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Vermicompost application improves yield and quality of table grapes *var.* king's ruby (*Vitis vinifera*)

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Abstract

A field experiment was carried out to check the effect of vermicompost application on the yield and quality of table grapes variety King's Ruby. Vermicompost (VC) was prepared by earthworm species *Eisinia fetida* using cow dung and sugarcane filter cake in the ratio 4 to 1. VC was applied alone (1,2 and 3 tons ha^{-1}), and with NPK (1/3 recommended dose), to compare their effect with NPK (100-150-850) kg h^{-1} and control (no addition of vermicompost or fertilizers) during the years 2012-13. Each treatment was consists of four plants with three replications. Each line was considered as block. The design was RCBD. Different yield and quality parameters of table grapes like berry weight, bunch weight, yield, total soluble solids, reducing sugars, non-reducing sugars, ascorbic acid, protein, titratable acidity and total soluble solids ratio titratble acidity (TSS: TA) were studied. In the first year 2012 of study, the bunch weight differed significantly amongst the treatments being highest under NPK (full recommended dose), followed by vermicompost (3 tons + NPK 1/3 recommended dose per ha^{-1}) and lowest in the control. In the year 2013, however the data recorded varied non-significantly among the treatments but exhibited the same trend as of the last year 2012. In case of yield the difference between highest (NPK) and untreated was 3.10 kg while 2.73 kg between (VC 3ton + 1/3 NPK) and untreated plants.

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Introduction

Soil fertility management in agricultural fields including the vineyards is vital for higher crop yields and quality. Generally, chemical fertilizers are applied to make up nutrient deficiency in agricultural soils, however, there have been several agricultural and environmental hazards associated with the sole use of chemical fertilizers. It has been reported that applications of higher doses of soluble inorganic nutrients change the microbial colonization of roots (Schloter *et al.,* 2003), negatively affect the mycorrhizal colonization (Gryndler *et al.,* 2006; Kliekamp and Joergenson, 2006), and may reduce number of roots. Hence, the biodynamic vineyard management systems involving the use of organic fertilizers such as farmyard manure, poultry litter, composts etc. are gaining increasing interest (Reeve *et al.,* 2005).

Compost is the stabilized product undergone degradation and depolymerization of the hydrolyzed products through a cycle of mesophillic, thermophillic and again processes carried out by microorganisms. During the process of composting, thermophillic decomposition reduce the microbial diversity, so many vital processes are not triggered due to lack of diverse microbial functions. Moreover the thermophillic decomposition results in losses of N from the composting material in different forms (De Bertoldi *et al.,* 1983; Zucconi and De Bertoldi, 1987), thus the product formed has low value as an organic fertilizer.

Vermicomposts are the products derived from accelerated biological degradation of organic wastes by interaction between earthworms and microorganisms (Edwards *et al.,* 2004). Vermicomosts produced from animal wastes rich in mineral elements than commercial plant growth media, and that mineral elements are available in the forms that could be taken up by plants such as nitrates, orthophosphates, and soluble K, Ca and Mg (Arancon and Edwards, 2004). Vermicomposts are superior organic amendments due to their excellent biological properties which in addition to diverse microbial populations capable of nutrient recycling, contains PGH's, auxins, gibberellins, cytokinins, humic and fulvic acids functioning as plant growth regulators (PGR's) (Arshad and Frankenberger, 1993).

Vermicompost are rich in bacteria, actinomycetes, fungi, and cellulose degrading bacteria which play an important role in nutrient mineralization from crop residues and other organic sources (Edwards, 1983; Tomati, 1987; Werner and Cueves, 1996) Studies have shown that the application of vermicompost increased the growth and yield of several crops including banana, peppers and straw berries (Ushakumari *et el.,* 1999; Athani *et al.,* 1999; Nenthra *et al.,* 1999; 2003; Arancon *et al.,* 2004 & 2005). As far as grapes are concerned, vermicompost application caused significant increases in grapes yield, 55% by grape marc vermicompost on grape cv. Pinnot Noir (wine grapes), and 35% by animal manure vermicompost on grape cv. Chardonnay (Venkatesh *et al.,* 1998). However, in the above studies, focus of researchers has been on the grapes yield, while the fruit quality parameters were not explored extensively. In present study, vermicompost prepared from the cow dung and sugarcane filter cake using earthworm species *Eisinia fetida,* was band placed in the active root zone area of grapes vines, and its effect on the yield and fruit quality parameters studied. At present in Pakistan, 16 thousand hectares of the cultivated area lies under table grapes vineyards mainly in Baluchistan (Agriculture statistics of Pakistan, 2011-2012). However grapes plantation is in rise in other parts of the country and more than two hundred hectares had been established since 2006 in the Potohar region.

Materials and methods

Experimental material

A field experiment was conducted to evaluate the effect of vermicomposts application at different rates on the yield and quality of table grapes cultivar 'King's Ruby' for two consecutive years i.e., 2012 and 2013. Grapes plants raised from cuttings grown in farmer's vineyard consisting of 2 hectares at village Malhoo (33°55ˈ12.90ˈˈ72° 25ˈ25.10ˈˈ), Tehsil Hazro District Attock were selected for the study. The irrigation was given by flooding. The distance between plants to plant was 8 feet and the line to line distance was 10 feet. The plants had been trained on two wires, four arms cordons. Each line was considered as a block to layout the experiment according to randomized complete block design (RCBD).

Vermicompost was prepared from cow dung as a substrate using earthworm species *Eisinia fetida* and was applied at different levels with or without chemical fertilizers.

