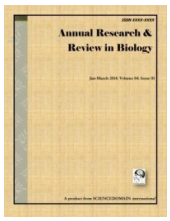

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Effect of Soil Amendment Materials on Some of the Physicochemical Properties of Soil and Wheat Yield

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Author's contribution

The sole author designed, analyzed and interpreted and prepared the manuscript.

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ABSTRACT

Aims: This research was performed for investigating the effect of two kinds of soil amendment materials on physicochemical properties of soil and wheat yield.
Study Design: Experimental design was factorial experiments based on randomized complete block design with two factors and three replications.
Place and Duration of Study: The experiment was carried out in private field in Khoy, (Latitude 38° 46' 09" N, Longitude 45° 02' 07" E) West Azerbaijan of Iran in 2013.
Methodology: The factors included sulfur at 4 levels (0, 200, 400, 600 $kg.ha^{-1}$) and organic matters (from decomposed cow manure) at three levels (0, 20, 40 $t.ha^{-1}$).
Results: The results showed that main effect sulfur was significant on grain and biological yield and pH of soil. Effect of OM was significant on all of studied traits, while interaction effect of two factors was significant statistically on grain yield. Comparison of mean of traits also showed that levels of experimental factors lead to improvement in studied traits and in terms of grain yield, maximum of 5249 $kg.ha^{-1}$ was related to application of 600 $kg.ha^{-1}$ sulfur along with application of 20 $t.ha^{-1}$ OM that showed 1625 $kg.ha^{-1}$ increase compared to that of the control treatment of both of experimental factors. Among different levels of sulfur the application of 600 $kg.ha^{-1}$ was related to application of

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20 t.ha^{-1} OM, which caused improvement in studied traits of soil so that when application amount of OM increased, pH, bulk density and particle density decreased, while EC, OC and soil porosity increased.

Conclusion: Considering other studied traits in this research, we can conclude that application of 600 kg.ha^{-1} sulfur and 20 t.ha^{-1} OM is appropriate for increasing or promoting of quality and quantity yield of wheat and improving of physicochemical properties soil.

Keywords: Soil properties; sulfur; wheat; manure; yield.

1. INTRODUCTION

With increase of population, demand is increased for agricultural crops and based on it, use of soil resources, toxins and chemical fertilizers have been increased for increasing of production rate per hectare. Because of shortage of organic matters in soils and undesirable use of agricultural lands, amounts of soils are exposed to destruction every year [1]. Therefore, using organic and fertilizers and other fertilizers is unavoidable for increasing or at least protection of soil fertility and yield improvement. On the other hand, in terms of calcareous conditions of soils in Azerbaijan district, soil pH is considered an important factor in cation exchange, solubility, ion availability, nutrient absorption and also activity of soil microorganisms. Research showed that the use of OM and acidifying matters for adjusting soil pH physicochemical properties of soil in such conditions are beneficial [1,2].

Addition of OM with sulfur into soil with high pH is a possible alternative for pH reduction and solution of required elements of plants. Useful effects of sulfur application in subculture soils have been proven, such as increase of crop yield and decrease of calcareous soils pH and increase of absorption ability of nutrients [3]. Since, wheat is one of the strategic products of Iran that provides up to 46% needed protein and 55% needed calories of the country [4], this plant can be a bridge for the transfer of needed elements for the body and its metabolic activities from the soil.

Khalej and Mostashari [5] during an experiment observed that simultaneous addition of OM and sulfur was effective on increasing wheat yield with up to 800 kg.ha^{-1} compared to the control group. Heterotrophic microorganisms of sulfur oxidation use organic matter as carbon resource and energy, so adding OM to soil leads to increase of their activity and as the result increase of speed of sulfur oxidation.

OM in addition to providing nutrient elements has different effects on physicochemical properties of soil [6]. In treatments that had received manure of up to 25 ton.ha^{-1} during one or two years, no significant increase in organic carbon level and nitrogen was observed. When levels of 100 ton.ha^{-1} with increasing frequency of fertilization was added, trend of increase in yield was observed [7]. Kayser et al. [8] reported that addition of 36 mol.m^{-2} (11520 kg.ha^{-1}) sulfur to soil caused a decrease of pH from 7.2 to 6.9 and this reduction has been done during a 54 day period. Rahimian [9] investigated the effect of sulfur and *Thiobacillus* with organic matters on canola quantity and quality traits and reported that with increase of sulfur of up to 500 kg.ha^{-1}, yield and dry matter were increased by 4.39 and 15.28% respectively. Based on results of their research, sulfur addition with manure led to decrease of soil pH and as a result yield also increased with increased absorption rate of nutrients.

