

Impact of an organic fertiliser on the yield of white cabbage (*Brassica oleracea* var. *capitata*) and the soil productivity

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Abstract: The aim of this study was to determine the effect of a granular poultry manure fertiliser on the yield and the quality of white cabbage (*Brassica oleracea* var. *capitata*), and to determine the effect on the soil agrochemical properties. The effect of the granular poultry manure fertiliser and mineral fertiliser (applied separately and combined at different times – in early spring and in autumn) on the cabbage yields was determined. Investigations were carried out in the fields of the Institute of Horticulture, the Lithuanian Research Centre for Agriculture and Forestry. The object of the research – white cabbage ‘Socrates’ H. The highest white cabbage marketable yield (80.5 t/ha) and the highest amount of vitamin C (7.80 mg per 100 g of products) was obtained by applying the granular poultry manure fertiliser in the autumn and the mineral fertiliser in the spring, where the granular poultry manure fertiliser applied in the early spring and the granular poultry manure fertiliser applied in the autumn with the mineral fertiliser applied in spring retained a higher content of humus (1.82–1.94%), organic carbon (1.06–1.12%) and total nitrogen (0.099–0.147%). The mineral nitrogen residue in the soil decreased when the cabbage was fertilised in the spring with the mineral fertiliser and when fertilised in the spring with the mineral fertiliser in combination with the granular poultry manure fertiliser by 8.1–10.8 kg/ha. The minimum content of nitrates in the heads of the white cabbage was found after using the granular poultry manure fertiliser in the autumn.

Keywords: granular poultry manure fertiliser; harvest; humus; mineral fertiliser; nitrates; white cabbage

Intensive mechanical soil cultivation, the abundant use of mineral fertilisers (especially nitrogen), pesticide use, and other factors have stimulated the mineralisation of the incoming plant residue and soil organic matter and inhibited the humification processes (Ayeni, Adetunji 2010) and have led to a lower organic matter content (Li et al. 2018). Organic manure plays a direct role in plant growth as a source of all the necessary macro- and micro-nutrients in the available forms during mineralisation, improving the agrophysical, agrochemical and physiological properties of the soil (Damiyal et al. 2017).

Moyin-Jesu (2015) states that poultry manure applied at 6 t/ha gave the best results in improving

the soil fertility, growth, and head yield of cabbage due to the balanced nutrient composition and the lowest C/N ratio. The application of manure in fertilising vegetables can improve the soil quality, crop production and financial returns in the long term. The use of manure closes the nutrient and carbon cycles and contributes to several ecosystem services (de Haan, van Geel 2018). Manure is widely used to increase the soil organic matter and fertility, improve the soil health, and stimulate the populations of a wide range of beneficial soil micro-organisms (Islam et al. 2017). However, organic inputs alone will not meet the nutritional needs of crops because they contain a comparatively lower quantity of nutrients compared

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to mineral fertilisers, thus, the need to integrate the two forms in order to achieve better plant yields (Suge et al. 2011). Most studies have shown that mineral fertilisers increase the plant yields, but according to some studies, their excessive rates have a negative effect on the plant growth and soil fertility. Increasing the mineral fertilisers from 50% to 100% rates leads to the direct increased growth and yield and fruit quality parameters of eggplants (Suge et al. 2011). Interest in soil organic fertilisation has grown in recent years. Some scientists point out that increasing the amount of organic manure and reducing the amount of inorganic nitrogen fertiliser can improve the nutritional and storage quality of cabbage heads (Yadav et al. 2001). Ibukunoluwa (2015) argues that poultry manure applied at 6 t/ha gave the best results in improving the soil fertility, growth and head yield of cabbage, and this was because of its balanced nutrient composition and the lowest C/N ratio. According to Coetzer et al. (2012) organic fertilisers had a positive effect on the cabbage growth and yield, but chicken manure gave the greatest yield and highest cabbage quality. In recent years, organic fertilisers have been increasingly used in horticulture. Hypothesis – fertilising cabbage with granular poultry manure fertiliser will lead to a higher and better quality yield and improve the soil properties. The aim of this study was to determine the effect of a granular poultry manure fertiliser applied at different times on the yield and quality of white cabbage and the agrochemical properties of the soil.

