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Original article

Influence of sowing windows and genotypes on growth, radiation interception, conversion efficiency and yield of guar

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ABSTRACT

Crop growth largely depends on radiation. Radiation is the main impetus for photosynthesis and movement of photosynthates from source to sink. Therefore, identification of the optimum sowing windows and suitable cultivars for efficient utilization of radiation is of prime importance. A field study was conducted in red clay soil during 2014 and 2015 *Kharif* season and the treatments consisted of three genotypes and three sowing windows by using randomized complete block design with three replications. The effect of genotypes and sowing windows was found significant with respect to number of trifoliate leaves, leaf area ratio, dry matter production, grain numbers, pod length, test weight, grain yield, and stover yield of guar during 2014 as compared to 2015 sown crop. Statistically significant plant height, number of trifoliate leaves, number of branches, leaf area ratio, absolute growth rate, leaf area index, dry matter, grain number, pod length, grain yield, stover yield and a higher cumulative radiation interception were recorded with 15th August sown crop as compared to other sowing windows. The plant height, number of trifoliate leaves, number of branches, leaf area ratio, absolute growth rate, leaf area index, dry matter, grain number, pod length, grain yield, stover yield and maximum cumulative interception of radiation were significant with RGC-1003 as compared to RGC-936 and HG-365. It is observed that the incident PAR to dry matter accumulation conversion efficiency was varied with cultivars and different sowing windows which ranges from 0.74 g MJ^{-1} to 0.79 g MJ^{-1}.

1. Introduction

Guar (*Cyamopsis tetragonoloba* L. Taub.) is drought hardy, annual short-duration legume plant that grows mainly in rainfed regions. Guar crop is being cultivated in India, Sudan, Australia, South Africa, Pakistan, Brazil, Zaire, Malawi, and USA. India is the primary producer and net exporter of guar and guar gum in the global market (Saha et al., 2019). India contributes about 80 percent of the total world's guar production. The crop is grown mainly for multiple purposes *viz.,* tender pods for vegetable, seed endosperm for gum extraction, green plants used for cattle feed and manure purpose. It bears pods containing six to nine small, rounded seeds resembling bean shape (Anuradha Rajendra et al., 2017). The guar seed is structured with germ (40–46 percent), endosperm (38–45 percent) and husk (14–16 percent). The by-product of guar seed as gum is obtained from the endosperm after grounding (Khichar et al., 2012). The gum guar has as a wide range of application in industries *viz.,* petroleum, pharmaceutical and food industries contributing significant share of demand to enhance the national economy.

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Natural resource like solar radiation is the essential source of energy for photosynthesis and in turn production of above ground biomass. Hence, identification of ideal set of agronomic practices and varieties to enhance radiation capture and utilization play an important role in realizing maximum grain yield (Caviglia and Andrade, 2010). The portion of intercepted radiation during the crop growth period depends on the canopy cover during its various phenophases. Further the partial absorption of photosynthetically active radiation (PAR) by plants is the function of leaf area index (LAI) during crop growing season (Li et al., 2008, Plenet et al., 2000, Xie et al., 2015). Guar cultivars have differential growth habit and sensitive to different climatic conditions. The amount of radiation intercepted as well as the grain yield varies depending upon the genotype adopted for cultivation. Several genotypes of differential growth habit and duration were released for general cultivation of guar in India for northern part. However the performances of these genotypes in terms of grain yield and radiation capture were not studied so far in the southern part of India.

The radiation energy distribution is mainly influenced by plant canopy architecture. The efficiency of the dry matter production is mainly based on the extent to which photosynthetically active radiation is utilized by the plants. The interception of solar radiation and the use of radiant energy by plants for their production of biomass represent fundamental processes that control crop growth and yield. The amount of biomass produced (g m^{-2}) per unit of intercepted light determines the radiation use efficiency of the crop (g biomass MJ^{-1}) (Monteith, 1977). The variation in the plant growth cycle and the fractions of light intercepted (Sivakumar and Virmani, 1984) depend largely on the green area of the leaf and the light extinction coefficient. The light extinction coefficient indicates the attenuation of transmitted light within the crop canopy and inversely proportional to canopy spread. Radiation use efficiency is a measure of the light profile intercepted by the canopy (Campbell and Norman, 1998).

Knowledge of plant environment interaction needs to be understood to improve crop yield. Optimum sowing time and selection of appropriate cultivars play a remarkable role in harnessing the yield capacity of the crop under complex agro-climatic conditions. The sowing date has been proved to be one of the most non-monetary inputs affecting guar yield. Suboptimal thermal requirements during crop growing season are known to have a profound effect on crop productivity. The optimum sowing time is vital to exploit the environmental conditions during guar growth for maximum production. The productivity of guar fluctuates as it responds differently due to their variation in the thermal requirements of given cultivars in particular climatic conditions (Khichar et al., 2012; Lakshmi, 2012). The present investigation was undertaken to identify suitable sowing windows as well as genotypes to enhance crop yield and radiation use efficiency (RUE) of guar as well as to assess the growth.

