

Effect of poultry manure on growth and yield of forage sorghum (*Sorghum bicolor* L.)

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Abstract

The increasing demand of poultry meat in Pakistan has prompted more poultry forming with consequent effect on increase utilization of organic wastes (poultry manure) as fertilizers. In organic manures have considerable amount of organic matter, water content and mineral nutrients. A field experiment was conducted in research area of College of Agriculture, University of Sargodha, Sargodha, Punjab, Pakistan, to investigate the effect of poultry manure on the growth and yield of forage sorghum. For this purpose, four treatments (0 t/ha, 1t/ha, 2.5 t/ha and 4 t/ha) with three replications were used in Randomized Complete Block Design (RCBD). Plant height (cm), number of leaves per plant, stem diameter (cm²), fresh weight of forage (t/ha), dry weight of forage (t/ha), nitrogen% in plants, phosphorous% in plants and potassium % in plant were measured. The results showed that there were significant differences among treatments in most parameters during the growing period for growth characteristics under study. Maximum plant height (130 cm), number of leaves per plant (11), stem diameter (49 cm), fresh weight of forage (20 t/ha), dry weight of forage (5.5 t/ha), nitrogen % in plant (2.25%), phosphorous% in plants (18%), and potassium % in plant (17%) were examined where we applied 4 t/ha poultry manure. We concluded from this experiment that application of poultry manure at the rate of 4 t/ha improve the growth and yield of forage sorghum (*Sorghum bicolor* L.).

Keywords: poultry, manure, plant height, growth, yield

1. Introduction

Sorghum (*Sorghum bicolor* L.) is mostly grown in semi-arid regions of the worlds. It is fifth among cereal crops. Common name of sorghum in Pakistan is Jowar and is known as kharif crop. Worldwide annual production of sorghum is 60 million tons. Area under cultivation of sorghum in Pakistan is 0.34 million hectares with annual production of 0.21 million-ton ha⁻¹. It is 12% of the total cultivated area (Akram *et al.*, 2007) [2]. Sorghum is not only a fodder crop but its seeds are also used as food for poultry birds. It is used as raw material in many industries for manufacturing useful products like alcohols, and starch etc. It is great source of biofuel. It is also used as staple food in different countries in all over the globe (Mehmood *et al.*, 2008) [15]. In Pakistan sorghum is grown for both fodder and grain purpose. The term fodder is used for those crops that can be preserved as hay for livestock for the seasons when green forage is not available. The nutritious value of sorghum is equal to maize, but farm animals mostly prefer it due to its sweet taste. The varieties of sorghum that produce both seed and fodder are preferred, because sorghum straw is used as a food for livestock when other types of fodder are not available (Hall, 2000) [7].

The composition of sorghum grains consists of proteins, fats and carbohydrates about 10-12, 3 and 70% respectively. The use of inorganic fertilizer has not been helpful under intensive agriculture because it is often associated with reduced crop yield, soil acidity and nutrient imbalance (Obi and Ebo, 1995; Ojeniyi, 2000 and Ayoola and Adeniyani, 2006) [17, 18, 4]. Soil fertility and soil physical properties are improved by organic matter (Hoitink and Grebus, 1994) [10].

Soil physical properties are very important for good plant growth and consequently proficient production of crops. When soil surface is mulched with several types of organic materials it results in increased microbial activity, soil moisture conservation and prevents weeding. When we apply organic matter to the soil, it helps to reduce the use of chemical fertilizers and soil conditioners, as organic matter helps the soil microbes to release polysaccharides to improve soil condition (Zheljazkov and Warman, 2004 and Hashim *et al.*, 2013) [25, 8]. Soil physical properties like aeration, water holding capacity and fertility are improved by adding organic matter and it also helpful in better seedling emergence and development of root (Guar, 1992) [6].

