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# Bird Droppings Biodegradation and Its Use as Fertilizer for Tomato Cultivation

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## Abstract

This article presents the results of studying the effect of a microbial biological product based on Pseudomonas putida 90 biovar A (171) and Azotobacter chroococcum 31/8 R strains on the process of biodegradation of native litter of broiler chickens and quails. An assessment of the physicochemical and sanitary-bacteriological characteristics of the processed manure showed an improvement in safety indicators. There had noticed that the experimental samples of processed litter, were decreasing ammonia nitrogen emitting and unpleasant odor significant reduction. Also, there had studied the effectiveness of processed manure as an organic fertilizer in tomato cultivation. Agrotechnological experiments have shown that the fruits in the experimental group had increased productivity and better accumulation of sugars and ascorbic acid in their composition.

**Disciplinary**: Sustainable Agriculture (Soil and Fertilizer), Poultry Science, Horticulture.



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## 1 Introduction

Organic fertilizers are a necessary element of crop cultivation technologies, because of their wide effect on the soil-microorganisms-plant system. They are an important source of mineral nutrients for plants and soil microorganisms, increasing the efficiency of applied mineral fertilizers by 20–30%. In addition, the applied organic fertilizers make it possible to re-engage part of the

nutrients taken out with the harvest into the cycle (Chew et al., 2019; Daadi and Latacz-Lohmann, 2021).

Organic fertilizers, to some extent, neutralize the negative effects of the use of mineral fertilizers and plant protection products. They contribute to the utilization of pesticide residues, heavy metals, and radioactive substances into compounds inaccessible to plants. Physiologically active substances that activate growth and production processes enter the soil with organic fertilizers (Grenon et al., 2021; Grzyb et al., 2021).

One type of organic fertilizer is bird droppings - a biologically active product containing all the macro-and microelements necessary for plants in large quantities. Microelements released as organic matter decomposes are available to plants for a longer time than microelements of mineral additives (Imas, 2000). There had revealed that bird droppings are a fast-acting organic fertilizer with high nutrient content. Its phosphorus is better absorbed than mineral fertilizer phosphorus (Akhtar et al., 2007; Li et al., 2011).

The major limiting factor in using poultry manure as a fertilizer is the need to ensure compliance with sanitary safety standards (Chastain et al., 2010; Katsura et al., 2021; Muola et al., 2021).

Thus, the use of organic fertilizers based on bird droppings is promising, and the search for means to speed up its natural decomposition process is an urgent direction.

The purpose of the research work is to study the effect of organic fertilizers from a processed litter of broiler chickens and quails on the growth, development, yield, and quality of vegetable fruits, using the example of an open ground tomato.

## 2 Materials and Methods

For bird droppings processing in Krasnodar Region farming, had used a developed 2-component bioutilizer comprising a mixture of Pseudomonas putida 90 biovar A (171) and Azotobacter chroococcum 31/8 R cultures.

**Table 1:** Scheme of a field scientific and economic experiment on tomatoes

| Group | Type of processed manure | Dose of applying processed manure applied to the soil, kg/m2 |
|---|---|---|
| Control | – | – |
| 1st experience | from broiler chickens | 1.5 |
| 2nd experience | from broiler chickens | 3.0 |
| 3rd experience | from broiler chickens | 4.5 |
| 4th experience | from quails | 1.0 |
| 5th experience | from quails | 1.5 |
| 6th experience | from quails | 2.0 |

Manure processing was on isolated farm sites equipped with a manure storage facility. There had processed four tons of broiler and quail manure. The research, carried out the physical-chemical and sanitary-bacteriological control of the initial bird droppings and the final product by GOST 31461-2012. Also, studied the ammonia nitrogen level and the total microbial number of the experimental samples (Britt et al., 2002; Kim and Patterson, 2003; Williams et al., 1999).

There had been studied the impact of the processed manure of broiler chickens and quails on the growth, development, yield, and quality of tomato cultivation. The test organic fertilizer was applied to the area allotted for laying the field experiment on tomatoes, according to the experimental schemes (Table 1).

