INNSPUB

International Journal of Biosciences | IJB |
ISSN: 2220-6655 (Print) 2222-5234 (Online)
http://www.innspub.net
Vol. 5, No. 2, p. 99-105, 2014

RESEARCH PAPER OPEN ACCESS

The effect of different levels of humic acid and potassium fertilizer on physiological indices of growth

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Key words: Cowpea, potassium fertilizer, humic acid, physiological indices.

http://dx.doi.org/10.12692/ijb/5.2.99-105 Article published on July 25, 2014

Abstract

In order to investigate the interactive effect of humic acid and different levels of potassium fertilizer on physiological indices of cowpea, a split plot experiment in the form of randomized complete blocks design with four replications was carried out in Shahid Salemi Field located in Ahvaz in 2011-20121. The studied factors include three levels of potassium fertilizer (0, 200, and 300 kg/h) and three levels of humic acid (0, 50, 100ppm). Traits such as leaf area index (LAI), total dry weight (TDW), crop growth rate (CGR), net assimilation rate (NAR) were measured. Changes trend of dry matter significantly increased at density of 100 ppm humic acid and 300 kg/ha potassium. Leaf area index increased at density of 100 ppm humic acid and 300 kg/ha potassium. NAR index, like other growth indices, responded to consumption of humic acid and potassium fertilizer.

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Introduction

Legumes as one of the most important plant resources are full of protein and after grains are considered as the second most important source of food for human being. The rate of protein in legumes grains is twice or three times more than that of grain cereals and 10 to 20 times more than that of tuberous crops like potatoes (Kuchaki and Banayan Aval, 2007). Cowpea with scientific name of Vignasinensis is one of the legumes which are planted in tropical and semitropical countries particularly African and South American countries (Marschner, 1995).

Humic acid is extracted from different sources such as soil, Humus, peat, oxidized lignite, and coal. Humic acid can directly have positive effects on plant growth and increases the growth of shoots and roots, absorption of nitrogen, potassium, calcium, magnesium, and phosphorus by plant. Humic acid is consistent with nature and is not dangerous for the plant and environment (Haghighi *et al.,* 2011). Abdel-Mawgoud *et al.,* (2007) states that humic acid increases plant growth through chelating different nutrients to overcome the lack of nutrients, and has useful effects on growth increase, production, and quality improvement of agricultural products due to having hormonal compounds. Among legume family plants, humic acid foliar spray has remarkable effects on vegetative growth of plant and increases photosynthetic activity and leaf area index. Ghorbani *et al.,* (2010). The results of the research on wheat showed that the interactive effect of different concentrations of humic acid at three foliar spraying times on leaf area was significant (Sabzevari and Khazaei 2009). Sharif *et al.,* (2002) stated that humic acid could sustain photosynthetic tissues and thus total dry weight would increase. Potassium is very important as one of the macronutrients and even though it is not a part of plant structure, it has a key role in internal reactions of the plant, so that it is called quality element. The main role of potassium is to activate many enzymes in plant and such enzymes act as catalyst for making materials such as starch and protein. Potassium also plays a role in photosynthesis, osmotic adjustment, cell growth, stomatal regulation, water system of plant, downloading hydrocarbons made in the leaves into phloem, transporting them within the plant, anion-cation balance, and as accompanying cation in nitrogen transfer.

Xiumeil and Yaping (2003) showed that the use of potassium has a major role in increasing the yield. Azizi (1998) reported that the use of potassium oxide would increase leaf area index.

This research aimed to investigate the effect of foliar application of humic acid and potassium fertilizer consumption on growth trend of cowpea and determining the best application level of humic acid and potassium.

