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Effect of Rootstocks on the Performance of Autumn Royal Grape in Vertisols of Tropical India

T.S. Shelake*, J.N. Kalbhor, S.D. Shikhamany, S.S. Tapkir, T.S. Mungare
R & D Unit, Maharashtra Grape growers' Association, Manjri Farm, Pune-412307.
*Corresponding author email id: mrdbsho@gmail.com

Abstract – **With an aim to improve the productivity in terms of brix-yield of Autumn Royal grape in saline-alkali vertisols of tropical India, a field trial was conducted during 2015-2017 employing four rootstocks, namely Dog Ridge, 110 R, Salt Creek and 1103 P. In the overall analysis considering the effects of rootstocks on vine growth, fruit yield, quality and nutrient absorption, Dog Ridge rootstock was found the best. Improved performance on Dog Ridge was attributed to i) its positive effects on prunings weight and canes/vine, cane diameter and shoot length which had positive correlation with brix-yield, and ii) less absorption of N, Na and Cl which are detrimental to growth and productivity of grapes.**

Keywords – **Grape, Autumn Royal, Rootstock, Saline-alkali soils, Vertisol, Brix-yield.**

I. Introduction

Autumn Royal is a black seedless grape variety developed and released in 1996 by the USDA Agricultural Research Service, Parlier, California. According to the California Table Grape Commission, it is among the 14 top-selling grapes in the state. Because its largest natural berry size among seedless grapes, was introduced by the Maharashtra State Grape Growers' association at their R&D farm, Pune, India. Its performance was tested on its own root in a saline - alkali vertisol, typical to majority of the grape growing soils in India, irrigating with 500 mm of poor quality water/annum (Composition of the soil and water are given in Material and Methods). Autumn Royal vines on their own root were poor in vigour and yielded very low. Rootstocks were found to influence the nutrient absorption (Cook and Lider, 1964; Fisarakis *et al*., 2005), limit the absorption of Na and Cl (Alexander and woodham, 1968; Downton, 1977), eventually increase vine vigour and fruit yield (Loomis, 1952; Satisha *et al*., 2010) in different varieties of grape. Hence, the present trial was conducted to improve the yield and quality of this variety through increased vine vigour, nutrient absorption and tolerance to soil and water salinity by employing rootstocks and eventually identify a suitable rootstock.

II. Material and Methods

The experiment was carried out at the R&D Farm of the Maharashtra State Grape Growers' Association, Pune during the cropping years 2016 and 2107. The soil of the experimental site was a vertisol medium in clay predominated by montmorillionite with 1.30 per cent OC, 7.64 pH, 0.45 $dSm^{-1}EC_e$, 15 per cent $CaCO_3$ and 650 ppm exchangeable Na. Water used for irrigation had 1.46 dSm^{-1} EC, 4.08 SAR, 4.04 RSC and 5.20 me Cl. Autumn Royal was grafted on four rootstocks, namely Dog Ridge, 110R, Salt Creek and 1103P; and on its own root were planted in randomized block design with five replications with five vines per plot. The vines were planted at the spacing of 3.0M between the rows and 1.8M between the vines. They were trained to expanded Y trellis and grown under double pruning-single cropping system. Plot-wise observation on prunings-weight, cane number /vine and cane diameter at fruit pruning, shoot length at full bloom; number of clusters and yield/vine at harvest were recorded during the fourth and fifth year after grafting. Mean weight of cluster was calculated by dividing the yield by the cluster number /vine under each plot. Fifty berries from the middle of the cluster were collected at random from each plot for recording berry diameter and TSS content and estimating the titratable acids content. Brix-yield/vine (kg/vine) was derived by dividing the product of yield x TSS by 100. Pooled samples of replications consisting of 80 petioles opposite to clusters at full bloom were collected and analyzed for total N, P, K, Ca, Mg, Na and Cl contents as per the standard procedures.

The significance of the difference in vine vigour, yield and quality parameters and petiole nutrient contents due to rootstocks and cropping years was tested by the analysis of variance (ANOVA) in a factorial RBD, taking the years as a factor. Petiole nutrient contents were not subjected to ANOVA, but the treatment means over two - years were categorized into ' Normal', 'Below normal, or 'Above normal' based on standard deviation in respect of each nutrient. Year-wise variation in petiole nutrient contents is presented graphically.

III. Results and Discussion

Rootstocks were found to influence the vine growth parameters, yield attributes and quality components varyingly in Autumn Royal grapes.