Different types of organic manures like crop stubbles, animal urine, poultry manure, compost and biochar, when added to soil results in increase in microbial population ultimately improve in soil health as well as the sustainability of the soil is achieved (Sharif *et al.*, 2003 and Zia *et al.*, 1998) [23, 26]. Poultry manure is the feces of poultry birds used as an organic fertilizer, especially for soil low in nitrogen (Mishra and Bangar, 1986) [16]. Among all animal manures, it contains highest amount of nitrogen, phosphorus, and potassium (Sigh and Amberger, 1991) [24]. Poultry manure is sometimes pelletized for use as a fertilizer, and this product may have additional phosphorus, potassium and nitrogen. Optimal storage conditions for poultry manure includes it being kept in a covered area and retaining its liquid, because a significant amount of nitrogen exists in the feces. Fresh poultry manure contains 0.8% potassium, 0.4-0.5% phosphorus and 0.9-

1.5% nitrogen. One poultry chicken produces approximately 8-11 pounds of manure per month. Poultry manure can be used as organic plant fertilizer. Poultry manure is rich source of nutrients, easily available and very cheap source of plant nutrients. Therefore, this research trial was planned to investigate optimum dose of poultry manure for achieving maximum growth and yield of forage sorghum (*Sorghum bicolor* L.).

2. Materials and Methods

2.1. Site and soil

The experiment was carried out at research area of Department of Soil and Environmental Sciences, College of Agriculture, University of Sargodha, Sargodha, Punjab-Pakistan during spring 2015. The soil was clay loam and had a good drainage capacity. Before sowing of crop, analysis of soil was done. The study was carried out with the objectives to assess the growth, quality and yield components of sorghum by the application of different poultry manure levels. Additional information regarding experiment and soil is presented in table 2.1.

Table 1: Physio-chemical analysis of experimental soil

Chemical properties	Pre analysis	Post analysis
pH (—)	7.9	7.21
Electric conductivity(dS/m)	1.72	1.8
Organic matter (%)	0.84	1.10
P (mg/kg)	9	13
N (%)	0.01	0.016
Physical properties (%)	Pre analysis	Post analysis
Coarse sand	10.6	10.6
Fine sand	35.5	35.5
Silt	26	26
Clay	28	28
Texture	Sandy	Clay loam

2.2. Climate

The experimental area was situated in the sub-tropical region of Punjab, Pakistan. This area falls under monsoon climatic conditions with annual mean rainfall of 400mm during monsoon season of July to September. The characteristics of sub-tropical region include high humidity and temperature as well as heavy rainfall in Kharif season while low rainfall and moderately low temperature in Rabi season.

2.3. Experimental design and treatments

The experiment was laid out in RCBD having three replications, keeping net plot size 13 m × 13 m. The treatments were 0 t/ha, 1 t/ha, 2.5 t/ha and 4 t/ha of poultry manure. Crop was sown during the spring season with the help of dibbler keeping plant to plant distance 25cm and row to row distance of 75cm after land preparation with the help of disc plough; disc harrow was used to crush clods and levelled out to maintain a well levelled seed bed. Nitrogen, Phosphorus and potassium were used at the rate of 200, 125 and 125kg/ha, respectively. All other cultural practices, such as hoeing, irrigation and plant protection measures were kept normal for the crop at experimental station.

2.4 Procedure of crop cultivation

2.4.1. Sowing of sorghum seeds

The seed bed was prepared by cultivating the field for 2-3 times with tractor-mounted cultivar. Sorghum seeds were

sown uniformly at 60 cm apart in rows using 80 Kg/ha. Thinning was done leaving 10 cm apart plant to plant distance at early stages of crop development. Crop was kept free of weeds by hoeing twice to avoid weed-crop competition. Insecticide 'Imidacloprid' was sprayed at the rate 125 g per acre with the help of knapsack hand sprayer at 2-3 leaf stage to protect the crop against shoot fly. The first irrigation was applied after 7 days of germination while other irrigations were applied to the crop according to water requirements.

2.4.2. Fertilizer application

Inorganic fertilizer including N, P and K were applied with the dose of 100-50-50 kg/ha, respectively as urea, di-ammonium phosphate and potassium sulphate. Whole P and K were applied at the time of sowing while urea was applied in three splits (at sowing, 30 and 60 days).

