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Effect of water and nutrient management practices on the yield attributes and yield of field pea (*Pisum sativum* L.)

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Abstract
A field experiment entitled "Effect of water and nutrient management practices on the growth and yield of field pea (*Pisum sativum* L.)" was conducted at the Instructional Farm, Dau Kalyan Singh College of Agriculture and Research Station, Bhatapara (C.G.) during the *rabi* season of 2024-25. The study was laid out in a split-plot-design with three replications. The main-plot treatments consisted of four irrigation levels: I_1 - No irrigation, I_2 - One irrigation at Branching stage, I_3 - Two irrigations at Branching and Pod development stages, and I_4 - Three irrigations at Branching, Flowering, and Pod development stages. The sub-plot treatments included six nutrient management practices: N_1 - Control, N_2 - Recommended Dose of Fertilizers (RDF: 20:50:20 kg NPK ha^{-1}), N_3 - 75% RDF + Biofertilizer, N_4 - 100% RDF + Biofertilizer, N_5 - 75% RDF + Biofertilizer + Nitrobenzene at 30 DAS and pre-flowering, and N_6 - 100% RDF + Biofertilizer + Nitrobenzene at 30 DAS and pre-flowering. The results revealed that irrigation management significantly enhanced yield attributes such as the number of pods per plant, pod length, number of seeds per pod, seed index, grain yield, stover yield, and harvest index of field pea. Among the irrigation treatments, three irrigations applied at the branching, flowering, and pod development stages (I_4) consistently recorded the highest values for all yield attributes and yield, followed by two irrigations at branching and pod development stages (I_3).
Regarding nutrient management, the treatment comprising 100% RDF + Biofertilizer + Nitrobenzene applied at 30 DAS and pre-flowering stage (N_6) resulted in the maximum improvement in all yield attributes and overall productivity, whereas the control (N_1) recorded the lowest performance. Notably, the interaction effect between irrigation and nutrient management on yield attributes and yield was found to be non-significant.

Keywords: Field pea, irrigation, biofertilizers, Pisum, RDF and yield

Introduction
Field pea (*Pisum sativum* L.) is one of the most significant pulse crops among the various grain legumes cultivated in India. A member of the Leguminaceae family, it thrives as a nutrient-rich, cool-season crop. This short-duration pulse is widely grown across different regions of the country and serves as an excellent source of protein. Per 100 grams of dried edible grains, field peas contain 1.8 g of fat, 62.1 g of carbohydrates, 21-25% protein, 0.15 g of riboflavin, 0.72 mg of thiamine, 2.4 mg of niacin, 64 mg of calcium, 4.8 mg of iron, 11% moisture, along with essential vitamins A and C (Gupta *et al.*, 2017) [3].
In India, field pea ranks as the third most important *rabi* pulse crop after chickpea and lentil. It is cultivated on approximately 0.76 million hectares, yielding an annual production of around 1.04 million tonnes, with an estimated average yield of 13.18 q ha^{-1} (Anonymous, 2021) [1]. In Chhattisgarh, field pea is primarily grown during the *rabi* season, covering an area of 13,690 hectares with a total production of 5,354 metric tonnes. Specifically, in the Balodabazar, Bhatapara district, the crop is cultivated over 429 hectares, producing approximately 145 metric tonnes (Anonymous, 2023) [2].
Excessive use of chemical fertilizers in agriculture has led to negative impacts on biodiversity, human health, food and water contamination, soil degradation, and nutrient imbalances (Negi *et*

al., 2006) [14]. Although chemical fertilizers boost crop yield, their overuse reduces soil organic matter, disrupts microbial balance, contaminates groundwater, and increases production costs. To address these issues, integrating chemical fertilizers with bio-fertilizers is essential for sustainable agriculture.

Bio-fertilizers are an eco-friendly and cost-effective alternative that enhance soil fertility by fixing atmospheric nitrogen, solubilizing insoluble phosphates, and promoting beneficial microbial activity (Rather *et al.,* 2010) [19]. Long-term application of organic manures, such as farmyard manure (FYM), improves micronutrient availability and soil microbial processes, which cannot be restored solely by chemical fertilizers (Singh *et al.,* 2016) [22].

Microbial inoculants, such as Rhizobium, Azotobacter, Azospirillum, and phosphate-solubilizing microorganisms (*Pseudomonas, Bacillus, Penicillium, Aspergillus*), enhance nitrogen fixation and phosphorus availability, improving crop productivity (Kumawat *et al*., 2013) [9]. The Indian government supports bio-fertilizer production through the National Bio-fertilizer Development Centre to ensure quality and distribution.

