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The effect of plant population densities and cultivars on forage yield, qualitative traits and growth indices in canola forage (*Brassica napus* L.)

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ABSTRACT

In order to investigate the effect of the amount plant density on yield, yield components and growth characteristics of spring type of forage canola in summer cultivation, this experiment was conducted in Ghazvin(Esmail Abad) at 2011- 2012. This experiment was done in split plot form and with a randomized complete block design with three replications. The main factor included five levels of plant density :(100, 125, 150, 175 and 200 plant per m^2). The sub factor included two varieties of spring type of Canola including RGS003 and SARIGOL. The impact of plant density ($p\leq0.01$) on final dry forage was significant. The highest dry forage yield was obtained from applying 100 plants per m^2 and RGS003 variety with the average of 7381($kg.h^{-1}$). The highest forage protein (%) was obtained from using 100($plant.m^{-2}$) and RGS003 variety with the average of 13.12(%) whereas the lowest forage protein (%) was approached from200($plant.m^2$) and SARIGOL variety with average of 11.06(%). The highest forage fat(%) was obtained from using 100($plant.m^{-2}$) with average of 2.44(%). The RGS003 variety with average of 2.192(%) compared to SARIGOL variety with the average of 1.580(%) produced more forage fat. The highest LAI was obtained from using 200($plant.m^{-2}$) with average of 18.04. Increasing or decreasing in plant density resulted to decreasing in LAI. The effect of plant density and cultivars were significant on crop growth rate (CGR), relative growth rate (RGR), net assimilation rate (NAR), specific leaf weight (SLA), leaf area ration (LAR) and leaf area index (LAI).

Key words: Canola, Plant density (PD), forage fat, protein.

INTRODUCTION

Oilseed rape is cultivated and processed for many different purposes. The importance of rape has thus increased in recent years and today it is one of the most important oil seed crops in the world[3]. Canola (*Brassica napus* L.) belonged to *Crucifer* a family has received remarkable attentions for forage production potential as well as oil and meal source, to the best of our knowledge, there are rare researches in literatures on forage canola in Iran, however, in recent years, it has been central focused research area. Canola forage has been widely cultivated and used since 600 years ago for feeding livestock, although its water demand is exorbitant as summer forage [9]. Average Canola forage yield in three harvesting dates ranged from 4350 to 5690 ($kg.h^{-1}$). Harvesting at September gave 5540 ($kg.h^{-1}$) forage yield, while at end of October, it was amounted to 7900 ($kg.h^{-1}$) [22].Canola is first choice to supplying needed vegetable oil to country. According studies Canola planting is more considerable than other oily seeds due to its compatibility with most the country region and it's higher qualitative oil. In this experiment studied effect of planting density on growth traits of canola varieties. Canola contains 40-48% oil, 38-45% protein in the meal with 5% grain moisture. Linoleic to linolenic acids ratio in canola oil is known to be 2:1 which is normal for human diets purposes. Canola meals contain 13% fiber. Much fiber concentration present in meal serves as a limiting factor for feeding livestock, because it loses potential to release energy in ration. Analysis of quantitative aspects of growth of

whole plant can be effectively conducted using the functional growth analysis techniques which use regression procedure.

Yield is a complex trait resulting from the interaction of morphological, physiological and environmental parameters on the growth of plants. Identification of the variations of morphological and physiological traits influencing the yield of a plant in a certain environment is an essential tool for selecting and breeding of yield [1]. The growth of the plants in certain environmental conditions can be measured by classic growth analysis. One of the main goals in agriculture is determining best plant density to yielding desired yield. Desired density obtain when canopy have maximum leaf area to up taking sunlight at the beginning of reproductive stage 18]. Goals such as improving absorbed sunlight by changing plant density and also changing row spacing perused in agricultural plants planting [19]. Increasing light penetrating into lower parts of canopy by changing its structure is a management way with cause to improving yield [28]. Heikkinen, and Auld, (1991) recommended densities more than to plants.m^{-2} to canola [13].Considering canola density status has a great deal of importance to achieve high yield and quantity forage yield. The main objective for the present research is to shed light on the best plant density treatment and subsequently to determine suitable cultivar for cultivation.

