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# EFFECT OF IRRIGATION LEVELS ON THE YIELD OF GROUNDNUT

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**ABSTRACT**

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The experiment was conducted in the research field of Irrigation and Water Management Division (IWM), BARI, Gazipur during the *rabi* seasons of 2010-2011 and 2011-2012 to find an appropriate irrigation schedule for optimum yield of groundnut. There were five irrigation treatments and each is replicated thrice in a randomized complete block design (RCBD). According to the investigation results showed that in the first year, the highest yield (2.10 t/ha) and the lowest yield (1.30 t/ha) were obtained in the treatments of $T_1$ (no water stress) and $T_5$ (water stress at vegetative and pod formation stages), respectively. Whereas, in the second year, the highest (1.65 t/ha) and the lowest (1.34 t/ha) yields were obtained in the treatments of $T_5$ and $T_3$ (irrigation at vegetative, pod formation and seed filling stage), respectively. The flowering and pod formation stages were critical stage of groundnut cultivation. The highest and lowest seasonal water were used 329 mm and 209 mm in the treatments of $T_1$ and $T_5$, respectively for the first year, but in the second year these values were obtained 204 mm and 124 mm in the same treatments including an effective rainfall of 164 mm and 68 mm, respectively. The highest benefit cost ratio (BCR) of 1.55 was found in the treatment of $T_5$ while the lowest BCR of 1.04 was obtained from treatment of $T_1$ in the second year.

***Key words:*** *irrigation, groundnut, growth stage, seasonal water use, yield, economic analysis*

## INTRODUCTION

Groundnut is the sixth important oil seed crop in the world and it is grown in 19.3 million ha of land in about 82 countries. More than half of the production area is in arid and semi-arid regions. Among the oil crops in Bangladesh, groundnut stands third position both in area and production (BBS 2009). Groundnut can be grown in "Char" areas during winter season (November-April) under rain fed condition. Being a photo insensitive crop, it can be grown round the year. It is well suited as intercrop with other long duration crops and fits well in various crop rotations.

In Bangladesh, groundnut is grown in both *rabi* (winter) and *kharif* (summer) seasons, but it covers the lager area in the winter than in summer due to its higher yield in the winter. It responses significantly to the different levels of irrigation and weeding during the *rabi* season (BARI Annual Report, 1993-94). It doesn't response to irrigation in the normal *kharif* season, while, it responses in the winter (IARI 1977) under humid climate, moisture stress at any stage of the growth and development affects the groundnut yield (Kaul and Das, 1986).

Soil moisture is the most common limiting factor for better yield in groundnut production. Timing of irrigation or rainfall has a significant effect on crop yield and quality. The yield can be increased substantially by irrigation. It has been found that the different levels of irrigation significantly influenced the growth parameters, yield components, yield and water use efficiency of groundnut (Jana *et al.* 1989). A good crop of groundnut with high pod yield can be raised with 11-12 irrigations (Reddy 1984). In India and its neighboring countries, mostly check basin method is used by the groundnut growers where irrigation is practiced.

Preliminary studies reveal that certain growth stages of this crop are very susceptible to moisture stress. Therefore, this study was undertaken to identify the stages of crops growth sensitive to irrigation levels at different magnitudes and to determine a suitable irrigation options against drought for sustainable production.

## MATERIALS AND METHODS

The experiment was conducted at the research field of Irrigation and Water Management Division, BARI, Gazipur during the *rabi* seasons of 2010-2011 and 2011-2012 on groundnut (variety : BARI Chinabadam-8) with a randomized complete block design (RCBD) and three replications. The treatments were selected based on applying irrigation levels at different growth stages of groundnut given as follows:

$T_1$ = Irrigation at vegetative, flowering, pod formation and seed filling stage (Full irrigation)
$T_2$ = Irrigation at flowering, pod formation and seed filling stage
$T_3$ = Irrigation at vegetative, pod formation and seed filling stage
$T_4$ = Irrigation at vegetative, flowering and pod formation stage
$T_5$ = Irrigation at vegetative and pod formation stage

The soil was silty clay loam having a bulk density of 1.50 gm/cc and volumetric water content at permanent wilting point (PWP) and field capacity (FC) equal to 23% and 43.5%, respectively. Seeds were sown in line on 28 November, 2010 and 21 December, 2011 at the rate of 100 kg/ha. The unit plot size and line to line spacing

were 4 × 3 m and 30 cm, respectively. Fertilizers were applied at the rate of $N_{12}$, $P_{32}$, $K_{36}$, $S_{54}$, and $B_2$ kg/ha. Two-thirds of N and total amount of other fertilizers were applied at the time of final land preparation and remaining N was applied as top dress after first irrigation. A common irrigation (5 mm) was applied before the sowing for ensuring good germination of seed. Intercultural operations such as weeding, ear thing up and pesticide application were done as when necessary. Groundnut was harvested on 23 June, 2011 and 27 May, 2012; data on yield and yield parameters were recorded.

