

ROLE OF ORGANIC AND MINERAL FERTILIZATION AND SOIL MULCHING ON QUALITY CHARACTERISTICS OF BROCCOLI

Y. F. Saloom*
Researcher

F . H. AL- Sahaf **
Prof.

yasamen_master@yahoo.com

fadhil_alsahaf@yahoo.com

*Department of Horticulture, College of Agriculture, University of Baghdad

** Department of Horticulture, College of Agriculture, University of kufa

ABSTRACT

To study the effect of organic and mineral fertilization and soil mulching on quality characteristic of broccoli a field experiment was conducted during the season 2013- 2014 at the vegetable field of Hort. Dept., Agric. Coll., Abu-Ghraib, Randomized Complete Block Design (RCBD) within split plot arrangement was used main plots include type of soil mulching (without mulch M₀, black M₁, blue M₂, red plastic mulch M₃) and sub-plot represented by 5 fertilizer treatments: Recommended chemical fertilizers (RCF) T₁, Spent Mushroom Compost (SMC) 5% v/v + 75% RCF (T₂), SMC 10% v/v + 50% RCF (T₃), SMC 15% v/v + 25% RCF (T₄) and 20% v/v (SMC) T₅. Results showed superiority of black plastic mulch M₁ in TSS%, Vitamin C content, high Folic acid, carbohydrate and protein in curd (8.83%), (89.62 mg.100g⁻¹), (54.80 mcg.100g⁻¹), (7.06 %) and (26.77 %), while low nitrate content of curd (0.76 mg.g⁻¹), respectively compared with control treatment M₀. Treatment T₄ resulted in highest percentage of TSS (8.83%), Vitamin C (93.35 mg.100g⁻¹), carbohydrate (7.03%) and protein (27.41%) in cured, while highest Folic acid (54.78 mc.100g⁻¹) was found in T₃, and lowest nitrate content of curds was in T₅ (6.67 mg.g⁻¹) as compared to T₁.

Key word: broccoli, Spent Mushroom Compost (SMC), organic fertilizer, nitrate, Folic acid.

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سلوم والصحاف

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دور التسميد العضوي والمعدني وتغطية التربة في الصفات النوعية لنبات البروكلي

فاضل حسين الصحاف²

ياسمين فاضل سلوم¹

fadhil_alsahaf@yahoo.com

yasamen_master@yahoo.com

¹قسم البستنة، كلية الزراعة، جامعة بغداد

²قسم البستنة، كلية الزراعة، جامعة الكوفة

المستخلص

لدراسة تأثير التسميد العضوي والمعدني وتغطية التربة في الصفات النوعية لنبات البروكلي نفذت تجربة حقلية للموسم 2013 و 2014 في حقل الخضار - قسم البستنة - كلية الزراعة - أبو غريب - جامعة بغداد. استخدم تصميم القطاعات الكاملة المعشاة (RCBD) ضمن ترتيب القطع المنشقة Split-plot. تضمنت الألواح الرئيسية أغطية التربة (بدون تغطية M₀، بلاستيك أسود M₁، بلاستيك أزرق M₂، بلاستيك أحمر M₃) بينما تضمنت الألواح الثانوية خمس معاملات T₁ سماد كيميائي حسب الموصى به، T₂ سماد فطر 5% من حجم التربة + 75% سماد معدني، T₃ سماد فطر 10% من حجم التربة + 50% سماد معدني، T₄ سماد فطر 15% من حجم التربة + 25% سماد معدني، T₅ سماد فطر 20% من حجم التربة. أظهرت النتائج تفوق التغطية باللون الأسود في إعطاء أعلى نسبة للمواد الصلبة الذائبة الكلية 8.83% وأعلى محتوى من فيتامين C 89.62 ملغم. 100غم⁻¹ وأعلى تركيز من الـ Folic acid 54.80 مايكروغرام. 100غم⁻¹ وأقل تركيز للنترات 0.76 ملغم. 100غم⁻¹ وأعلى نسبة كربوهيدرات 7.06% وأعلى نسبة بروتين في الأقرص الزهرية 26.77%. أعطت المعاملة T₄ أعلى زيادة في المواد الصلبة الذائبة الكلية 8.83% وأعلى محتوى من فيتامين C 93.35 ملغم. 100غم⁻¹ وأعلى نسبة كربوهيدرات 7.03% وأعلى نسبة بروتين في الأقرص الزهرية (27.41%) وأعطت المعاملة T₃ أعلى تركيز من Folic acid 54.78 مايكروغرام. 100غم⁻¹ فيما أعطت المعاملة T₅ أقل تركيز للنترات 6.67 ملغم. 100غم⁻¹.