Al-Barzinjy et al. (1999) investigated the effects of different plant densities ranging from 20 to 130 plants.m^{-2} in rapeseed [2]. They concluded that dry matter per plant decreased as plant density increased. Previous studies have shown that plant density is an important factor affecting rapeseed yield. Plant density in rapeseed governs the components of yield, and thus the yield of individual plants. A uniform distribution of plants per unit area is a prerequisite for yield stability [6].In oilseed rape, row spacing or plant density vary considerably worldwide, depending on the environment, production system and cultivar. The growth is analyzed by measuring two factors, namely leaf area and dry weight of the organs and other quantities are calculated based on these two factors. When necessary, these quantities may be calculated either for whole plants or for different parts of the plants like root, crown and leaves (Karimi,2005)[14].Crop growth rate (CGR) is slow at early growth stages because the plant cover is incomplete and the plants absorb just a part of the solar radiation. As the plants develop, their growth rate is quickly increased because of the expansion of leaf area and the penetration of less radiation through plant cover to the soil surface. Maximum CGR (the steepest slope in total biomass variations graph) is realized when the plants are tall and dense enough to be able to maximally utilize all environmental parameters (Radford, 1967) [25].

Zajac*et al*. (2005) found a positive relation between dry matter yield and growth indices like CGR and LAD [35]. Also, Mahdavi*et al*. (2006) and Katsura*et al*. (2007) reported that rice grain yield can be increased by selection on the basis of physiological growth indices like LAD, CGR, relative growth rate (RGR) and net assimilation rate[15, 20].NAR is determined primarily by the ratio of carbon gained through photosynthesis and carbon lost through respiration. LAR reflects the amount of leaf area a plant develops per unit total plant mass and, therefore, depends on the proportionof biomass allocated to leaves relative to total plant mass (leaf mass ratio, LMR) and how much leaf area a plant develops per unit leaf biomass (specific leaf area, SLA), where LAR = LMR x SLA.(NAR) and leaf area ratio (LAR) are good measures of solar radiation capture during growth with NAR and LAR for an individual plant and LAI for population helping to explain differences in RGR.Sanches (1997) stated that investigation of forage fat and protein percent in eight canola varieties in Brazil showed that oil and protein percent are 41.3, 36.8, 24.7 and 20.9 respectively and varieties difference significantly in terms of forage fat and protein percent yield.

The studies on lentil showed that such traits as biological yield, harvest index as well as leaf area index (LAI) and CGR can be used as indices for improving seed yield of lentil [11].Siahpoosh*et al*. (2003) indicated that out of the studied physiological indices, net assimilation rate (NAR) and leaf area duration (LAD) were effective indices in increasing yield [32].In a three-year study on linseed cultivars, Zajac*et al*. (2005) found a positive relation between dry matter yield and growth indices like CGR and LAD [35]. Also, Mahdavi*et al*. (2006) and Katsura*et al*. (2007) reported that rice grain yield can be increased by selection on the basis of physiological growth indices like LAD, CGR, relative growth rate (RGR) and net assimilation rate[15, 20].

MATERIALS AND METHODS

The experiment was carried out at Esmael Abad agricultural research station (Lat49° 54´ E, long 36° 15´ N), Iran in 2011- 2012. In order to evaluate effect of different plant density applications on quantity and quality forage of two spring canola cultivars in summer cultivation, an experiment was conducted in Ghazvin province in agronomical year of 2011-2012. Study area is located at 1285 m above sea level with annual average rainfall 310-320(mm), annual average temperature 13.9(C), minimum and maximum absolute annual temperatures of 17.4 and 37.8(C) respectively. Soil texture in study area is loam and silt loamy with pH 7.9-8 and its electrical conductivity found to be 1.1-1.29(ds.m^{-1}) (table1). This experiment was arranged as split plot in completely randomized block designs in the 3 replication. Plant density was considered as the main factor involving five levels of 100, 125, 150, 175 and 200

(plant.m^{-2}). Two spring canola cultivars RGS003 and SARIGOL were used in the present research. Seeds provided from department of oil seed researches, research center of seed and seedling breeding and preparation in Karaj (RGS003: German and spring type, SARIGOL: Iranian and spring type).

