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Rationalization of Bio-slurry and Chemical Fertilizer Combinations for Growth and Pod Yield of Pea (*Pisum sativum* L.) under two Growing Seasons

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ABSTRACT: Because of its widespread appeal as a healthy vegetable, pea (*Pisum sativum* L.) is one of the world's best - known grain legumes in the temperate region. Cultivation of exhaustive crops and continuous use of inorganic fertilizers disturbs soil solution concentrations and depresses microbial growth that leads to poor plant growth and yield. This specific problem could be mitigated by crop rotation practices and use of organic fertilizers especially legumes (biological source of N) to improve soil health. Incorporation of organic fertilizers into soil causes a large and rapid increase in the soil microbial biomass which plays an important role in nutrient cycling and plant nutrition, due to its fast turnover. In this field experiment conducted at Department of Horticulture, Gomal University, D. I. Khan, Pakistan, and the objective of the study was to check the effect of bio-slurry and chemical fertilizer (NPK) on Pea growth and pod yield. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications for two consecutive years 2016-17 and 2017-18. In control plots, minimum days taken for emergence (5.66 days) were noted during 2016-17, while maximum days to emergence (7.11 days) and maximum days to flowering ((49.05)) were taken in NPK @ 100:225:225 kg ha-1 + 8 t ha-1 bio-slurry. Maximum plant height (67.96 cm), N^{PP} (25.67), W^{PP} (59.60 g), P^{L} (6.45 cm), P^{W} (1.70 cm), N^{GP} (6.67), 100 ^{GW} (52.70 g) and the most remarkable P^{Yha} (9.43 t ha^{-1}) was shown in plot receiving 60:135:135 kg ha^{-1} + 8 t ha^{-1}bio-slurry. In 2017-18, NPK @ 100:225:225 kg ha^{-1} + 8 t ha^{-1} bio-slurry delayed germination (7.08) and flowering (49.17). It is concluded that during both the years, treatments impacted growth and yield in the order of 60:135:135 kg ha^{-1}>40:90:90 kg ha^{-1} + 6 t ha^{-1} > 80:180:180 kg ha^{-1} + 8 t ha^{-1}> 100:225:225 kg ha^{-1}+ 8 t ha^{-1}. It was evident from the results that organic and inorganic fertilizer combinations showed better yield over singlet use of inorganic fertilizer. Hence, it is highly recommended that bio-slurry should be incorporated in soil in combination with chemical fertilizers for sustainable crop production.

Keywords: Fertilizer, NPK, Bio-slurry, Yield and Growth, *Pisum sativum*. L

I. INTRODUCTION

During the era of Green Revolution, introduction of high-yielding varieties, expansion of cultivation area, utilization of high inorganic NPK fertilizers and increase in cropping intensity made Pakistan self-sufficient in food production. But it started a race of utilizing more synthetic fertilizers and natural composts were replaced. Injudicious use of inorganic fertilizers started negatively impacting soil physical heath and soil microbial imbalance [1]. C: N ratio is an important criterion to guess nitrogen availability to plants and biogas slurry balances this ratio which ultimately leads to help plants uptake nitrogen. During the last two or three decades, although heavy application of chemical fertilizers boosted yield and crop productivity, but their use has reduced soil properties and crop yields over time [2] while, the organic fertilizer alone or in combination with chemical fertilizers has positive effects in maintaining the soil properties. Such concerns and issues presented by reduced agricultural productivity brought forth new ideas in agriculture, for example, natural farming, distinctive cultivation, biodynamic agriculture, and eco-friendly agricultural practices (FAO, 1999). It is reported in previously conducted studies that soil fertility is declining in irrigated areas of Pakistan that will put sustainable crop production at stake and consequently, lesser food will be produced and country will be food insecure [3,4]. It is imperative to ensure sustainable crop production by using eco-friendly techniques without sacrificing yield [5]. Crop yield is the inter-play of genetic, environmental and management factors. Among management factors, application of balanced fertilizer is key component that increases vegetative as well as reproductive growth leading to high productivity and standard of the produce [6]. Fertilizers make up a basic contribution to current farmhouse innovation in upgrading crop yields by improving crop growth, development and improving soil fertility [5]. Wise and adjusted utilization of fertilizers have assumed a key task in reasonable improvement of agriculture [7]. A pragmatic use of organic fertilizers and bio-manures alongside synthetic fertilizers is successful for continuing produce efficiency and enhancing soil fertility [8]. Besides, organic manures improve the water holding capacity, root proliferation and effectiveness of synthetic fertilizers that ultimately leads to more productivity [9]. Balanced use of fertilizers improves soil physical properties, sustainable crop production and yield higher economic benefits [10, 11]. It was reported that crop yield increases as the rate of fertilizer application increases but at compensation point yield starts to decline that could be maintained by application of bioactive fertilizers like biogas slurry [12].

It is previously reported by researchers that fertilizers increase pea yield and its contributing traits many folds. Chemical fertilizer combination (20:80:50 NPK kg ha-1) enhanced plant growth and pod yield [13], and if potassium was skipped by only applying NP at the rate of 25:50 kg ha^{-1}[14], 69:100 PK kg ha^{-1}[15, 16] did not affect yield. In a study, only nitrogen fertilizer was applied at the rate of 80 kg ha^{-1} in two split doses i.e. 1/4 at sowing and 3/4 at flowering and got maximum pod yield [17, 18] hence, it may be concluded that most demanded supplements for higher pea production were N and P. [19] combined variable portions of N (0, 25, 50, 75, 100, 125 kg ha-1) with basal portion of PK 60:40 kg ha^{-1} and revealed most noteworthy results for all the traits with 100 kg ha^{-1} N. [20] evaluated variable rates of P (0, 25, 50, 75, 100 kg ha-1) with basal portion of NK @ 10:90 kg ha^{-1} on various ranges and accomplished the most noteworthy yield and yield contributing traits with most astounding portion of P (100 kg ha^{-1}) for off-season pea production.