MATERIAL AND METHODS

Site description. The two-year experiment was carried out in 2015 and 2016 in the fields of the Institute of Horticulture, the Lithuanian Research Centre for Agriculture and Forestry (Babtai, Kaunas district, Central Lithuania, 55°60'N, 23°48'E).

Soil. The experiment was conducted on *Calc(ar)i – Epihypogleyic Luvisolls (LVg-p-w-cc)* [WRB 2014] texture – sandy with sandy clay loam in the deeper layers, soil pH_{KCl} (7.4), organic matter content (2.5%), humus content (1.8%), organic carbon content (1.04%), content of plant available phosphorus as P₂O₅ (313 mg/kg), and potassium as K₂O (183 mg/kg).

Experimental design. The preceding crop for the main cultivated crop was winter wheat. The winter wheat residue – 10–12 cm high stubble and straw

chopped to 3–6 cm in length – was treated with ammonium nitrate at 50 kg/ha and mulched down to a depth of 10–12 cm. In late autumn, the field was deep ploughed. White cabbage maintenance has been carried out in accordance with the cabbage cultivation technology. The investigated object was white cabbage 'Socrates' H. The plants were grown on a flat surface. Planting scheme – 70 × 0 cm. Cabbage seedlings (35–40 days old, with 3–4 leaves) were planted in the field on 28 May 2015, and on 26 May 2016. The plot area accounted for 6.2 m². The area of the trial was 124 m². Four replications were undertaken in a systematic design.

Scheme of the trial: (1) mineral fertilisers used in spring (Control): main fertilisation before planting the cabbage seedlings + additionally, with nitrogen fertilisers twice during the growing season MFs; (2) granular poultry manure fertiliser used in autumn – OFa; (3) granular poultry manure fertiliser used in early spring – OFes; (4) granular poultry manure fertiliser used before planting the cabbage seedlings – OFp; (5) granular poultry manure fertiliser used in autumn + mineral fertilisers in spring before planting the cabbage seedlings – OFa + MFs. The granular poultry manure fertiliser was used on 29 October 2014 and 16 November 2015, the mineral fertilisers were applied on 16 March 2015 and 22 March 2016. The total N during the growing season in all the treatments was 122 kg/ha, the amount of granular poultry manure fertiliser – 2 650 kg/ha. The main fertilisation in variants 1 and 5 was carried out applying the complex mineral fertiliser Crop care 10:10:22 with microelements. Nitrogen fertiliser for additional fertilisation, introduced as ammonium nitrate (34% N), was used two weeks after planting and calcium nitrate (15.5% N and 26.4% CaO) was used at the beginning of the cabbage head formation. The granular poultry manure fertiliser had the following characteristics: organic substances 82.02%, organic C 41.66%, humic acid 14.57%, fulvic acid 1.21%, total nitrogen 4.6%, total P 1.2%, total K 2.3%, and total Mg 0.76. The cabbages were harvested at technical maturity, and then divided into marketable and non-marketable ones.

Soil, plant sampling and analytical methods. After harvesting, the biometric measurements of the white cabbage heads (mass and diameter of the heads) were performed, and their biochemical composition was determined. The following biochemical parameters were determined: to determine the content of dry matter (DM), the samples were dried in a drying oven (Venticell, MBT, 2 Czech Republic)

