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Research Article

THE EFFECT OF SOWING DATE AND PLANT DENSITY ON GROWTH ANALYSIS PARAMETERS OF COWPEAS

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ABSTRACT
Beans are among major legumes which have high percentage of protein, and are considered as one important source of plant protein in human nutrition. In addition, beans are planted in Iran in a wide area and knowing optimal farming factors can be an important step in increasing them. In order to investigate the effect of sowing date and plant density on growth physiological parameters, yield and yield components, a split plot experiment on cowpea (local cultivar) was carried out as randomized complete block design with four replications in Dehloran area in Ilam in 2010-2011. Experimental treatments included three sowing dates (July 6, July 23, and August 6) as main plots and four plant densities (17, 24, 31, and 38 plants per square meter) as sub plots. The highest rate of grain yield in terms of sowing date belonged to treatment with sowing date of July 23 by 1817 kg/ha and the lowest rate was related to treatment with sowing date of July 6 by 1457 kg/ha and in terms of plant density the highest rate of grain yield was related to density of 31 plants/m2 by 1631 kg/ha. The best sowing date and density in terms of parameters such as leaf area index (LAI), crop growth rate (CGR), relative growth rate (RGR), net assimilation rate (NAR), and harvest index was related to sowing date of August 23 and density of 31 plants/m2.

Keywords: *Cowpea, Growth Analysis Parameters, Plant Density, Sowing Date*

INTRODUCTION
Legumes after grains are the second source of human food and in Iran the second most important food after the wheat. Legumes' protein is four times as much as that of grains and 10 to 20 times as much as that of glandular plants (Koocheki and Bananiyan, 2002). One of the most important factors determining the yield of cowpea (Vigna sinensis L.) is appropriate sowing date. In general, climate parameters such as temperature, rainfall, day length, wind, and non-climate factors such as pests, diseases, weeds, birds, economy of production are effective in selecting appropriate sowing date (Mazaheri and Majnoon, 2005). Delay in sowing, decreases the length of vegetative and reproductive growth stages and reduces the grain yield. The decrease of grain yield in delayed sowing could be due to the fact that plant vegetative stage faces intense heat of the season which results in decrease of vegetative growth stage, production of fewer vegetative organs, decrease of assimilation, early flowering, increases of flowers' loss and infertility, and decrease of grain components yield (Sreelatha *et al.*, 1997). Another important factor determining the yield of cowpea is optimal density. Optimal density is the density through which environmental factors (water, weather, light, and soil) are used perfectly and at the same time inter-plant and intra-plant competition is minimizedso that maximum possible yield and optimal quality are achieved. On the other hand, the density should provide enough space for breeding and harvesting operations (CSIDC, 2001; Shirtliffe and Johnston, 2002). In a study conducted by Dhanjal *et al.*, (2001) on French bean, they showed that the increase of density to some extent increased the yield and further increase of density led to decrease of yield due to reduction of nutritional space and launch of competition. Plants physiology researchers often pay attention to changes trend of dry weight before knowing the ultimate results of crops yield and products. Studying the rate of effect of various factors on of growth and development and yield trend of plants is known as growth analysis. Studying the net assimilates accumulation trend during the time and after receiving temperatures above physiological zero is one of the most important indices in this regard (Koocheki and Sarmadnia, 1997). Crops growth indices are affected by agronomic factors such as sowing density. Sowing density affects most of growth parameters by influencing the light

intensity and its penetration into plant population. Among growth indices, crop growth rate (CGR), leaf area index (LAI), and leaf area duration (LAD) are more important in physiological studies of dry matter production (Sarmadnia and Koocheki, 1998). Mousavi *et al.,* (1999) reported that the highest leaf area index in local cultivar of red bean (4/2) belonged to sowing date of April 28 on 50 cm rows and 10 cm space between plants. Torabi *et al.,* (2001) stated that as the space between two plants in a row decreased and sowing density increased in several cultivars of red bean, the crop growth rate increased. Other researchers have studied the effect of plant density on growth rate of some crops such as soybeans and beans andhave attributed the increase of crop growth rate in higher densities to the increase of leaf area and light absorption (Luas and Milborn, 1976). Talaeei *et al.,* (1999) investigated the changes trend of CGR and grain yield in response to different sowing arrangements and reported a high correlation between maximum CGR and grain yield. In general, this research aims to investigate and analyze growth indices (LAI, CGR, RGR) and also to investigate the effect of sowing date and different plant densities on yield of cowpeas in Dehloran, Ilam.

