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Influence of growth parameters on productivity potential in chilli (*Capsicum annuum* L.) genotypes

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Abstract

Experiments were conducted for two years during *kharif*, 2018 and 2019 at University of Agricultural Sciences, Dharwad to identify potential chilli (*Capsicum annuum* L.) genotypes for higher productivity. Among fifty two genotypes, the genotypes DCA-33, DCA-37 and DCA-34 recorded maximum CGR (11.85, 8.84 and 8.33 g m⁻² day⁻¹), AGR (426.64, 318.18 and 299.93 g plant⁻¹ day⁻¹ x100), RGR (14.58, 14.48 and 13.63 g g⁻¹ day⁻¹ x1000) and NAR (15.20, 11.29 and 10.68 g dm⁻² day⁻¹) respectively during maximum peak vegetative growth stage between 60 and 90 DAP. Further, significant positive association of fruit yield with CGR (0.94**), AGR (0.94**), RGR (0.80**) and NAR (0.93**) at 60-90 DAP was observed. It is thus inferred that for developing ideotypes in chilli, higher CGR, higher AGR, higher RGR and higher NAR can be considered as an important physiological traits since, these parameters possess significant positive relationship with yield.

Keywords: *Capsicum annuum* L., chilli, genotypes, yield, CGR, AGR, RGR, NAR

Introduction

Chilli (*Capsicum annuum* L.) is a member of the *Solanaceae* family, originated from South and Central America. Chilli is an economically important vegetable cum an indispensable spice crop valued for its aroma, taste, appealing colour, flavour and pungency. It is grown in all parts of the world. India is the largest producer, consumer and exporter of chilli in the world. Chilli (Dried) is raised over an area of 1.78 million hectares (mha) in the world, with a production of 7.18 million tonnes (mt). India ranks first in the world with an area of 0.75 mha with a production of 2.15 mt and an average productivity of 2.86 tonnes per ha. The productivity of chilli in Karnataka is low (2.04 tons/ha) as compared to the Indian average of productivity (Anon, 2018) [2]. Growth and productivity of a crop is built up through a series of growth and developmental processes in the ontogeny. Various studies on the physiological analysis of growth and yield in cereal crops have been done and have emphasized the importance of growth and yield analysis (Hay, 1999 and Sharifi *et al.*, 2014) [4, 13].

Growth analysis is still the most simple and precise method to evaluate the contribution of different physiological processes in plant development. The physiological indices such as crop growth rate (CGR), absolute growth rate (AGR), relative growth rate (RGR) and net assimilation rate (NAR) are influenced by genotypes, climate and soil fertility. Under adequate input condition, production is primarily determined by the average canopy cover (LAI), net assimilation rate (NAR) and crop growth duration. The translocation of carbohydrates into economic parts is in turn dependent upon the efficiency of partitioning/harvest index (HI) of the plant. Chilli in India is dominated by open pollinated varieties and area under hybrid varieties is low. The productivity of the chilli crop is low in view of coverage of large area under low yielding genotypes (Pandit and Adhikary, 2014) [10]. Growth and productivity of a crop and its cultivar is built up through a series of growth and developmental processes in the ontogeny. There is a need for development of new genotypes with high productivity. The continuing pressure to evolve high yielding varieties has stimulated interest in physiological processes. Study of genetic variation in physiological processes by means of growth analysis is an extremely powerful physiological tool, which can lead to the development of hypothesis for initiating breeding programmes, since growth analysis has an advantage of providing an

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integrated management of net photosynthetic capacity in the field (Imran and Sridevi), 2018^[5]. Hence, the present investigation was carried out to find out the physiological approaches for improving productivity in chilli genotypes.

Material and Methods

The experiment was conducted for two *kharif*, seasons during 2018 and 2019 at Department of Crop Physiology Farm, University of Agricultural Sciences, Dharwad with fifty two genotypes of chilli along with Byadgi dabbi as a check in a randomized block design with two replications. The nursery was raised during first fortnight of June and seedlings were transplanted at a spacing of 60 cm x 60 cm during last week of July. Two rows for each genotype and each row consisted of 15 plants. The crop was raised as per the recommended package of practices. Plants were separated into leaf, stem and reproductive parts at different stages of growth and initially dried in open field under bright sunlight and later on dried in hot air oven at 80 °C until constant dry weight was achieved. Various growth parameters viz., crop growth rate (Watson, 1952)^[15], absolute growth rate, relative growth rate and net assimilation rate (Radford, 1967)^[12] were computed at an interval of 30 days after transplanting (DAP) till the maturity of the crop. The data was analysed statistically by following the method of Panse and Sukhatme (1967)^[11].

