Research article

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The Response of Common Bean (*Phaseolus vulgaris* L.) to Different Levels of Organic and Inorganic Fertilizers

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ABSTRACT

The high cost and excess use of inorganic fertilizers are the important concerns for high and beneficial yield of common bean and at the same time the integrated crop management practices are the universal demands for agriculture and environment. Therefore, the research was carried out from June to September of 2018 in the botanical garden of Agriculture Faculty, Kabul University, Afghanistan to evaluate the influence of sole and combine application of diammonium phosphate (DAP) and Poultry Manure (PM) with different concentrations on the growth, yield and yield components of common bean. According to the results achieved, it was found that combination of 80 kg DAP ha^{-1} + 5 ton PM ha^{-1} improved the performance of common bean, with respect to 2272.33 kg grain yield (GY) ha^{-1} over the alone used of DAP and PM (10 ton PM ha^{-1}, 130 kg DAP ha^{-1}, respectively) and control. In addition, the application of 5 ton PM + 80 kg DAP ha^{-1} showed positive effects on growth and yield attributes while no significant effects were observed on control (without any fertilizer application) for any trait of common bean. There were also strong positive correlations within the growth and yield components which indicate the importance for common bean GY. The present research showed that integrated application of DAP + PM is a good source of Phosphorus and other primary elements for the growth and yield performance of common beans.

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Introduction

The genus *Phaseolus* has about 80 cultivated species, but common bean (*Phaseolus vulgaris* L.) is the most cultivated once worldwide [1]. There are other synonyms for common beans like dry bean, French bean and green bean [2, 3, 4]. *Phaseolus vulgaris* is an annual self – pollinated crop that belongs to the family of *Fabaceae* [5, 6] and domesticated in Mesoamerica and Andes about 7000 years ago [5]. In developing countries common bean is very important in the nutrition of an increasing population where they deliver a fairly cheaper source of protein in the diet [7], fodder for animals [8] and source of elements for plant nutrition are the other benefits of common beans [9, 10]. It is broadly cultivated all over the world with a total global production of about 25 million metric ton with a productivity of 792 kg ha^{-1} [11]. The top five countries that export more

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dry bean are Myanmar, China, United States of America, Argentina and Canada, respectively. Afghanistan is also the country which produced about 20.25 thousands metric tons dry bean annually [12]. By 2050, an increase in cereal food supply is required to feed the predicted world population of 9.8 billion people [13]. Common bean like other crops, its yield affected by many external and internal factors (soil fertility degridation, less input of fertilizers, soil properties, irrigation, weed and pest control, genetic improvements etc.), that decrease its yield [14, 15]. For soil fertility and nutrational management there is need for new strategies in fertilzer formulation and application techniques [16]. To raise and improve the yields of common bean, there are different adopted management practices. The use of an integrated organic and inorganic fertilizers is practice that often lead to increase organic matter (OM) in soil, improved soil structure, increase water holding capacity, improved nutrient cycling and helps to biological activities of living beings in soil [17]. For better crop productivity, it is important to input inorganic fertilizers, but for a long period the use of an inorganic fertilizer is associated with decline in some soil properties and crop yields [18]. Worldwide, the requirement to use recharge forms of energy and reduce expense of fertilizing crops has revitalized the use of organic amendment [19].

Organic amendments can be used for improving and availability of soil Phosphorus (P) to crop growth [20] among them, Poultry Manure (PM) is the concentrated basis of P and other elements for improving crop growth [21]. Microorganisms in soil act and decompose organic molecules and release inorganic P by phosphate energy, thus improving the phosphorus availability for crops growth in soil [22].

Phosphorus is the primary essantial element for plant growth that makes up approximately 0.2% dry weight of plant [23]. Phosphorus (P) is vital to plant growth and is found in every living plant cell. It is involved in several key plant functions, including energy transfer, photosynthesis, transformation of sugars and starches[24]. Phosphorus as a plant-essential nutrient plays a dynamic role from germination to maturity viz., root development, flower and seed formation, strengthening of stem and stalk, fixation of nitrogen in legume crop and crop resistance to diseases [25, 26]. Phosphours deficiency is a major abiotic stress that limits plant growth and crop productivity [27] and it also results in establishment of small leaves and a reduction in stem diameter of crops [28]. Phosphorus levels are high in most soils. [29] but the chemical nature and nutritive status

of soil reaction may be limited the availability of P to crop plants[30, 31]. Farmers use large amount of P fertilizer but it become unavailable to the crops due to the fixation with soil mineral [32] and there is need for P management to get optimum yield and reduce the P fixation with soil particles. Therefore, an integrated use of both inorganic fertilizers with organic manures is an ecological approach for nutrient use efficiency and reducing nutrient losses [33].

