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Effect of growth parameters and growth analysis of soybean as influenced by varieties and crop geometries

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Abstract
A field experiment was conducted at College farm, Agricultural College, Polasa, Jagtial, PJTSAU, during the *kharif* season of 2018 to study the ''Evaluation of varieties at varied crop geometry for yield maximization in Soybean'' The experiment was laid out in split-plot design with three replications to evaluate the performance of promising varieties of soybean (V_1- Basar,V_2- JS 335, V_3- KDS 756 and V_4- MACS 1281) and to standardize the crop geometry for Soybean varieties (S_1- 45 x 10 cm, S_2- 30 x 10 cm, S_3- 45 x 05 cm and S_4- 35 x 05 cm) under rainfed semi arid conditions of Telangana. The results indicated that among the four varieties tested, plant height, dry matter production, leaf area, SPAD chlorophyll readings, number of branches plant^{-1}, number of root nodules plant^{-1}, dry weight of root nodules plant^{-1}, crop growth rate (CGR) and relative growth rate (RGR) of KDS 756 variety was significantly higher as compared to other varieties followed by Basar, MACS 1281, respectively. JS 335 showed inferior performance regarding to growth parameters. Growing degree days and photo thermal units were higher with the variety Basar followed by MACS 181, KDS 756 and JS 335. Among crop geometry 30 x 10 cm recorded higher observations on growth parameters followed by 45 x 05 cm, 30 x 05 cm and 45 x 10 cm, respectively. Dry matter production was higher under closer crop geometry of 30 x 05 cm followed by 45 x 05 cm, 30 x 10 cm and 45 x 10 cm due to higher plant population per unit area.

Keywords: Parameters, analysis, soybean, influenced, varieties, geometries

1. Introduction
In India, soybean crop ranked second among oilseed crops of India and these are the important source of our economy contributing five per cent to Gross Net Profit (GNP). Soybean [*Glycine max* (L.) Merrill] the miracle crop of 21st century is called as poor meat and golden bean because of its multiple uses. It is the only crop which included both in the oilseed crop and pulse crop categories. Soybean crop is rich in high quality protein (40-42%), oil (18-20%) and other nutrients like calcium, iron and glycine. It is a good source of isoflavones and therefore it helps in preventing heart diseases, and cancer (Kumar and Badiyala 2004) [7]. It is a legume crop belongs to family Leguminaceae and sub-family Papillionaceae. Being a legume plant, soybean has ability to fix atmospheric nitrogen with the help of root nodule and to add organic matter to the soil, thereby increasing the productivity of soil. The major soybean growing states are Madhya Pradesh, Maharashtra, Rajasthan, Karnataka, Telangana and Andhra Pradesh. In Telangana and Andhra Pradesh, the crop is grown in an area of 110 lakh ha with 147 Lakh ton of production and a productivity of 1350 q ha^{-1} (Anonymous, 2017) [1]. The cultivation of soybean crop is increasing at a faster rate and is extensively grown in Adilabad, Nizamabad, Medak and Karimnagar districts of Telangana state.
Soybean is generally grown under rainfed conditions. It grows in tropical, sub tropical and temperate climates. By adopting the suitable methods there is a chance for getting higher yields. Varieties play a unique role in maximization of yield by improving the fertilizer-use efficiency and water-use efficiency. Thus, the selection of suitable variety of soybean is of prime importance as the genetic potential of a variety limits the expression of its yield and affects plant growth in response of varying environmental condition.
The varieties with higher dry matter production and its proper distribution towards reproductive parts results in higher productivity. The newly released varieties due to their high yield potential and other advantages like early maturity, free from shattering habit, tolerance for disease and insect pests are registering higher productivity. Optimum number of plants per unit area is required to utilize the available production factors efficiently such as water, nutrients, light and CO_2.

The optimum number of plants per unit area is one of the important parameter in increasing the crop productivity. The optimum plant density with proper geometry of planting is dependent on variety, its growth habit and agro-climatic conditions. The competition for resources like nutrients, light, moisture and carbon di-oxide may be optimised by suitable geometry of plants. Hence, crop geometry and varieties are considered as main factors of crop production.