Treatments

The plan of treatments was as ; 1) control, 2) Vermicompost (VC), 1 t ha^{-1}, 3) VC, 2 t ha^{-1}, 4) VC, 3 t ha^{-1}, 5) VC, 1 t ha^{-1} + 1/3 NPK, 6) VC, 2 t ha^{-1} + 1/3 NPK, 7) VC, 3 t ha^{-1} + 1/3 NPK and 8) NPK (100-150-850) kg h^{-1}. Each treatment was consisting of four plants. Each treatment was replicated four times. Vermicompost along with full doze of P and half doze of N and K was applied at bud break, and the remaining N and K were added 30 days after the blooming stage. The doses of NPK were adjusted on the basis of initial soil and plant analysis following the Bhargava *et al.* (2001) soil fertility norms.

Parameters

Plant growth and yield parameters such as berry weight, bunch weight and yield per vine were recorded. The parameters for fruit quality such as pH of juice, total soluble solids (TSS), titratable acidity, reducing sugars, total sugars, TSS/ sugar ratio, and vitamin C were also recorded. The fruits were analyzed for total soluble solids as described by (Dong *et al.* 2001) by a hand refract meter. Reducing sugars of juice were estimated by the method described by (Horwitz, 1960). Total sugars of juice were estimated using the method described by (Horwitz, 1960).

Statistical analysis

Experimental data was analyzed by using Statistix 8.1 software for analysis of variance (ANOVA) following the randomized complete block design (RCBD) and the treatment mean were compared using Least Significant Difference (Steel *et al.*, 1997).

Results

The value of bunch weight (Table 3 and Fig 9) significantly affected during the year 2012 with the application of vermicompost different levels alone and with different levels of chemical treatments compared to control value. Maximum difference 154 gram was recorded between NPK and control followed by 107.2 gram between VC 3 ton + 1/3 NPK and control in the year 2012. Then in the second year 2013, maximum difference 124 g was recorded between NPK and control value followed by 120 g between VC 3 ton + 1/3 NPK and control. As far as yield was concerned significant difference was recorded between control and treatments. Maximum difference recorded between NPK and control was 3.8kg followed by 2.2kg between VC 3 ton + 1/3 NPK and control in the year 2012. Though in the year 2013 the data was non-significant between control and treatments however the maximum difference between NPK and control was 3.93kg followed by 2.73kg between VC 3 ton + 1/3 NPK and control. Treatments have non-significant effect on fruit skin brightness (L*) values in both the years (2012 and 2013). Similar behavior of the applied fertilizers was noted on fruit blush color (a*) in the year 2012. In the year 2013 the value of a* in different treatments was significantly different than untreated fruit; highest value of fruit skin blush color was recorded in VC 1 ton, VC 1 and 2 ton in combination with 1/3 NPK (5.5) compared to untreated trees (5.0). The values of ground color (b) in the year 2012 were non-significant while in the 2013 the values were significantly different. Maximum value (6.6) repeatedly were recorded in VC 3 ton and VC 1 ton in combination with 1/3 NPK as compared to control where minimum value (6.2) was recorded in the fruit taken from untreated plants (Table 4 Fig 6, 7, 8).

Table 1. Chemical properties of the soil at the experimental site.

Parameter	Value
Texture	Silt loam
Organic C (%)	0.71
Total N (%)	0.06
Olsen P (mg kg^{-1})	4.21
Extractable K (mg kg^{-1})	85.72
Extractable Fe (mg kg^{-1})	25.42
Extractable Cu (mg kg^{-1})	5.29
Extractable Zn (mg kg^{-1})	12.38
Extractable Mn	3.21

Table 2. Chemical characteristics of cattle manure vermicompost.

Parameter	Value
EC (dS m-1)	1.68
pH	6.61
Organic C (%)	12.30
Total N (mg kg-1)	6.13
Total P (mg kg-1)	4.74
Total K (mg kg-1)	5.36
Total Ca (mg kg-1)	295.52
Total Mg (mg kg-1)	113.71
Fe (mg kg-1)	531.24
Zn (mg kg-1)	405.82
Mn (mg kg-1)	370.17
Cu (mg kg-1)	251.49

Effect on fruit quality characteristics

Table 5 Figs. 2, 4, shows the effect of different levels of VC and chemical fertilizers on fruit chemical characteristics in the years 2012 and 2013. Applied treatments significantly affected the values of TSS in both the years.

In 2012 highest value (15.9) was observed in NPK as compared to fruit obtained from the plants receiving no treatment (14.4). Treatments of VC 1, 2, 3 ton in combination with 1/3 NPK, having the values of 15.6, 15.5 and 15.4 were at par while significantly higher when compared against untreated plants. Results regarding reducing and total sugars showed that higher levels of vermicompost had significantly higher values of reducing sugars as compared to fruits taken from the plants which left untreated for both the years under study.

Table 3. Effect of vermicompost (VC) applied alone and in combination with chemical fertilizers on berry weight, bunch weight and yield of table grapes cv. King's ruby.