Table1. Analysis results of soil experiment

Depth	0-30(cm)	30-60(cm)
EC(ds.m^{-1})	1.1	1.29
PH	8	7.9
SAR	3.80	4.2
T.N.V%	7.5	7.8
O.C%	0.64	0.57
Total N %	0.09	0.06
Texture	SiltLoam	Loam

In this experiment was fertilized before sowing by to the following fertilization rates: 60 kg N/ha as ammonium sulphate and 60 kg P2O5/ha as triple superphosphate. Additional 60 kg N/ha was applied in the study.In order to analyze and calculate the growthindices, the plots were sampled four times; eachtime 0.5 m of each row was harvested.In laboratory, the organs of the plants were dissected and then, their fresh weights were measured. Afterwards, the leaf blade area of the samples was measured. Next, the samples were transferred to in bags to lose their moisture. After one week, they were completely oven-dried at 105°C. Then, their dry weight was measured by a 0.001g digital scale. After collecting the data of leaf area and shoot dry and fresh weights, the growth indices were calculated as follows (Sarmadnia and Koucheki, 1989) [30]:

Leaf area index (LAI): To measure LAI, one m^2 was sampled fromeach plot. Then, the leaves of the plants wereparted and their area was measured by leaf-areameter.

$$LAI = \frac{\text{Leaf area}}{\text{Land area}}$$

Crop growth rate (CGR): It was calculated in terms of g.m^{-2}.day^{-1} by the following equation (Rahnama, 2006) [27]:

$$CGR = \frac{W_2 - W_1}{GA(T_2 - T_1)}$$

Net assimilation rate (NAR): It was calculated in terms of g.m^{-2} leaf area.day^{-1} by the following equation (Rahnama, 2006) [27]:

$$NAR = \frac{W_2 - W_1}{T_2 - T_1} \times \frac{\ln LA_2 - \ln LA_1}{LA_2 - LA_1}$$

Relative growth rate (RGR): It was calculated in terms of g.g^{-1}.day^{-1} by the following equation (Rahnama, 2006) [27]:

$$RGR = \frac{W_2 - W_1}{W_1(T_2 - T_1)}$$

Leaf area ratio (LAR): It was calculated in terms of cm^2.g^{-1} by the following equation (Rahnama, 2006)[27]:

$$LAR = \frac{\frac{LA_1}{W_1} + \frac{LA_2}{W_2}}{2}$$

Leaf weight ratio (LWR): This dimensionless index was calculated by the following equation:

$$LWR = \frac{\frac{LW_1}{W_1} + \frac{LW_2}{W_2}}{2}$$

Specific leaf area (SLA): It was calculated in terms of $cm^2.g^{-1}$ by the following equation:

$$SLA = \frac{\frac{LA_1}{LW_1} + \frac{LA_2}{LW_2}}{2}$$

The symbols used in foregoing equations were as follows:
W1: total biomass measured at the first sampling
W2: total biomass measured at the second sampling
T1: first sampling time
T2: second sampling time
LA1: leaf area measured at the first sampling
LA2: leaf area measured at the second sampling
LW1: leaf biomass measured at the first sampling
LW2: leaf biomass measured at the second sampling

Oil content was determined by extracting the oil with diethyl ether in a Soxleth extraction apparatus, while content protein was determined using DUMAS, s procedure.

The data were subjected to analysis of variance using the SAS software. When the *F*-test indicated statistical significance at the *P* = 0.05or 0.01 levels, Duncan's multiple- range test was used to determine the significance between means.

RESULTS AND DISCUSSION

Total dry weight in 25% flowering: Results from variance analysis indicate that cultivar was significant but plant density and cultivar*plant density interactions were not significant. Mean comparison of cultivar showed that cultivar RGS003 showed highest dry weight with average 6583.853($kg.h^{-1}$) followed by SARIGOL with average 5135.667($kg.h^{-1}$). Plant density were classified in various statistical classes so that the highest dry weight was obtained by plant density (100 $plant.m^{-2}$) on average 6626($kg.h^{-1}$) and the least was attributed to 150($plant.m^{-2}$) treatment with average 5295($kg.h^{-1}$). Mean comparison of plant density*cultivar interaction showed the highest dry weight in cultivar RGS003 and 100($plant.m^{-2}$) with average 7381($kg.h^{-1}$) and least dry weight in cultivar SARIGOL and 200($PLANT.M^{-2}$) with average 4502($KG.H^{-1}$). (Tables 2, 3, 4).

