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INTERACTIVE EFFECT OF GENOTYPES AND ORGANIC MANURES ON PHENOTYPIC ATTRIBUTES OF CHICKPEA (*CICER ARIENTINUM L.)*

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Abstract: *Chickpea (Cicer arietinum L.) belongs to the legume family, one of the most important pulse crops due to its high nutritional values compared to other pulses. Chickpea production is very low in Pakistan compared to other countries because of low soil fertility. Organic manure like farmyard manure and poultry manure have good water and nutrient holding capacity, which nourish the plants. To this end, an experiment was conducted at BZU Bahadur Sub-campus Layyah, Pakistan, to investigate farmyard manure's and poultry manure's effects on chickpea. Data were collected for the number of buds and pods, plant height, biological yield, economical yield, and 100-grain weight. Results showed that farmyard manure significantly increased all chickpea varieties' measured traits compared to both control and poultry manure treatments. The variety Parbat produced the highest economical yield under farmyard manure fertilization compared to all other varieties and treatments. Correlation analysis revealed that all the measured traits were strongly positively correlated with economical yield, and path coefficient analysis revealed that biological yield and numbers of the pod have a highest positive direct effect on economical yield, which showed that manures enhance the yield-related traits, which increased the economical yield in chickpea. The present study revealed that applying farm yard manure and poultry manure is essential for better seed production of chickpea.*

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Keywords: Chickpea, Organic manure, Farmyard manure, Poultry manure, Phenotypic variation

Introduction

Chickpea (*Cicer arietinum* L.) is the world's third most important pulse crop after dry beans and dry peas (Nouri et al., 2021). It belongs to the legume family of plants and maybe originate in South-eastern Turkey and some parts of Syria (Grasso et al, 2022). It is cultivated in over 60 countries and traded in over 190 countries for production and consumption. It is a good source of carbohydrates and protein, and protein quality is better than other pulses (Merga and Haji, 2019; Ali and Ahsan 2011; Waseem et al. 2014). Legumes are considered a dual answer to increase crop productivity and soil quality due to their ability to fix atmospheric nitrogen. Due to legume plants' biological N_2 fixation, legume-based cropping methods increase seed yields and enhance soil fertility (Nouri et al., 2021; Sarwar et al., 2021; Sarwar et al., 2022). Organic manures have recently gained popularity due to the growing expense of chemical fertilizers and their incapacity to condition soil. Using organic manures (farmyard and poultry manure) or other farm waste is a key aspect of effective organic farming to improve soil's physical, chemical, and biological qualities (Priyanka et al., 2021). Farmyard and poultry manure has been used to improve soil quality since the beginning of civilization; in certain circumstances, these fertilizers were the only source of nitrogen for crop development (Samanhudi, 2014). Crop productivity may be significantly improved by improving the physical condition of the soil and conserving moisture. Farmyard and poultry manures are high in nitrogen, phosphorus, and potassium and a fair proportion of exchangeable micronutrients such as calcium, magnesium, salt, and other minerals. Farmyard manure and poultry manure increased nitrogen efficiency and thus increased crop yields on a long-term basis (Ahmadi et al., 2014), increased plant growth and water conservation (Khan et al., 2015), and also improved soil health by reducing nitrate leaching, soil erosion, (Yagioka et al., 2015), and other nitrogen losses (Zhao et al., 2016). Farmyard and poultry manures are rich in vitamins and growth hormones and act as a powerful biocide against disease and nematodes (Priyanka et al., 2021).On average, Farmyard Manure contains