The present investigation was, therefore, undertaken to generate the informations on the ability of different soybean varieties and crop geometries on yield of soybean

2. Material and Methods

A field experiment was conducted at College farm, Agricultural College, Polasa, Jagtial, PJTSAU, during the *kharif* season of 2018 in split plot design with three replications. To evaluate the performance of promising soybean varieties, namely (V_1- Basar, V_2- JS 335, V_3- KDS 756 and V_4- MACS 1281) and to standardize the crop geometry for promising soybean varieties (S_1- 45 x 10 cm, S_2- 30 x 10 cm, S_3- 45 x 05 cm and S_4- 35 x 05 cm) under rainfed semi-arid conditions of Telangana. The experimental soil was sandy clay loam with pH 7.4, medium in organic carbon (0.5%), low in available nitrogen (247.3 kg ha^{-1}), high in available phosphorus (23.05 kg ha^{-1}) and potassium (326.8 kg ha^{-1}). The crop was supplied with recommended dose of fertilizer, i.e. 60 kg N, 60 kg P2 O5 and 40 kg K2 O/ha, through urea, single superphosphate and muriate of potash respectively. The weekly mean maximum and minimum temperature during crop-growth period was 31.7°C and 23.1°C, respectively, and total rainfall received was 618 mm in 31 rainy days. Crop was sown on 3^{rd} July, 2018 at varied geometry levels and each variety was harvested according to their duration as variety Variety KDS 756, JS 335 were harvested at 95 DAS while MACS 1281 at 98 DAS and Basar was harvested at 103 DAS respectively. The observations on crop growth parameters of the soybean were recorded on the basis of 5 random plants and analyzed statistically by split plot technique. While regarding on physiological parameters are Crop growth rate (CGR) is the rate of dry matter production per unit ground area per unit time. Relative growth rate (RGR) is the rate of increase in the dry weight per unit dry weight. The GDD or heat unit explains the linear relationship between growth duration and temperature. Photo thermal units (PTU) the product of GDD and corresponding day length for that day were computed on daily basis.

3. Results and discussion

3.1 Growth parameters

3.1.1 Plant height (cm)

Height of the plant is an important growth parameter. It exhibits the vigour of the plant. Environmental factors and genetic characteristics of plants play an important role in determining plant height. Data pertaining to plant height of soybean influenced by varieties and crop geometry at different growth stages are presented in Table 1. The plant height of soybean increased progressively with advance in age of the crop 60 DAS and thereafter the increment in height is very less up to maturity.

Plant height was affected significantly by varieties and crop geometry. Among the varieties, the KDS 756 exhibited highest plant height at harvest (55.2 cm) which was followed by Basar at (53.4 cm), MACS 1281 (53.3 cm) and JS 335 (44.2 cm). The variation in plant height among varieties of soybean might be due to disparity in genetic character and make up of varieties which made efficient utilization of available resources such as nutrient, water and sunlight in addition to adaptability of varieties to given climatic conditions. The differential varieties response in respect of plant height was also reported by Halvankar (2001) [5] and Varsha (2018) [20].

Among the various crop geometry levels, highest plant height at harvest stage of soybean was observed in 30 x 10 cm (53.9 cm) and was followed by 45 x 05 cm (51.4 cm) which was at par with 30 x 05 cm (50.9 cm) whereas minimum plant height recorded under crop geometry 45 x 10 cm (49.6 cm).

The lower plant height under narrow spacings was due to more competition between the inter and intra plants for sunlight, water and nutrients compared to wider spacing that promote self-thinning of branches and enhanced vertical growth rather than horizontal growth which leads to higher plant height. Similar results were reported by Thakur *et al.* (2003) [19] and Naresh Kumar Meena (2010) [11].

The interaction between varieties and crop geometry was found non significant on plant height of soybean.

3.1.2 Number of branches $Plant^{-1}$

The data regarding to number of branches $plant^{-1}$ at 30 and 60 DAS as influenced by different varieties and various crop geometries was presented in Table 1. Among the varieties, the KDS 756 exhibited highest branches $plant^{-1}$ throughout the crop growth period at 30 DAS (10.5) and 60 DAS (13.8) which was significantly higher than Basar at 30 DAS (9.8) and at par at 60 DAS (12.9). At 60 DAS, number of branches $plant^{-1}$ of Basar was in turn at par with MACS 1281 and also MACS 1281 was at par with JS 335. In KDS 756 has increased in number of branches $plant^{-1}$ at 30 DAS (6.6%, 18.1 and 37.1) and at 60 DAS (6.5%, 15.2% and 26%), compared to Basar, MACS 1281 and JS 335 respectively. The number of branches plant-1 is one of the important yield parameter that determines the number of pods $plant^{-1}$ and in turn results in higher yield. It was supported by Billore *et al.* (2000) [2] and Patel and Singh (2010).

