	.372 ^{NS}	1.04^{NS}	0.67 ^{NS}	0.04 ^{NS}
Error (b)	12	139.29	090	0.69	0.31
Total	23	222.61	2.25	2.17	0.27

Appendix Table 3 Analysis of variance for effects of cow dung and ethephon on LAI of corn hybrid grown under water stress condition.

Source of variation	d.f.	Mean square		
		V6	50% flowering	3 weeks after 50% flowering
Replication	3	0.00 NS	0.00NS	0.10 NS
Main plot (A)	1	0.00NS	0.22 NS	0.06 NS
Error (a)	2	0.00	0.08	0.20
Sub plot (B)	3	0.00 NS	1.47*	1.19*
A× B	2	0.00 NS	0.05NS	0.02 NS
Error (b)	12	0.00	0.05	0.13
Total	23	0.00	0.18	0.22

Appendix Table 4 Analysis of variance for effects of cow dung and ethephon on soil water tension of corn hybrid grown under water stress condition.

Source of variation	d.f.	Mean square			
		V6	50% Flowering	3 weeks after 50% flowering	at Harvest
Replication	1	5.33NS	12.00 NS	1.82 NS	3.00NS
Main plot (A)	1	0.33 NS	1.33 NS	29.05 NS	3.00 NS
Error (a)	1	1.33	9.33	10.35	17.33
Sub plot (B)	2	4.00 NS	1.33NS	81.90 NS	8.33 NS
A× B	2	1.33 NS	5.34 NS	26.12 NS	0.00 NS
Error (b)	4	2.33	6.67	20.31	8.67
Total	11	2.45	6.42	24.27	7.61

Appendix Table 5 Analysis of variance for effects of cow dung and ethephon on ear of corn hybrid grown under water stress condition.

Source of variation	d.f.	Mean square		
		Ear Length	Ear length to the top-most seed	Ear Diameter
Replication	3	0.19 NS	0.87 NS	0.07 NS
Main plot (A)	1	0.04 NS	0.21 NS	0.59 *
Error (a)	3	0.22	0.04	0.63
Sub plot (B)	2	0.52 NS	0.89 NS	0.04 NS
A× B	2	0.18 NS	0.04 NS	0.33 NS
Error (b)	12	0.84	0.89	0.33
Total	23	0.55	0.78	0.29

Appendix Table 6 Analysis of variance for effects of cow dung and ethephon on dry accumulation in plant and HI of corn hybrid grown under water stress condition

Source of variation	d.f.	Mean square	
		Dry accumulation in plant	HI
Replication	1	0.02 NS	0.00 NS
Main plot (A)	1	0.07 NS	0.01 NS
Error (a)	1	0.24	0.01
Sub plot (B)	2	0.46 NS	0.02 NS
A× B	2	0.01 NS	0.01 NS
Error (b)	4	0.07	0.00
Total	11	0.14	0.00

Appendix Table 7 Analysis of variance for effects of cow dung and ethephon on yield of corn hybrid grown under water stress condition..

Source of variation	d.f.	Mean square		
		Number of Seeds / Ear	Weight of 1000 seeds	Seed Yield at 15% of Moisture
Replication	3	390.15^{NS}	69.60 ^{NS}	74985.90 ^{NS}
Main plot (A)	1	511.53 ^{NS}	442.04 ^{NS}	86919.20 ^{NS}
Error (a)	2	519.27	189.88	19904.50
Sub plot (B)	2	4048.74*	50.26 ^{NS}	58063.50 ^{NS}
A× B	3	416.08 ^{NS}	71.791^{NS}	10464.60 ^{NS}
Error (b)	12	688.74	743.89	15323.00
Total	23	888.45	445.72	30109.70

Appendix Table 8 Analysis of variance for effects of cow dung and ethephon on height of corn hybrid grown under non water stress condition.