2.5. Harvesting and plant analysis

At maturity crops were harvested. The harvested plants were washed with distilled water and weighed to get fresh weight. These plants were oven dried at 70°C for constant weight.

2.6. Observations

The following parameters were examined by using standard procedures.

2.6.1. Plant height (cm)

Plant height was taken as the length between the bases of the plant to the tip. Plant height was recorded at maturity with the help of meter rod.

2.6.2. Number of leaves per plant

This parameter was measured by calculating all leaves of ten randomly selected plants at harvest. The mean of leaves per plant was recorded.

2.6.3. Stem diameter (cm)

Measured by using a vernier caliper from the middle of the 2nd inter-node of ten plants selected randomly of each plot and the mean stem diameter was calculated.

2.6.4. Fresh weigh of plant (g)

The weight of five selected plants was taken on electrical balance separately for each replication. Then the average fresh weight of plant was calculated by dividing the total number of plants taken.

2.6.5. Dry weight of plant (g)

The selected plants were oven dried at 70°C for 24 hours then the dry weight of plants was measured on electrical balance for each treatment separately. Then the average dry weight of plant was worked out.

2.6.6. Chemical analysis of plant samples

For the determination of nitrogen and phosphorus from straw of sorghum plants. In digestion tubes 0.1g dried and ground plant sample was taken. Three milliliter (ml) of concentrated sulphuric acid was added and incubated overnight at room temperature. Subsequently 1 ml of H₂O₂ (35% pure) was put into digestion tubes and rotated. Positioning of the tube in digestion block and rise in temperature up to 350°C pending to fumes generation and persisted heat up for 20 min. Followed by removal of

digestion tubes, addition of 1 ml H₂O₂ slowly and again the digestion tubes were positioned back till production of fumes over 20 min above step was repeated. By adding distilled water the volume was made up to 50 ml.

2.6.7. Digestion of plant samples for the determination of K, N and P contents

Plant samples of 0.5 g were transferred into digestion vessel 10 ml of diacid mixture (HNO₃: HClO₄ = 2:1) were added into the vessel and kept overnight. Next day, samples were digested on the hot plate at 250°C till material was become transparent. After digestion, material was cooled and diluted up to 50 ml by adding distilled water. The digested samples were filtered with Whatman filter paper # 40 and stored in air tight plastic bottles.

Nitrogen (%): Nitrogen in plants was determined by Kjeldahl's method (Ryan *et al.*, 2007) [22].

Phosphorus (%): Phosphorus in plants was determined by wet digestion method.

Potassium (%): Potassium in plants was determined by flame photometer procedures.

2.7. Statistical Analysis

Data analyses were carried out by using the Statistics software (version, 8.1Statistix, Tallahassee, FL, USA). The least significant difference (LSD) test was employed to compare the means at 5% Probability level. Microsoft office (MS-2010) was used to draw figures.

3. Results and Discussion

3.1. Plant height (cm)

Plant height is an important character which contribute in yield or production. It is the resultant of collective effects of genetic dynamics and applied inputs. Generally, it displays the relative growth and vigor of crop plant. Results (Fig. 3.1) revealed that when the level of poultry manure becomes higher in soil along with recommended N.P.K. the plant height increased significantly. The height of sorghum plant was recorded at maturity and is given in figure 3.1. Supplementation of poultry manure by using different level, contributed toward plant height improvement. Statistical analysis showed that the difference among different treatment was significant. The maximum plant height (130.33 cm) was noted when poultry manure with dose 4 t/ha was applied which was followed by poultry manure 2.5 t/ha. While, the minimum height of plant (113 cm) was seen in 0 t/ha (control treatment) having zero level of poultry manure. However, poultry manure enhanced significantly the plant height as compared to control. These results coincide with the results of Ismaeil *et al.*, (2012) [12], who said that by using chicken manure taller plants can be obtained.