2. Materials and methods

The field experiment was conducted at the Center for Climate Resilient Agriculture, the University of Agricultural and Horticultural Sciences, Shivamogga (13°.58′ N latitude, 75°.4′E longitude and 650 m elevation), Karnataka, India, during *Kharif* 2014 and 2015 to study the effect of sowing windows and genotypes on growth, radiation interception, conversion efficiency and yield of Guar. The experiment consists of nine treatments: three dates of sowing (15thAugust, 30thAugust, and 15thSeptember) and three genotypes (RGC-1003, RGC-936, and HG-365). The field experiment was conducted in factorial randomized complete block design with three replications. The physio-chemical properties of the experimental site were red clay in texture, having pH 5.6 with low available nitrogen (241 kg/ha), higher available Phosphorus (87 kg/ha), and low available Potassium (241 kg/ha). The 20 kg N was applied as a basal dose with 40 kg P_2O_5 and 20 kg K_2O at the time of sowing. The amount of fertilizer required for the plot size of 10.8 m^2 was calculated and applied in the furrows just before sowing. The crop was exclusively grown under rainfed conditions. The seeds were sown in the furrows at 30 cm apart and two seeds per hill were placed at 10 cm spacing. Thinning was done 15 days after sowing to retain one plant per hill. The growth attributes were recorded at 30 days interval and yield parameters at the time of harvesting.

2.1. Measurements

The plant growth in terms of height (cm) was taken from ground level to tip of the plant at 30 days interval. Number of fully opened green leaves and the total number of branches per plant was counted at 30 days interval. The leaf area (LA) was measured from each treatment by uprooting five plants at 30 days interval after sowing. The leaves were separated from the plants and leaf area was measured with a leaf area meter (LICOR 3100, LI-COR, Inc.) and the average was determined and expressed in cm^{-2}. The leaf area index was computed in each treatment by using the formula leaf area / land area (spacing). The uprooted plants were dried at 80 °C and dry weight (g) was recorded. Further, the dry matter was used to compute Leaf area ratio (LAR), Absolute growth rate (AGR) and Relative growth rate (RGR).

The leaf area ratio was estimated by dividing leaf area (cm^2 p^{-1}) by total dry matter (g p^{-1}).

Absolute growth rate was computed by using formula

$$AGR = g\ p^{-1}\ day^{-1}()$$

where W_1 and W_2 are dry weight of plants at time t_1 and t_2 respectively

Relative growth rate was computed by using formula

$$RGR = g\ g^{-1}\ day^{-1}()$$

where W_1 and W_2 are dry weight of plants at time t_1 and t_2 respectively

$log_{e,}$ natural logarithm

The plants uprooted for measuring leaf area were also used for recording dry matter accumulation from leaf, stem, and pod separately at 30 days intervals after sowing. Further the summation of dry matter from all these parts is recorded as dry matter accumulation (g p^{-1}). At harvest, the total number of pods from five plants was measured as average pod number per plant. Apart from these five randomly selected pods from each plant were used for measuring pod length. The length of pod was measured from its base to tip and the mean pod length was expressed in centimeter. The grain number per pod was counted from five randomly selected pods after shelling. Grain yield was obtained after shelling the thoroughly dried pods collected from the net plot and is computed for hectare and expressed as kilogram per hectare. Similarly, stover yield (kg ha^{-1}) was estimated from the net plot by weighing the thoroughly dried plants. The weight of the randomly selected hundred seeds for each treatment is expressed as test weight (100 seed weight) in gram.

From the weather station of Zonal Agricultural and Horticultural Research Station, Shivamogga, located on the studied area, the daily data on maximum temperature, minimum temperature, average temperature, rainfall, and solar radiation were recorded. The weather data pertaining to the experimental period from August to December during 2014 and 2015 were only presented. The intercepted radiation (IR) was measured using a line quantum sensor (LI-COR, Inc.) of 1 m length at 30 days interval from each treatment and this was measured at solar noon by placing the sensor above and below the canopy. For each treatment, measurements were made five times and the average of light intercepted by the canopy has arrived. The daily solar radiation was converted into PAR (Photosynthetically Active Radiation) by multiplying the solar radiation by 0.5 as suggested by Monteith (1972). Cumulative PAR was multiplied by the percent light interception and the quantum of radiation intercepted by the canopy has arrived.

Radiation use efficiency was determined by dividing the above-ground biomass by the cumulative PAR intercepted by the canopy. Apart from this average radiation use efficiency was also worked out by fitting a linear regression equation between above-ground biomass versus cumulative PAR intercepted by the canopy.