Materials and methods

The research was conducted in 2011-2012 in Shahid Salemi Field in Ahvaz. Ahvaz is located in southwest of Khuzestan Province which is an arid and semiarid area. It was a split plot experiment in the form of randomized complete blocks design with four replications. The experiment included 36 plots, and each replication included 3 main plots and each main plot included 3 sub plots. The space between main plots was 2.5m and the space between sub plots was 2m. the first and the last line were considered as the marginal effect. The studied factors included three levels of potassium fertilizer (0, 200, 300 kg/ha) and three levels of humic acid fertilizer (0, 50, 100 ppm) used as foliar spray. Potassium fertilizer was added to the treatments before cultivation and humic acid was used before flowering stage. Khuzestan local cultivar of cowpea was used in the experiment.

Measured Traits and Their Measurement Method

Determining Leaf Area Index (LAI)

In order to measure leaf area index, in every case of sampling, the area of the leaf was copied on a piece of A4 paper. Then, leaf area index was obtained by the ratio of leaf area of single plant to the area of the land it had occupied.

Crop Growth Rate (CGR)

After measuring dry weight of the samples, crop growth rate was calculated through the difference of dry weight of the sample at two sampling interval using the formula CGR = $\frac{W2-W1}{T2-T1}$. In this formula, $W_2 - W_1$ is dry weight of samples in two consecutive samplings and $T_2 - T_1$ is the interval between two samplings. Crop growth rate is expressed in g/m² per day.

Net Assimilation Rate (NAR)

After calculating two parameters of leaf area index and crop growth rate it is easy to calculate other growth indices. Net assimilation rate was calculated using the equation NAR = CGR$\times\frac{\ln LAI2-\ln LAI1}{(LAI2-LAI1)}$. In this formula, $LAI_2 - LAI_1$ is leaf area index in two consecutive samplings.

Relative Growth Rate (RGR)

Relative growth rate was calculated using the formula RGR = $\frac{LN\ W2-LNW1}{T2-T1}$

Total Dry Weight (TDW)

In order to measure dry weight of plant in area unit, the sample was placed in the oven for 48 hours at 75^{oC} and then it was weight by a digital scale with accuracy of 0.01 g. (Mosavijangali *et al.*, 2005).

Statistical Calculations

Calculating the measured traits and drawing the curves were done by EXCEL software.

Results and discussion

Total Dry Weight

Review of total dry weight trend (Fig. 1) shows that at different growth stages, total dry weight of plant has increased. As it is observed, total dry weight of plant in treatment with 100 ppm humic acid is more than that of other treatments. This shows that as humic acid increases, total dry weight increases, too. The results obtained in this section are consistent with the findings of (Haghighi *et al.*, 2011). Torkaman *et al.*, (2005) stated that humic acid could sustain photosynthetic tissues and thus total dry weight would increase.

Lack of access to soil potassium supply particularly at sensitive stages of reproductive growth (including grain aggregation) has led to production and transfer of less photosynthetic material and reduction of dry weight at zero level of potassium. All levels of potassium fertilizer and humic acid 98 days after planting maximized dry matter accumulation and then they showed a descending trend. The plant transferred its accumulated dry matter into reproductive organs, and the loss of leaves led to decrease of dry matter accumulation. The highest descending trend was observed in control treatments due to lack of consumption of potassium and humic acid. Majedi and Khademi (1999) showed that application of potassium had a key role in increasing the yield. The results were consistent with the findings of xiumeil and Yaping (2003) and Ziaeian (2006) and Azizi (1998).

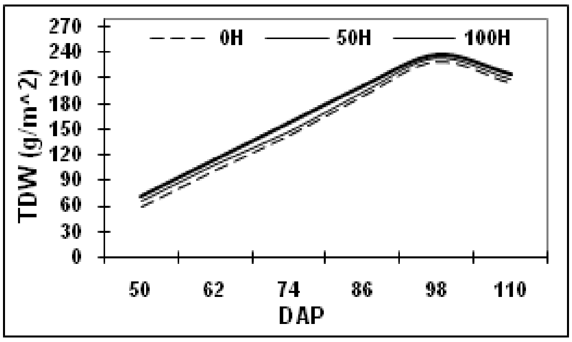

Fig. 1. changes trend of total dry weight at different levels of humic acid fertilizer.