Shallow plowing to a depth of 10-15cm was introduced into the soil with the applied fertilizers. The accounting area of the plots was $5m^2$, the repetition was four times. Seedlings at 60 days from germination had been planted in the open ground according to the scheme 70×50cm.

All activities for the care of plants (loosening of row spacings, watering, weed control, harvesting) were done manually. Soil moisture was supported at the level of 75% of the lowest moisture capacity.

The selection of plants to determine growth parameters (plant height, number of branches and leaves, total leaf surface, biomass, and dry mass of aboveground organs) was at the beginning of fruit formation. Fruits harvested were every 3-4 days as they reached biological ripeness with simultaneous structural analysis (determination of the diameter and weight of each fruit). During the period of mass harvesting of fruits, the content of total sugars and vitamin C in them was determined. The yield was determined by the sum of fruits harvested from the accounting area.

As a vegetable crop were tomatoes of the variety «Dar Zavolzh'ya». The «Dar Zavolzh'ya» is a mid-early variety of tomatoes, usually from 103 to 109 days pass from the moment of seed germination to the fruiting period. It's cultivated by seedlings and intended for planting in open ground. An adult plant reaches a height of only 50-70cm. Tomato "Dar of the Volga" is not susceptible to diseases of septoria and alternariosis. The fruits have a rounded shape, the color is red-orange, and the weight of one fruit is on average 80-100g. The fruits have an excellent taste and have good resistance to long-term transportation. On average, the variety's yield is between 4 and $5kg/m^2$.

# 3 Results and Discussion

## 3.1 Soil and climatic conditions during experiments

Soil type - leached chernozem. The thickness of the humus horizon exceeds 150cm. In the upper horizon, the soils are rich in phosphorus with a concentration of 0.18%. The main part of phosphorus contains mineral compounds (in the upper horizons by 55–65%, in the lower horizons - over 90% of the gross amount). Organic phosphorites are in the amount of 43% in the upper and 8–10% in the lower horizons. Chernozems have a high water-holding capacity but have a low range of active moisture. Of the total amount of soil moisture, less than 50% belongs to the category of active or productive moisture.

Climate - the area of the experiment (Krasnodar), belongs to the unstable-humid zone. Moisture coefficient 0.25-0.30, 500-600 mm of precipitation falls per year. Air temperature transition in spring over + 5°C is in the second half of March - early April. A distinctive feature of the spring period of the zone is the rapid temperature rise.

The weather during the growing season of the studied culture (Table 2) was formed for its growth and fruiting in different ways.

**Table 2**: Weather during the tomato growing season, 2021

| Month | Air temperature, °C | | Precipitation, mm | | Relative humidity, % | |
|---|---|---|---|---|---|---|
| | average long-term | during the growing season | average long-term | during the growing season | average long-term | during the growing season |
| April | 10.9 | 11.1 | 48.0 | 85.4 | 69.0 | 82.0 |
| May | 16.8 | 18.0 | 57.0 | 64.7 | 67.0 | 71.0 |
| June | 20.4 | 21.7 | 67.0 | 36.1 | 65.7 | 76.3 |
| July | 23.2 | 25.1 | 58.0 | 16.0 | 64.3 | 68.0 |

The optimal temperature and moisture supply during the planting of seedlings (for tomatoes on 12 April 2021) activated the rooting of seedlings and provided a high start for growth processes and fruit formation. However, prolonged high temperatures and air drought (June–July) reduced the initial effect and adversely affected the production process, yield, and fruit quality.

## 3.2 Compliance of Processed Poultry Manure with Indicators of Regulatory Documentation

The results of studies during the processing of native litter got from broiler chickens and quails with the developed biological product are in Tables 3 and 4.