0.5%Nitrogen, 0.2% P_2O_5, and 0.5% K_2O. Application of 1-ton FYM to the soil gives 5kg Nitrogen, 2 kg P_2O_5, and 5 kg K_2O (Tarafdar, 2016). Microbial respiration and biomass (carbon compounds) were also boosted when manures were added to the soil (Muhammad et al., 2018). The use of farmyard manure and chicken manure aided in optimal nutrition and soil fertility management (Muhammad et al., 2018). Farmyard manure and poultry manure are considered key substrates for replenishing soil organic matter (Rasool et al., 2007) and can be used as an alternative to fertilizer in organic farming to boost soil fertility and crop output. Plant growth and development are aided by microorganisms in the soil (Muhammad et al., 2018). Higher populations of microorganisms indicate high-quality soil, which also plays an important role in plant nutrient activation. For chickpea, the usefulness of manures originates from its high protein content, drought resistance, and ability to fix nitrogen from the atmosphere when cultivated in poor soil (Bolan et al., 2010). A successful plant breeding program is required to boost this crop's yield potential. The efficiency of breeding programs is influenced by genetic diversity and the amount of readily available nutrition in the soil (Chinivasagam et al., 2010). Combining farmyard and poultry manure with urea was also expected to be more effective in improving soil qualities (Muhammad et al., 2018). The goals of this study are to analyze the interaction between chickpea and organic manure (farm yard manure and poultry manure), determine which cultivar is performing well by the application of manures, and determine the changes in some morphological characters in seven different chickpea cultivars, identify the relationships between morphological and physiological parameters, and evaluate the high yielding and responsive variety by the addition of manures.

Materials and methods

Plant material

Two years of field experiments were conducted at the experimental field area of Bahauddin Zakariya University, Bahadur Sub-Campus, District Layyah, Punjab, Pakistan (30.90^{O} N and 70.96^{O} E), during the 2021 and 2022 growing seasons. During both experiments, an equal number of organic manures 400g (0.0004 t/ha each) were added to the field. The soil texture was sandy loam, and the pH of the soil was around 8. The structure of the soil was sand 61.4%, silt 21.3%, clay 16.3%, and bulk density was 1.28 g cm^{-3}. Seven cultivars of chickpea were selected for the experiment (Kabli Noor-2009, Parbet, TG-1618, TG-1415, TG-1601, TG-1513, and BK-2011).

Experimental design and treatments

The experiments were conducted as randomized complete block design with 3 blocks and 3 replications in each block. Each replication has an area of about 20.34 ft^2. The row-to-row distance was kept at 30cm, and the plant-to-plant distance was kept at 10cm.5 plants were planted in each row of each replication block. 400 grams of farmyard manure and poultry manure (2.1 tons of Farmyard Manure and Poultry Manure per hectare) were added to the selected replications in each block with complete randomization in both growing seasons. Recommended irrigation, plant production, and safety precautions were implemented.

Data collection

Data were collected from each plant in the field in both years. The numbers of buds and numbers of the pod were counted manually from each chickpea plant in the experimental field area. 5 plants were selected from each block to measure other required yield-related traits. The plant height was taken in centimeters (cm), including the roots; plant weight was taken in grams (g) on an electronic weighing balance, the biological yield was taken in grams (g) by the multiplication of the weight of the plant and the numbers of pod per plant, and the economical yield was taken in grams (g) by weighing the seeds per plant. Collected data were examined for statistical analysis of the measured parameters. Microsoft Excel 2016 was used for the graphical representation of data. Correlation and path analysis were determined with the help of excel 2016, while Statistix 8.1 was used for the analysis of variance (ANOVA) and probability values which helped to find out the significance of the data.