2.2. Statistical analysis

The analysis of data was carried out using ANOVA to calculate significant effect among the treatments, across sowing dates, genotypes as well as years. An LSD (α = 0.05) was used to compare the significance or otherwise of the treatment differences with respect to grain yield, stover yield, leaf area index (LAI), total dry matter (TDM), cumulative radiation interception and radiation use efficiency and other growth indices like RGR, AGR and LAR. The data was statistically analyzed by using Statistical Package for Social Science (SPSS-V 25.0) and the graphs were drawn by using in collaboration with colleagues from Princess Noura bint Abdulrahman University.

3. Results

3.1. Weather prevailed during the cropping seasons

The variation in weather parameters was observed during the cropping seasons, and it directly influenced the crop phenology. Weather data during the cropping season for 2014 and 2015 season from August to December is presented in Fig. 1. The crop experienced uniform distribution of rainfall during the entire growing season during the first season (2014). However, high-intensity rainfall with prolonged dry spell conditions was noticed during the second season (2015). The total amount of rain fall received during the first season was 779.4 mm and it was 457.8 mm during second season. The maximum and minimum temperature was higher in the second year than the first year of cropping season (Fig. 1). The mean temperature experienced by the crop was 24.8 °C during the first season and it was 25.6 °C during second season. Similarly, the cumulative solar radiation received during first season was 2240.0 MJ m^{-2} and it was 2218.0 MJ m^{-2} during second season.

3.2. Growth and growth attributes

The growth and growth attributes differed significantly with different seasons, sowing windows and genotypes at 90 days after sowing (Table 1). The plant height did not differ significantly during different seasons. However, the plant height was maximum (49.94 cm) during second season. Among the sowing windows, crop sown on August 15th recorded significantly higher plant height (55.10 cm) compared to other sowing windows. The plant height was significant (51.69 cm) with genotype RGC 1003 and it was found on par with RGC 936 (50.77 cm). Number of trifoliate leaves was significantly higher (10.47) during 2014 compared to second season (2015). The crop sown on August 15th produced a greater number of trifoliate leaves (11.17) and it was statistically significant with other sowing windows. Similarly, RGC 1003 produced higher number of leaves (10.23) and it was superior to HG 365 (9.32). However, it was on par with RGC 936 (10.04). There

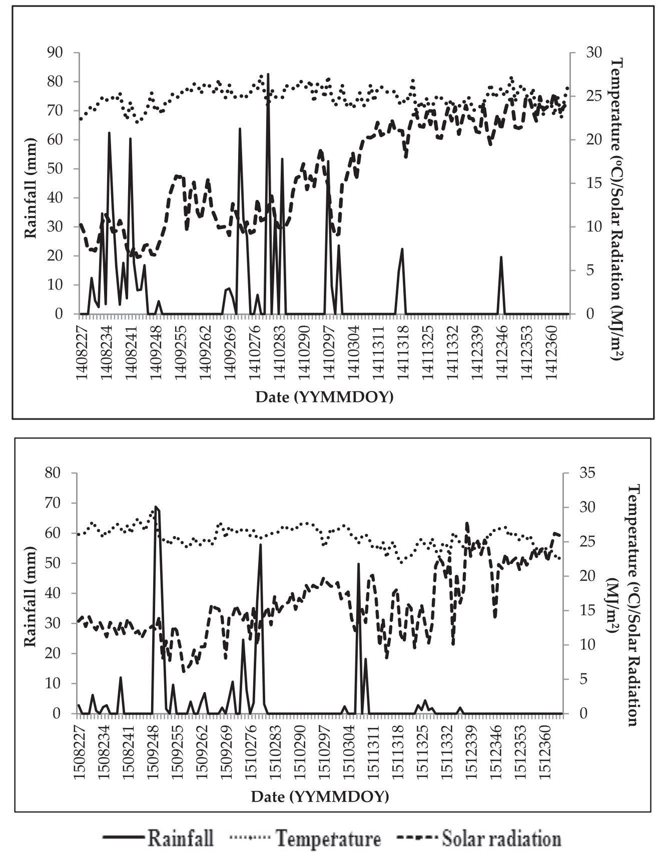

Fig. 1. Rainfall (RF), air temperature (Temp) and solar radiation (SR) during the 2014 and 2015 guar growing seasons.

was no significant difference on number of branches per plant was noticed between the seasons. However, significantly higher number of branches recorded with August 15th sown crop (3.95) and RGC 1003 genotype (3.65) as compared to other sowing windows and genotypes. Leaf area ratio was significant between seasons and sowing windows. Higher LAR was recorded by the crop grown during first season (17.61 cm^{-2} g^{-1}) and on August 15th (20.70 cm^{-2} g^{-1}). Absolute growth rate and Relative growth rate was recorded at 60 to 90 days interval. The AGR differed significantly with sowing windows and it was found more on August 15th sown crop (0.33 g plant^{-1} Day^{-1}) compared to other sowing windows whereas, RGR did not differ with different factors.

