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Optimizing pea yield and quality through integrated nutrient management strategy

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Abstract
An experiment was conducted at student research farm, Department of Agronomy, Punjab Agricultural University, Ludhiana, Punjab (India) during 2018-19 and 2019-20 with four treatment combinations randomized in pea *viz.*, 100% NPK to maize (previous season) + 100% NPK to pea, 100% NPK to maize + 100% NPK + FYM @ 20 t ha^{-1} to pea, 100% NPK+ FYM @ 15 t ha^{-1} to maize + 100% NPK to pea and 100% NPK + FYM @ 15 t ha^{-1} to maize + 100% NPK + FYM @ 20 t ha^{-1} to pea. The experiment was conducted in randomized complete block design with three replications. The results revealed that yield attributes *viz.*, pods per plant, pod length, seed per pods and 100 seed weight recorded significantly higher with application of 100% NPK + FYM @ 15 t ha^{-1} to maize + 100% NPK + FYM @ 20 t ha^{-1} to pea during both the years. The pod yield (82.1 and 104.6 q ha^{-1}) and stover yield (157.5 and 193.3 q ha^{-1}) were recorded significantly higher where 100% NPK + FYM @ 15 t ha^{-1} and 100% NPK + FYM @ 20 t ha^{-1} applied to maize and pea during 2018-19 and 2019-20 respectively. Combined application of RDF and FYM to both maize and pea resulted with higher yield and attributes in pea during both the years.

Keywords: FYM, Integrated nutrient management and pod yield

Introduction

Pea (*Pisum sativum* L.) is a major temperate grain legume widely cultivated worldwide. Pea is commonly used in human diet throughout the world and it is rich in protein (21-25%), carbohydrates, vitamin A and C, calcium, phosphorous and has high levels of amino acids "lysine" and "tryptophan" (Bhat *et al* 2013) [1]. Cultivation of green pea maintains soil fertility through biological nitrogen fixation while being in association with symbiotic *Rhizobium* which is present in its root nodules. Thus the crop plays a vital role in fostering sustainable agriculture (Fernandez *et al* 2021) [4]. Legumes are popular components in diversification strategies, as they provide ecological services to other crops, as well as to the environment. Inclusion of legume will promotes the interaction of soil microorganism for legumes to acquire and use efficiently nitrogen and phosphorus, which will reduce the use of mineral-based fertilizers and increase carbon-dioxide sequestration. Because of the high protein content of their seeds, legumes are used both for food and feed. Legumes fix atmospheric N into the soil and increase grain yield of subsequent crop and consequently total SOC in legumes-cereals rotations (Shah *et al* 2011) [13].

Pea plays a significant role in integrated nutrient management (INM) systems by contributing to nitrogen fixation, improving soil fertility and supporting sustainable agricultural practices. It is a leguminous crop capable of forming symbiotic relationships with nitrogen-fixing bacteria called rhizobia. These bacteria reside in nodules on pea roots and convert atmospheric nitrogen into a form that plants can utilize for growth (Siddique and Loss 1999) [14]. This process, known as biological nitrogen fixation, reduces the need for synthetic nitrogen fertilizers, thereby promoting sustainable agriculture practices (Herridge *et al* 1995) [6]. Pea residues, including roots, stems, and leaves, are rich in nitrogen and other nutrients. When these residues decompose, they release nutrients back into the soil, thereby improving soil fertility (Jensen *et al* 2012) [7]. Incorporating pea into INM systems helps balance nutrient uptake and replenishment in the soil, reducing the risk of nutrient imbalances and deficiencies.

This balanced nutrient supply is essential for maintaining crop productivity and soil health INM practices that incorporate pea contribute to environmental sustainability by reducing nitrogen leaching, minimizing greenhouse gas emissions associated with fertilizer production and application and promoting soil health and biodiversity. pea contributes significantly to integrated nutrient management through nitrogen fixation, nutrient recycling, crop rotation, balanced nutrient supply, cost reduction, and environmental benefits. These contributions make pea a valuable component of sustainable agricultural systems.

