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Response of Growth Indices of Sunflower (*Helianthus annuus* L.) To Different Level of Deficit Irrigation and Nitrogen Fertilizer

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ABSTRACT

BACKGROUND: Growth analysis is a suitable method for plant response to the different environmental conditions during crop life. Nitrogen is the most significant nutrient to improve yield and quality of sunflower seeds. It is an essential plant nutrient to stimulate plant growth and development and ultimately yield and quality.
OBJECTIVES: This research was conducted to assessment effect of different levels of irrigation regime and nitrogen fertilizer on growth curves traits of sunflower.
METHODS: Current study was carried out according split plot experiment based on randomized complete blocks design with four replications. The main factor included irrigation regime and nitrogen fertilizer (N_1: 50, N_2: 100 and N_3: 150 $kg.ha^{-1}$) belonged to sub factor.
RESULT: Evaluation comparison different level of irrigation regime indicated that maximum amount of studied traits (instead net assimilation rate) was noted for I1 treatment and minimum of that belonged to I_2 and I_3 treatment, respectively. Compare different level of nitrogen revealed the highest amount of total dry weight, leaf area index, crop growth rate was belonged to use 150 $kg.ha^{-1}$ nitrogen (N_3) and the lowest ones was found for 50 $kg.ha^{-1}$ nitrogen (N_1), but net assimilation rate had the reverse trend.
CONCLUSION: The results show apply low irrigation should be done in stages that have less impact on the final yield crop needs less water and less sensitivity at that stage, and nitrogen can also play a constructive role, but it is recommended to use less nitrogen under deficit irrigation. Although I_1 treatment had the superior amount of growth indices but under water limitation I_3 treatment can considered for producers.

KEYWORDS: *Leaf area index, Oilseed, Physiological traits, Total dry weight, Urea.*