الكلمات المفتاحية: البروكلي، سماد الفطر، تسميد عضوي، فولك أسد، النترات.

* بحث مستل من أطروحة دكتوراه للباحث الأول.

INTRODUCTIO

Broccoli (*Brassica oleracea* var. *Italica*) on of Brassicaceae family known for 2700 year in the middle east and Asia. Edible part is curds at vegetative stage of flower buds and curds stem (17, 20) Broccoli is rich in vitamin A, C, Folic acid, Niacine, riboflavin and caroteins, in addition to same nutrients Ca, Fe, Na, P and K (11, 31). Broccoli also known rich in nutritive and medicinal compounds had antibiotic effect to a number at epidemic diseases such as blood pursuer regulation and improve bone construction, and preventing cardiac and urine system diseases. Broccoli also rich in sulforaphane which is anticancer compound because at high levels of glucosinolates and taken broccoli once a week will prevent the danger at cancer by 45% (31, 26, 40). Inorganic fertilizer usually used to increase crops yield, but because of the ecological pollution and increased health deterioration consequences through the increased levels of nitrates and oxalates and pollution of underground water in addition to the exaction of soil organic matter and reduction of soil microorganism activities (33). Accordingly there are a number of experiments to reduce above problems through the use organic farming or a mixed program of organic and inorganic fertilizers to produce plants yield with high productivity and better quality and improve environment (21, 3, 27). Recently, there are many efforts to use a system fertilization by using organic and inorganic fertilizers in integrated way to achive sustainable agriculture (15,14). because organic fertilizers will provide macro- and micro-nutrient to the plant growth (12). Makinde et al (28) reported that high yield could be produce when balanced fertilization is implemented using inorganic NPK fertilizers integrated with organic fertilizers. Kandil and Gad (25) tested the use of inorganic and organic fertilizer on broccoli and found that plants fertilized with both fertilizers had highest TSS% and protein content. AL-Mohamde (7) found that using different sources of organic fertilizer resulted in a reduction in nitrates in potato tubers. AL-Khalil (6) in a study using tomato plants found that application of organic fertilizer alone or with inorganic fertilizer increased fruit

content of vitamin C and TSS% in addition plants treated with organic fertilizer reduced nitrates by 35.8% as compared to control. Soil covering (mulching) is one of the field practices to eliminate the recessive effect of weeds in particular in organic farming in addition to reduction in water evaporation and nutrients leaching (39). Diaz-Perez (18) used different color of plastic mulch Blue, Black, Gray, Silver and White in broccoli field and found that black mulch improved yield quality. Moor et al (32) found increase in vitamin C of curds when black mulch was used. Spizeweski et al (36) reported an increase in carbohydrates content of cucumber by using black mulch. According to above finding this study aimed to examine the effect of integrated application of organic and chemical fertilizers to reduce the chemical fertilizers usage to a lowest level. In addition testing the interaction with the soil mulch under the middle region of Iraq on plant content of medicinal and biological compounds.

MATERIAL AND METHODS

Afield experiment was carried out during the growing season 2013-2014 at horticulture department, vegetable field, college of Agric., Abu-Graib in a silt clay loam soil (Table 1).