Greenhouse experiment Tarabily et al. [10] observed that the best growth of corn was with application of inoculated sulfur with sulfur oxidizing bacteria of sulfur was that increased soil EC and decreased soil pH in such conditions. Sulfur and OM affected chemical conditions of soil such as reduction of pH, led to increase of availability of nutrients for wheat [11]. The purpose of this research was to determine the effect of two kinds of soil amendment materials, i.e. sulfur and organic fertilizer, on physicochemical properties of soil and wheat yield.

2. MATERIALS AND METHODS

This research was performed in order to investigate the effect of two kind of soil amendment materials on wheat yield and some of physicochemical properties of soil in farm that is located 8 km from Khoy (Latitude 38° 46' 09" N, Longitude 45° 02' 07" E) in form of randomized complete block designs and as factorial experiment in three replications. Nitrogen

application was based on soil test, in this research sulfur was as a factor in four levels of 0, 200, 400, 600 kg.ha^{-1} as S_1, S_2, S_3, S_4, respectively and organic matter (OM) was as b factor in three levels of 0, 20, 40 ton.ha^{-1} as OM_1, OM_2, OM_3 respectively. In this research, organic matters(from decomposed manure) and sulfur(from agricultural sulfur) was distributed or scattered uniformly based on design treatments at least one month before planting and was mixed with required fertilizers until 30 cm depth of soil, in all of the experimental plots, nitrogenous fertilizer from urea [$CO(NH_2)_2$] is taken up uniformly. Surface area of every experimental plot was 18 m^2 and the wheat cultivar Zarrin was used and plant density was 450 seeds per m^2, while irrigation cycle was 12 days.

Before performing experiment, compound sample of soil was taken at depth of 30 cm in order to investigate the soil fertility and physicochemical properties of soil (Table 1).

After crop harvesting in second year of experiment, physicochemical soil properties were measured such as pH, EC.(Electrical conductivity), OC.(organic carbon), particle density.(p_s), bulk density.(p_b) and soil porosity, pH and EC (saturated extract) were determined by pH meter and conduction meter, OC with the way of Walkley Black, p_b way of pure sampling with soil samples and scaling after drying in temperature of 105°C, p_s with experimental method with using a piknometer and porosity by calculation based on obtained amounts from p_s and p_b, microelements including Fe, Mn and Zn extracting with EDTA, P with Olsen method and K extractable with ammonium Acetate [12].

Obtained data was presented as ANOVA-I using from SAS statistical program and comparison of means was done with using from several domain Duncan test in probability level of 5%.

3. RESULTS AND DISCUSSION

3.1 Grain Yield

Results of analysis variance (ANONA) of traits are indication of significant effect of sulfur, OM and also interaction effect of these two factors on grain yield (Table 2). It increases the grain weight with increasing amount of OM and sulfur application so that maximum amount of seed was 5234 kg.ha^{-1} that is related to application of 600 kg.ha^{-1} sulfur and 40 ton.ha^{-1} OM that is placed in one statistical group with rate of 20 ton.ha^{-1} OM while minimum amount of grain yield related to no application of sulfur and manure obtained only the amount of 3609 kg.ha^{-1} (Fig. 1). Moamen et al. [13] in Sistan region showed that increase of amount of sulfur fertilizer and compost caused increase in grain yield, 1000 seed weight, cluster, plant height and leaf area index.

Results of mean comparison of traits also showed that application of 400 kg.ha^{-1} sulfur with 20 ton.ha^{-1} OM lead a maximum grain yield of up to 4262 kg.ha^{-1} and 1000 seed weight amounted to 38 gram and number of seed in cluster amounted to 44.5. Moatamed [14] in his research on bread wheat from Pishtaz cultivar showed that grain yield was increased with increase of sulfur application up to 1000 kg.ha^{-1}. Ghodarzi [15] in consideration of sulfur and compost effects on availability increase of soil nutrient elements of soil, absorption increase by wheat and increase of wheat yield in extensive calcareous soils of Ghachsaran showed that application of sulfur increased crop efficiency of wheat yield up to 190 kg.ha^{-1} and simultaneous application of it with compost increased grain yield amount to 330 kg.ha^{-1} in comparison to control group. Efficiency increase because of increase in sulfur application seems related to acidifying some part of soil and increases of nutrient solubility and as a result increases of efficiency of nutrient absorption.