Materials and Methods

The present investigation was conducted at student research farm, Department of Agronomy, Punjab Agricultural University, Ludhiana during *rabi* season of 2018-19 and 2019-20. The soil of the experimental site is loamy sand and low in available nitrogen, high in phosphorus and medium in potassium. The experiment conducted in randomized complete block design and replicated thrice. Before pea, *kharif* maize was sown with two treatment combinations and after harvesting of *kharif* maize, pea was sown with four treatment combinations randomized into it *viz.*, 100% NPK to maize + 100% NPK to pea, 100% NPK to maize + 100% NPK + FYM @ 20 t ha^{-1} to pea, 100% NPK+ FYM @ 15 t ha^{-1} to maize + 100% NPK to pea and 100% NPK + FYM @ 15 t ha^{-1} to maize + 100% NPK + FYM @ 20 t ha^{-1} to pea. The recommended fertilizer dose applied to pea was 50:62.5:0 kg N:P_2O_5:K_2O ha^{-1}. All the fertilizers were applied as basal dose during sowing.

Weekly mean maximum air temperature during pea ranged between 17.2-31.7 ºC during 2018-19 and 10.4-30.5 ºC during 2019-20. While weekly mean minimum temperature ranged from 2.79-16.2 ºC during 2018-19 and 4.91-16.2 ºC during 2019-20. The weekly mean maximum temperature of 31.7 ºC and weekly mean minimum temperature of 2.79^{0}C were recorded during 42nd and 52nd week of crop season during 2018-19 which are 8.76 ºC higher and 6.2 ºC lower than respective mean maximum and minimum temperature of crop season. The weekly mean maximum temperature of 30.5 ºC and weekly mean minimum temperature of 4.91 ºC were recorded during 43rd and 6th week of crop season during 2019-20 which are 9.9 ºC higher and 4.5 ºC lower than respective mean maximum and minimum temperature of crop season. The minimum value 59.3 and 59.9 percent of weekly mean relative humidity was recorded during 47th and 45th week of crop season during 2018-19 and 2019-20 respectively. The total rainfall, sunshine hours and evapo-transpiration of 144.3, 127.9 mm, 687.0, 613.4 hrs and 218.3, 184.7 mm were recorded during 2018-19 and 2019-20 (Fig. 1 and 2).