Accumulation of dry matter in aboveground organs and transporting it to grain have been reported in some crops such as rice , soybean, wheat and canola [16, 17]. As a whole, firstly, accumulation of dry matter in above ground is slow, but it increases rapidly with increase canopy and subsequently slowing down as leaves senescent while grain refilling. Dry matter at following is maximum rate while flowering as well [33, 34].The highest total dry matter per plant was produced from the lowest plant density. This high total dry matter production per plant can be attributed to the fact that the plants from low densities were more vigorous, thicker in stems with more branches per plant. This can be a result of lesser interplant competition among plants and a better radiation distribution through open canopy. The negative effect of increasing plant population on total dry matter production is also reported by other workers [21, 23].

Forage fat (%): Results of variance analysis revealed that fat percent in forage was affected by plant density and cultivar individually in probability levels of 1% and but it was not significantly for nitrogen*cultivar interaction although. Analysis of mean comparison on cultivar effect showed that SARIGOL had the less fat percent (1.580 %) in Comparison to RGS003 (2.192 %). Mean comparison of nitrogen*cultivar interaction revealed the highest fat percent (2.76 %) in RGS003 when plant density (100 $plant.m^{-2}$) was applied. The lowest fat percent was achieved in SARIGOL with plant density (200 $plant.m^{-2}$) was applied with average1.08 (%) (Table 2, 3, 4).

Forage Protein (%):forages raw protein serves as one of the most important criteria widely used to evaluate forage quality. Variance analysis showed that plant density and cultivar were significant at protein percentage in probability levels of 1% and but it was not significantly for nitrogen*cultivar interaction although. Mean comparison on cultivar effect showed that RGS003 had much protein (12.606 %) than SARIGOL (12.120 %). Different plant density levels

were classified in various statistical classes. The lowest protein was related to 200 (plant.m-2) treatments with average (11.41 %). Applying 100 and 125 plant.m^{-2}, resulted in 12.95 and 12.85(%) proteins respectively, categorized into the same statistical class. Mean comparison of nitrogen*cultivar interaction revealed the least protein (11.06 %) in SARIGOL when 200(plant.m^{-2}) treatment was applied. The highest protein was achieved in RGS003 once 100(plant.m^{-2}) was applied with average 13.12(%), there are no significant differences to SARIGOL and RGS003 cultivars when 100 and 125(plant.m^{-2}) were applied respectively (Table 2, 3, 4).

Table2. Variance analysis of dry weight, Forage fat and Forage protein

SOV	df	Final dry weight in 25% flowering(kg.h^{-1})	Forage fat (%)	Forage protein (%)
Replication	2	5678380.306^{ns}	0.005^{ns}	0.007^{ns}
density(D)	4	1885783.849^{ns}	1.532**	2.553**
error	8	1733749.254	0.021	0.054
Cultivars (V)	1	15729334.378**	2.809**	1.771**
N* D	4	46676.555^{ns}	0.055^{ns}	0.033^{ns}
error	10	674284.619	0.021	0.059
Total	29			
CV%		14.01	7.64	1.96

**, ** and ^{ns}: significantat5%, 1% probability levels, and Non-significant.*

Table 3. Mean comparison of effects plant density and cultivars

Plant density	Final dry weight in 25% flowering (kg.h^{-1})	Forage fat (%)	Forage protein (%)
100	6622a	2.440a	12.95a
125	5822a	2.285a	12.85ab
150	5295a	1.930b	12.62b
175	6188a	1.555c	11.98c
200	5368a	1.220d	11.41d
RGS003	6583.853a	2.192a	12.606a
SARIGOL	5135.667b	1.580b	12.120b

Means in each column having similar letter (s), are not significantly at the 5% level.

Table4. Mean comparison of effect plant density * cultivar interaction

Plant density	Cultivar	Final Dry weight in 25% flowering(kg.h^{-1})	Forage fat(%)	Forage protein (%)
100	**RGS003**	7381a	2.76a	13.12a
100	**SARIGOL**	5872abcde	2.12bc	12.78abc
125	**RGS003**	6499abc	2.62a	13.09ab
125	**SARIGOL**	5145cde	1.95c	12.62bcd
150	**RGS003**	5969abcde	2.28b	12.89ab
150	**SARIGOL**	4623de	1.58d	12.35cd
175	**RGS003**	6839ab	1.94c	12.16de
175	**SARIGOL**	5536bcde	1.17ef	11.79e
200	**RGS003**	62333abcd	1.36de	11.77e
200	**SARIGOL**	4502e	1.08f	11.06f

Means in each column having similar letter (s), are not significantly at the 5% level.