Among the various crop geometry levels, highest number of branches $plant^{-1}$ of soybean at 30 and 60 DAS was observed in 30 x 10 cm (10 and 14) which was followed by 45 x 05 cm (9.4 and 12.6), 30 x 05 cm (8.7 and 11.5) and 45 x 10 cm (7.4 and 10.7). At 30 DAS, spacing of 30 x 10 cm was at par with 45 x 05 cm which was in turn at par with 30 x 05 cm. At 60 DAS, 30 x 05 cm was at par with 45 x 10 cm. In 30 x 10 cm has increased in number of branches $plant^{-1}$ at 30 DAS (5%, 13%. and 26%) and at 60 DAS (14%, 25% and 33%) compared to 45 x 05 cm, 30 x 05 cm and 45 x 10 cm. Similar results were reported by Kumar and Badiyala (2004) [7] and Rahman *et al.* (2013) [16].

The interaction between varieties and crop geometry was found non significant on number of branches $plant^{-1}$ of soybean at all stages of crop growth.

3.1.3 Leaf area (cm^2 $plant^{-1}$)

The data pertaining to leaf area of soybean was significantly influenced by both varieties and crop geometry at all the growth stages was Table 1. Leaf area (cm^2 $plant^{-1}$) recorded was lowest at 30 DAS and gradually increased with increase in age of the crop and reached its peak at 60 DAS and thereafter shown declined trend towards maturity due to senescence of foliage. Among the varieties tested, KDS 756 (266.7 and 1476.1) showed superiority over the other three varieties at 30 and 60 DAS, and thereafter, there is a decrease in leaf area (cm^2 plant^{-1}) at 90 DAS and at harvest. At 90 DAS and at harvest, Basar (1279 and 955.3 cm^2 plant^{-1}) has highest leaf area due to its longer duration followed by MACS 1281, KDS 756 and JS 335. MACS 1281 was at par with KDS 756 at 90 DAS. This might be due to more plant height and number of leaves plant^{-1} with KDS 756 and Basar. Lowest leaf area (cm^2 plant^{-1}) was recorded in JS 335 at 30, 60, 90 DAS and at harvest. Results were in conformity with Gavli Ashutosh Shivram (2010) [4].

An increase in crop geometry of soybean leaf area was decreased gradually at all the growth stages. Among the various crop geometry levels, highest leaf area (cm^2 plant^{-1}) of soybean at 30, 60, 90 DAS and at harvest was observed in 30 x 10 cm followed by 45 x 05 cm, 45 x 10 cm and 30 x 05 cm. 45 x 05 cm was at par with 45 x 10 cm at 60, 90 DAS and at harvest. Lowest leaf area (cm^2 plant^{-1}) was observed in closer spacing 30 x 05 cm due to more number of plant population m-2 and there is a competition for resources like water, nutrients and light between the intra and inter plant population. These results were in line with Pawar Ganesh Ravindra (2010) [14].

Interaction between varieties and crop geometry was found non significant on leaf area (cm2 plant^{-1}) of soybean.

3.1.4 Dry matter production (kg ha^{-1})

The data pertaining to dry matter production as influenced by varieties, crop geometry was presented in Table 1. The dry matter production of soybean increased progressively with advancement in age of the crop up to harvest. However higher increment in dry matter production was noticed between 60 and 90 DAS.

Dry matter production was affected significantly by varieties and crop geometry. Among the varieties, KDS 756 exhibited highest dry matter production at harvest (6937 kg ha^{-1}) and significantly higher than other varieties. It was followed by Basar (6506 kg ha^{-1}) and was at par with MACS 1281 (6465 kg ha^{-1}). Lower dry matter production was reported by JS 335 (5572 kg ha^{-1}). KDS 756 has recorded higher dry matter production at harvest (3.2%, 3.4%, 19.9%) compared to Basar, MACS 1281 and JS 335. The variety KDS 756 exhibited higher plant height, number of branches plant^{-1}, leaf area plant^{-1} and resulted in higher dry matter production. Similar results were reported by Nigam *et al.* (1989) [9] and Naidu *et al.* (2017) [10].