Based on the results of investigations, it was found that the combine application of organic and inorganic fertilizer significantly increased the crops yield compare to isolat application of them[17, 34, 35, 36], but Santosa et al. [37] founded in his research that the use of 50: 150: 50 kg ha^{-1} dose of NPK, produced the high value of plant height (PH), pods per plant (PP) and growth attributes on grean bean against to the application of cow manure and control.

The sufficient use of PM can enhance the growth of legumes compared to inorganic fertilizers[38, 39, 40]. The foliar spray of NPK can increase the grain yield of *Phaseolus vulgaris* compared to PM and DAP [6]. Thus, the current research was projected to study the influence of DAP and PM (alone and in combination) application on the growth and yield of common bean and to find the correlations among the growth and yield attributes to common bean grain yield (GY).

Material and Methods

Study area

This research was conducted on an experimental field at the botanical garden, Agriculture Faculty, Kabul University (altitude of 1791 m above sea level, latitude 34° 54' 44" N and longitude 70° 10' 09" E) from June to September, 2018. The soil (0–25 cm) texture is sandy loam, pH of 8.4, with a soil organic matter (SOM) of 0.90%. In addition, the total nitrogen content, available phosphorus and potassium contents of the soil are 2.2%, 6.9 mg kg^{-1} and 190 mg kg^{-1}, respectively. Temperature and rainfall for the growing season are presented in Fig 1.

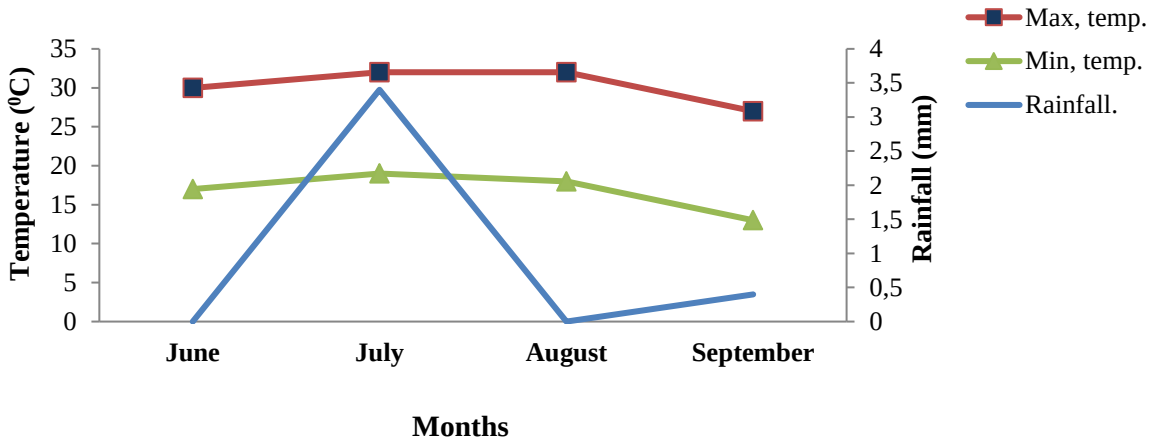

Fig 1 Rainfall and temperature during the study year, 2018

Experimental design, treatments and plant material

The treatments contained different levels of diammonium phosphate (DAP) and poultry manure (PM), alone and cmbined including the control for comparison (Table 1). Randomized Complete Block Design (RCBD) with three replications was used for the experiment. Local variety of common bean (*Phaseolus vulgaris* L.) by the name of Capsuly was cultivated.

