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GROWTH, DEVELOPMENT AND YIELD OF MAIZE AS AFFECTED BY DIFFERENT IRRIGATION LEVEL

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ABSTRACT

Alam MM, Chowdhury MF, Bahadur MM, Rana MS, Saha KC (2017) Growth, development and yield of maize as affected by different irrigation level. *Int. J. Sustain. Crop Prod.* 12(3), 13-21.

The study was conducted in Crop Physiology and Ecology Research Field and Laboratory, Hajee Mohammad Danesh Science and Technology University during the period of November 2014 to July 2015 to investigate the growth, development and yield of maize as affected by different irrigation levels. Three maize varieties (V_1=NK 40, V_2=Hybrid 981 and V_3=BHM 11) and three levels of irrigation (I_0= no irrigation, I_1= 300 mm irrigation in total life span and I_2= 450 mm irrigation in total life span at different days after sowing) were included as experimental treatments which were evaluated in randomized complete block design with three replications. Maize variety NK 40 required the highest duration to attain teaseling, cob initiation, silking, pollen shading and maturity. LAI, LAD, CGR, RGR and NAR were significantly influenced by the maize varieties and irrigation levels. The variety NK 40 with the irrigation treatment (450 mm) gave the highest values of all the growth parameters. The highest yield (5.84 t ha^{-1}) was found in NK 40 and the lowest yield (5.24 t ha^{-1}) was obtained from Hybrid 981. Irrigation levels also significantly influenced yield of maize. The highest grain yield (5.95 t ha^{-1}) was obtained from the plant growing with the irrigation treatment (450 mm) while the lowest yield (4.20 t ha^{-1}) was found from the control plant (no irrigation). The interaction between the maize variety and irrigation levels was significant on the growth and yield. It is indicated that NK 40 with 450 mm irrigation showed the best performance in respect of growth, development and yield of maize.

Key words: *irrigation, growth parameters, yield, maize*

INTRODUCTION

Maize (*Zea mays* L.) is one of the most versatile cereal crops grown widely throughout the world in a range of agro ecological environment. Maize was introduced into Africa in the 1500s and has since become one of Africa's dominant food crops. Globally, maize is known as "Queen" of cereals for its highest genetic yield potential among the cereals (Anonymous 2011). Maize is an important grain crop in many countries of the world and it ranks 3rd after wheat and rice in area basis and total production (FAOSTAT 2013). The total area covers by maize in 1989 and 2013 was 129 and 185.12 million hectares, respectively, *i.e.* an increase of about 43% in area and 116% increase in the production (470 million tons in 1989 to 1018.12 million tons in 2013 (FAOSTAT 2013). These figures reflect the steep increase in the yields per hectare due to the wide spread use of hybrids and improved crop management practices. The production area of maize is increasing day by day in Bangladesh. Presently the crop covers an area of about 3.5 lac hectare and produces 2.3 million metric ton in this country (BBS 2015).

Due to urbanization and industrialization the cultivable land decreases day by day. On the other hand, the population is increasing day by day. Bangladesh is facing problem of malnutrition due to her high population growth and low productivity of crops. The traditional crop including rice and wheat seem quite unable to meet up the nutritional requirements to the increasing population. So, it is a time demand to new crop like maize to the casting cropping pattern of our country. Maize grain has greater nutritional value as it contains 72% starch, 10% protein, 4.8% oil, 8.5% fiber, 3.0% sugar and 1.7% ash (Chaudhary 1983).

Yield is the cumulative effect of variety with its inherent characteristics, environmental condition in which it is grown and management practices. Variety is one of the most important factors for increasing yield. In general, it is understood that there are differences in morph-physiological aspects among the traditional and modem varieties. Yield of maize depends on different growth process such as days to tasseling, cob initiation, sulking, pollen shading and maturity which occur in the ontogeny of wheat plant. Proper growth and development of maize needs favorable soil moisture in root zone. The moisture content in the soil gradually decreases with the passing of time during dry season. Limited water supply during the growing season results in soil and plant water deficits and reduces maize yields (Gordon *et al.* 1995; Patel *et al.* 2006). In areas that are poor in precipitation, irrigation guarantees yield. Irrigation in general, especially in cases of drought, highly increases the yield of maize. Proper time and supplemental irrigation should be realized in irrigation scheduling for the most effective use of available water in optimizing maize production. Water deficit has little effect on timing of emergence, number of leaves per plant but delayed tasseling initiation and silking, reduced plant height and vegetation growth of maize (Abrecht and Carberry, 1993; Singh *et al.* 2007). Heading o milking stage is the most important sensitive period of water stress and has ultimate impact on grain yield (Shaozong and Mingannang, 1992; Hossain 2008).