Results

Application of farmyard manure and poultry manure on chickpea during two years of study (2021 and 2022) significantly increased almost all yield characteristics compared to the control (Tables 1 and 2). Yield attributes, including numbers of buds, number of pods, plant height, biological yield and 100-grain weight, increased significantly on second-year application of farmyard manure and poultry manure. The highest numbers of bud were observed in TG-1513 (240), followed by Kabuli Noor (229) and BK-2011 (218) which was treated with farmyard manure in the second year and also some improvements were seen in plants that were treated with poultry manure in the second year. The highest numbers of the pod were observed in Kabuli Noor (217) followed by TG-1513 (212) and TG-1415 (202), that was treated with farmyard manure in the second year, and also some plants were responsive to poultry manure in second-year application. The highest plant height was noticed in the plants that were treated with farmyard manure, like TG-1618 (61.2 cm), followed by TG-1415 (56.47 cm) and TG-1513 (56.13 cm). Also, it was noticed that all genotypes were responsive to farmyard manure and poultry manure compared to controlled plants. Biological yield is the total weight of the plant. The highest biological yield was observed in Parbat (168 g), followed by TG-1618 (159 g) and TG-1513 and BK-2011 (142.67 g and 142 g, respectively). The other genotypes were also responsive to farmyard manure in both years compared to controlled plants. Economical yield is the grain weight of the plant, and the highest economical yield was observed in Parbat (71.67 g), followed by BK-2011 (63.3 g) treated with farmyard manure and Parbat (63.3 g) treated with poultry manure in the second year of the application. The highest values of 100-grain weight were observed in Parbat (321.3 g), followed by TG-1415 and TG-1601 (295.3 g) and (294.67 g), respectively. The overall performance of farmyard manure and poultry manure on seven different chickpea genotypes are shown in Tables 1 and 2 during the years 2021 and 2022.

Table 1. Effect of FYM and poultry manure on yield and physical characteristics of seven chickpea genotypes during the years 2021 and 2022

