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Evaluation of growth parameters and yield variation in field pea genotypes

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Abstract
Legumes, particularly field pea (*Pisum sativum* L.), are vital for human nutrition and animal feed due to their high protein content. However, their production is often limited by reduced light levels, especially when grown as intercrops. This study aimed to evaluate the variation in growth parameters among different field pea genotypes to identify superior varieties under diverse conditions. Conducted using a randomized complete block design (RCBD) with three replications, the experiment measured specific leaf weight (SLW), net assimilation rate (NAR), absolute growth rate (AGR), crop growth rate (CGR), and relative growth rate (RGR) across various growth stages. Results indicated significant genotype differences in growth parameters. IC381455 exhibited the highest CGR (6.85 g m^{-2} day^{-1}) and AGR (0.548 g day^{-1}) during early growth stages and maintained high NAR (0.0767 mg dm^{-2} day^{-1}) and RGR (0.0722 g g^{-1} day^{-1}). In contrast, Nippani local-2 showed the lowest CGR, RGR, and seed yield per plot (454 g). The study highlights that high CGR, RGR, and NAR are positively correlated with seed yield, suggesting that genotypes with these traits are more productive. Notably, IC381455, IPFD6-3, and Rachana demonstrated high yield potential, indicating their suitability for cultivation under varying conditions. These findings contribute valuable insights into selecting field pea genotypes with superior growth and yield characteristics, which is essential for improving production efficiency.

Keywords: Field pea, crop growth rate, relative growth rate, net assimilation rate and seed yield

Introduction

Legumes (Leguminosae) represent a large group of plants recognized for their high nutritional value, serving as a crucial food source for both humans and animals. As the global population continues to increase, the demand for legumes is also rising, leading to a corresponding growth in their production. Field pea (*Pisum sativum* L.) is a significant pulse crop widely utilized in human nutrition. However, during cultivation, field peas often face reduced light levels when grown as intercrops, which can significantly limit their production (Akhter and Kanrun, 2009) [1]. The cultivated field pea is a self-pollinated diploid species (2n=14 chromosomes) belonging to the family Fabaceae, characterized by green and yellow cotyledons. Originating from the Mediterranean region of Southern Europe and Western Asia, field pea plants exhibit herbaceous, bushy, or climbing growth. The stems are weak, round, and slender, ranging from 30 to 150 cm in length. The leaves are alternate, pinnate with 1-3 pairs of leaflets and a terminal branched tendril, while the leaflets are ovate or elliptic. The inflorescence of the pea is a raceme arising from the axil of the leaf (Le *et al*., 2007) [9].

Globally, pea is the third most important pulse crop after dry bean and chickpea. In India, it ranks third among rabi pulses, following chickpea and lentil. Field pea is nutritionally rich, containing all essential amino acids and high-quality vegetable protein, making it a valuable substitute for animal meat products, particularly in developing countries such as India. Fresh green peas are widely accepted as a nutritious vegetable (Singh *et al*., 2011) [11]. Field peas are cultivated across a range of soil types, from light sandy loams to heavy clays, though they do not tolerate saline or waterlogged conditions. As a winter season crop, they require a cool growing season with moderate temperatures throughout their lifecycle. High temperatures are more detrimental to pea crops than frost, and high humidity associated with cloudy weather can lead to the spread of fungal diseases such as damping-off and powdery mildew (Santalla *et al*., 2001) [10].

Several factors influence seed and biomass yield in field pea, including cultivar, location, and environmental growth conditions. Significant variation in pea seed quality within a year suggests a considerable impact of environmental conditions, agronomic practices, and genetic factors (Kasturikrishna and Ahlawat, 1999) [7]. Yield variability and instability are major issues for pea cultivation due to poor adaptability and low tolerance to biotic and abiotic stresses. Key yield-limiting constraints include aphids, low-yielding local varieties, lodging, diseases (ascochyta blight, powdery mildew), and pod shattering. Abiotic stresses such as high temperatures and soil water deficits are also significant challenges that can substantially reduce yields (Kumar *et al*., 2003) [8]. This study aims to observe the variation in different growth parameters among various pea genotypes to identify the superior genotype under diverse conditions.

