

EFFECTS OF ANIMAL MANURES ON YIELD QUALITY AND NUTRIENT CONTENT IN ORGANIC BROCCOLI (*BRASSICA OLERACEA* L. VAR. *ITALICA*)

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Abstract. This study was conducted to determine the animal manures on yield, quality, and nutrient content of broccoli heads. Treatments consisted of 0, 30 and 60 t ha⁻¹ of sheep and cattle manure and organic commercial fertilizer (B5A). Manure rates significantly increased yield, average weight of main and secondary heads, and the diameter in broccoli compared to control. The highest total yield (27.74 t ha⁻¹) was obtained using sheep manure (30 t ha⁻¹). At harvest, the highest amount of the total N in broccoli heads was measured at organic commercial fertilizer application. Potassium (K), sodium (Na), iron (Fe) and manganese (Mn) content increased with higher doses but, phosphorus (P), calcium (Ca), copper (Cu) and zinc (Zn) contents were not influenced. Additionally, the highest nutrient removal for broccoli heads was obtained at 30 t ha⁻¹ sheep manure application rate.

Keywords: *nutrients contents, yield, quality, removed nutrient, sheep manure, cattle manure*

Introduction

Broccoli (*Brassica oleracea* L. var. *italica*) belongs to the Brassicaceae family is a perennial plant widespread in the west and northwest part of Turkey. Broccoli production in Turkey has increased considerably in recent years. The production reached 69592 tons in 2019 (Anonymous, 2019a). Broccoli is high in nutritional value and is found in the most efficient group of vegetables from the standpoint of food production. Also, Broccoli has been shown to be very useful for human health in terms of its ingredients and to provide protection against certain types of cancer (Yoldas, 2003; Yoldas and Eşiyok, 2004; Yoldas et al., 2008, 2009, 2019; Anonymous, 2019b; Vanduchova, 2019). Broccoli is not a very selective vegetable in terms of soil requirements. Soils rich in organic matter are suitable for broccoli cultivation.

Fertilization is very important for increasing yield and quality in crop production. Plant nutrition is one of the most important factors that increase plant production (Ninou et al., 2017). However, fertilizer needs vary according to varieties, soil properties, organic matter content and ecology. One of the most important problems in plant production is the accumulation of nitrate. Farmer's unconscious and excessive use of fertilizer plants may cause nitrate accumulation and environmental pollution (Mordoğan et al., 2001; Yoldas et al., 2017). Intensive fertilizer and pesticide use often leads to occurring of significant hazards for humans and their environment (Atılgan et al., 2007). The use of organic and plant-based organic substances in agriculture as an alternative to chemical fertilizer or as a way of reducing their amount is becoming widespread (Yoldas et al., 2009). Comparisons of conventional and organic farms compared to soil type indicated that organic practices improved soil quality (Liebig and Doran, 1999).

Healthy life and environmental awareness are important today. This case it caused to increase on naturel human nutrition. Using of chemical fertilizer was decreased and natural production became important. Increasing the productivity of our soil resources by natural manure will be appropriate. Soil organic matter improves physical, chemical, biological properties of soil and is also affect the availability of nutrient (Sezen, 1995; Chaterjee et al., 2005; Kandil and Gad, 2009). In sustainable agriculture, organic fertilizers not only supply plant nutrients but also improve soil organic matter contents (Yaldız et al., 2017). The importance of organic fertilizers in soil fertility and the fact that the soils of the region are poor organic matter in sandy texture reveals the need for organic fertilizers (Yoldas and Ceylan, 2010).

The objectives of this study were to (i) evaluate broccoli yield and yield components according to different organic manure doses, (ii) to find effects of organic manure doses on nutrient content in heads, and (iii) to determine amounts of nutrients removed by broccoli heads.