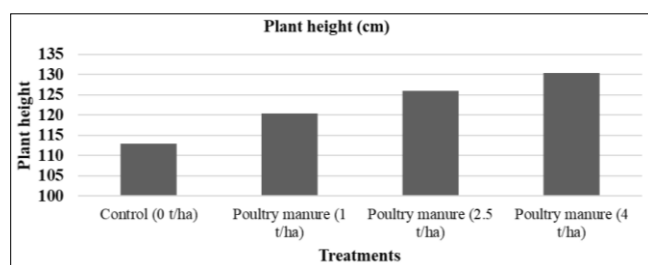


Fig 1: Effect of poultry manure on sorghum plant height

3.2 No. of leaves per plant

It is a key factor which ultimately contribute in yield. More the no. of leaves per plant more will be the vegetative growth which leads to higher yield of sorghum plant. Results (Fig. 3.2) showed that number of leaves per plant improved significantly due to the higher levels of poultry manure in soil along with the application of recommended NPK. Number of leaves of sorghum per plant was counted at the time of maturity and shown in the figure 3.2. Supplementation of poultry manure contributed toward number of leaves per plant improvement. The treatments were significantly different when statistically compared. The poultry manure with dose of 4 t/ha proved superior as, maximum number of leaves per plant (11.67) was observed when poultry manure at the rate of 4 t/ha was applied, which is statistically similar with poultry manure 2.5 t/ha. Whereas, minimum number of leaves per plant (7.33) was recorded for the 0 t/ha (control treatment) receiving zero dose of poultry manure. Poultry manure levels improve the number of leaves per plant significantly when compared with the control treatment in term of statistics. Kareem *et al.*, (2017) [13] depicted that number of leaves, leaf area, plant height, and stem girth when 5t/ha of poultry manure was applied at the time of sowing. Farhad *et al.*, (2009) [5] stated that plant height, biological yield and harvest index of maize crop were increased when poultry manure at the rate of 12 t/ha was applied.

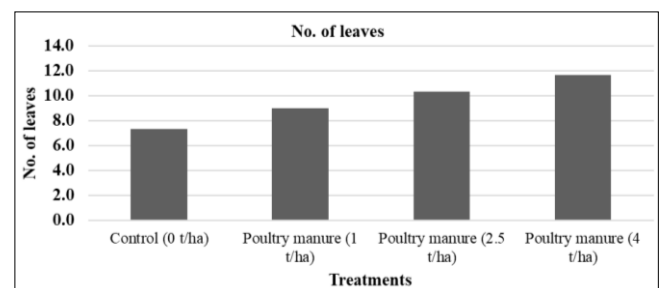


Fig 2: Effect of poultry manure on number of leaves of sorghum plant

3.3 Stem diameter (cm²)

The stem diameter is the vital agro-morphological character of crop plants and usually it represents the growth and resistance of the plants. Results (Fig. 3.3) revealed that in sorghum the diameter of stem increased significantly in all treatments as compared to control treatment in which zero level of poultry manure was applied along with recommended NPK. All the treatments were significant with each other when compared statistically. Data regarding stem diameter of sorghum was presented in figure 3.3. Maximum stem diameter (0.49 cm²) of sorghum was noted under the poultry manure at the rate of 4 t/ha while, the minimum stem diameter (0.42 cm²) was noted with control treatment where poultry manure was not applied. According to this experiment, stem diameter was significantly affected by increasing level of poultry manure, which showed that the effect of poultry manure on sorghum plant growth. Kareem *et al.*, (2017) [13] depicted that number of leaves, leaf area, plant height, and stem girth when 5t/ha of poultry manure was applied at the time of sowing. Onyema *et al.*, (2010) [20] reported that with the application of 10800 kg/ha poultry manure significantly enhanced the leaf formation, increase in stem girth and height growth tropical vine.