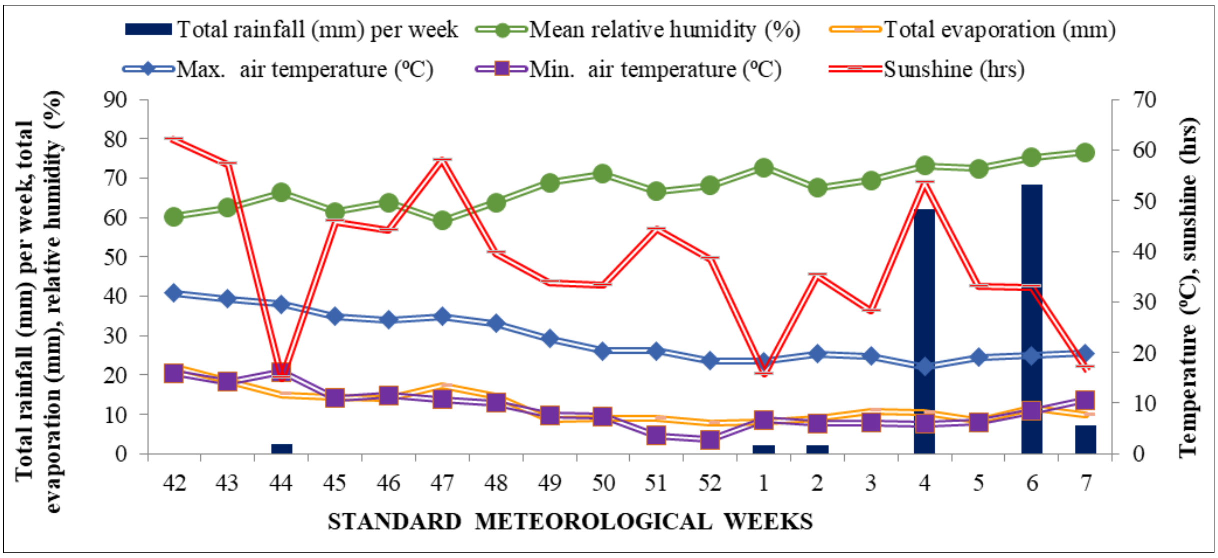

Fig 1: Standard meteorological weather data for pea 2018-19

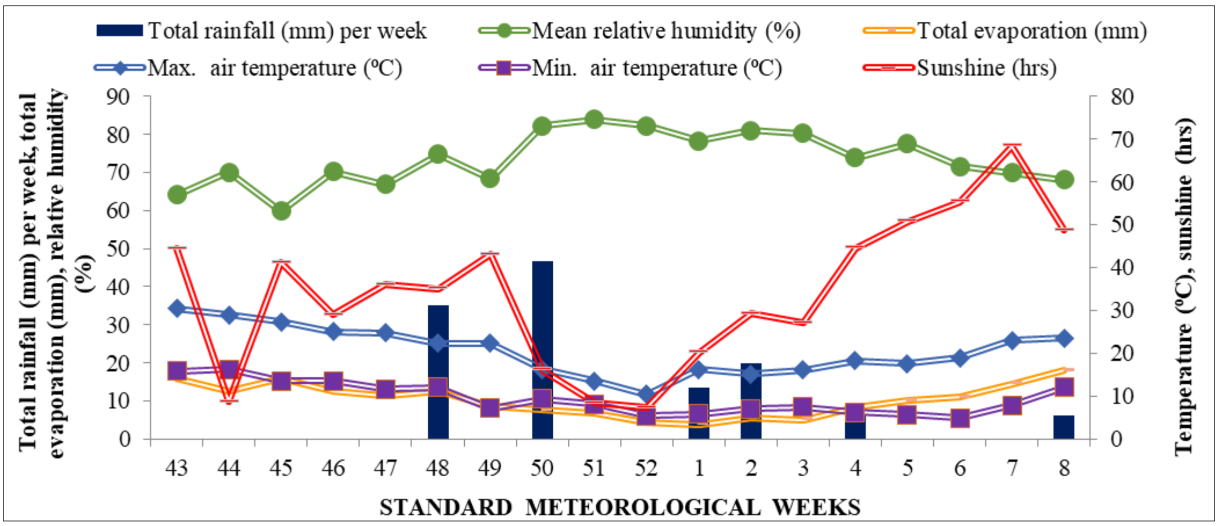

Fig 2: Standard meteorological weather data for pea 2019-20

Number of pods were picked and counted from tagged plants for each picking and at the end of season, the average was expressed as number of pods per plant. Ten pods from each plot were selected randomly during pickings and length of each pod was measured with measuring scale. The average pod length was worked out and expressed in centimeter. Total number of seeds of ten randomly selected pods from each plot was taken and average was expressed as number of seeds per pod. Seed taken for number of seeds per pod were used for 100 seed-weight on fresh weight basis and average 100-seed weight was worked out for each treatment by subtracting the moisture content. The pods per plot were harvested separately and after final picking pods yield per plot was worked out and total yield q ha^{-1} was calculated. Stover obtained from each plot after separating the pods was sun dried for a week and weight was recorded and expressed as q ha^{-1}.

Analysis of variance was performed using procedure proposed by Cochran and Cox (1967) [3]. For analysis of data, statistical package CPCS-1, software was developed by department of Mathematics and Statistics, PAU, Ludhiana. Treatments comparison was made at 5 percent level of significance.

Results and Discussion

Yield attributes

Data in respect to yield attributes of pea *viz.*, pods per plant, pod length, seeds per pod and 100 seed weight were presented in table 1. A scrutiny of the mean data indicated that application of inorganic fertilizers coupled with FYM had a profound effect on all the yield attributes of pea.