3.3. Leaf area index (LAI)

Leaf area index was increased drastically from emergence to pod filling stage in all the cultivars (Fig. 2). The maximum LAI was reached during flowering/pod filling stage (60 DAS). The LAI differed significantly due to sowing windows. Table 2 shows ANOVA for years, the crop was produced slightly higher LAI during the first year of the cropping season. Similarly, significantly higher LAI was observed in the August 15th sown crop (2.78) of all cultivars than the August 30th (2.20) and September 15th (1.43) sown crop (Table 2). The cultivar RGC 1003 recorded significantly higher LAI (2.39) compared to RGC-936 (2.20) and HG-365 (1.82).

3.4. Dry matter production

The total dry matter production varied between the growing seasons (Table 2). In the first growing season (2014), the plant pro-

Table 1
Effect of sowing windows and genotypes on growth and growth attributes of guar.

Factors	Plant height (cm)	Number of leaves	Number of branches	LAR (cm^{-2} g^{-1})	AGR (g $plant^{-1}$ Day^{-1})	RGR (g g day^{-1})
Year (A)	NS	*	NS	*	NS	NS
2014	49.36	10.47	3.53	17.61	0.28	1.10
2015	49.94	9.25	3.44	17.59	0.30	1.13
CD @5%	NS	0.39	NS	1.27	NS	NS
Sowing windows (B)	*	*	*	*	*	NS
15th August	55.10	11.17	3.95	20.70	0.33	1.13
30th August	49.39	9.99	3.59	17.95	0.29	1.11
15th September	44.44	8.42	2.93	14.14	0.25	1.11
CD @5%	2.79	0.48	0.24	1.56	0.04	NS
Genotypes (C)	*	*	*	NS	NS	NS
RGC 1003	51.69	10.23	3.65	18.27	0.30	1.13
RGC 936	50.77	10.04	3.53	17.82	0.28	1.12
HG 365	46.47	9.32	3.29	16.70	0.29	1.10
CD @5%	2.79	0.48	0.24	NS	NS	NS
A * B	NS	NS	NS	2.21	NS	NS
A * C	NS	NS	NS	NS	NS	NS
B * C	NS	0.83	NS	NS	NS	NS
A * B * C	NS	NS	NS	NS	NS	NS

Note: CD @5%: Critical difference @ 5%, and NS: Non significant, LAR: Leaf area ratio, AGR: Absolute growth rate, RGR: Relative growth rate.

