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Potential Impacts of Organic Treatments on Pea Yield Related Traits at Different Plant Densities

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ABSTRACT

Background: Sustainable crop production requires strategies that reduce chemical fertilizer dependence while maintaining or improving yield. Organic amendments and natural stimulants, when combined with appropriate planting densities, can enhance crop performance. In pea (*Pisum sativum* L.), the integration of compost and foliar stimulants such as Razormar (Rz) may improve pod quality and yield under varying plant population levels.

Methods: Field experiments were conducted during the 2022-23 and 2023-24 winter seasons at the Experimental Farm, Faculty of Environmental Agricultural Sciences, Arish University, Egypt. The study was arranged in a split-plot design with three replications. Main plots were assigned to two intra-row spacings (25 cm and 40 cm), while subplots included ten fertilization treatments combining composted rice straw at 3 t/fed, recommended levels of mineral fertilizers and foliar application of Razormar (1.5 cm/L applied three times after sowing). The pea cultivar "Master-B" was used and standard cultural practices were applied. Pod traits and yield components were measured to assess treatment effects.

Result: Wider spacing (40 cm) promoted longer pods, higher seed number per pod and more pods per plant compared to narrower spacing. Although yield per plant was reduced under 25 cm spacing, the greater plant density compensated, leading to higher total yield per feddan. Across both seasons, treatments that combined compost with Razormar consistently improved yield and pod attributes over mineral fertilization alone. These findings underline the potential of integrating organic fertilizers and natural stimulants with optimized spacing as an effective and sustainable alternative for pea production.

Key words: Density, Foliar spray, Organic fertilizer, Pea (*Pisum sativum* L.), Sustainable agriculture, Yield traits.

INTRODUCTION

Pea (*Pisum sativum* L.) is a major vegetable and export crop in Egypt, cultivatped on about 43.5 thousand acres (7% of winter vegetables) in 2020 with a 35% production decline during the 2019-20 season (Ministry of Agriculture, Egypt, 2020), while by 2022 national production reached 166,126 ton (FAOSTAT, 2022). It is nutritionally rich in proteins (7.2%), carbohydrates (19.8%), minerals (0.8%) and vitamins A, B and C (El-Desuki *et al*., 2010).

Production relies heavily on costly and less available inorganic fertilizers, emphasizing the need for organic alternatives. Organic fertilization improves soil structure and microbial biomass (Naeem *et al*., 2006), enhances environmental and health safety (Jongtae, 2010) and serves as a sustainable nitrogen source (Yoldas *et al*., 2020).

In this context, compost has been reported to improve soil properties and root growth (Michigan State University, 2023), with rice straw compost proving more effective than manure in peas (Salamba *et al*., 2021). Furthermore, natural plant stimulants such as seaweed extracts, amino acids and composted rice straw enhance stress tolerance *via* hormonal and antioxidant regulation (Shukla *et al*., 2021).

More recently, studies on pea demonstrated that omission of surface soil removal combined with FYM at 5 t ha^{-1} resulted in the maximum seed yield of 447.64 kg ha^{-1}, confirming the importance of conserving topsoil while applying organic manures (Haiguipeung *et al*., 2025).

On the other hand, planting plant spacing is another crucial factor influencing legume productivity. In grass pea (*Lathyrus sativus* L.), closer spacing (20 × 10 cm) produced the highest grain yield (739 kg/ha) due to a greater plant population per unit area, while wider spacing (30 × 10 cm) resulted in higher pods per plant (12.05) and seeds per pod (4.43) (Sharma and Jain, 2018). Similarly, narrow

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spacing (30 × 10 cm) in pigeon pea cultivar Pusa Arhar-16 improved plant height, leaf area index and overall yield, whereas wider spacing (50 × 25 cm) enhanced branching and yield attributes per plant (Singh *et al*., 2021).

Accordingly, the present study aimed to evaluate the performance of the pea cultivar "Master-B" under two planting densities and to assess the interaction between fertilizer types and plant spacing in North Sinai, Egypt.