Table 1 Treatments list used in this study

Treatments	Description
T0	Control(without any fertilizer use)
T1	DAP 130 kg ha^{-1}
T2	PM 5 ton ha^{-1}
T3	PM 10 ton ha^{-1}
T4	DAP 30 kg ha^{-1} + PM 10 ton ha^{-1}
T5	DAP 80 kg ha^{-1} + PM 5 ton ha^{-1}

Sowing and data collection

The land for trail was ploughing a depth 20- 25 cm along the decay poultry manure (PM) before planting to mix with soil for fast decomposition. Individual plot size was 2 x 3m ($6m^2$) and space between blocks and plot was 1 M. The common bean crop was grown by hand on both ridges of the furrow, space between the ridge was 40 cm and apart from the crop was 20 cm. Some agriculture practices (weeding and irrigation) were done by the need of common bean during the growing season. The data were ollected for plant

height (PH), number of leaves per plant (NLP), number of branches per plant(NBP), number of pods per plant(NPP), Hundred seed weight (HSW) and grain yield(GY) parameters.

Statistical Analysis

Collected data were subjected to analysis of variance (ANOVA), using Statistical Tool for Agriculture Research (STAR) software (version 2.0.1). To separate significant differences in the means of the treatments, Tukey's Honest Significant Difference (HSD) test was used at $p< 0.05$ % probability level.

Results and Discussion

Growth of common bean

The growth responses of common bean (Capsuly bean) that were applied by inorganic and organic fertilizers were significant for Plant height (PH), number of leaves plant^{-1} (NLP)and number of branches plant^{-1} (NBP), Table 2.

The data in Table 2 show that there are significant difference ($p<0.01$) among the treatments. The high mean value of PH was produced in T5 treatment (39.13a) while the T0 (control) produced the minimum value (28.91d), but the effects on non-combined applications were insignificant {Table 3 and fig. 2 (a)}. The greater PH might be attributed to the gradual release of essential nutrients needed by beans from PM fertilizer and the availability of P and N elements from DAP manure during the growing time. Our finding is confirmed by Baghdadi et al. [41] who reported that 50% of NPK + 50% PM ha^{-1} resulted the same PH which was produced by 100% NPK used and also confirm by Saleem et al. [35] and Mitchell et al. [42] , who stated that, 50%PM + 50% inorganic fertilizer resulted in the tallest corn plants in corn-legume cropping system against to control. Similarly the combine application of PM and DAP in T5, responded well to NLP and NBP (55.89a and 18.42a respectively) followed by alone and unamended (control) treatments by producing the lowest means {Table 3 and Fig 2 (b) and (c)}. It is harmony with Saha et al. [17] who founded that the integrated use of PM and NPK produced better growth in maize crop compared to alone and combined used of NPK and other FYM and also agreement by Lima et al. [43] who reported that due to the application of organic amended the yield of crop is increased and soil properties are improved.

Table 2 Analysis of Variance (ANOVA) for the bean observed parameters: Plant height (PH), number of leaves plant^{-1} (NLP), number of branch plant^{-1} (NBP), number of pod plant^{-1}, number of seed plant^{-1}, 100 seed weight (HSW) and grain yield (GY)

Source of Variance	df	Mean Square						
		PH	NLP	NBP	NPP	NSP	HSW	GY
Replication	2	4.80	1.80	2.25	0.85	0.16	3.50	27376.22
Treatments	5	37.71**	107.84*	27.68**	12.25**	1.24*	73.83**	254209.82**
Error	10	2.29	21.90	0.80	1.34	0.23	10.63	70852.62
CV%		4.50	10.02	6.27	6.79	11.52	6.13	13.90

**Significant difference at 1%, *significant difference at 5%, CV: coefficient of variation, df: degrees of freedom

Table 3 Response of growth, yield and yield components of common bean to DAP and PM

Treatments	PH(cm)	NLP	NBP	NPP	NSP	HSW(g)	GY(kg)
T0	28.91d	37.25b	9.23c	14.41c	3.13b	46.67c	1600.00bc
T1	33.97bc	45.72ab	14.41b	17.79ab	4.11ab	52.67abc	1779.00ab
T2	31.30cd	46.64ab	13.16b	15.71bc	4.03ab	48.67bc	1635.33b
T3	33.08bcd	45.95ab	15.27b	16.38bc	4.16ab	54.33abc	2062.33ab
T4	35.66ab	48.80ab	15.38b	18.17b	4.43ab	56.67ab	2136.67a
T5	39.13a	55.89a	18.42a	20.12a	5.12a	60.00a	2272.33a
LSD	4.29**	13.27*	2.54**	3.29**	1.36*	9.24**	484.25**