Some researchers such as [21-25] have reported the most incredible pea yields with the integrated usage of NPK with organic manures. Like numerous crops, the development of peas is extensively based on supplement availability. By cultivating high producing, insect, and pest resistant cultivars along with balanced and careful use of crop supplements, the per hectare production of peas can be increased. All the modern cultivars of pea have higher genetic potential to produce better yield but due to lack of input, their actual yield is much lower than potential yield. The difference between yield potential and real yield could be maintained by applying organic and inorganic fertilizer combination [1]. Present research was aimed to explore the yield potential of pea by applying variable combinations of organic and inorganic fertilizers.

II. MATERIALS AND METHODS

Present research was carried out in Gomal University, D. I. Khan, Pakistan during two normal growing seasons i.e. 2016-17 and 2017-18. The first and second growing seasons are referred to as Y^1 and Y^2. All the experimental material was managed in triplicate randomized complete block design (RCBD). Cultural practice and plant protection practices were adopted as per Pakistan Agriculture Department recommendation. Experiment was comprised of following treatments T_1: Control (00:00:00), T_2: 25% SDF (10:22.5:22.5 NPK kg ha^{-1}) + 8 t ha^{-1}, T_3: 50% SDF (20:45:45 NPK kg ha^{-1}) +8 t ha^{-1}, T_4: 100% SDF (40:90:90 NPK kg ha^{-1}) + 8 t ha^{-1}, T_5: 150% SDF (60:135:135 NPK kg ha^{-1}) + 08 t ha^{-1}, T_6: 200% SDF (80:180:180 NPK kg ha^{-1}) + 8 t ha^{-1}, T_7: 250% SDF (100:225:225 NPK kg ha^{-1}) + 8 t ha^{-1}. Phosphorus, potassium, bio-slurry and half of nitrogen were mixed in soil while seed bed preparation while rest of nitrogen was incorporated after 30 days of sowing. Net plot estimate was kept as 2.4m x 4.5m making total area of 226.8 m^2. Seed of variety (Climax) was collected from Ayub Agriculture Research Institute (AARI) Faisalabad and treated with fungicide to avoid soil born diseases. After overnight soaking, seed was sown on 25th September, 2016 while the next experiment was planted on 20th September 2017. First irrigation was applied soon after seed sowing while the next irrigations were planned according to crop water requirement. In all treatments, uniform field activities were maintained during experimentation. At maturity, data were collected from 10 selected plants of each replication for following traits. Morphological and yield parameters were included days taken to emergence (D^E), days to flower initiation (F^I), plant height (cm, P^H), pods $plant^{-1}$ (P^P), fresh pods weight $plant^{-1}$ (g, P^{WP}), pod length (cm, P^L), pod width (cm, P^W), number of grains pod^{-1} (NG^P), 100-grains weight (g, G^W) and pod yield (t ha^{-1}, P^Y). Collected data were analyzed by analysis of variance technique as described by [26] and further, significant traits were analyzed by Least Significant Difference (LSD) for comparison of treatment means.

III. RESULTS AND DISCUSSION

A. Days to emergence (D^E)

Various NPK and bio slurry doses have a major impact on the days of development during Y1 and Y2. The evidence that has days to emerge is described in the (Fig. 1). During Y1, the check plots reported slightly less time taken for evolution (5.66 days) when the more time needed for advancement (7.11 days) was found in the therapy obtaining NPK@100:225:225 kg ha^{-1} + 08 tha^{-1}. Almost similar resulted noted during Y^2, minimum days taken for emergence in check plot with 6.05 whereas the maximum days taken for germination in NPK @ 100:225:225 kg ha^{-1} + 08 t ha^{-1}. The outcome demonstrated indicated that larger amount of NPK are in charge of deferring the emergence. Both the years were taken into consideration for time taken to germination. In spite of these outcomes [16] revealed prior germination with the increased rates of P application.

B. Days to flowering (D^F)

Days taken to start of flower compared with untreated plots were also positively affected by the Bio-slurry and chemical fertilizers combinations (Fig. 1). During Y^1, maximum days taken to the emergence of flower (49.05) were appeared in NPK @ 100:225:225 kg ha^{-1} + 08 t ha^{-1} followed by 80:180:180 + 10 t ha^{-1} and 60:135:135 kg ha^{-1} + 08 t ha^{-1} taking 48.32 and 48.13 days, respectively and all these treatments were statistically at par. The control plots took minimum days for flowering (43.26 days) that differed significantly from all other treatments. During Y^2, the maximum days taken to flowering (49.17) were observed in the plot with NPK @ 100:225:225 kg ha^{-1} + 08 t ha^{-1} while the minimum days taken (42.16) in control plot. Nitrogen fertilizers are reported to promote vegetative growth and delay reproductive growth but most importantly, it was observed nitrogen before or at anthesis delayed fruiting. The findings showed that with higher NPK usage levels, blooming was delayed. In comparison to these observations, [17] observed no important impact on the time taken for flowering with split application of N.

