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Growth indices of chia (*Salvia hispanica* L.) as influenced by varied crop geometries and organic nutrient levels

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Abstract
A field experiment was conducted during *Rabi* 2020 and 2021 at Research Institute on Organic framing (RIOF), University of Agricultural sciences, GKVK, Bengaluru to find out the effect of various crop geometries and organic nutrient levels on growth indices of Chia (*Salvia hispanica* L.). A two factorial randomized complete block design was employed with first factor as spacing and nutrient levels as second factor. The treatment includes five varied crop geometries spacings *Viz*., S_1- 60 cm × 30 cm, S_2- 75 cm × 15 cm, S_3- 75 cm × 30 cm, S_4- 90 cm × 15 cm, S_5 - 90 cm × 30 cm and three different organic nutrient levels *viz.*, N_1 - 60 kg N equivalent ha^{-1}, N_2 - 80 kg N equivalent ha^{-1} and N_3 - 100 kg N equivalent ha^{-1}. The pooled data results indicated that at 30 and 60 DAS 90 cm × 30 cm spacing resulted in higher leaf area (400.05 and 1240.44 cm^2 respectively). At 30 - 60 DAS and 60-harvest higher Absolute growth Rate- AGR (1.60, 2.87 g / plant / day respectively), Relative Growth Rate-RGR (0.0183 and 0.144 g /g / day) was observed with 90 cm × 30 cm, whereas higher Crop growth rate-CGR (10.95 and 20.49 g / m^2 / day respectively) was recorded with spacing of 75 cm × 15 cm. Among different nutrient levels application of 100 kg N equivalent ha^{-1} recorded higher leaf area at 30, 60 DAS (357.30 and 1187.16 cm^2). At 30 - 60 DAS and 60 - at harvest higher AGR (1.58 and 2.78 g / plant / day respectively), RGR (0.0180 and 0.0138 g / g / day) and CGR (9.40 and 16.68 g / m^2 / day respectively) was recorded with 100 kg N equivalent ha^{-1}. However, the interaction of spacing and nutrient levels on growth indices was found to be non-significant.

Keywords: AGR, CGR, leaf area, RGR, chia, spacing, yield

Introduction
The world's population is expected to surpass 9.6 billion by the mid of the century, affordably meeting the nutritious food demand without deteorating the natural resources in a sustainable way is a great challenge. One of the counter measures is the usage of potential crops, they are also known as underutilized crops, orphan crops or neglected crops. Potential crops are the plants that acts as life support species in extreme environmental conditions, with promising nutritional utility for the present as well as future needs of human kind. Chia (*Salvia hispanica* L.) is one of the potential crops belonging to *Lamiaceae* family. It is a rediscovered super food or nutraceutical or functional food originated in areas of Mexico and Guatemala. Chia is considered to be one of the greatest vegetarian source of omega (ω) 3 fatty acid 50 to 57 percent and omega (ω) 6 fatty acid 17 to 26 percent, oil 24.36 to 33.50 percent, protein 18 to 25 percent, carbohydrates 26 to 41 percent, fiber 18 to 30 percent (Prathyusha *et al*., 2019) [10]. Currently, chia seed offer huge potential in the food, animal feed, nutraceuticals and pharmaceutical industries due to its functional components.
The word "Chia" or "Chien" is derived from Spanish language which means "Oily" (Kulczynski *et al*., 2019) [5]. Chia could grow up to height of 60-180 cm. It is an annual short day herb, with sub angular ramified stem and with leaves of 4 to 8 cm long and 3 to 5 cm width and serrated with different degrees of pubescence. Flowers grow in clusters on spike protected by small bracts with pointed tip. The flowers are hermaphrodite with either white or bluish tinge and measures about 3 to 4 mm in size Munoz *et al.* (2013) [7] and Bochicchio *et al.* (2015) [2]. Seeds of chia are oval and flat measuring between 2.0 to 2.5 mm in length, 1.2 to 1.5 mm width and 0.8 to 1.0 mm thickness. Seed surface is shiny and smooth with different shades like dark brown to black and sometimes grey or white.
Tropical and subtropical environments with maximum and minimum growth temperatures of 11 °C and 36 °C respectively with an optimum range of 16 °C to 26 °C are most suitable for chia cultivation. It can establish from 400 to 2500 meters above mean sea level.