**Table 3**: Physico-chemical and sanitary-biological parameters of broiler chickens' manure

| Indicator | Type of manure | | | Requirements according to GOST 31461-2012 |
|---|---|---|---|---|
| | Droppings from young broiler chickens | | | |
| | Duration of studies, days | | | |
| | 0 | 15 | | |
| | original manure | without processing | processed | |
| *physical and chemical indicators* | | | | |
| Consistency (phase state), visual inspection | viscous | Viscous | viscous-flowing | viscous-flowing |
| Mass fraction of moisture, g/kg | 664 | 668 | 501 | no more 550 |
| Mass fraction of organic matter, g/kg | 341 | 340 | 375 | no more 350 |
| Mass fraction of ash, g/kg | 84 | 85 | 113 | no more 100 |
| $pH_{KCl}$ | 7.3 | 7.4 | 7.3 | 6,8–8,0 |
| Nitrogen total, g/kg | 12 | 12 | 19 | at least 15 |
| Phosphorus total, g/kg | 14 | 15 | 9 | no more 10 |
| Potassium total, g/kg | 9 | 9 | 4 | no more 4 |
| Lead, mg/kg dry matter | 73.2 | 72.6 | 38.2 | no more 130* |
| Arsenic, mg/kg dry matter | 11.2 | 11.4 | 5.1 | no more 10* |
| Copper, mg/kg dry matter | 124.9 | 124.3 | 69.3 | no more 132* |
| Cadmium, mg/kg dry matter | 1.76 | 1.74 | 0.76 | no more 2* |
| Nickel, mg/kg dry matter | 62.7 | 61.5 | 26.7 | no more 80* |
| Zinc, mg/kg dry matter | 253.7 | 250.3 | 147.0 | no more 220* |
| Ammonia nitrogen, $mg/m^3$ | 74 | 76 | 19 | not standardized |
| *Sanitary and biological indicators* | | | | |
| Index coli group bacteria | 4 | 4 | 2 | 3 |
| Enterococcus index | 4 | 4 | 2 | 3 |
| Index of pathogenic microorganisms | Missing | Missing | Missing | Missing |
| Eggs and larvae of helminths (ind./g) | 4 | 4 | Missing | Missing |
| Cysts of intestinal pathogenic protozoa (ind./100 g) | 1 | 1 | Missing | Missing |
| TMC index, cells/g | 4 | 4 | 10 | not standardized |
| *According to SanPiN 1.2.3685-21 | | | | |

**Table 4**: Physico-chemical and sanitary-biological parameters of quails' manure

| Indicator | Type of manure | | | Requirements according to GOST 31461-2012 |
|---|---|---|---|---|
| | Droppings from young quails | | | |
| | Duration of studies, days | | | |
| | 0 | 15 | | |
| | original litter | without processing | processed | |
| *physical and chemical indicators* | | | | |
| Consistency (phase state), visual inspection | viscous | viscous | viscous-flowing | viscous-flowing |
| Mass fraction of moisture, g/kg | 615 | 612 | 537 | no more 550 |
| Mass fraction of organic matter, g/kg | 368 | 360 | 391 | no more 350 |
| Mass fraction of ash, g/kg | 121 | 120 | 142 | no more 100 |
| $pH_{KCl}$ | 7,5 | 7,4 | 7,4 | 6,8–8,0 |
| Nitrogen total, g/kg | 14 | 14 | 21 | at least 15 |
| Phosphorus total, g/kg | 14 | 13 | 10 | no more 10 |
| Potassium total, g/kg | 6 | 6 | 3 | no more 4 |
| Lead, mg/kg dry matter | 47.7 | 46.8 | 25.1 | no more 130* |
| Arsenic, mg/kg dry matter | 9.7 | 9.6 | 3.7 | no more 10* |
| Copper, mg/kg dry matter | 69.6 | 69.1 | 43.8 | no more 132* |
| Cadmium, mg/kg dry matter | 1.54 | 1.50 | 1.15 | no more 2* |
| Nickel, mg/kg dry matter | 37.4 | 36.8 | 23.9 | no more 80* |
| Zinc, mg/kg dry matter | 187.5 | 185.3 | 102.1 | no more 220* |
| Ammonia nitrogen, $mg/m^3$ | 67 | 66 | 13 | not standardized |
| *Sanitary and biological indicators* | | | | |
| Index coli group bacteria | 4 | 4 | 1 | 3 |
| Enterococcus index | 4 | 4 | 3 | 3 |
| Index of pathogenic microorganisms | Missing | Missing | Missing | Missing |
| Eggs and larvae of helminths (ind./g) | Missing | Missing | Missing | Missing |
| Cysts of intestinal pathogenic protozoa (ind./100 g) | Missing | Missing | Missing | Missing |
| TMC index, cells/g | 4 | 4 | 10 | not standardized |
| *According to SanPiN 1.2.3685-21 | | | | |