at 105 °C for 24 hours. The dry soluble solids (DSS) were determined by refractometer, the sugar was determined by the Bertrand method. The nitrate content in the cabbage heads was measured by a potentiometric method (Geniatakis et al. 2003) using an ion meter (Oakton, USA) and the combined nitrate was determined with an HI4113 ion selective electrode (HANNA instruments, USA). Soil samples for the agrochemical analyses were collected before the beginning of the experiments and after harvesting the cabbage. The following soil agrochemical parameters were established: soil pH(KCl) – potentiometrically, the mineral nitrogen was determined by the spectrometric method according to ISO 14265-2:2005, the available P_2O_5 and K_2O were determined by the Egner-Riehm-Domingo (A–L) method, the humus was determined by dry burning according ISO 10694:1995. The calcium was determined by the atomic absorption spectrometric method according to Directive 71/250 EEC, and the magnesium was determined by the atomic absorption spectrometric method according to Directive 73/46/EEC.

Statistical analysis. A data analysis was performed using an analysis of variance (ANOVA). The treatment means were assessed using the least significant difference (LSD) and the effects of the fertilisers were evaluated at a 5% level of probability ($P \leq 0.05$). The STAT-ENG program was used to evaluate the relationship between the variables. Used symbols: r coefficient of correlation, ** level of probability 01, * level of probability 05, SD standard deviation.

Meteorological conditions. The average air temperature during the growing season months (April–October) in both years of investigation was higher than the average multiannual (by 0.7 °C in 2015, by 1.1 °C in 2016) (Table 1). During the 2016 growing season, it was higher than that in 2015, especially in May, when the air temperature was higher than the mul-

tiannual one by 3.5 °C, compared to 2015, which was 3.6 °C. In both years of investigation, the precipitation was lower during the growing season compared to the multiannual average, but, in 2015, it was dryer than in 2016. The precipitation distribution in the various growing season months was very different. In May and June 2016 and in June and August 2015, it was very dry. In July of both years: 21.1% and 42.9% more precipitation, respectively, was recorded compared to the multiannual average; however, August of both years was dryer than the multiannual average.

RESULTS AND DISCUSSION

Impact of the granular poultry manure fertiliser on the cabbage yield. Some scientists argue that organic fertilisers have a positive effect on the yield and quality of cabbage and onions (Bhattarai, Kunwor 2011; Hasan, Solaiman 2012). According to studies by Engelbrecht et al. (2012), organic fertilisers clearly had a positive influence on the cabbage growth and yield, but chicken manure yielded the highest and best quality cabbage (Engelbrecht et al. 2012). In our study, the highest yields (total and marketable) were obtained when the cabbage was fertilised with the granular poultry manure and mineral fertilisers. The granular poultry manure fertiliser had a higher effect on the cabbage yield. When the cabbages were fertilised with the granular poultry manure fertiliser alone, independent of the time of application, their marketable yield was 16.1–17.5% higher compared to the control (Figure 1). The time of fertilisation with these fertilisers did not influence the yield. The marketable yield was almost uniform. The highest marketable yield (80.5 t/ha) and head mass (3.58 kg) of the white cabbage were obtained from the autumn fertilisation with the granular poul-

Table 1. Air temperature and precipitation. Babtai agro-meteorological station data using the iMETOS program

Month	Air temperature (°C)			Precipitation (mm)		
	2015	2016	multiannual	2015	2016	multiannual
April	7.5	7.4	6.2	48.2	47.2	41.7
May	12.0	15.6	12.3	63.2	11.2	50.7
June	15.9	17.4	15.9	26.8	45.8	71.2
July	17.6	18.5	17.3	91.2	107.6	75.3
August	19.7	17.4	16.7	4.6	77.4	78.4
September	14.0	13.6	12.1	43.4	13.4	58.7
October	6.0	5.6	7.1	2.4	94.4	50.5
Average 04–10	13.2	13.6	12.5	40.0	56.7	60.9