Materials and Methods

The experiment was conducted using a randomized complete block design (RCBD) with three replications. Each plot measured 3 m x 2.25 m (gross plot size) and 2.4 m x 2.15 m (net plot size), with inter-row and intra-row spacings of 45 cm and 10 cm, respectively. The land was prepared by plowing and harrowing twice, followed by planking to achieve a fine tilth. Fertilization was applied at a rate of 20:40:60 kg NPK per hectare using urea, single super phosphate, and muriate of potash as a basal dose at sowing. Field pea genotypes, sourced from AICRP College of Agriculture, Vijayapur, University of Agricultural Sciences, Dharwad, were sown on October 21, 2021, at a depth of 5.0 cm. Post-sowing care included irrigation at critical growth stages, earthing up at 30 days, and maintaining weed-free plots through interculture and hand weeding. Fungicidal and insecticidal sprays were applied as recommended. The crop was harvested at physiological maturity when pods turned yellow, sundried for a day, and seeds were manually separated, cleaned, and dried to a 13% moisture content before recording the net plot yield.

Measurement of Growth Parameters

Specific Leaf Weight (g dm^{-2})

Specific leaf weight (SLW) was measured as the leaf weight per unit leaf area, expressed as g dm^{-2}. It was calculated using the formula:

$$\text{SLW} = \frac{\text{Leaf weight}}{\text{Leaf area}}$$

Net Assimilation Rate (g dm^{-2} day^{-1})

Net assimilation rate (NAR) was calculated as the rate of increase in dry weight per unit leaf area per unit time, expressed as g dm^{-2} day^{-1}, using Gregory's (1926) [5] formula:

$$\text{NAR} = \frac{(\text{W2} - \text{W1})\ (\text{Loge LA2} - \text{Loge LA1})}{(\text{t2} - \text{t1})\ (\text{LA2} - \text{LA1})}$$

Were, L1 and W1 = leaf area (dm2) and dry weight (g) of plant respectively at time t1. L2 and W2 = leaf area (dm2) and dry weight (g) of plant respectively at time t2.

Absolute Growth Rate (g day^{-1})

Absolute growth rate (AGR) was calculated as the dry matter production per unit time, expressed as g day^{-1}, using the formula:

$$\text{AGR} = \frac{(\text{W2} - \text{W1})}{(\text{t2} - \text{t1})}$$

Were, W_1 and W_2 = total dry matter content taken at time t_1 and t_2 respectively.

Crop Growth Rate (g m^{-2} day^{-1})

Crop growth rate (CGR) was calculated as the rate of dry matter accumulation per unit ground area, using Watson's (1952) [14] formula:

$$\text{CGR} = \frac{(\text{W2} - \text{W1})}{(\text{t2} - \text{t1})} \times \frac{1}{\text{A}}$$

Where, W_1 = Dry weight of plant at time t_1; W_2 = Dry weight of plant at time t_2; A = Land area occupied by plant

Relative Growth Rate (g g^{-1} day^{-1})

Relative growth rate (RGR) was calculated as the increase in dry weight per unit dry weight already present, using Blackman's (1919) [2] formula:

$$\text{RGR} = \frac{\text{Loge W2} - \text{loge W1}}{(\text{t2} - \text{t1})}$$

Where, W_1 and W_2 = total dry weights of plant at time t_1 and t_2 respectively.

Seed yield per plot

The pods from each net plot were threshed, cleaned, and the seed yield was calculated and expressed in grams per plot (g plot^{-1}).

Results

Growth Parameters

Field pea genotypes exhibited significant differences in various growth parameters, including specific leaf weight (SLW), crop growth rate (CGR), relative growth rate (RGR), net assimilation rate (NAR), and absolute growth rate (AGR) at various growth stages.

Crop Growth Rate (g m^{-2} day^{-1})

Significant differences in crop growth rate (CGR) among genotypes were observed at all stages (Table 1). The mean CGR was highest between 30-60 days after sowing (5.78 g m^{-2} day^{-1}) and decreased from 60 days after sowing to harvest (1.36 g m^{-2} day^{-1}). The genotype IC381455 recorded a significantly higher CGR (6.85 g m^{-2} day^{-1}), comparable to IPFD6-3 (12.29 g m^{-2} day^{-1}) at 30-60 DAS. During 60 DAS to harvest, IC381455 (3.17 g m^{-2} day^{-1}) and IPFD6-3 (2.95 g m^{-2} day^{-1}) had the highest CGR, while Nippani local-2 (0.49 g m^{-2} day^{-1}) had the lowest, on par with TRCP-8 and EC292167.