3.2 Biological Yield

Main effect of sulfur and OM was significant on biological yield, however it was not observe as significant at level of sulfur and OM between 20 and 40 t.ha^{-1} and both of them are placed in one statistical group (Fig. 2).

One of the aspects of sustainable agriculture is improvement and fertility and quality that are obtained by application of organic matters and adjusting optimal application of fertilizer. Karimi et al. [16] investigating the effect of sulfur and manure application on some yield components of canola in two calcareous soils showed that manure has significant effect on amount of oil, protein, 1000 seed weight and total dry matter. Simultaneous application of manure and sulfur also increased dry matter of full plant such that maximum amount of full dry matter was obtained from treatment of 300 kg.ha^{-1} sulfur along with 50 t.ha^{-1} organic matter.

Table 1. The result of soil analysis before planting

ρ_b	Mn	Zn	Fe	$K_{ava.}$	$P_{ava.}$	Clay	Silt	Sand	OC	T.N.V.	pH_e	EC	(depth)
$g.cm^{-3}$	$mg.kg^{-1}$					$g.kg^{-1}$				%		$dS.m^{-1}$	cm
1.47	6.9	0.87	8.3	380	12.51	410	330	360	101.1	11.2	7.67	0.97	30

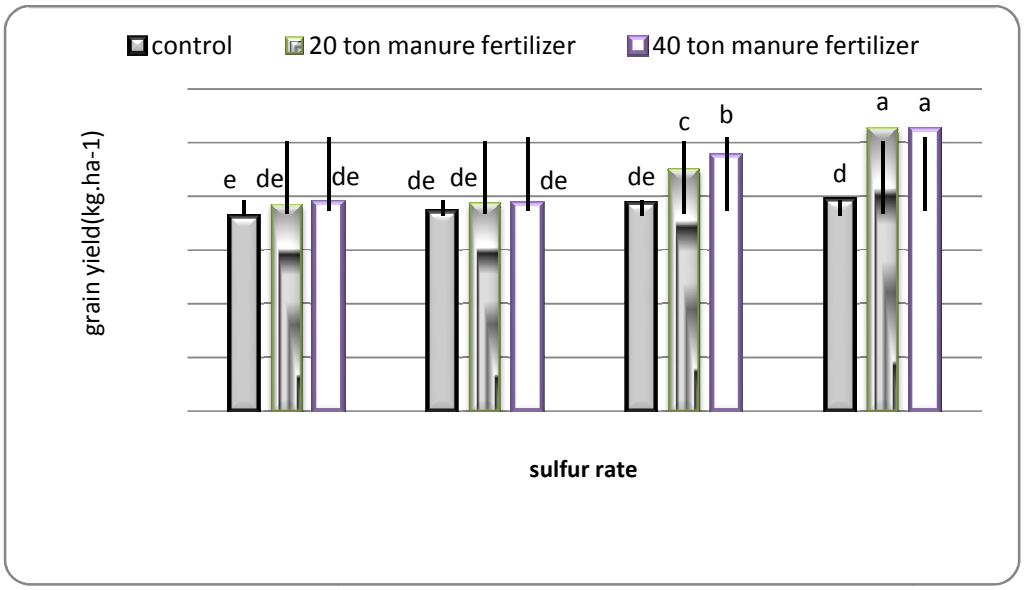

Fig. 1. Interaction effect of sulfur and manure fertilizer on grain yield of wheat; the bars labeled by the same letter did not significantly differ at A=0.05