C. Plant Height (cm)

Plant height (cm, P^H) of pea was effectively influenced by the variable rates of NPK as presented in (Table 2). In Y^1, the tallest plants (67.96 cm) were seen in treatment getting NPK @ 60:135:135 kg ha^{-1} + 08 t ha^{-1}followed by 80:180:180 kg ha^{-1} + 08 t ha^{-1} and 100:225:225 kg ha^{-1} + 8 t ha^{-1} with plant height of 67.23 and 66.62 cm, respectively. Minimum plant height (25.00 cm) was found in control considerably different by 10:22.5:22.5 kg ha^{-1} + 08 t ha^{-1} and 20:45:45 kg ha^{-1} + 08 t ha^{-1} with 41.35 and 54.31 cm height, respectively. During Y^2, maximum plant height (69.15 cm) was observed in plots getting 60:135:135 kg ha^{-1} + 08 t ha^{-1}followed by plants treated with 80:180:180 kg ha^{-1} + 08 t ha^{-1}, 100:225:225 kg ha^{-1} + 08 t ha^{-1} and 40:90:90 kg ha^{-1} + 08 t ha^{-1} where height was noted as 68.78, 68.33 and 67.59 cm, respectively and all these four treatments were statistically similar. Lower plant height (27.00 cm) was noted in control plot followed by 10:22.5:22.5 kg ha^{-1} + 08 t ha^{-1} and 20:45:45 kg ha^{-1} + 08 t ha^{-1} with 45.22 and 60.85 cm, respectively. Findings presented that the plant development and size could be improved by applying various rates of NPK + Bio slurry. The higher the NPK rates were, the most vigorous the growth was. Although, the plants getting the most elevated rates of NPK were tallest, yet these were weak and slender which means that nitrogenous fertilizers promote vegetative growth, but stem stiffness is not achieved. Use of NPK along with biogas-slurry maintained growth as well as quality of growth and development. Plots getting fertilizer doze at the rate of 60:135:135 kg ha^{-1} + 08 t ha^{-1} showed better performance. It could be reported that combination of organic and inorganic nutrients improved vegetative growth of plants. Our results are similar to the findings of [13, 14, 15, and 17]who additionally reported that organic and inorganic fertilizer combinations not only improved growth but also enhanced the nutrient uptake of plants.

D. Number of Pods plant^{-1} (N^{PP})

Results regarding number of pods per plant showed that both organic as well as inorganic fertilizers significantly affected pod yield during both seasons (Table 1). In Y^1, the plants getting 60:135:135 kg ha^{-1} + 8 t ha^{-1} had the greatest number of pods per plant (25.67) followed by 40:90:90 kg ha^{-1} + 08 t ha^{-1}, 80:180:180 kg ha^{-1} + 08t ha^{-1}, 100:225:225 kgha^{-1} + 08 tha^{-1} and 20:45:45 kgha^{-1} + 08 t ha^{-1} with 25.00, 24.67, 24.33 and 20.00 N^{PP}, respectively. Nevertheless, every one of these treatments were statistically different with minor differences that may be due to soil fertility patches. Minimum N^{PP} were produced in control treatment followed by plot getting 10:22.5:22.5 kg ha^{-1} + 08 t ha^{-1} with 15.00 N^{PP}.

During Y^2, number of N^{PP} differed to 26.67 being most extreme in 60:135:135 kg ha^{-1} + 8 t ha^{-1}, which was followed by 40:90:90 + 08 t ha^{-1}, 80:180:180 + 08 t ha^{-1}, 100:225:225 + 08 t ha^{-1} and 20:45:45 kg ha^{-1} + 08 t ha^{-1} with 26.00, 25.33, 25.00 and 21.00 N^{PP}, respectively and all these five treatments were statistically similar. The plants producing least N^{PP} were significantly like plants of 10:22.5:22.5 kg ha^{-1} and 20:45:45 kg ha^{-1} having 16.67 and 21.00 N^{PP}, respectively. The results confirmed that pod number was expanded with augmentation in nutrients levels and highest pods were recorded in NPK at 60:135:135 kg ha^{-1} + 8 t ha^{-1}. It is evident from the information that nutrients application accelerates the flowering and produces more pods. In addition, [27] portrayed that the nitrogen is the key nutrient in plant production that not only improves vegetative growth but also promotes assimilate accumulation while Phosphorus is associated with pod yield[28] and potash improves quality of fruit. Present findings are correlated with those of [13, 14, 29, 30] who reported that different doses of NPK fertilizers promote plant growth and yield compared with untreated control.

E. Weight of fresh pods plant^{-1} (g)

Use of NPK and biogas slurry mixture at various concentrations significantly ($P< 0.05$) inclined the weight of fresh pods plant^{-1} (W^{PP}) in both years (Y^1 and Y^2) (Fig. 2). In Y^1, the measurably most maximum W^{PP} (59.60 g) was accounted for treatments NPK 60:135:135 kg ha^{-1} + 08 t ha^{-1} , 40:90:90 kg ha^{-1} + 08 t ha^{-1}, 80:180:180 kg ha^{-1} + 08 t ha^{-1} and 100:225:225 kg ha^{-1} + 08 t ha^{-1} with 58.61, 58.45 and 58.30 g W^{PP}, respectively. All the treatments statistically similar results. Most minimal W^{PP} was shown in 10:22.5:22.5 kg ha^{-1} + 08 t ha^{-1} and 20:45:45 kg ha^{-1} + 08 t ha^{-1} with 30.30 and 41.44 g W^{PP} showing significant variability. The most astounding W^{PP} (62.73 g) was accounted for treatment 60:135:135 kg ha^{-1} + 08 t ha^{-1}similar to 40:90:90 kg ha^{-1} + 8 t ha^{-1}, 80:180:180 kg ha^{-1} + 08 t ha^{-1} and 100:225:225 kg ha^{-1} + 08 t ha^{-1} with 61.75, 61.55 and 61.13 g W^{PP}, respectively. Minimal W^{PP} (25.25 g) was depicted in control pursued by statistically different 10:22.5:22.5 kg ha^{-1} + 08 t ha^{-1} and 20:45:45 kg ha^{-1} + 08 t ha^{-1} with 33.50 and 45.53 g, respectively. The results demonstrated that NKP when mixed with biogas slurry in different dozes impressively improved the W^{PP}, indicating the role of biogas slurry in pod yield improvement. Previously researchers pointed out similar results when they applied organic fertilizers in different dozes along with organic manures [13, 15, 17, and 22].