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1. BACKGROUND

Sunflower with an annual production of about 26 Mha, following rapeseed and soybean, is one of the most important oil crops worldwide (FAO, 2014). Sunflower because of its quantity and quality of edible oil occupies an important position in the world among the new oil seed crops. The yield of sunflower is controlled by several factors, including selection of suitable hybrids, proper production technology and management practices especially optimum plant population in the field, judiciously use of fertilizer, particularly nitrogen and social and marketing systems (Ali *et al*., 2011). Under semi arid and arid conditions where soil moisture is a limiting factor, maintaining an optimum plant population is a key factor for increasing yield (Koutroubas *et al*., 2008; Ali *et al*., 2012a). Sunflower seed oil is highly rich in unsaturated fatty acids [oleic acid (20%) and linoleic acid (70%)] required for cell structure. It is also light colored, delicious and easily digested. Sunflower oil catalyzes the intake of oil-soluble vitamins (A, D, E and K) in to body and plays a remedial role in cardiovascular and cholesterol diseases (Kolsarici *et al*., 2005). Growth analysis is a way to assess what events occurs during plant growth. Growth analysis is a suitable method for plant response to the different environmental conditions during plant life (Tesar, 1984). Leaf area index changing through alteration in nitrogen fertilizer levels is one of the most practical ways. In every region, leaf area index which produces the maximum yield is different and it should be obtained by the local research (Azarpour *et al*., 2014). Identification of growth physiological indices in analysis of factors affecting yield and its components has a great importance and its stability determines the dry matter production which is a criterion of yield components and in this regard leaf area index, total dry weight and leaf dry weight should be measured in periodic intervals during the growing season (Gardner *et al*., 1985). The above indices plus crop growth rate, relative growth rate, net assimilation rate, leaf area duration, leaf area rate, leaf weight rate and specific leaf area are indices which often use for evaluation of plant productivity capability and environmental efficiency (Anzoua *et al*., 2010). Leaf area index and dry matter production is the main growth factor which may directly reflect to cotton yield. Growth analysis parameters like crop growth rate are product of LAI. Relative growth rate measures the increase in dry matter with a given amount of assimilatory material at a given point of time (Rajput *et al*., 2017). Sharifi *et al*., (2014) reported that during plant growth stages RGR values are interrelated to dry matter accumulation and crop growth rate. The amount of growth and photosynthetic translocation is related to nutrients availability (Munir *et al*., 2012). Dwyer and Tewart (1986) reported that leaf area index is major factor determining photosynthesis and dry matter accumulation. Crop growth rate is related to leaf area index, for this reason that crop growth rate changes is depended to two parameters: namely leaf area index and net assimilation rate. Leaf area index is the component of crop growth analysis that accounts for the ability of the crop to capture light energy and is critical to understanding the function of many crop management practices. Leaf area index can have importance in many areas of agronomy and crop production through its influence on: light interception, crop growth weed control, crop-weed competition, crop water use, and soil erosion. To measure LAI, scientists generally have cut a number of plants at the soil surface, separated leaves from the other plant parts, and measured the area of individual leaves to obtain the average leaf area per plant. The product of leaf area per plant and the plant population gives the LAI. Alternatively, LAI could be measured none destructively with this procedure if area of individual leaves was determined by some combination of leaf length and width measurements (Shirkhani and Nasrolahzadeh, 2016). Nitrogen is the most significant nutrient to improve yield and quality of sunflower seeds. It is an essential plant nutrient to stimulate plant growth and development and ultimately yield and quality (Ullah *et al*., 2010). Fertilizer needs of common sunflower cultivars vary based on ecological conditions annul precipitations, irrigation regimes and plant species. Higher nitrogen doses improve photosynthesis process, increase leaf area and net digestion rates (Munir *et al*., 2007). However, excessive nitrogen treatments may result in environmental pollution, imbalanced plant nutrition, decreased quality and increased production cost (Gok *et al*., 2006). Evci *et al*. (2006) indicated that decreasing soil moistures may result in significant decreases in sunflower seed yields. Water stress especially during the flowering or vegetative growth periods may significantly reduce seed yields (Kadayifci and Yildirim, 2000). Thusly in previous studies, Ozer *et al*. (2004) reported significant effects of nitrogenous fertilizers on seed yield and quality and Ali *et al*. (2012b) and Nasim *et al*. (2012) reported increasing sunflower yield levels with increasing nitrogen doses. Thavaprakash (2004) and Namvar *et al*. (2012) observed the highest seed yield levels at 12 kg nitrogen dose and Evci *et al*. (2006) reported the highest yield at nitrogen doses of between 5-10 kg. Al-Thabet (2006) indicated that nitrogen rates are always related to oil yield in every part of the world where sunflower is cultivated. While Foroud and Bohrani (2000) indicated significantly increasing seed and oil yields and head diameters with increasing nitrogen doses, Hussain *et al*. (2011) reported significantly decreasing oil yield with increasing nitrogen doses.

2. OBJECTIVES

This research was conducted to assessment effect of different levels of irrigation regime and nitrogen fertilizer on growth indices of sunflower.

3. MATERIALS AND METHODS

3.1. Field and Treatments Information

Current study was carried out to via split plot experiment based on the randomized complete blocks design with four replications. Place of research was located in Ahvaz city at longitude 48°40'E and latitude 31°20'N in Khuzestan province (Southwest of

Iran). The main factor included irrigation regime (Table 1) and nitrogen fertilizer (N_1: 50, N_2: 100 and N_3: 150 $kg.ha^{-1}$) belonged to sub factor. This experiment had 36 plots. Each plot consisted of 6 lines with a distance of 75 cm and 5 meters length. The distance between shrubs on every row was 10 cm. In late July, sunflower seeds were planted by hand at a distance of 20 cm on the ridges and at a depth of 3-5 cm.

Table 1. Irrigation regime treatments

I_1	**Conventional Irrigation**
I_2	Deficit irrigation at R_3 stage (At this stage, the node between the reproductive buds continues to lengthen and the inflorescence rises more than 2 cm above the leaves) and conventional irrigation after mentioned stage
I_3	Deficit irrigation at R_5 stage (Start pollination as the side flowers are fully spread) and conventional irrigation after mentioned stage

3.2. Farm Management

Irrigation was done based on the requirement and via siphon. In order to prevent the possible combination of adjacent fertilizing treatments and leaching, the distance between sub plots, main plots, and blocks was 1.5 m (two rows), 2.25 (three rows), and 2 m, respectively. During the land preparation, 100 $kg.ha^{-1}$ phosphorus and 100 $kg.ha^{-1}$ potassium from ammonium phosphate and potassium sulfate sources were added to the soil before planting.