Leaf Area Index in 25% flowering (LAI): Variance analysis Showed that simple effects (plant density and cultivar) and interaction effect of plant density*cultivar were significant at probability level of 1%.Mean comparison of cultivar effect indicated highest leaf area index in cultivar SARIGOL with average 10.887 followed by RGS003 with average 9.214. Different plant density levels were categorized in statistical classes. The highest leaf area index was observed during applying 200(plant.m^{-2}) with average 18.04. In contrast, the least value was attributed to 100 (plant.m^{-2}) application treatments on average 6.812. Mean comparison of plant density*cultivar interaction indicated that different plant density*cultivar levels fall into various statistical classes. The highest and the least LAI were observed in SARIGOL and RGS003 (with averages 20.35 and 6.212 respectively),when 200 and 100(plant.m^{-2}) were applied respectively (Table 5, 6, 7).Yesari et al., (2008) pointed out that low leaf area index at start and end of growth season is common, presumably attributes to leaves senescent and scattering, specifically those old ones located at lower canopy layers [34]. Canola leaves serve as the main photosynthesis source from emerging until middle of flowering period. Although they may not have direct contribution in development process, they, however, are vital in developing sink capacity. Not only maximum leaf area, but also leaf area durability (consistency) is important to quantify leaf development [34].Salehian*et al*. (2002) showed that the highest plant density (i.e. 110 plants m-2) produced the highest LAI.LAI plays a key role in determining CGR, both because it acts directly and substantially, and because of its indirect negative effect on NAR.LAR plays an important, albeit negative, role both directly and indirectly through NAR. The negative effects on NAR both of LAI and LAR may be attributed to reciprocal shading of the leaves when leaf area becomes excessive, which means that the crop requires the right

sowing density while in crop management it is necessary to control practices that lead both to a deficit and an excess of leaf development. This explains the great interest shown in LAI as regards its interception of light energy and production of plant dry matter(Sarkar and pal, 2005)[29].

Leaf area ratio (LAR) at 25% flowering: Results of variance analysis showed that plant density, cultivar and plant density * cultivar was significant influence on leaf area ratio at probability level of 1%. Results obtained by mean comparison analysis in cultivars that genotype SARIGOL dedicated itself higher specific leaf area by 0.009 $m^2.g^{-1}$ TDW followed by RGS003 with 0.007 ($m^2.g^{-1}$ TDW).Different plant density levels were categorized in the different statistical class. The highest leaf area ratio was observed during applying 100(plant.m^{-2}) with average 0.01($m^2.g^{-1}$ TDW). In contrast, the least value was attributed to 125 (plant.m^{-2}) application treatments on average 0.007($m^2.g^{-1}$ TDW). Mean comparison of plant density*cultivar interaction indicated that the highest leaf area ratios (0.013 $m^2.g^{-1}$ TDW) were recorded in SARIGOL when 100(plant.m^{-2}) were applied (Table 5, 6, 7).Observed that LAR was highest during the early vegetative stage but later decreased rapidly with the advancement of plant age, possibly due to abscission of older leaves. Similar result was reported by Haque (1993) and Rahman (1993) [12].

Specific leaf area (SLA) at 25% flowering: Analysis of variance denoted significant effects of plant density, cultivar and plant density*cultivar interaction on specific leaf area on probability levels of 1%.Mean comparison of cultivar effect indicated that genotype RGS003 dedicated itself higher specific leaf area by 0.019 $m^2.g^{-1}$ TDW followed by SARIGOL with 0.018 ($m^2.g^{-1}$ TDW). Different plant density application levels were categorized in the different statistical class and showing significant difference. Result of mean comparison on nitrogen*cultivar interaction indicated that different plant density levels and cultivar were classified in the different statistical class and showing significantdifference.The highest specific leaf areas (0.025 $m^2.g^{-1}$ TDW) was recorded in RGS003, when amounts of plant density 200(plant.m^{-2}) were applied (Table 5, 6, 7).The lowest specific leaf areas (0.015 $m^2.g^{-1}$ TDW) was recorded in RGS003 and RGS003, when amounts of plant density 175(plant.m^{-2}) were applied (Table 5, 6, 7).This central role of SLA in determining seedling potential RGR is thus general across European grasses, herbs and woody perennials (Cornelissen*et al*., 1996)[5].This refers to the fact that amount of leaf area per unit total plant weight is more important (as related to light attenuation) than allocation of biomass per unit leaf area. The increased LAR enhances the RGR and thus the competitive potential (Peltzer and Kochy, 2001)[24]. Thus the high RGR of grass in competition can be attributed to NAR and LAR.