The duration of crop usually ranges from 140-180 days, as it is a crop sensitive to day length the crop cycle depends upon the latitude where it is planted. The crop can be grown in rain fed and irrigated conditions. Rain fall ranging from 300 to 1000 mm during growing season is beneficial to chia crop (Yeboah *et al*., 2014) [14].

Modern agricultural practices damage the soil health and leads to low crop productivity and quality besides, causing environmental pollution, so the present agricultural research is much focused on inventing the sustainable, socio economically viable and ecologically sound interventions like organic system of farming which completely avoids usage of chemical fertilizers and pesticides (Pathak and Ram, 2006) [8]. Systemic cultivation with optimum crop geometries and nutrient management practices are the base that helps in development of proper production technology especially for a new crop in a particular region. Better crop establishment with adequate crop geometry and nutrient recommendation practices can help the plant to gain sufficient resources from soil and can influence the yield attributes and yield thereby enhancing crop productivity.

Chia crop is not acquainted by the farming community but there is a bright scope in the Indian market to address malnutrition problem in the country. In India, chia grown in some areas of Himachal Pradesh and Himalayan region (Peperkamp, 2015) [9]. In Karnataka Chia (*Salvia hispanica L.*) crop is a new introduction by Central Food Technological Research Institute, (CFTRI) to farmers near Mysuru, Chamarajanagar, Belgaum and other districts of Karnataka and presently the cultivation has spread to the neighboring states. Reason behind cultivation of this new crop is remunerative price for the crop or produce and good buy back. Keeping all these factors in view a field trail was conducted to evaluate the influence of crop geometry and organic nutrient levels on growth indices of chia.

Material and Methods

The experiment was carried out at research and demonstration block of Research Institute of Organic Farming (RIOF), University of Agricultural sciences, Gandhi Krishi Vigyan Kendra, Bengaluru, during *Rabi* 2020-21 and *Rabi* 2021-22. It is situated at a latitude of 13^0 09′ North latitude, 77^0 57′ East longitude and at an altitude of 924 m above mean sea level in Eastern Dry Zone (Zone-V) of Karnataka. The soil chemical analysis of the experimental site revealed that the texture was red sandy loam with pH of 6.1, electric conductivity of 0.40 dS m^{-1} and organic carbon content of 0.7 percent. The soil was medium in available nitrogen (313.60 kg ha^{-1}), phosphorus (27.08 kg ha^{-1}) and potassium (250.49 kg ha^{-1}). The trial was laid out in Factorial Complete Randomized Block Design (FRCBD) with first factor being spacing and second as nutrient levels. There were fifteen treatment combinations having five different spacings (S_1- 60 cm × 30 cm, S_2- 75 cm × 15 cm, S_3- 75 cm × 30 cm, S_4- 90 cm × 15 cm, S_5- 90 cm × 30 cm) and three different nitrogen levels (N_1 - 60 kg ha^{-1}, N_2 - 80 kg ha^{-1} and N_3 - 100 kg ha^{-1}) applied based on N equivalent through FYM and vermicompost.

Chia Local variety was sown with a spacing according to the treatment on second fort night of November and harvested on first fort night of march. The organic nutrient sources used were Farm yard Manure, vermicompost which were applied on N equivalent basis after analysis of nutrient content present in them. Basal dose of FYM @ 10 t ha^{-1} was common for all the treatments as per package of practices.75 percent of nitrogen requirement is supplied through FYM after sowing and remaining 25 percent was supplemented through vermicompost by top dressing at 30 days after sowing (DAS). At 15 DAS hand weeding was done and cycle weeder was passed at 25 and 40 DAS to maintain weed free environment. Biometric observations on leaf area were recorded randomly selected five plants at 30, 60 DAS and dry matter accumulation at 30, 60 DAS and at harvest in the net plot by destructive sampling method. Standard formulae given by Watson (1952) [15] were used to calculate the growth indices. Absolute growth rate (AGR), AGR = W_2-W_1/ t_2- t_1 and expressed in g / plant / day. Crop growth rate (CGR), CGR= W_2-W_1/ t_2- t_1 × P. Relative growth rate (RGR), RGR = Log_e W_2- Log_e W_1/ t_2- t_1. W_1 = Dry weight of plant at time t_1, W_2 = Dry weight of plant at time t_2, t_1 and t_2 are the time intervals between crop growth period in days, P is the land area. The data collected from the experiment at different growth stages were subjected to statistical analysis as described by Gomez and Gomez (1984) [4]. Wherever the F-test was found significant for comparison among treatment means, an appropriate value of critical difference (CD) was worked out. Otherwise, the abbreviation NS was indicated against the CD values.