Initial soil water content was measured using both a digital moisture meter and laboratory method (Gravimetric method). Irrigation water was applied to bring the soil moisture up to field capacity considering the effective root zone depth. Soil moisture at every 10 days intervals, prior to irrigation and at the time of harvest was determined by the same method. Basin irrigation was applied to each plot by hose pipe system.

Irrigation water was calculated using the following equation (Michael 1978):

$$d = \frac{F_c - M_{ci}}{100} \times A_s \times D$$

Where $d$ = Depth of water applied, mm; $F_c$ = Moisture content, %; $M_{ci}$ = Moisture content of the soil at the time of irrigation, %; $A_s$ = Apparent specific gravity of the soil; $D$ = Depth of root zone, mm

## RESULTS AND DISCUSSION

### Yield and yield components

All the collected data related to crop growth and yield were analyzed statistically and are presented in Tables 1 and 2. It shows that the treatments had significant variation among them in respect of plant height, number of branches per plant, seeds per plant, pods per plant, 100 pods weight and yield in the year of 2010-2011 but in the year 2011-2012, only plant height and 1000 seeds weight had significant variation but other parameters didn't vary statistically.

Table 1. Yield and yield contributing characters of groundnut during the year of 2010-2011

| Treatments | Plant height (cm) | No. of branches per plant | No. of pods per plant | No. of seeds per plant | 100 pod weight (g) | Yield (t/ha) | Yield reduction (%) |
|---|---|---|---|---|---|---|---|
| $T_1$ | 58.53 | 26 | 27 | 40 | 106.107 | 2.10 | 0 |
| $T_2$ | 57.13 | 25 | 25 | 40 | 98.540 | 1.97 | 6.19 |
| $T_3$ | 62.40 | 26 | 27 | 39 | 95.707 | 1.93 | 8.10 |
| $T_4$ | 57.20 | 23 | 22 | 37 | 85.59 | 1.34 | 36.04 |
| $T_5$ | 62.33 | 24 | 24 | 34 | 82.95 | 1.30 | 38.10 |
| CV | 4.11 | 3.22 | 9.43 | 2.51 | 2.33 | 7.11 | - |
| LSD | 3.21 | 4.15 | 0.650 | 0.876 | 5.43 | 0.960 | - |

Table 2. Yield and yield contributing characters of groundnut during the year of 2011-2012

| Treatments | Plant height (cm) | No. of pods per plant | No. of seeds per plant | Yield per plant (g) | 100 pod weight (g) | 1000 seed weight (g) | Yield (t/ha) | Biomass (kg/ha) | Shelling % (mech.) | Yield reduction (%) |
|---|---|---|---|---|---|---|---|---|---|---|
| $T_1$ | 51.67 | 32 | 46 | 25.00 | 86.7 | 687 | 1.40 | 7708.33 | 64.02 | 15.15 |
| $T_2$ | 52.97 | 26 | 39 | 21.00 | 93.3 | 670 | 1.46 | 6266.67 | 59.41 | 11.52 |
| $T_3$ | 48.57 | 23 | 32 | 16.00 | 83.3 | 667 | 1.34 | 5991.67 | 65.24 | 18.78 |
| $T_4$ | 47.8 | 23 | 34 | 17.00 | 81.7 | 643 | 1.63 | 5216.67 | 68.84 | 1.2 |
| $T_5$ | 47.7 | 28 | 35 | 23.00 | 93.3 | 673 | 1.65 | 5000.00 | 65.70 | 0 |
| CV | 7.77 | 21 | 18 | 19.38 | 18.6 | 7.04 | 21.9 | 18.19 | 12.11 | - |
| LSD | 5.636 | NS | NS | NS | NS | 0.065 | NS | NS | NS | - |

In the year of 2010-2011, the height yield (2.10 t/ha) was obtained in the treatment of $T_1$ (no water stress) followed by 1.97 t/ha for the treatment of $T_2$ (irrigation at flowering, pod formation and seed filling stage) and the yield reduction was found only 6.19%. Hence, the lowest yield (1.30 t/ha) was obtained in the treatment of $T_5$ (irrigation at vegetative and pod formation stage). Whereas, in the second year of 2011-2012, the highest yield (1.65 t/ha) was obtained in the treatment of $T_5$ and the second height yield was 1.63 t/ha for the treatment of $T_4$ (irrigation at vegetative, flowering and pod formation stage). But, the lowest yield (1.34 t/ha) was obtained in the treatment of $T_3$ (Irrigation at vegetative, pod formation and seed filling stage). On the other hand, only 1.2% yield variation was obtained in the second year between the treatments of $T_4$ and $T_5$ due to heavy rainfall.