Relative Growth Rate (g g^{-1} day^{-1})

Relative growth rate (RGR) values showed significant differences among genotypes at all stages (Table 1) and decreased with crop growth. IC381455 recorded the highest RGR (0.0722 g g^{-1} day^{-1}) at 30-60 DAS, on par with IPFD6-3 (0.0711 g g^{-1} day^{-1}). Nippani local-2 had the lowest RGR (0.0652 g g^{-1} day^{-1}). During 60 DAS to harvest, IC381455 had the highest RGR (0.0104 g g^{-1} day^{-1}), comparable to IPFD6-3 and Rachana, while Nippani local-2 had the lowest (0.0031 g g^{-1} day^{-1}).

Net Assimilation Rate (mg dm⁻² day⁻¹)

Significant differences in net assimilation rate (NAR) were observed among genotypes at all stages (Table 2). The mean NAR ranged from 0.0739 mg dm^{-2} day^{-1} (30-60 DAS) to 0.0191 mg dm^{-2} day^{-1} (60-harvest). NAR increased up to 60 DAS and decreased thereafter in all genotypes. IC381455 exhibited the maximum NAR at 30-60 DAS (0.0767 mg dm^{-2} day^{-1}) and 60-harvest (0.0283 mg dm^{-2} day^{-1}), while Nippani local-2 had the minimum NAR at 30-60 DAS (0.0700 mg dm^{-2} day^{-1}) and 60-harvest (0.0122 mg dm^{-2} day^{-1}).

Absolute Growth Rate (g day⁻¹)

Absolute growth rate (AGR) showed significant differences among genotypes at all stages (Table 2) and declined with crop growth. IC381455 recorded the highest AGR (0.548 g day^{-1}) at 30-60 DAS, on par with IPFD6-3 (0.546 g day^{-1}). Nippani local-2 had the lowest AGR (0.355 g day^{-1}). During 60 DAS to harvest, IC381455 had the maximum AGR (0.159 g day^{-1}), comparable to IPFD6-3 and Rachana, while Nippani local-2 had the lowest (0.039 g day^{-1}), on par with TRCP-8 and EC292167.

Specific Leaf Weight (g dm⁻²)

Specific leaf weight (SLW) increased up to 60 DAS and then decreased in all genotypes (Table 2). Significant differences were observed among genotypes at all three stages. At 30 DAS, IC381455 (4.749 g dm^{-2}) and IPFD6-3 (4.655 g dm^{-2}) recorded the maximum SLW, while Nippani local-2 (1.834 g dm^{-2}) and TRCP-8 (2.063 g dm^{-2}) had the minimum. At 60 DAS and harvest, IC381455 recorded the maximum SLW (4.930 g dm^{-2} and 4.727 g dm^{-2}, respectively), and Nippani local-2 had the minimum (2.729 g dm^{-2} and 1.587 g dm^{-2}, respectively).

Seed Yield per Plot (g)

Seed yield per plot showed significant differences among genotypes (Fig. 1). IC381455 recorded the highest seed yield per plot (918 g), on par with IPFD6-3 (805 g) and Rachana (800 g), while Nippani local-2 had the lowest seed yield per plot (454 g).

Table 1: Genotypic variation in crop growth rate (g m^{-2} day^{-1}) and relative growthrate (g g^{-1} day^{-1}) at different growth stages in field pea

Sl. No.	Genotypes	CGR (g m⁻² day⁻¹)		RGR (g g⁻¹ day⁻¹)	
		30-60 DAS	60-harvest	30-60 DAS	60-harvest
1.	IPF4-9	5.17	0.86	0.0684	0.0071
2.	IPF99-25	6.12	1.00	0.0678	0.0076
3.	KPMR-400	4.93	1.71	0.0698	0.0074
4.	IC381455	6.85	1.98	0.0722	0.0104
5.	IC208399	5.50	0.97	0.0669	0.0059
6.	EC292167	5.52	0.97	0.0667	0.0057
7.	EC598851	5.59	1.31	0.0700	0.0084
8.	P725	5.50	1.24	0.0681	0.0077
9.	P744	5.90	1.68	0.0706	0.0088
10.	HUP-2	60.5	1.70	0.0705	0.0086
11.	IPFD6-3	6.83	1.81	0.0711	0.0099
12.	TRCP-8	4.89	0.75	0.0656	0.0052
13.	DMR-7	6.30	1.76	0.0699	0.0085
14.	RACHANA	6.58	1.79	0.0709	0.0092
15.	Nippani local -2	4.71	0.49	0.0652	0.0031
16.	DWD Local	6.04	0.93	0.0670	0.0059
	Mean	5.78	1.36	0.0688	0.0075
	S.Em. ±	0.0023	0.0017	0.0021	0.0002
	CD at 5%	0.007	0.005	0.0061	0.0006