Results and Discussion

Effect on Leaf area per plant (cm^2)

The results of pooled data indicated that leaf area of chia varied significantly at 30 and 60 DAS as influenced by different spacings and organic nutrient levels is presented in table 1. Spacing of 90 cm × 30 cm recorded significantly higher leaf area (400.05, 1240.44 cm^2 at 30 and 60 DAS respectively) which was found to be statistically on par with spacing of 75 cm × 30 cm (374.24, 1219.04 cm^2 at 30 and 60 DAS respectively) and the lower leaf area was recorded with spacing of 60 cm × 30 cm (205.51, 888.22 cm^2 at 30 and 60 DAS respectively).

Leaf area was significantly influenced by nutrient levels at 30 and 60 DAS. Among the nutrient level's application of 100 kg N equivalent ha^{-1} recorded significantly higher leaf area (357.30, 1187.16 cm^2 at 30 and 60 DAS respectively) which was found to be on par with 80 kg N equivalent ha^{-1} (335.82, 1153.82 cm^2 at 30 and 60 DAS respectively) and the lower leaf area was recorded with 60 kg N equivalent ha^{-1} (181.95, 841.78 cm^2 at 30 and 60 DAS respectively). Leaf area did not differ significantly due to the interaction of spacing and organic nutrient levels at 30 and 60 DAS.

In wider spacing more number branches and leaves have attributed to more leaf area per plant. In wider orientation there will be scope for higher photosynthetic surface which might have contributed to more leaf area. The results are in close conformity with Shukla *et al.* (2014) [13] in cotton. Application of more quantity of FYM and vermicompost improves soil water and nutrient holding capacity that resulted in higher growth rate of vegetative parts which in turn increased the leaf area per plant of chia.

Effect on Absolute Growth Rate (AGR)

Absolute growth rate (AGR) is the total growth of a plant per unit time. The observations pertaining to pooled data of two years related to Absolute growth rate (AGR g / plant / day) of chia as influenced by crop geometry and organic nutrient levels at 30-60 DAS and 60 DAS - at harvest is represented in table 2 and fig.1. It is apparent from the data that crop geometry and nutrient levels have significantly influenced the AGR. Significantly higher AGR at 30- 60 DAS and 60 DAS- at harvest (1.60 and 2.87 g / plant / day respectively) was recorded with spacing of S_5 (90 cm × 30 cm) and was found on par with S_3 and lower AGR at 30 -60 DAS and 60 - at harvest (1.00 and 2.25 g / plant / day respectively) was recorded with spacing of S_1 (60 cm × 30 cm).

Among different nutrient levels application of N_3 (100 kg N equivalent ha^{-1}) resulted in significantly higher AGR at 30- 60 DAS and 60 DAS - at harvest (1.58 and 2.78 g / plant / day respectively) and was found on par with N_2 and lower AGR at 30-60 DAS and 60 DAS - at harvest (0.85 and 21.2 g / plant / day respectively) was recorded with N_1 (60 kg N equivalent ha^{-1}). The interaction of spacing and nutrient levels on AGR was found to be non-significant. AGR is a function of dry matter accumulation at particular time. Lesser competition among chia plants and availability of all the resources sufficiently in wider spacing might have resulted in increased AGR. The higher AGR with higher nutrient levels are due to application of organic manures which might have improved the soil quality and water holding capacity of soil and helped in supply of nutrients throughout the crop growth stage and slow availability of more nitrogen which might have improved the dry matter production in chia plants. The results are in line with findings of Ramesh *et al* (2017) [11] in quinoa.

Effect on Relative growth Rate (RGR)

RGR is gram of dry matter produced by gram of existing dry matter in a day. The pooled data pertaining to Relative growth rate (RGR g /g / day) of chia at 30-60 DAS and 60 DAS - at harvest as influenced by crop geometry and organic nutrient levels is presented in table 3 and fig. 2. At 30-60 DAS the influence of spacing and nutrient levels on RGR of chia was found to be non-significant. However, numerically higher RGR (0.0183 g / g / day) was recorded with spacing of S_5 (90 cm × 30 cm) followed by S_3 and S_4 and lower RGR of 0.0172 g / g / day was recorded with S_1 (90 cm × 30 cm). At 60-harvest significant influence of crop geometry and nutrient levels was observed. Significantly higher RGR of 0.144 g /g / day was recoded with S_5 (90 cm × 30 cm) spacing followed by S_3 and lower RGR of 0.0116 g /g / day was with S_1.