Source of variation	d.f.	Mean square			
		V6	50% Flowering	3 weeks after 50% flowering	at Harvest
Replication	3	1.28^{NS}	23.20 ^{NS}	151.63 ^{NS}	194.07^{NS}
Main plot (A)	1	0.15 ^{NS}	410.44 ^{NS}	10.010 ^{NS}	157.90^{NS}
Error (a)	3	4.86	24.5443	178.49	24.378
Sub plot (B)	2	1.61 ^{NS}	1485.25**	3368.69**	2184.68**
A× B	2	1.27 ^{NS}	13.86 ^{NS}	114.628^{NS}	5.41 ^{NS}
Error (b)	12	2.52	26.03	97.63	127.14
Total	23	2.23	168.01	397.33	292.13

Appendix Table 9 Analysis of variance for effects of cow dung and ethephon on development characteristics of corn hybrid grown under non water stress condition.

Source of variation	d.f.	Mean square			
		Ear Height	Days to Tasselling	Days to Silking	ASI
Replication	3	51.45 NS	1.89 NS	1.153 NS	0.26 NS
Main plot (A)	1	158.62 NS	4.17 NS	7.04 NS	0.38 NS
Error (a)	2	642.00	9.04	9.04	0.00
Sub plot (B)	3	51.10 *	1.39 *	1.93 *	0.26 NS
A× B	2	9.51 NS	1.29 NS	1.29 NS	0.00 NS
Error (b)	12	77.86	1.72	2.00	0.22
Total	23	117.53	2.41	2.65	0.20

Appendix Table 10 Analysis of variance for effects of cow dung and ethephon on LAI of corn hybrid grown under non water stress condition.

Source of variation	d.f.	Mean square		
		V6	50% flowering	3 weeks after 50% flowering
Replication	3	0.00 NS	0.21 NS	0.21 NS
Main plot (A)	1	0.00*	0.26 NS	0.68 NS
Error (a)	2	0.02	0.58	0.29
Sub plot (B)	3	0.00 NS	2.31*	2.17*
A× B	2	0.00 NS	0.22 NS	0.18 NS
Error (b)	12	0.00	0.49	0.50
Total	23	0.00	0.59	0.56

Appendix Table 11 Analysis of variance for effects of cow dung and ethephon on water tension of corn hybrid grown under non water stress condition.

Source of variation	d.f.	Mean square			
		V6	50% Flowering	3 weeks after 50% flowering	at Harvest
Replication	1	0.00^{NS}	8.33 ^{NS}	0.15 ^{NS}	3.00 ^{NS}
Main plot (A)	1	1.33 ^{NS}	0.33 ^{NS}	1.33 ^{NS}	8.33 ^{NS}
Error (a)	1	0.58	6.33	2.33	3.08
Sub plot (B)	2	0.33 ^{NS}	16.33 ^{NS}	10.72 ^{NS}	16.33 ^{NS}
A× B	2	1.58 ^{NS}	0.33 ^{NS}	1.78 ^{NS}	7.583 ^{NS}
Error (b)	4	1.42	9.33	3.38	3.67
Total	11	1.06	6.88	3.08	5.79

Appendix Table 12 Analysis of variance for effects of cow dung and ethephon on ear of corn hybrid grown under non water stress condition.

Source of variation	d.f.	Mean square		
		Ear Length	Ear length to the top-most seed	Ear Diameter
Replication	3	0.08^{NS}	0.34 ^{NS}	0.13 ^{NS}
Main plot (A)	1	0.05 ^{NS}	0.00^{NS}	0.28*
Error (a)	3	1.32	2.31	0.65
Sub plot (B)	2	1.09 ^{NS}	0.83 ^{NS}	0.33 *
A× B	2	0.42 ^{NS}	0.05 ^{NS}	0.04^{NS}
Error (b)	12	0.89	1.65	0.01
Total	23	0.78	1.22	1.18

Appendix Table 13 Analysis of variance for effects of cow dung and ethephon on dry accumulation in plant and HI of corn hybrid grown under non water stress condition.