Table 2: Genotypic variation in Net assimilation rate (mg dm^{-2} day), Absolute growth rate (g day^{-1}) and Specific leaf weight (g dm^{-2}) at different stages in field pea

Sl. No.	Genotypes	NAR (mg dm⁻² day⁻¹)		AGR (g day⁻¹)		Specific leaf weight (g dm⁻²)		
		30-60 DAS	60-harvest	30-60 DAS	60-harvest	30 DAS	60 DAS	At harvest
1.	IPF4-9	0.0746	0.0154	0.472	0.080	2.899	3.614	2.700
2.	IPF99-25	0.0735	0.0203	0.447	0.078	2.294	3.186	2.035
3.	KPMR-400	0.0747	0.0204	0.414	0.099	2.795	3.468	2.616
4.	IC381455	0.0767	0.0283	0.548	0.159	4.749	4.930	4.727
5.	IC208399	0.0716	0.0146	0.394	0.074	2.183	3.198	1.905
6.	EC292167	0.0715	0.0138	0.391	0.069	2.182	3.120	1.886
7.	EC598851	0.0722	0.0159	0.484	0.136	3.982	4.160	3.907
8.	P725	0.0739	0.0188	0.483	0.134	3.734	4.326	3.632
9.	P744	0.0761	0.0224	0.504	0.143	4.311	4.654	4.229
10.	HUP-2	0.0755	0.0222	0.490	0.141	4.171	4.466	4.111
11.	IPFD6-3	0.0766	0.0262	0.546	0.152	4.655	4.890	4.512
12.	TRCP-8	0.0712	0.0132	0.377	0.060	2.063	2.958	1.791
13.	DMR-7	0.0743	0.0190	0.440	0.137	2.336	3.127	2.070
14.	RACHANA	0.0765	0.0233	0.526	0.145	4.382	4.830	4.246
15.	Nippani local -2	0.0700	0.0122	0.355	0.039	1.834	2.729	1.587
16.	DWD Local	0.0732	0.0164	0.442	0.104	2.221	3.130	1.958
	Mean	0.0739	0.0191	0.457	0.109	3.17	3.80	2.99
	S.Em. ±	0.0030	0.0006	0.014	0.004	0.09	0.11	0.08
	CD at 5%	0.0090	0.0017	0.041	0.010	0.29	0.32	0.24