Treatments	Berry Weight (g)		Bunch Weight (g)		Yield (Kg)	
	2012	2013	2012	2013	2012	2013
Control	15.0 a	16.3 a	453.8 b	445.0 ab	9.10 b	9.07 ab
VC 1 ton	15.0 a	16.6 a	562.8 a	525.0 ab	11.2 a	11.2 ab
VC 2 ton	15.0 a	17.5 a	556.2 a	550.0 ab	11.1 a	11.1 ab
VC 3 ton	16.7 a	18.0 a	564.5 a	540.0 ab	11.3 a	11.2 ab
VC 1 ton + 1/3 NPK	15.0 a	17.3 a	559.2 a	389.3 b	11.2 a	11.1 b
VC 2 ton + 1/3 NPK	16.7 a	17.0 a	554.6 a	550.0 ab	11.1 a	11.0 ab
VC 3 ton + 1/3 NPK	15.0 a	18.0 a	591.6 a	565.0 ab	11.8 a	11.8 ab
NPK	15.0 a	18.0 a	607.8 a	590.0 a	12.2 a	12.1 a
LSD	4.7	2.1	98.3	178.5	1.9	3.6

LSD= Least significant difference.

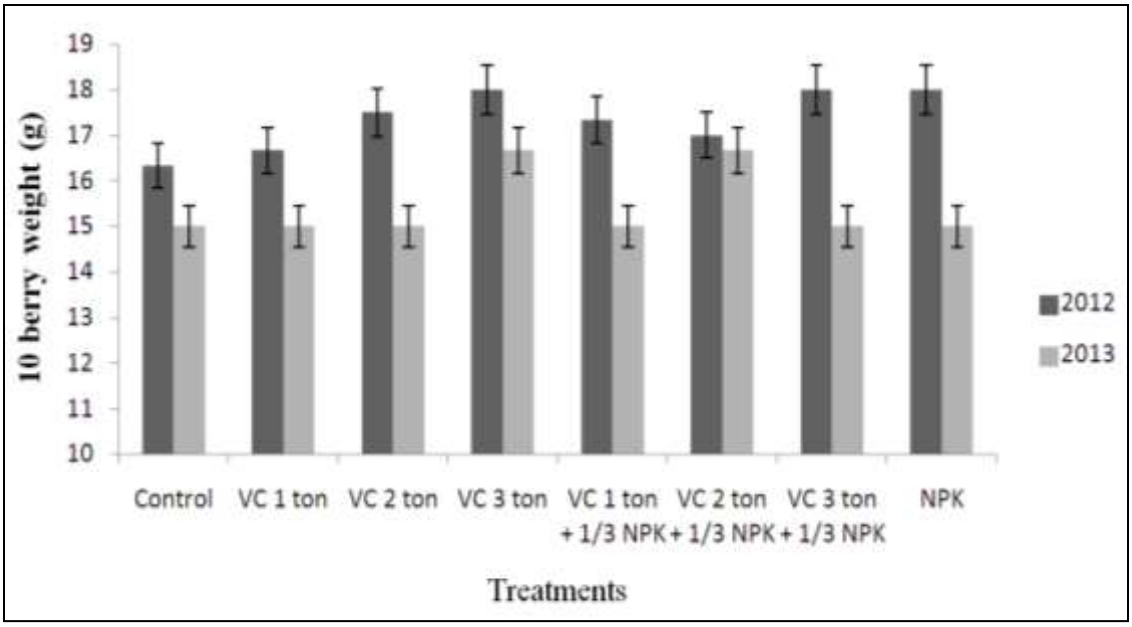

Fig. 1. Effect of vermicompost alone and in combinations with chemical fertilizer on 10 berry weight of grapes.

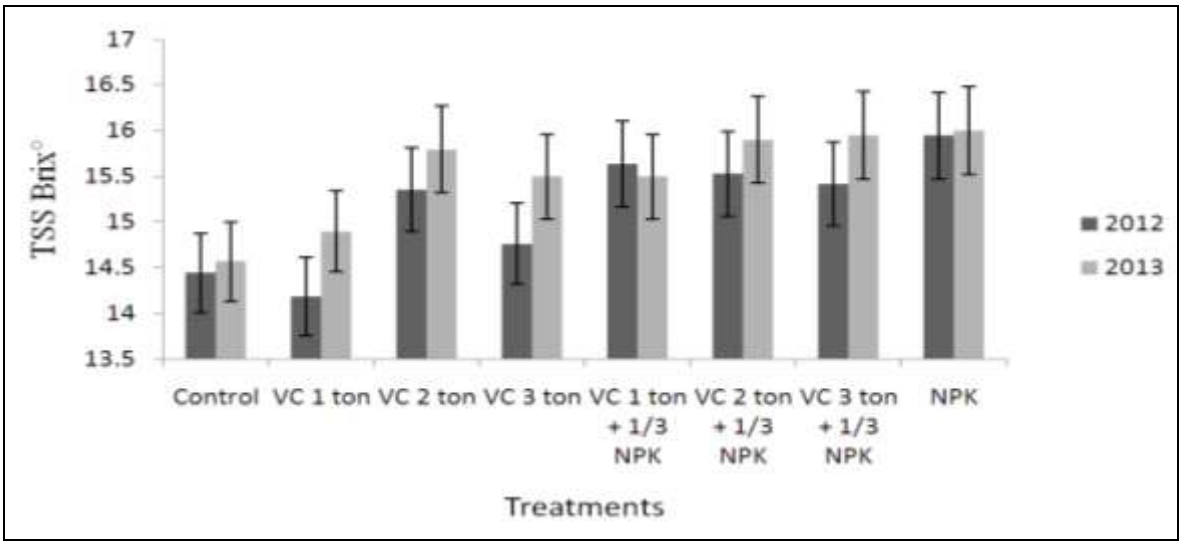

Fig. 2. Effect of vermicompost alone and in combinations with chemical fertilizer on TSS Brix.