MATERIALS AND METHODS

Experimental Location

This research was carried out in 2010-2011 in a research field in Dehloran, Ilam, at longitude 36°32'E and latitude 23°47'N in a land with an area of 456 m2. Dehloran is about 232 m above sea level, the average annual rainfall is 233.6 mm and the average temperature is 28.97°C. The soil texture of the experiment site was loamy soil and pH = 6.3 and Ec = 4.7 ds/m-1. The experiment was conducted as split plots in the form of randomized complete block design with four replications. Treatments included three sowing dates ((July 6, July 23, and August 6) as main plots and four plant densities (17, 24, 31, and 38 plants per square meter) as sub plots. To ensure the desired densities, seeds with higher density were planted and after full establishment of plants at 3-4-leaf stage, additional plantlets were removed. Each experimental plot contained 7 sowing rows as long as 3m and as wide as 2m. To prevent the interactive effect of treatments, the space between treatments was considered to be 2 m. Planting was done manually on July 6 on the stacks. Maintaining operations including irrigation and control of weeds immediately began after sowing. Due to hot weather at the beginning of growth stage, irrigation interval was 3-4 days and then during the growth stage irrigation interval gradually increased to once a week. Weeds were cut by hand in two stages. Moreover, in order to fight the ticks 75 ml/ha Ortho Insecticide (Fenpyroximate) was used on September 5, 2010. To determine the total plant dry matter (TDW) at each sampling, shoots were chopped and located in the oven in the temperature of 72°C for 48 hours. Leaf area index was determined by leaf area meter (LP-80 Accupar PAR/LAI Ceptometer).

Crop growth rate (CGR) was worked out by adopting the formula of Watson (1967) and expressed as g m^{-2} day^{-1}. CGR (g m^{-2} day^{-1}) = W_2-W_1/t_2-t_1

W_1 = dry weight (g m^{-2}) at time t_1 , W_2= dry weight (g m^{-2}) at time t_2

t_1 - t_2 = time interval in days

Relative growth rate (RGR) is the ratio of increase in dry weight per unit dry weight already present, expressed in g per g dry weight per day. Relative growth rate at various stages was calculated as suggested by Radford (1967):

RGR (g g^{-1} day^{-1}) = LN W_2 – LNW_1 / (t_2 - t_1)

Where W_1 = dry weight of plant (g) at time t_1, W_2= dry weight of plant (g) at time t_2 and t_1 - t_2 = Time interval in days

Net assimilation rate (NAR) was worked out by adopting the formula of Radford (1967) and expressed as

NAR (g m^{-2} day^{-1}) = (Ln (LAI_2) – Ln (LAI_1)/LAI_2-LAI_1) × CGR

LAI_1= leaf area index at time t_1 and LAI_2= leaf area index at time t_2.

Statistical analysis of data was performed using computer software MINITAB and MSTAT-C and comparison of the means was done by Duncan's test at a probability level of 5 percent.

RESULTS AND DISCUSSION

Leaf Area Index (LAI)

Diagram (1) shows the effect of different sowing dates on leaf area index. It is observed that during the days after planting in all three sowing dates leaf area index first increased until 64 days after planting and then it had a descending trend. The highest slope of leaf area increase is related to sowing date of July 23 and the lowest one is related to sowing date of July 6. Even though during 40 days after the sowing date of July 6 leaf area index is maximized, this trend generally changes until 64 days after sowing and the minimum leaf area index ultimately belongs to the same sowing date, as well. Plants sowed on August 6, have a higher leaf area index during 52 to 76 days after planting date than that of August 23; however, the sowing date of July 23 produces the highest leaf area index, ultimately.