Improper scheduling of irrigation results not only in wastage of water but decrease the crop growth and yield. Irrigation found to be significant for ear length, ear diameter, number of barren per plants, plant yield, grain yield and biological yield (Khalil and Samia, 2006). Growth parameter, i.e. plant height and leaf area index, which ultimately resulted in higher grain and straw yield significantly increased by irrigation (Singh and Sudhanshu, 2005). Proper phenological development takes place with the application of optimum water and also increased accumulation of TDM, maximum RGR, NAR and yield (YaJun *et al.* 2006).

The choice of high yielding varieties is very important for maximum production as well as better agronomic practices directly correlated with yield. For maximum production of maize, new promising HYV is prior concern. On the other hand, proper irrigation scheduling is necessary for securing good yield of maize. However, little is known about the morphology and physiology of maize varieties for tolerance to water stress. Therefore, keeping the view in mind, to increase the yield of maize through improved management practices the present investigation would be framed to know the effect of irrigation on some morpho-physiological and growth parameters of maize.

MATERIALS AND METHODS

The experiment was conducted at Research Field and Laboratory in the Department of Crop Physiology and Ecology, Hajee Mohammad Danesh Science and Technology University, Dinajpur, during the period of November, 2014 to July, 2015 to study the growth, development and yield of maize as affected by irrigation level. The experimental site was a medium high land belonging to the non-calcareous dark gray floodplain soil under the Agro-ecological zone-1 (AEZ-1) named Old Himalayan Piedmont Plain (FAO 2005). The experiment comprised of two sets of factors i.e. Factor A: Three maize varieties *viz.* V_1 =NK4O, V_2 = Hybrid 981 and V_3=BHM 11 and Factor B: Three irrigation level *viz.* I_0 = control, I_1 = 300 mm in total life span and I_2 = 450 mm in total life span. The experiment was laid out in a randomized complete block design (RCBD) with three replications. There were 9 treatment combinations. The space between blocks and between unit plots was 1.0 m and 0.5 m, respectively. The unit plot size was 3.0 m x 3.0 m. The selected land was prepared through ploughing and cross ploughing and fertilized with urea, triple super phosphate (TSP), muriate of potash (MOP), gypsum, zinc sulphate and boron as per recommendation. The seeds of all varieties were sown in rows as per treatment on 12 November 2014. During the growing period, the experimental land was irrigated three times first at 30 DAS, the second at 55 DAS and the third at 80 DAS with the help of a bucket. At the time of irrigation sufficient care was taken to avoid the flow of irrigation water from one plot to another. To study the ontogenetic growth characteristics a total nine harvests including final harvest were made. Data were collected on some phonological, morpho-physiological and growth parameters and yield. The first crop sampling was done at 30 DAS and continued with 15 days interval up to 150 DAS. From each plot three plants were randomly selected and uprooted to collect necessary parameters at every harvest. Growth analyses such as leaf area index (LAI), crop growth rate (CGR), leaf area duration (LAD), relative growth rate (RGR) and net assimilation rate (NAR) were furnished following the formula of Radford (1967) and Hunt (1978). Finally, the collected data was analyzed by using the "Analysis of variance" (ANOVA) technique with the help of a computer package (MSTAT-C) program (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Phonological parameters

Days to tasseling: Days to tasseling was significantly influenced by variety and different levels of irrigation (Table 1). The maize variety NK 40 was taken the maximum days (55.11) to attain their tasseling stage, while the maize variety Hybrid 981 needed the lowest days (54.00) to attain their tasseling stage. Results revealed that tasseling was earlier in control condition. The I_2 (450 mm irrigation in total life) plants took the maximum days (64.11) for tasseling and the lowest days (46.44) was taken for tasseling in I_1(300 mm irrigation in total life) treatment. Similar result was also reported by Sepaskhah and Parand (2006), YaJun *et al.* (2006) and Hossain (2008) in maize. They stated that irrigated plant required maximum days to tasseling than non-irrigated plant. The interaction effect of variety and irrigation level was also significant. The highest days (64.66) were required for tasseling in V_1 plants combined with 450 mm irrigation in total life cycle (I_2). On the other hand the lowest days (45.33) were required for tasseling in V_1xI_0 combination.