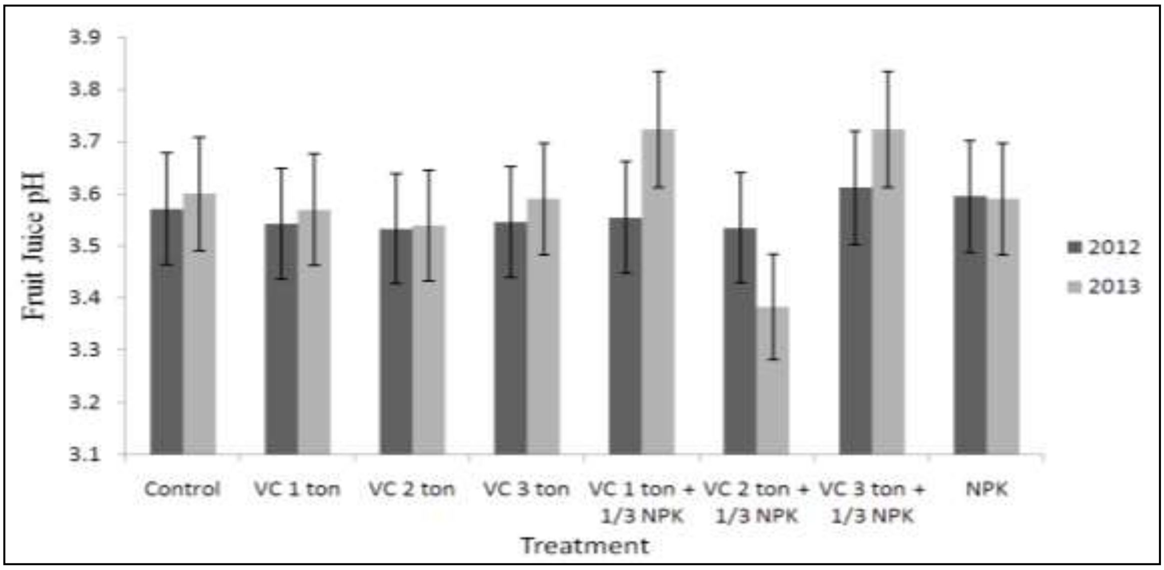

Fig. 3. Effect of vermicompost alone and in combinations with chemical fertilizers on fruit Juice pH.

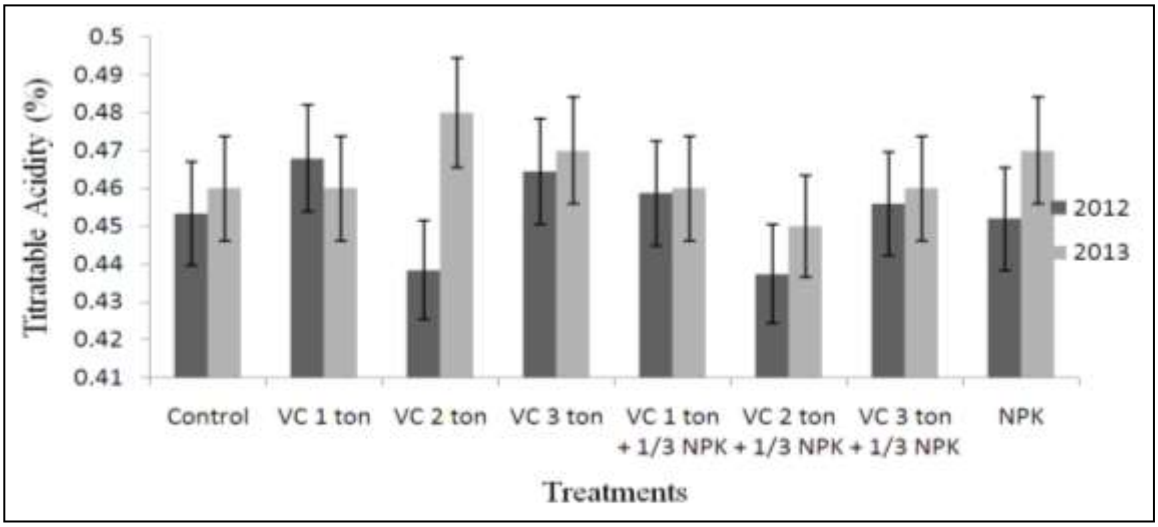

Fig. 4. Effect of vermicompost alone and in combinations of chemical fertilizers on titratable acidity (%).

Table 5 shows the effect of VC different levels on the total soluble solids (TSS), titaratable acidity (TA), reducing sugars (RS), and total sugars (TS) of the fruit in the years 2012 and 2013. TSS in the 1st year of the study showed significant results, while similar trend was in the 2nd year of the study.

In the 1st year highest value of (15.9) was observed in NPK as compare to (14.4) in fruit obtained from the plants receiving no treatment. Treatments VC 1,2,3 ton in combination with 1/3 NPK, having the values of 15.6, 15.5 and 15.4 were at par non-significant amongst one another while significantly higher when compared against the control value (14.4), similar situations was VC 2 ton and VC 3 ton (Fig 2).

Results of RS showed reducing sugars so its discussion same as for TSS and these results confirmed the validity of reducing sugars as the trend is similar TS in both of the years were recorded significantly different than that of untreated. In the year 2012 maximum value of 16.1 was recorded where VC 2 ton + 1/3 NPK was applied as compare to fruit untreated plants (14.44), While in VC 2 ton and VC 3 ton 15.5% and 15.8 values are significant different than control (14.4). TS in the year 2013 recorded maximum in VC 3 ton + 1/3 NPK and NPK, 16.5 and again 16.5 respectively as compare to control, (14.5).