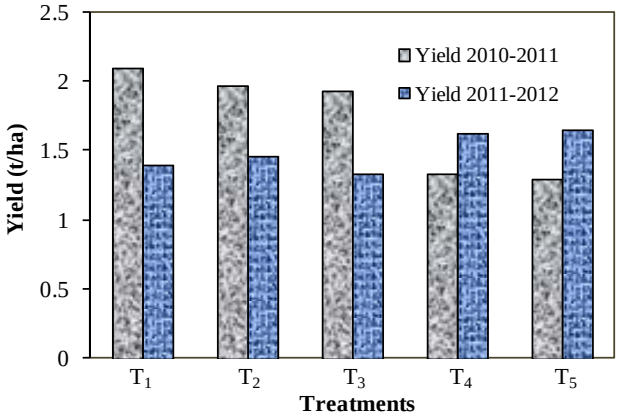


Fig. 1. Yield of groundnut shown under different irrigation treatments

Fig. 1, depicts a bar diagram between the yield and irrigation levels at different treatments for the years of 2010-2011 and 2011-2012. From this figure, it shows that the maximum and minimum yields were obtained in the treatments of $T_1$ and $T_5$, respectively in the year of 2010-2011. Hence, in the year of 2011-2012, the highest and lowest yield values were found in the treatments of $T_5$ and $T_3$, respectively.

From the first year investigation, it was observed that the irrigation at different growth stages of groundnut cultivation is important. Whereas, in the second year, it was revealed that the flowering and pod formation stages were critical stage of groundnut yield.

**Seasonal water use**

Tables 3 and 4 represent the seasonal water use of groundnut under different levels and timing of irrigation. The crop yield was reduced remarkably as compared to the different water stresses of the crop during the flowering and pod formation stages.

Table 3. Seasonal water used by groundnut during the growing season of 2010-2011

| Treatments | Applied irrigation (mm) | | | Effective rainfall (mm) | Seasonal water use (mm) | Yield (t/ha) | Water productivity (kg/m$^3$) |
|---|---|---|---|---|---|---|---|
| | 1$^{st}$ | 2$^{nd}$ | 3$^{rd}$ | | | | |
| $T_1$ | 40 | 60 | 65 | 164 | 329 | 2.1 | 0.64 |
| $T_2$ | - | 55 | 60 | 164 | 279 | 1.97 | 0.71 |
| $T_3$ | 45 | - | 62 | 164 | 271 | 1.93 | 0.71 |
| $T_4$ | 40 | 58 | - | 164 | 267 | 1.34 | 0.50 |
| $T_5$ | 45 | - | - | 164 | 209 | 1.30 | 0.62 |

Table 4. Seasonal water used by groundnut during the growing season of 2011-2012

| Treatments | No of irrigation (mm) | | | | Effective Rainfall (mm) | SMC (mm) | Irrigation applied (mm) | Seasonal water used (mm) | Yield (t/ha) | Water productivity (kg/m$^3$) |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | | | | | | |
| $T_1$ | 37.5 | 37.5 | 42.5 | 87.5 | 68 | -69.3 | 205.0 | 204 | 1.40 | 0.70 |
| $T_2$ | - | 37.5 | 42.5 | 87.5 | 68 | -69.3 | 167.5 | 166 | 1.46 | 0.88 |
| $T_3$ | 37.5 | - | 42.5 | 87.5 | 68 | -69.3 | 167.5 | 166 | 1.34 | 0.81 |
| $T_4$ | 37.5 | 37.5 | - | 87.5 | 68 | -69.3 | 162.5 | 161 | 1.63 | 1.01 |
| $T_5$ | 37.5 | - | - | 87.5 | 68 | -69.3 | 125 | 124 | 1.65 | 1.33 |

The highest seasonal water (329 mm) was used in the treatment of $T_1$ and the lowest (209 mm) was in the treatment of $T_5$ for the year of 2010-2011, In the year of 2011-2012, the highest (204 mm) and the lowest seasonal water use (124 mm) were also found in the same treatments with an effective rainfall of 164 mm and 68 mm, respectively. On the other hand, the highest water productivity (0.71 kg/m$^3$) was obtained both in the treatments of $T_2$ and $T_3$ but the lowest value (0.50 kg/m$^3$) was in the treatment of $T_4$ in the year of 2010-2011. Whereas, in the year 2011-2012, the highest water productivity (1.33 kg/m$^3$) was found in treatment of $T_5$ and the lowest (0.70 kg/m$^3$) was in treatment of $T_1$. When severe water stress follows, the crop rapidly depletes the soil water stored in the root zone and wilt before the completion of additional root development of greater soil depth (Kirda and Kanber, 1999). According to the results, water stress during the flowering, pod formation and early seed filling stages are reduced in the final grain yield in a considerable amount for the both years of investigation.