Days to cob initiation: Significant variations were observed in days to cob initiation due to variety, different levels of irrigation and their interaction (Table 1). The highest days (75.33) to cob initiation required in the maize variety NK 40 and the lowest days (73.66) was recorded in the variety hybrid 981. Results showed that cob initiation was taken maximum days (84.22) in the plants grown with application of 450 mm irrigation in total life span and the controlled plants needed the lowest days (66.44) for cob initiation. Similar result was also reported by YaJun *et al.* (2006) in maize. They observed that all the phenological stage taken maximum days with irrigation than control. Interaction effect indicated that the highest days (84.66) required for cob initiation was found V_1I_2 and the lowest days (66.33) was found V_2I_0.

Days to silking: The number of days required to silking significantly affected by variety, different levels of irrigation and their interaction (Table 1). The lowest days (60.33) was needed for silking in the maize Hybrid 981 and the highest day (79.88) was required in variety NK 40. Result showed that silking was earlier in the plants grown with no irrigation. The highest number of days (85.24) for silking was found in I_2 (application of 450 mm water in total life span) and the lowest (58.22) days required in Io (control) condition. The result of the present study is similar to the result of Sepaskhah and Parand (2006) and YaJun *et al.* (2006) where, they found that silking taken higher days in irrigated crops. The interaction effect of variety and irrigation levels showed that treatment combination of variety Hybrid 981 with control treatment (I_0) needed lowest days (71.00) for silking whereas variety NK 40 with 450mm irrigation (I_2) required the highest days (89.66) for silking.

Table 1. Some phenological stages of maize as affected by variety and irrigation level

Treatments	Day to tasseling	Day to cob initiation	Days to silking	Days to pollen shading	Days to maturity
Variety					
V_1	55.11a	75.33a	79.88a	81.22a	110.20a
V_2	54.00c	73.66c	60.33c	79.55c	108.00c
V_3	54.77b	75.11b	78.55b	80.78b	109.30b
Level of significance	**	**	**	**	**
Irrigation level					
I_0	46.44c	66.44c	58.22c	72.33c	10l.30c
I_1	53.33b	73.44b	71.33b	79.22b	108.00b
I_2	64.11a	84.22a	85.24a	90.00a	118.00a
Level of significance	**	**	**	**	**
Interaction (Variety x Irrigation level)					
$V_1 \times I_0$	45.33h	66.33g	71.66f	72.66g	101.66g
$V_1 \times I_1$	54.33d	74.33d	79.00d	80.66d	109.66d
$V_1 \times I_2$	64.66a	84.66a	89.66a	90.33a	119.33a
$V_2 \times I_0$	47.33f	66.33g	71.00h	72.00i	101.00i
$V_2 \times I_1$	51.33e	71.33e	76.00e	77.00f	106.00f
$V_2 \times 1_2$	63.33c	83.33b	88.66c	89.66c	117.00c
$V_3 \times I_0$	46.66g	66.66f	71.33g	72.33h	101.33h
$V_3 \times I_1$	54.33d	74.66c	79.00d	80.00e	109.00e
$V_3 \times I_2$	64.33b	84.66a	89.00b	90.00b	117.66b
CV (%)	4.58	5.48	3.59	3.47	2.79
Level of significance	**	**	**	**	**

Note: In a column, figures having same letter(s) do not differ significantly at P 0.05 by DMRT. Here, V_1 =NK 40, V_2 =Hybrid 981, V_3=BHM 11, I_0=No irrigation, I_1=300 mm irrigation in total life pan and I_2=450 mm irrigation in total life span

Days to pollen shading: Days to pollen shading was significantly influenced by different maize variety. The lowest days (79.55) was taken for pollen shading in variety Hybrid 981 and the highest days (81.22) was needed in variety NK 40 followed by BHM 11(80.78 days). Table 1 showed that pollen shading was delayed in the plants grown with 450mm irrigation in total life span. The highest days (90.00) to pollen shading was found in I_2 (450 mm water) and the lowest days (72.33) was required in I_0. Interaction effect revealed that treatment combination of V_2 (var. Hybrid 981) with Io (control) needed lowest days (72.00) for pollen shading whereas, V_1 (var. NK 40) with I_2 (450 mm irrigation in total life cycle) required the highest days (90.33) for pollen shading.

Days to maturity: Days to maturity was significantly influenced due to different maize varieties, different levels of irrigation and their interaction (Table 1). The lowest days (108.00) needed for maturity was recorded in the maize var. Hybrid 981 and the highest day for maturity (110.20) was recorded in var. NK 40. Result showed that plants grown with I_2 (application of 450 mm water in total life cycle) needed highest days (118.00) for maturity whereas I_0 (control) required the lowest days (101.30) for maturity. Similar result was also reported by Hossain (2008) in maize and Hafiz *et al.* (2009) and Rahman (2008) in barley. They stated that irrigated plant takes maximum days to maturity than non-irrigated plant. The interaction effect presented that maize variety Hybrid 981 (V_2) with Io irrigation (control) needed lowest days (101.0) for maturity. Whereas, the maize var. NK 40 (V_1) with I_2 (application of 450mm irrigation in total life span) required the highest days (119.33) for maturity.