Results and Discussion

Results revealed significant differences among the genotypes for all the physiological parameters studied indicating the presence of genetic variability in the genotypes and considerable scope for their improvement. The growth parameters such as crop growth rate (CGR) and absolute growth rate (AGR) increased upto 90 days after transplanting (DAP) and were more in high yielding genotypes (Table 1). Between 60 and 90 DAP stage, CGR was highest in the genotype DCA-33 (11.85 g m⁻² day⁻¹) followed by DCA-37 (8.84 g m⁻² day⁻¹), DCA-34 (8.33 g m⁻² day⁻¹) and DCA-23 (8.28 g m⁻² day⁻¹). While, the genotype DCA-36 (3.36 g m⁻² day⁻¹) had significantly lowest CGR value and it was on par with DCA-18 (3.81 g m⁻² day⁻¹), DCA-13 (4.07 g m⁻² day⁻¹) and DCA-1 (4.20 g m⁻² day⁻¹) compared to Byadgi dabbi (5.76 g m⁻² day⁻¹) with a mean of 5.76 g m⁻² day⁻¹. Similarly, AGR (actual value multiplied with 100) was highest in the genotype DCA-33 (426.64 g plant⁻¹ day⁻¹) followed by DCA-37 (318.18 g plant⁻¹ day⁻¹), DCA-34 (299.93 g plant⁻¹ day⁻¹) and DCA-23 (298.00 g plant⁻¹ day⁻¹). Whereas, the genotype DCA-36 (120.93 g plant⁻¹ day⁻¹) had significantly lower AGR value and it was on par with DCA-18 (137.14 g plant⁻¹ day⁻¹), DCA-13 (146.67 g plant⁻¹ day⁻¹) and DCA-1 (151.37 g plant⁻¹ day⁻¹) compared to Byadgi dabbi (229.73 g plant⁻¹ day⁻¹) with a mean of 207.30 (g plant⁻¹ day⁻¹). Further, significant positive association of fruit yield with CGR (0.94**) and AGR (0.94**) was observed at 60-90 DAP. Thus, these parameters indicated the development of crop in a logical sequence and explicate the causes for differences in yield through the events, thereby indicating the efficiency of dry matter production per unit area and revealing the efficiency index of the genotypes. Similar findings were reported in chilli by Nawalagatti *et al.*, (2000)^[9] in chilli, Koppad *et al.*, (2015)^[6] in ridge gourd genotypes, Anitha *et al.*, (2016)^[1] in fenugreek varieties and Eko and Akbar (2017)^[3] in sweet potatoes.

Results indicate that plant growth is an accumulation of dry weight on a period of time. Plant dry weight is a description of translocation photosynthate to all parts of the plant. The relationship of CGR and AGR at different intervals was also observed (Fig.1). Therefore, CGR and AGR are determined by the leaf area that intercepts the solar radiation with optimum photosynthesis rate.

Relative growth rate (RGR) is widely used to quantify the speed of plant growth. It is a prominent indicator of plant strategy with respect to productivity. In the present investigation, RGR varied from 5.88 (g g⁻¹ day⁻¹) in DCA-52 at 30-60 DAP to 14.58 (g g⁻¹ day⁻¹) in DCA-33 at 60-90 DAP (Table 2). Between 60 and 90 DAP stage, RGR was highest in the genotype DCA-33 (14.58 g g⁻¹ day⁻¹) and it was on par with DCA-37 (14.48 g g⁻¹ day⁻¹), DCA-22 (14.09 g g⁻¹ day⁻¹) and DCA-9 (13.96 g g⁻¹ day⁻¹). While, the genotype DCA-11 (10.98 g g⁻¹ day⁻¹) had significantly lowest RGR value which was on par with DCA-32 (11.29 g g⁻¹ day⁻¹), DCA-49 (11.41 g g⁻¹ day⁻¹) and DCA-28 (11.56 g g⁻¹ day⁻¹) compared to Byadgi dabbi (12.20 g g⁻¹ day⁻¹) with a mean of 12.81 (g g⁻¹ day⁻¹) at 60-90 DAP. Further, significant positive association of fruit yield with RGR (0.80**) was observed. Thus, results indicates that the chilli genotypes which recorded significantly higher RGR are also maintained higher yield. These results were conformity with results of Nawalagatti (1997)^[8] in chilli, Mukesh *et al.*, (2010) and Sunaryanti *et al.*, 2018^[7, 14] in tomato genotypes.