Nutrient levels did not significantly influence the RGR of chia at 30-60 DAS, but numerically higher RGR (0.0180 g /g / day) was with N_3 (100 kg N equivalent ha^{-1}), N_2 and lower was with 60 kg N equivalent ha^{-1}(0.0177 g / g / day). Significant influence of nutrient levels on RGR of chia was observed at 60 DAS - at harvest. Significantly higher RGR was with 100 kg N equivalent ha^{-1} (0.0138 g /g / day) and was on par with N_2, whereas lower RGR was with 60 kg N equivalent ha^{-1} (0.0123 g / g / day). The interaction of spacing and nutrient levels was found to be non-significant at different growth stages. Wider spacing provides favourable conditions for better performance of individual plants for dry matter production by effective utilization of above and below ground resources as compared to narrow spacing. The slow release of nutrients to soil through out the crop growing period might have coincided with the period of nutrient requirement of chia crop and reflected in improvement of dry matter of plant and improved RGR. The results are in line with Sanodiya *et al*. (2022) [12] who reported that improvement in RGR with wider spacing of Quinoa.

Effect on Crop Growth Rate (CGR)

Periodical observations of pooled data pertaining to (CGR g / plant / day) of chia as influenced by crop geometry and organic nutrient levels at 30-60 DAS and 60 DAS - at harvest is represented in table 4 and fig 3. Significant influence of crop geometry and nutrient levels are observed at different growth stages. The significantly higher CGR at 30-60 DAS and 60 DAS - at harvest (10.95 and 20.49 g / m^2 / day respectively) was recorded with spacing of S_2 (75 cm × 15 cm) and was found on par S_4. The lower CGR (5.55 and 10.62 g / m^2 / day respectively) was recorded with spacing of S_1 (60 cm × 30 cm).

Among different nutrient levels application of 100 kg N equivalent ha^{-1} recorded significantly higher CGR at 30-60 DAS and 60 DAS - at harvest (9.40, 16.68 g / m^2 / day respectively) and was on par with 80 kg N equivalent ha^{-1} whereas lower CGR at 30-60 DAS and 60 DAS - at harvest (5.08 and 12.55 g / m^2 / day respectively) was with 60 kg N equivalent ha^{-1}. The interaction of spacing and nutrient levels was found to be non-significant at different growth stages. The higher CGR with 75 cm × 15 cm might be attributed to higher plant population and higher dry matter production on unit area basis in narrow spacing, that led to more light interception. Followed to this, wider spacing produced lower CGR at all stages. Though the individual plant canopy was increased in these spacings CGR was decreased as the plant population and dry matter production on unit area basis was less. The above results are in line with the findings of Awais *et al*. (2013) [2]. Higher level of nutrients might have supplied more amount of nitrogen that might have led to more vegetative growth and photosynthesis. Greater leaf area index might have caused more light interception which in turn might have improved CGR Mondal *et al*. (2017) [6].

Effect on seed yield (kg ha^{-1})

Seed yield of chia as influenced by different spacings and organic nutrient levels pooled data of two years is presented in table 5. Spacing and organic nutrient levels have significantly influenced the chia seed yield. Significantly higher seed yield of chia was recorded with spacing of 90 cm × 15 cm (1099 kg ha^{-1}) which was found to be on par with spacing of 75 cm × 15 cm (1012 kg ha^{-1}) and the lower seed yield of chia was recorded with spacing of 90 cm × 30 cm (846 kg ha^{-1}).

Nutrient levels have significantly influenced chia seed yield. Application of 100 kg N equivalent ha^{-1} recorded significantly higher seed yield (1078 kg ha^{-1}) which was found on par with application of 80 kg N equivalent ha^{-1} (1008 kg ha^{-1}) and the lower seed yield of chia was recorded with 60 kg N equivalent ha^{-1} (805 kg ha^{-1}). Seed yield of chia did not differ significantly due to interaction of spacing and organic nutrient levels.