Leaf area index (LAI): LAI varied significantly due to variety and different levels of irrigation at 30 to 150 DAS (Fig. 1). The LAI values increased progressively up to 90 DAS and afterwards declined in the same way till maturity. The declining of leaf area index after attaining a peak value was due to leaf rolling and senescence

with aging. The maize var. NK 40 was found to have the ability to produce maximum LAI (8.50) at 90 DAS with 450 mm irrigation (I_2) and the lowest LAI was produced with no irrigation (I_0) in association of maize var. Hybrid 981. This result is in agreements with Kusaksz and Kusaksz (2005), ChunYan *et al.* (2004) and YaJun *et al.* (2006) in maize. They stated that irrigated plants had the highest LAI in every sampling. Higher LAI values due to increase in irrigation frequencies were also reported by Pal *et al.* (1996) in wheat, and Hafiz *et al.* (2009) in barley.

Leaf area duration (LAD): LAD was evaluated for three different maize varieties and irrigation levels (Fig. 2). The pattern of LAD curves was found almost similar in all maize varieties for each irrigation level. Results revealed that maize var. NK 40 (V_1) produced the highest LAD while the var. Hybrid 981 produced the lowest LAD in all stages of growth. Among the different irrigation, LAD increased with the increasing irrigation level. The LAD values increased progressively up to 90-105 DAS and afterwards declined till maturity. Decline in LAD after attaining a peak was due to leaf rolling and senescence. I_0 (no irrigation) produced the lowest LAD for all the varieties. On the other hand, the highest value of LAD was recorded with I_2 (450 mm irrigation). This result is in agreements with Pal *et al.* (1996) in wheat and Hafiz *et al.* (2009) and Rahman (2008) in barley.

Crop growth rate (CGR): Crop growth rate was significantly influenced by variety and irrigation level (Fig. 3). Results revealed that the effect of irrigation on CGR was almost similar for every variety. In all varieties and irrigation regimes CGR was started from a lower value and reached at peak (90-120 DAS) and thereafter showed a declining pattern in all cases. Generally, 450 mm irrigation (I_2) produced the highest CGR in all the cases. The highest (37.29 $gm^{-2}day^{-1}$) CGR at 90-105 DAS was observed in the maize var. NK 40 with I_2 (450mm irrigation) and the lowest (30.90$gm^{-2}day^{-1}$) in var. Hybrid 981 (V_2) with I_0 (no irrigation) treatment at 90-105 DAS. Similar result was reported by Abdorrabmani *et al.* (2005) and Riaz *et al.* (2002) in maize who reported that CGR increased with the increasing irrigation level.

Relative growth rate (RGR): The influence of variety and irrigation level on RGR was calculated from 30-45 to 135-150 DAS. Irrespective of variety and irrigation level, the RGR showed its highest values in the early stage of plant development (Fig. 4). Results revealed that irrigation had significant influence on RGR at all growth stages. There was an inverse relationship between RGR and plant age in all treatments. However, results revealed that I_2 (450 mm irrigation) produced the maximum RGR with the maize var. NK 40 (V_1) while the control treatment (I_0) gave the minimum RGR with the var. Hybrid 981 (V_2). The results of the present study is in agreement with the results of Hafiz *et al.* (2009) in barley where they observed greater RGR was recorded in irrigated plant over control.

Net assimilation rate (NAR): The significant variation of NAR due to variety and irrigation level showed that there was an inverse relationship between NAR and plant age (Fig. 5). The highest NAR was recorded at 30-45 DAS and then followed by a continued decrease until attaining the lowest value at 135-150 DAS with heavy fluctuations for all varieties and irrigation treatments. However, results showed that I_2 (450 mm irrigation) in early stages had better influence on NAR, whereas I_0 (Control) had the minimum NAR with the var. Hybrid 981 at all growth stages. The results of the present study as in agreement with the results Riaz *et al.* (2002) and Mandal *et al.* (1991), where they observed higher NAR in irrigated plant compared to control.