Source of variation	d.f.	Mean square	
		Dry accumulation in plant	HI
Replication	1	0.10^{NS}	0.00^{NS}
Main plot (A)	1	0.10^{NS}	0.00^{NS}
Error (a)	1	0.17	0.00
Sub plot (B)	2	0.00^{NS}	0.00^{NS}
A× B	2	0.00^{NS}	0.00^{NS}
Error (b)	4	0.10	0.00
Total	11	0.09	0.01

Appendix Table 14 Analysis of variance for effects of cow dung and ethephon on yield of corn hybrid grown under non water stress condition.

Source of variation	d.f.	Mean square		
		Number of Seeds / Ear	Weight of 1000 seeds	Seed Yield at 15% of Moisture
Replication	3	45.06^{NS}	401.82^{NS}	12233.30^{NS}
Main plot (A)	1	1928.20*	51.04^{NS}	87115.30^{NS}
Error (a)	2	38.11	565.63	32819.00
Sub plot (B)	2	562.24^{NS}	345.15^{NS}	68251.20^{NS}
A× B	3	80.026^{NS}	50.042^{NS}	38764.8^{0NS}
Error (b)	12	321.68	166.28	15317.10
Total	23	318.36	239.94	26961.30

Appendix Table 15 Analysis of variance for effects of cow dung in combination with chemical fertilizer on height of corn hybrid grown under water stress condition.

Source of variation	d.f.	Mean square			
		V6	50% Flowering	3 weeks after 50% flowering	at Harvest
Replication	3	18.92 NS	55.77 NS	73.06 NS	66.71 NS
Main plot (A)	1	0.607NS	217.50 NS	337.50 *	487.80*
Error (a)	3	2.12	45.96	114.43	94.43
Sub plot (B)	2	18.94*	97.52 NS	72.44 NS	21.68 NS
A× B	2	0.09 NS	38.02 NS	7.242 NS	16.288 NS
Error (b)	12	3.13	82.24	52.99	102.82
Total	23	6.06	77.42	71.88	96.01

Appendix Table 16 Analysis of variance for effects of cow dung in combination With chemical fertilizer on development characteristics of corn hybrid grown under stress condition.

Source of variation	d.f.	Mean square			
		Ear Height (cm)	Days to Tasselling	Days to Silking	ASI
Replication	3	57.67NS	1.26 NS	3.15 NS	0.72 NS
Main plot (A)	1	1.78 NS	2.04 NS	2.04 NS	0.00 NS
Error (a)	2	12.35	0.79	0.49	0.11 NS
Sub plot (B)	3	49.06 NS	0.15 NS	1.54 NS	0.17 NS
A× B	2	59.77 NS	0.04 NS	0.04 NS	0.12 NS
Error (b)	12	44.35	1.08	1.57	0.25
Total	23	44.35	0.91	1.52	0.25

Appendix Table 17 Analysis of variance for effects of cow dung in combination with chemical fertilizer on LAI of corn hybrid grown under water stress condition.

Source of variation	d.f.	Mean square		
		V6	50% flowering	3 weeks after 50% flowering
Replication	3	0.01^{NS}	0.02^{NS}	0.02^{NS}
Main plot (A)	1	0.02^{NS}	0.12**	0.08^{NS}
Error (a)	2	0.01	0.03	0.25
Sub plot (B)	3	0.02^{NS}	0.01^{NS}	0.01^{NS}
A× B	2	0.00^{NS}	0.02^{NS}	0.00^{NS}
Error (b)	12	0.01	0.08	0.02
Total	23	0.01	0.02	0.04

Appendix Table 18 Analysis of variance for effects of cow dung in combination with chemical fertilizer on water tension of corn hybrid grown underwater stress condition.