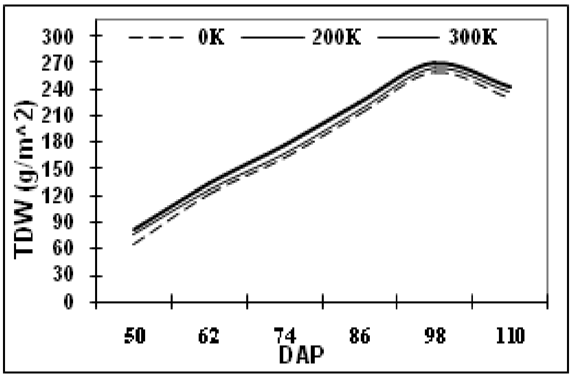

Fig. 2. changes trend of total dry weight at different levels of potassium fertilizer.

Leaf Area Index

With regard to (Fig. 3), the highest leaf area index was obtained after applying 100 ppm humic acid at vegetative growth stage in comparison to other treatments and the lowest leaf area index was related to the control treatment.

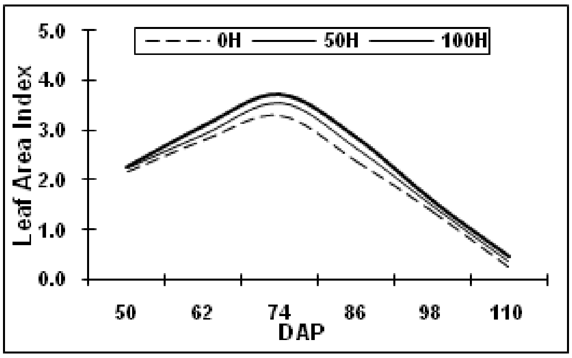

Fig. 3. Changes trend of leaf area index at different levels of humic acid fertilizer.

Albairak and Camas (2005) stated that that humic acid increases plant growth through chelating different nutrients to overcome the lack of nutrients, and has useful effects on growth increase, production, and quality improvement of agricultural products due to having hormonal compounds. Ghorbani *et al.,* (2010) stated that in legume family plants, humic acid foliar spray has remarkable effects on vegetative growth of plant and increases photosynthetic activity and leaf area index. Haghigh *et al.,* (2011) investigated the effect of humic acid on growth parameters of cowpea and found that humic acid would increase leaf area index.

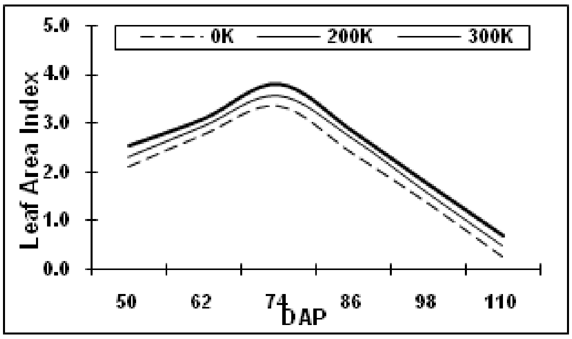

Fig. 4. Changes trend of leaf area index at different levels of potassium fertilizer.

According to (Fig. 4), application of 300 kg/ha potassium fertilizer has increased leaf area index in comparison to other treatments and the highest leaf area index was observed 74 days after planting which reduced slow growth period. Potassium shortage, due to shortage of soil potassium or decrease of access to it because of drought, stopped leaf area expansion and dramatically reduced carbon exchange rate. The increase of leaf area index as the application of potassium increased could be resulted from increase of root surface and increase of plant access to necessary elements. Moreover, potassium has a very important role in photosynthesis, cell division, growth, and water economy for the plant (Sober *et al.,* 1981).