Moreover, VC 2 ton + 1/3 NP K is also significant and near to maximum value. The results were in agreement with Blidariu and Sala (2012) and Doberi *et al.* (2009).

Increasing trend of the TS in both of the year as compare to control especially in VC 3 and 2 tons along with chemical fertilizers could be due to microbial decomposition and mineralization of nutrient which were made available to the plants leaded to maximum photosynthetic activity resulted into the maximum accumulation and then translocation in the berries.

In the year 2012, maximum value of 12.1 was observed in T8 and then 11.7 and 11.4 in VC 3 ton + 1/3 NPK and VC 2 ton + 1/3 NPK which were significantly different also in comparison with control 4.40 and 4.30 in VC 1 ton. While VC 2 ton and VC 1 ton + 1/3 NPK were also significantly different than control also. In the year 2013 maximum value of 11.7 was observed in NPK as compare to control with a value of 4.2. Moreover along with NPK, VC 3 ton + 1/3 NPK and VC 2 ton + 1/3 NPK values of 11.1 and 11.5 respectively were nearest to maximum value of 11.7. In addition VC 2 ton, VC 3 ton and VC 1 ton, VC 2 ton were significantly different in comparison with control. Grapes are non-climacteric fruit so up to end of maturity translocation from the leaves continued opposite of climacteric fruit where during the process of ripening TSS rises where in addition to monosaccharide's sugars glucose and fructose disaccharides sugars sucrose accumulates which recorded to utilized for increase of ethylene production and increase in respiration (Dhillon and Gill, 2011) In grapes major portions of total soluble sugars are reducing sugars.

Table 4. Effect of vermicompost applied alone and in combination with chemical fertilizers on color maturity index of table grapes cv. King's Ruby.

Treatments	Fruit Skin Lightness (L) values		a		b	
	2012	2013	2012	2013	2012	2013
Control	37.0 a	38.51 ab	5.0 a	5.3 c	6.6 a	6.2 c
VC 1 ton	35.6 a	36.28 d	5.9 a	5.5 ab	6.6 a	6.4 b
VC 2 ton	36.5 a	38.40 abc	5.5 a	5.4 abc	6.6 a	6.6 a
VC 3 ton	38.0 a	38.52 ab	5.8 a	5.4 bc	6.8 a	6.6 a
VC 1 ton + 1/3 NPK	37.8 a	38.66 ab	5.2 a	5.5 ab	6.6 a	6.5 a
VC 2 ton + 1/3 NPK	35.5 a	39.82 a	5.8 a	5.3 bc	6.7 a	6.4 b
VC 3 ton + 1/3 NPK	36.6 a	36.61 cd	5.6 a	5.5 ab	6.2 a	6.5 a
NPK	36.6 a	37.48 bcd	5.8 a	5.6 a	6.9 a	6.4 b
LSD	2.90	1.26	1.20	0.19	1.30	0.07

LSD= Least significant difference. L=lightness. a= values from green to red. b= values from blue to yellow.

Table 5. Effect of vermicompost applied alone and in combination with chemical fertilizers TSS, TA, RS, and TS of table grapes cv. King's Ruby.

Treatments	TSS (°Brix)		TA (%)		RS (%)		TS (%)	
	2012	2013	2012	2013	2012	2013	2012	2013
Control	14.4 cd	14.5 e	0.45a	0.46 ab	4.40 c	4.2 h	14.4 bc	14.5 c
VC 1 ton	14.2 d	14.9 d	0.47 a	0.46 ab	4.30 c	5.0 g	13.7 c	14.5 c
VC 2 ton	15. abc	15.7 b	0.44 a	0.48 a	7.60 b	6.9 e	15.5 ab	16.2 a
VC 3 ton	14. bcd	15.5 c	0.46 a	0.47 ab	4.30 c	6.2 f	15.8 ab	16.3 a
VC 1 ton + 1/3 NPK	15.6 ab	15.5 c	0.46 a	0.46 ab	6.60 b	7.5 d	13.7 c	15.2 b
VC 2 ton + 1/3 NPK	15.5 ab	15.9 ab	0.44 a	0.45 b	11.4 a	10.5c	16.1 a	16.0 a
VC 3 ton + 1/3 NPK	15.4 ab	15.9 ab	0.46 a	0.46 ab	11.7 a	11.1b	16.0 a	16.5 a
NPK	15.9 a	16.0 a	0.45 a	0.47 ab	12.1 a	11.7a	15.7 ab	16.5 a
LSD	0.95	0.192	0.0331	.0211	1.0621	0.181		0.3

LSD= Least significant difference, TSS= Total soluble solids, TA= Titratable acidity, RS= Reducing sugars, TS= Total sugars.