Application of 100% NPK + FYM @ 15 t ha^{-1} to maize and 100% NPK + FYM @ 20 t ha^{-1} to pea resulted in maximum number of pods per plant (23.2 and 22.7), pod length (11.2 and 11.4 cm) seeds per pod (9.4 & 9.6) and 100 seed weight (23.9 & 24.8 gm) followed by 100% NPK to maize and 100% NPK + FYM @ 20 t ha^{-1} to pea, which was also statistically at par with 100% NPK + FYM @ 15 t ha^{-1} to maize and 100% NPK + FYM @ 20 t ha^{-1} to pea during both the year. Lowest number of pods per plant, pod length were recorded under treatment which involves 100% NPK application to both maize and pea during 2018-19 and 2019-20. The percent increase in number of pods per plant, pod length, seeds per pod and 100 seed weight under 100% NPK + FYM @ 15 t ha^{-1} to maize and 100% NPK + FYM @ 20 t ha^{-1} to pea was 25.4 & 17.0%, 8.7 & 11.7%, 10.7 & 17.7% and 22.6 & 18.7% over 100% NPK applied to both maize and pea during 2018-19 and 2019-20, respectively. Treatments having combined application of organic and inorganic nutrient resulted with maximum number of pods per plant as compared to sole application of synthetic fertilizer. This may be attributed to greater root extension under integrated nutrient management that might have helped in greater uptake of different macro and micronutrients and enhanced photosynthesis and photosynthates production and ultimately increased number of pods per plant. These results are in conformity with findings of Singh and Singh (2002) [15], Meena *et al* (2007) [9] and Chattoo *et al* (2009) [2] who observed higher number of pods per plant under mixed application of poultry manure and synthetic fertilizers as compared to use of 100% RDF alone in garden pea. Pandey *et al* (2006) [10] and Gopinath and Mina (2011) [5] also reported that integrated nutrient management i.e. application of RDF + FYM recorded maximum pod length than use of RDF alone in garden pea.

Table 1: Effect of nutrient application in preceding *kharif* maize and pea on number of pods per plant and pod length of pea

Nutrient application to preceding maize and pea	Number of pods per plant		Pod length (cm)		Number of seeds per pod		100-seed weight (g)	
	2018-19	2019-20	2018-19	2019-20	2018-19	2019-20	2018-19	2019-20
Maize (100% NPK) + Pea (100% NPK)	18.5	19.4	10.3	10.2	8.4	8.2	19.5	20.9
Maize (100% NPK) + Pea (100% NPK + FYM @ 20 t ha^{-1})	20.2	22.0	10.7	10.7	8.7	8.9	21.9	22.5
Maize (100% NPK+ FYM @ 15 t ha^{-1}) + Pea (100% NPK)	19.2	21.1	10.5	10.4	8.5	8.7	20.6	21.7
Maize (100% NPK + FYM @ 15 t ha^{-1}) + Pea (100% NPK + FYM @ 20 t ha^{-1})	23.2	22.7	11.2	11.4	9.3	9.6	23.9	24.8
CD (p=0.05)	3.0	2.2	0.4	0.6	0.7	0.7	2.9	2.6

Pod yield: Yield is of paramount importance in the field of agriculture as it directly correlated with net returns and benefit cost ratio. A perusal of the data given in table 2 and fig. 3 showed that significantly higher pod yield was recorded (82.1 and 104.6 q ha^{-1}) under treatment which consists application of 100% NPK + FYM @ 15 t ha^{-1} to maize and 100% NPK + FYM @ 20 t ha^{-1} to pea during 2018-19 and 2019-20, respectively and it was on par with the treatment involving application of 100% NPK to maize and 100% NPK + FYM @ 20 t ha^{-1} to pea. During 2018-19 and 2019-20, sole use of synthetic fertilizers i.e 100% NPK application to both maize and pea resulted in minimum pod yield (68.6 and 82.9 q ha^{-1}). The increase in pod yield up to a margin of 19.7 and 26.1% was observed under application of 100% NPK + FYM @ 15 t ha^{-1} to maize and 100% NPK + FYM @ 20 t ha^{-1} to pea during 2018-19 and 2019-20, respectively, over 100% NPK applied to both maize and pea. This may be due to the fact that initially the chemical fertilizers provided rapidly better nutrition with all essential nutrients and their uptake by the plant which leads to better plant growth. In latter stages, the required plant nutrients are provided through decomposed organic manures for better development of the plants which in turn resulted into higher yield of the crop. These findings are in agreement with those of Kumari *et al* (2012) [8], Sepehya *et al* (2012) [12] and Pawar *et al* (2017) [11] who reported higher pod yield under integrated application of organic manure and synthetic fertlizers in garden pea.