MATERIALS AND METHODS

This study was conducted as a part of the requirements for the (Ph.D.) degree at the Institute of Environmental Studies, Arish University. The field experiments the study was carried out during the two successive winter seasons of 2022-23 and 2023-24 at the Experimental Farm, Faculty of Environmental Agricultural Sciences, Arish University, North Sinai Governorate, Egypt to investigate the efficacy of organic fertilizer (O) including compost rice straw (3 ton/fed.) soil application and plants sprayed with Razormar (Rz. 1.5 cm/L at three times, starting 30 days after sowing and at 15 days intervals) compared to the prescribed rate of mineral fertilizer (N30.75, P30 K36, kg/fed, M) at the two planting space treatments and examining the impact on pea cultivar (Master-B) quality and yield. Seeds were obtained from the vegetable research departments of Dokki, Horticulture Research Institute. Razormar, is NPK fertilizer riches in amino acids and microelements, a special compound that increases the plant's ability to with stand different production conditions, was obtained from local market of Shoura Chemicals Company, Cairo-Alexandria Desert Road, Egypt, *i.e.* Active ingredient as marine algae extract 11% - free amino acids 7% - total nitrogen 4% - phosphorus 4% - potassium 3% - stimulating agents 1.52 - iron 0.4 - zinc 0.085 - manganese 0.1%, boron 0.1% - copper 0.02%, Country of origin: Atlantica Agricole, Spain. The chemical properties of the compost rice straw (Samy, 2022) along with the experimental field's physical and chemical soil characteristics, which were displayed in Table 1.

The experiment was conducted in a split-plot design with three replicates under RCBD. Each plot measured 15 m^2 (1/280 fed, 5.0 × 0.60 m, 5 rows oriented north south). Two weeks before sowing (October 17th, both seasons), rows were prepared by incorporating either phosphorus (mineral fertilizer) or compost (organic fertilizer), followed by irrigation. Pea seeds (*cv*. Master-B) were planted at two densities (25 cm and 40 cm) assigned randomly to the main plots. Subplots included five fertilizer treatments organic and inorganic fertilizers with or without Razormar foliar spray resulting in 10 treatment combinations. Nitrogen was applied in three equal doses (20.5% ammonium sulphate at soil preparation; 33.5% ammonium nitrate at 30 and 60 days), while potassium sulphate (48-52% K, O) was applied in two doses (half at soil preparation, half after emergence). All other practices followed the recommendations of the Egyptian Ministry of Agriculture and Land Reclamation.

Table 1: The chemical properties of the composted rice straw (CRS) and both physical and chemical soil properties of the experimental field during 2.21-2022 and 2022-2023 seasons.

Seasons	N (%)	P (%)	K (%)	C/N Ratio	Fe (ppm)	Mn (ppm)	Zn (ppm)
Composted rice straw (CRS)							
2022-23	1.43	0.62	0.80	24.83	558.4	266.52	43.36
2023-24	1.45	0.60	0.81	25.17	568.65	278.42	46.07
Soil							
Seasons	Organic matter %	CaCO3 %	EC (dS/ml)	PH (1- 2.5 suspension)	Sand (%)	Silt (%)	Clay (%)	Texture
2022-23	0.16	14.9	1.6.0	7.5	19.0	11.4	10.2	Sandy loam
2023-24	0.16	16.0	1.6.0	7.9	19.8	12.3	10.0	

Data recorded

At green harvesting time, yield characteristics were recorded as following:

Pod length (cm)

The average length of ten randomly selected green pods per plot that were picked at the ideal consuming time was used to measure this.

Seeds No in each pod

A random sample of twenty pods was taken and threshed individually during harvesting and subsequently Seeds No in each pod divided by twenty to get the average number of seeds per pod.

Pods No per plant

Calculated as the mean of five randomly selected plants.

Total pod yield

Computed as the ton per fed. by adding up all of the harvested pods for each plant (kg/plant).

Statistical analysis

Data were analyzed using ANOVA for a randomized complete block design (Gomez and Gomez, 1984) with Statistics 11 software and treatment means were compared using LSD at the 5% level.

RESULTS AND DISCUSSION

According to the obtained results, plant spacing, organic treatments and their interaction had a clear influence on pea pod length (cm) and number of seeds, as illustrated in Table 3, 4 and 5 and Fig 1 and 2.