Grain yield: Grain yield was significantly influenced due to maize varieties, different levels of irrigation and their interaction (Fig. 6 and 7). The highest grain yield (5.84 t ha^{-1}) was observed in maize var. NK 40 (V_1) and the lowest grain yield (4.24 t ha^{-1}) was observed in maize var. Hybrid 981 (V_2). Yield is the cumulative effect of variety with its inherent characteristics, environmental condition in which it is grown, and management practices. Yield of maize depends on different growth processes such as days to tasseling, cob initiation, silking, pollen shading and maturity which occur in the ontogeny of maize plant. All this morpho-physiological characteristics of the maize var. NK 40 having the higher value might be lead to maximum yield in the present study. Grain yield increased with increasing level of irrigation over control. The highest grain yield (5.95 t ha^{-1}) was recorded in I_2 and the lowest grain yield (4.20 t ha^{-1}) was found in I_0 condition. Similar effect of irrigation on grain yield was reported by Sarwar *et al.* (2010), Sikder *et al.* (2009), Patil *et al.* (2006), Ghulam *et al.* (2005) and Saif *et al.* (2003) in maize where they reported that irrigation increase the grin yield. Yield increase with increasing irrigation probably due to positive effect of irrigation for higher morpho-physiological characteristics as observed in the present study and also because of optimum moisture helped in proper utilization of nutrients. Interaction effect revealed that the highest grain yield (6.60 t ha^{-1}) was obtained from maize var. NK 40 (V_1) with I_2 (450mm irrigation), while the lowest grain yield (4.10 t ha^{-1}) was produced in maize var. Hybrid 981 (V_2) with I_0 treatment combination. From the overall growth period it was observed that in V_1 and higher irrigated condition, days to tasseling, days to cob initiation, days to silking, days to pollen shading and days to took highest days i.e., maximum growth period and LAI, LAD, CGR, RGR and NAR production also maximum that help to increase yield of crop.

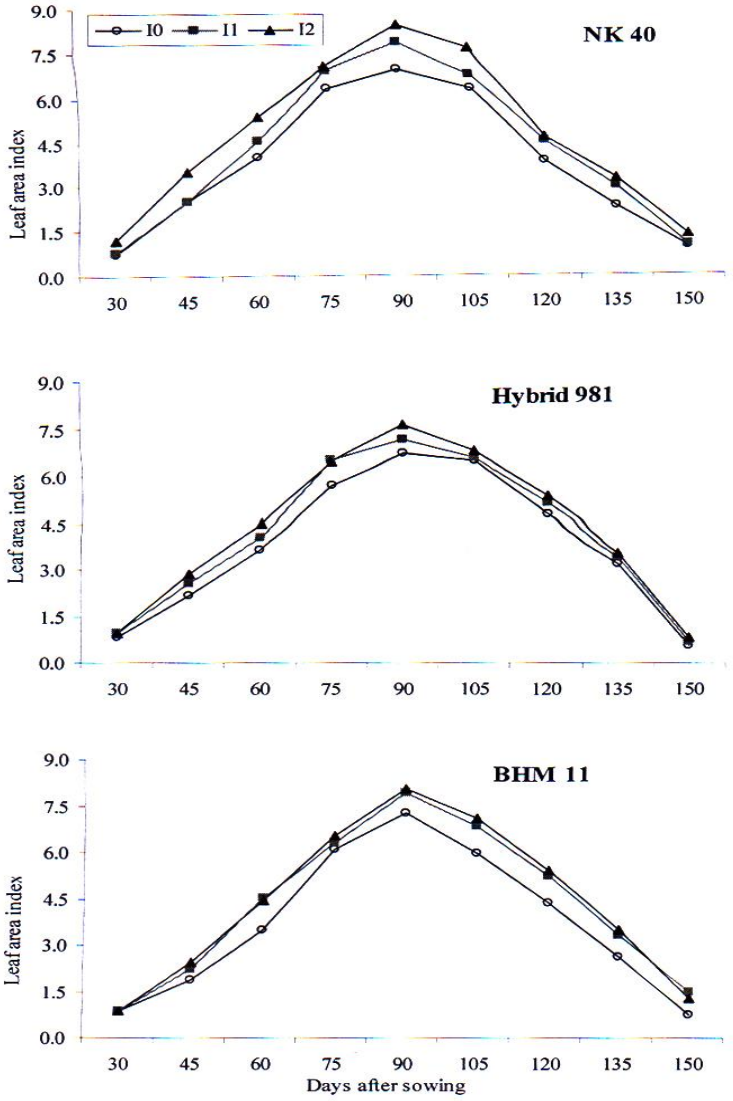

Fig. 1. The pattern of leaf area index with time in three maize varieties under different irrigation levels