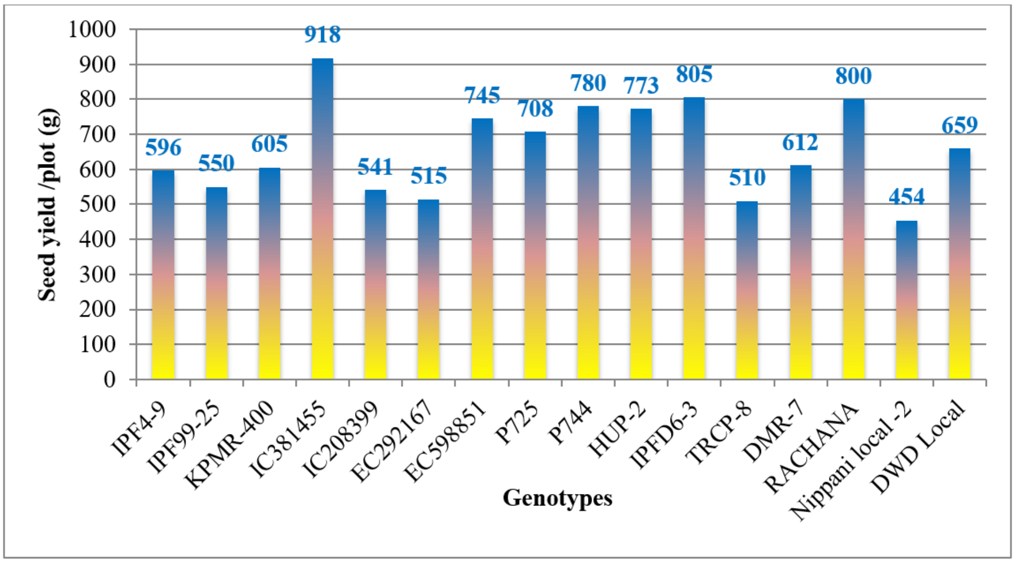

Fig 1: Seed Yield per Plot for Different Field Pea Genotypes

Discussion

Yield variation in field pea genotypes is influenced by various growth parameters, including Crop Growth Rate (CGR), Relative Growth Rate (RGR), Net Assimilation Rate (NAR), Absolute Growth Rate (AGR), and Specific Leaf Weight (SLW). These parameters are essential in understanding the development of the crop and its productivity, as they reflect the plant's physiological processes and response to internal and external factors.

The present study indicated that CGR increased up to 30 to 60 days after sowing (DAS) and decreased thereafter towards maturity. Genotype IC381455 recorded the highest CGR, whereas Nippani local-2 exhibited the lowest CGR. The positive correlation between CGR and seed yield is significant, suggesting that higher CGR leads to better productivity. This finding is consistent with Fikreselassie *et al*. (2012) [4], who reported a positive correlation between CGR and yield in field pea. The initial increase in CGR can be attributed to the expansion of leaf area and enhanced photosynthetic activity, while the decline towards maturity is due to leaf senescence and reduced photosynthetic efficiency. RGR, another crucial physiological parameter, measures the plant's ability to produce dry matter per unit of existing dry matter. The study revealed that RGR increased up to 30 to 60 DAS and decreased thereafter. The significant positive correlation between RGR (30-60 DAS) and grain yield indicates that higher RGR contributes to better yield. The decrease in RGR at later stages is primarily due to a reduction in leaf area, which diminishes the plant's assimilation capacity and efficiency in accumulating dry matter. Wallace *et al*. (2002) [13] attributed varietal differences in RGR and CGR to variations in Leaf Area Index (LAI), which significantly influences growth.

NAR, representing the capacity of green leaves to produce dry matter, showed considerable genotypic variation at all stages. The genotype IC381455 exhibited the highest NAR, reflecting its efficient photosynthetic rate and leaf area utilization. However, NAR decreased towards maturity due to leaf shading and senescence. The findings align with Das (2020) [3], who observed genotypic and temporal differences in NAR and RGR. The decrease in NAR at later stages underscores the importance of maintaining healthy leaf area for sustained productivity. SLW, an indicator of leaf thickness, varied significantly among genotypes. It was initially low at 30 DAS, peaked at 60 DAS, and then declined up to harvest. This pattern suggests that thicker leaves contribute to higher biomass production, which positively affects yield. Gul *et al*. (2015) [6] observed similar trends in field pea, noting that SLW reached its maximum value at 60 DAS before declining. Singh and Singh (2012) also reported a strong association between SLW and seed yield, highlighting SLW's substantial contribution to productivity. Among the test genotypes, IC381455, IPFD6-3, Rachana, P-744 and HUP-2 were found to be high yielding potential genotypes.

Conclusion

The study highlighted significant variation in growth parameters among field pea genotypes, with genotypes IC381455, IPFD6-3, and Rachana demonstrating superior performance across various metrics. Key parameters such as Crop Growth Rate (CGR), Relative Growth Rate (RGR), Net Assimilation Rate (NAR), and Specific Leaf Weight (SLW) were pivotal in determining genotype productivity. IC381455 exhibited consistently high values for CGR, RGR, NAR, and SLW, correlating strongly with higher seed yield. Conversely, Nippani local-2 showed lower values in these parameters, leading to reduced yield. The results underscore the importance of these physiological traits in enhancing field pea productivity and suggest that selecting genotypes with high CGR, RGR, and NAR can significantly improve seed yield under diverse conditions. Further studies on these traits could inform breeding programs aimed at developing high-yielding and stress-resistant field pea varieties.

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Conflict of interest

Authors have declared that no Conflict of interest exist

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