The net assimilation rate (NAR) is the ability of the plant can be produced dry matter assimilation proceeds per unit leaf area per unit time. NAR was significantly increase from 30-60 DAP to 60-90 DAP. The NAR varied from 1.36 (g dm⁻² day⁻¹) in DCA-36 at 30-60 DAP to 15.20 (g dm⁻² day⁻¹) in DCA-33 at 60-90 DAP (Table 2). NAR was maximum in the genotype DCA-33 (15.20 g dm⁻² day⁻¹) followed by DCA-37 (11.29 g dm⁻² day⁻¹), DCA-34 (10.68 g dm⁻² day⁻¹) and DCA-23 (10.60 g dm⁻² day⁻¹) at 60-90 DAP. However, the genotype DCA-36 (4.21 g dm⁻² day⁻¹) had significantly minimum NAR value and it was on par with DCA-18 (4.80 g dm⁻² day⁻¹), DCA-13 (4.96 g dm⁻² day⁻¹) and DCA-1 (5.33 g dm⁻² day⁻¹) compared to Byadgi dabbi (8.20 g dm⁻² day⁻¹) with a mean of 7.31 g dm⁻² day⁻¹ at 60-90 DAP. Significant positive association of fruit yield with NAR (0.93**) was observed. Further, relationship of RGR and NAR at different intervals was observed (Fig.2). Thus, the genotypes DCA-33, DCA-37 and DCA-34 were significantly recorded higher NAR and also maintained higher dry fruit yield. While, DCA-36, DCA-18 and DCA-11 were significantly recorded lower NAR and maintained lower dry fruit yield. The NAR is a measurement of efficiency of photosynthesis on the leaves in the use of solar radiation as well as nutrients that exist in the microclimate zone around the plant. Increasing number and area of leaf means more absorption of solar radiation. This occurs during the process of photosynthesis, so that more energy is generated for the growth of plants. The young leaves at the top of the plant absorb radiation at most and have a high CO₂ assimilation rate and translocate a large number of assimilation into another part of the plant. Conversely, the older leaves at the base of the canopy and shaded have low CO₂ assimilation rate and it do not provide a result of assimilation to other parts of the plant. Similar results were recorded by Nawalagatti, 1997^[8] and Eko and Akbar, 2017^[3].

Table 1: Pooled mean performance of genotypes for crop growth rate (CGR) and absolute growth rate (AGR) at different stages in chilli