In modern agriculture, plant growth regulators (PGRs) play a crucial role in enhancing crop productivity, quality, and resilience to environmental stress. Among them, Nitrobenzene ($C_6H_5NO_2$) has gained attention for its ability to stimulate plant growth, flowering, and yield. As an aromatic compound, Nitrobenzene influences key physiological and biochemical processes, including cell elongation, chlorophyll synthesis, and photosynthetic activity. It promotes the production of growth-regulating phytohormones such as auxins, gibberellins, and cytokinins, which govern critical stages of plant development, including flower initiation, fruit setting, and seed formation (Srinivasan *et al.,* 2018) [23]. Foliar application of Nitrobenzene has been reported to improve both vegetative and reproductive growth in crops like cotton, groundnut, mustard, and pulses (Patel *et al.,* 2014) [18]. Additionally, it enhances nutrient absorption and translocation, leading to higher photosynthetic efficiency and increased chlorophyll content (Kumar *et al.,* 2016) 6[].

Pea (*Pisum sativum*) productivity in Chhattisgarh remains low due to rainfed cultivation and poor irrigation practices. Pea is highly sensitive to moisture stress, especially during flowering and pod filling, which hampers nodule formation and nitrogen fixation (Marouelli *et al.,* 1987) [10]. Supplemental irrigation improves water use efficiency (WUE), enhances nutrient uptake, and mitigates moisture stress, increasing yield potential (Hyder *et al.,* 2016; Kumari *et al.,* 2012) [4, 8].

Efficient irrigation management is critical in regions facing water scarcity. Proper soil moisture positively affects plant growth, aeration, and nutrient availability. Well-managed irrigation can increase pulse crop yields by 100-150%, depending on soil type and climatic conditions (Panwar and Malik, 1977; Martin and Tabley, 1981) [15, 12].

Materials and Methods

A field experiment was carried out during the *rabi* season of 2024-25 at the Instructional Farm, Dau Kalyan Singh College of Agriculture and Research Station, Bhatapara, Chhattisgarh (21.73° N latitude, 81.98° E longitude, 262 m above mean sea level). The experimental soil was sandy loam in texture, slightly alkaline in reaction (pH 7.10), low in organic carbon (0.49%), low in available nitrogen (214 kg ha^{-1}), medium in available phosphorus (11.06 kg ha^{-1}), and high in available potassium (326 kg ha^{-1}). The experiment was laid out in a split-plot-design (SPD) with three replications and 24 treatment combinations. The main-plot treatments comprised four irrigation levels: I_1 - No irrigation, I_2 - One irrigation at Branching stage, I_3 - Two irrigations at Branching and Pod development stages, and I_4 - Three irrigations at Branching, Flowering, and Pod development stages. The sub-plot treatments included six nutrient management practices: N_1 - Control, N_2 - Recommended Dose of Fertilizers (RDF: 20:50:20 kg NPK ha^{-1}), N_3 - 75% RDF + Biofertilizer, N_4 - RDF + Biofertilizer, N_5 - 75% RDF + Biofertilizer + Nitrobenzene at 30 DAS and pre-flowering, and N_6 - RDF + Biofertilizer + Nitrobenzene at 30 DAS and pre-flowering. Weather data during the crop season were recorded at the Meteorological Observatory, DKS CARS, Bhatapara. No rainfall was received during the crop growth period. Relative humidity ranged from 37.8% (15th SMW, 2025) to 94.6% (48th SMW, 2024). The weekly mean maximum temperature varied from 22.9 °C (6th SMW, 2025) to 34.9 °C (15th SMW, 2025), while bright sunshine hours ranged from 2.58 to 9.32 hrs day^{-1}. The test crop was field pea (*Pisum sativum* L.) variety IPFD 12-2, sown on 16th November 2024 at a spacing of 30 cm × 10 cm using a seed rate of 80 kg ha^{-1}. Seeds were treated with Trichoderma, Rhizobium, PSB, KSB, and ZSB biofertilizers at the rate of 10 ml kg^{-1} seed prior to sowing. The RDF (20:50:20 kg $N:P_2O_5:K_2O$ ha^{-1}) was applied as basal through urea, diammonium phosphate (DAP), and muriate of potash (MOP). Nitrobenzene was applied in two sprays: 30 DAS and flowering stage. The gross plot size was 5.0 m × 4.5 m, while the net plot size was 4.2 m × 4.1 m. Standard agronomic practices were followed uniformly to ensure a healthy crop. The crop was harvested manually at physiological maturity. Data were recorded on growth attributes, seed yield, and stover yield using standard procedures. The economics of treatments was computed by estimating gross returns, net returns, and benefit-cost ratio (B:C ratio) on the basis of prevailing market prices of pea grain and stover. The data generated were statistically analysed following the split-plot design method, and results were interpreted accordingly.