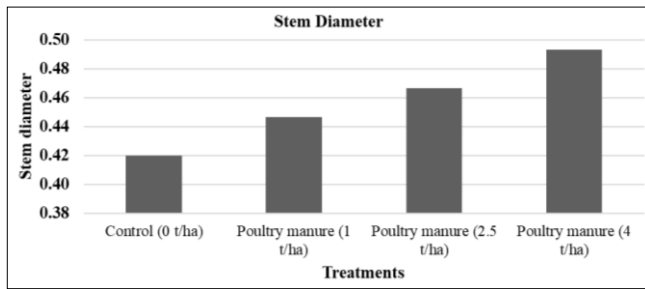


Fig 3: Effect of poultry manure on stem diameter of sorghum

3.4 Forage fresh weight (t/ha)

The total biomass of a plant is called its fresh weight. The net return from the plant is depicted by this parameter. As the fresh weight increases it means the net return of the crop can also be increased. It is the most important parameter which depicts the net return from the crop. As more the fresh weight more will be the net return from sorghum crop. Fig. 3.4 indicated the impact of poultry manure along with recommended dose of NPK on forage fresh weight of sorghum which was significant. The highest forage fresh weight (20.20 t/ha) of sorghum was obtained where sorghum was grown with poultry manure 4 t/ha. However, among all the treatments, lowest forage fresh weight (10.27 t/ha) of sorghum was measured with 0 t/ha (control treatment). All poultry manure levels improve the forage fresh weight significantly when compared with the control treatment in term of statistics. These results were supported by Hassan (2002) [9], who said that the maximum forage yield of sorghum was obtained by using 7.5 tons chicken manure as compared to control.

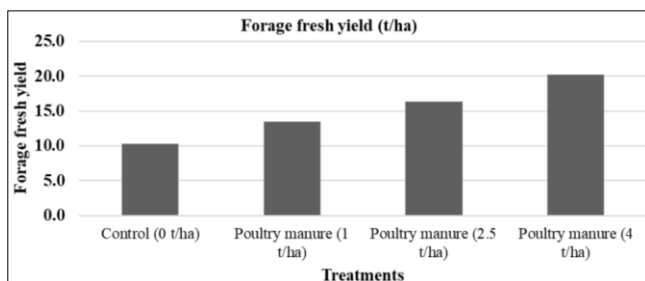


Fig 4: Effect of poultry manure on forage fresh yield of sorghum plant

3.5 Forage dry weight (t/ha)

Dry weight of sorghum crop is an essential feature for attaining the vegetative growth and ultimately the production of crop. Effect of poultry manure along with recommended dose of NPK was shown in fig 3.5 which was statistically significant. The highest forage dry weight (5.39 t/ha) of sorghum was obtained where sorghum was grown with poultry manure 4 t/ha. However, among all the treatments, the lowest dry weight (3.55 t/ha) was noted with poultry manure 0 t/ha (control treatment). All poultry manure level improved the forage dry weight significantly, when statistically compared with the control treatment. Abu Suwar and El Zilal (2010) [1], said that both fresh and dry forage weight was increased significantly by using chicken manure. They demonstrated that by increasing manure application the fresh and dry matter also increased. Maximum dry weight was obtained by using highest dose of manure.