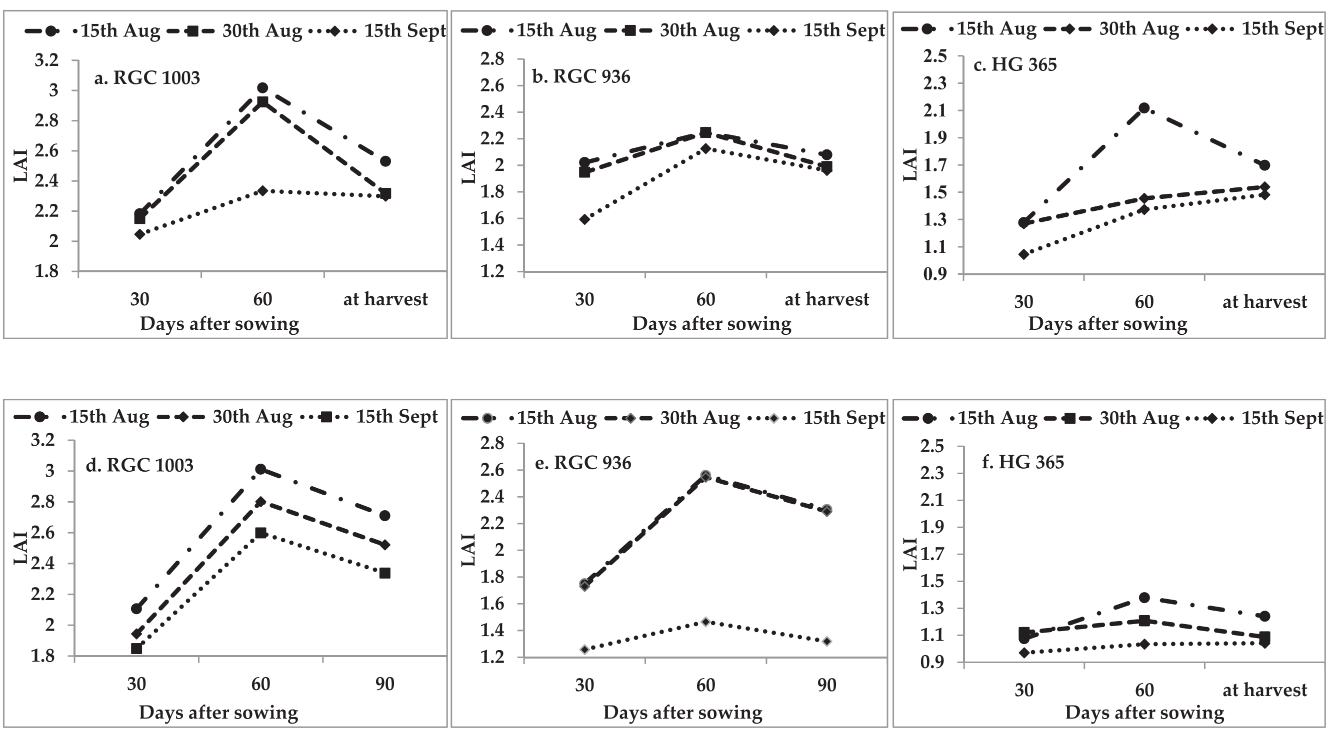

Fig. 2. Effect of genotypes and sowing windows on leaf area index of guar during 2014 (a, b, c) and 2015 (d, e, f).

duced significantly maximum total dry matter (24.22 g p^{-1}) to an extent of 9 per cent compared to second season (22.22 g p^{-1}). The sowing window also influenced the plant dry matter. The TDM production was significantly higher (25.51 g p^{-1}) with August 15th sown crop than other sowing windows. Late sowing by thirty days compared to early sown crop has resulted in reduction in the TDM production to an extent of 20.00 per cent. The dry matter production is also a varietal characteristic and the significantly higher TDM was noticed with RGC-1003 (24.23 g p^{-1}) as compared to other cultivars.

3.5. Radiation interception and radiation use efficiency (RUE)

The cumulative radiation intercepted by guar is significantly influenced by sowing windows as well as genotypes (Table 2). The early sown crop (August 15^{th}) has intercepted significantly higher amount of radiation (734.2 MJ m^{-2}) compared to late sown crop (392.4 MJ m^{-2}). Meanwhile the genotype RGC-1003 has intercepted significantly higher radiation (597.4 MJ m^{-2}) compared to rest of the genotypes. The total canopy IPAR values indicate the canopy spread and the interception ability of the canopy. We have noticed significantly superior effect of sowing dates on absorbed photosynthetically active radiation. The mean IPAR was higher in early sown crop (August 15th) throughout the growing period and found significant as compared to other treatments (Fig. 3).

The mean RUE is not influenced by sowing windows or genotypes (Table 2). However, the mean RUE of guar ranged from 0.75 to 0.78 g MJ^{-1} for sowing dates and it ranges from 0.74 to 0.79 g MJ^{-1} for genotypes. The pattern of IPAR depends on the extent of canopy development (Fig. 4). Among the different date

Table 2
Effect of sowing windows and genotypes on yield, related growth traits and radiation use efficiency.

Factor	LAI	TDM (g)	GN (pod^{-1})	PL (cm)	C. IR (ΣMJ/m^2)	TW (g)	GY (kg ha^{-1})	SY (kg ha^{-1})	RUE (g MJ^{-1})
Year (A)	NS	*	*	*	NS	*	*	*	NS
2014	2.21	24.22	5.62	4.95	576.7	3.16	401	1026	0.78
2015	2.07	22.22	4.95	4.49	558.9	3.03	378	899	0.75
CD @5%	NS	0.73	0.23	0.19	NS	0.10	21.8	33.3	NS
Sowing windows (B)	*	*	*	*	*	NS	*	*	NS
15th August	2.78	25.51	6.03	5.41	734.2	3.12	445	1009	0.75
30th August	2.20	23.78	5.40	4.82	576.9	3.09	383	972	0.77
15th September	1.43	20.38	4.42	3.93	392.4	3.06	342	907	0.78
CD @5%	0.18	0.90	0.29	0.24	27.3	NS	26.6	40.7	NS
Genotypes (C)	*	*	*	*	*	NS	*	*	NS
RGC 1003	2.39	24.23	5.56	4.89	597.4	3.12	417	983	0.79
RGC 936	2.20	23.32	5.27	4.84	586.9	3.09	387	972	0.77
HG 365	1.82	22.12	5.02	4.43	519.1	3.06	366	933	0.74
CD @5%	0.18	0.90	0.29	0.24	27.3	NS	26.6	40.7	NS
A * B	0.26	NS	NS	NS	38.6	NS	NS	NS	NS
A * C	NS	NS	NS	NS	NS	NS	NS	NS	NS
B * C	NS	NS	NS	NS	47.3	NS	NS	NS	NS
A * B * C	0.45	NS	NS	NS	NS	NS	NS	NS	NS

Note: CD @5%: Critical difference @ 5%, and NS: Non significant, LAI: Leaf area index (Peak flowering stage), TDM: Total dry matter accumulation, GN: Grain number, PL: Pod length, C.IR: Cumulative Intercepted radiation, TW: Test weight, GY: Grain yield, SY, Stover yield, RUE: Radiation use efficiency. (LAI and TDM at Peak flowering/pod formation stage).