Among the various crop geometry levels, highest dry matter production of soybean at harvest was observed in 30 x 05 cm (10082 kg ha^{-1}) and was distinctly higher than other geometry levels. The higher plant population at 30 x 05 cm (66 plants m^{-2}) may be one of the reasons for higher dry matter production. Lowest dry matter production was observed with 45 x 10 cm (3206 kg ha^{-1}) due to less plant population (22 plants m^{-2}). Though the individual plant performance was better under wider spacing, but could not produce higher leaf area and dry matter production per unit area due to low plant population per unit area. Similar results were reported by Kumar and Badiyala (2004) [7], Naresh Kumar Meena (2010) [11], and Pawan Prakash Sharma (2011) [15].

Interaction between varieties and crop geometry was found non significant on dry matter production (kg ha^{-1}) of soybean.

3.1.5 SPAD chlorophyll meter reading (SCMR)

The data regarding to SCMR as influenced by varieties, crop geometry at harvest was presented in Table 1. The SCMR value represents photosynthetic area and activity present in the leaves that determines the production potential of that variety. SCMR values are relatively higher at 30 DAS and there is gradual decline at 60, 90 DAS and reached less value at harvest.

SCMR values were affected significantly by varieties and crop geometry. Among the varieties, the KDS 756 exhibited highest SCMR values at harvest (35.6) which was followed by Basar (32.7). KDS 756 has recorded higher percentage of SCMR at harvest (8.1%, 8.4% and 13.2%) compared to Basar, MACS 1281 and JS 335. The higher photosynthetic activity in these varieties is responsible for production of more branches plant^{-1} and in turn higher yield attributes i.e., number of pods plant^{-1} and number of seeds pod^{-1}. Lower SCMR values were noted with JS 335 (31.0).

Among the various crop geometry levels, highest plant height of soybean at harvest, was observed in 30 x 10 cm (35.2) and was at par with 45 x 05 cm (33.5). Wider spacing of 45 x 10 cm exhibited lower SCMR values at all stages of crop growth and was at par with 30 x 05 cm (32.3) spacing.

Interaction between varieties and crop geometry levels was found non significant on SCMR values of crop at all stages of crop growth.

3.1.6 Number of root nodules plant^{-1}

The data pertaining to number of root nodules plant^{-1} as influenced by varieties and crop geometry was presented in Table 1. The number of root nodules plant^{-1} of soybean increased progressively from 15 to 45 DAS with advance in age of the crop up to maturity.

Number of root nodules plant^{-1} was significantly varied by varieties and crop geometry. Among the varieties, the KDS 756 exhibited highest number of root nodules plant^{-1} at 45 DAS (68.1). KDS 756 has recorded highest number of root nodules plant^{-1} at 45 DAS (6%, 9.8% and 10.1%) compared to Basar, MACS 1281 and JS 335. The nitrogen assimilation is highly correlated to number of root nodules plant^{-1} and found to increase the growth and yield parameters of soybean. Similar results were reported by Sharma *et al.* (2009) [18] and Komal Patel (2016) [6].

Among the crop geometry levels 30 x 10 cm spacing were significantly higher number of root nodules plant^{-1} at 45 DAS (65.2). Plant geometry levels did not showed significant effect on number of root nodules plant^{-1} even though higher number is registered with 30 x 10 cm spacing. This was supported by Pawar Ganesh Ravindra (2010) [14].

The interaction between varieties and crop geometry levels on number of root nodules plant^{-1} was non significant at 45 DAS

3.1.7 Dry weight of root nodules plant^{-1} (mg)

The data pertaining to dry weight of root nodules plant^{-1} as influenced by varieties, crop geometry was presented in Table 1. The dry weight of root nodules plant^{-1} of soybean increased progressively from 15DAS to 45 DAS.

Dry weight of root nodules plant^{-1} was significantly varied by varieties and crop geometry. Among the varieties, the KDS 756 exhibited highest dry weight of root nodules plant^{-1} at 45 DAS (390.2 mg) which was followed by Basar (337.5 mg). Lowest dry weight of root nodules plant^{-1} was recorded by JS 335 (292.8 mg). KDS 756 has recorded highest dry weight of root nodules plant^{-1} at 45 DAS (13.5%, 14.7% and 24.9%) compared to Basar, MACS 1281 and JS 335. Similar response in respect of root nodules was reported by Sarawgi *et al*. (2005) [17] and Sharma *et al.* (2009) [18].