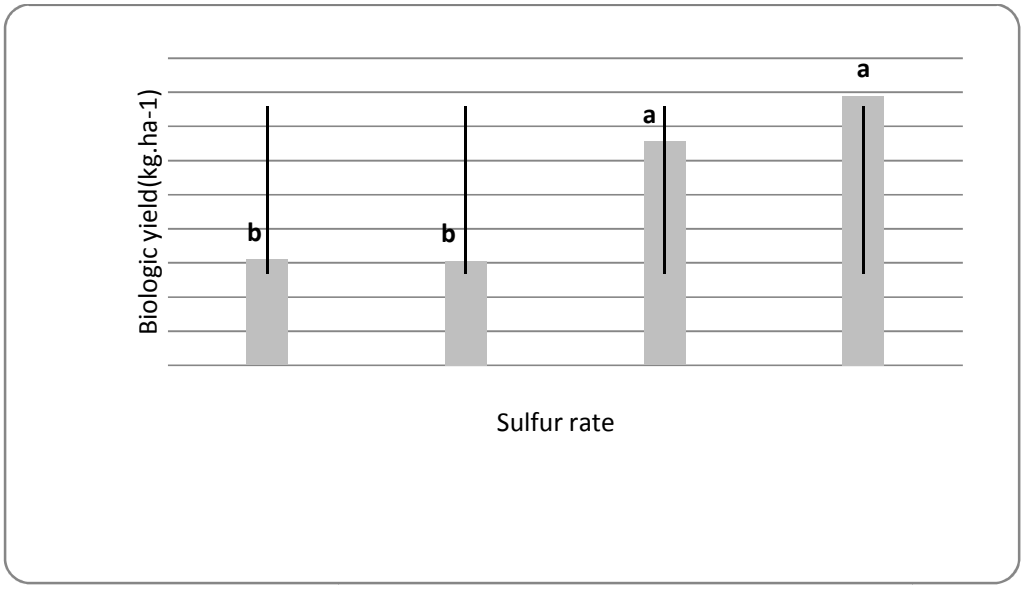

Fig. 2. The effects of sulfur rate application on biological yield; the bars labeled by the same letter did not significantly differ at α=0.05

3.3 Soil PH

Main effects of sulfur amount and OM have been significant on this trait (Table 2). Maximum decrease of pH compared to the control treatment (no application of sulfur) was related to application of 600 kg.ha^{-1} sulfur and is placed in c statistical group with pH equal to 7.33. Application of 400 kg.ha^{-1} is placed in same group with pH equal to 7.31 (Fig. 3). Also, application of 200 kg.ha^{-1} sulfur compared to control group caused to decrease in soil pH, however, it was not observed significant difference between application of 20 and 40 t.ha^{-1} OM statistically and soil pH amount have been 7.37 and 7.30 respectively (Table 3). Interaction effect of two factors such as manure and sulfur application was not significant on this trait.

Management of crop residues and OM is one of the main elements of production in agriculture and especially in double cropping system, because these methods have important role in soil fertility and improvement of its physical traits and as a result increase of production of agricultural crops with direct effect on soil traits in long term. Du Preea et al. [1] reported that burning plant remainders caused an increase of nutrient elements of soil and yield of plants compared to returning them to soil and that this yield increase continued until 4 year, he also expressed that use of burning crop residues caused to significantly increase soil pH.

Reason for soil pH reduction after addition of organic fertilizers can be decomposition of OM that existed in these materials that caused (lead to) production of carbonic acid and organic acids [17]. Srikanth et al. [18] also reported reduction of soil pH with adding vermicompost to soil similar to results obtained from this research. Parthasarathi et al. [19] also reported that soil pH was reduced significantly by application of vermicompost.

3.4 Soil EC

The main effect of sulfur levels and interaction effect of OM and sulfur was not significant, but OM levels have significant effect on this trait so that with increase of amount of consumed manure, it to increases the rate of soil electrical conductivity (EC) (Table 2) and with application of 40 t.ha^{-1} OM, rate of electrical conductivity is increased to 1.2 dS.m^{-1} that show 18% increase compared to the treatment without OM application (Table 3). As we know many fertilizers are full of cations and mineral elements that with its breakdown or decomposition, these minerals come free into soil solution and cause an increase of rate of soil minerals availability and as result electrical conductivity. Mirzayi et al. [20] when investigating the effect of applying organic fertilizers on physicochemical properties of soil and crop production and dry matter production in tomato concluded that effect of treatments on chemical properties of soil was significant at probability level of 1% such as percentage of organic carbon, pH and pure nitrogen, but was not significant on some physical properties of soil such as bulk density of soil, percentage of soil porosity and saturation hydraulic conductivity at level of 1% but had not significant effect on granular property of soil. Therefore, with application of OM in soil, sponginess of soil texture will increase as well as the porosity percentage and finally reduction of bulk density of soil.