The possible reason for increased yield might be due to more number of plants per unit area. Similar findings were made by Anbarasu *et al*. (2018) [1] in castor. The higher yield by organic manures might be traced back to improvement of yield attributes. Combined application of FYM and vermicompost benefit of crop during the entire growth period than compared to sole application of manures.

Table 1: Leaf area of chia as influenced by different spacings and organic nutrient levels at 30 and 60 DAS

Treatments	Leaf area (cm^2)							
	30 DAS				60 DAS			
	N1	N2	N3	Mean	N1	N2	N3	Mean
S_1	137.41	226.89	252.23	205.51	735.61	945.89	983.16	888.22
S_2	151.25	257.55	265.28	224.69	798.23	1018.22	1019.56	945.34
S_3	222.71	437.34	462.66	374.24	945.61	1333.36	1378.14	1219.04
S_4	174.10	281.74	306.05	253.96	835.48	1081.98	1117.21	1011.56
S_5	224.26	475.60	500.29	400.05	893.94	1389.63	1437.73	1240.44
Mean	181.95	335.82	357.30		841.78	1153.82	1187.16	
	S.Em ±		CD (p=0.05)		S.Em ±		CD (p=0.05)	
Spacing (S)	12.48		36.14		34.91		101.13	
Nutrient level (N)	9.66		28.00		27.04		78.33	
Interaction (S×N)	21.61		NS		60.46		NS	

Note: S_1: 60 cm × 30 cm, **S_2**: 75 cm × 15 cm, **S_3**: 75 cm × 30 cm, **S_4**: 90 cm × 15 cm, **S_5**: 90 cm × 30 cm
N_1: 60 Kg N equivalent ha^{-1}, **N_2**: 80 Kg N equivalent ha^{-1}, **N_3**:100 Kg N equivalent ha^{-1}, **DAS=** Days after sowing

Table 2: Absolute growth rate (AGR) of Chia as influenced by varied spacings and organic nutrient levels at 30- 60 DAS and 60- harvest

Treatments	Absolute growth rates (g / plant / day)							
	30 - 60 DAS				60 DAS – harvest			
	N_1	N_2	N_3	Mean	N_1	N_2	N_3	Mean
S_1	0.58	1.22	1.19	1.00	1.83	2.46	2.47	2.25
S_2	0.83	1.41	1.38	1.20	1.86	2.49	2.52	2.29
S_3	0.97	1.79	1.76	1.51	2.29	2.95	2.95	2.73
S_4	0.83	1.60	1.60	1.35	2.08	2.80	2.85	2.58
S_5	1.02	1.87	1.90	1.60	2.53	2.96	3.11	2.87
Mean	0.85	1.56	1.58		2.12	2.73	2.78	
	S.Em ±		CD (p=0.05)		S.Em ±		CD (p=0.05)	
Spacing (S)	0.05		0.15		0.09		0.26	
Nutrient level (N)	0.04		0.11		0.07		0.20	
Interaction (S×N)	0.09		NS		0.16		NS	

Note: S_1: 60 cm × 30 cm, **S_2**: 75 cm × 15 cm, **S_3**: 75 cm × 30 cm, **S_4**: 90 cm × 15 cm, **S_5**: 90 cm × 30 cm
N_1: 60 Kg N equivalent ha^{-1}, **N_2**: 80 Kg N equivalent ha^{-1}, **N_3**:100 Kg N equivalent ha^{-1}, **DAS=** Days after sowing

Table 3: Relative growth rate (RGR) of Chia as influenced by varied spacings and organic nutrient levels at 30- 60 DAS and 60- harvest

Treatments	Relative growth rates (g / g /day)							
	30 - 60 DAS				60 DAS – harvest			
	N_1	N_2	N_3	Mean	N_1	N_2	N_3	Mean
S_1	0.0172	0.0172	0.0174	0.0172	0.0113	0.0116	0.0119	0.0116
S_2	0.0174	0.0179	0.0175	0.0176	0.0112	0.0131	0.0149	0.0131
S_3	0.0183	0.0177	0.0184	0.0181	0.0138	0.0147	0.0132	0.0139
S_4	0.0172	0.0190	0.0181	0.0181	0.0110	0.0118	0.0174	0.0134
S_5	0.0183	0.0182	0.0184	0.0183	0.0142	0.0174	0.0117	0.0144
Mean	0.0177	0.0180	0.0180		0.0123	0.0137	0.0138	
	S.Em ±		CD (p=0.05)		S.Em ±		CD (p=0.05)	
Spacing (S)	0.0006		NS		0.0004		0.0012	
Nutrient level (N)	0.0005		NS		0.0003		0.0009	
Interaction (S×N)	0.0010		NS		0.0007		NS	