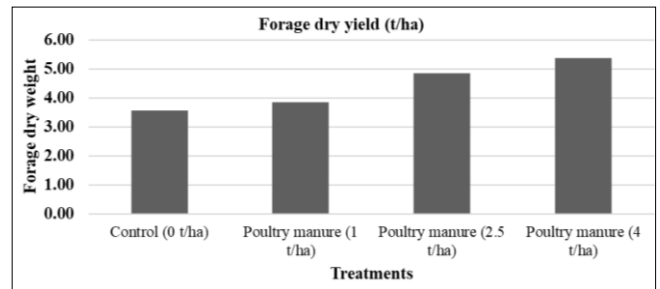


Fig 5: Effect of poultry manure on forage dry weight of sorghum plant

3.6. Nitrogen (%) in sorghum plant

Nitrogen plays an important role in various physiological processes of plants. It is an important part of many organic compounds like proteins and nucleic acid. It is an important component of chlorophyll and involves in energy processes. Influence of poultry manure along with recommended dose of NPK was showed in fig 3.6. Results showed that the nitrogen content in plants can be affected significantly by the application of poultry manure. The maximum increase in sorghum nitrogen (2.33%) was seen with the application of poultry manure 4 t/ha. The nitrogen contents of sorghum were also high with application of poultry manure 2.5 t/ha (2.17%) and 1 t/ha (2.01%) followed by poultry manure 4 t/ha. On the other hand, minimum nitrogen contents (1.85%) of sorghum was observed in 0 t/ha (control treatment). The results revealed that by the application of poultry manure, the nitrogen content of sorghum plant was also increased. Many researchers (Abusuwar and El Zilal, 2010; Magid *et al.*, 1998; Postma *et al.*, 1998 and Hue and Sobieszczyk, 1999) [1, 14, 21, 11], said that by using poultry manure the uptake of nitrogen and phosphorus increased significantly. Ojeniyi *et al.*, (2013) [19] reported that poultry manure applied at rate of 7.5 t/ha significantly enhanced the nutrient uptake of N, P, K, Ca and Mg and improved the soil structure and texture by cocoyam.

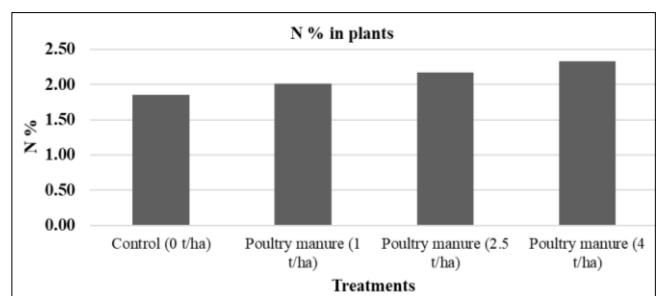


Fig 6: Effect of poultry manure on nitrogen (%) in sorghum plant

3.7. Phosphorous (%) in sorghum plant

Phosphorus is involved in many processes like storage and supply of energy, photosynthesis, enzymes regulation and transport of carbohydrates. The effect of poultry manure was significant on phosphorus contents of the sorghum plants is shown in fig. 3.7. Results revealed that when the level of poultry manure becomes higher in soil along with recommended NPK the phosphorous (%) in sorghum plant increased significantly. Supplementation of poultry manure by using different level, contributed toward phosphorous (%) improvement. Highest phosphorus (0.19%) in sorghum plant was observed under the application of poultry manure 4 t/ha which was followed by 2.5 t/ha application of poultry

manure. However, the lowest phosphorous of plant (0.11%) was seen with 0 t/ha (control treatment) having zero level of poultry manure. Poultry manure enhanced significantly the phosphorous (%) as compared to control. Ojeniyi *et al.*, (2013) [19] reported that poultry manure applied at rate of 7.5 t/ha significantly enhanced the nutrient uptake and other yield attributes of cocoyam. Ayeni and Adetunji, (2010) [3] told that an effective increase in nutrient availability and maize production was observed with the application of poultry manure and NPK.