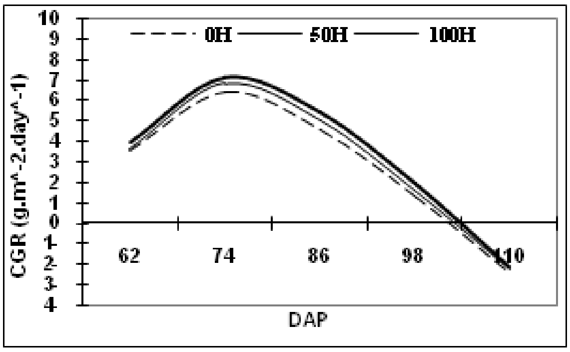

Fig. 5. Changes trend of relative crop growth rate at different levels of humic fertilizer.

Azizi (1998) reported that consumption of potassium oxide would improve leaf area index.

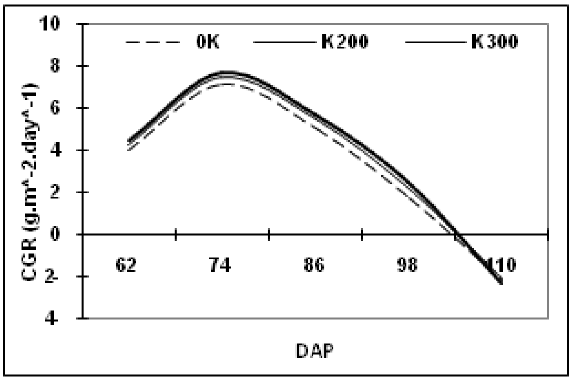

Fig. 6. Changes trend of relative crop growth rate at different levels of potassium fertilizer.

Crop Growth Rate (CGR)

In the treatment with application of 300 kg/ha potassium fertilizer and 100 ppm humic acid, crop growth rate was more than other treatments and increasing trend of crop growth rate is observed. This trend is due to gradual increase of absorbing solar radiation together with increase of green cover percentage at the beginning of growth season and consequently the increase of dry matter accumulation in plants. As it is observed in other treatments when the leaves get old and the rate of dry mater accumulation decreases crop growth rate decreases, too. The decrease of crop growth rate at final stages could be due to decrease of plant dry matter because of the fall of leaves. Generally, crop growth rate depends on canopy photosynthesis per area unit of land.

The results of this part are consistent with the findings of Haghighi *et al.,* (2011) and Daur and Bakhashwain (2013), as the increase of humic acid increased crop growth rate till flowering stage and pod filling stage and then CGR decreased. Potassium consumption has increased crop growth rate in comparison to control treatment, which is consistent with the findings of Azizi (1998) and Beik Nejad (2007). They reported that potassium consumption increased CGR in comparison to control treatment.

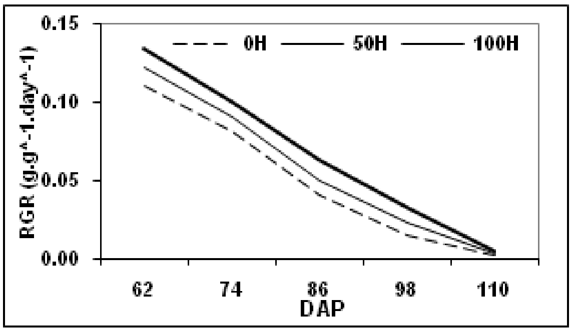

Fig. 7. Changes trend of relative growth rate at different levels of humic fertilizer.

Relative Growth Rate

Changes trend of relative growth rate at different levels of potassium fertilizer and different levels of humic acid is shown in (Fig. 7 and Fig. 8). It is a decreasing trend because as the time passes plant weight increases and consequently the number of tissues which have died or which are quite mature and do not have any role in production will increase, too. In other words, at the beginning of growth, all plant weight and cells play some roles in production but dead tissues and cells that play no role in production will increase over the time. The decrease of relative growth rate of plants during the growth season is due to increase of structural tissues in comparison to photosynthetic tissues. Shadowing and aging of lower leaves of plant canopy also somewhat affects such drop. However, he treatment with 100 ppm humic acid has sustained plant growth more than other treatments. The results were consistent with the findings of (Haghighi *et al.,* 2011) and (Ayous *et al.,*1996).

