*Original Article*

# Investigating the Impact of Generation on the Growth and Yield of Pea (*Pisum Sativum L.*)

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## Abstract

Considering the nutritional value of pea (*Pisum sativum L.)* and its seed generations in crop yield, this study was conducted to investigate the effects of various generations of pea on yield and yield components in the Gorgan region of Iran. The treatments included three generations: F1, F2, and F3. Planting was carried out with a row spacing of 33 cm and an intra-row distance of 10 cm. This experiment was designed as a randomized complete block design with three replications. Sampling occurred during the flowering, green pod, and ripening stages. The following traits were measured: the number of plants with red flowers, leaf area index, stem height, number of pods per plant, weight of green pods, number of seeds per pod, weight of one hundred grains, dry biomass weight, yield of green pods, seed yield, and the harvest index. The data were analyzed using Excel and SAS software. Based on the findings of this study, it can be concluded that the green pod yield and several other traits measured in the second generation of pea did not exhibit a statistically significant difference compared to the first generation; any observed differences were minimal. However, the use of seeds from the third generation resulted in a significant decrease in yield (3,088.99 kg/ha, 2,873.71 kg/ha, and 2,095.44 kg/ha in the F1, F2, and F3 generations, respectively.) and yield components when compared to both the first and second generations. It was concluded that uilizing second-generation pea seeds from the Wolf variety can help reduce planting costs while achieving the desired yield of green pods.

**Keywords:** Green pods, Generation impact, *Pisum sativum*, Yield.

## Introduction

Legumes have a special place in the agricultural systems of the world due to their important agricultural and nutritional characteristics. These plants are considered as an important and valuable protein source in some developing countries [1]. Pea is the most widely cultivated plant in temperate climates. This annual plant produces seeds that can be harvested either in their immature state with full pods or as peeled immature seeds. These seeds can be consumed fresh, frozen, or canned. In addition, they can be stored as dried seeds for food use [2].

According to the available reports, one of the most effective agricultural factors to achieve high yield is the selection and improvement of cultivars with favorable climate and soil conditions [3].

Combined or hybrid F1 seeds refer to the selective cultivation of a plant that was created through the pollination of two different plants, and in genetics, the term Filal1 or "children of the first generation" is called (F1). One of the most important achievements of F1 plants is resistance to diseases and pests and environmental stress (salinity and drought). These plants have faster growth and survival, and they need less poisons and other chemical methods to survive, which are beneficial for both health and the environment. But in the next generations, these traits are declining [4,5].

Apricio *et al.* [6] mentioned that the value of the leaf area index is a function of both the cultivar and the growth stage of the plant, as well as the environmental conditions.

Pirzadeh Biranvand *et al.* [7] conducted research on the mode of gene action and the compatibility of various chickpea lines for different traits, examining six lines and fifteen F1 progeny resulting from crosses. They reported that

the average effect of heterosis on the number of pods per plant and the number of seeds was significant, indicating a notable difference between the means of the parent plants and the hybrids. Similarly, Ramezani and Mansoori [8] found that plants derived from two sesame cultivars exhibited increased height in the earlier generations. Furthermore, Jeffrey and Larry [9] reported that the harvest index is defined as the ratio of seed weight to the maximum plant weight achieved at the end of the reproductive stage. For a specific variety, the harvest index is a stable trait, with the primary variations resulting from the environmental conditions experienced during the plant's growth. Golestan province in Iran has 598 thousand hectares of agricultural land. Most of the agricultural lands located in the center of Golestan province (70.51%) have favorable conditions for growing Peas [10]. In 2023, about 2,800 hectares of agricultural land in the province were dedicated to Peas cultivation, and the average yield of green pods per hectare was about 8 tons [11].