The bird droppings treated with a 2-component bio-utilizer evanesced their color and state of aggregation during visual observation. Through, a versatile gas analyzer, there had been discovering decreasing ammonia in the ambient environment. Regardless of the type of bird droppings, the experimental batches treated with the biological product met the requirements of GOST 31461-2012. Native litter from broiler chickens and quails, not treated with a biological product, in all experiments during the study did not show results that would meet the regulatory document. The content of ammonia nitrogen in the external environment was 2-3 times higher than in the experimental batches and was above the level of the permissible concentration limit. The total microbial count in the untreated litter on the 15th day remained the same as in the original by-product. Bird droppings, not treated with the proposed biological product, did not undergo significant changes in performance while retaining a pungent, unpleasant ammonia odor.

Also, in the studies (on the 15th day), had been studying the hazard class of treated and untreated bird droppings (Antonov et al., 2021; Modak et al., 2019; Pokrant et al., 2021). The calculation method had established the danger indicator of untreated broiler chickens' manure - 26.57, of quails' manure - 22.72, which belongs to the III class of danger (moderately dangerous). The risk index of manure treated with a 2-component biological product got of broiler chickens was 9.45, and of quails - 8.68, which belongs to the IV hazard class (low-dangerous).

Thus, native manure treated with a bio-utilizer from a mixture of Pseudomonas putida 90 biovar A (171) and Azotobacter chroococcum 31/8 R cultures improves the physicochemical and sanitary-bacteriological characteristics of the final product. There is also a stimulation of the growth of specific microflora, which ensures its biodegradation and a decrease in the level of ammonia nitrogen in the environment. Together, this reduces the hazard class, which makes it possible to use this by-product of poultry farming as an organic raw material used in the production of fertilizers.

## 3.3 The Effect of Processed Poultry Manure on the Growth, Development, and Yield of Tomatoes

Vegetables - a source of vitamins, a balanced complex of minerals, fiber, and organic acids play an important role in human nutrition. Tomato fruits contain pectin and nitrogenous substances, sugar 4%, organic acids 0.4-0.9% (citric, malic, oxalic, tartaric), fats and essential oils 0.2%, various mineral salts (especially much potassium and magnesium), and vitamins (B1, B2, B6, K, PP, C 25-45 mg%). High productivity, good taste, and a variety of uses have made tomato a vegetable crop common in Russia (Kuzmitskaya and Kuliakina, 2020).

Vegetable crops consume a lot of nutrients. To get a high- and high-quality yield, they need large amounts of macronutrients (N, P, K, Ca, Mg, S), and small amounts of microelements (B, Mn, Zn, Co, Cu, Mo). It manifested especially prime requirements for the nutritional regime when growing tomatoes through seedlings with an underdeveloped root system (Hidayat et al., 2021; Palumbo et al., 2020; Widyastuti et al., 2019).

Using the tested bird droppings as the main fertilizer provided a constant level of nutrition, better seedling establishment, and optimal conditions for the growth of tomato plants (Table 5).