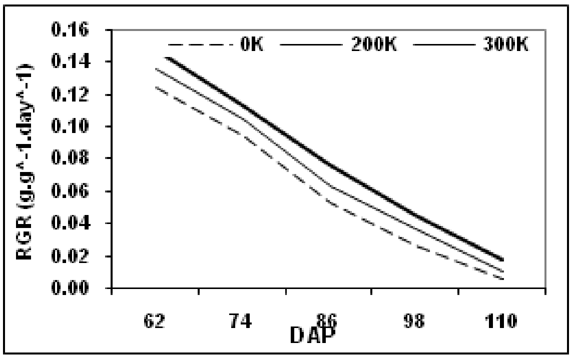

Fig. 8. Changes trend of relative growth rate at different levels of potassium fertilizer.

Fig.8 shows that application of 300 kg/ha potassium increased RGR in comparison to other treatments because plants keep their leaves a longer time than control treatment and the treatment with 200 kh/ha potassium and consequently have higher RGR. Sarvari (2008) reported that application of 80 kg/ha potassium caused higher growth rate than control treatment in soybean. Azizi (1998) reported that RGR in high levels of potassium was more than that of control treatment.

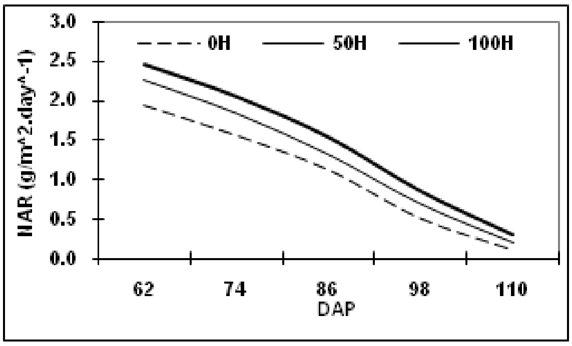

Fig. 9. changes trend of net assimilation rate at different levels of humic fertilizer.

Net Assimilation Rate (NAR)

Changes trend of net assimilation rate (NAR) at different levels of humic acid and potassium is shown in (Fig. 9 and Fig. 10). As it is observed, with increasing trend of days after planting, cumulative growth of NAR decreases and the decreasing trend is very similar at different levels of both potassium and humic acid. The highest NAR was achieved by consumption of 300 kg/ha potassium and 100 ppm humic acid. NAR index, like other growth indices, responded to the consumption of humic acid and potassium fertilizer.

The results of experiments (El-hendi *et al.,* 2011) showed that as the plant gets older NAR decreases due to leaves aging and their shadows on each other and decrease of active photosynthesis area. When all leaves are exposed to sunlight completely, NAR is maximized.

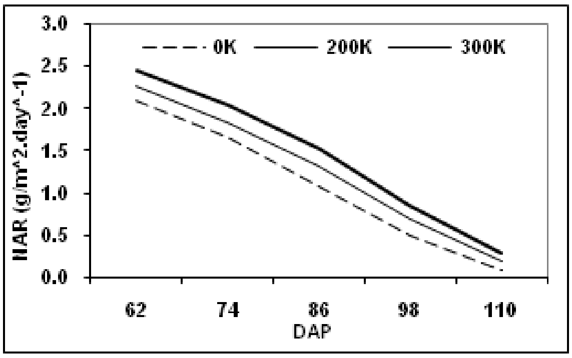

Fig. 10. Changes trend of net assimilation rate at different levels of potassium fertilizer.

Azizi (1998) reported that high levels of potassium in soil lead to highest NAR during the flowering stage to grain aggregation. It seems that this is due to stimulation of formation and photosynthetic activity of new reservoirs which are created due to more availability of potassium during this period of time.

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