Effect on Vine Growth Parameters

Vine vigour as indicated by prunings weight, canes/vine, cane diameter and shoot length did not vary significantly between the years but were influenced by the rootstocks (Table 1). Prunings weight, cane diameter and shoot length were least, while cane number/vine was highest in own rooted vines. Rootstock 110 R was at par with own root in respect of prunings weight, but significantly higher weight was recorded on Salt Creek, 1103 P and Dog Ridge., highest being on Dog Ridge. Prunings weight was also influenced significantly by the interaction of year with rootstock (Table 2A). Variation due to years was significant on Dog Ridge and own root, but not the rest of rootstocks. Less weight was recorded on both the root in 2017. Canes/vine were significantly more on own root compared to the rootstocks except 110 R. Cane diameter was highest on Salt Creek, but at par with 1103 P and Dog ridge. It was significantly less on own root compared to any rootstock. Shoots on Dog Ridge were significantly longer, while shorter on own root compared to any rootstock. The reason for less prunings weight in spite of more canes/vine on own root and 110 R could be less cane diameter and shoot length (Table 1).

Effect on Yield Attributes

Number of clusters/vine was influenced significantly by the rootstocks, but not in the years. Whereas, yield/vine and mean weight of cluster were influenced by both the factors (Table 1). Rootstock 1103 P resulted in significantly more clusters compared to own root, Salt Creek and Dog Ridge, but at par with 110 R. Cluster weight was significantly more in 2017 compared to 2016. It was significantly more on Salt Creek than on 1103 P, 110 R and own root, but at par with Dog Ridge. Year x rootstock interaction also influenced the cluster weight. Variation due to years was significant on Salt Creek only but not on others (Table 2C). Yield was significantly more in 2017 than 2016. It was more on Dog Ridge, but less on own root compared to other rootstocks. Yield on Dog Ridge, Salt Creek and own root varied with year, but not on other rootstocks (Table 2B). Number of clusters/vine and cluster weight are, in general, the contributory factors of Yield/vine in grape (Chadha and Shikhamany, 1999). In spite of higher cluster weight on Salt Creek and own root, yield was less because of less clusters and vice versa on 1103 P. Such variation in yield contribution was observed by Shikhamany *et al*. (2015) in grape varieties. Number of clusters contributed more than the cluster weight towards yield in Autumn Royal as evidenced by the significant correlation of clusters/vine with yield (Table 3). More clusters but less cluster weight on 1103 P and less clusters but more cluster weight on own root and Salt Creek can be attributed to the negative correlation observed between cluster weight and clusters /vine (Table 3). Higher weight of prunings, more number of canes/vine, larger cane diameter and longer shoots on Dog Ridge must have contributed to its higher yield/ vine through higher number of cluster/vine, since these growth parameters correlated positively with the number of clusters/vine (table 3). More number of weak canes/vine could be the reason for poor yield on own root, mediated through less number of clusters/vine. Taking the immature canes removed at fruit pruning, the shoot density was more during the growth season on own root, possibly impairing the fruit bud formation, since light plays a major role in fruit bud differentiation in *vinifera* varieties (Baldwin, 1964; Buttrose, 1970). Yet another reason for poor yield on own root as compared to Dog Ridge was higher absorption of nitrogen, sodium and chlorides by own roots (Table 4 & fig.1). The deleterious effects of higher levels of N (Baldwin, 1966; Christensen et al., 1994) and Na and Cl (Downton, 1977) on fruiting in grapes are well established.

Effect on Quality Components

Berry diameter, the physical quality of grape**,** as well as the total soluble solids (TSS) content and acidity of berry juice did not vary significantly with years but varied with rootstock (Table 1). Berry diameter was significantly more on Dog Ridge, while less on own root when compared to other rootstocks. The difference in berry diameter could be attributed to weight of prunings, cane diameter and shoot length, which bore positive relationship with berry diameter (Table 3). TSS content was significantly more on own root. It was mainly due to more number of canes but less clusters/vine and less cane diameter on own root, since cane number had positive relationship but clusters/vine and cane diameter negative relationship with TSS content (Table 3). Less cluster/ cane ratio and cane diameter indicates more accumulation of metabolites in the clusters, which resulted in more weight of cluster and TSS content on own root. Negative relationship between yield and TSS content is a well established fact. Acids content was significantly less on own root and Dog Ridge when compared to other rootstocks, while it was significantly more on 110 R compared to all other rootstock. Acidity is basically an indicator of ripeness of grapes. TSS contents increase but that of acids decrease during the process of ripening in grapes (Winkler *et al*., 1974). Hence at any stage of ripening they are negatively correlated as evidenced in this study (Table 3). Within a variety, higher ratio of acids to TSS indicates less ripeness. Based on this it can be inferred that, ripening was delayed on 110 R but hastened on own root. Early ripening on own root was because of less crop load. Higher crop load was shown to delay ripening (Winkler *et al*., 1974).