Source of variation	d.f.	Mean square			
		V6	50% Flowering	3 weeks after 50% flowering	at Harvest
Replication	1	8.33^{NS}	0.33^{NS}	110.05^{NS}	16.33^{NS}
Main plot (A)	1	0.33^{NS}	0.33^{NS}	0.09^{NS}	8.33^{NS}
Error (a)	1	1.58	20.33	259.11	64.00
Sub plot (B)	2	3.00^{NS}	3.00 *	228.12^{NS}	8.33^{NS}
A× B	2	0.08^{NS}	0.33^{NS}	10.75^{NS}	1.33^{NS}
Error (b)	4	0.67	15.67	64.25	5.33
Total	11	1.61	9.79	103.18	16.82

Appendix Table 19 Analysis of variance for effects of cow dung in combination with chemical fertilizer on ear of corn hybrid grown under water stress condition.

Source of variation	d.f.	Mean square		
		Ear Length	Ear length to the top-most seed	Ear Diameter
Replication	3	2.10 ^{NS}	1.123 ^{NS}	0.20 ^{NS}
Main plot (A)	1	12.18*	12.37**	1.65*
Error (a)	3	0.08	0.27	0.02
Sub plot (B)	2	0.13 ^{NS}	0.27 ^{NS}	0.29 ^{NS}
A× B	2	0.39 ^{NS}	0.01 ^{NS}	0.02 ^{NS}
Error (b)	12	0.72	0.62	0.10
Total	23	1.23	1.07	0.18

Appendix Table 20 Analysis of variance for effects of cow dung in combination with chemical fertilizer on dry accumulation in plant and HI of corn hybrid grown under water stress condition.

Source of variation	d.f.	Mean square	
		Dry accumulation in plant	HI
Replication	1	0.02 ^{NS}	0.02 ^{NS}
Main plot (A)	1	0.07 ^{NS}	0.02 ^{NS}
Error (a)	1	0.04	0.00
Sub plot (B)	2	0.14 ^{NS}	0.00 ^{NS}
A× B	2	0.02 ^{NS}	0.00 ^{NS}
Error (b)	4	0.08	0.00
Total	11	0.06	0.00

Appendix Table 21 Analysis of variance for effects of cow dung in combination with chemical fertilizer on yield of corn hybrid grown under water stress condition.

Source of variation	d.f.	Mean square		
		Number of Seeds / Ear	Weight of 1000 seeds	Seed Yield at 15% of Moisture
Replication	3	213.10^{NS}	983.71^{NS}	34615.80^{NS}
Main plot (A)	1	282.15^{NS}	63.38^{NS}	129270*
Error (a)	2	87.06	79.79	19474.9
Sub plot (B)	2	473.10^{NS}	38.54^{NS}	3420.97^{NS}
A× B	3	11.63^{NS}	25.13^{NS}	849.759^{NS}
Error (b)	12	906.53	518.33	14114.10
Total	23	566.54	417.43	19713.00

Appendix Table 22 Analysis of variance for effects of cow dung in combination with chemical fertilizer on height of corn hybrid grown under non water stress condition.

Source of variation	d.f.	Mean square			
		V6	50% Flowering	3 weeks after 50% flowering	at Harvest
Replication	3	1.94^{NS}	22.82^{NS}	120.81^{NS}	69.66^{NS}
Main plot (A)	1	21.77*	220.52^{NS}	77.04^{NS}	248.97^{NS}
Error (a)	3	2.09	29.03	9.23	68.74
Sub plot (B)	2	10.30*	130.86^{NS}	167.07^{NS}	211.09^{NS}
A× B	2	0.39^{NS}	65.41^{NS}	32.53^{NS}	13.36^{NS}
Error (b)	12	0.39	151.06	58.97	65.71
Total	23	1.41	112.23	68.43	82.68

Appendix Table 23 Analysis of variance for effects cow dung in combination with chemical fertilizer on development characteristics of corn hybrid grown under non water stress condition.