Concerning the importance of Chickpea in the country and Golestan province, and since farmers in the region use approximately 80 to 120 kg of seeds per hectare, with an average of 100 kg for growing Pea, the cost of hybrid seeds— about three times that of second and third generation seeds—poses a significant challenge. Many farmers lack the financial resources to purchase the first-generation seeds and often resort to use the second and the third-generation seeds for cultivation. Therefore, this study was conducted to investigate the effect of different generations of pea on growth, yield, and yield components in Gorgan region in Iran.

## Materials and Methods

This experiment was conducted at the educational research farm of Gorgan

University of Agricultural Sciences and Natural Resources in 2021-2022. Geographically, the farm is located at latitude of 36 degrees and 49 minutes north, a longitude of 54 degrees and 19 minutes east, and an elevation of 12 meters above sea level.

**Table 1** Rainfall and average temperature during the growing season of pea in the crop year 2022-2023

| Month | November | December | January | February | March | April | May |
|---|---|---|---|---|---|---|---|
| Rainfall(mm) | 43.5 | 20.0 | 55.5 | 99.0 | 66.5 | 22.3 | 47.5 |
| Temperate (°C) | 13.4 | 13.1 | 9.7 | 8.9 | 12.0 | 14.9 | 19.1 |

In terms of climate, the long-term average annual rainfall is 607 mm, the long-term average annual temperature is 17.9 degrees Celsius, and the long-term average relative humidity is 70%. Based on the measurements, the farm soil contained 14% sand, 48% silt, and 38% clay, indicating a loamy texture with clay and silt. The electrical conductivity was measured at 2.37 d S/m, and the soil acidity was recorded at 7.88.

Meteorological information, along with a graph illustrating the amount of rainfall and the average temperature during the growth period of the pea plant for the crop year 2021-2022, is presented in Table 1.

The experiment was conducted using a factorial design in the form of a randomized complete block design with three replications. The treatments included three levels of generation of Wolf variety Pea: F1, F2, and F3, with a row spacing of 33 cm and a plant spacing of 10 cm, a density of 30 plants per square meter was achieved. Before planting, bed preparation, which included plowing, disking, and leveling, was completed. Planting was conducted manually on November 26, 2021. Fertilization of the land was carried out using 50 kg of urea, 100 kg of potassium sulfate, and 100 kg of triple superphosphate, based on the soil test results. The planting depth for all seeds was uniformly set at 5 cm. Each plot was divided into five rows, each measuring 6 meters in length, with a spacing of 1.5 meters between plots. On April 4, 2022, irrigation was carried out due to insufficient soil moisture. A worker performed the weeding operation. Since no pests or serious diseases were observed on the farm, no spraying was required. After the pea began to green, sampling was conducted at three stages: flowering, green pods, and ripening.

*Traits Measured at the Flowering Stage: Red Flower Plant Percentage and Leaf Area Index*

To measure the red flower bushes, the total number of bushes in each plot was calculated. Subsequently, the number of red flower bushes in each plot was counted, and the percentage of red flower bushes was determined. To assess the leaf area index, three middle rows, each 50 cm in length, were selected from each plot. After being transported to the laboratory, the leaf area was measured using a leaf area meter.

*Traits Measured at the Green Pod Harvesting Stage*

*Measuring the Height of the Stem and the Number of Pods Per Plant*

Seven pea plants were randomly selected from each plot. The height of each plant was measured from the collar (soil level) to the tip of the stem. In addition, the number of pods on each plant was counted and weighed using a scale with an

accuracy of 0.001 grams. The average number and weight of the pods were subsequently calculated. The weight of the pods was determined by counting and weighing the pods from seven randomly selected pea plants to calculate the average weight of each green pod.

### Green Pod Yield

To determine the green pod yield using the Cavins classification method at the R6 growth stage [12,13], when the pods are fully developed, three rows measuring 100 cm in length were harvested from each experimental unit, excluding the margins. After separating the pods, their weight was measured using a precision scale with an accuracy of 0.001 grams, and the green pod yield per hectare was subsequently calculated.