F. Pod Length (cm)

Pod length (P^L) showed variable response to the rates of NPK used as depicted in (Fig. 2). Data calculated during Y^1 showed that P^L (cm) impressive results and differential response was shown in various application of NPK and Bio-slurry. Highest P^L (6.45 cm) was shown in plants amended with 60:135:135 kg ha^{-1} + 08 t ha^{-1} in all respects intently followed by 80:180:180 kg ha^{-1} + 08 t ha^{-1},100:225:225 kg ha^{-1} + 08 t ha^{-1} and 40:90:90 kg ha^{-1} + 08 t ha^{-1} which had fundamentally identical pod length of 6.40, 6.30 and 6.25 cm, respectively. The plants in control plot contained smaller P^L (3.50 cm) followed by 10:22.5:22.5 kg ha^{-1} + 08 t ha^{-1} and 20:45:45 kg ha^{-1} + 08 t ha^{-1} NPK with 4.12 and 5.54 cm long pods, respectively. In Y^2, the highest pods (6.52 cm) were accounted for in plants provided with 60:135:135 kg ha^{-1} + 08 t ha^{-1} NPK, 80:180:180 kg ha^{-1} + 08 t ha^{-1}, 100:225:225 kg ha^{-1} + 08 t ha^{-1} and 40:90:90 kg ha^{-1} + 08 t ha^{-1} with of 6.48, 6.40, and 6.37 cm long separately. The plants developed in control plot produced smaller pods (3.75 cm), followed by 10:22.5:22.5 kg ha^{-1} + 08 t ha^{-1} and 20:45:45 kg ha^{-1}+ 08 t ha^{-1} creating 4.50 and 5.75 cm long pods, respectively. The results demonstrated that consolidation of nutrients significantly improved the length of pods which expanded with addition in nutrients levels up to 150% RDF (NPK @ 60:135:135 kg ha^{-1} + 08 t ha^{-1}) and afterward declining pattern was watched. The outcome demonstrated that utilization of 60:135:135 kg ha^{-1} + 08 t ha^{-1} NPK could be the discretionary and affordable NPK portion to get most extreme pod length (cm) and it may drive to the potential capacity of the cultivar. Moreover, [15, 16, 19, 32] detailing most astounding qualities for pod length with suggested dosages of nutrients.

G. Pod Width (cm)

Inorganic and organic fertilizer combinations significantly (P< 0.05) improved the pod width P^W during two growing years (Y^1& Y^2) (Table 2). In Y^1, the greatest P^W (1.70 cm) was observed in the two plots 60:135:135 kg ha^{-1} + 08 t ha^{-1} and 40:90:90 kg ha^{-1} + 08 t ha^{-1}whereas plots getting fertilizer combinations 80:180:180 kg ha^{-1} + 08 t ha^{-1} and 100:225:225 kg ha^{-1} + 08 t ha^{-1} were statistically at par showing 1.60 and 1.50 cm P^W, respectively. Later two treatment (80:180:180 kg ha^{-1} + 08 t ha^{-1} and 100:225:225 kg ha^{-1} + 08 t ha^{-1}) also correlated with treatment 20:45:45 kg ha^{-1}having 1.56 cm width while 100:225:225 kg ha^{-1} + 14 t ha^{-1} and 20:45:45 kg ha^{-1} + 6 t ha^{-1} and were similar to 10:22.5:22.5 kg ha^{-1} + 4 t ha^{-1} having pods of 1.40 cm width. In Y^2, plants getting treatment 60:135:135 kg ha^{-1} + 08 t ha^{-1} had pods of most prominent width (1.80 cm) that varied from other treatment with the exception of 40:90:90 kg ha^{-1} + 08 t ha^{-1}which created P^W of 1.72 cm. The 40:90:90 kg ha^{-1} + 08 t ha^{-1} was significantly similar 80:180:180 kg ha^{-1} + 08 t ha^{-1} (1.65 cm) unit width which thusly was essentially indistinguishable to 100:225:225 kg ha^{-1} + 08 t ha^{-1} and 20:45:45 kg ha^{-1} + 08 t ha^{-1}, both containing 1.60 cm and 1.60 cm respectively. The plants from control plot had pods of littlest width (1.30 cm) trailed by 10:22.5:22.5 kg ha^{-1} + 08 t ha^{-1} (1.45 cm) and the two medicines fluctuated altogether.

The results showed that utilization of nutrients improved the P^W and most significant value were observed with the use of 60:135:135 kg ha^{-1} + 08 t ha^{-1} while nutrients levels more higher than 60:135:135 kg ha^{-1} + 08 t ha^{-1}neglected to deliver pods of significantly more prominent width than 60:135:135 kg ha^{-1} + 08 t ha^{-1}, thus it could be recommended that use of nutrients in the range of 60:135:135 kg ha^{-1}+ 08 t ha^{-1}would prompt yield. Previously findings reported similar results when inorganic fertilizers were used in different combinations [15, 19, 32, and 33].

H. Number of Grains pod^{-1}

Significant difference (P<0.05) was seen in N^{GP} with the application of NPK in different combinations during the two years (Table 3). In Y^1, the most superior N^{GP} (6.57) was enlisted in 60:135:135 kg ha^{-1} + 08 t ha^{-1} all around intently followed by 40:90:90 kg ha^{-1} + 8 t ha^{-1}, 80:180:180 kg ha^{-1} + 12 t ha^{-1} and 100:225:225 kg ha^{-1} + 14 t ha^{-1} with 6.33, 6.33 and 6.00 N^{GP}, respectively and all these four treatments were statistically similar. The 100:225:225 kg ha^{-1} + 08 t ha^{-1} was likewise statistically much the same as 20:45:45 kg ha^{-1} + 08 t ha^{-1} which delivered 4.33 N^{GP}. The minimal pod count (2.67) was showed in unfertilized plants that was statistically like 10:22.5:22.5 kg ha^{-1} and 20:45:45 kg ha^{-1} with 3.67 and 4.33 N^{GP}, respectively.