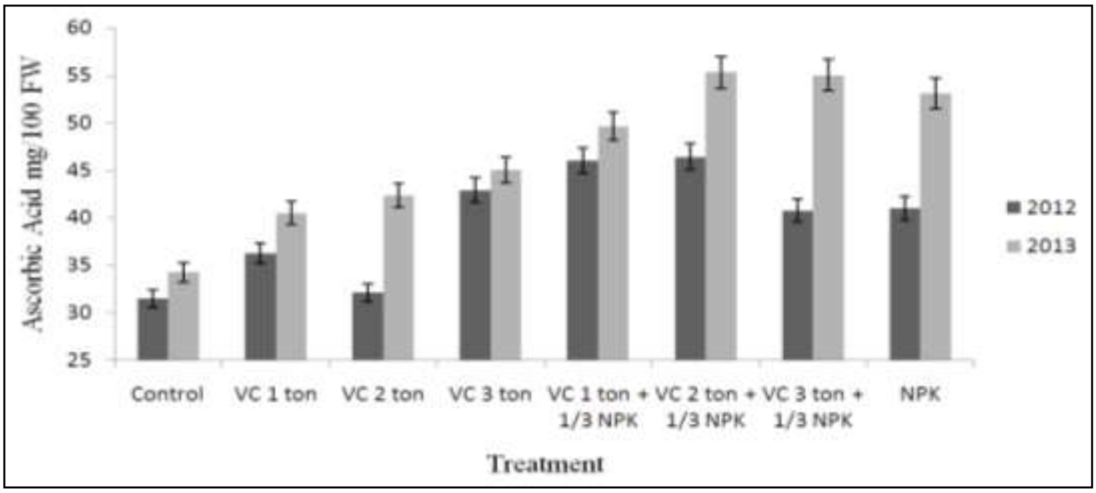

Fig. 5. Effect of vermicompost alone and in combination with chemical fertilizer on ascorbic acid mg/100 FW.

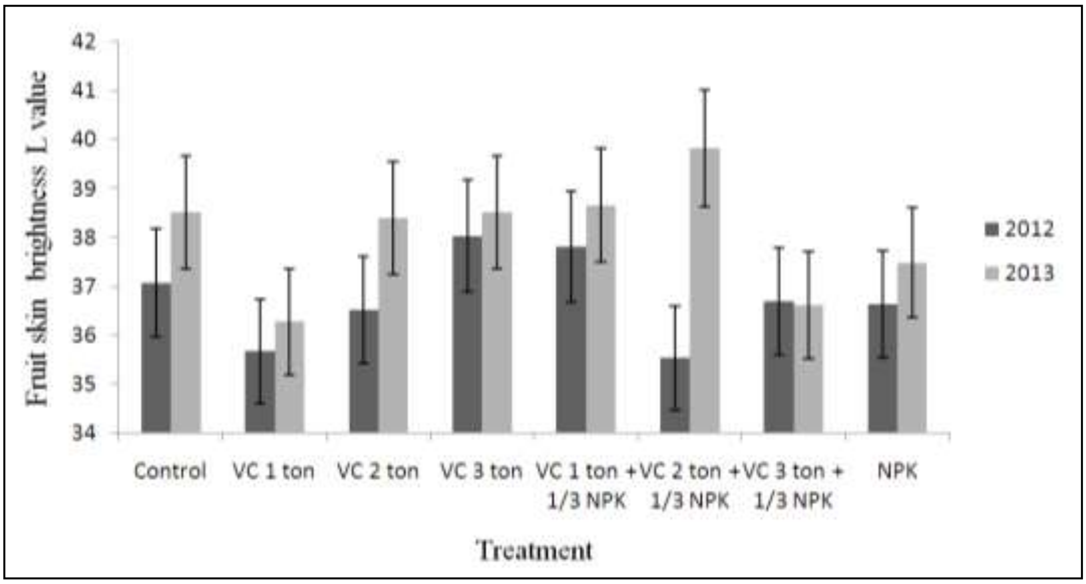

Fig. 6. Effect of vermicompost alone and in combination with chemical fertilizer on fruit skin brightness L value.

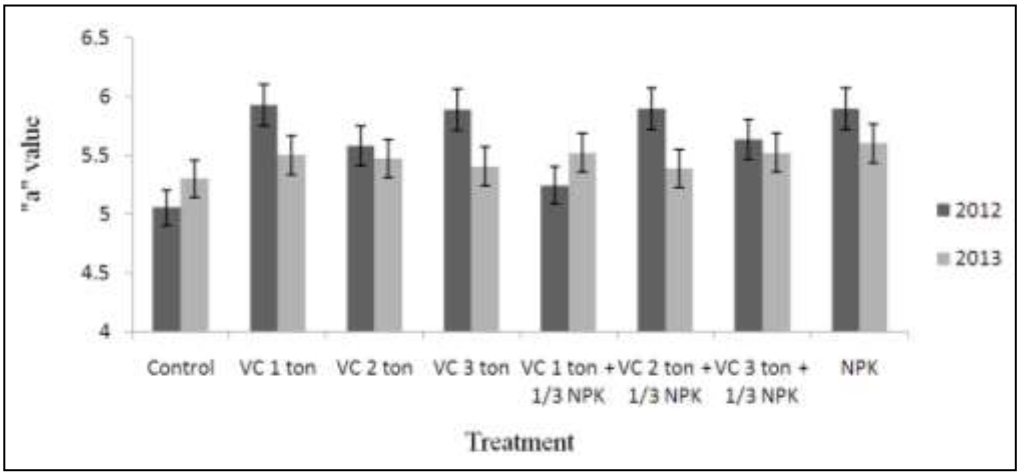

Fig. 7. Effect of vermicompost alone and in combination with chemical fertizer on "a" value of berries.