3.5 OM

The effect of increase in amount of applied OM was significant on amount of soil OM, however, sulfur and also, interaction effect were not significant on this trait (Table 2). Maximum amount of OM of 1.49% was related to application of 40 t.ha^{-1} organic matters, OM of soil also increased with application of 20 t.ha^{-1} OM compared to control group but this increase was not significant statistically (Table 3).

Farhoodi et al. [2] concluded that returning wheat remainders to soil caused significant increase of OM rate and ratio of C/N in soil, but had not significant effect on soil pH. Foley and Cooperband [21] reported that adding of paper paste wastes and obtained compost from it to soil caused increase of organic carbon of soil and after continuous adding of this matter for two years, amount of available water of soil was increased between 5 to 45%. Lee et al. [22] showed that physical properties of soil changed with adding of organic matters, proportion related to added OM amount.

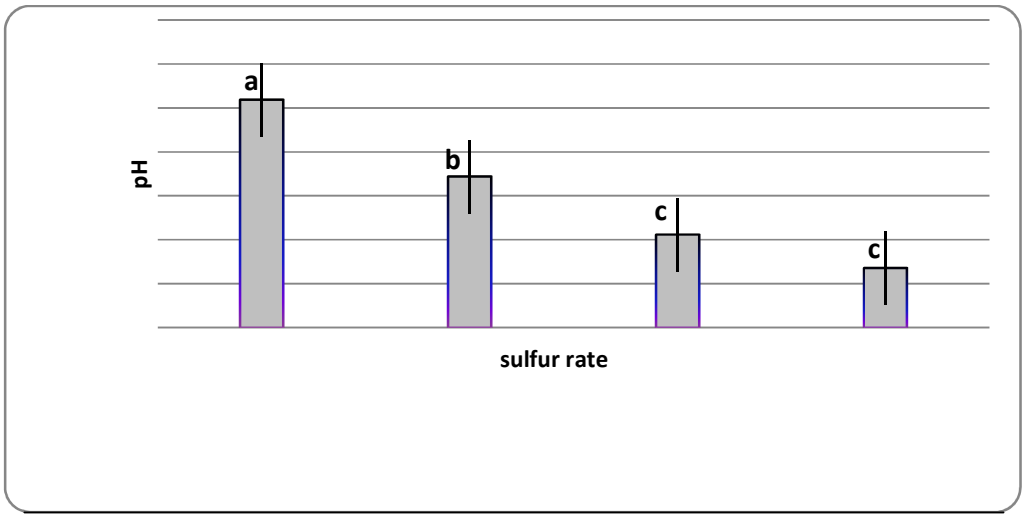

Fig. 3. Main effect of sulfur on soil pH; the bars labeled by the same letter did not significantly differ at α=0.05

3.6 Soil Bulk Density

This property of soil shows soil mass proportion to volume of all of soil and every factor that cause to increase its volume in definite weight unit, will lead to reduction of bulk density (pb) of soil. Results of analysis of variance show that interaction effect of sulfur and organic matters was not significant on this trait but effect of organic matters was significant on this trait (Table 2), such that bulk density was reduced with increase of amount of organic matters and maximum rate of reduction was related to application of 40 $t.ha^{-1}$ organic matters amount to 1.26 $g.cm^{-3}$ that show 15.4% reduction than control treatment (1.49 $g.cm^{-3}$) (Table 3).

The reason for effect of organic matters and compost on bulk density of soil is low density of organic matters and compost and its effect on size increase and amount of soil porosity [23]. Celik et al. [23] investigated effect of compost, mycorrihza and organic fertilizer on some physicochemical properties of soil and reported that mycorrihza have effective role in solidity of granular soils and both of treatments caused, decrease of bulk density and increase of organic matters. Ridvan [24] also during his experiment, with application of 0, 20 and 25 $g.kg^{-1}$ levels of vermicompost concluded that maximum rate of reduction in bulk density was related to treatment of 50 $g.kg^{-1}$ vermincompost.