Genotypes	Treatments	Numbers of bud		Numbers of pods		Plant height	
		2021	2022	2021	2022	2021	2022
Kabuli Noor	Control	144 ± 2.60 efg	160 ± 2.88 ghi	128 ± 2.02 f-i	141 ± 2.02 hij	47 ± 0.86 efg	49.2 ± 0.92 fg
Kabuli Noor	FYM	208 ± 2.40 ab	229 ± 2.08 ab	205 ± 2.90 a	217 ± 1.45 a	53.4 ± 1.24 bcd	55.9 ± 0.81 bcd
Kabuli Noor	PM	169 ± 2.02 c	188 ± 2.02 d	156 ± 2.72 e	168 ± 2.66 e	49.2 ± 1.17 c-g	51.9 ± 1.22 d-g
Parbet	Control	128 ± 2.40 hi	143 ± 2.40 jk	121 ± 3.17 hij	132 ± 3.17 jk	47.1 ± 1.04 fg	49.03 ± 0.99 fg
Parbet	FYM	187 ± 2.90 c	214 ± 2.90 c	172 ± 2.33 d	184 ± 0.57 d	54.7 ± 1.68 abc	56.4 ± 1.30 abc
Parbet	PM	149 ± 1.76 ef	165 ± 1.76 fgh	134 ± 1.76fg	145 ± 2.33 ghi	50.1 ± 1.09 d-g	51.5 ± 1.13 d-g
TG-1618	Control	135 ± 2.64 ghi	139 ± 1.73 jk	108 ± 2.02 k	119 ± 2.02 l	48.8 ± 1.21 d-g	50.3 ± 0.83 efg
TG-1618	FYM	140 ± 2.33 efg	178 ± 1.66 de	133 ± 2.30 fgh	162 ± 2.33 ef	59.4 ± 1.02 a	61.2 ± 0.81 a
TG-1618	PM	129 ± 2.02 hi	157 ± 1.73 hi	127 ± 2.40 f-i	139 ± 2.02 ij	54.7 ± 0.52 abc	55.8 ± 0.76 bcd
TG-1415	Control	96 ± 1.76 j	140 ± 3.60 jk	86 ± 3.21 l	97 ± 2.72 m	49.2 ± 0.75 c-g	51 ± 0.40 efg
TG-1415	FYM	199 ± 3.17 bc	210 ± 3.17 c	190 ± 4.61 bc	202 ± 3.21 bc	53.5 ± 1.10 bcd	56.5 ± 0.95 abc
TG-1415	PM	124 ± 2.33 i	168 ± 2.08 fgh	130 ± 1.73 gh	142 ± 1.52 hij	50.9 ± 0.99 c-f	53.03 ± 0.76 c-f
TG-1601	Control	128 ± 2.33 hi	133 ± 2.72 kl	113 ± 2.64 jk	121 ± 2.08 l	46.2 ± 0.75 fg	48.6 ± 0.57 fg
TG-1601	FYM	130 ± 2.90 ghi	171 ± 2.90 efg	119 ± 1.45 ijk	152 ± 1.73 fgh	56.8 ± 1.53 ab	58.4 ± 1.53 ab
TG-1601	PM	124 ± 2.40 i	150 ±2.40 ij	118 ± 1.20 ijk	132 ± 1.45 jk	51.2 ± 1.11 b-e	52.2 ± 1.37 c-f
TG-1513	Control	109 ± 2.02 j	122 ± 2.02 l	95 ± 1.76 l	107 ± 1.20 m	49.3 ± 0.70 c-g	51.4 ± 0.45 d-g
TG-1513	FYM	213 ± 3.17 a	240 ± 3.17 a	200 ± 2.33 ab	212 ± 1.45 ab	52.8 ± 0.50 b-e	56.1 ± 0.88 a-d
TG-1513	PM	155 ± 3.05 e	173 ± 2.02 ef	137 ± 1.20 f	156 ± 2.30 fg	50.9 ± 1.63 cde	52.8 ± 1.46 def
BK-2011	Control	130 ± 2.40 hi	137 ± 0.66jk	114 ± 2.02 jk	124 ± 1.45 kl	45 ± 1.52 g	47.1 ± 0.73 g
BK-2011	FYM	193 ± 2.90 c	218 ± 2.90 bc	183 ± 1.45 cd	199 ± 1 c	53.3 ± 0.75 bcd	54.9 ± 0.54 bcd
BK-2011	PM	133 ± 2.90 ghi	161 ± 1.15 ghi	124 ± 2.70 g-j	150 ± 2.96 gh	50.7 ± 0.63 c-f	52.1 ± 0.98 def