Note: S_1: 60 cm × 30 cm, **S_2**: 75 cm × 15 cm, **S_3**: 75 cm × 30 cm, **S_4**: 90 cm × 15 cm, **S_5**: 90 cm × 30 cm
N_1: 60 Kg N equivalent ha^{-1}, **N_2**: 80 Kg N equivalent ha^{-1}, **N_3**:100 Kg N equivalent ha^{-1}, **DAS=** Days after sowing

Table 4: Crop growth rate (CGR) of Chia as influenced by varied spacings and organic nutrient levels at 30- 60 DAS and 60- harvest

Treatments	Crop growth rates (g /m /day)							
	30 - 60 DAS				60 DAS – harvest			
	N_1	N_2	N_3	Mean	N_1	N_2	N_3	Mean
S_1	3.25	6.59	6.80	5.55	9.36	10.98	11.53	10.62
S_2	7.52	12.53	12.79	10.95	16.65	22.34	22.49	20.49
S_3	4.43	8.00	8.13	6.85	10.42	13.40	13.42	12.41
S_4	6.40	12.33	12.34	10.36	16.02	21.52	21.95	19.83
S_5	3.79	7.02	6.92	5.91	10.32	13.85	13.99	12.72
Mean	5.08	9.29	9.40		12.55	16.42	16.68	
	S.Em ±		CD (p=0.05)		S.Em ±		CD (p=0.05)	
Spacing (S)	0.28		0.81		0.52		1.50	
Nutrient level (N)	0.22		0.62		0.40		1.16	
Interaction (S×N)	0.48		NS		0.90		NS	

Note: S_1: 60 cm × 30 cm, **S_2**: 75 cm × 15 cm, **S_3**: 75 cm × 30 cm, **S_4**: 90 cm × 15 cm, **S_5**: 90 cm × 30 cm
N_1: 60 Kg N equivalent ha^{-1}, **N_2**: 80 Kg N equivalent ha^{-1}, **N_3**:100 Kg N equivalent ha^{-1}, **DAS=** Days after sowing

Table 5: Seed yield of chia as influenced by different spacings and organic nutrient levels

Treatments	Seed yield (kg ha^{-1})			
	N1	N2	N3	Mean
S_1	804	1011	1026	947
S_2	885	1069	1083	1012
S_3	794	974	980	916
S_4	831	1088	1377	1099
S_5	712	899	927	846
Mean	805	1008	1078	
	S.Em ±		CD (p=0.05)	
Spacing (S)	32.34		93.69	
Nutrient level (N)	25.05		72.57	
Interaction (S×N)	56.01		NS	

Note: S_1: 60 cm × 30 cm, S_2: 75 cm × 15 cm, S_3: 75 cm × 30 cm, S_4: 90 cm × 15 cm, S_5: 90 cm × 30 cm
N_1: 60 Kg N equivalent ha^{-1}, N_2: 80 Kg N equivalent ha^{-1}, N_3:100 Kg N equivalent ha^{-1}, **DAS=** Days after sowing