### Harvest Stage

### The number of Seeds Per Pod, Seed Yield, Weight of One Hundred Seeds, and Total Biomass

To determine the number of seeds in a pod, seven plants were randomly selected from each plot. After separating the pods, ten pods were randomly chosen and the number of seeds in each pod was counted. The average number of seeds per pod was then calculated. To determine the seed yield at the ripening stage, three middle rows, each one meter in length, were harvested from each plot. The pods were then manually separated from the seeds. The seeds were dried at 55 °C for 72 hours, after which they were weighed, and the yield of dry seeds per hectare was calculated. To determine the weight of one hundred dry seeds, three groups of one hundred seeds were randomly selected from the oven-dried batch. The weights and averages were recorded using a precise scale with an accuracy of 0.001 grams. After separating the seeds, the remaining plant materials were

placed in paper envelopes and dried at 72 °C for 48 hours. Subsequently, the samples were weighed using a scale with an accuracy of 0.001 grams. The dry weight of the straw and stubble was determined for each plot. The biomass per hectare was calculated by summing the dry grain yield and the plant residues. The harvest index for pea was calculated and analyzed using the following formula.

HI= Grain yield/Total biomass

### Statistical Analysis

After preparing the data using Excel software, statistical analysis was conducted with SAS Version 9.2, and the means were compared using the Least Significant Difference (LSD) test. Additionally, Excel 2013 was used to create graphs.

## Results and Discussion

### Percentage of Red Flower Plants and Leaf Area Index

The analysis of variance for the effect data indicated that generation significantly impacted the percentage of plants with red flowers (Table 2). Generally, pea plants have white flowers; however, a few plants exhibit red flowers. The results indicated that the first generation produced from hybrid seeds did not contain any red-flowered plants, but red-flowered plants were observed in the second and third generations (Figure 1). This finding suggests that the degree of trait differentiation increases in subsequent generations. The results of the analysis of variance indicated that the leaf area index during the flowering stage was influenced by generation (Table 2). A comparison of the average data regarding the effect of generation on the leaf area index revealed that the F1 and F2 generations produced a higher leaf area index than F3 generation (Figure 1).

**Table 2** Variance analysis of the impact of generation of pea plants during the flowering and green pod stages on percentage of red flowers, Leaf area index, plant height, number of pods per plant, green pod weight, and green pod yield

| Source of variation | df | Mean square | | | | | |
| --- | --- | --- | --- | --- | --- | --- | --- |
| | | percentage of red flowers | Leaf area index | plant height | Number of pods per plant | Green pod Weight | Green pod Yield |
| Blok | 2 | 0.021ns | 0.001ns | 0.195ns | 0.192 ns | 0.039ns | 207367.7ns |
| Generation | 2 | 5.277** | 0.613** | 414.297* | 1.940** | 1.647** | 25753706.6** |
| Error | 2 | 0.016 | 0.013 | 1.957 | 0.236 | .042 | 346247.7 |
| CV (%) | 4 | 6.35 | 6.48 | 1.65 | 4.79 | 5.54 | 5.50 |

*Ns, ** and *, not-significant, significant at 1% and 5% level, respectively.*

**Table 3** Variance analysis of the impact of pea generation during the seed ripening stage on number of grain per pod, 100 dry grain weight, dry grain yield, total biomass, and harvest index

| Source of variation | df | Mean square | | | | |
| --- | --- | --- | --- | --- | --- | --- |
| | | Number of grain per pod | 100 dry grain Weight | Dry grain yield | Total biomass | Harvest index |
| Blok | 2 | 0.043ns | 0.25ns | 46433.50ns | 95785.30ns | 1.55ns |
| Generation | 2 | 0.135ns | 44.86** | 2458765.10** | 10563325.34** | 3.30ns |
| Error | 4 | 0.046 | 0.61 | 26115.60 | 29523.20 | 2.38 |
| CV (%) | -- | 3.48 | 5.07 | 5.24 | 3.29 | 3.34 |