Table5. Variance analysis of SLA, LAR and LAI

SOV	df	LAI in25% Flowering	LAR in 25% flowering ($m^2.g^{-1}$)	SLA in 25% flowering ($m^2.g^{-1}$)
Replication	2	0.036^{ns}	0.042^{ns}	0.007^{ns}
Density(D)	4	124.077**	13.686**	43.250**
error	8	0.032	0.015	0.015
Cultivars (V)	1	20.987**	40.833**	3.745**
N* D	4	31.670^{ns}	10.490**	52.987^{ns}
error	10	0.572	0.022	0.01
Total	29			
CV%		2.38	1.73	0.52

**, ** and ^{ns}: significantat5%, 1% probability levels, and Non-significant.*

Table 6. Mean comparison of effects plant density and cultivars on SLA, LAR and LAI

Plant density	LAI in 25% flowering	LAR in 25% flowering ($m^2.g^{-1}$)	SLA in 25% flowering ($m^2.g^{-1}$)
100	6.812d	0.01a	0.020b
125	7.675c	0.007e	0.016d
150	8.904b	0.008c	0.016e
175	8.826b	0.007d	0.018c
200	18.04a	0.01b	0.022a
RGS003	9.214b	0.007b	0.019a
SARIGOL	10.887a	0.009a	0.018b

Means in each column having similar letter (s), are not significantly at the 5% level.

Leaf weight ratio (LWR) at 25% flowering: Variance analysis showed there are significant difference of plant density, cultivar and plant density *cultivar interaction in 1% level. Mean comparison cultivar individually denoted that cultivar SARIGOL had higher leaf weight ratio (0.51 $g.g^{-1}$TDW) than RGS003 (0.38 $g.g^{-1}$ TDW). Mean comparison plant density showed that 100(plant.m^{-2}) had higher leaf weight ratio (0.50 $g.g^{-1}$ TDW) than 100(plant.m^{-2}) (0.38 $g.g^{-1}$ TDW).Mean comparison of nitrogen*cultivar interaction showed that the highest leaf weight ratio was observed in SARIGOL and plant density (200 plant.m^{-2}) (0.56 $g.g^{-1}$ TDW) and least value (0.33$g.g^{-1}$ TDW) was attributed to cultivar RGS003 and plant density (200 plant.m^{-2}).Cultivars RGS003 and SARIGOL showed the highest leaf weightratios (0.44 and 0.56$g.g^{-1}$ TDW) in 100 and 200 (plant.m^{-2}) treatments respectively

(Table 8, 9, 10).LAR is determined by both LAR and SLA (Causton and Venus, 1981)[4]. This increase in LAR is largely determined by due to changes in LWR and often due to the changes in SLA.

Table7. Mean comparison of density * cultivars interaction on SLA, LAR and LAI

Plant density	Cultivar	LAI in25% flowering	LAR in 25% flowering ($m^2.g^{-1}$)	SLA in 25% flowering ($m^2.g^{-1}$)
100	RGS003	6.211h	0.007f	0.017g
100	SARIGOL	7.412f	0.013a	0.023b
125	RGS003	8.447e	0.007f	0.019e
125	SARIGOL	6.903g	0.006g	0.014j
150	RGS003	8.319e	0.007f	0.018f
150	SARIGOL	9.488d	0.008e	0.014i
175	RGS003	7.376f	0.005h	0.015h
175	SARIGOL	10.28c	0.009c	0.021c
200	RGS003	15.72b	0.008d	0.025a
200	SARIGOL	20.35a	0.011b	0.020d

Means in each column having similar letter (s), are not significantly at the 5% level.