During Y^2, the most excessive N^{GP} (6.90) was delivered in plants organized with 60:135:135 NPK kg ha^{-1}+ 08 t ha^{-1}, all around intently prevailing by 40:90:90 kg ha^{-1}+ 08 t ha^{-1}, 80:180:180 kg ha^{-1} + 08 t ha^{-1} and 100:225:225 kg ha^{-1}+ 08 t ha^{-1} with 6.67, 6.33 and 6.33 N^{GP}, respectively and all these four treatments were factually similar. These were trailed by 20:45:45 kg ha^{-1} + 08 t ha^{-1} and 10:22.5:22.5 kg ha^{-1}+ 08 t ha^{-1} with 4.67 and 4.00 N^{GP}, respectively, which were at standard with one another. The least N^{GP} (3.00) was observed from check plants, which was statistically like 10:22.5:22.5 kg ha^{-1}+ 08 t ha^{-1}.

The data demonstrated that utilization of nutrients extensively prolonged the quantity of grains per unit proposing that nutrients supported the development of plants and improved the N^{GP}. Plants accepting 60:135:135 NPK kg ha^{-1} + 08 t ha^{-1} created the most astounding number of grains per while the grain include in treatments receiving nutrients past this rate were factually at par, proposing that utilization of largest amounts of nutrients isn't attainable. As per these outcomes, [31, 32] recorded improvement in number of grains per pod because of utilization of large-scale nutrients.

I. 100-grains weight (g)

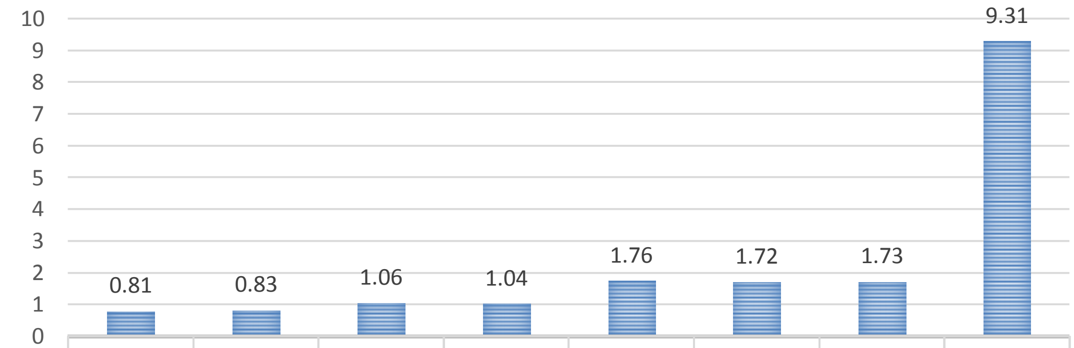
Data relating to 100-grains weight (100^{GW}) deciphered that use of various portions of NPK significantly expanded test weight (Table 3). In Y^1, the greatest 100^{GW} (52.70 g) was accounted for in treatment getting 60:135:135 kg ha^{-1} + 08 t ha^{-1}, prevailing by 40:90:90 kg ha^{-1}+ 08 t ha^{-1} and 80:180:180 kg ha^{-1}+ 08 t ha^{-1} with 100^{GW} of 50.80 and 49.92 g, respectively where the two treatment were statistically at par. In any case, 80:180:180 kg ha^{-1}+ 08 t ha^{-1} thusly was likewise fundamentally like 100:225:225 kg ha^{-1}+ 08 t ha^{-1} with 48.95 g weight. Every other treatment contrasted from one another. The least 100^{GW} (30.25 g) was found in unfertilized treatment control.

During Y^2, comparative pattern of results was recorded for year Y^1. Excessive 100^{GW} (54.20 g) was noted in 60:135:135 kg ha^{-1}+ 8 t ha^{-1} that outperformed all treatments. Its supplanted by factually identical 40:90:90 kg ha^{-1}+ 08 t ha^{-1} and 80:180:180 kg ha^{-1}+ 08 t ha^{-1} with 100^{GW} of 51.50 and 50.60 g, respectively which thusly was additionally similar to 100:225:225 kg ha^{-1}+ 08 t ha^{-1}. Factually, different 100^{GW} was seen in 20:45:45 kg ha^{-1}+ 08 t ha^{-1} and 10:22.5:22.5 kg ha^{-1}+ 08 t ha^{-1} NPK with 47.10 and 40.10 g, respectively. Minimal reaction for 100^{GW} was recorded in control plants with 31.00 g.

The outcomes concealed that use of NPK at various rates astoundingly improved the 100^{GW} and most elevated values were seen with NPK at 60:135:135 kg ha^{-1}+ 08 t ha^{-1} beyond this utmost, declining pattern for 100^{GW} was recorded with an expansion in NPK levels. The improvement in 100^{GW} may be because of arrangement of development and yield advancing supplements in satisfactory amount. The most elevated amounts of nutrients did not expanded load past 150% RDF. In concurrence with these outcomes [15, 16, and 19] likewise detailed upgrade in 100^{GW} of peas with various rates of inorganic and natural excrements.

J. Pod Yield (t ha^{-1})

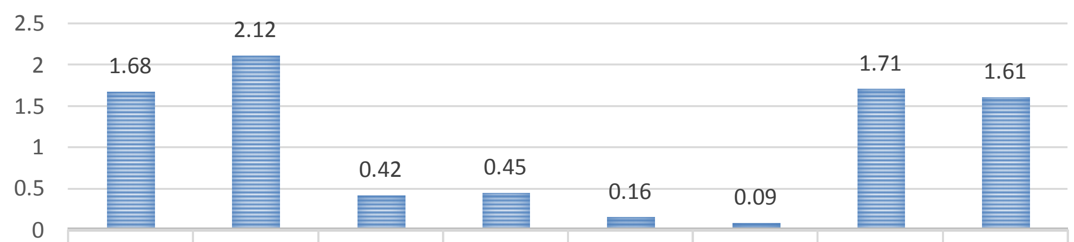
Data regarding P^{YHa} as influenced by use of variable dimensions of NPK are represented in (Fig. 2). The examination of table shows significant difference among the treatment. In Y^1, the most remarkable P^{Yha} (9.43 t ha^{-1}) was enrolled in treatment accepting NPK at 60:135:135 kg ha^{-1} + 08 t ha^{-1} that was differed altogether.