The results of diagram (2) indicate the effect of different plant densities on changes of leaf area index after planting. According to the results, as density increases, leaf area index increases, too. As it is observed, leaf area index increases until 64 days after sowing and then it decreases. The highest leaf area belongs to density of 31 plants/m2 and 64 days after sowing and the lowest leaf area index which is recorded belongs to density of 17 plants/m2 and 88 days after sowing. Njoku and Muoneke (2008) found that sowing density significantly increased leaf area index at 5% level which was due to increase of number of leaves in area unit. Bennett *et al.*, (1977) reported that the highest effect of plant density is due to the shadow which is made during maximum LAI during early reproductive stage of beans. Redden *et al.*, (1987) stated that beans canopy at flowering stage in treatment with planting space 0f 18 cm was 24% more than that of the treatment with planting space of 71 cm and in density of 33plants/m2 the canopy was 21% more than density of 11plants/m^2.

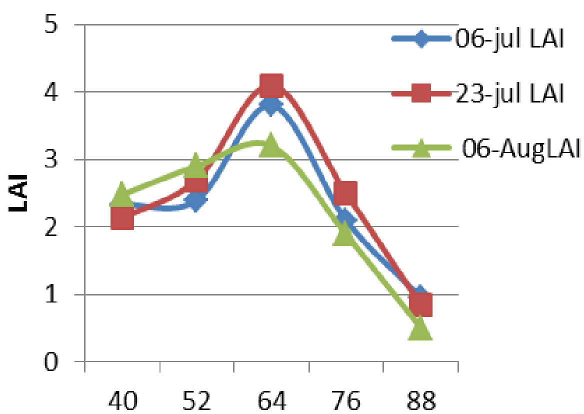

Figure 1: The trend of changes in LAI affected by different sowing dates

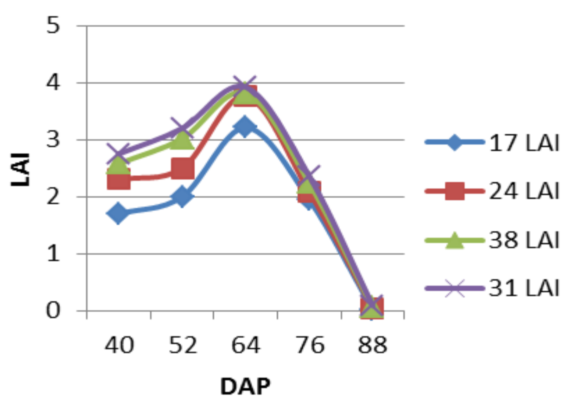

Figure 2: The trend of changes in LAI affected by different levels of density

Crop Growth Rate (CGR)

Crop growth rate (CGR) in all sowing dates first increased slightly and then increased more quickly until 64 days after planting. Then CGR decreased with a sharp slope. Gradual increase of CGR at first was due to insufficient vegetative meristems; however, as the plant canopy was completed and due to more efficient application of light and increase of leaf area the rate of CGR increased quickly so that it was maximized and then it decreased due to increase of interplant competition, decrease of light penetration into canopy photosynthetic organs' getting late and also assimilates mobilization into grains. The lowest rate of growth recorded during growth stage in this study belonged to plants which were sowedon July 6 and the highest rate belonged to sowing date of July 23. By investigating the effect of different plant densities on crop growth rate it is observed that CGR in all sowing densities at first increased slightly (until 52 days after sowing) and then increases more quickly until 64 days after sowing. In the next step, CGR decreased with a sharp slope (Diagram 4). Crop growth rate at early growth stages was low due to incomplete plant canopy and low amount of light absorbed by plant. As plant grew, CGR increased rapidly because leaves area increased and more light was absorbed by plant and then due to increase of interplant competition and decrease of light penetration into canopy CGR decreased seriously and then as photosynthetic organs got yellow and assimilates were mobilized into grains, CGR decreased more slowly. The lowest CGR recorded during the growth stage in this study belonged to sowing density of 17 plants/m2 and the highest one belonged to sowing density of 31 plants/m2. It seems like that as sowing density increases this index increases, too. The main reason of this increase seems to be increase of number of plants per area unit which enhances efficiency of applying light and available resources and consequently increases the yield.