Net assimilation rate (NAR) at 25% flowering: Results of variance analysis showed that plant density, cultivar and plant density *cultivar interactions in probability level of 1% were significant. Mean comparison of cultivar revealed that cultivar RGS003 had higher net assimilation rate (2.041 $g.day^{-1}.m^{-2}$) than SARIGOL (1.70 $g.day^{-1}.m^{-2}$). Plant density levels were categorized in four different statistical classes. Mean comparison of plant density revealed that 125($plant.m^{-2}$) had higher net assimilation rate (2.376 $g.day^{-1}.m^{-2}$) but Mean comparison of plant density revealed that 150($plant.m^{-2}$) had lower net assimilation rate (1.492 $g.day^{-1}.m^{-2}$) Mean comparison of nitrogen*cultivar interaction indicated that different plant density levels and cultivars fell into different statistical classes. Highest net assimilation rate (2.592 $g.day^{-1}.m^{-2}$) in genotype SARIGOL was recorded when 125($plant.m^{-2}$) was added. The least value (1.271$g.day^{-1}.m^{-2}$) was recorded in SARIGOL, when 100 ($plant.m^{-2}$) was applied. The highest net assimilation rates in genotypes SARIGOL and RGS003 (2.592 and 2.462 $g.day^{-1}.m^{-2}$) were obtained when application of 125 and 100($plant.m^{-2}$) respectively (Tables 8, 9, 10). However, plant photosynthesis, hence NAR, is known to be greatly affected also by other factors such as radiation, temperature, nutrient availability.

Crop growth rate (CGR) at 25% flowering: Variance analysis indicated significant effect for plant density, cultivar and plant density *cultivar interactions on CGR at probability level of 1%. Mean comparison of plant density showed that the highest crop growth rate (27.61 $g.day^{-1}.m^{-2}$) was recorded in 200($plant.m^{-2}$) followed by 125($plant.m^{-2}$) (15.63 $g.day^{-1}.m^{-2}$).Mean comparison of cultivar showed that the highest crop growth rate (17.613 $g.day^{-1}.m^{-2}$) was recorded in RGS003 followed by SARIGOL (15.135 $g.day^{-}1.m^{-2}$). Different plant density levels fell into different statistical classes. Results obtained from mean comparison on plant density *cultivar interaction that genotype RGS003 exhibited the highest CGR (29.10 $g.day^{-1}.m^{-2}$), when 200($plant.m^{-2}$) was applied.Also, the least CGR value (7.506 $g.day^{-1}.m^{-2}$) was obtained when SARIGOL with100($plant.m^{-2}$) was added. Both genotypes RGS003and SARIGOL showed the highest crop growth rate (29.10 and 26.13 $g.day^{-1}.m^{-2}$), when 200($plant.m^{-2}$) was applied respectively (Tables 8, 9, 10). Some researchers reported that crop growth rate is affected by plants photosynthetic area directly (HabibZadeh et al., 2006; Shilbes and Weber, 1995)[10, 31].

Relative growth rate (RGR) at 25% flowering: Variance analysis indicated that significant plant density, cultivar and plant density *cultivar interactions on RGR at probability level of 1%. Mean comparison of cultivar showed that the highest relative growth rate (0.014 $g.day^{-1}.m^{-2}$) was recorded in RGS003 followed by SARIGOL (0.013 $g.day^{-1}.m^{-2}$). Different plant density levels fell into different statistical classes. The highest and least relative growth rates were obtained (0.015 and 0.011 $g.day^{-1}.m^{-2}$) when 200 and 150($plant.m^{-2}$) were applied respectively. Results obtained from mean comparison on plant density *cultivar interaction that genotype RGS003 exhibited the highest RGR (0.016 $g.day^{-1}.m^{-2}$), when 100($plant.m^{-2}$) was applied in both genotypes RGS003and SARIGOL showed the lowest relative growth rate (0.011 $g.day^{-1}.m^{-2}$), when 150($plant.m^{-2}$) were applied respectively (Tables 8, 9, 10).RGR is a complex parameter determined by a number of physiological, morphological and biomass allocation components. In addition, some researchers reported that crop growth rate is affected by plants photosynthetic area directly [10, 31].Increased plant density significantly increased crop growth rate (CGR) during early stage and reduced the net assimilation rate (NAR) and CGR during later part of crop growth. Higher CGR at vegetative stage originates from which high leaf area index (LAI) and that CGR at reproductive and ripening stages is controlled by NAR. There was an increase relationship between leaf area and NAR. The increase in CGR was ascribed to the increased in NAR and leaf area. Plant growth analysis decomposes RGR into net assimilation rate (NAR, rate of dry matter production per unit leaf area) and leaf area ratio (LAR, leaf area per unit total plant mass), where RGR=NAR x LAR [4, 8]. NAR is determined primarily by the ratio of carbon gained through photosynthesis and carbon lost through respiration. LAR reflects the amount of leaf area a plant develops per unit total plant mass and, therefore, depends on the proportion of biomass allocated to leaves relative to total plant mass (leaf mass ratio, LMR) and how