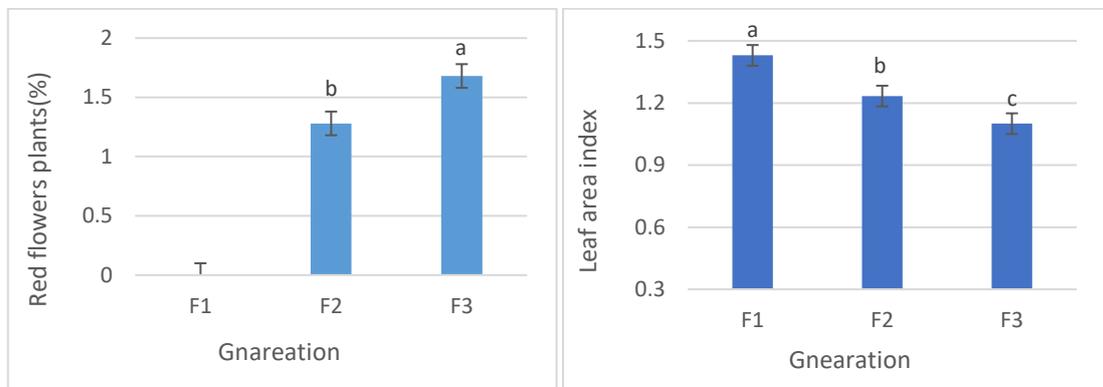*Ns, ** and *, not-significant, significant at 1% and 5% level, respectively.*



**Figure 1** The effect of generation on the percentage of red flower and leaf area index in pea

Apricio *et al.* [9] suggested that the value of the leaf area index is a function of both the cultivar and the growth stage of the plant, as well as the environmental conditions.

*Plant Height and Number of Pods per Plant*

The results of the analysis of variance indicated that plant height was influenced by generation (Table 2). The F1 generation exhibited the greatest height at 89.91 cm, while the shortest height was recorded in the F3 generation at 78.91 cm (Figure 2). Ramezani and Mansoori [7] also reported that plants from two sesame cultivars were taller in the earlier generations. The results of the analysis of variance indicated that the generation effect significantly influenced the number of pods per plant (Table 2).
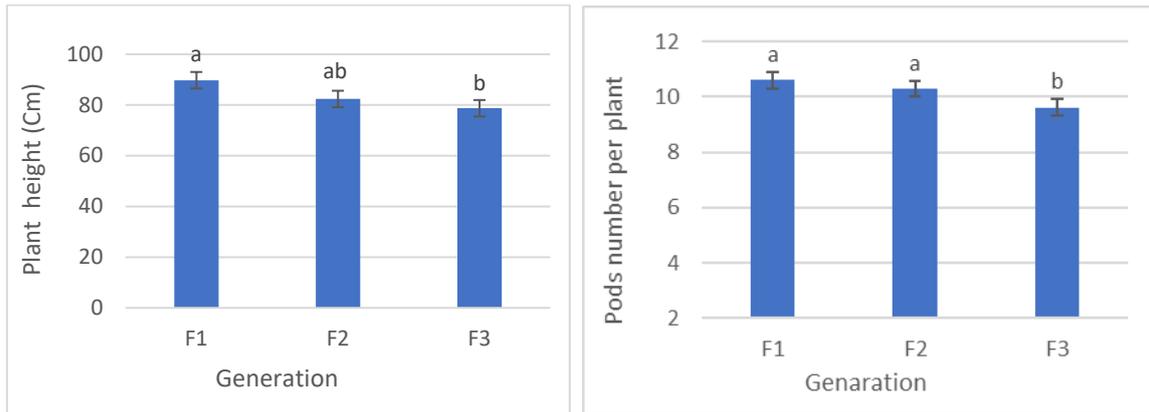
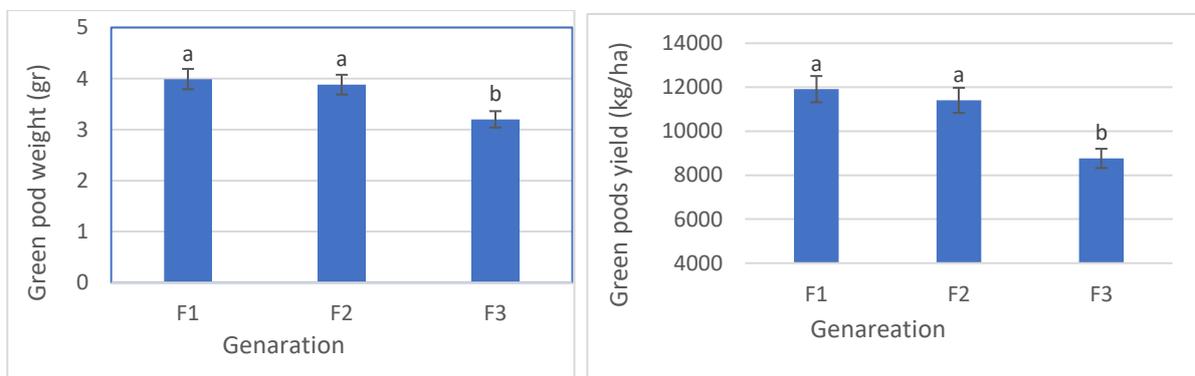**Figure 2** The Impact of generation on stem height and the number of pods per plant in pea