**Significant difference at 1%, *significant difference at 5%, LSD: least Significant Difference , PH: Plant height, NLP: Number of leaves plant^{-1}, NBP: Number of branches plant^{-1}, NPP: Number of pods plant^{-1}, NSP: Number of seed pod^{-1}, HSW: Hundred seeds weight and GY: Grain yield

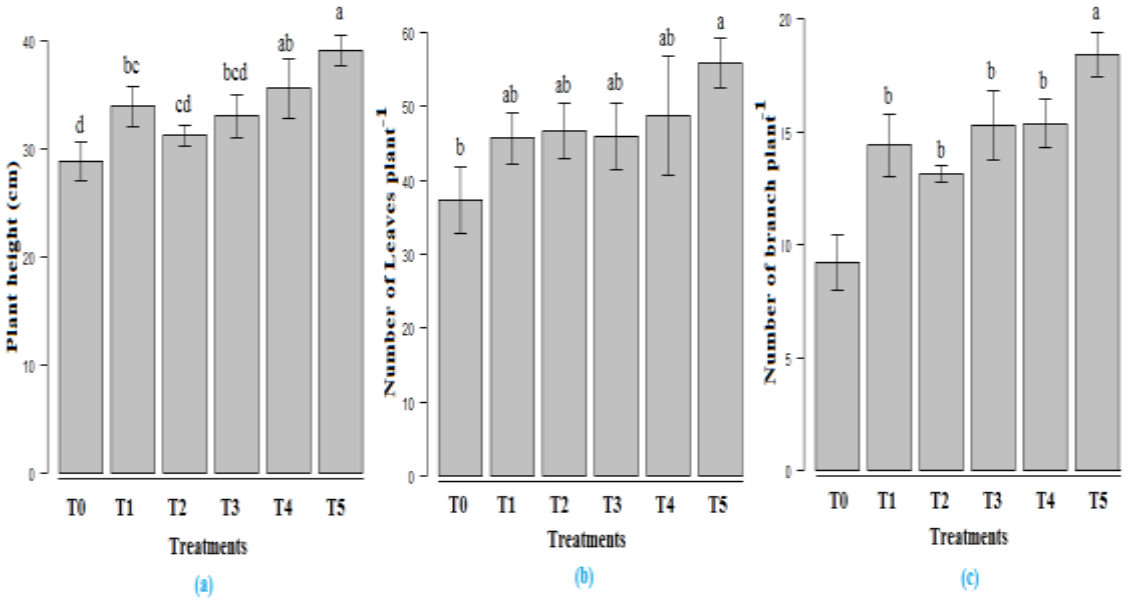

Fig 2 Effects of organic and inorganic fertilizers on (a) plant height, (b) number of leaves plant^{-1} and (c) number of branches plant$^{-1.}$ Upright bars sharing a letter in common are not significantly different at p<0.05. Treatments description are same as in table 3

Yield and yield components of common bean

The yield components of common bean which play major roles in yield production are NPP, NSP and HSW. In the present research, these attributes were significantly high (20.12a, 5.12a and 60.00a, respectively) on T5 while the lowest were noted (14.41c, 3.13b and 46.67c, respectively) on T0 (control), {Table 2 and Fig 3. (d), (e), (f)}. The data on GY of common bean are also indicated highly significant differences in results by combining application of PM and DAP from all other isolated applications. The treatments consisted of sole application showed non-significant variation as compared to combined while both of them showed significance from control (Table 2). The Maximum GY was recorded on T5 and T4 (2272.33a and 2136.67a), respectively. While minimum GY was documented in control (1600.00bc) as shown in Fig 3 (g). The findings of this study confirm with the results of Zafar et al. [34], Maman et al. [36] and Baghdadi et al. [38] who reported that the integrated application of organic and inorganic fertilizer produced better yield and yield components compare to individual use. Mohamed et al. [44] and Timsina [45] also observed that increase in the yield components might be associated with the release of essential micro and macro soil nutrients by the PM. Similar reports were also made by Dorahy et al. [23] who reported significant increases in the maize yield biomass and other yield components with the application of

PM + NPK but Rahman et al. [6] reported that the foliar application of NPK result better in yield compare to DAP and PM.