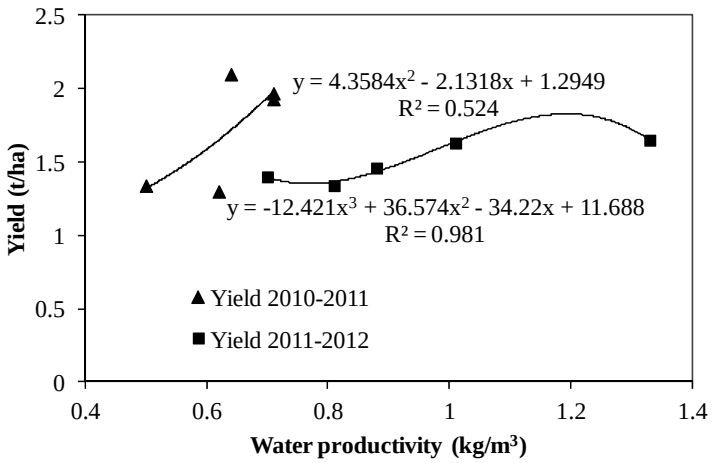


Fig. 2. Yield of groundnut as a function of water productivity

The Fig. 2 shows the polynomial relationship between the yield and water productivity for both in the year of 2010-2011 and 2011-2012. There was a positive relationship in both years. In first year, a 2nd degree polynomial relationship was found with $R^2$ value of 0.524. But in second year, a 3rd degree polynomial relationship was found with $R^2$ value of 0.981.

**Economic analysis**

Data pertaining to economic comparison is presented in Table 5. All the variable costs except the irrigation costs were same in all the treatments. The highest benefit-cost ratio (1.55) was found in the treatment of $T_5$, while the lowest benefit-cost ratio (1.04) was obtained from the treatment of $T_1$. This might be due to the fact that the treatment $T_5$ experienced water stress in the vegetative and pod formation stages during the growing season of groundnut and thus produced maximum yield and the highest benefit-cost ratio (BCR). On the other hand, the lowest net margin and benefit-cost ratio was found in the treatment of $T_1$, it may be attributed to no water stress (irrigation water applied at all the stages of crop growth).

Table 5. Economic analysis of groundnut production under different irrigation treatments during the year of 2011-2012

| Indicators | Treatments | | | | |
|---|---|---|---|---|---|
| | $T_1$ | $T_2$ | $T_3$ | $T_4$ | $T_5$ |
| Variable costs (Tk./ha) | | | | | |
| Land preparation | 7000 | 7000 | 7000 | 7000 | 7000 |
| Labor | 40000 | 40000 | 40000 | 40000 | 40000 |
| Fertilizers | 9380 | 9380 | 9380 | 9380 | 9380 |
| Groundnut | 6000 | 6000 | 6000 | 6000 | 6000 |
| Pesticide | 2000 | 2000 | 2000 | 2000 | 2000 |
| Irrigation | 69,472 | 56,763 | 56,763 | 55069 | 42361 |
| Total cost (Tk./ha) | 133852 | 121141 | 121143 | 119449 | 106741 |
| Yield (t/ha) | 1.40 | 1.46 | 1.34 | 1.63 | 1.65 |
| Price (Tk./ton) | 100000 | 100000 | 100000 | 100000 | 100000 |
| Gross return (Tk./ha) | 140000 | 146000 | 134000 | 163000 | 165000 |
| BCR | 1.04 | 1.21 | 1.11 | 1.36 | 1.55 |

## CONCLUSION

From this study, it is revealed that the flowering and pod formation stages of groundnut cultivation were the most sensitive to water stress both in the years of 2010-2011 and 2011-2012. The yield is reduced 18.78%, when only the stress occurs at the flowering stages in the year of 2011-2012. Therefore, to justify the results of both the years, the groundnut is grown well under proper irrigation schedule at the flowering and pod formation stages and it gives sufficient return to the farmers of Bangladesh.

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