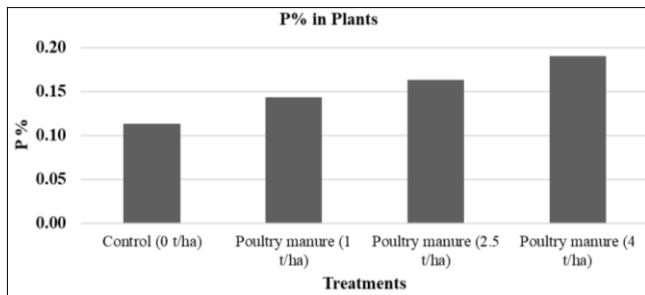


Fig 7: Effect of poultry manure on phosphorous (%) in sorghum plant

3.8. Potassium (%) in sorghum plant

Potassium plays an important role in different mechanisms like protein synthesis, glycolytic enzymes and photosynthesis. Potassium in sorghum plants was affected significantly by the application of poultry manure is shown in fig. 3.8. Results revealed that when the level of poultry manure becomes higher in soil along with recommended NPK the potassium (%) in sorghum plant increased significantly. Supplementation of poultry manure by using different level, contributed toward potassium (%) improvement. The maximum potassium (1.68%) of sorghum plant was recorded when poultry manure at the rate of 4 t/ha was applied which is statistically similar with poultry manure 2.5 t/ha. While, the minimum potassium of sorghum plant (1.37%) was seen in 0 t/ha (control treatment) having zero level of poultry manure. Among all the treatments, application of poultry manure 4 t/ha in combination with NPK was superior with respect to potassium (%). However, poultry manure enhanced significantly the phosphorous (%) as compared to control. Ayeni and Adetunji, (2010) [3] told that an effective increase in nutrient availability and maize production was observed with the application of poultry manure and NPK. Ojeniyi *et al.*, (2013) [19] reported that poultry manure applied at rate of 7.5 t/ha significantly enhanced the nutrient uptake and other yield attributes of cocoyam.

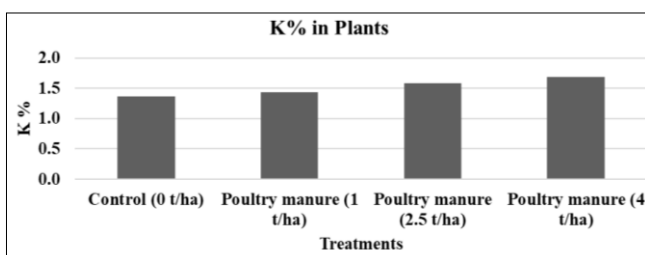


Fig 8: Effect of poultry manure on potassium (%) in sorghum plant

Conclusion

It is concluded that poultry manure imparts significant

Impact on growth, yield and nutrient concentration in sorghum plant. By increasing the poultry manure level, growth and nutrients concentration increased in sorghum plant. It is concluded that the poultry manure at the rate of 4.0 t/ha produced higher fresh and dry forage at harvest.

References

1. Abusuwar AO, El Zilal HA. Effect of chicken manure on yield, quality and HCN concentration of two forage Sorghum (*Sorghum bicolor* (L) Moench) cultivars. *Agric. Biol. JN Am.* 2010; 1(1):27-31.
2. Akram A, Fatima M, Ali S, Jilani G, Asghar R. Growth, yield and nutrients uptake of sorghum in response to integrated phosphorus and potassium management. *Pakistan Journal of Botany.* 2007; 39(4):1083-1087.
3. Ayeni LS, Adetunji MT. Integrated application of poultry manure and mineral fertilizer on soil chemical properties, nutrient uptake, yield and growth components of maize. *Nature and science.* 2010; 8(1):60-67.
4. Ayoola OT, Adeniyi ON. Influence of poultry manure and NPK fertilizer on yield and yield components of crops under different cropping systems in south west Nigeria. *African Journal of Biotechnology.* 2006; 5(15):1386-1392.
5. Farhad W, Saleem MF, Cheema MA, Hammad HM. Effect of poultry manure levels on the productivity of spring maize (*Zea mays* L.). *J. Anim. Plant Sci.* 2009; 19(3):122-125.
6. Gaur AC. Bulky organic manures and crop residues. *Fertilisers, Organic Manures, Recyclable Wastes and Biofertilisers: Components of Integrated Plant Nutrition.* edited by H. Tandon. New Dehli: Fertiliser Development and Consultation Organisation, 1992.
7. Hall AJ. Sorghum utilization and the livelihoods of the poor in India: A review of findings and recommendations. *Biological sciences,* 2000; 61:117-124.
8. Hashim S, Marwat KB, Saeed M, Haroon M, Waqas M, Shah F, *et al.* Developing a Sustainable and Eco-Friendly Weed Management System Using Organic and Inorganic Mulching Techniques. *Pakistan Journal of Botany,* 2013; 45:483-486.
9. Hassan EAH. Effect of chicken manure and season on the performance and HCN Content of two Forage sorghum cultivars (Doctoral dissertation, Ph. D. Thesis, Faculty of Agriculture, University of Khartoum, Sudan), 2002.
10. Hoitink HA, Grebus ME. Status of biological control of plant diseases with composts. *Compost Science & Utilization.* 1994; 2(2):6-12.
11. Hue NV, Sobieszczyk BA. Nutritional values of some biowastes as soil amendments. *Compost science & utilization.* 1999; 7(1):34-41.
12. Ismael FM, Abusuwar AO, El Naim AM. Influence of chicken manure on growth and yield of forage sorghum (*Sorghum bicolor* L. Moench). *International Journal of Agriculture and Forestry.* 2012; 2(2):56-60.
13. Kareem I, Jawando OB, Eifediyi EK, Bello WB, Oladosu Y. Improvement of growth and yield of maize (*Zea mays* L.) by poultry manure, maize variety and