Values: mean, ± standard error, means within columns with the same letters are statistically non-significant ($p \leq 0.05$)

Table 2. Effect of FYM and poultry manure on yield and physical characteristics of seven chickpea genotypes during the years 2021 and 2022

Genotypes	Treatments	Biological yield		Economical yield		100-grain weight	
		2021	2022	2021	2022	2021	2022

Kabuli Noor	Control	61.33 ± 0.88 k	82.23 ± 0.88 klm	34.7 ± 1.33 hij	47.7 ± 0.88 ijk	233.3 ± 3.33 fgh	236.3 ± 3.75 hij
Kabuli Noor	FYM	82.67 ± 2.33 f-i	104.7 ± 2.33 gh	45.3 ± 1.20 b-e	61.3 ± 0.88 bc	260 ± 5.77 cd	271 ± 5.51 cde
Kabuli Noor	PM	74 ± 1.73 hij	91 ±1.73 jkl	38.7 ± 0.67 fgh	53.7 ± 1.20 def	243.3 ± 3.33 d-g	251.7 ± 3.71 def
Parbet	Control	110.3 ± 1.45 de	125.3 ± 1.45 cd	51 ± 1.15 b	57.7 ± 1.20 cde	243.3 ± 3.33 d-g	249.3 ± 5.84 efg
Parbet	FYM	151.3 ± 1.45 a	168.3 ± 1.45 a	57.7 ± 0.88 a	71.7 ± 1.33 a	313.3 ± 3.33 a	321.3 ± 1.85 a
Parbet	PM	118.7 ± 2.02 bcd	134.3 ± 2.90 bc	50.3 ± 1.20 bc	63.3 ± 1.76 b	256.7 ± 3.33 de	266.7 ± 3.33 cde
TG-1618	Control	64.3 ± 2.60 jk	81.3 ± 2.60 lm	42.3 ± 1.20 def	50.5 ± 0.76 fgh	223.3 ± 6.67 gh	229.3 ± 4.17 ij
TG-1618	FYM	146.7 ± 2.60 a	159 ± 2.33 a	47.7 ± 1.20 bcd	62.3 ± 2.02 b	263.3 ± 3.33 cd	272.7 ± 2.67 bcd
TG-1618	PM	111.7 ± 2.72 cde	126.7 ± 1.67 cd	41.3 ± 1.20 efg	55.3 ± 0.88 def	233.3 ± 3.33 fgh	240.3 ± 4.09 ghi
TG-1415	Control	74 ± 3.05 hij	88 ± 3.05 klm	33.7 ± 1.20 hij	42.3 ± 0.88 kl	260 ± 5.77 cd	260 ± 4.50 def
TG-1415	FYM	92 ± 2.08 f	118 ± 2.02 def	37.3 ± 0.88 f-i	52.7 ± 0.88 efg	286.7 ± 3.33 b	295.3 ± 3.71 b
TG-1415	PM	82.3 ± 1.45 f-i	99.3 ± 1.85 hij	32 ± 0.58 ij	46.7 ± 0.88 ijk	253.3 ± 3.33 def	266 ± 3.60 cde
TG-1601	Control	65.3 ± 2.02 jk	78.9 ± 2.02 m	36 ± 0.57 ghi	47 ± 0.58 hij	263.3 ± 3.33 cd	266 ± 3.61 cde
TG-1601	FYM	106.7 ± 2.02 e	122.7 ± 2.02 de	45.3 ± 0.88 b-e	59.3 ± 1.45 bcd	286.7 ± 3.33b	294.7 ± 2.60 b
TG-1601	PM	74.3 ± 1.45 hij	103 ± 1.73 ghi	40.7 ± 1.20 efg	51.7 ± 1.76 fgh	280 ± 5.77 bc	286 ± 5.19 bc
TG-1513	Control	77.3 ± 1.45 ghi	93 ± 1.45 ijk	30 ± 0.58 j	41.5 ± 0.87 l	236.7 ± 3.33 e-h	242.7 ± 5.23 ghi
TG-1513	FYM	124.7 ± 1.67 b	142.7 ± 1.67 b	43 ± 1.15 def	56.3 ± 0.88 cde	260 ± 5.77 cd	266.3 ± 4.98 cde
TG-1513	PM	86.7 ± 1.76 fg	112.7 ± 0.88 efg	38 ± 1.15 fgh	49 ± 1.52 ghi	246.7 ± 3.33 def	253 ± 2.84 def
BK-2011	Control	72 ± 2 ijk	87 ± 2 klm	34.3 ± 0.88 hij	45.3 ± 0.33 jkl	220 ± 5.77 h	225.7 ± 7.84 j
BK-2011	FYM	123 ± 3.21 bc	142 ± 3.21 b	49.7 ± 0.88 bc	63.3 ± 0.88 b	236.7 ± 3.33 e-h	247 ± 2.18 fgh
BK-2011	PM	84 ± 2.51 fgh	110 ± 1.52 fgh	44.7 ± 1.20 cde	55.7 ± 1.67 cde	223.3 ± 3.33 gh	229.3 ± 3.84 ij

Values: mean, ± standard error, means within columns with the same letters are statistically non-significant ($p \leq 0.05$)

All correlations were analyzed in comparison with their corresponding phenotypic correlations. It is observed that correlations were significant ($p<0.05$) among all traits (Table 3 and 4). In table 3, the parameters that were measured during 2021 indicated that there was a strong positive correlation between the number of buds and the numbers of pods (0.9709) and also a strong positive correlation between economical yield and biological yield (0.7544). Overall analysis indicated that there was a strong positive correlation between all traits.

Table 3. Correlation analysis among different traits of chickpea genotypes during year 2021

	EY	**BY**	**100GW**	**Nob**	**Nop**
BY	0.7544**				
100GW	0.3387**	0.4267**			
Nob	0.4245**	0.3978**	0.2877*		
Nop	0.4036**	0.4180**	0.3181**	0.9709**	
PH	0.4555**	0.6448**	0.4691**	0.3349**	0.3781**

**= Highly significant, BY: biological yield; EY: economical yield; 100GW: 100 grain weight; Nob: numbers of buds; Nop: numbers of pods; PH: plant height

In table 4, the data observed during the 2022 experiment showed a strong positive correlation between the numbers of buds and numbers of pods (0.9649) and a strong positive correlation between economical yield and biological yield (0.8102). Overall analysis indicated that there was strong positive correlation between all traits.