Effect of plant density

The major effect of plant spacing was significant in both seasons with respect to the number of seeds/pod and pods/plant, as well as the effect on pod length (cm) (Table 3 and Fig 1). When the intra-row spacing increased from 25 to 40 cm, the outcome was a much longer pod with the maximum number of seeds/pod and pods/plant in the wider plant spacing (D_2). Pod length and number of both seeds/pod and pods/plant were also greatly increased. D_1 plant spacing, however, produced the smallest pod and the fewest seeds/pod and pods/plant. These outcomes hold true for both seasons. These results can be further explained by the interaction with fertilizer applications detailed in Table 2, where the combined effect of plant spacing and organic/mineral fertilizer treatments (CRS + 25%, 50%, 75% NPK) influences nutrient availability per plant. Wider spacing (40 cm) allows better light interception, root expansion and access to nutrients, thereby supporting longer pod formation and higher numbers of seeds and pods per plant. In contrast, narrower spacing (25 cm)

Table 2: Plant distances, organic and inorganic fertilizers treatments used in this study.

Main plot		Sub plot				
Plant spacing	25 cm	M	O	ORz+M25	ORz+M50	ORz+M75
	40 cm	M	O	ORz+M25	ORz+M50	ORz+M75
25 cm plant spacing refers		100% NPK	3 ton/fed. CRS	ORz+25% NPK	ORz+50% NPK	ORz+75% NPK
to 28000 plants (D1)		30.75 N (kg)		7.688 N (kg)	15.38 N (kg)	23.06 N (kg)
40 cm plant spacing refers to		30 P_2O_5 (kg)		7.5 P_2O_5 (kg)	15 P_2O_5 (kg)	22.5 P_2O_5 (kg)
17500 plants (D2)		36 K_2O (kg)		9 K_2O (kg)	18 K_2O (kg)	27 K_2O (kg)

The recommended doses fertilizers 100% M treatment got the appropriate amounts of N, P and K as specified by the Agricultural Ministry, Egypt with no additional nutrients added, Rz: Razormar (1.5 cm/L foliar spray at three times), CRS: Composted rice straw.

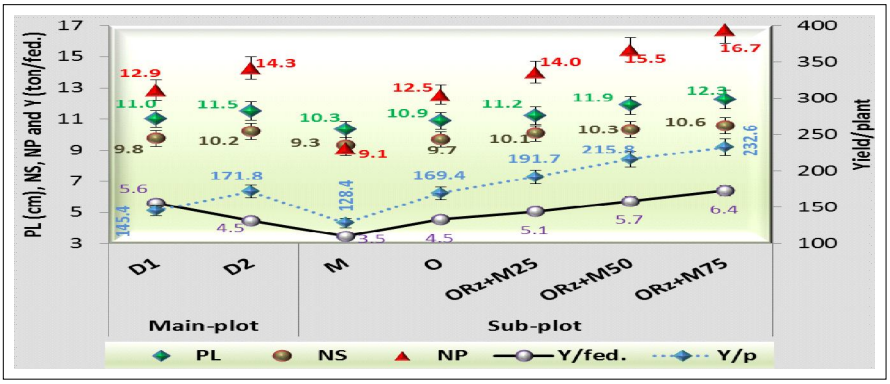


Fig 1: Pod length (PL), number of pods/plant (NP), number of seeds/pod (NS) and yield/fed of pea as affected by plant density (D) and organic fertilizer (O) with stimulating foliar spray (Rz) comparing to mineral fertilizer (M) in average of both studied years.

increases competition among plants, limiting nutrient uptake and pod development, which results in smaller pods with fewer seeds and pods per plant.

Pod development in peas has been shown to benefit from wider spacing, with longer pods recorded at 50 cm compared to shorter ones at 30 cm (Shaukat *et al*., 2012). Comparable patterns occur in other crops, where reduced competition under wider spacing improved assimilate partitioning and seed filling; for example, soybean exhibited more seeds per pod due to enhanced light interception (Zhang *et al*., 2023), while sesame under semi-arid conditions produced superior seed traits with greater inter-row spacing (Ali *et al*., 2022). High green pea yields at lower plant densities were mainly linked to variation in seeds per

Table 3: Pod length, number of seeds/pods, pods/plant and yield of pea as affected by plant spacing during the two studied years.

Main-plot	Pod length (cm)	Number of seeds	Number of pods	Yield (ton/fed.)
		1st season		
D_1	10.84	9.61	12.44	5.01
D_2	11.32	10.07	13.79	3.921
LSD	0.369	0.391	1.156	0.494
		2nd season		
D_1	11.16	9.9	13.28	6.2
D_2	11.71	10.34	14.76	5.03
LSD	0.432	0.39	0.846	0.578

Table 4: Pod length, number of seeds/pod, pods/plant and yield of pea as affected by organic fertilizer (O) with stimulating foliar spray (Rz) comparing to mineral fertilizer (M) during the two studied years.