3.3. Measured Traits

In order to determine the yield two planting lines from each plot harvested and after the removal of marginal effect were carried to the laboratory and were placed in the oven at 75°C for 48 hours and after ensuring that the samples were completely dry, they were weighed and finally the total yield was measured. By measuring three factors including leaf area, leaf dry weight and total dry weight, the physiological parameters of growth including LAI, NAR, CGR and RGR were obtained using the following equations. To determine the leaf area of linear relationship S= K. L.W was used in which S, L and W were the leaf area, L and W respectively, the maximum length and width of each leaf and K= 0.75 correction coefficient. The leaf area index was calculated by leaf area ratio to ground level. Crop growth rate, net assimilation rate and relative growth rate were measured according fallowing formula (Buttery, 1970; Enyi, 1962):

Equ.1. CGR ($gr.m^{-2}.day^{-1}$) =
TDW_2- TDW_1/T_2-T_1
TDW_1= Primary dry weight (g),
TDW_2= Secondary dry weight (gr)
T_1= initial sampling time,
T_2= Secondary sampling time

Equ.2. NAR ($gr.m^{-2}.day^{-1}$) =
CGR× $LnLA_2$-$LnLA_1/LA_2$-LA_1
CGR = Growth rate in grams per day per square meter
LA_1 = Initial leaf area,
LA_2 = Secondary leaf area

Equ.3. RGR ($gr.gr^{-1}.day^{-1}$) =
[Ln (TDW_2) – Ln (TDW_1)]/T_2-T_1
RGR= relative growth rate ($gr.gr^{-1}.day^{-1}$)

3.4. Statistical Analysis

Analysis of variance and mean comparisons were done via SAS (Ver.8) software and Duncan multiple range test at 5% probability level.

4. RESULT AND DISCUSSION

4.1. Total dry weight (TDW)

The effect of low irrigation treatment on the total dry weight process of the crop is presented in Fig. 1. As can be seen, the TDW process is slow at the beginning of the growth stages and then increases rapidly and is finally fixed.

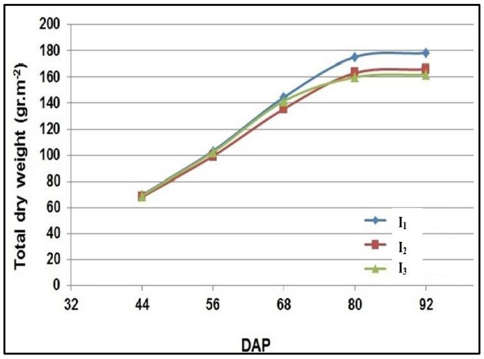

Fig. 1. Effect of different level of irrigation treatments on TDW.

The highest amount of TDW was related to the optimal irrigation I_1 and also the lowest one was related to I_3 treatment. It seems the reason for the decrease in TDW can be attributed to the decrease in plant leaf area, decrease in net photosynthesis, climatic factors such as air temperature and their effect on increasing the evaporation and transpiration. Another researcher such as (Mojaddam *et al*., 2012; Qoli Nejad, 2012; Karimi-Kakhaki and Sepehri, 2011) was confirmed mentioned result. Moghimi *et al*. (2014) reported low irrigation in early vegetative growth reduced dry matter content of maize plants, but at reproductive stage it decreased more severely. According to the result of result of Fig.2 application of nitrogen fertilizer had a positive effect on TDW accumulation.

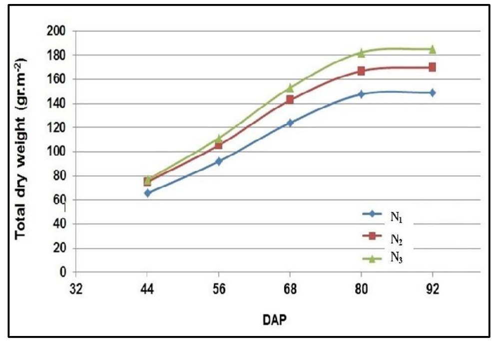

Fig. 2. Effect of different level of nitrogen treatments on TDW.