**Table 5**: Influence of the use of processed poultry manure in tomato cultivation technology on plant growth

| Group | Plant height, cm | Number per plant, pcs. | | Leaf area, $dm^2$/plant | Mass of aboveground organs, g/plant | |
|---|---|---|---|---|---|---|
| | | branches | leaves | | raw | dry |
| Control | 46.9 | 4.0 | 14.1 | 12.01 | 54.12 | 8.94 |
| 1st experience | 51.1 | 4.3 | 16.7 | 12.72 | 60.44 | 10.58 |
| 2nd experience | 53.5 | 4.6 | 18.4 | 13.11 | 66.08 | 11.70 |
| 3rd experience | 52.0 | 4.5 | 17.6 | 12.98 | 64.35 | 11.26 |
| 4th experience | 52.8 | 4.4 | 17.3 | 12.92 | 62.78 | 11.11 |
| 5th experience | 56.7 | 4.8 | 20.0 | 14.22 | 69.06 | 12.36 |
| 6th experience | 54.6 | 4.7 | 18.9 | 13.48 | 67.24 | 11.89 |
| $HCP_{05}$* | 2.2 | 0.2 | 0.8 | 0.59 | 2.77 | 0.49 |
| * – Least significant difference | | | | | | |

In the experiment had been discovering that all the experimental variants of tomato plants grew most tall (51.1-56.7cm, in control - 46.9cm), leafier (number of leaves 16.7-20.0 pieces, in control 14.1 pieces; the total area of leaves 12.72-14.22 and 12.01 $dm^2$/plant, respectively). The influence of organic fertilizer had been activating not only growth but also intensifying the assimilation processes. This led to an increase in biomass (60.44–69.06g/plant, in control–54.12g/plant) and dry weight of aboveground organs (10.58–12.36g/plant, in control–8.94g/plant).

However, it had been noticed that the strength of the effect of the tested organic fertilizers on plant growth largely depended on the type of bird droppings (broiler chickens or quails) and the applied dose. The maximum absolute growth rates were by using processed broiler chicken manure at a dose of 3.0kg/m$^2$ and processed quail manure at a dose of 1.5kg/m$^2$. Obviously, in these options, the ratio of the nutrients included in the tested fertilizers is optimal, and the content and demand for them for plants suffices to activate growth and production processes to get a high-quality crop.

**Table 6**: Effect of tested fertilizers on the fruit formation of tomato plants

| Option | Number of tomatoes, pieces/bush | Weight of tomatoes, kg/bush | Tomatoes parameters | |
|---|---|---|---|---|
| | | | diameter, cm | mass, g |
| Control | 13.1 | 0.824 | 4.0 | 62.88 |
| 1st experience | 13.8 | 0.906 | 4.3 | 65.67 |
| 2nd experience | 15.2 | 1.014 | 4.5 | 66.70 |
| 3rd experience | 14.6 | 0.966 | 4.4 | 66.14 |
| 4th experience | 13.9 | 0.915 | 4.4 | 65.82 |
| 5th experience | 15.6 | 1.052 | 4.7 | 67.44 |
| 6th experience | 15.1 | 1.005 | 4.6 | 66.53 |
| $HCP_{05}$ | 0.6 | 0.039 | 0.2 | 0.039 |

The data in Table 6 shows that the tested bird droppings stimulated the process of fruit formation. A greater number of tomatoes was growing in the experimental variants (13.8–15.6pcs/plant, in the control - 13.1pcs/plant). They were larger (4.3-4.7 and 4.0cm diameter) and with weights (65.67-67.44 and 62.88g). The formation of the bush in the experimental variants of a larger number of larger fruits and their total mass contributed to an increase in the yield and quality of tomato fruits (Table 7).