much leaf area a plant develops per unit leaf biomass (specific leaf area, SLA), where LAR = LMR x SLA. Most work evaluating RGR variation among species has compared species from habitats differing in fertility or productivity. The ecological advantage of high RGR is very clear. Due to high RGR, a plant will rapidly increase in size and is able to occupy a large space, both below and above ground. A high RGR may also facilitate rapid completion of life cycle of a plant.

Table8. Variance analysis of LWR,NAR, CGR, and RGR

SOV	df	LWR in 25% flowering ($m^2.g^{-1}$)	NAR in 25% flowering ($g.day^{-1}.m^2$)	CGR in 25% flowering ($g.day^{-1}.m^2$)	RGR in 25% Flowering ($g.day^{-1}.m^2$)
Replication	2	0.009^{ns}	0.002^{ns}	0.229^{ns}	0.019^{ns}
Density(D)	4	131.633**	0.760**	260.980**	17.122**
error	8	0.012	0.006	0.154	0.129
Cultivars (V)	1	1289.696**	0.874**	46.066**	8.112**
N* D	4	61.880**	0.612**	11.466**	3.229^{ns}
error	10	0.01	0.003	0.463	0.046
Total	29				
CV%		0.22	2.91	4.16	1.57

**, ** and ^{ns}: significantat5%, 1% probability levels, and Non-significant.*

Table 9. Mean comparison of effects density and cultivars on NAR, CGR, LWR and RGR

Plant density	LWR in 25% flowering ($m^2.g^{-1}$)	NAR in 25% Flowering($g.day^{-1}.m^2$)	CGR in 25% Flowering($g.day^{-1}.m^2$)	RGR in 25% Flowering($g.day^{-1}.m^2$)
100	0.50a	1.886c	10.46e	0.015ab
125	0.42d	2.376a	15.63b	0.014b
150	0.48b	1.492d	13.17d	0.011c
175	0.38e	1.585d	14.99c	0.011c
200	0.44c	2.032b	27.61a	0.015a
RGS003	0.38b	2.041a	17.613a	0.014a
SARIGOL	0.51a	1.7b	15.135b	0.013b

Means in each column having similar letter (s), are not significantly at the 5% level

Table10. Mean comparison of density * cultivars interaction on NAR, CGR, LWR and RGR

Plant density	Cultivar	LWR in 25% flowering ($m^2.g^{-1}$)	NAR in 25% flowering ($g.day^{-1}.m^2$)	CGR in 25% Flowering ($g.day^{-1}.m^2$)	RGR in 25% Flowering ($g.day^{-1}.m^2$)
100	**RGS003**	0.44e	2.462b	13.42ef	0.016a
100	**SARIGOL**	0.56b	1.271h	7.506g	0.013d
125	**RGS003**	0.38h	2.161d	16.17cd	0.014c
125	**SARIGOL**	0.46d	2.592a	15.10d	0.014c
150	**RGS003**	0.41g	1.422g	12.49f	0.011f
150	**SARIGOL**	0.55c	1.562f	13.86e	0.011f
175	**RGS003**	0.34i	1.868e	16.89c	0.012e
175	**SARIGOL**	0.43f	1.302h	13.09ef	0.11f
200	**RGS003**	0.33j	2.292c	29.10a	0.015b
200	**SARIGOL**	0.56a	1.771e	26.13b	0.014c

Means in each column having similar letter (s), are not significantly at the 5% level.

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