Table 2: Effect of nutrient application in preceding *kharif* maize and pea on pod yield and stover yield of pea

Nutrient application to preceding maize and pea	Pod yield (q ha^{-1})		Stover yield (q ha^{-1})	
	2018-19	2019-20	2018-19	2019-20
Maize (100% NPK) + Pea (100% NPK)	68.6	82.9	114.0	145.0
Maize (100% NPK) + Pea (100% NPK + FYM @ 20 t ha^{-1})	74.6	93.3	144.8	182.3
Maize (100% NPK+ FYM @ 15 t ha^{-1}) + Pea (100% NPK)	70.8	84.7	135.9	152.0
Maize (100% NPK + FYM @ 15 t ha^{-1}) + Pea (100% NPK + FYM @ 20 t ha^{-1})	82.1	104.6	157.5	193.3
CD (p=0.05)	8.1	11.8	25.8	24.6

Stover yield

The data given in table 2 and fig. 3 revealed that integrated application of organic and inorganic nutrients significantly influence the stover yield of pea. Conjoint application of organic and synthetic fertilizer i.e. 100% NPK + FYM @ 15 t ha^{-1} to maize and 100% NPK + FYM @ 20 t ha^{-1} to pea resulted in significantly higher stover yield (157.5 and193.3 q ha^{-1}) in comparison to 100% NPK application to both maize and pea, but it was statistically at par with 100% NPK application to maize and 100% NPK + FYM @ 20 t ha^{-1} to pea during both the years. With application of 100% NPK + FYM @ 15 t ha^{-1} to maize and 100% NPK + FYM @ 20 t ha^{-1} to pea, the increase in stover yield was 38.2 and 33.3% as compared to 100% NPK applied to both maize and pea during 2018-19 and 2019-20, respectively. During both years, 100% NPK application to both maize and pea resulted in the lowest stover yield (114.0 and 145.0 q ha^{-1}). Higher stover yield in integrated nutrient management was due to better nutrient and water availability leads to better plant height, dry matter accumulation and leaf area of the plant which ultimately recorded higher stover yield. Pawar *et al* (2017) [11] also reported higher growth of the plant and stover yield with combined application of organic fertilizers along with chemical fertilizers as compared to sole use chemical fertilizers.

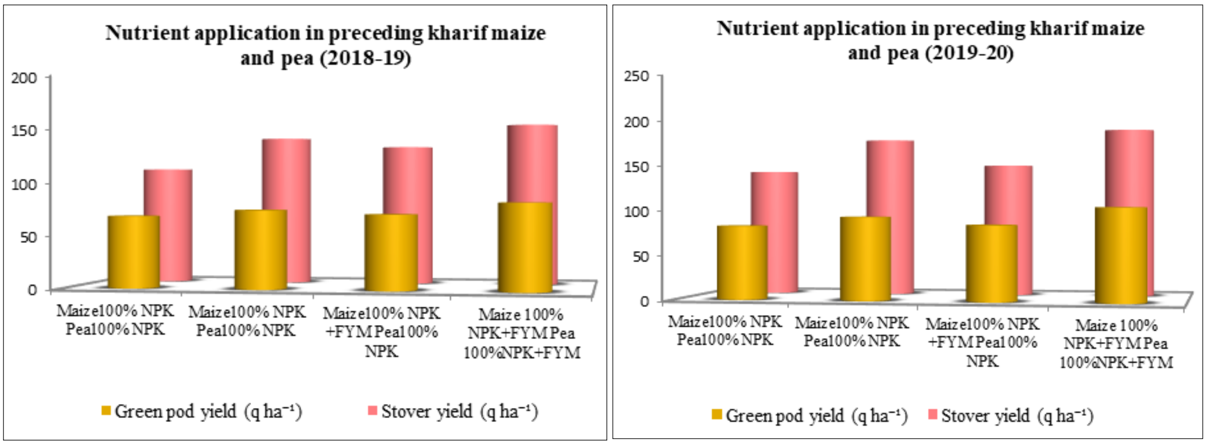

Fig 3: Effect of nutrient application in preceding maize and pea on pod and stover yield of pea

Conclusion

Based on the findings it can be concluded that integrated application of recommended dose of fertilizer and farm yard manure to the crops resulted with significant increase is yield and yield attributes of pea as compared to sole application of synthetic fertilizer.

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