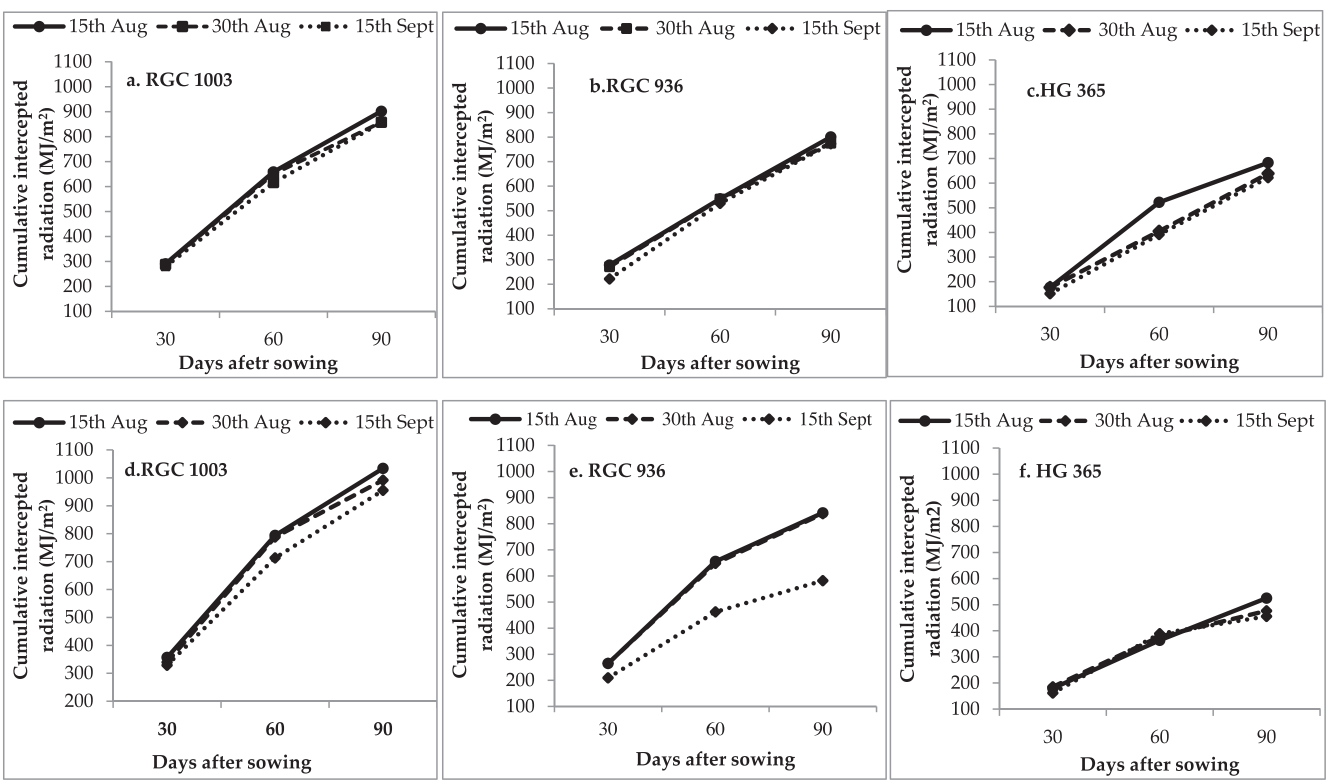

Fig. 3. Cumulative intercepted radiation (MJ/m^2) of guar genotypes as influenced by sowing date during 2014 (a, b, c) and 2015 (d, e, f).

of sowing, the relationship between intercepted photosynthetically active radiation and biomass above the ground was significant with a coefficient of determination (R^2) of 0.88 and 0.85 during 2014 (Fig. 4a) and 2015 (Fig. 4d), respectively. The coefficient of determination (R^2) is 0.87 and 0.91 for genotypes during 2014 (Fig. 4b) and 2015 (Fig. 4e) respectively.

3.6. Yield and yield attributes

The yield and yield attributes *viz.,* grain number and pod length, differs significantly among the seasons, sowing windows, and genotypes excluding the test weight (Table 2). Significantly higher grain number (5.62), pod length (4.95 cm), test weight (3.16 g), grain yield (401 kg ha^{-1}), and stover yield (1026 kg ha^{-1}) was recorded during the first season as compared to the second season. During the second season, the yield reduction is to an extent of 5.7 (grain) and 12.3 (stover) per cent compared to the first season. Among the different sowing windows, the early sown crop (August 15th) had an advantage of better resource use efficiency in terms of cumulative radiation interception hence resulted in higher grain number (6.03), pod length (5.41 cm), test weight (3.12 g), grain yield (445 kg ha^{-1}), and stover yield (1009 kg ha^{-1}) than other