**Figure 3** The impact of generation on green pod weight and green pod yield in pea

### *Green Pod Weight and Green Pod Yield*

A comparison of the average data revealed that the number of pods per plant in the F1 (10.51 number) and F2 (10.31 number) generations did not differ statistically. However, the F3 generation exhibited a significant decrease in the number of pods (9.62 number) (Figure 2). The number of pods per plant is a crucial component of yield; the lack of a significant difference between the first and second generations suggests that the seeds of the second generation have maintained their capacity to produce a comparable number of pods per plant. Variance analysis of the data showed the significant impact of generation on green pod weight (Table 3).

The comparison of average green pod weights across generations indicated no significant difference between the F1 and F2 generations, which had weights of 3.99 grams and 3.88 grams, respectively. However, in the third generation, the green pod weight decreased to 3.20 grams (Figure 3). In this study, the yield of green pods was significantly affected by different generations (Table 3). The difference in green pod yield between the F1 and F2 generations was not significant; however, a notable difference was observed in the F3 generation when compared to both the F1 and F2 generations. The highest yield of green pods, recorded at 11,915.42 kg/ha, was observed in the F1 generation, followed by the F2 generation at 11,404.89 kg/ha. The lowest yield, at 8,763.77 kg/ha, was noted in the F3 generation (Figure 3).

### *The Number of Grains per Pod*

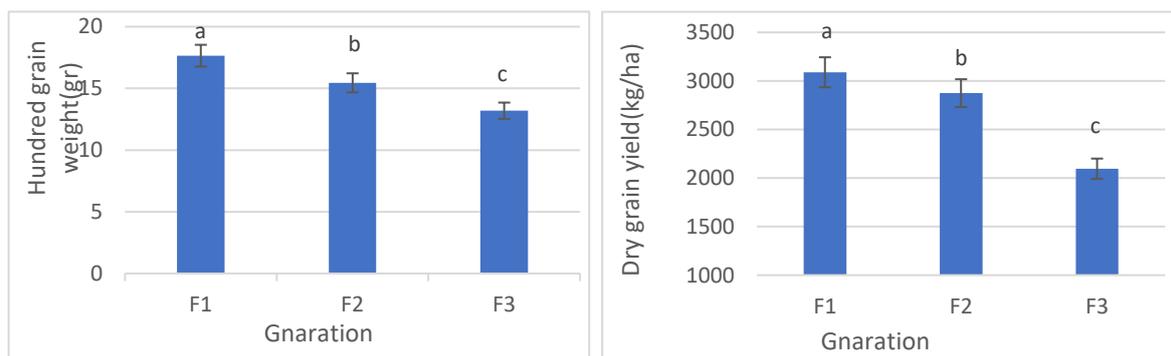The analysis of variance results indicated that the effect of generation on

the number of grains per pod was not significant (See Table 3).