Table 1. chemical characterize of SMC

Characterize	Unite	SMC
EC	dSm ⁻¹	4.20
pH	—	7.3
C	g.kg ⁻¹	335
N	g.kg ⁻¹	25.0
C/N ratio	—	13.4
P total	mg.kg ⁻¹	12.3
K total	mg.kg ⁻¹	13.5

A Randomized Complete Block Design in Split Plot arrangement with three replicates was used. Main plots included plastic mulch color without mulch M₀; black M₁; blue M₂; red plastic mulch M₃. Sub-plots includes five fertilizers treatments: 0 Spent Mushroom Compost (SMC)+100% of recommended chemical fertilizers (92 kgN.ha⁻¹, 200 kgP₂O₅.ha⁻¹ and 150 kgK₂O.ha⁻¹) RCF, T₁; 5% SMC v/v of soil + 75% RCF, T₂; 10% SMC+50% RCF, T₃; 15% SMC+25% RCF, T₄ and 20% v/v SMC+0% RCF, T₅. Each experiment unit was represented by 3 furrows

each of 3m length and with 0.75m apart and each furrows content 8 plants with 40cm in between. Spent Mushroom Compost was incorporated to the soil according to different treatments the plastic mulch was lay out and trickle irrigation was used. Broccoli hybrid (TSX-0788) seeds were sown in 1 August 2013 in seedling trays and at 4 true leaves seedlings were transplanted in open field on 27th September 2013. At curds collection (harvest), six plant were randomly choosed of each experimental unit and determination of TSS% according to Ibrahim (23), ascorbic acid content using 2,6 Dichloro-phenol indophenol indicator in the curds was practice (23). Curds Folic acid (B9) was determined (35), Nitrates content according to Cataldo et al (13), total carbohydrates and protein content (16).

RESULTS AND DISCUSSION

TSS% of the curds

Results in table 2 show the superiority of T₄ and T₅ the TSS% in curds 8.83% and 8.67% respectively followed by T₃ (7.29%). Color of plastic mulch also affected TSS% where M₁ had the highest TSS% (8.83%) followed by M₂ 8.27% while M₀ had the lowest TSS% 7.57%. Interaction is significant where M₁T₄ had the highest TSS% (9.67%) as compared to lowest TSS% (6.33%) found in M₀T₁. Increased TSS% in T₄ and T₅ could be due to the good balance of organic and chemical fertilizer ratio (T₄) as sololy organic fertilizer in T₅, where the availability and uptake of nutrient were the highest and improved vegetative growth traits (total leaf and chlorophyll content) which increase the amount of assimilates and improve plant constituents include total soluble solids% in the curds (25, 29).

Table 2. Effect of organic and inorganic fertilization and mulching on TSS% broccoli

% T.S.S.					
Mulch Treat.	M ₀	M ₁	M ₂	M ₃	Treat. Rate
T ₁	6.33	8.17	7.67	7.00	7.29
T ₂	7.17	8.33	8.17	8.00	7.92
T ₃	7.83	8.50	8.00	7.67	8.00
T ₄	8.33	9.67	8.83	8.50	8.83
T ₅	8.17	9.50	8.67	8.33	8.67
Mulch rate	7.57	8.83	8.27	7.90	
L.S.D. 0.05 M.T		L.S.D. 0.05 T		L.S.D. 0.05 M	
1.39		0.73		0.55	

Ascorbic acid content (mg.100g⁻¹fresh weight) (vitamin C)

Results in table 3 revealed that curds vitamin C was effected by fertilizer treatment where organic+chemical fertilizer T₄ had the highest Vit.C content 93.35 mg.100g⁻¹ followed by T₅ (organic fertilizer only) 89.60 mg.100g⁻¹ as compared to lowest content in T₁ (RCF) 75.39 mg.100g⁻¹. Mulching treatments also affect curds Vit.C were the highest 89.62 mg.100g⁻¹ in M₁ plans and the lowest 77.26 mg.100g⁻¹ in M₀ plants. Interaction treatment affected Vit.C in curds significantly and M₁T₄ produced highest Vit.C 103.09 mg.100g⁻¹ and the lowest in M₃T₁ 71.21 mg.100g⁻¹. Positive effect of organic fertilizers on Vit.C content could be due to the release of organic compounds and amino acids, a humic and non humic acids release as organic matter decompose which increase the nutrients availability to the plant and affecting as Buffer agent against soil pH. These factors improve vegetative plant growth and increase assimilates production so increase accumulation of carbohydrates, proteins and enzymes activity and increase Vit.C (1, 10, 2). Black mulch effect on Vit.C may be due to increase NO₃⁻ in soil which enhance the organic acids production including Vit.C (32, 9).