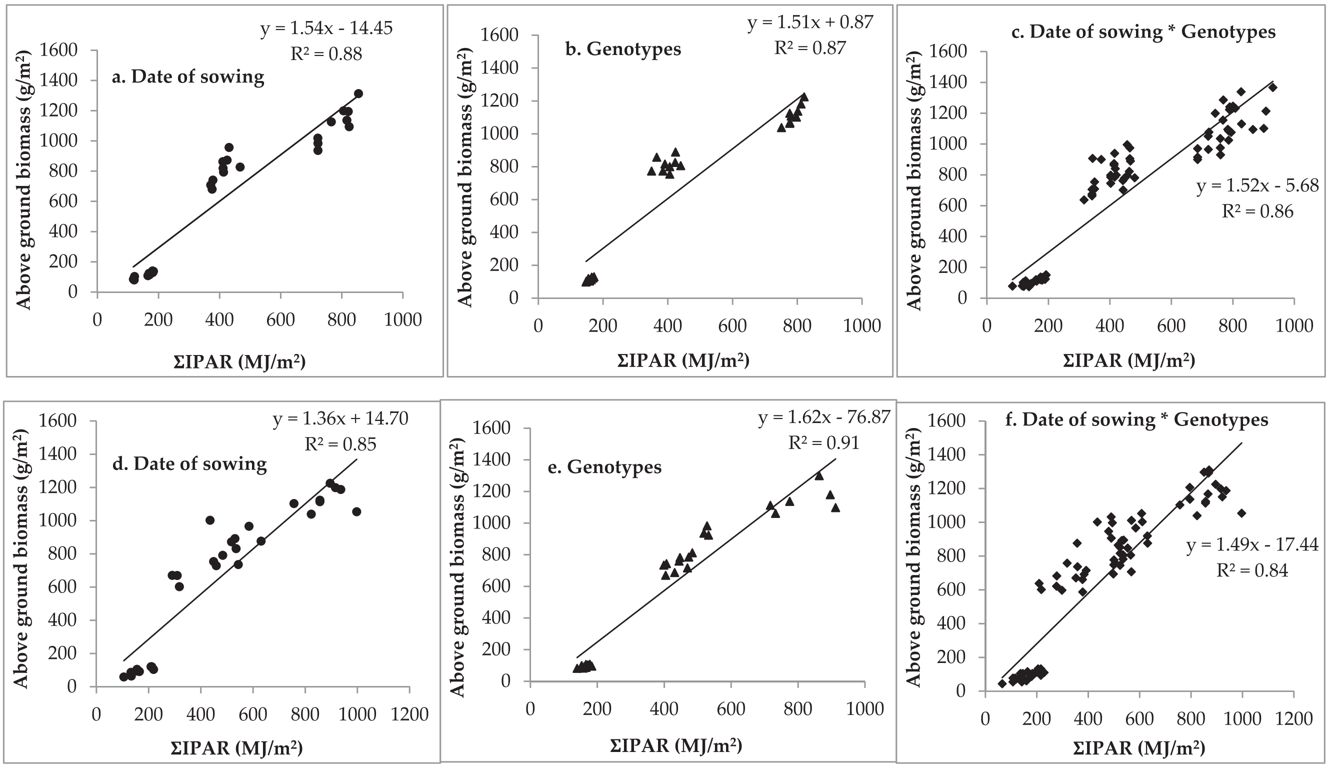

Fig. 4. Relationship between radiation interception and dry matter production during 2014 (a, b, c) and 2015 (d, e, f).

sowing windows. Delay in sowing beyond August-15 has resulted in reduction in yield and yield parameters significantly. Among the genotypes, RGC-1003 recorded significantly higher grain numbers, maximum pod length, highest test weight, grain yield, and stover yield (5.56, 4.89 cm, 3.12 g, 417 kg ha^{-1}, and 983 kg ha^{-1}, respectively) as compared to other genotypes. The interaction effect of all factors did not differ significantly.

4. Discussion

4.1. Growth and growth attributes

The crop response was superior with respect to growth and growth attributes when crop was sown on August 15th might be due to favorable climatic conditions in terms of temperature and photoperiod and other climatic parameters during different growth stages which in turn results higher growth. These findings were in corroboration with Chovatia et al. (1998) and Chavan et al. (1998). Patil et al. (2003); Ramakrishna et al. (2000); Reddy (2009) and Anuradha Rajendra et al. (2017) also opined that the growth and growth attributes among the genotypes are the genetic potentiality of the genotypes.