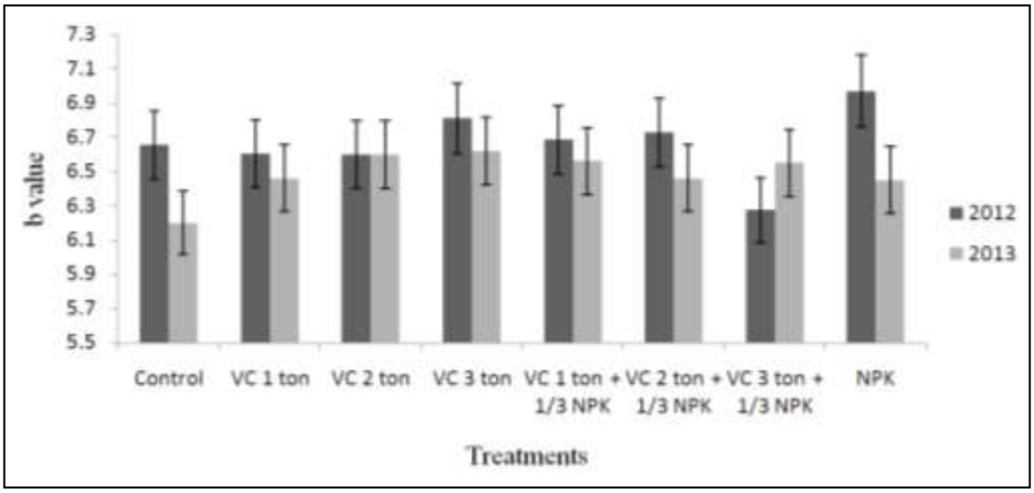

Fig. 8. Effect of vermicompost alone and in combination with chemical fertilizer on b value of berries.

Table 6 shows the result of ascorbic acid (AA), protein and maturity index in terms of taste (TSS:TA) in response to different levels of vermicompost (VC) alone and in combination with the chemical fertilizers in the year 2012 and 2013. The observations recorded for AA for the 1st year remained significant as compare to most of the variants. Maximum value was recorded under the VC 2 ton in combination with 1/3 NPK (46.4mg/100g) followed by the VC 1 and 3 ton in combination with 1/3 NPK, and NPK alone with the values 46 mg/100g, 40.7mg/100 g and 41mg/100g respectively as compared to control (31.5 mg/100g). Similarly in the subsequent year, the results were also significant. Maximum value was observed under VC 2 ton in combination with 1/3 NPK that was 55.3 mg/100g as compared to 34.2 mg/100g in untreated plants. However VC 3 ton in combination with 1/3 NPK and NPK values remained near the highest values which were 55 mg/100g and 53 mg/100g respectively (Fig. 5). The observations recorded for protein in response to different treatments in the berries was non-significant in the both of the years 2012 and 2013. The data recorded for the maturity index in terms of fruit taste TSS: TA ratio was significant for both of the years 2012 and 2013. In the year 2012 maximum value 35.5 of TSS: TA was recorded in response of VC 2 ton in combination with 1/3 NPK as compared to minimum value of 31.6 in untreated plants. However V 3 ton and NPK values were nearest to VC 2 ton in combination with 1/3 NPK which is highly significant that was 35.1 and 35.3 while the highest was 35.5. In the subsequent year the data recorded was significantly different in response to the treatments. Maximum value was recorded in response to VC 2 ton in combination with 1/3 NPK that was 35.3 in comparison with untreated plants (31.6).

Table 6. Effect of vermicompost applied alone and in combination with chemical fertilizers on AA, Protein, and TSS: TA ratio, of table grapes cv. King's Ruby.

Treatments	AA		PROTEIN		TSS: TA	
	2012	2013	2012	2013	2012	2013
Control	31.5 c	34.2 e	3.5 a	3.4 b	31.9 bc	31.6 d
VC 1 ton	36.2 bc	40.4 d	3.5 a	3.5 ab	30.3 c	32.4 cd
VC 2 ton	32.1 c	42.3 d	3.5 a	3.5 a	35.1 a	32.9 cd
VC 3 ton	42.9 ab	45.0 c	3.2 a	3.4 b	31.8 bc	32.9bcd
VC 1 ton + 1/3 NPK	46.0 a	49.6 b	3.2 a	3.2 d	34.1 ab	33.7abc
VC 2 ton + 1/3 NPK	46.4 a	55.3 a	3.2 a	3.2 d	35.5 a	35.3 a
VC 3 ton + 1/3 NPK	40.7 ab	55.0 a	3.2 a	3.2 d	33.8 ab	34.6 ab
NPK	41.0 ab	53.0 a	3.3 a	3.3 c	35.3 a	34.0abc
LSD	7.80	2.27	0.56	0.06	2.61	1.77

LSD= Least significant difference. AA= Ascorbic Acid, TSS: TA ratio= Total soluble solids. TA= Titratable Acidity.

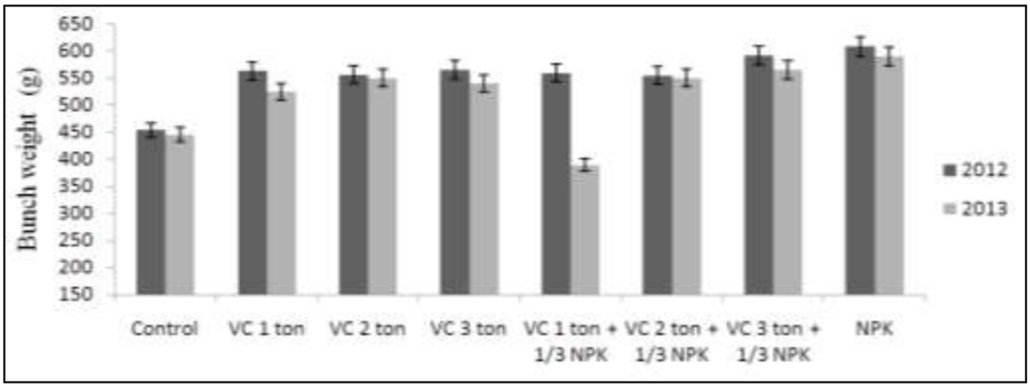

Fig. 9. Effect of vermicompost alone and in combination with chemical fertilizers on bunch weight.