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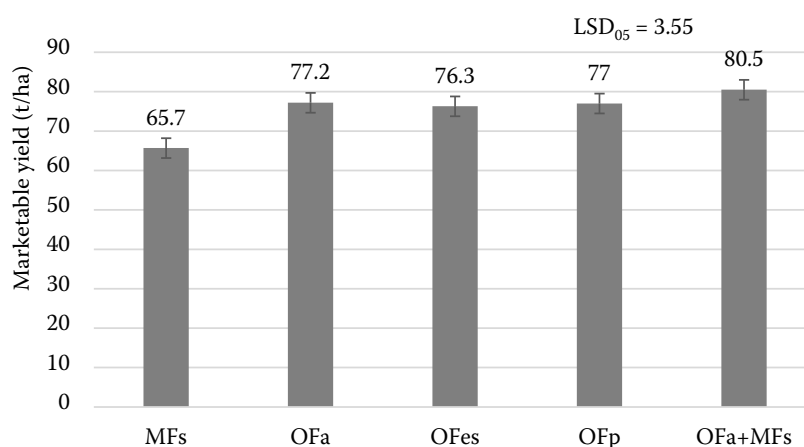


Figure 1. Impact of the granular poultry manure fertiliser on the yield of the white cabbage

MFs – main fertilisation before planting + additionally, with nitrogen fertilisers; OFa – granular poultry manure fertiliser used in autumn; OFes – granular poultry manure fertiliser used in early spring; OFp – granular poultry manure fertiliser used before planting the cabbage seedlings; OFa + MFs – granular poultry manure fertiliser used in autumn + mineral fertilisers in spring before planting the cabbage seedlings

try manure fertiliser and from the fertilisation during the growing season with the mineral fertilisers (OFa + MF) (Figures 1 and 2). The marketable yield increased by 22.5% and the head weight increased by 49.2% compared to the control and this yield increased with the increasing head weight ($R = 0.706^*$). These results agree with those of Maghfoer et al. (2018) and Ncayiyana et al. (2018) who claim that the application of organic fertilisers increased the cabbage yield. This is likely to be due to the organic mineral fertilisers attributing to the rapid mineralisation of N from the inorganic fertiliser and the steady release of N in the organic fertiliser, which might have met the N requirement of the crop at critical

stages (Olaniyi, Ojetayo 2011). The use of the granular poultry manure fertiliser in combination with the mineral fertiliser for the fertilisation of a few vegetables has also been shown to have positive results by several researchers. The combined use of poultry manure with urea (N 50:50) increased the cabbage yield by 22.4% and head mass by 27.7% compared with the control (Dalal et al. 2010). The maximum curd yield of cauliflower was recorded when using 50% of the recommended mineral fertiliser rate by adding 16.6% farmyard manure, 16.6% vermicompost and 16.6% poultry manure and the minimum was recorded using 20 t/ha farmyard manure (Lodhi et al. 2017). Chand et al. (2006) found that fertilising

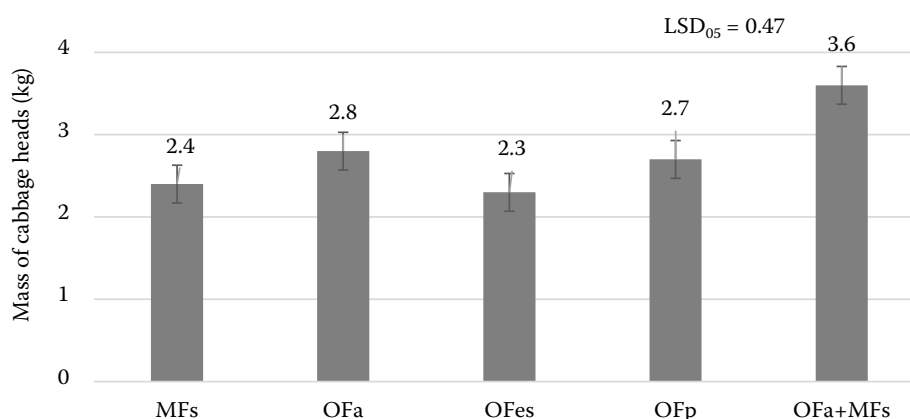


Figure 2. Impact of the granular poultry manure fertiliser on the mass of the white cabbage head