Among the various crop geometry levels, highest dry weight of root nodules plant^{-1} of soybean at 45 DAS was observed in 30 x 10 cm (356.5 mg) was at par with 45 x 05 cm which was in turn at par with 30 x 05 cm and 30 x 05 cm was at par with 45 x 10 cm. Lowest dry weight of root nodules plant^{-1} was recorded in wider spacing of 45 x 10 cm. 30 x 10 cm has recorded higher dry weight of root nodules plant^{-1} at 45 DAS (4.5%, 7.2% and 8.7%) compared to 45 x 05 cm, 30 x 05 cm and 45 x 10 cm. The similar results were reported by Pawar Ganesh Ravindra (2010) [14].

The interaction between varieties and crop geometry was found non significant on dry weight of root nodules plant^{-1} at 45DAS of soybean.

3.2. Growth analysis at different phenophases

3.2.1 Crop growth rate (CGR) (g m^2 day^{-1})

Data pertaining to crop growth rate are presented in Table 2. Crop growth is a measure of rate of biomass production per unit of ground area per unit time. Crop growth rate of soybean varieties was initially low and increased with the advancement of crop age and reached to its peak between 30 to 60 DAS and slightly declined at 90 DAS. Variation in crop growth rate attributed to dry matter variation per unit area.

CGR (g m^2 day^{-1}) of KDS 756 variety was significantly higher at 61-90 DAS (5.1) and it was at par with Basar. Lowest crop growth rate was observed with JS 335 variety at all stages. Similar results were supported by Varsha (2018) [20].

Among the crop geometry levels, distinct variation in crop growth rate was observed with significantly higher values at closer spacing of 30 x 05 cm (10.4, 14.3 and 7.0) at 61-90 DAS followed by 45 x 05 cm, 30 x 10 cm and 45 x 10 cm spacings. This was supported by Pawan Prakash Sharma (2011) [15].

Interaction between varieties and crop geometry levels was found non significant at 90 DAS.

3.2.2 Relative growth rate (RGR) (g g^{-1} day^{-1})

Relative growth rate of soybean was significantly influenced by varieties and crop geometry at different growth period depicted in Table 2. It is a measure of rate of dry matter increase per unit dry matter per unit time. It decreased with the age of crop. The decrease in RGR values between 60 DAS to harvest may be attributed to senescence of leaves and reduction in SPAD chlorophyll meter reading values which might have resulted in reduction of photosynthetic rate thereby reduction in total dry matter.

RGR (g g^{-1} day^{-1}) of KDS 756 was significantly higher at 61-90 DAS (0.005) was significantly higher over other three varieties. Lowest RGR (g g^{-1} day^{-1}) was recorded by JS 335 at all the stages. Similar results were reported by Varsha (2018) [20]. Among the various crop geometry levels, there is a variation in relative growth rate was observed significantly highest values at closer spacing of 30 x 05 cm. It indicated that soybean produced maximum relative growth rate under narrow spacing rather than wider spacing. Similar results were reported by Khushbu Khubele (2015) [8].

The interaction between varieties and crop geometry was found non significant on relative growth rate (g g^{-1} day^{-1}) at 90 DAS.

3.2.3 Growing degree days (GDD)

Data pertaining to growing degree days of soybean was significantly influenced by varieties and crop geometry at different growth period was presented in Table 2. The development of phenophases is most essential component of the study of crop weather relationship of soybean. In present investigation, the whole life cycle of the soybean (from germination to maturity) sub divided into 3 distinct phenological stages, which is shown in Figure 1.a and 1.b on the basis of genetic and morphological characteristics. The results revealed that accumulated heat units were higher with long duration variety Basar at pod formation to pod maturity (720.1 °C days) followed by medium duration MACS 1281 (716.5 °C days), KDS 756 (698.6 °C days) and JS 335 (682.0°C days). The results attributed to higher assimilation and energy production for optimum vegetative growth and yield attributes like number of pods plant^{-1} which ultimately resulted in higher seed yield.

Soybean being photosensitive and short day plant has not performed well in semi arid condition of Jagtial. As higher mean temperature induced the early flowering in soybean resulted shortening in length of growing period that caused reduction in production of photosynthates into sink and resulted in lower yield compared to traditional growing areas of soybean (Madhya pradesh). Occurrence of phonological stages was linearly related to accumulated growing degree days (with base temperature 10° C). Likewise, results have been observed by Chavan *et al.* (2018) [3].

The results revealed that accumulated heat units were higher with closer crop geometry 30 x 05 cm at pod formation to pod maturity (711.5 °C days) followed by medium duration of 30 x 10 cm (706.1 °C days), 45 x 05 cm (701.3 °C days) and 45 x 10 cm (698.2°C days).