Genotypes	CGR (g m ⁻² day ⁻¹)			AGR (g plant ⁻¹ day ⁻¹)		
	Days after planting					
	30 - 60	60 - 90	90 - Harvest	30-60	60 - 90	90 - Harvest
DCA-1	1.49	4.21	1.09	53.60	151.37	39.25
DCA-2	1.95	5.55	1.42	70.21	199.70	51.06
DCA-3	1.90	5.36	1.43	68.48	192.96	51.37
DCA-4	2.29	6.51	2.22	82.46	234.51	80.06
DCA-5	2.38	6.55	1.86	85.52	235.71	66.88
DCA-6	2.38	6.76	1.83	85.55	243.17	65.69
DCA-7	2.43	6.53	1.41	87.32	235.20	50.83
DCA-8	2.19	5.88	1.29	78.88	211.82	46.34
DCA-9	2.16	6.40	1.67	77.65	230.27	59.98
DCA-10	1.75	4.84	0.96	62.88	174.36	34.65
DCA-11	1.46	4.26	0.93	52.60	153.46	33.35
DCA-12	1.63	4.34	1.11	58.70	156.26	40.10
DCA-13	1.38	4.07	1.02	49.74	146.67	36.62
DCA-14	2.04	5.96	1.60	73.43	214.42	57.51
DCA-15	1.80	4.88	0.83	64.93	175.73	29.81
DCA-16	1.75	4.61	0.98	63.06	166.02	35.40
DCA-17	1.80	4.69	1.05	64.73	168.69	37.65
DCA-18	1.37	3.81	0.65	49.28	137.14	23.46
DCA-19	2.08	6.31	1.84	74.84	227.01	66.10
DCA-20	1.96	5.80	1.85	70.71	208.80	66.56
DCA-21	2.27	6.65	2.01	81.88	239.41	72.30
DCA-22	2.43	7.23	2.67	87.29	260.43	96.00
DCA-23	2.79	8.28	2.83	100.47	298.00	101.78
DCA-24	2.19	6.18	1.99	78.98	222.60	71.78
DCA-25	2.28	7.12	2.32	82.15	256.33	83.37
DCA-26	1.76	5.23	1.28	63.38	188.37	46.09
DCA-27	1.54	4.27	0.84	55.45	153.86	30.38
DCA-28	1.56	4.86	1.15	56.23	175.04	41.22
DCA-29	2.02	5.85	1.42	72.69	210.61	50.99
DCA-30	1.97	6.08	1.76	70.74	218.70	63.52
DCA-31	1.83	5.80	1.69	65.92	208.93	60.84
DCA-32	1.60	5.12	1.44	57.50	184.18	51.81
DCA-33	4.02	11.85	4.64	144.76	426.64	166.93
DCA-34	2.62	8.33	2.67	94.18	299.93	96.00
DCA-35	1.88	5.92	1.73	67.70	213.00	62.15
DCA-36	1.17	3.36	0.73	42.22	120.93	26.23
DCA-37	2.90	8.84	3.21	104.28	318.18	115.62
DCA-38	1.54	4.63	1.27	55.46	166.71	45.56
DCA-39	2.50	7.21	2.41	90.04	259.51	86.73
DCA-40	1.61	5.03	1.42	58.07	181.08	51.19
DCA-41	1.96	5.79	1.58	70.72	208.59	56.69
DCA-42	1.67	4.99	1.17	60.12	179.69	42.17
DCA-43	1.33	4.39	1.16	47.71	158.20	41.85
DCA-44	1.84	5.70	1.91	66.18	205.06	68.88
DCA-45	1.75	5.19	1.14	62.80	186.98	41.00
DCA-46	1.97	5.60	1.82	71.00	201.56	65.48
DCA-47	1.82	5.54	1.50	65.59	199.58	53.81
DCA-48	1.54	4.37	0.96	55.53	157.12	34.50
DCA-49	1.67	4.72	0.93	60.07	169.88	33.46
DCA-50	2.07	6.42	1.96	74.38	231.02	70.64
DCA-51	1.71	5.50	1.33	61.36	197.84	48.04
DCA-52	1.40	5.44	1.59	50.53	195.89	57.17
Byadgi dabbi	2.13	6.38	1.73	76.56	229.73	62.15
Mean	1.95	5.76	1.61	70.31	207.30	57.91
S.Em.±	0.13	0.33	0.17	4.66	11.80	6.28
C.D. (5%)	0.37	0.93	0.49	13.21	33.50	17.81

Table 2: Pooled mean performance of genotypes for relative growth rate (RGR) and net assimilation rate (NAR) at different stages and fruit yield in chilli genotypes