MFs – main fertilisation before planting + additionally, with nitrogen fertilisers; OFa – granular poultry manure fertiliser used in autumn; OFes – granular poultry manure fertiliser used in early spring; OFp – granular poultry manure fertiliser used before planting the cabbage seedlings; OFa + MFs – granular poultry manure fertiliser used in autumn + mineral fertilisers in spring before planting the cabbage seedlings

Table 2. Impact of the granular poultry manure fertiliser on the soil agrochemical properties

Treatment	Organic matter	Humus	Organic carbon	N total	N min
	(% in dry matter)				(ng/ha)
In spring, before planting of cabbage					
MFs	2.61 ± 0.06	1.67 ± 0.09	0.97 ± 0.01	0.110 ± 0.00	26.86 ± 0.23
OFa	2.71 ± 0.06 ^A	1.89 ± 0.09 ^A	1.09 ± 0.02 ^A	0.117 ± 0.00 ^A	33.88 ± 0.73 ^A
OFes	2.71 ± 0.07 ^A	1.78 ± 0.06 ^B	1.03 ± 0.04 ^A	0.098 ± 0.00 ^B	36.58 ± 1.11 ^A
OFp	2.61 ± 0.04 ^B	1.67 ± 0.03 ^B	0.97 ± 0.01 ^B	0.110 ± 0.01 ^B	26.86 ± 0.70 ^B
OFa + MFs	2.71 ± 0.08 ^A	1.89 ± 0.12 ^A	1.10 ± 0.04 ^A	0.117 ± 0.00 ^A	33.88 ± 0.71 ^A
LSD ₀₅	0.091	0.139	0.039	0.005	1.285
In autumn, after harvesting					
MFs	2.26 ± 0.13	1.61 ± 0.09	0.93 ± 0.01	0.081 ± 0.00	20.85 ± 0.57
OFa	2.37 ± 0.04 ^A	1.68 ± 0.04 ^B	1.02 ± 0.03 ^A	0.084 ± 0.00 ^B	22.99 ± 0.89 ^A
OFes	2.44 ± 0.11 ^A	1.94 ± 0.12 ^A	1.12 ± 0.02 ^A	0.147 ± 0.01 ^A	24.14 ± 0.35 ^A
OFp	2.38 ± 0.05 ^A	1.76 ± 0.08 ^A	1.02 ± 0.02 ^A	0.089 ± 0.00 ^B	27.00 ± 0.75 ^A
OFa + MFs	2.42 ± 0.07 ^A	1.82 ± 0.07 ^A	1.06 ± 0.01 ^A	0.099 ± 0.01 ^A	25.81 ± 0.08 ^A
LSD ₀₅	0.100	0.129	0.029	0.009	0.961

All the values in the table are expressed as standard deviation ($x \pm SD$, $n = 3$)

^A Significantly more than the control; ^B significantly less than the control

MFs – main fertilisation before planting + additionally, with nitrogen fertilisers; OFa – granular poultry manure fertiliser used in autumn; OFes – granular poultry manure fertiliser used in early spring; OFp – granular poultry manure fertiliser used before planting the cabbage seedlings; OFa + MFs – granular poultry manure fertiliser used in autumn + mineral fertilisers in spring before planting the cabbage seedlings

mint and mustard with organic and mineral fertilisers resulted in higher yields.