Table 3. Effect of organic and inorganic fertilization and mulching on Vit.C in broccoli

Vit.C					
Mulch Treat.	M ₀	M ₁	M ₂	M ₃	Treat. Rate
T ₁	71.48	80.40	78.49	71.21	75.39
T ₂	72.51	82.53	78.67	76.77	77.62
T ₃	79.40	85.66	81.21	79.62	81.47
T ₄	83.53	103.09	94.34	92.46	93.35
T ₅	79.39	96.42	91.48	91.09	89.60
Mulch rate	77.26	89.62	84.84	82.23	
L.S.D. 0.05 M.T		L.S.D. 0.05 T		L.S.D. 0.05 M	
7.06		3.78		2.43	

Folic acid content (B9) (mg.100g⁻¹) in the curd

Data in table 4 reveal that T₃ domiated over other treatment in Folic acid content 54.78 mg.100g⁻¹ followed by T₄ 52.92 mg.100g⁻¹, while lowest content 46.80 mg.100g⁻¹ found in

T₁. Mulching with black plastic M₁ increased folic acid to 54.80 mg.100g⁻¹ while M₀ gave the lowest content 47.36 mg.100g⁻¹. Interaction M₁T₄ had the highest folic acid content 58.40 mg.100g⁻¹ and M₀T₁ gave the lowest content 43.70 mg.100g⁻¹. Increased folic acid content of the high organic fertilizer treatments could be due to the vegetative traits improvement such as chlorophyll content and increase the accumulation of carbon assimilates including folic acid.

Table 4. Effect of organic and inorganic fertilization and mulching on folic acid in broccoli

Folic acid					
Mulch / Treat.	M ₀	M ₁	M ₂	M ₃	Treat. Rate
T ₁	43.70	50.60	47.80	45.10	46.80
T ₂	45.60	52.30	46.20	47.70	47.95
T ₃	52.80	57.10	54.33	54.90	54.78
T ₄	48.20	58.40	53.90	51.20	52.92
T ₅	46.50	55.60	49.70	54.30	51.92
Mulch rate	47.36	54.80	50.39	50.64	
L.S.D. 0.05 M.T		L.S.D. 0.05 T		L.S.D. 0.05 M	
4.72		2.26		2.83	

Nitrates concentration in curd (mg.g⁻¹)

Table 5 shows an increase in nitrates contents of curds when chemical fertilizer sololy 100% (T₁) was used (0.99 mg.g⁻¹), whereas organic fertilizer treatments gradually reduced nitrate and T₅ sololy MSC had the lowest content 0.67 mg.g⁻¹ followed by T₄ 0.77 mg.g⁻¹. Plastic mulch color has affected nitrate content of curds where black mulch reduced nitrates as compared to other colors where M₁ gave 0.76 mg.g⁻¹ while blue mulch, without mulch (M₂ and M₀) had the highest nitrates content 0.88 mg.g⁻¹ for both of them. Interaction is significant where M₁T₅ had the lowest content 0.58 mg.g⁻¹ and M₀T₁ had the highest 1.03 mg.g⁻¹. Reduction of curds nitrate in organically fertilized plants could be due to slow release of nitrogen and other nutrients as organic material gradually decompose and plant taken up released nitrogen as NH⁺₄ so small amount of released NH⁺₄ could be oxidized to NO⁻₃ (3). However, the highest nitrates content of RCF treatment 100% in due to the fast dissolve of applied fertilizer so high amounts of released NH⁺₄ so most of it could be oxidized to nitrates by soil microorganism

to NO⁻₃ and NO⁻₂ and accumulates in plant tissues (22, 6, 4).