Table 3. Correlation analysis among different traits of chickpea genotypes during year 2022

	BY	EY
EY	0.8102**	
100GW	0.5012**	0.4714**
Nob	0.5918**	0.6265**
Nop	0.557**	0.6299**
PH	0.6684**	0.5797**

**= Highly significant, BY: biological yield; EY: economical yield; 100GW: 100 grain weight; Nob: numbers of buds; Nop: numbers of pods; PH: plant height

Path coefficient analysis

Path coefficient analysis was done to identify the direct and indirect effects of measured traits on the economical yield of chickpea genotypes, while economic yield was used as a dependent character, and other yield components were independent characters (Figures 1 & 2). According to the study done in 2021, path analysis showed that all the traits had a positive direct effect on economical yield except the numbers of pods and plant height. It was revealed that biological yield exhibited a maximum positive direct effect on economic yield (0.736) as it positively correlated with grain yield per plant. In figure1, all the traits had positive indirect effects via other traits on economical yield but the number of pods and plant height had low and negative indirect effects on economical yield.

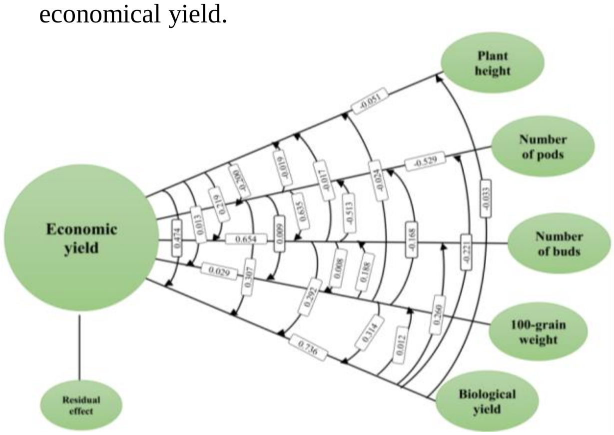

Figure 1: Path analysis diagram for yield components effect on economic yield in chickpea genotypes in the year 2021. Straight lines represent the direct effects, whereas arrow lines show indirect effects.

During the experiment in 2022, path analysis showed that all the traits had a positive direct effect on economical yield except the numbers of bud and plant height. Maximum direct effects were observed in biological yield (0.679), followed by the number of pods (0.542) on economic yield. In figure 2, all the traits had positive indirect effects via other traits on economical yield. Still, negligible, and negative indirect effects were observed via the number of buds and plant height on economical yield.

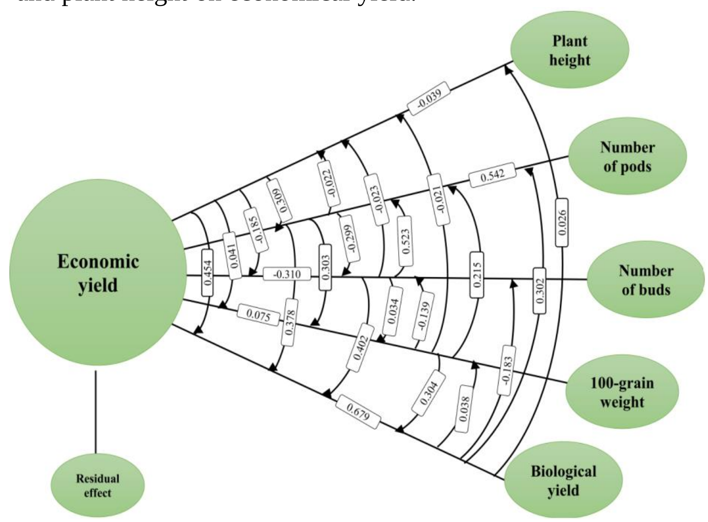

Figure 1: Path analysis diagram for yield components effect on economic yield in chickpea genotypes in the year 2022. Straight lines represent the direct effects whereas arrow lines showed indirect effects.