Materials and methods

This research was conducted during the winter growing season at Odemis Technical Training College of Ege University (altitude 123 m and 38° 13' 8.4216" North and 27° 58' 18.3432" east). Ironmen variety was used as a test crop (the head that reaches the harvest maturity -80-85 days after transplanting- has the feature of waiting like the main head without spoiling its quality). The experiment was designed in a randomized block with three replications (in October). The experimental design included unfertilized control plots. Seeds were sown in pots which had included 105 ml torf. They were transplanted 50 cm apart between plants and 70 cm apart in rows (Yoldas, 2003), when they became optimum size for planting. The experimental area was dripped with discharrow. Each plot area was 3.5 m² and contained 10 plants. Marketable parts of broccoli were collected (Yoldas, 2003). Fertilizer treatments included control (no fertilizer treatment) four rates of organic manures (30, 60 t ha⁻¹ sheep manure and 30, 60 t ha⁻¹ cattle manure), organic commercial fertilizer (B5A-production by BMR Agriculture) were mixed with the soil before planting. In experiment, weeds are cleaned by hand during the plant development period and irrigation was conducted regularly (Vural et al., 2000).

Broccoli heads of marketable size were harvested (in February - for 1.5 months) from each plot: total yield (t ha⁻¹), main head yield (t ha⁻¹), secondary head of yield (t ha⁻¹), average weight of main head (g), average weight of secondary head (g), diameter of head (cm), and length of head (cm) of broccoli were determined.

Soil samples were taken from depths of 0-30 cm and 30-60 cm of the experiment area. Samples were air dried, ground and passed through 2 mm sieve for the determination of chemical parameters (Kacar, 1984). Some physical and chemical characteristics of experimental soils, determined by standard analytical methods specified in Klute (1986) and Page et al. (1982).

Available K, Ca, Na flame photometer (Eppendorf) and Mg, Fe, Zn, Mn and Cu were determined by atomic absorption spectrophotometer (AAS; Varian AA 240 FS) (Lindsay and Norvell, 1978; Atalay et al., 1986) some physical and chemical properties of soils before applications are given in *Table 1*.

When *Table 1* is examined, the soil of the trial area is neutral at 30 cm depth. Total N at 0-30 cm depth low, 30-60 cm depth medium, available K and Ca content poor (Güneş

et al., 2000), the available P content is sufficient when evaluated according to Chapman and Pratt (1982). Mg content is in good condition at both depths. Micronutrients Fe, Cu, Mn, Zn were found to be good and adequate (Güneş et al., 2000).

Table 1. Some physical and chemical properties of soil

Properties	Unit	0-30 cm	30-60 cm
pH		6.60	7.24
Total salt	(%)	0.030	0.001
Lime	(%)	0.737	0.395
Sand	(%)	66.8	74.8
Clay	(%)	7.6	7.6
Silt	(%)	25.6	17.6
Texture		Sandy loam	Sandy loam
Organic matter	(%)	1.17	1.34
Total N	(%)	0.09	0.04
Available P	mg kg ⁻¹	44	30
Available K	mg kg ⁻¹	79	44
Available Ca	mg kg ⁻¹	720	641
Available Mg	mg kg ⁻¹	181	172
Available Fe	mg kg ⁻¹	13	12
Available Cu	mg kg ⁻¹	1.0	0.07
Available Zn	mg kg ⁻¹	0.7	0.2
Available Mn	mg kg ⁻¹	14	6

In the experiment, organic manures fermented for 6 months were used. Organic sheep and cattle manure samples were also analyzed with methods used in plant samples. The manure and broccoli heads samples were wet digested [(nitric (HNO₃): perchloric acid (HClO₄); 4:1] for P, K, Ca, Mg, Na, Fe, Cu, Zn and Mn analyses. Following the digestions, Quantifications were made for phosphorus colorimetric method, for K, Ca and Na by flame photometer for Mg, Fe, Cu, Zn and Mn by AAS (Moore, 1992; Campbell and Plank, 1992). Total nitrogen in plant samples was analyzed according to the modified Kjeldahl method (Baker and Thompson, 1992). The results of the analysis of organic manures are given in *Table 2*.