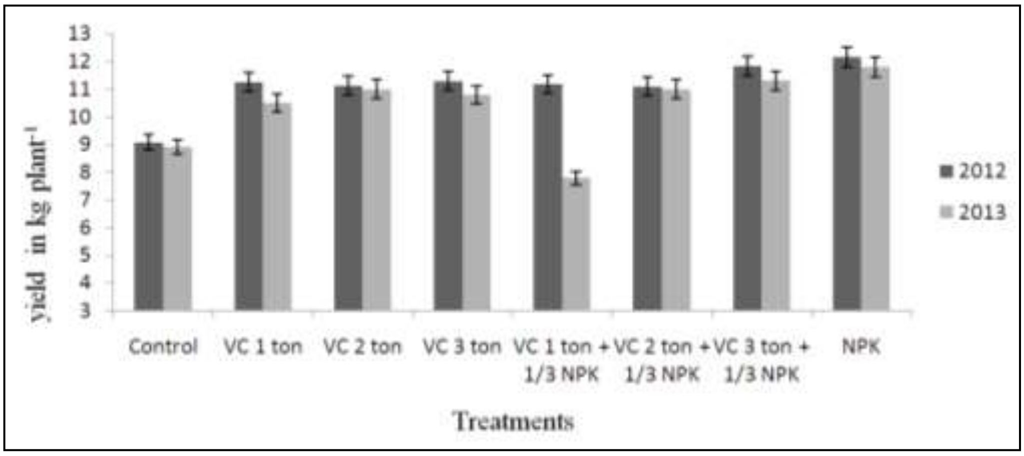

Fig.10. Effect of vermicompost alone and in combination with chemical fertilizer on yied in kg.

Discussion

Application of vermicompost significantly improved fruit physical characteristics like bunch weight and yield. This may result in greater price in the market, since larger bunches are more appreciated in the market.

The results are in agreement with the findings of (Ferrara and Brunetti, 2008). Higher yield by application of NPK could be attributed to its characteristics of fulfilling the plant nutrient requirement. Improvement of yield as a result of application of organic amendments (OA) alone or in combination could be ascribed to enhancing the availability and uptake of nutrients. OA are involved in multiple soils chemical and biochemical processes which result in lowering of pH. Furthermore, microbial biomass releases root exudates leading to acidification which resulted in availability of phosphate, K, NO_3^{-1}, metals and metalloids (Edwards *et al.,* 2004).

In the present study higher doses of fertilizers significantly affected the fruit skin color specially the values of a & b during the year 2012. But the treatments did not have any significant effect regarding fruit skin brightness during both the years under study (Table 4). The results are in agreement with (Wrostad *et al.,* 2005). Vermicompost is involved in the production of PGR's, ABA and phenolics through diverse microbial activity in the soil (Arshad and Frankenberger, 1993). By application of VC which had been established as diverse microbial rich amendment. Effects for color development had been established by (Celia *et al.* 2007) and (Zahedi *et al.*, 2013) by the application of ABA and ethephon. Maximum color development by the NPK may be ascribed to synthesis of PAL (Phenyl Alanine Lyase) enzyme in the outer periphery of the berries which converts phenyl alanine amino acid into fumaric acid and phenolic compounds (Peppi *et al.*, 2006) hence, improving fruit color development.

The treatments had significant effect on soluble solid, sugars ascorbic acid and protein contents at harvest, while the organic amendment or NPK were remained ineffective in improving titratable acidity and. The significant effect on sugar accumulation in case of different combinations of VC and chemical fertilizers might be explained through its effect on enhancing photosynthetic activity due to continuous slow release of mineral nutrient (macro and micronutrients) which resulted in better output of carbohydrate. The results were in agreement with some previous findings (Blidariu and Sala, 2012; Peuke, 2009; Doberi *et al.* 2009; Wang *et al.,* 2010).

Increasing trend of the TS in both of the year as compare to control especially in VC 3 and 2 tons along with chemical fertilizers could be due to microbial decomposition and mineralization of nutrient which were made available to the plants leaded to maximum photosynthetic activity resulted into the maximum accumulation and then translocation in the berries. Difference in both of the years 2012 and 2013.Results of TA for both of the year were non-significant. The significant effect of sugar accumulation in case of different combinations of VC and chemical fertilizers might be explained through its effect on enhancing photosynthetic activity due to continuous slow release of mineral nutrient (macro and micronutrients) which resulted in better output of carbohydrate which in turns converted into total soluble solids consisting of major portion of sugars. Moreover the results of NPK are already established. Results of TA for both of the year were non-significant (Peuke, 2009). Higher values of ascorbic acid in berries from the treated plants, might be due to the fact that in grapes organic acids accumulates at early stages and amino acids (produced by VC) are the precursor for organic acids which in turn are the precursor for the respiration during fruit ripening, so during ripening supra-optimal temperature leads to reduced respiration due to closing of stomata results in increased accumulation of acids (Dhillon and Gill, 2011). While, the enhanced values of TSS: TA ratio ascribed to microbial mineralization, mobilization of nutrients made ease of availability and uptake by the plant thereby enhanced photosynthetic activities so the enhanced translocation of photosynthates to leaves and fruit. From the table it is obvious that the treatments did not have any effect on titratable acidity and protein contents of berries for both the years under study.

Conclusion

Fruit quality parameters like TSS, TA, protein, ascorbic acid and TSS: TA ratio significantly affected by the different combinations of VCs and 1/3 NPK treatments. Most of the quality parameters gave significant results in 2nd year (2013).

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