Results

Yield attributes

Effect of Irrigation Management: The data presented in the table 1 indicate a significant influence of irrigation management on yield-attributing characters of field pea. The number of pods per plant, pod length number of seeds per pod, and seed index all increased progressively with the number of irrigations.

The highest number of pods per plant (23.5), pod length (4.41 cm), number of seeds per pod (4.99), and seed index (20.5 g) were recorded with three irrigations applied at branching, flowering, and pod development stages (I_4). This treatment was found to be significantly superior over all other irrigation levels. The two-irrigation treatment (I_3) applied at branching and pod development stages recorded moderate values (20.4 pods $plant^{-1}$, 3.88 cm pod length, 4.54 seeds pod^{-1}, and 19.9 g seed index), whereas the lowest values were observed under no irrigation (I_1). This improvement under higher irrigation frequency might be attributed to the maintenance of optimum soil moisture throughout the critical growth stages, which promotes better nutrient uptake, photosynthetic activity, and efficient translocation of assimilates towards reproductive parts. Similar findings were reported by Singh *et al*. (2021) [21] and Kumar *et al.* (2020) [5], who observed that adequate irrigation at branching and flowering stages markedly increased yield components of field pea.

Effect of Nutrient Management: Nutrient management practices also exerted a significant effect on all yield-attributing

parameters. The treatment N_6 (RDF + Biofertilizer + Nitrobenzene at 30 DAS and pre-flowering) recorded the highest values for number of pods plant^{-1} (23.4), pod length (4.46 cm), number of seeds pod^{-1} (4.87), and seed index (20.4 g). This was followed by N_4 (RDF + Biofertilizer), which produced 20.2 pods plant^{-1}, 3.92 cm pod length, 4.51 number of seeds pod^{-1} and a seed index of 19.9 g.

In contrast, the control plot (N_1) exhibited the lowest performance (12.0 pods plant^{-1}, 2.42 cm pod length, 3.46 seeds pod^{-1}, and 18.7 g seed index). The improvement in yield components under N_6 treatment can be attributed to the synergistic effect of balanced fertilization, microbial inoculation, and growth stimulation by Nitrobenzene, which enhances flowering, pod formation, and seed filling. These results are in agreement with the findings of Patel *et al.* (2018) [17] and Meena *et al.* (2021) [13], who reported that integration of biofertilizers with chemical fertilizers and PGRs enhances growth and yield in legumes by improving nutrient availability and physiological efficiency.

Interaction Effect: The interaction between irrigation and nutrient management levels was found to be non-significant for all the studied parameters, indicating that the combined effect did not vary significantly from their individual effects. This suggests that both irrigation and nutrient management independently contributed to the improvement of yield attributes without any antagonistic or synergistic interaction.

Table 1: Effect of water and nutrient management practices on number of pods, pod length, number of seeds and seed index of field pea.

Treatments	Number of pods plant^{-1}	Pod length (cm)	Number of seeds pod^{-1}	Seed index (cm)
Irrigation management				
I_1: No irrigation	12.8	2.56	3.55	18.8
I_2: 1 Irrigation at Branching stage	16.5	3.23	4.01	19.4
I_3: 2 Irrigation at Branching and Pod development stage	20.4	3.88	4.54	19.9
I_4: 3 Irrigation at Branching, Flowering and Pod development stage	23.5	4.41	4.99	20.5
S.Em (±)	0.55	0.11	0.09	0.12
CD (5%)	1.92	0.37	0.31	0.41
Nutrient management				
N_1: Control	12.0	2.42	3.46	18.7
N_2: RDF (20:50:20 kg NPK ha^{-1})	19.8	3.75	4.43	19.8
N_3: 75% RDF + Biofertilizer	15.4	2.96	3.99	19.2
N_4: RDF + Biofertilizer	20.2	3.92	4.51	19.9
N_5: 75% RDF + Biofertilizer + Nitrobenzene at 30 DAS and at pre- flowering	19.1	3.58	4.36	19.7
N_6: RDF + Biofertilizer + Nitrobenzene at 30 DAS and at pre- flowering	23.4	4.46	4.87	20.4
S.Em (±)	0.89	0.16	0.14	0.18
CD (5%)	2.56	0.47	0.41	0.53
Nutrient management at same level of irrigation management				
S.Em (±)	1.35	0.26	0.21	0.29
CD (5%)	NS	NS	NS	NS
irrigation management at same or different level of nutrient management				
S.Em (±)	1.72	0.32	0.27	0.35
CD (5%)	NS	NS	NS	NS

Yield

The data on grain yield, stover yield and harvest index of field pea under different irrigation and nutrient management practices are presented in Table 2.