**Table 7**: Yield and quality of tomato fruits depending on the use of processed poultry manure in its cultivation technology

| Option | Productivity, kg/m$^2$ | Control Gain | | Content in tomatoes | |
|---|---|---|---|---|---|
| | | kg/m$^2$ | % | sugars, % | vitamin C, mg % |
| Control | 2.390 | – | – | 3.3 | 35.2 |
| 1st experience | 2.627 | 0.237 | 9.9 | 3.5 | 37.6 |
| 2nd experience | 2.941 | 0.551 | 23.1 | 3.8 | 39.4 |
| 3rd experience | 2.801 | 0.411 | 17.2 | 3.6 | 38.8 |
| 4th experience | 2.654 | 0.264 | 11.1 | 3.6 | 37.9 |
| 5th experience | 3.051 | 0.661 | 27.7 | 3.9 | 40.7 |
| 6th experience | 2.915 | 0.525 | 22.0 | 3.7 | 39.2 |
| $HCP_{05}$ | 0.122 | | | | |

The research results showed that, in the experimental variants, the tomato yield increased significantly (2.627-3.051kg/m$^2$, in the control - 2.390kg/m$^2$, HCP05 - 0.122kg/m$^2$). The maximum yield increase in tomato cultivation technology was 23.1 and 27.7%. It had been in variants with the use of processed broiler chicken manure at a dose of 3.0kg/m$^2$ and quail manure at a dose of 1.5kg/m$^2$. In these variants, the content of total sugars and vitamin C in tomato fruits was maximum (3.8% and 39.4 mg%, 3.9% and 40.7 mg%, respectively, in the control 3.3% and 35.2 mg%).

## 4 Conclusion

Thus, native manure got from young broiler chickens and quails, treated with a microbial biological product from a mixture of Pseudomonas putida 90 biovar A (171) and Azotobacter chroococcum 31/8 R cultures, improves the physicochemical and sanitary and microbiological characteristics of the final product. There is a stimulation of the growth of specific microflora of the litter, which ensures its biodegradation, as well as a decrease in the level of ammonia nitrogen in the environment. Together, this reduces the hazard class, which makes it possible to use this by-product of poultry farming as organic raw material. The agrotechnological methods carried out have shown that the high biological efficiency of the tested organic fertilizers (processed litter of broiler chickens and quails) on the studied crop is because of the high yield of high-quality tomato fruits. With a yield in tomato control of 2.390kg/$m^2$, the maximum gains of 23.1 and 27.7% were in variants with introducing processed broiler chicken manure into the soil at a dose of 3.0kg/$m^2$ and processed manure a week before planting seedlings into the soil, quails at a dose of 1.5kg/$m^2$. Also in these options were the tomatoes of the highest quality.

## 5 Availability of Data and Material

Data can be made available by contacting the corresponding author.

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## 7 References

Akhtar MS, Oki Y, Adachi T, Murata Yand Khan MHR. Relative phosphorus utilization efficiency, growth response, and phosphorus uptake kinetics of brassica cultivars under a phosphorus stress environment. Communications in Soil Science and Plant Analysis. 2007;38(7–8): 1061-1085. DOI: 10.1080/00103620701280266

Antonov A, Ivanov G and Pastukhova N. Quail Droppings Utilization System. In IOP Conference Series: Earth and Environmental Science. 2021;666(2):022073. DOI: 10.1088/1755-1315/666/2/022073

Britt C, Bullard M, Hickman G, Johnson P, King J, Nicholson F, Nixon P and Smith N. Bioenergy Crops and Bioremediation - A Review. Crops. 2002.

Chastain JP, Camberato JJ and Skewes P. Poultry Manure Production and Nutrient Content. Production. 2014.

Chew KW, Chia SR, Yen HW, Nomanbhay S, Ho YC and Show PL (2019). Transformation of biomass waste into sustainable organic fertilizers. Sustainability (Switzerland). 2019;11(8):2266. DOI: 10.3390/su11082266

Daadi BE and Latacz-Lohmann U. Organic fertilizer use by smallholder farmers: Typology of management approaches in northern Ghana. Renewable Agriculture and Food Systems. 2021;36(2): 192–206. DOI: 10.1017/S1742170520000228

GOST 31461-2012. Poultry dung. Raw material for the manufacture of organic fertilizers. https://docs.cntd.ru/document/1200096492