4.2. Leaf area index (LAI)

The crop expressed its maximum LAI due to the production of maximum trifoliate leaves in response to optimum availability of soil moisture (Fig. 1) as a result crop vegetative growth was longer. During the second season, crop experienced high rainfall intensity during its establishment stage, followed by a prolonged dry spell during its pod filling stage (Fig. 1). These conditions are responsible for reduction in canopy cover expressed as LAI. Further, reduction in the chlorophyll content and reduction in photosynthetic rate due to moisture stress in turn reduces the expansion of the leaves thereby reducing LAI of the crop (Qian et al., 2003). Identification of suitable sowing window is the primary objective of the present research. Early sown crop (August 15th) produced significantly higher LAI compared to the other two sowing windows. As early sown crop experienced a long growing season with the optimum rate of soil moisture, this favored the balanced uptake of nutrients and is often associated with the translocation of photosynthates. Ahn et al. (1989) recorded similar results when the crop was sown early, resulting in significantly higher LAI in Soybean. The cultivar differences with respect to LAI may be due to a greater number of trifoliate leaves; more branches in RGC-1003 compared to other two cultivars. Similar results were reported by Arora et al. (2011) in clusterbean.

4.3. Dry matter production

The seasonal differences in TDM may be attributed to differential weather parameters prevailed during the growing season in terms of rainfall distribution as well as availability of radiation (Fig. 1). Mirosavljevic et al. (2018) observed higher dry matter in barley when crop experienced uniform distribution of precipitation during the first season than the second season of experimentation. The reduction in TDM due to delayed sowing is attributed to lesser LAI and in turn reduction in radiation interception (Table. 2). Further, the early sown crop remains in the field for a longer period and these crops are grown vigorously due to maximum utilization of solar radiation to produce photosynthates. Farz et al. (2006), Miah et al. (2009) and Samant et al. (1999) also recorded higher dry matter production in early sown crop of Mungbean. Patil et al. (2003), Ramakrishna et al. (2000) and Reddy (2009) opined that a plant's ability to produce dry matter depends on the size and length of the photosynthetic area. The genetic potentiality of the cultivar to produce and translocate higher assimilates in turn converts into total dry matter.

4.4. Radiation interception and radiation use efficiency (RUE)

The differences in radiation interception are attributed to higher canopy spread measured in terms of LAI. The mean IPAR was higher in early sown crop (August 15th) throughout the growing period. This might be explained as favorable climatic conditions prevailed during the early sown crop that might have resulted in profuse growth, which consequently reflected more accumulation of dry matter and IPAR. Andhale et al. (2012) observed similar results in chickpea. The genotype RGC-1003 has intercepted significantly higher radiation compared to rest of the genotypes.

4.5. Yield and yield attributes

The year-to-year differences in yield of guar may be attributed to higher rainfall during early crop growth, causing aeration stress to the roots during 2015. Thomas (2013) has also reported a yield reduction of wheat due to aeration stress. Optimum sowing time helps in the efficient use of moisture, solar radiation, and higher photosynthetic rates which might have favored higher yield. Delay in sowing, decreases the length of vegetative and reproductive growth stages due to excess heat prevailed during the season which retards the growth, development, decreased assimilation, early flowering, increase of flower loss, and infertility (Nandini et al., 2017; Sreelatha et al., 1997). Among the genotypes, RGC-1003 recorded significantly higher yield and yield attributing characters than RGC-936 and HG-365. This difference in yield is attributed to the varietal potential as expressed in higher dry matter production and RUE by RGC-1003 compared to rest of the cultivars. Shivaran et al. (1996) also observed similar yield differences in different cultivars of guar.

5. Conclusions

Agronomic practices like sowing dates and cultivars play an important role in enhancing the growth and yield of guar. The amount of radiation received and the crops ability to absorb and convert into biomass is also influenced by agronomic practices. Early sown crop during both the seasons produced more biomass as well as higher grain yield compared to late sown crop. The difference between the years is attributed to variation in quantum of rainfall received as well as radiation intercepted by the crop. The average radiation use efficiency of guar genotypes ranged from 0.74 to 0.79 g MJ^{-1}. Sowing dates as well as genotypes did not influence the RUE, but the final grain yield of guar was greatly influenced by genotypes as well as by sowing dates. Among the genotypes RGC-1003 found to out yield the remaining two genotypes with higher RUE. Hence the findings of the present investigation can be used as a base line recommendation for successful cultivation of guar in southern India. Further the studies are required to understand the performance of guar during summer season under irrigation.

CRediT authorship contribution statement

Pavithra A. Honnaiah: Experimentation, Manuscript writing. **Shankarappa Sridhara:** Methodology. **Pradeep Gopakkali:** Analysis and Manuscript writing. **Nandini Ramesh:** Writing - review & editing. **Eman A. Mahmoud:** Writing - review & editing. **Shaimaa A.M. Abdelmohsen:** Analysis and manuscript writing. **Fatema H. Alkallas:** Manuscript writing and reviewing. **Diaa O. El-Ansary:** Writing - review & editing. **Hosam O. Elansary:** Writing - review & editing..

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Declaration of Competing Interest

The authors have no conflict of interest.

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