Sub-plot	Pod length (cm)	Number		Yield (ton/fed.)
		Seeds	Pods	
		1st season		
M	10.15	9.07	8.58	3.057
O	10.66	9.57	11.98	3.944
ORz+M25	10.95	10.07	13.69	4.541
ORz+M50	11.66	10.07	15.07	5.222
ORz+M75	12	10.41	16.25	5.562
LSD	1.27	1.23	2.82	0.476
		2nd season		
M	10.54	9.57	9.63	3.889
O	11.11	9.81	13.11	5.153
ORz+M25	11.51	10.09	14.32	5.569
ORz+M50	12.11	10.57	15.84	6.228
ORz+M75	12.53	10.73	17.18	7.236
LSD	1.31	0.98	1.51	0.592

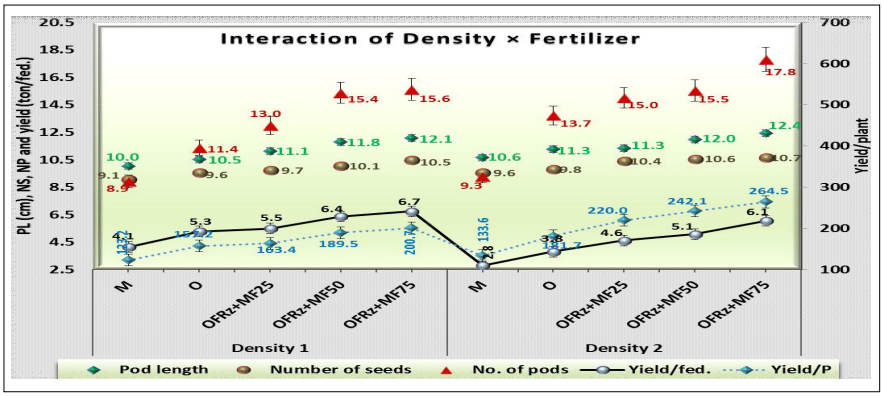


Fig 2: Pod length, Number of seeds/pods, Pods/plant and both yield/plant and ton/fed of pea as affected by the dual interaction (D×F) in average of both studied years.

pod, while wider spacing (D_2) promoted vigorous growth, greater branching and consequently mor pods per plant. In contrast, narrow spacing caused crowding, reduced growth and fewer pods per plant (Abonmai *et al*., 2022).

Regarding pod yield per feddan, plant spacing showed a significant effect in both seasons (Table 3, Fig 1). Narrow spacing (D_1, higher plant density) produced greater total pod yield than wider spacing, mainly due to the higher number of plants per unit area.

Effect of fertilizer applications

Data in Table 4 show that all organic treatments (O, ORz+M25, ORz+M50, ORz+M75) increased pod number and yield compared to mineral fertilizer (M). ORz+M50 and ORz+M75 significantly enhanced pod length and seed number in both seasons (except ORz+M50 for seed number in the 1st season), with ORz+M75 recording the longest pods, highest seed and pod numbers and greatest yield/fed, followed by ORz+M50, differing only in yield during the 2nd season. as shown in Table 1. The stable N, P and K levels, along with the slight increase in trace elements (Fe, Mn, Zn) and balanced C/N ratio of CRS, contributed to enhanced nutrient availability, supporting pod development, seed formation and overall yield. Moreover, the prolonged decomposition period of CRS ensured a gradual and sustained release of nutrients, improving nutrient uptake efficiency and crop performance across both seasons. These findings align with reports that composted rice straw improves crop yield and quality (Abbas *et al*., 2014; Metwally, 2015; Gewaily, 2019; Salamba, 2021). The beneficial effect of Razormar foliar spray on pod traits may relate to its growth-promoting compounds and nutrient content and amino acids, which support metabolism, protein synthesis and biomass accumulation. Similar findings were reported by Abd El-Moniem and Abd-Allah (2008), Sahu *et al*. (2012); Shariatmadari *et al*. (2013); Grzesik and Romanowska-Duda (2015) and Noha, (2020) on various crops, showing that natural extracts improve pod and yield traits while allowing a reduction of mineral nitrogen fertilizer to 1/4-1/2 of the recommended dose.