	DE		DF		PH (cm)		NPP	
	Y1	Y 2	Y 1	Y2	Y1	Y 2	Y 1	Y2
	7.11a	7.08 a	49.05 a	49.17 a	66.62 ab	68.33 ab	24.33 b	25.00 abc
	7.07ac	6.93 ab	48.32 ab	48.17 b	67.23 ab	68.78 a	24.67 b	25.33 abc
	6.86 ab	6.33 abc	48.13 ab	46.34 b	66.97 a	69.15 a	25.67 a	26.67 a
	6.98 bc	6.33 abc	45.26 b	45.31bc	66.02 b	67.59 a	25.00 b	26.00 ab
	7.01 bc	6.33 abc	45.26 b	43.32 ab	54.31 c	60.85 b	20.00 c	21.00 abcd
	7.03 ab	6.00 ab	44.53 b	42.93 bc	41.35 d	45.25 c	15.00 d	16.67 cd
	5.66 c	6.05 c	43.26 c	42.16 c	25.00 e	27.00 d	10.00 e	12.00 d
LSD at P0.05	0.81	0.83	1.06	1.04	1.76	1.72	1.73	9.31

Mean followed by similar letter(s) do not differ significantly at 5% level of significance.
D^E = Days to emergence, D^F = Days to flowering, P^H = Plant height (cm), N^{PP} = Number of pods/ plant, Y^1 = Growing season 2016-2017, Y^2 = Growing season 2017-18

Fig. 1. Rationalization of bio-slurry and chemical fertilizer effect on pea in two growing seasons.



	WPP		PL (cm)		PW (cm)		NGP	
	Y1	Y 2	Y 1	Y2	Y1	Y 2	Y 1	Y2
	58.30 a	61.13 a	6.30 a	6.40 a	1.50 bc	1.60 c	6.00 ab	6.33 a
	58.45 a	61.55 a	6.40 a	6.48 a	1.60 ab	1.65 bc	6.33 a	6.33 a
	59.60 a	62.73 a	6.45 a	6.52 a	1.70 a	1.80 a	6.67 a	6.90 a
	58.61 a	61.75 a	6.25 a	6.37 a	1.70 a	1.72 ab	6.33 a	6.67 a
	41.44 b	45.53 b	5.54 b	5.75 b	1.56 abc	1.60 c	4.33 bc	4.67 b
	30.30 c	33.50 c	4.12 c	4.50 c	1.40 c	1.45 d	3.67 c	4.00 bc
	23.50 d	25.25 d	3.50 d	3.75 d	1.20 d	1.30 e	2.67 c	3.00 c
LSD at P0.05	1.68	2.12	0.42	0.45	0.16	0.09	1.71	1.61

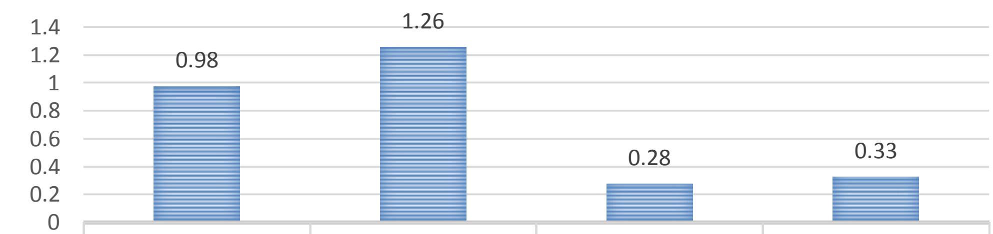
Mean followed by similar letter(s) do not differ significantly at 5% level of significance.
W^{PP} = Weight of pods/ plant (gm), P^L = Pod length (cm), P^W = Pod width (cm), N^{PP} = Number of grains/ plant, Y^1 = Growing season 2016-2017, Y^2 = Growing season 2017-18

Fig. 2. Rationalization of bio-slurry and chemical fertilizer effect on pea in two growing seasons.

It was prevailing by fundamentally comparative 40:90:90 kg ha^{-1} + 08 t ha^{-1}, 80:180:180 kg ha^{-1} + 08 t ha^{-1}and 100:225:225 kg ha^{-1} + 08 t ha^{-1} with 9.04, 8.83 and 8.76 P^{Yha}, respectively and all these three treatment got factually similar yields. The most minimal P^{Yha} (2.89 t ha^{-1}) was seen in control supplanted by 10:22.5:22.5 kg ha^{-1} + 08 t ha^{-1} and 20:45:45 kg ha^{-1} + 08 t ha^{-1} with P^{Yha} of 4.76 and 6.62 t ha^{-1}, respectively.

During Y^2, most significant P^{Yha} (9.62 t ha^{-1}) was accomplished with 60:135:135 NPK kg ha^{-1} + 8 t ha^{-1}, which differed fundamentally, trailed by factually identical 40:90:90 kg ha^{-1} + 08 t ha^{-1}, 80:180:180 kg ha^{-1} + 08 t ha^{-1}and 100:225:225 kg ha^{-1} + 08 t ha^{-1} with case yields of 9.15, 8.94 and 8.89 t ha^{-1}, respectively. The P^{Yha} (2.96 t ha^{-1}) was gotten from unfertilized plots control, trailed by plots prepared with NPK @ 10:22.5:22.5 + 2 t ha^{-1} + 08 t ha^{-1} and 20:45:45 kg ha^{-1} + 4 t ha^{-1} with P^{Yha}5.87 and 6.74 t ha^{-1} (Fig. 3).