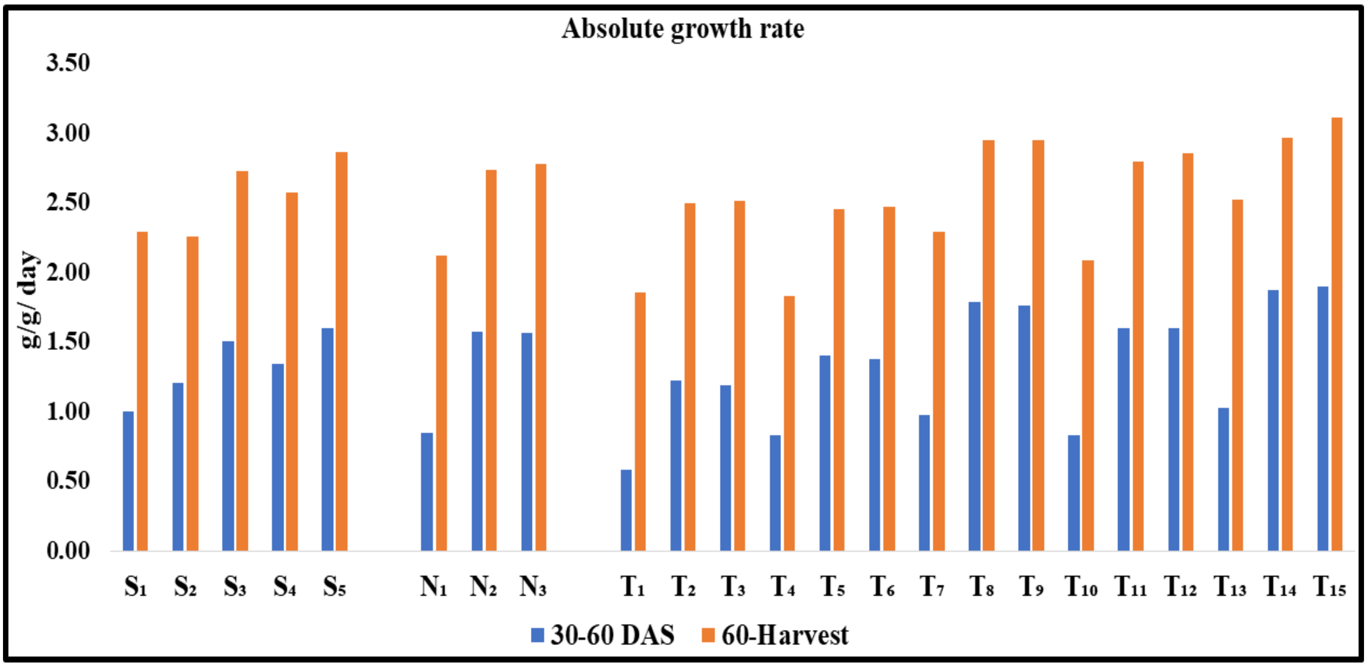

Fig 1: Absolute growth rate of chia as influenced by varied spacings and organic nutrient levels at 30- 60 DAS and 60- harvest