Data were analyzed using the SPSS 25.0 statistical package programme and findings were determined based on differences between the mean LSD multivariate analyses (SPSS, 2017).

Yield and yield components

Yield and some yield characteristics are presented in *Table 3*. Organic manure and organic commercial fertilizer (B5A) application significantly increased the total yield, yield of main and secondary heads ($p < 0.01$). The highest total and secondary head yield was obtained from 30 t ha⁻¹ doses of sheep manure (27.74 t ha⁻¹ and 10.35 t ha⁻¹, respectively) (*Fig. 1*). Also, the highest yield of main head was obtained from 30 t ha⁻¹ doses of sheep manure. The yield of main head, secondary head, and total yield were increased by treatments compared with control (64%, 45% and 13%, respectively). But,

total yield decreased with excessive sheep manure (60 t ha⁻¹) applications. Similar results were obtained by Zebarth et al. (1995), Babic and Elkner (2000), Belec et al. (2001).

Table 2. Results of analysis of organic manures

Properties	Unit	Cattle manure	Sheep manure
pH		7.75	8.04
Total salt	(%)	2.73	3.26
Dry matter	(%)	90.29	58.71
Organic matter	(%)	33.55	52.75
C/N		22.67	31.29
Total N	(%)	0.86	0.98
P	(%)	0.59	0.46
K	(%)	1.55	1.03
Ca	(%)	2.03	2.20
Mg	(%)	0.92	0.40
Na	(%)	0.10	0.07
Fe	mg kg ⁻¹	3.19	1.28
Cu	mg kg ⁻¹	28	16
Zn	mg kg ⁻¹	536	202
Mn	mg kg ⁻¹	221	111

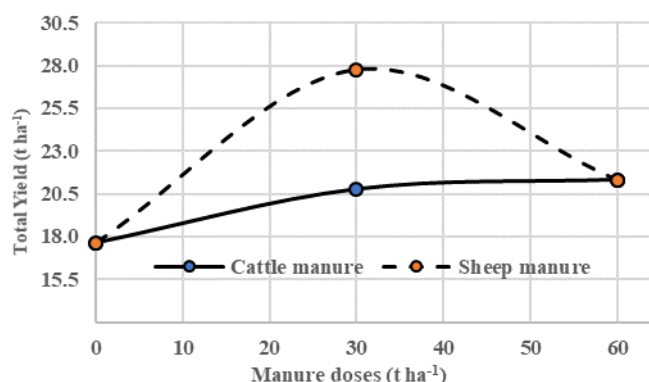


Figure 1. Effect of manure doses on total yield (t ha⁻¹)

But, Castellanos et al. (1999) has reported the highest marketable yield of broccoli was obtained from 400 kg N ha⁻¹. Our findings, in regards to yield, are in agreement with observations made by many researchers (Yoldas, 2003, 14.6–18.6 t ha⁻¹; Rekowska, 2000, 18.8–19.3 t ha⁻¹; Mihov and Antonova, 2000, 15–19.4 t ha⁻¹; Kunicki et al., 1999, 16.6 t ha⁻¹; Albarracin et al., 1995, 20 t ha⁻¹).

Ceylan et al. (2000) determined that the amounts of N, P, K, Ca, Mg, Fe, Cu, Zn and Mn in lettuce leaves increased significantly with organic fertilizer application.

Ceylan et al. (2006) found that, the maximum yield determined by using cattle manure at doses 60 t ha⁻¹. When the results compared to the control, application the yield increased 21%.

Average weight of main and secondary head, weight of secondary head and diameter of head, which are the important quality criterion, were significantly increased by organic manure rates ($p < 0.01$). The highest weight of head and length of head values were determined for 30 t ha^{-1} (608 g, 16.4 cm, respectively) (Table 3). Similar results have been reported by Dellacecca et al. (1994). However, Griffith and Carling (1991), Kunicki et al. (1999), Callens et al. (2000) and Yoldas et al. (2008) found smaller head diameters than ours. Head diameter was found 16.2-16.3 cm by Albarracin et al. (1995).