Effect of irrigation management: Irrigation management exerted a significant influence on grain and stover yield of field pea, while the harvest index remained unaffected. Among the irrigation treatments, three irrigations applied at the branching, flowering, and pod development stages (I_4) recorded the highest grain yield (1458 kg ha^{-1}) and stover yield (2239 kg ha^{-1}), with a harvest index of 38.9%. This treatment (I_4) resulted in a 66.4% higher grain yield and 42.3% higher stover yield compared to no irrigation (I_1), which produced the lowest grain yield (876 kg ha^{-1}) and stover yield (1574 kg ha^{-1}) with a harvest index of 34.4%. The treatment with two irrigations at branching and pod development stages (I_3) also performed well, recording 1167 kg ha^{-1} grain yield and 2008 kg ha^{-1} stover yield, representing 33.2% and 27.6% increases, respectively, over the control (I_1). These results clearly demonstrate that optimum and timely irrigation enhances photosynthate accumulation and translocation, thereby improving overall productivity. Similar findings were reported by Kumar *et al.* (2020) [7] and Patel *et al.* (2019) [16], who observed substantial yield enhancement in mustard with increased irrigation frequency.

Effect of Nutrient Management: Nutrient management treatments also significantly influenced yield and yield attributes of field pea. The treatment comprising 100% RDF + Biofertilizer + Nitrobenzene applied at 30 DAS and pre-flowering stage (N_6) recorded the highest grain yield (1429 kg ha^{-1}) and stover yield (2214 kg ha^{-1}), with a harvest index of 37.9%. This represented a 94.2% increase in grain yield and a 50.6% increase in stover yield over the control (N_1), which produced only 736 kg ha^{-1} grain yield and 1471 kg ha^{-1} stover yield, with a harvest index of 34.8%. Treatment N_6 was also statistically superior to RDF alone (N_2), which yielded 1210 kg ha^{-1} grain and 2004 kg ha^{-1} stover, and 100% RDF + Biofertilizer (N_4), which produced 1186 kg ha^{-1} grain and 2006 kg ha^{-1} stover yield. The improvement under integrated nutrient management can be attributed to enhanced nutrient availability and uptake, improved root activity, and the growth-promoting effect of nitrobenzene, which stimulates flowering and pod setting. These results corroborate the findings of Singh *et al.* (2021) [21] and Yadav *et al.* (2020) [24], who also reported significant yield enhancement under integrated nutrient management practices.

The interaction effects of irrigation and nutrient management were found to be non-significant for grain yield, stover yield, and harvest index, indicating that both factors independently

influenced crop performance. Similar non-significant interactions have been observed in mustard and chickpea by (Meena *et al.*, 2018) [11] and (Sharma *et al.*, 2019) [20].

Table 2: Effect of water and nutrient management practices on grain yield, stover yield and harvest index of field pea

Treatments	Grain yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Harvest index (%)
Irrigation management			
I_1: No irrigation	876	1574	34.4
I_2: 1 Irrigation at Branching stage	939	1720	35.1
I_3: 2 Irrigation at Branching and Pod development stage	1167	2008	36.2
I_4: 3 Irrigation at Branching, Flowering and Pod development stage	1458	2239	38.9
S.Em (±)	36.4	51.6	1.06
CD (5%)	126	182	NS
Nutrient management			
N_1: Control	736	1471	34.8
N_2: RDF (20:50:20 kg NPK ha^{-1})	1210	2004	36.2
N_3: 75% RDF + Biofertilizer	1003	1704	35.6
N_4: RDF + Biofertilizer	1186	2006	36.6
N_5: 75% RDF + Biofertilizer + Nitrobenzene at 30 DAS and at pre- flowering	1096	1913	35.8
N_6: RDF + Biofertilizer + Nitrobenzene at 30 DAS and at pre- flowering	1429	2214	37.9
S.Em (±)	50.6	83.3	1.03
CD (5%)	145	239	NS
Nutrient management at same level of irrigation management			
S.Em (±)	89.2	126	2.6
CD (5%)	NS	NS	NS
irrigation management at same or different level of nutrient management			
S.Em (±)	99.3	160	2.17
CD (5%)	NS	NS	NS

Conclusion

The study revealed that both irrigation and nutrient management significantly influenced the yield-attributing characters and yield of field pea. Three irrigations applied at branching, flowering, and pod development stages (I_4) proved most effective in enhancing yield components and overall productivity. Similarly, the integrated nutrient management treatment (N_6: RDF + Biofertilizer + Nitrobenzene) recorded the highest grain and stover yields, indicating the synergistic benefits of balanced fertilization, biofertilizer inoculation, and growth stimulation. The improvements were mainly due to better soil moisture maintenance, enhanced nutrient uptake, and increased photosynthetic efficiency. Interaction effects between irrigation and nutrient levels were non-significant, suggesting their independent contribution to crop performance. Overall, the combination of timely irrigation and integrated nutrient management offers a sustainable strategy for maximizing field pea productivity

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