3.7 Soil Particle Density

The main effect of manure was significant on particle density (p_s), however, sulfur effect and interaction effect of these two factor were not significant on this trait (Table 2). Increase of application of OM caused reduction of p_s of soil and highest amount of reduction in levels of applied manure was related to application of 40 $t.ha^{-1}$ OM that had 10.5% reduction than control treatment (2.57$g.cm^{-3}$) and reached to 2.30 $g.cm^{-3}$ (Table 3).

Ahmad Abadi et al. [25] concluded that experimental treatments had significant effect on all of studied traits such as pH, EC, bulk and particle density of soil, that is organic carbon and soil EC, pH, bulk and particle density of soil was reduced with increase of amount of vermicompost. Garcia Orenes et al. [26] considered factors of stability controller of soil grains and specific mass in two different treated by sludge and concluded that adding of biosoalids to soil caused a significant increase of organic carbon and percentage of soil grain stability and reduction of particle density in two soils. Tejada and Gonzales [27] in investigation of effect of four kinds of organic fertilizer on soil structure and its erosion under simulated rain concluded that all four organic fertilizers (compost of cotton wastes, compost of olive wastes, sludge and compost of waste materials) caused a reduction of particle density and soil grain instability and loss of soil.

Table 2. Soil result analyses after crop harvesting

Means square								df	S.o.V
Porosity	**p_s**	**p_b**	**OM**	**EC**	**pH**	**Biologic yield**	**Grain yield**		
17.057	0.010	0.009	0.026	0.003	0.024	425465.33	25299.84	2	Replication
1.793^{ns}	0.003^{ns}	0.004^{ns}	0.036^{ns}	0.001^{ns}	0.254**	2169646.50**	2207970.52**	3	Sulfur(S)
32.345**	0.216**	0.154**	0.609**	0.237**	0.170**	552039.63*	1505767.08**	2	Organic matters(OM)
2.942^{ns}	0.002^{ns}	0.001^{ns}	0.015^{ns}	0.003^{ns}	0.007^{ns}	179660.33^{ns}	307774.59**	6	S*OM
5.262	0.001	0.002	0.05	0.005	0.008	136835.47	22099.05	22	error
3.69	1.40	3.12	17.97	6.69	1.23	3.02	3.55	CV (%)	

*ns, * and **: Non significant, significant at 5% and 1% levels respectively*

Table 3. Means of main effect of organic matters on soil properties

Porosity ($cm^3.cm^{-3}$)	**($g.cm^{-3}$) p_s**	**($g.cm^{-3}$) p_b**	**(%) OM**	**($dS.m^{-1}$) EC**	**pH_e**	**Biologic yield ($kg.ha^{-1}$)**	**Organic matter**
42.03b	2.57a	1.49a	1.05b	0.92c	7.53a	11983.8b	OM1
42.76b	2.41b	1.38b	1.18b	1.02b	7.37b	12331.4a	OM2
45.17a	2.31c	1.26c	1.49a	1.2a	7.30b	12375.3a	OM3

Means in each column followed by similar letters are not significantly different at 5% probability level, using Duncan's test

3.8 Soil Porosity

The main effect of organic matters on soil porosity was significant based on analysis of variance results, but main effect of sulfur and interaction effect of sulfur and organic matters was not significant on this trait (Table 2), maximum rate of soil porosity with average of 45.17 $cm^3.cm^{-3}$ was related to application of 40t.ha^{-1} organic matters that had significant difference than treatment of 20 t.ha^{-1} application and control treatment statistically (Table 3), it was not observed significant difference between control treatment and application of 20 t.ha^{-1} organic matters. In experiment of Ridvan [24] and also Jat and Ahlavat [28], increase of amount of organic fertilizer application and compost caused increase of soil porosity rate in comparison with control group.

4. CONCLUSION

Application of soil amendment materials in all traits was affective. Sulfur has effect on some traits, but OM all measured traits. Efficiency increase due to increase of sulfur application rate seems to be related to acidifying some part of soil and increases of nutrient solubility and as a result increases the efficiency of nutrient absorption. With increase in sulfur and organic matters application, all traits was increased, but since two soil amendment materials were used simultaneously, efficiency was more increased. Thus in order to increase quantity and quality of crop, the use of both soil amendment materials in calcareous soil is recommended.

COMPETING INTERESTS

Author has declared that no competing interests exist.

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