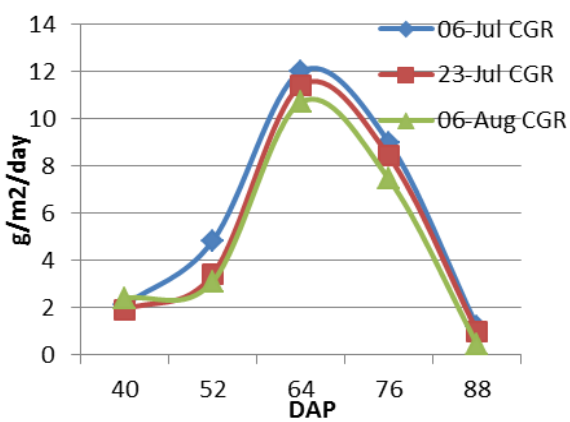

Figure 3: The trend of changes in CGR affected by different sowing dates

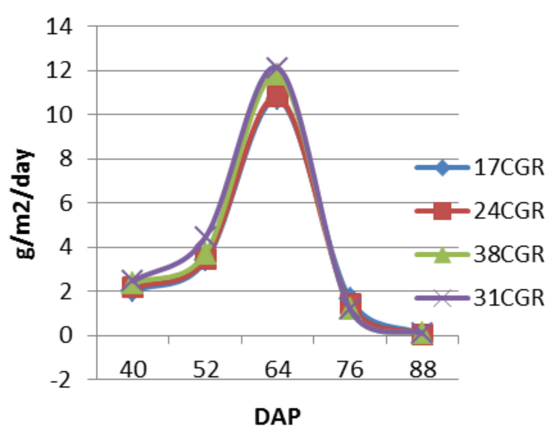

Figure 4: The trend of changes in CGR affected by different levels of density

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Relative Growth Rate (RGR)

In all sowing dates in this study, relative growth rate decreased as the plant age increased so that at the end of growth season RGR was close to zero. At the beginning of growth stage, due to more penetration of light into canopy and less shadow of the leaves on each other and less respiration, RGR is more and its reduction slope is less. As time passes and vegetative and reproductive organs grow more, the shadow of leaves on each other increases and RGR decreases. Sowing date of July 6 shows the highest primary RGR and sowing date of August 6 shows the lowest one. The highest RGR in the 64th day has been related to sowing plant of July 23. Relative growth rate (RGR) in this study in all densities decreased as plant age increased, so that at the end of growth season RGR got close to zero. Sowing density of 31 plants/m2 had the highest primary RGR and the lowest one was related to sowing density of 17 plant/m2. The highest RGR in the 64th day was related to sowing date of 31 plants/m2. It seems like that in this study as the sowing density increased up to 31 plants/m2 the efficiency increased and RGR enhanced and after the density of 31 plants/m2, RGR decreased very slightly.