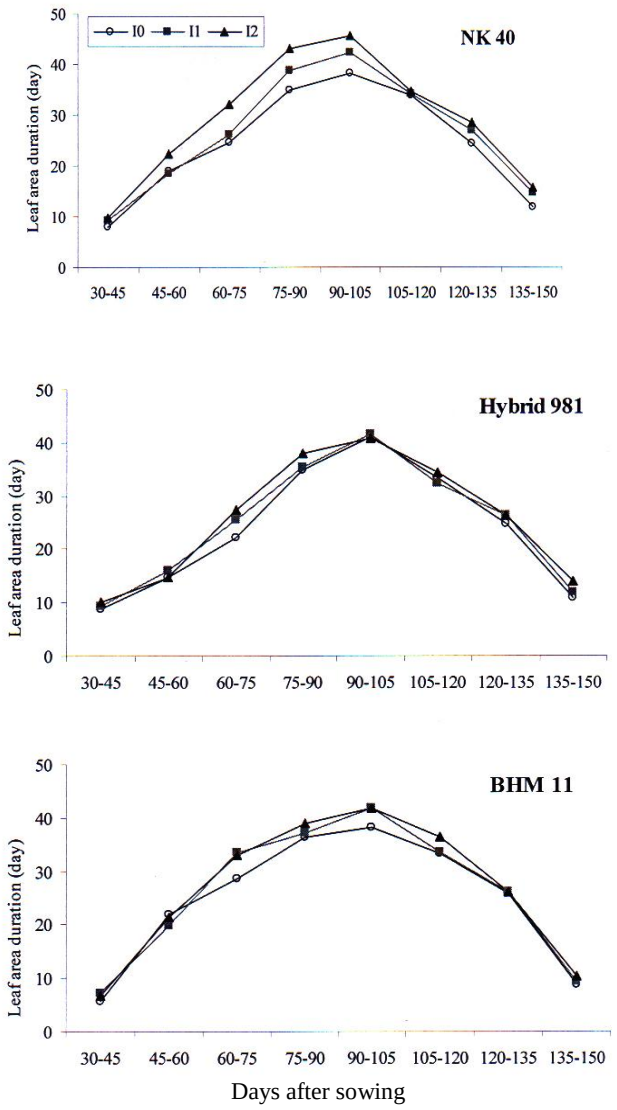

Fig. 2. The pattern of leaf area duration (day) with time in three maize varieties under different irrigation levels

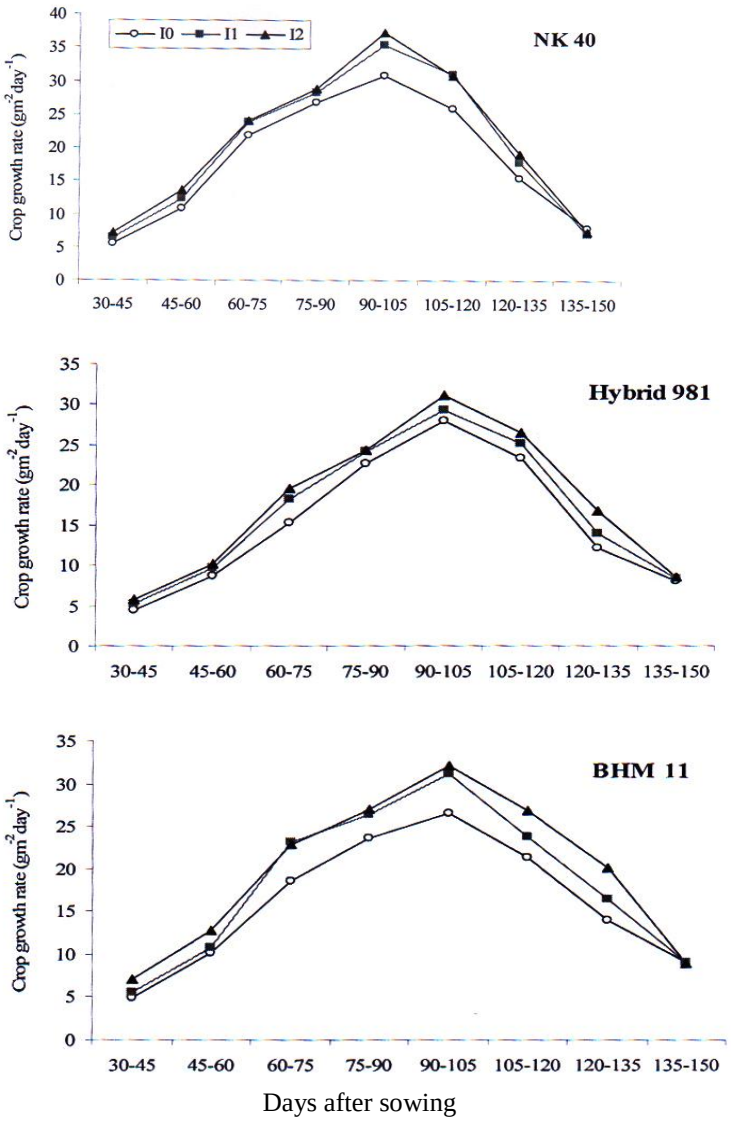

Fig. 3. The pattern of crop growth rate (gm^{-2}day^{-1}) with time in three maize varieties under different irrigation levels