Impact of the granular poultry manure fertiliser on the soil agrochemical properties. The soil organic matter determines the availability of nitrogen, phosphorus, potassium, and other nutrients to the plants and stimulates the plant growth and directly affects the accumulation of organic mat-

ter in the soil (de Haan, van Geel 2018). A higher content of available soil nitrogen, phosphorus and potassium was observed under the poultry manure application (Amusan et al. 2011). Magagula et al. (2010) showed that poultry manure alone increased the soil organic matter content by 45%, while the addition of legume residue increased the organic matter content slightly by 11%. The granular poultry

Table 3. Impact of the granular poultry manure fertiliser on the biochemical parameters in the cabbage heads

Treatment	Dry soluble solids (%)	Sugars (%)	Vitamin C	Nitrates
	(% + standard deviation)		(mg/100 g)	(mg/kg)
MFs	7.30 ± 0.01	5.16 ± 0.02	6.70 ± 0.01	275.0 ± 1.08
OFa	6.90 ± 0.02 ^B	4.96 ± 0.05 ^B	5.80 ± 0.05 ^B	267.5 ± 4.10 ^B
OFes	7.05 ± 0.01 ^B	5.30 ± 0.03 ^A	6.15 ± 0.0 ^B	277.0 ± 4.30 ^B
OFp	7.05 ± 0.00 ^B	5.03 ± 0.03 ^B	6.30 ± 0.03 ^B	270.5 ± 7.25 ^B
OFa + MFs	7.00 ± 0.02 ^B	5.09 ± 0.03 ^B	7.80 ± 0.02 ^A	273.0 ± 4.78 ^B
LSD ₀₅	0.014	0.055	0.048	6.51

All the values in the table are expressed as standard deviation ($x \pm SD$, $n = 3$)

^A significantly more than the control; ^B significantly less than the control

MFs – main fertilisation before planting + additionally, with nitrogen fertilisers; OFa – granular poultry manure fertiliser used in autumn; OFes – granular poultry manure fertiliser used in early spring; OFp – granular poultry manure fertiliser used before planting the cabbage seedlings; OFa + MFs – granular poultry manure fertiliser used in autumn + mineral fertilisers in spring before planting the cabbage seedlings

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manure fertiliser had an influence on the soil agrochemical properties. Our research shows that, in the soil samples collected in autumn after harvest where the granular poultry manure fertiliser had been applied, the soil retained a higher content of humus, organic carbon, and total nitrogen (Table 2). This suggests that the soil became richer for the plants next year. The highest content of humus, organic C and total nitrogen was determined after applying the granular poultry manure fertiliser in autumn, after harvesting, but the mineral nitrogen content was lower. The residue of mineral nitrogen in the soil decreased accordingly by 8.1–10.8 kg/ha. The reduced mineral nitrogen content means a reduction in the nitrogen leaching ability. Ayeni and Adetunji (2010) indicate that the addition of an NPK fertiliser to the poultry manure increased the soil nutrients and performance of maize even one year after their application. The results of Magagula et al. (2010) show that the organic matter content in the soil positively ($r = 0.247$) correlate with the total sweet potato tuber yield; the resulting coefficient of determination, R^2 , showed that the 6.1% increase in the organic matter could be associated with an improved sweet potato tuber yield. The soil pH was positively, but not significantly, correlated with the total sweet potato tuber yield ($R = 0.274$), showing that the 7.5% increase in total tuber yield could be ascribed to the increased soil pH. In agreement with the findings of these researchers, our results showed that the organic matter content ($R = 0.937^{**}$), humus content ($R = 0.801^{**}$), total nitrogen ($r = 0.589^*$) and mineral nitrogen ($r = 0.725^*$) were positively correlated with the marketable cabbage yield.

Impact of the granular poultry manure fertiliser on the biochemical properties of the cabbage. Fertilisation is one of the most important factors influencing a vegetable's biochemical composition. According to Nurhidayati (2016), the application of organic fertilizers to vegetables decreased the nitrate content, but increased the sugar and vitamin C content. The results of Ncayiyana et al. (2018) showed that the ascorbic acid concentration in onion bulbs significantly increased with the use of poultry manure and cattle manure, compared with 120 kg/ha of inorganic N, but no significant effects were observed on the total phenolics and total soluble solids of the onion bulbs following the different fertiliser treatments. Our study shows that the fertilisation of cabbage with the granular poultry manure fertiliser reduced the soluble solids, vitamin C and