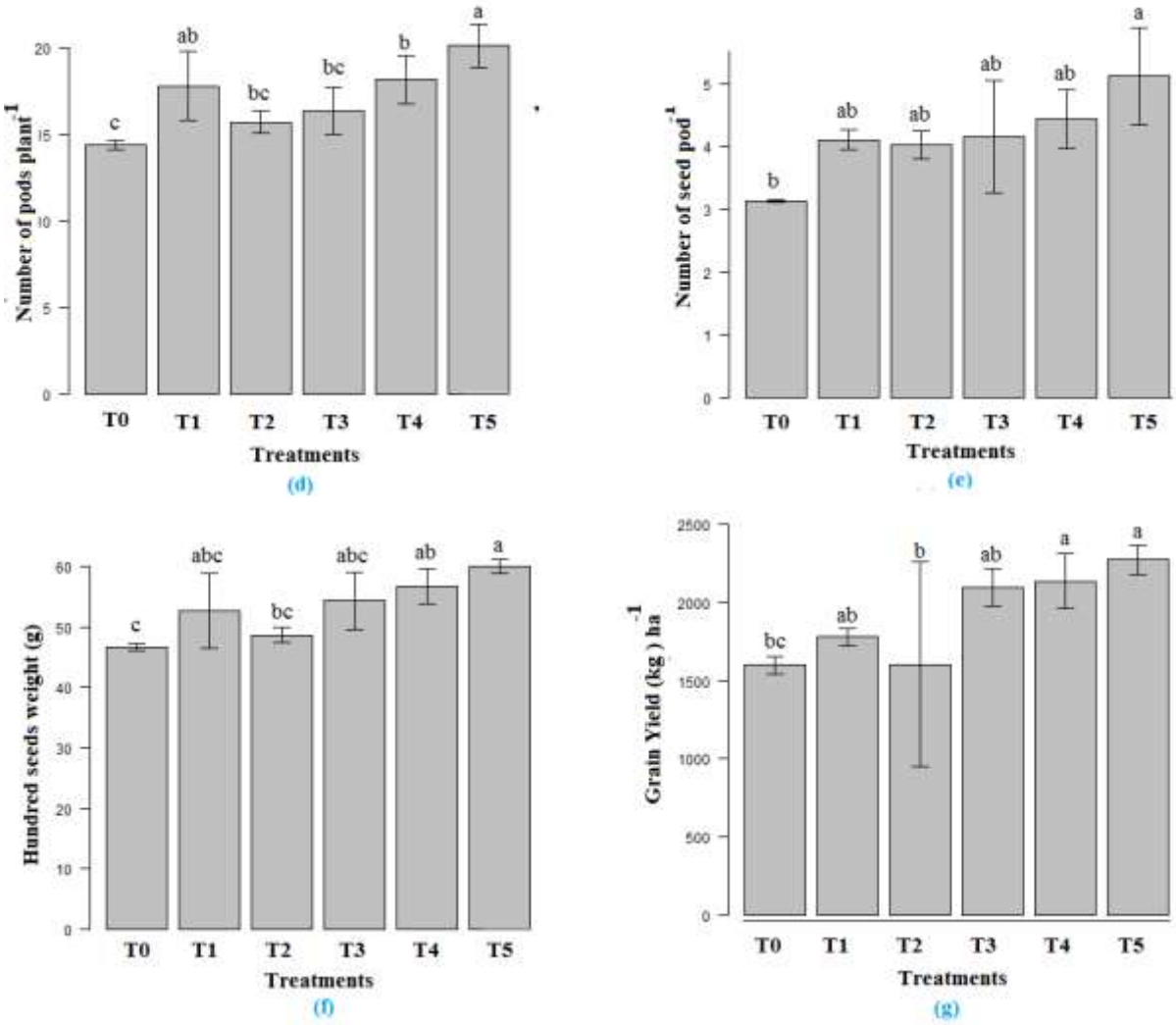

Fig 3 Effects of organic and inorganic fertilizers on (d) number of pods plant^{-1}, (e) number of seed pod^{-1}, (f) hundred seeds weight) and (g) grain yield of common bean. Upright bars sharing a letter in common are not significantly different at p<0.05. Treatments description are same as in table 3

Correlation among the growth and yield components

The correlation between growth, yield and yield components of common bean in this research is given in Fig 5. It is seen from the figure that there are positive correlations within all growth, yield and yield components. There are strong positive correlation among the PH and NLP (r= 0.85***), PH and NBP(r= 0.86***), PH and NPP(r=0.77***), PH and HSW(r= 0.81***), NLP and NBP(r= 0.78***), NBP and NPP (r= 0.76***), NBP and NSP (0.82***), NBP and HSW(r= 0.79***) and HSW and GY (0.74***). Our result is harmony with Zafar et al. [34], who founded positive correlation among the yeild and

yield components within the treatments which were applied by DAP + poultry manure compared to sole applications.