Discussion

All yield-related attributes significantly increased due to application of farmyard manure and poultry manure. The highest values were almost always observed in the second year of the experiment. An increase in the numbers of buds, number of the pod, plant height, economical and biological yield and 100-grain weight might be affected by the application of farmyard manure and poultry manure, as shown in Tables 2 and 3. The experiments noticed that the numbers of buds, numbers of the pod, plant height, economical yield, biological yield and 100-grain weight significantly increased with the application of farmyard manure and poultry manure as compared to control during the first year experiment in 2021 while in the second year, all the traits gave better results compared to the previous year. It is known that farmyard manures and poultry manures are good sources of macro-nutrients (N, P, K, Ca, Mg, S) and micro-nutrients (Zn, Cu, Fe, Mn, B) that can improve the C and N content, porosity, and microbial activity of the soil (Aslam, 2013). Approximately 74% of total Phosphorus and 40% of total Nitrogen in farmyard manure and poultry manure is bio-available. Because of its high nutritional value, using organic manure instead of inorganic fertilizers could help in the improvement of crops and soil. Chickpea can fix atmospheric nitrogen into ammonia, and organic manure boosts the microbial activity in plants, ultimately increasingsoil fertility. The residues from the previous crop help the next crop to grow well and also increase the yield and growth of the crop. Poultry manure contains some toxic elements that restrict the development of crops. This might be the reason that plants treated with farmyard manure gave better results as compared to poultry manure.

The results demonstrated that the impact of poultry manure and farmyard manure on the investigated attributes was statistically significant, with farmyard manure treatment producing the greatest outcomes. Due to a shortage of forage, the soil at the experimental site had low levels of organic matter and a weak ability to return crop leftovers to the soil. By enhancing the soil's physical, chemical, and biological characteristics, applying FYM under the aforementioned conditions above considerably increases soil organic matter (SOM). It can promote crop growth (Nouraein et al., 2019). However, the second year's application of FYM produced better results, which can be attributed to the improved soil quality and plant leftovers from the prior trial. Under appropriate soil moisture regimes, FYM enhances crop productivity and seed quality. Because of the historical assumption that manure can worsen the effects of heat on crops because it contains ammonium, which can burn crops when applied to planting holes, manure use is banned in arid locations (Murungweni et al., 2016). Additionally, it appears that the application of FYM improved soil conditions, promoted root growth, increased nutrient uptake, and provided a uniform canopy as a suitable platform for greater absorption of bio-stimulants and micronutrients, has improved soil conditions. The results are similar to certain earlier findings (Ahmad et al., 2012; Ali et al., 2010ab; Ali et al., 2011; Naveed et al., 2012; Pasandi et al., 2018; Kheyrkhah et al., 2018). To improve plant growth and development and boost chickpea production, it is required to apply farmyard and poultry manure. The comparison of this finding to that made by Janmohammadi et al. (2015) and (Nouraein et al., 2019).

Conclusion

According to the findings of this study, the use of farm yard manure and poultry manure increased the quality of seeds and nutritional content of Kabuli and Desi chickpeas. In addition, studies revealed that using FYM in the field substantially enhanced the economic and biological output compared to plants treated with poultry manure and control plants. It is possible to conclude that farmyard manure and chicken manure boost soil fertility, directly impacting chickpea growth and development. According to our findings, it is recommended to apply2.4 tons/ha of farm yard manure and 2 tons/ha of chicken manure to the chickpea crop, which can be helpful in the dry region of Layyah, Pakistan. More study is needed to demonstrate their beneficial effects at the subcellular level.

Conflict of interest

The authors declared absence of conflict of interest.

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