Source of variation	d.f.	Mean square			
		Ear Height	Days to Tasselling	Days to Silking	ASI
Replication	3	86.61 NS	1.44 NS	1.22 NS	0.67 NS
Main plot (A)	1	28.76 NS	0.17 NS	0.17 NS	0.00 NS
Error (a)	2	29.69	0.50	0.50	0.00
Sub plot (B)	3	27.37 NS	3.79*	4.04 NS	0.17 NS
A× B	2	44.60 NS	0.04 NS	0.04 NS	0.00 NS
Error (b)	12	44.53	0.81	0.99	0.08
Total	23	44.53	1.01	1.10	0.14

Appendix Table 24 Analysis of variance for effects of cow dung in combination with chemical fertilizer on LAI of corn hybrid grown under non water stress condition.

Source of variation	d.f.	Mean square		
		V6	50% flowering	3 weeks after 50% flowering
Replication	3	0.04 NS	0.15 NS	0.02 NS
Main plot (A)	1	0.05*	0.04 NS	0.19 NS
Error (a)	2	0.04	0.18	0.03
Sub plot (B)	3	0.04 NS	0.08 NS	0.05 NS
A× B	2	0.00 NS	0.00 NS	0.08 NS
Error (b)	12	0.00	0.07	0.04
Total	23	0.00	0.08	0.04

Appendix Table 25 Analysis of variance for effects of cow dung in combination with chemical fertilizer on water tension of corn hybrid grown under non water stress condition.

Source of variation	d.f.	Mean square			
		V6	50% Flowering	3 weeks after 50% flowering	at Harvest
Replication	1	0.83^NS	0.00 ^NS	15.94 ^NS	16.33 ^NS
Main plot (A)	1	0.08 ^NS	5.33 ^NS	12.34 ^NS	27.00 ^NS
Error (a)	1	0.08	5.33	5.54	0.33
Sub plot (B)	2	0.08 ^NS	6.33 ^NS	17.38 ^NS	36.33 ^NS
A× B	2	1.08 ^NS	0.33 ^NS	0.02 ^NS	1.00 ^NS
Error (b)	4	2.58	6.67	1.35	11.33
Total	11	1.17	4.61	6.73	14.88

Appendix Table 26 Analysis of variance for effects of cow dung in combination with chemical fertilizer on ear of corn hybrid grown under non water stress condition.

Source of variation	d.f.	Mean square		
		Ear Length	Ear length to the top-most seed	Ear Diameter
Replication	3	0.98^NS	0.75 ^NS	0.41 ^NS
Main plot (A)	1	11.82**	14.95**	0.31 ^NS
Error (a)	3	1.09	1.00	0.27
Sub plot (B)	2	0.35^NS	0.24 ^NS	1.40 ^NS
A× B	2	0.14^NS	0.01 ^NS	0.10 ^NS
Error (b)	12	0.50	0.69	0.20
Total	23	1.09	1.26	0.34

Appendix Table 27 Analysis of variance for effects of cow dung in combination with chemical fertilizer on dry accumulation in plant and HI of corn hybrid grown under non water stress condition.

Source of variation	d.f.	Mean square	
		Dry accumulation in plant	HI
Replication	1	0.14 NS	0.02 NS
Main plot (A)	1	1.14*	0.09 **
Error (a)	1	0.02	0.02
Sub plot (B)	2	0.11 NS	0.00 NS
A× B	2	0.01 NS	0.00 NS
Error (b)	4	0.03	0.00
Total	11	0.15	0.01

Appendix Table 28 Analysis of variance for effects of cow dung in combination with chemical fertilizer on yield of corn hybrid grown under non water stress condition.

Source of variation	d.f.	Mean square		
		Number of Seeds / Ear	Weight of 1000 seeds	Seed Yield at 15% of Moisture
Replication	3	398.37 NS	1512.60 NS	43029.30 NS
Main plot (A)	1	70.49 NS	551.04 NS	227085.00*
Error (a)	2	239.57	528.38	45827.7
Sub plot (B)	2	740.42 NS	327.79 NS	6647.99 NS
A× B	3	162.68 NS	21.792 NS	762.63 NS
Error (b)	12	1389.94	270.24	22780.30
Total	23	889.99	461.56	32289.60

CURRICULUM VITAE

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EDUCATION :

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