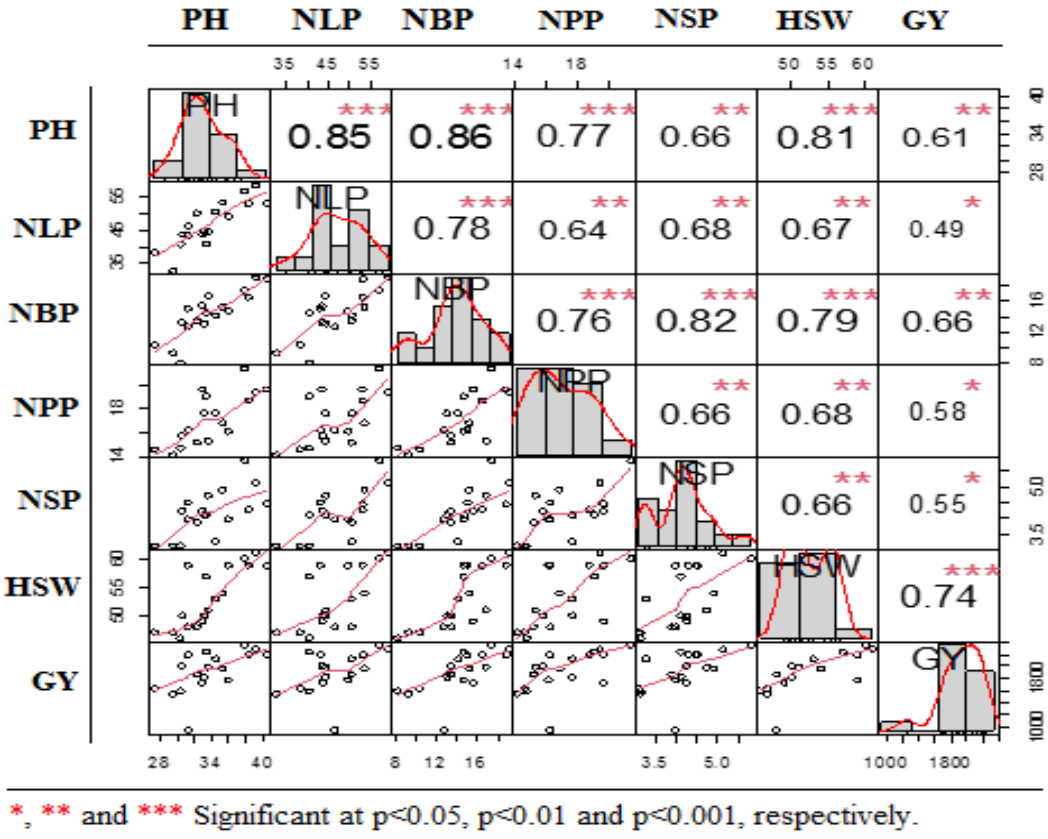

Fig 5 Correlations and distribution of the growth (PH: Plant height, NLP: number of leaves, NBP: number of branch plant^{-1}), yield components (NPP: Number of pods plant^{-1}, NSP: Number of seed pod^{-1}, HSW: Hundred seeds weight) and GY: Grain yield of common bean

Conclusion

From the findings of the current research it can be concluded that integrated application of PM and DAP showed outstanding effects on the growth, yield and yield components of common bean. The combined application of DAP + PM produced better GY (2272.33a and 2136.67a) on T5 and T4, respectively while the use of DAP and PM alone effects were low on growth, yield and yield attributes. Therefore, PM can be applied with DAP together to increase the bean productivity. Additional investigation should be conducted on DAP + Poultry manure application to study the duration of its effects on environment and economic benefits for soils fertility and crops.

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Availability of data and material
Please contact the corresponding author for any data request.

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