*Hundred-Grain Weight and Grain Yield*

The variance analysis of the data indicated that the weight of one hundred seeds across different generations was significant at the 1% probability level (Table 3). A decreasing trend in seed weight was observed from the F1 generation to subsequent generations, with the highest weight recorded in the F1 generation at 17.29 grams, followed by the F2 generation at 15.45 grams, and the lowest weight in the F3 generation at 13.19 grams (Figure 4).

The results of the variance analysis indicated the impact of generation on grain yield (Table 3). An examination of grain yield across different generations revealed that the F1 generation produced the highest yield at 3,088.99 kg/ha, compared to the F2 and F3 generations. The yield for the F2 generation was 2,873.71 kg/ha, while the F3 generation recorded the lowest yield at 2,095.44 kg/ha. The decrease in grain yield from the F1 to the F2 generation was approximately 7%, and the decline from the F2 to the F3 generation was 27%. Based on these results, the yield difference between the first and the second generations is statistically insignificant. Furthermore, concerning the cost of seeds for these two generations, purchasing the more expensive seeds of the first generation is not economically justified for planting (Figure 4).



**Figures 4** The impact of generation on the weight of one hundred dry seeds and dry grain yield in pea
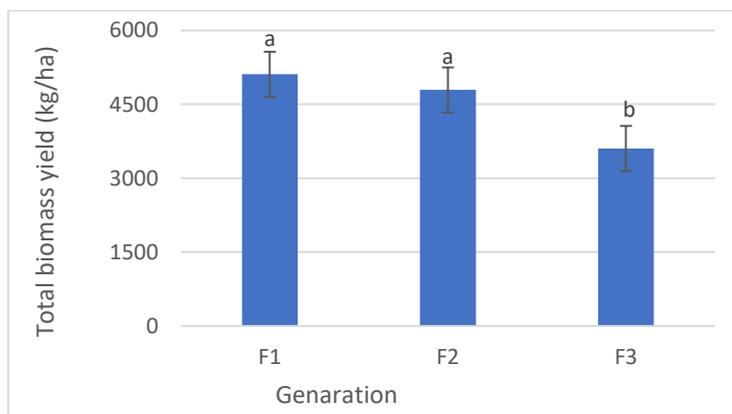


**Figure 5** The impact of generation on total biomass yield

*Total Biomass Yield and Harvest Index*

The results of the analysis of variance indicated that the effect of generation on total biomass yield was significant (Table 3). The comparison of average generation effects revealed that the difference in biomass between the first and second generations was not significant. However, in the third generation, the biomass yield decreased significantly compared to both the first and the second generations (Figure 5).

The results of the variance analysis indicated that the effect of generation on the harvest index was not significant (Table 3). The harvest index for a given variety is a stable trait, with the primary differences arising from the environmental conditions during the plant's growth [10].

## Conclusion

In this study, the yield of green pods and various other measured traits in the second generation of pea were not significantly different from those in the first generation; any differences were minimal. However, the use of third-generation seeds resulted in a significant decrease in yield and yield components compared to both the first and the second generations. Therefore, it can be concluded that utilizing second-generation of pea seeds which are considerably less expensive for farmers than first-generation seeds, can help reduce planting costs. Therefore, based on the findings of this study, it is recommended that additional research be conducted on the impact of generation on growth and yield in other pea cultivars, as well as in other crops where generation significantly affects yield.

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