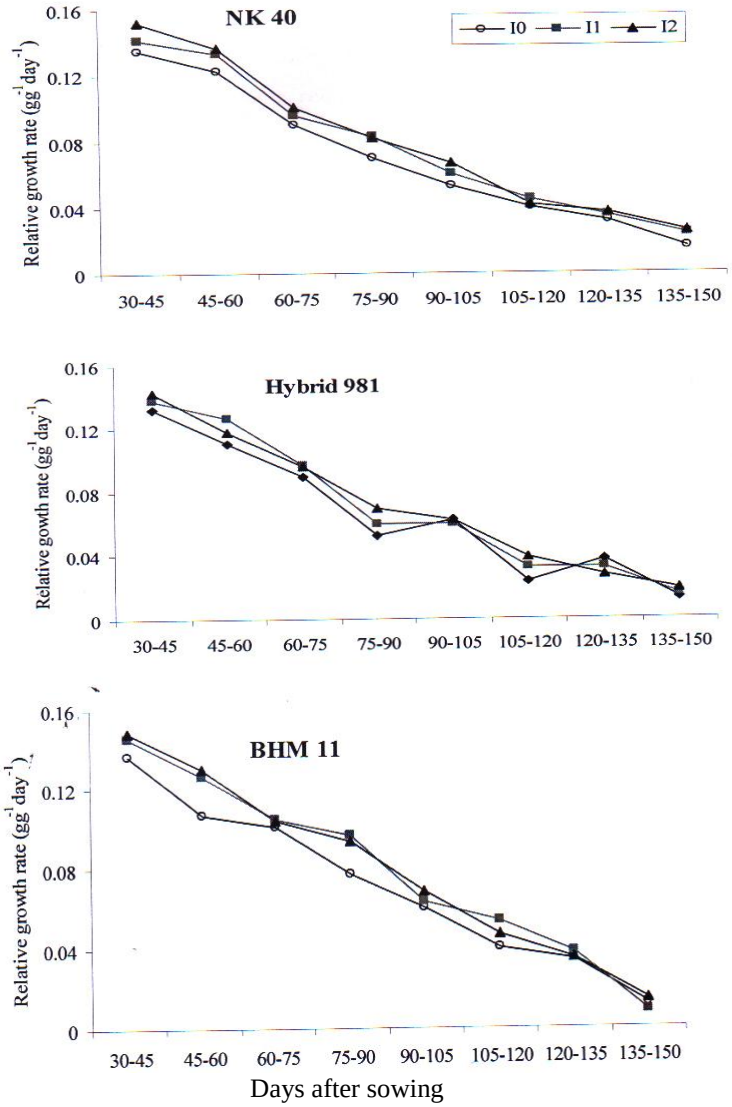

Fig. 4. The pattern of relative growth rate (gg^{-2}day^{-1}) with time in three maize varieties under different irrigation levels