- plant population. *Cercetari Agronomice in Moldova*. 2017; 50(4):51-64.
14. Magid HMA, Abdel-Aal SI, Rabie RK, Sabrah REA. Chicken manure as a biofertilizer for wheat grown on sandy soils of Saudi Arabia. *Egyptian Journal of Soil Scienc.* 1998; 38:329-338.
 15. Mehmood S, Bashir A, Ahmad A, Akram Z, Jabeen N, Gulfray M, *et al.* Molecular characterization of regional Sorghum bicolor varieties from Pakistan. *Pakistan Journal of Botany.* 2008; 40(5):2015-2021.
 16. Mishra MM, Bangar KC. Rock phosphate composting: transformations of phosphorus forms and mechanisms of solubilization. *Biological agriculture & horticulture.* 1986; 3(4):331-340.
 17. Obi ME, Ebo PO. The effects of organic and inorganic amendments on soil physical properties and maize production in a severely degraded sandy soil in southern Nigeria. *Bioresource Technology.* 1995; 51(2-3):117-123.
 18. Ojeniyi SO. Effect of goat manure on soil nutrients and okra yield in a rain forest area of Nigeria. *Applied Tropical Agriculture*, 2000; 5:20-23.
 19. Ojeniyi SO, Amusan OA, Adekiya AO. Effect of poultry manure on soil physical properties, nutrient uptake and yield of cocoyam (*Xanthosoma saggitifolium*) in southwest Nigeria. *American-Eurasian J Agric. & Environ. Sci.* 2013; 13(1):121-125.
 20. Onyema MC, Nzezbule EC, Akachuku CO. Effect of Organic Manure Application on the Leaf Production, Height Growth and Stem Girth Enlargement in a Tropical Vine (*Cissus Striata*), Abia State Nigeria. *Biodiversity, Development rsity, Development and Poverty Alleviation and Poverty Alleviation*, 2010, 31-36.
 21. Postma R, Erp PV, Van EP. Nutrient management in arable farming and outdoor vegetable growing. *Mestoto Hen*, 13-19. *CAB Abstract 1998/99*, 1998.
 22. Ryan J, Estefan G, Rashid A. Soil and plant analysis laboratory manual. *ICARDA*, 2007.
 23. Sharif M, Khattak RA, Sarir MS. Residual Effect of Humic Acid and Chemical Fertilizers on Maize Yield and Nutrient Accumulation. *Sarhad Journal of Agriculture.* 2003; 19(4):543-550.
 24. Singh CP, Amberger A. Solubilization and availability of phosphorus during decomposition of rock phosphate enriched straw and urine. *Biological Agriculture & Horticulture.* 1991; 7(3):261-269.
 25. Zheljzkov VD, Warman PR. Source-separated municipal solid waste compost application to Swiss chard and basil. *Journal of Environmental Quality.* 2004; 33(2):542-552.
 26. Zia MS, Baig MB, Tahir MB. Soil environmental issues and their impact on agricultural productivity of high potential areas of Pakistan. *Sci. Vis*, 1998; 4:56-61.