Secondary head's weight was changed by an increase of manure doses (Table 3). Increasing manure rates significantly increased head diameter compared to the control. The highest value was recorded from sheep manure (30 t ha^{-1}). It again decreased with increasing doses. There was not significant effect of treatments on length of head.

Table 3. The effects of treatments on yield and yield components (total yield (TY, t ha^{-1}), main head yield (Mhy, t ha^{-1}), secondary head of yield (Shy, t ha^{-1}), average weight of main head (Awh, g), average weight of secondary head (Awsh, g), diameter of head (Dh, cm), length of head (Lh, cm) of broccoli

	TY	Mhy	Shy	Awh	Awsh	Dh	Lh
Rates	t ha^{-1}	t ha^{-1}	t ha^{-1}	(g)	(g)	(cm)	(cm)
Control	17.63 c	13.05 c	4.58 b	457 c	160 b	14.5	13.7
Organic commercial fertilizer (B5A)	19.06 bc	13.91 bc	5.14 b	487 bc	180 b	13.9	14.6
Cattle manure 30 t ha^{-1}	20.76 b	14.46 bc	6.30 b	506 bc	221 b	14.8	14.2
Cattle manure 60 t ha^{-1}	21.31 b	15.73 ab	5.58 b	550 ab	195 b	14.0	13.8
Sheep manure 30 t ha^{-1}	27.74 a	17.39 a	10.35 a	608 a	362 a	15.2	16.4
Sheep manure 60 t ha^{-1}	21.29 b	14.35 bc	6.94 b	502 bc	243 b	15.6	15.3
Minimum	17.63	13.05	4.58	457	160	13.9	13.7
Maximum	27.74	17.39	10.35	608	243	15.6	16.4
LSD	2.904**	2.473**	3.107**	86.979**	108.99**	ns	ns

a, b, c, d: average which is shown with different letters in the same column, is between differences are significant

**The difference is significant at the $P < 0.01$ level. ns: No significant difference

Mineral contents of broccoli head

Mineral contents of broccoli head are given in Table 4. K, Na, Fe and Mn contents in broccoli head were significantly affected by sheep and cattle manure treatments ($p < 0.01$). Highest K and Fe content in broccoli were determined in the parcels which the cheap manure was applied as 60 t ha^{-1} . The effect of organic manure on Fe-uptake at these doses, could be due to the reason that organic carbon acts as a source of energy for soil microorganism, which upon mineralization releases organic acids that decreased soil pH and improves availability of makes Fe (Bokhtiar and Sakurai, 2005). However highest Na content in the heads were obtained in the parcels which the animal manure was applied compared to the control and organic commercial fertilizer parcels.

Nitrogen is the most recognized in plants for its presence in the structure of the protein molecule (Ninou et al., 2017). In this study, it was determined that maximum N content in the heads were obtained by organic commercial fertilizer applied. However, significant effect of the applications has not been determined statistically on the nitrogen content of broccoli. This result may be due to low nitrogen content of soils before planting and slow release of organic fertilizers and their effects on the

subsequent products. P, K, Ca and Zn contents were reached maximum at 60 t ha⁻¹ sheep manure. But, N, P, Ca, Mg, Cu and Zn in head were not significantly affected by applications.

Table 4. The effects of treatments on macro and micro element contents in head of broccoli

Rates	%					mg kg ⁻¹				
	N	P	K	Ca	Mg	Na	Fe	Cu	Mn	Zn
Control	5.80	0.22	3.36 b	1.12	0.36	583 b	74.33 ab	4.90	23 b	77.00
Organic commercial fertilizer (B5A)	6.33	0.21	3.44 b	1.06	0.40	598 b	63.67 b	5.00	31 a	75.00
Cattle manure 30 t ha ⁻¹	5.70	0.21	3.25 b	1.03	0.36	771 a	63.33 b	5.03	22.33 b	73.66
Cattle manure 60 t ha ⁻¹	6.17	0.22	3.71 ab	1.13	0.31	788 a	74.67 ab	5.90	25.67 b	74.67
Sheep manure 30 t ha ⁻¹	5.90	0.21	3.88 ab	1.12	0.34	665 ab	90.33 a	4.87	23 b	74.67
Sheep manure 60 t ha ⁻¹	6.03	0.22	4.31 a	1.13	0.33	759 a	57.67 b	5.30	22.33 b	79.67
Minimum	5.70	0.21	3.25	1.03	0.31	583	57.67	4.87	22.33	73.66
Maximum	6.33	0.22	4.31	1.13	0.40	788	90.33	5.90	25.67	79.67
LSD	ns	ns	0.691**	ns	ns	157.15**	17.769**	ns	5.036**	ns