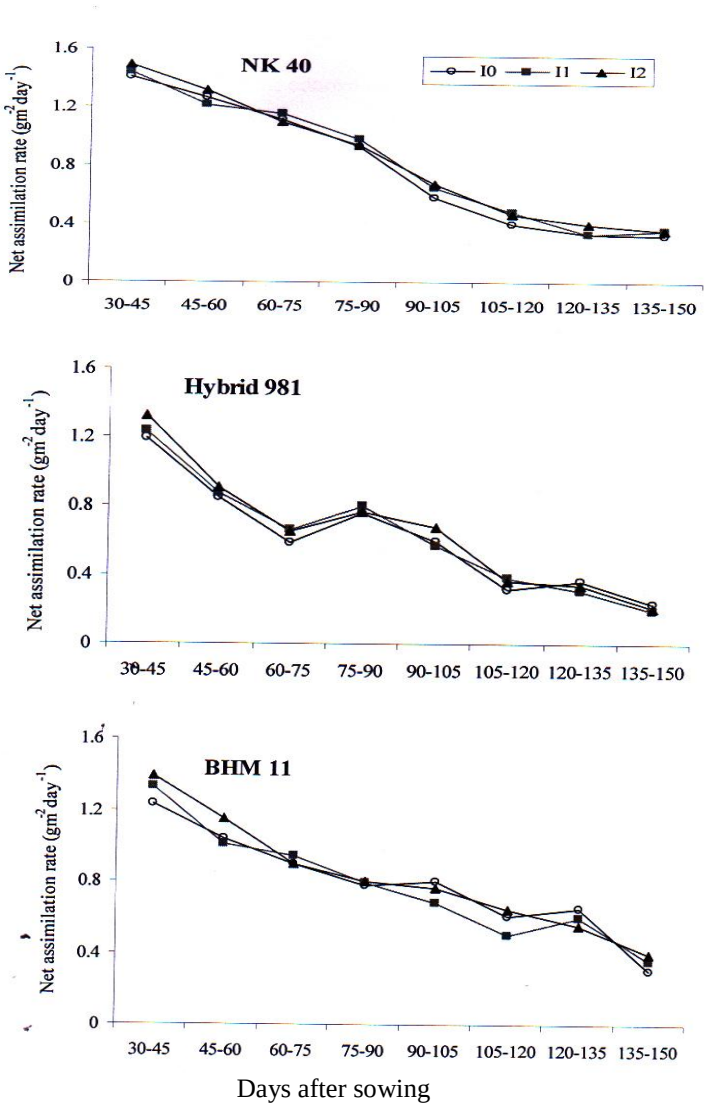

Fig.5. The pattern of net assimilation rate (gm^{-2}day^{-1}) with time in three maize varieties under different irrigation levels

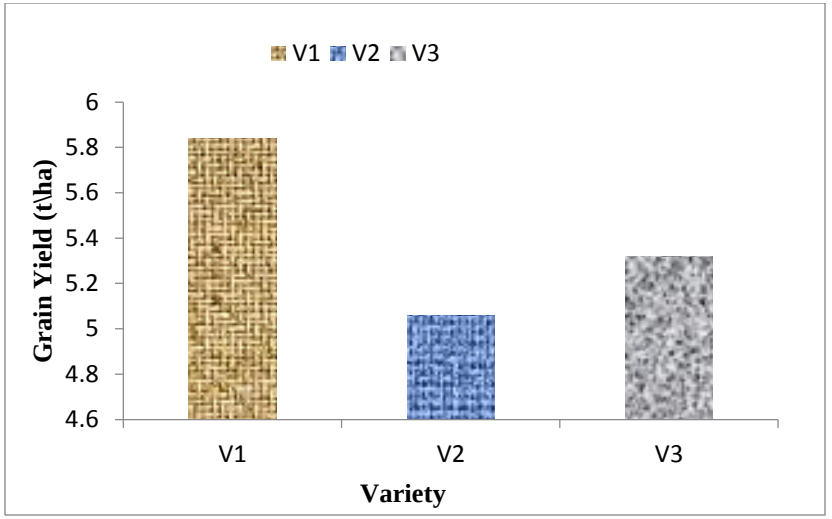

Fig. 6. Grain yield of maize as influenced by variety

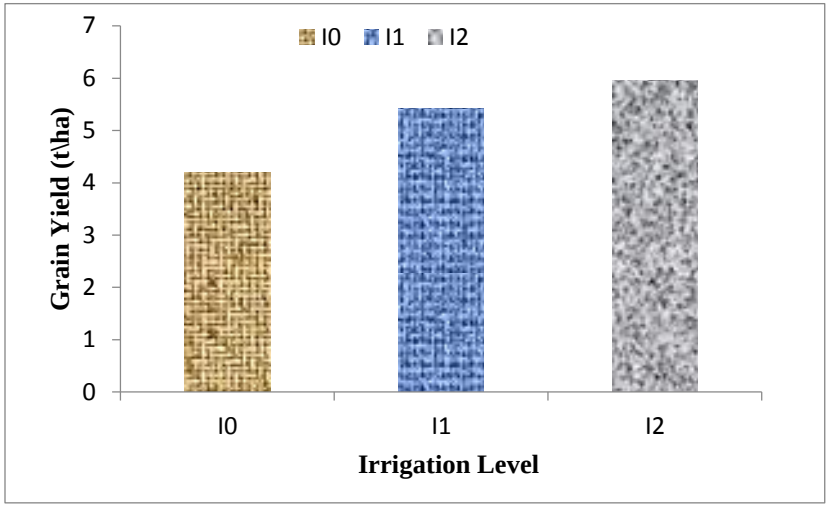

Fig. 7. Grain yield of maize as influenced by irrigation level

CONCLUSION

From the above discussion it could be concluded that the higher morpho-physiological characteristics and grain yield per plant of maize could be obtained from maize var. NK 40 with 450 mm irrigation in total life span.

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