3.2.4 Photo Thermal Unit (PTU)

Data pertaining to photo thermal units of soybean was significantly influenced by varieties and crop geometry at different growth period was presented in Table 2. The development of phenophases (seedling emergence to pod maturity) is most essential component of the study of crop weather relationship of soybean. In present investigation, the whole life cycle of the soybean (from germination to maturity) was sub divided into 3 distinct phenological stages, which is shown in Figure 2.a and 2.b on the basis of genetic and morphological characteristics. The maximum photo thermal units were observed with long duration variety Basar at pod formation to pod maturity (5395.4 °C days hour) followed by medium duration MACS 1281 (5354.2 °C days hour), KDS 756 (5137.6 °C days hour) and JS 335 (5042.3 °C days). The similar results were also indicated by the Chavan *et al.* (2018) [3].

Among the crop geometry levels accumulated photo thermal units were higher with closer crop geometry 30 x 05 cm at pod formation to pod maturity (5269.4 °C days hours) and was followed by medium spacing of 30 x 10 cm (5260.5 °C days hours), 45 x 05 cm (5206.0 °C days hour) and long duration of 45 x 10 cm (5193.6 °C days hour).

Table 1: Crop growth parameters and growth analysis of soybean influenced by varieties and crop geometry

Treatments	Plant height (cm)	Number of branches plant^{-1}	Total dry matter (kg ha^{-1})	Leaf area (cm^2 plant^{-1})	SPAD chlorophyll meter readings	No of root nodules plant^{-1}	Dry weight of root nodules (mg plant^{-1})	CGR (g m^{-2} day^{-1})	RGR (g g^{-1} day^{-1})	GDD (^{0}C days)	PTU (^{0}C days hour)
Varieties											
V_1:Basar	53.4	12.9	6506	955.3	32.7	64.0	337.5	4.9	0.004	720.1	5395.4
V_2:JS 335	44.2	10.3	5572	670.4	31.0	61.2	292.8	4.3	0.003	682.0	5042.3
V_3: KDS 756	55.2	13.8	6937	760.5	35.6	68.1	390.2	5.1	0.005	698.6	5137.6
V_4:MACS1281	53.3	11.7	6101	873.4	32.6	61.4	332.5	4.6	0.004	716.5	5354.2
S.Em ±	0.6	0.4	78.2	17.0	0.8	0.9	5.7	0.1	0.0	-	-
CD (P=0.05)	2.1	1.5	276	60.0	2.8	3.3	20.2	0.5	NS	-	-
Crop geometry (cm)											
S_1: 45 × 10	49.6	10.7	3206	796.5	30.9	62.1	325.6	2.4	0.004	698.2	5193.6
S_2: 30 × 10	53.9	14.0	5354	903.3	35.2	65.2	356.5	3.7	0.003	706.1	5260.5
S_3: 45 × 05	51.4	12.6	6838	836.7	33.5	64.3	340.3	5.8	0.004	701.3	5206.0
S_4: 30 × 05	50.9	11.5	10082	722.1	32.3	63.0	330.6	7.0	0.004	711.5	5269.4
S.Em ±	0.3	0.3	130	20.7	0.8	0.7	6.2	0.2	0.0	-	-
CD (P=0.05)	0.9	0.9	381	60.7	2.3	1.9	18.1	0.6	NS	-	-
Interaction V × S											
S.Em ±	0.8	0.7	242	39.7	1.5	1.5	12.1	0.001	-	-	-
CD (P=0.05)	NS	NS	NS	99.0	NS	NS	NS	NS	-	-	-
Interaction S × V											
S.Em ±	1.2	0.9	128	34.0	1.6	1.9	11.4	0.001	-	-	-
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	-	-	-

4. Conclusions

From the above studies it is concluded that among the varieties tested KDS 756 gave higher crop growth parameters and growth analysis with growing degree days and Photo thermal unit. Under crop geometry of 30 x 10 cm which gave highest crop growth parameters, growth analysis with growing degree days and Photo thermal unit. The interaction of KDS 756 at geometry level 30 x 10 cm followed by same variety at next closer spacing 45 x 05 cm had higher growth and growth analysis with growing degree days and Photo thermal unit. Accumulation of dry matter was higher at closer spacing 30 x 05 cm due to higher plant population per unit area.

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