Genotypes	RGR (g g ⁻¹ day ⁻¹)			NAR (g dm ⁻² day ⁻¹)			Fruit yield per plant
	Days after planting						
	30 - 60	60 - 90	90 - Harvest	30-60	60 - 90	90 - Harvest	
DCA-1	11.46	13.57	2.12	1.78	5.33	1.28	40.82
DCA-2	11.44	13.55	2.09	2.38	7.16	1.70	62.14
DCA-3	10.66	13.08	2.13	2.27	6.83	1.66	56.64
DCA-4	11.01	13.34	2.72	2.68	8.14	2.53	77.80
DCA-5	12.84	13.93	2.36	2.88	8.40	2.18	82.18
DCA-6	12.23	13.95	2.27	2.90	8.69	2.20	83.57
DCA-7	11.87	13.33	1.79	3.08	8.69	1.74	72.90
DCA-8	11.78	13.19	1.73	2.72	7.67	1.56	69.43
DCA-9	11.53	13.96	2.17	2.60	8.08	1.97	74.27
DCA-10	9.61	12.35	1.57	2.12	6.24	1.14	44.35
DCA-11	7.15	10.99	1.58	1.81	5.53	1.11	26.68
DCA-12	10.91	12.71	2.02	1.92	5.45	1.28	43.41
DCA-13	9.13	12.52	1.96	1.60	4.96	1.17	37.78
DCA-14	11.39	13.76	2.19	2.44	7.59	1.85	69.30
DCA-15	9.50	12.07	1.33	2.24	6.32	0.99	42.38
DCA-16	12.80	13.49	1.78	2.06	5.61	1.11	53.83
DCA-17	11.67	13.01	1.81	2.17	6.04	1.25	50.82
DCA-18	8.58	11.72	1.31	1.65	4.80	0.76	29.11
DCA-19	11.00	13.93	2.40	2.49	7.91	2.14	73.95
DCA-20	11.06	13.69	2.58	2.29	7.09	2.11	68.89
DCA-21	11.30	13.79	2.45	2.76	8.59	2.42	79.57
DCA-22	11.60	14.09	3.00	2.87	9.04	3.07	93.23
DCA-23	10.21	13.26	2.70	3.42	10.60	3.36	93.12
DCA-24	12.16	13.85	2.62	2.55	7.52	2.27	73.98
DCA-25	8.64	12.68	2.52	2.75	9.16	2.72	69.77
DCA-26	9.58	12.92	1.94	2.13	6.71	1.53	51.12
DCA-27	10.76	13.02	1.60	1.84	5.46	0.99	39.28
DCA-28	7.32	11.56	1.75	1.89	6.23	1.36	32.44
DCA-29	10.36	13.12	1.98	2.45	7.37	1.69	61.83
DCA-30	7.55	11.76	2.16	2.38	7.83	2.12	47.98
DCA-31	7.41	11.86	2.18	2.21	7.34	1.98	47.54
DCA-32	6.67	11.29	2.05	1.95	6.58	1.71	33.48
DCA-33	12.88	14.58	3.21	4.82	15.20	5.45	165.80
DCA-34	9.79	13.63	2.58	3.20	10.68	3.18	91.62
DCA-35	7.85	12.17	2.22	2.27	7.49	2.03	49.98
DCA-36	8.26	11.70	1.64	1.36	4.21	0.82	24.21
DCA-37	12.11	14.48	3.00	3.45	11.29	3.71	112.43
DCA-38	9.87	13.14	2.19	1.80	5.92	1.44	46.43
DCA-39	9.93	12.86	2.60	3.01	8.98	2.82	79.43
DCA-40	8.09	12.27	2.17	1.91	6.24	1.64	43.07
DCA-41	9.24	12.60	2.13	2.37	7.30	1.84	55.53
DCA-42	8.51	12.16	1.81	2.02	6.29	1.39	41.20
DCA-43	7.84	12.53	2.07	1.53	5.34	1.34	33.54
DCA-44	8.91	12.80	2.60	2.12	7.23	2.16	58.08
DCA-45	7.74	11.63	1.65	2.14	6.72	1.36	37.54
DCA-46	9.70	12.60	2.51	2.36	7.14	2.11	61.24
DCA-47	9.23	12.86	2.16	2.14	6.76	1.67	52.15
DCA-48	8.74	11.89	1.69	1.86	5.48	1.11	35.43
DCA-49	7.98	11.41	1.48	2.05	6.07	1.10	34.88
DCA-50	8.17	12.29	2.34	2.50	8.07	2.33	57.70
DCA-51	7.03	11.68	1.82	2.05	6.91	1.57	39.91
DCA-52	5.89	11.95	2.18	1.69	6.99	1.88	33.55
Byadgi dabbi	8.52	12.20	2.08	2.60	8.20	2.08	56.63
Mean	9.76	12.81	2.13	2.35	7.31	1.89	58.38
S.Em.±	0.70	0.54	0.24	0.16	0.43	0.21	4.54
C.D. (5%)	1.98	1.52	0.68	0.46	1.21	0.58	12.89

Fig 1: Relationship of CGR and AGR at different stages in chilli genotypes

Fig 2: Relationship of RGR and NAR at different stages in chilli genotypes

Conclusion

In the present study, a range of variability was observed for all the physiological approaches among the genotypes. The characters showing wide range of variation provide an ample scope for selecting superior types and the selected genotypes can be used in further crossing programme for introgression of their desired genes and to obtain heterotic hybrids. It is thus inferred that for developing ideotypes in chilli, higher CGR, higher AGR, higher RGR and higher NAR can be considered as important physiological traits since, these parameters possess significant positive relationship with yield.

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