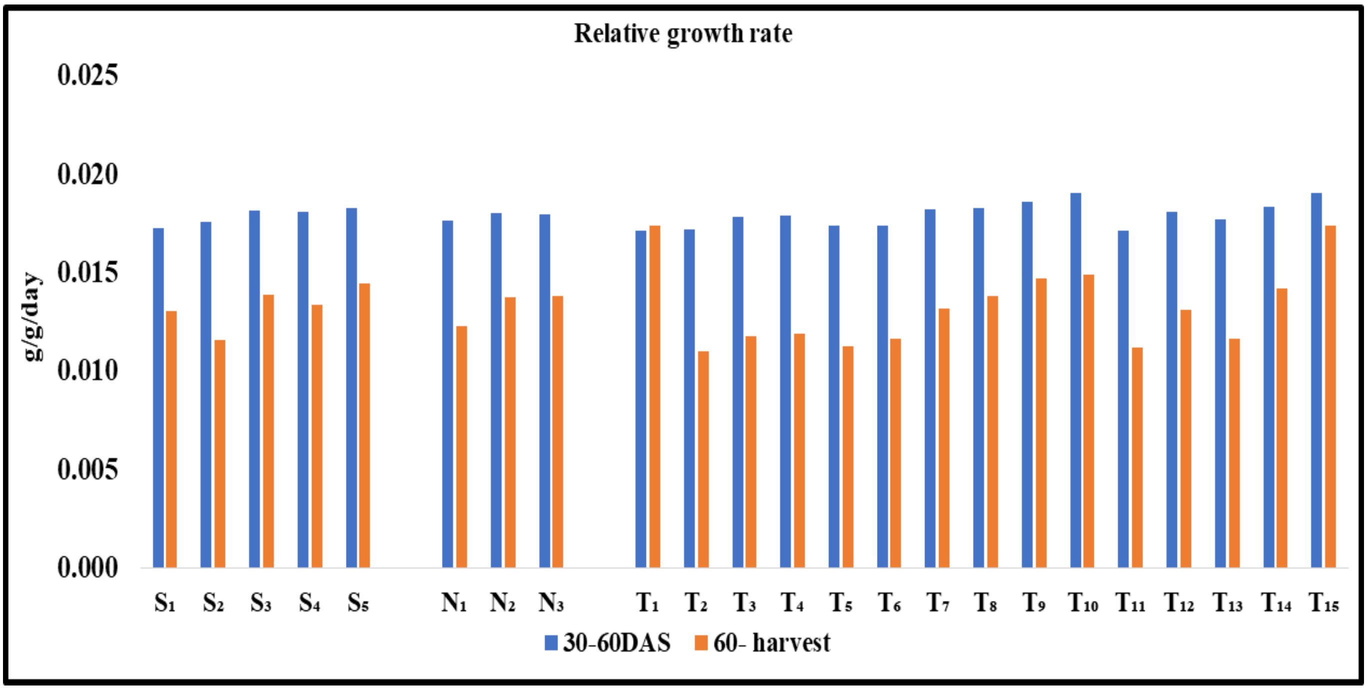

Fig 2: Relative growth rate of chia as influenced by varied spacings and organic nutrient levels at 30- 60 DAS and 60- harvest

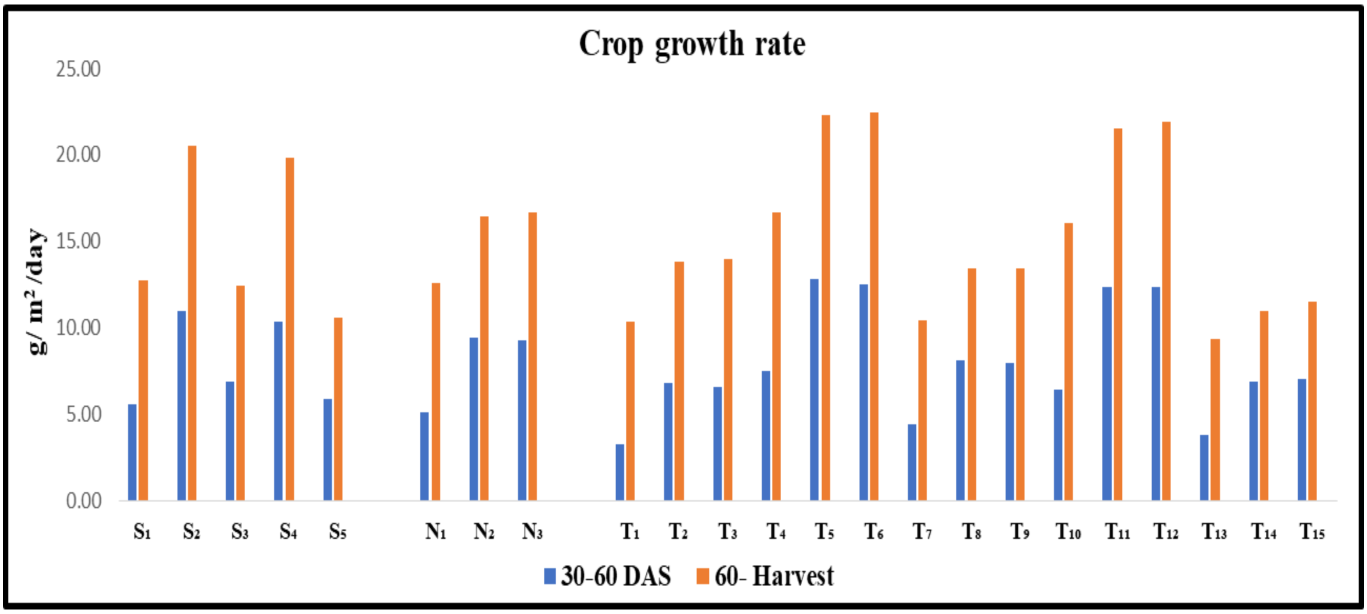

Fig 3: Crop growth rate of chia as influenced by varied spacings and organic nutrient levels at 30- 60 DAS and 60- harvest

Conclusion

Based on the experiment results of two years it can be known that crop geometry and organic nutrient levels have significantly influenced the dry matter production and growth indices of chia crop. Hence it can be concluded that wider spacing of 90 cm × 30 cm have significantly influenced the leaf area, AGR and RGR of chia, 75 cm × 15 cm spacing have significantly influenced the CGR. Spacing of 90 cm × 15 cm resulted in higher seed yield. Among the nutrient levels 100 kg N equivalent ha^{-1} have influenced leaf area, seed yield and all the growth indices of chia at all the growth stages.

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