nitrate content in the heads compared to the mineral fertiliser fertilisation alone (Table 3). The time of the granular poultry manure fertiliser application had a positive effect on the biochemical composition of the cabbage. The lowest nitrate content was found when the granular poultry manure fertiliser was applied in autumn (OFa). The highest vitamin C content (7.80 mg per 100 g) in the heads of the white cabbage was found after using the granular poultry manure fertilizer in autumn with the mineral fertilisers during the growing season (OFa + MFs). Contrary, Kumar et al. (2011) states that the highest vitamin C levels were recorded when the vegetables were fertilised with organic fertilisers alone, without the use of nitrogen fertilisers.

CONCLUSION

The application of a granular poultry manure fertiliser in the soil is one of the best ways to improve the soil properties and yield of cabbage. The granular poultry manure fertiliser applied to the cabbage and the time of their application influenced the yield and quality of the cabbage. The highest white cabbage marketable yield and head mass were obtained by applying the granular poultry manure fertiliser in the autumn with mineral fertilisers. The time of the granular poultry manure fertiliser application had a positive effect on the biochemical composition of the cabbage. The lowest nitrate content was found when the granular poultry manure fertiliser was applied in the autumn. The highest vitamin C content in the heads of the white cabbage was found after using the granular poultry manure fertiliser in the autumn with mineral fertilisers. The granular poultry manure fertiliser also influenced the soil agrochemical properties. In the autumn after the harvest, higher levels of humus, organic carbon and total nitrogen were obtained in the soil where the granular poultry manure fertiliser was applied. This indicates that the soil became richer for the plants the following year.

REFERENCES

- Amusan A.O., Adetunji M.T., Azeez J.O., Bodunde J.G. (2011): Effect of the integrated use of legume residue, poultry manure and inorganic fertilizers on maize yield, nutrient uptake, and soil. *Nutrient Cycling in Agroecosystems*, 90: 321–330.