Table 5. Effect of organic and inorganic fertilization and mulching on nitrates in curds

Nitrates					
Mulch / Treat.	M ₀	M ₁	M ₂	M ₃	Treat. Rate
T ₁	1.03	0.95	0.98	1.01	0.99
T ₂	0.92	0.81	0.87	0.95	0.89
T ₃	0.88	0.76	0.82	0.91	0.84
T ₄	0.81	0.69	0.73	0.84	0.77
T ₅	0.74	0.58	0.66	0.70	0.67
Mulch rate	0.88	0.76	0.81	0.88	
L.S.D. 0.05 M.T		L.S.D. 0.05 T		L.S.D. 0.05 M	
0.03		0.05		0.09	

Carbohydrates content of curd (%)

Results in table 6 shows different carbohydrates content in curds due to different fertilizer treatments, treatment T₄ and T₃ dominated in carbohydrates content 7.03 and 7.01% respectively, while T₁ had the lowest 5.70%. mulching also affected this trait where M₁ (black) had the highest carbohydrates content 7.06% followed by M₂ 6.57% which is not differ significantly from M₃ treatment (6.24%). Highest carbohydrates content found in M₁T₄ 7.68% while M₀T₁ had the lowest (5.18%). The positive effect of T₄ and T₃ on carbohydrates content of curds may be due to the effect of balanced fertilizers of organic and chemical fertilizers on assimilates accumulation through the increased leaf content of chlorophyll and leaf area (38, 41). Increased carbohydrates content due to plastic mulching could be attributed to reduced water evaporation, keeping soil in field capacity and reduce nutrients leaching so increase photosynthetic activities and assimilates accumulation. These result coincided with the findings of Spizewski et al (36) who found that cucumber carbohydrates content increased when black plastic mulch was used. Mulching treatments could also increase CO₂ concentration in the soil which may be liberated to above ground so could be taken by plants and utilize it in photosynthesis process (37) similar results found by Percival et al (34).

Table 6. Effect of organic and inorganic fertilization and mulching on carbohydrates

Carbohydrates %					
Mulch Treat.	M ₀	M ₁	M ₂	M ₃	Treat. Rate
T ₁	5.18	6.21	5.86	5.54	5.70
T ₂	5.74	6.76	6.19	5.83	6.13
T ₃	6.71	7.45	7.02	6.84	7.01
T ₄	6.49	7.68	7.29	6.67	7.03
T ₅	6.17	7.20	6.47	6.33	6.54
Mulch rate	6.06	7.06	6.57	6.24	
L.S.D. 0.05 M.T		L.S.D. 0.05 T		L.S.D. 0.05 M	
0.20		0.24		0.46	

Protein content in curd (%)

Percentage of protein in curds has been significantly affected by fertilizer treatments (Table 7) highest protein content was obtained from T₄ 28.31% followed by T₃ and T₅ 26.66 and 25.53% respectively, while it reduced to 20.55% in T₁. Mulching treatment (M₁) dominated other mulch treatments in protein% in curds (26.77%) followed by M₂ (25.18%), while the lowest was in M₀ (22.48%). Interaction of fertilizer and mulching treatments is significant and M₁T₄ had highest protein content in curds (30.69%) while the lowest content was 20.00% in M₀T₂ treatment. Increased protein content of curds in high rates of organic treatments T₄, T₃, T₅ could be attributed to the effective role of organic fertilizer through for plant growth and development which is reflected on great root and vegetative systems size and this increase the ability of plants to uptake greatest amount of nutrients in particular nitrogen which is a constituent of amino acids (19). In addition, potassium plays a key role in nitrogen assimilation to amino acids and proteins through the activation of nitrate reductase that reduces nitrate to nitrite then to ammonia (NH₃), this ammonia will be bound to keto-acid to produce amino acids then proteins (30). These results are agreement with AL-Zahawi (8), AL-Mohamde (7) Kandil and Gad (25). The increase in protein content of black plastic mulch may be related to inhibition to weeds and reduces nutrient losses from the rhizosphere so increase plant growth and nutrient assimilation.

Table 7. Effect of organic and inorganic fertilization and mulching on protein content of curds

Protein %					
Mulch Treat.	M ₀	M ₁	M ₂	M ₃	Treat. Rate
T ₁	20.25	21.31	21.12	19.50	20.55
T ₂	20.00	24.06	22.69	20.06	21.70
T ₃	24.56	29.19	27.00	25.87	26.66
T ₄	25.81	30.69	28.75	28.00	28.31
T ₅	21.75	28.62	26.31	25.44	25.53
Mulch rate	22.48	26.77	25.18	23.77	
L.S.D. 0.05 M.T		L.S.D. 0.05 T		L.S.D. 0.05 M	
1.61		0.78		0.95	

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