Grenon G, Singh B, de Sena A, Madramootoo CA, von Sperber C, Goyal MK and Zhang T. Phosphorus fate, transport and management on subsurface drained agricultural organic soils: A review. Environmental Research Letters. 2021;16(1). DOI: 10.1088/1748-9326/abce81

Grzyb A, Wolna-Maruwka A and Niewiadomska A. The significance of microbial transformation of nitrogen compounds in the light of integrated crop management. Agronomy. 2021;11(7):1415. DOI: 10.3390/agronomy11071415

Hidayat H, Rostyanesia and Kurniati YS. Identification of lactic acid bacteria from tomato fruit extract and antibacterial activity test against Klebsiella pneumoniae. In AIP Conference Proceedings. 2021;2370:070001. DOI: 10.1063/5.0062681

Imas P (2000). Integrated Nutrient Management for Sustaining Crop Yields in Calcareous Soils.

Katsura H, Koseki K, Bito T, Takenaka S and Watanabe F. Characterization of vitamin B12 compounds in fermented poultry manure fertilizers. Agriculture (Switzerland). 2021;11(7):627. DOI: 10.3390/agriculture11070627

Kim WK and Patterson PH. Effect of minerals on activity of microbial uricase to reduce ammonia volatilization in poultry manure. Poultry Science. 2003;82(2):223-231. DOI: 10.1093/ps/82.2.223

Kuzmitskaya GA and Kuliakina NV. A comprehensive assessment of tomato collection varieties by yield and parameters of adaptability in monsoon climate conditions. In IOP Conference Series: Earth and Environmental Science. 2020;547:012018. DOI: 10.1088/1755-1315/547/1/012018

Li SX, Wang ZH and Stewart BA (2011). Differences of Some Leguminous and Nonleguminous Crops in Utilization of Soil Phosphorus and Responses to Phosphate Fertilizers. Advances in Agronomy. 2011;110:125-249. DOI: 10.1016/B978-0-12-385531-2.00003-7

Modak M, Chowdhury EH, Rahman MS and Sattar MN. Waste management practices and profitability analysis of poultry farming in Mymensingh district: A socioeconomic study. Journal of the Bangladesh Agricultural University. 2019;17(1):50-57. DOI: 10.3329/jbau.v17i1.40663

Muola A, Fuchs B, Laihonen M, Rainio K, Heikkonen L, Ruuskanen S, Saikkonen K and Helander M. Risk in the circular food economy: Glyphosate-based herbicide residues in manure fertilizers decrease crop yield. Science of the Total Environment, 2021;750:141422. DOI: 10.1016/j.scitotenv.2020.141422

Palumbo G, Carfagna S, Stoleru V, Torino V, Romano PM, Letizia F and Di Martino C. Environmental sustainability fruit quality and production in mycorrhizal tomato plants without p fertilizing. Agronomy Research. 2020;18(4):2535-2549. DOI: 10.15159/AR.20.204

Pokrant E, Yévenes K, Trincado L, Terraza G, Galarce N, Maddaleno A, San Martín B, Lapierre L and Cornejo J. Evaluation of antibiotic dissemination into the environment and untreated animals, by analysis of oxytetracycline in poultry droppings and litter. Animals. 2021;11(3):853. DOI: 10.3390/ani11030853

SanPiN 1.2.3685-21. Sanitary rules and norms: Hygienic standards and requirements for ensuring the safety and (or) harmlessness of environmental factors for humans. https://docs.cntd.ru/document/573500115

Widyastuti S, Geraldine BAFD, Sunarwidhi AL, Ariyana MD, Prasedya ES, and Sunarpi H. The use of brown algae extract to extend shelf life and improve post-harvest quality of tomato fruit. In AIP Conference Proceedings. 2019;2199:070008. DOI: 10.1063/1.5141322

Williams CM, Barker JC, and Sims JT. Management and utilization of poultry wastes. Reviews of Environmental Contamination and Toxicology. 1999;162:105-157. DOI: 10.1007/978-1-4612-1528-8_3

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