The highest amount of TDW was related the treatment 150 $kg.ha^{-1}$ (N_3) and the lowest one were belonged to the 150 $kg.ha^{-1}$ (N_1 treatment). Rahimi *et al*. (2009) and Karimian Klishadorkhi *et al*. (2009) reported same result.

4.2. Leaf area index (LAI)

Leaf area index is the ratio of leaf area to land occupied by the plant, which increases over time due to the production of new leaves and the increase in the area of each leaf. Leaf area index decreases after reaching a certain level, which varies depending on the cultivar and the environmental conditions, and the highest leaf area index was obtained at the flowering stage (Karimi-Kakhaki and Sepehri, 2011). Fig. 3 showed that application of low irrigation in sunflower plant at I_3 treatment and stop of irrigation in R_5 stage caused a sharp decrease in leaf area index. Also, I_2 treatment cut off irrigation in R_3 stage also reduced leaf area index. It seems decreased leaf area index was due to decreased cell growth, lack of leaf expansion, which disrupted photosynthesis, lack of water and reduced cell inflammation and yellowing of leaves, and finally accelerated leaf aging and premature leaf fall. The highest leaf area was obtained from optimal irrigation I_1 treatment. These finding were consistent with results of Haj Hassani Asl (2008) and Sharifi *et al*. (2008). Boudjabi *et al*. (2015) reported that drought stress significantly affected leaf area index and with increasing drought stress, leaf area index decreased significantly. Reducing leaf area index with increasing water deficit stress can be attributed to the decrease in leaf size due to lack of suitable moisture for maintaining turgor stress for growth of leaf cells along vegetative growth (Tarumingkeng and Coto, 2003). Fig. 4 showed that the highest leaf area index was obtained to use 150 kg.ha^{-1} (N_3) and the lowest one was related to level N_1 treatment. It seems increasing nitrogen consumption led to increase leaf area index. The reason for the positive effect of nitrogen is related to increase vegetative growth and photosynthesis. Imam *et al*. (2008) and Rahimi *et al*. (2009) reported same result.

4.3. Crop growth rate (*CGR*)

Product growth rate is an indicator of productivity for plants that grow within a plant community. This index indicates the amount of dry matter accumulation of plants in a certain time interval per unit area of soil. The highest value of this index is when leaf area index is at desired level, ie the flowering stage, and then decreases with shading and leaf aging (Karimi-Kakhaki and Sepehri, 2011). The highest CGR was related to I_1 treatment, which was observed in flowering stage and then decreased.

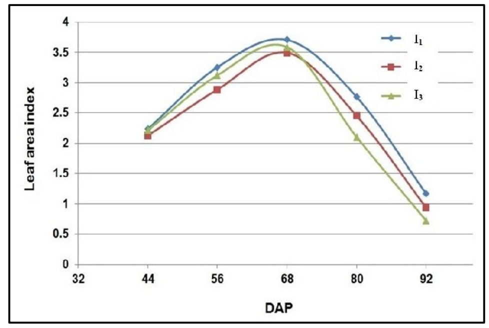

Fig. 3. Effect of different level of irrigation treatments on LAI.

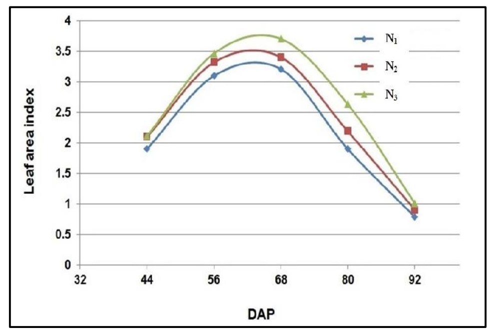

Fig. 4. Effect of different level of nitrogen treatments on LAI.

Crop growth rate in treatment (I_3) intensified after passing the peak stage due to cessation of irrigation. The reason for the decline in CGR after the flowering stage is related to increase the rate of aging and leaf fall (Fig.5). Karimi-Kakhaki and Sepehri (2011) and Qoli Nejad (2012) reported same result. Bomesa and Wayne (2008) reported that water stress by decrease leaf area, reduce photosynthesis area and the production of dry matter, and so amount of CGR of deficit irrigation were lower than conventional irrigation during plant growth, mentioned result which confirmed the findings of current study. Consumption of nitrogen fertilizer led to increase CGR. The highest CGR was related to use 150 kg.ha^{-1} (N_3), which was observed in flowering stage.