Results indeed exposed that use of NPK at variable application considerably improved the pod yield of pea. Pod yield expanded with expanding rates of NPK and most significant yields were gotten with the utilization of NPK upto a specific point of confinement at 60:135:135 kg ha^{-1} + 8 t ha^{-1}, recommending that arrangement of supplements in sufficient amounts helped pod yields. A diminishing pattern was seen in treatment accepting supplements more significant than 60:135:135 kg ha^{-1} + 8 t ha^{-1}. Correspondingly, [11, 13 14, 15, 16, 18, 33 & 34] detailed significant improvement in pod yields with the use of organic manures.



	100 GW (g) Y1	100 GW (g) Y 2	PY (t ha-1) Y 1	PY (t ha-1) Y2
	48.95 c	49.55 c	8.76 b	8.89 b
	49.92 bc	50.60 bc	8.83 b	8.94 b
	52.70 a	54.20 a	9.43 a	9.62 a
	50.80 b	51.50 b	9.04 b	9.15 b
	45.99 d	47.10 d	6.62 c	6.63 c
	38.70 e	40.10 e	4.76 d	5.07 d
	30.25 f	31.00 f	2.89 e	2.96 e
LSD at P0.05	0.98	1.26	0.28	0.33

Mean followed by similar letter(s) do not differ significantly at 5% level of significance.
P^L= Weight of 100 grains (cm), P^Y = Pod Yield (t ha^{-1}), Y^1 = Growing season 2016-2017, Y^2 = Growing season 2017-18

Fig. 3. Rationalization of bio-slurry and chemical fertilizer effect on pea in two growing seasons.

Economic Analysis of Pea Production using Different Rates of NPK

Agriculture scientist, economists and extension staff use various criterion to evaluate economic benefits of productivity while implementing alternative technology. The Benefits Cost Ratio (BCR) of financial metrics is the most useful instrument for assessing the efficiency of a technique or procedure. During 2016-17, the economics of pea development utilizing different rates of NPK + bio slurry (Table 5a) showed that higher doses of chemical fertilizers were added to higher overall revenue due to higher pod yields (t ha^{-1}). The maximum total revenue (Rs.282900/-) of 60:135:135 kg ha^{-1} + 08 t ha^{-1} was reported, followed by 40:90:90 kg ha^{-1} + 08 t ha^{-1} with total revenue of Rs. 271200/ (Fig. 4). However, with the implementation of 40:90:90 kg ha^{-1} + 08 t ha^{-1} the net benefit was maximum (Rs.169256/-) relative to 60:135:135 kg ha^{-1} + 08 t ha^{-1} (Rs.165481/-). With therapies earning higher NPK doses, the average expense was higher. The highest overall expense (Rs.148360/-) prevailed when NPK was added at 100:225:225 kg ha^{-1} + 08 t ha^{-1}. The highest BCR (1.66) of 40:90:90 kg ha^{-1} + 08 t ha^{-1} was reported, followed by 60:135:135 kg ha^{-1} + 08 t ha^{-1} with a BCR of 1.41. While 60:135:135 kg ha^{-1} + 08 t ha^{-1} recorded the highest yield and gross monetary return, the highest gain and BCR were found in 40:90:90 kg ha^{-1} + 08 tha^{-1}.

Similarly, the highest yield and overall revenue (Rs.288600/-) were highest at 60:135:135 kg ha^{-1} + 08 t ha^{-1} during 2017-18 (Table 4 b), replaced by 40:90:90 kg ha^{-1} + 08 t ha^{-1} (Rs.274500/-) while the highest net benefit (Rs.172556/-) was recorded at 40:90:90 kg ha^{-1} + 08 t ha-1 followed by 60:135:135 kg ha^{-1} + 08 t ha^{-1} (Rs.171184/-). At 20:45:45 kg ha^{-1} + 08 t ha^{-1}, 40:90:90 kg ha^{-1} + 08 t ha^{-1}, 60:135:135 kg ha^{-1} + 08 t ha^{-1} and 80:180:180 kg ha^{-1} + 08 t ha^{-1}, the BCR was found to be greater than unity.