Plant density and fertilizer interaction (D×F)

Results in Table 5 show that fertilizer × spacing interaction significantly affected pod traits and yield. The longest pods (13.18 and 13.69 cm) were obtained with ORz+M75 under D_2, while the shortest were with M (both spacings) and O under D_1. No significant differences occurred between ORz+(M50 or M75) × (D_1 or D_2) in both seasons, or among ORz+(M25, M50, M75) × (D_1 or D_2) in the 2nd season. For seeds per pod, treatments showed no marked differences, though the highest value was with ORz+M75 under D_2. Pod number was maximized with ORz+M75 × D_2 and minimized

Table 5: Pod length, number of seeds/pod, number of pods/plant and yield of pea as affected by the dual interaction (D×F) during the two studied years.

Interaction		Pod length (cm)	Number		Yield (ton/fed.)
			Seeds	Pods	
Density × Fertilizer			**1st season**		
D1	M	10.8	9.74	8.57	3.642
	O	11.3	10.41	10.77	4.745
	ORz+M25	11.8	10.74	12.73	4.983
	ORz+M50	12.6	10.74	15.05	5.786
	ORz+M75	12.8	11.41	15.07	5.893
D2	M	11.5	10.41	8.60	2.473
	O	12.1	10.74	13.20	3.142
	ORz+M25	12.1	11.41	14.64	4.099
	ORz+M50	12.8	11.41	15.08	4.658
	ORz+M75	13.2	11.41	17.43	5.232
LSD	0.993	2.067	2.875	0.484	
Density × Fertilizer			**2nd season**		
D1	M	11.30	10.41	9.30	4.638
	O	11.80	10.74	11.96	5.820
	ORz+M25	12.50	10.74	13.24	5.998
	ORz+M50	13.19	11.41	15.70	6.948
	ORz+M75	13.36	11.56	16.19	7.596
D2	M	11.79	10.74	9.96	3.139
	O	12.46	10.87	14.27	4.487
	ORz+M25	12.56	11.45	15.40	5.140
	ORz+M50	13.03	11.73	15.99	5.509
	ORz+M75	13.69	11.89	18.17	5.876
LSD		1.40	1.63	1.33	0.59

with M × D_1. Increases in pods/plant over M were 27.2, 45.4, 72.2 and 75% under O, ORz+M25, ORz+M50 and ORz+M75 with D_1 and 48, 61.8, 67.4 and 91.8% with D_2. Pod yield followed the same pattern, with the highest yield/plant from ORz+M75 × D_2. Yield increments over M were 27.6, 32.6, 53.8 and 62.9% with D_1 and 36, 64.6, 81.2 and 97.9% with D_2.

Optimal plant spacing enhances yield by reducing competition among plants (Al-Suhaibani *et al*., 2013). In this study, lowering density from 28,000 (D_1) to 17,500 (D_2) plants/fed increased pods and seed yield/plant due to larger leaf area, better light penetration and less competition. However, pod yield/fed showed the opposite trend, where (ORz+M75) × D_1 gave the highest yield. Despite a reduction of 8-70% in yield/plant under D_1 compared to D_2, the higher number of plants/fed compensated, increasing total yield (Mahdi *et al*., 2021). Organic fertilizers under D_1 improved pods/plant and seed yield, enhancing growth in reclaimed soils (Hemida *et al*., 2017). The combined use of compost rice straw and Razormar boosted photosynthesis, nutrient uptake and metabolism, thus improving yield (Mohsen *et al*., 2017; Dawood *et al*., 2019). Similar findings were reported by Mohammed and Salih (2012); Yucel (2013) and Shiferaw *et al*. (2018).

CONCLUSION

This study evaluated planting density and fertilization regimes including composted rice straw, mineral fertilizers and Razormar foliar spray on pea yield and pod traits. Results indicated that integrating organic residues with natural stimulants “Razormar” improves performance while reducing dependence on chemical inputs. Recycling rice straw and other by-products emerged as a sustainable fertilization strategy that enhances soil fertility, optimizes resource use and mitigates environmental pressures. Such practices support UN Sustainable Development Goals and offer a pathway toward resilient, eco-efficient, climate-smart agriculture.

Conflict of interest

On behalf of all authors, we hereby declare that the manuscript and all authors are free from any personal or financial interests, whether present or future, that could be related to the publication of this manuscript or the authors themselves. We confirm that there is no conflict of interest, either financial or non-financial, associated with the publication of this work. The authors declare that there are no competing interests that could have influenced the research reported in this paper.

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