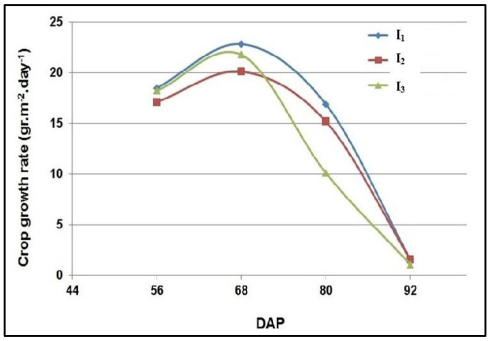

Fig. 5. Effect of different level of irrigation treatments on CGR.

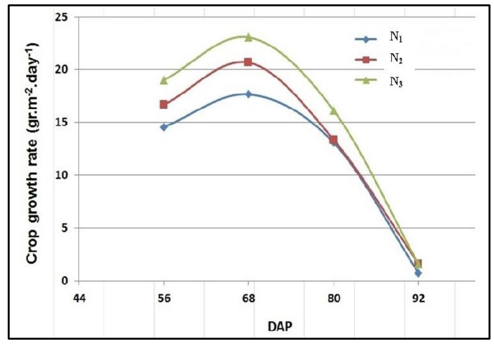

Fig. 6. Effect of different level of nitrogen treatments on CGR.

Also the lowest one belonged to N_1 treatment (Fig.6). It seems increasing the crop growth rate is due to the effect of nitrogen on increasing leaf area index and increasing the amount of light received by crop. These results were consistent with finding of experiments Qoli Nejad (2012) and Rafiei *et al*. (2008).

4.4. Relative growth rate (*RGR*)

Relative growth rate indicates the dry weight added to the initial weight over a period of time, which decreases over time due to increased shading and increased structural and ineffective parts of photosynthesis. This index is used as the main and basic criterion of dry matter production and it can be used to compare the efficiency of species or environmental effects in making dry matter under certain conditions Karimi-Kakhaki and Sepehri (2011). In general, RGR is at a higher level at the beginning of the growing season due to the penetration of light into plant community and less shading of leaves on each other and as a result less respiration, but with time and increasing vegetative organs and plant growth and shade its value decreases (Qoli Nejad, 2012).

Fig. 7 showed that the highest relative growth rate was observed in the optimal irrigation treatment (I_1), which was achieved due to proper cell inflammation, non-close of stomata cells and suitable conditions for photosynthesis. In I_2 low irrigation treatment, although the relative growth rate in the early stages of growth is high, but the stress conditions cause the stomata to close, reduce photosynthesis and finally reduce the amount of dry matter produced by the plant and RGR in compare to I_1 decreased. In I_3 treatment, by apply low irrigation in the pollination stage although the relative growth rate is high at the beginning of the growth stages, but over time, its amount decreases due to shading and aging of the leaves and intensified the pollination stage RGR is decrease. Mentioned result was similar to finding of Haj Hassani Asl (2008) and Qoli Nejad (2012). Fig. 8 showed that the application of nitrogen fertilizer had a positive effect on the decreasing trend of relative growth rate and reduced its downward trend, but with increasing the plant growth, changes in the relative growth rate showed a decreasing trend.

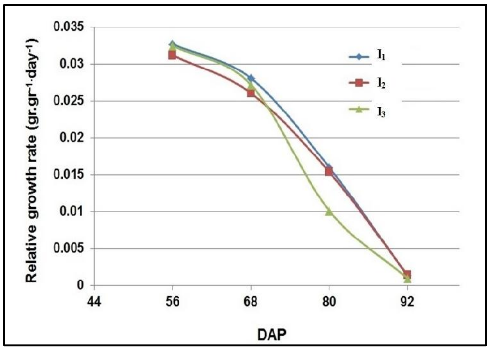

Fig. 7. Effect of different level of irrigation treatments on RGR.