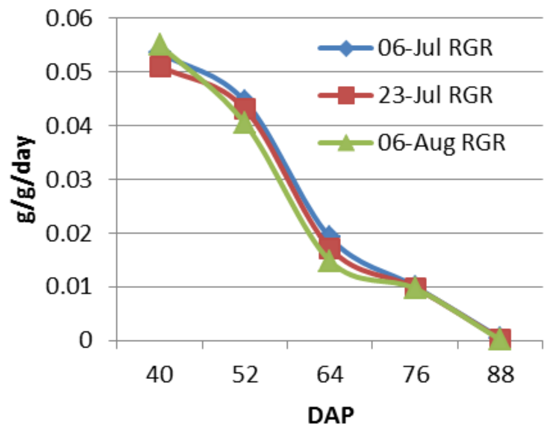

Figure 5: The trend of changes in RGR affected by different sowing dates

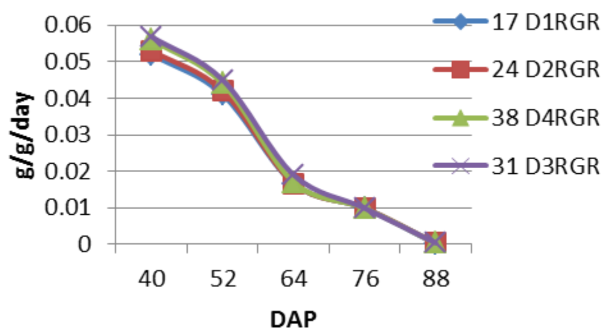

Figure 6: The trend of changes in RGR affected by different levels of density

Net Assimilation Rate

In this study, net assimilation rate decreased in all sowing dates as the plant age increased. It seems like that at the beginning of growth stage, due to more penetration of light into canopy and less shadow of the leaves on each other, net assimilation rate is more. As time passes and vegetative and organs grow more, the shadow of leaves on each other increases and NAR decreases and reduction slope decreases, too. During the period between 52nd to 64th days the slope raises more and then near grain filling stage the slope increase again and then decreases. Sowing date of July 6 showed the lowest net assimilation rate and sowing date of July 23 showed the highest NAR. Diagram (8) displays NAR changes in different

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sowing densities during the days after sowing until 88 days. In this study, net assimilation rate in all densities decreased as plant age increased. It seems like that net assimilation rate at the beginning of growth stage, due to more penetration of light into canopy and less shadow of the leaves on each other, is slightly more. As time passes and vegetative organs grow more, the shadow of leaves on each other increases and NAR decreases. Sowing density of 38 plants/m2 shows the lowest primary net assimilation rate and sowing density of 17 plants /m2 shows the highest one. The ultimate net assimilation rate for the treatments which have had the highest NAR at first is minimized; that is, in high densities photosynthesis rate decreases more quickly which is due to higher density and more competition at ending growth stages.

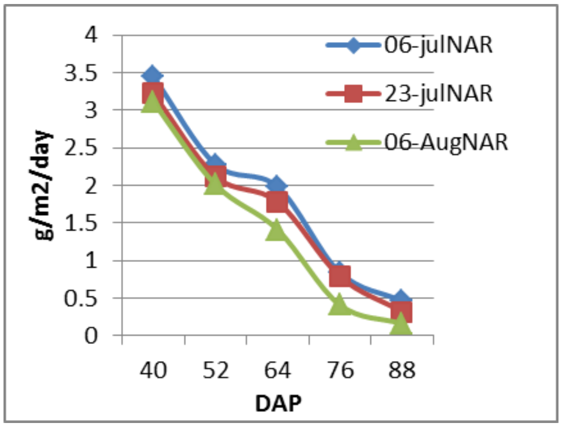

Figure 7: The trend of changes in NAR affected by different sowing dates

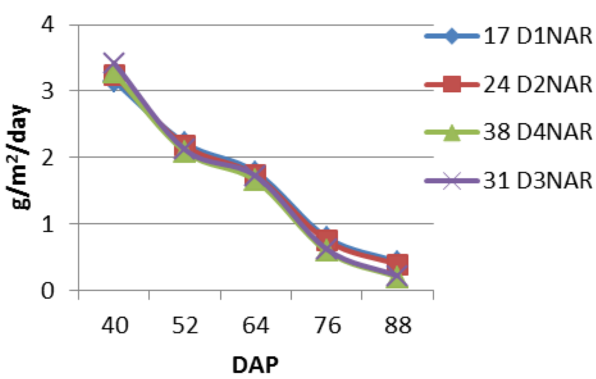

Figure 8: The trend of changes in NAR affected by different levels of density

Conclusion

The highest physiological indices of growth were ultimately obtained in sowing date of July 23 and density of 31 plants/m2 and the lowest ones were obtained in sowing date of July 6 and density of 17 plants/m2.

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