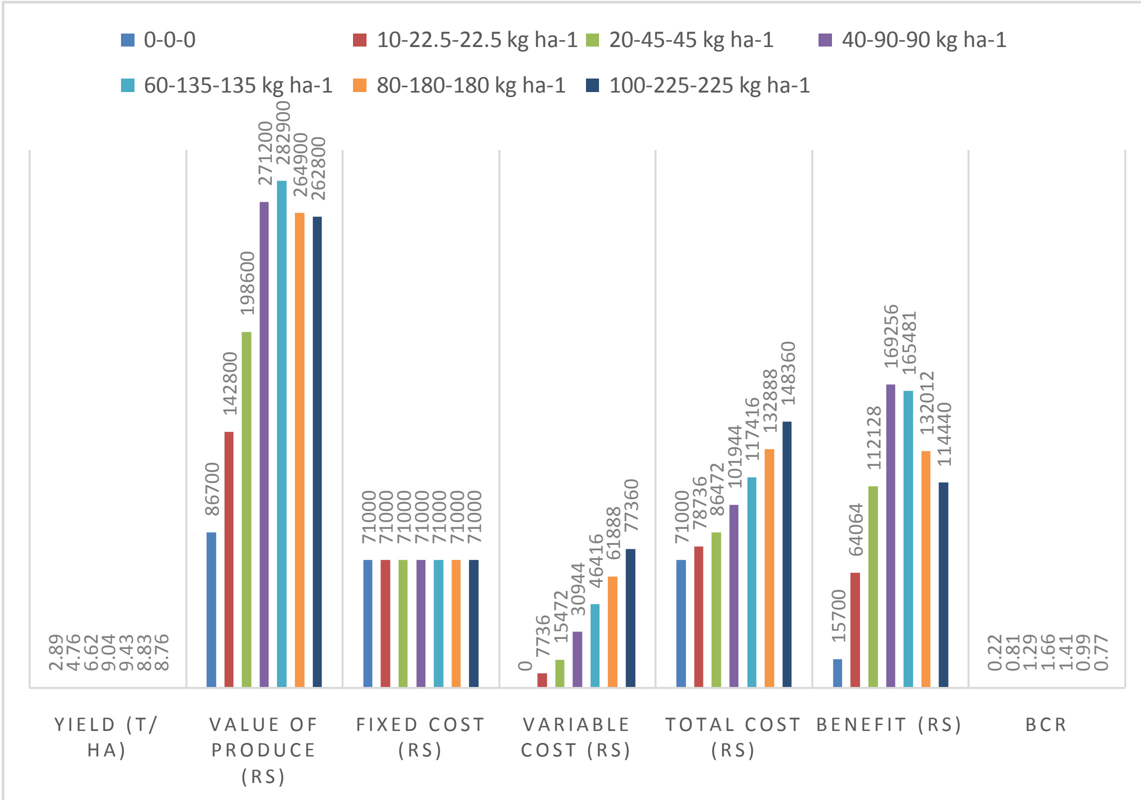


Fig. 4. Economics of fertilizer application on the production of pea during 2016-17.

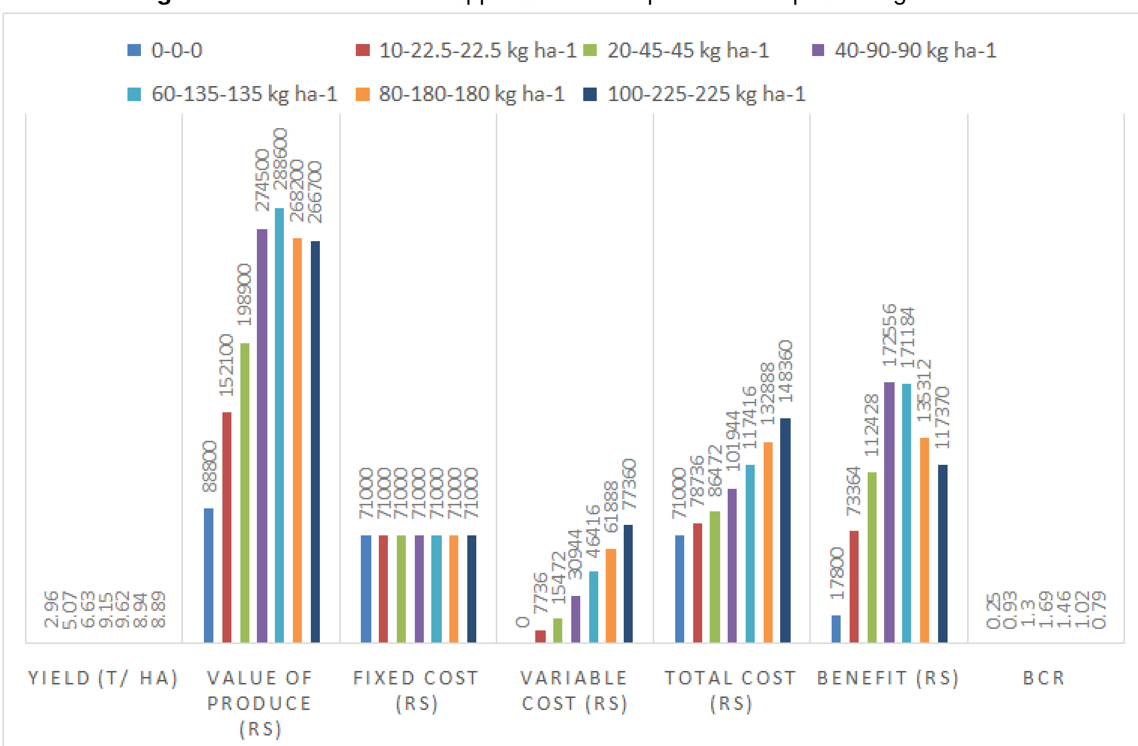


Fig. 5. Economics of fertilizer application on the production of pea during 2017-18.

The maximum BCR (1.69) was registered at 40:90:90 kg ha^{-1}, followed by 60:135:135 kg ha^{-1} at 1.46 BCR. 60:135:135 kg ha^{-1} had the highest yield and overall revenue, but 40:90:90 kg ha^{-1} + 08 t ha^{-1} had the highest gain and BCR. The estimation of the economic analysis showed that with the application of NPK at 40:90:90 kg ha^{-1} + 08 t ha^{-1}, the highest BCR was recorded, implying that this nutrient dosage is the most economical and may be suggested for productive pea development. The findings indicate that the addition of variable amounts of NPK greatly improved the quantitative characteristics of peas. With the application of 60:135:135 kg ha^{-1} + 08 t ha^{-1}, followed by 40:90:90 kg ha^{-1} + 08 t ha^{-1}, 80:180:180 kg ha^{-1} + 08 t ha^{-1} and 100:225:225 kg ha^{-1} 08 t ha^{-1}, the highest values for yield and yield contributing traits were observed (Fig. 5). The economic data analysis showed that the highest gross revenue was reported in treatment 60:135:135 kg ha^{-1}, but the highest net profit and BCR were found in 40:90:90 kg ha^{-1} + 08 t ha^{-1}, indicating that the most appropriate choice for obtaining productive pea yield is the application of 40:90:90 kg ha^{-1} + 08 t ha^{-1}. The largest NPK concentrations were not financially viable.

III. CONCLUSION

This work was planned to calibrate the proportionate use of bio-slurry in combination with inorganic fertilizer for pea production on small as well as large scale. Bio-slurry proved a cost-effective bio-fertilizer when used in combination with inorganic fertilizers. However, sole use of bio slurry had non-significant effects on pea yield but it, improved soil physical health. It was observed that continuous use of chemical fertilizer alone, without amendment of organic fertilizer deteriorates the soil physical health and its interaction with soil microbes. Hence, it is highly recommended that bio-slurry should be incorporated in soil in combination with chemical fertilizers for sustainable crop production.

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