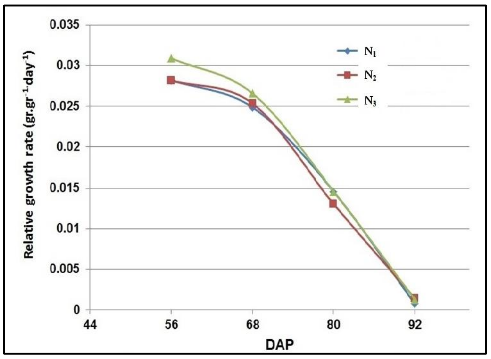

Fig. 8. Effect of different level of nitrogen treatments on RGR.

So the highest amount of RGR belonged to N_3 treatment and the lowest one was for N_1 treatment. Rahimi *et al.* (2009) reported same result.

4.5. Net assimilation rate (*NAR*)

Net uptake rate or net photosynthesis is a measure of the photosynthetic efficiency model of leaves in a plant community, which is expressed as the rate of accumulation of dry matter per unit area of leaves at a given time. With increasing leaf area index, in the shade of leaves and decreasing leaf efficiency, this index decreases over time (Karimi-Kakhaki and Sepehri, 2011). Fig. 9 showed that the highest rate of NAR was related to the conventional irrigation treatment and the lowest rate of uptake was in the low irrigation treatments in stages R_3 and R_5, respectively. The reason for the decrease in NAR was due to a decrease in leaf area index and a decrease in photosynthesis. The obtained results are consistent with the results of experiments and Haj Hassani Asl (2008) and Qoli Nejad (2012). Khodadadi Dehkordi *et al.* (2013) by evaluate the effects of water stress and superabsorbent on corn growth factors stated that stress had a negative effect on LAI, CGR and NAR, is due to lower leaf area cover, reduced absorption of sunlight and unnecessary changes in the process of absorbing and accumulate assimilates. Also by using superabsorbent in that study, the effect of water deficit on corn was reduced and led to achieve higher LAI, CGR and NAR than to control. The highest amount of NAR belonged to N_1 treatment and the lowest one was for N_3 treatment (Fig.10). In general, nitrogen consumption had little effect on the rate of net absorption because over time, metabolic tissues become structural and stored and lose their activity. Also, due to nitrogen consumption, the leaf area index has increased, which is the result of increasing the photosynthesis of the plant, but because these leaves shade each other and a number of leaves are located in areas that do not get enough light to produce and They are not even produced to meet their own needs and are considered consumers, thus reducing the rate of net absorption (Shirani Rad and Dehshiri, 2002).

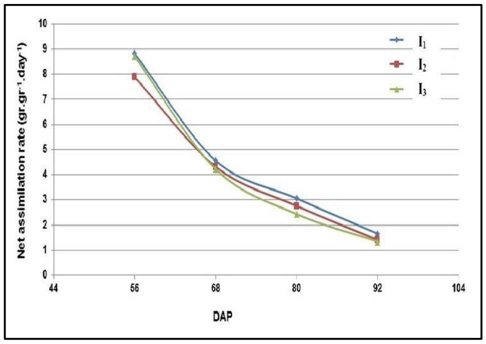

Fig. 9. Effect of different level of nitrogen treatments on NAR.

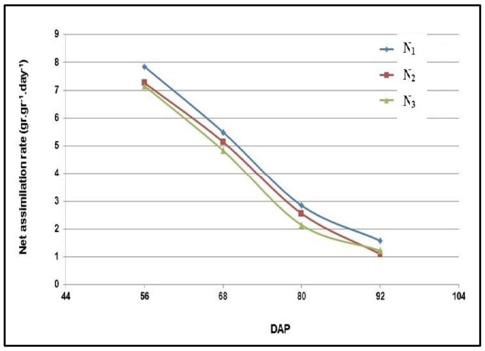

Fig. 10. Effect of different level of nitrogen treatments on NAR.

5. CONCLUSION

Apply low irrigation should be done in stages that have less impact on final yield crop needs less water and less sensitivity at that stage, and nitrogen can also play a constructive role, but it is recommended to use less nitrogen under deficit irrigation. Although I_1 treatment had superior amount of growth indices but under water limitation I_3 treatment can considered for producers.

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FOOTNOTES

AUTHORS' CONTRIBUTION: All authors are equally involved.

CONFLICT OF INTEREST: Authors declared no conflict of interest.

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