- Ayeni L.S., Adetunji M.T. (2010): Integrated application of poultry manure and mineral fertilizer on soil chemical properties, nutrient uptake, yield, and growth components of maize. *Nature and Science*, 8: 60–67.
- Bhattarai B.P., Kunwor P. (2011): Effect of organic nutrient management on growth, yield, and soil nutrient status of cabbage (*Brassica oleracea* var. *capitata*). *Nepalese Journal of Agricultural Science*, 9: 37–43.
- Chand S., Anwar M., Patra D.D. (2006): Influence of long-term application of organic and inorganic fertilizer to build up soil fertility and nutrient uptake in mint-mustard cropping sequence. *Communication in Soil Science and Plant Analysis*, 37: 63–76.
- Coetzer G., Ceronio G., Mbatha A.N. (2012): Influence of organic fertiliser on yield and quality of cabbage (*Brassica oleraceae* var. *capitata* L.). *Acta Horticulturae* (ISHS), 936: 243–250.
- Dalal V.V., Bharadiya P.S., Aghav V.D. (2010): Effect of organic and inorganic sources of nitrogen on growth and yield of cabbage (*Brassica oleracea* var. *capitata* L.). *Asian Journal of Horticulture*, 5: 291–293.
- Damiyal D.M., Manggoel W., Ali S., Dalokom D.Y., Mashat I.M. (2017): Effect of cattle manure and inorganic fertilizer on the growth and yield of hybrid maize (*Zea mays* L.). *World Research Journal of Agricultural Sciences*, 4: 102–110.
- de Haan J., van Geel W. (2018): Animal manure use in vegetable production in the Netherlands. *Acta Horticulturae* (ISHS), 1192: 73–80.
- Engelbrecht G.M., Ceronio G.M., Mbatha A.N. (2012): Influence of organic fertiliser on yield and quality of cabbage (*Brassica Oleraceae* var. *capitata* L.). *Acta Horticulturae* (ISHS), 936: 243–250.
- Geniatakis E., Fousaki M., Chaniotakis N.A. (2003): Direct potentiometric measurement of nitrate in seeds and produce. *Communication in Soil Science and Plant Analysis*, 34: 571–579.
- Hasan M.H., Solaiman A.H.M. (2012): Efficacy of organic and organic fertilizer on the growth of *Brassica oleracea* L. (Cabbage). *International Journal of Agriculture and Crop Science*, 4: 128–138.
- Ibukunoluwa M.-J.E. (2015): Use of different organic fertilizers on soil fertility improvement, growth and head yield parameters of cabbage (*Brassica oleraceae* L.). *International Journal of Recycling of Organic Waste in Agriculture*, 4: 291–298.
- Islam A., Ferdous G., Akter A., Hossai M., Nandwani D. (2017): Effect of organic, inorganic fertilizers and plant spacing on the growth and yield of cabbage. *Agriculture*, 7: 31.
- Kumar M., Das B., Prasad K.K., Kumar P. (2011): Effect of integrated nutrient management on quality of broccoli (*Brassica oleracea* var. *italica*) cv. Fiesta under Jharkhand conditions. *Asian Journal of Horticulture*, 6: 388–392.
- Li R.N., Zhang Y.C., Huang S.W., Wang L.Y., Tang J.W., Chen L.L., Zhai F.Z. (2018): Organic amendments increase soil phosphorus availability and yield in field-grown cabbage and Chinese cabbage. *Acta Horticulturae* (ISHS), 1192: 141–148.
- Lodhi P., Singh D., Tiwari A. (2017): Effect of inorganic and organic fertilizers on yield and economics of broccoli (*Brassica oleracea* var. *italica*). *International Journal of Current Microbiology and Applied Sciences*, 6: 562–566.
- Magagula N.E.M., Ossom E.M., Rhykerd R.L., Rhykerd L. (2010): Effects of chicken manure on soil properties under sweet-potato (*Ipomoea batatas* (L.) Lam.) culture in Swaziland. *American-Eurasian Journal of Agronomy*, 3: 36–43.
- Maghofer M.D., Koesriharti Islami T., Kanwa N.D.S. (2018): A study of the efficacy of various nutrient sources on the growth and yield of cabbage. *AGRIVITA, Journal of Agricultural Sciences*, 40: 168–176.
- Moyin-Jesu E.I. (2015): Use of different organic fertilizers on soil fertility improvement, growth and head yield parameters of cabbage (*Brassica oleraceae* L.). *International Journal of Recycling of Organic Waste in Agriculture*, 4: 291–298.
- Ncayiyana N.M., Maboko M.M., Bertling I. (2018): Alterations in yield, physico chemical components and mineral composition of onion following organic manure and inorganic nitrogen application. *Acta Agriculturae Scandinavica Section B - Soil and Plant*, 68: 213–219.
- Nurhidayat N., Ali U., Murwani I. (2016): Yield and quality of cabbage (*Brassica oleracea* L. var. *capitata*) under organic growing media using vermicompost and earthworm *Pontoscolex corethrurus* inoculation. *Agriculture Science Procedia*, 11: 5–13.
- Olaniyi J.O., Ojetayo A.E. (2011): Effect of fertilizer types on the growth and yield of two cabbage varieties. *Journal of Animal and Plant Sciences*, 12: 1573–1582.
- Suge J.K., Omunyin M.E., Omami E.N. (2011): Effect of organic and inorganic sources of fertilizer on growth, yield and fruit quality of eggplant (*Solanum Melongena* L.). *Archives of Applied Science Research*, 3: 470–479.
- Yadav V.S., Yadav B.D., Sharma Y.K. (2001): Effect of NICAST (organic manure) in comparison to recommended doses of manure and fertilizers in cabbage. *South Indian Horticulture*, 49 (special): 157–159.
- WRB (2014): World reference base for soil resources 2014. International soil classification system for naming soils and creating legends for soil maps. World Soil Resources Reports No. 106. FAO, Rome: 187–192.

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