a, b, c, d: average which is shown with different letters in the same column, is between differences are significant
**The difference is significant at the P < 0.01 level. ns: No significant difference

Removed minerals by yield (broccoli head)

Amount of removed minerals by broccoli head were increased by treatments compared with control generally (Table 5). These increases were statistically significant for P, K, Mg, Fe and Mn (p < 0.05).

Table 5. The effects of treatments on removed nutrients amount by heads

Rates	%					mg kg ⁻¹				
	N	P	K	Ca	Mg	Na	Fe	Cu	Mn	Zn
Control	0.09	15.3 b	220.6 c	896	93.00 c	34.33	6.83 ab	1.08	4.17 a	1.59
Organic commercial fertilizer (B5A)	0.10	16.3 b	230.3 c	1024	109.66 b	35.00	6.07 b	1.09	4.33 a	1.51
Cattle manure 30 t ha ⁻¹	0.10	25.3 ab	287.6 bc	1152	182.66 ab	45.33	8.38 a	1.17	4.33 a	1.76
Cattle manure 60 t ha ⁻¹	0.11	26.7 a	397.3 a	1166	231.66 a	39.66	5.61 b	0.81	2.51 b	1.62
Sheep manure 30 t ha ⁻¹	0.11	18.3 ab	317.0 b	1056	167.00 abc	35.00	6.15 b	0.92	2.75 b	1.64
Sheep manure 60 t ha ⁻¹	0.11	27.3 a	334.ab	1152	181.66 ab	36.00	7.39 ab	1.18	4.49 a	1.95
Minimum	0.09	15.3	220.6	896	93.00	34.33	5.61	0.81	2.51	1.51
Maximum	0.11	27.3	397.3	1166	231.66	45.33	8.38	1.18	4.49	1.95
LSD	ns	7.882*	77.092**	ns	86.908**	ns	1.986*	ns	1.381**	ns

a, b, c, d: average which is shown with different letters in the same column, is between differences are significant
*The difference is significant at the P < 0.05 level. ns: No significant difference

The highest amount of P, K, Mg, Fe and Mn removed was achieved at the rate of 60 t ha⁻¹ sheep manure, 60 t ha⁻¹ cattle manure, 60 t ha⁻¹ cattle manure, 30 t ha⁻¹ cattle manure and 60 t ha⁻¹ sheep manure doses, respectively.

Rincon et al. (1999) have shown that removed total quantity of N, P, K, Ca and Mg by crop were 243.9, 28.7, 240.9, 221.3, and 23.0 kg ha⁻¹, respectively.

It was determined that the amount of removed minerals by broccoli head were highest at the 60 t ha⁻¹ sheep manure and 60 t ha⁻¹ cattle manure doses, at which maximum total yield was also obtained.

Conclusions

Increasing health problems is also noteworthy the use of friendly organic fertilizers. Slow release organic fertilizers are beneficial for production with these properties. However, environmental pollution can be prevented by conscious use.

According to the results, increasing the application dose of organic manure increased the yield. The highest yield was obtained from supplying 30 t ha⁻¹ sheep manure. Therefore, 30 t ha⁻¹ sheep manure application can be recommended for broccoli under these conditions. In broccoli head, K, Na, Fe, and Mn contents, which are the important for healthy nutrition, increased with increases in organic manure doses.

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