Effect on Brix-yield

In view of the association of increasing contents of TSS with reduced yield, brix-yield was computed to assess the superiority of a treatment based on yield and quality together. Brix-yield/vine varied significantly with year, rootstock and their interaction (Table 1). It was higher in 2017 than 2016. Significantly more brix-yield was observed on Dog Ridge, while less on own root compared to other rootstocks. Although the TSS content was more on own root compared to Dog Ridge, the brix-yield was less because of extremely low yield.

In the overall analysis considering the effects of rootstocks on vine growth, fruit yield, quality and nutrient absorption, particularly Na and Cl, Dog Ridge rootstock was found best for Autumn Royal in saline-alkali soils of tropical India.

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Authors' Profiles

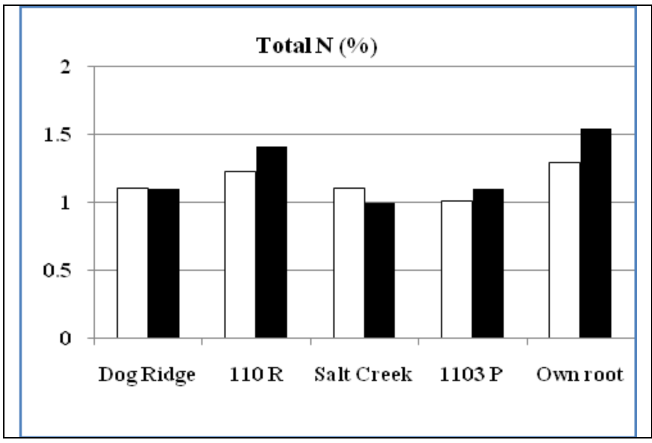
Author 1: **T.S. Shelake**.
Author 1 is MBA from, MPKV Rahuri University. He holds a farm manager position at MRDBS, Manjri farm Pune. He has published 5 scientific research articles and 80 popular articles.

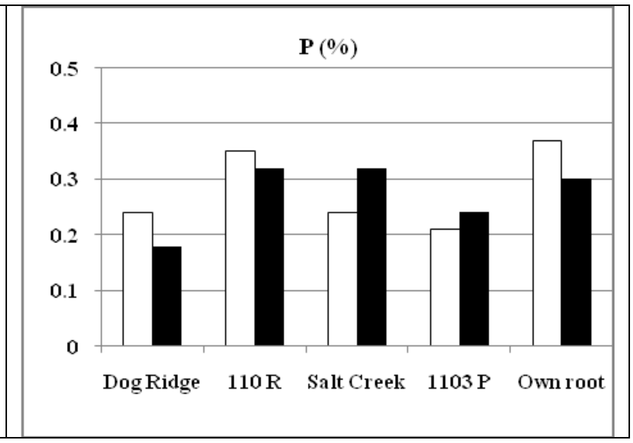
Author 2: **Jeevan N Kalbhor**
Author 2 is post graduate in chemistry from University of Pune, he holds a lab in-charge position at MRDBS lab, Manjri farm Pune since 2012. He has published 15 research papers and 40 popular articles.

Author 3: **Dr S.D.Shikhamany.**
Dr Shikhamany was Vice-Chancellor, Dr. YSR Horticultural University (2008 - 2011).
ii) Director, Indian Institute of Horticultural Research (ICAR), Bangalore (2002-2007).
iii) Director, National Research Centre for Grapes (ICAR), Pune(1997-2002).
He has published 97 research articles and 35 popular articles.

Author 4: **Shital Sachin Tapkir.**
Author 4 is graduate in chemistry from University of Pune, she holds a senior chemist position at MRDBS lab, Manjri farm Pune since 2016. She has published 3 research papers and 15 popular articles.

Author 5. **T.S, Mungare**.
Author 5 is MSc in Agriculture-Soil Science from MPKV Rahuri 19 years of teaching experience as well as conducted research in irrigation and jaggery. He has authored 40 research articles and around 80 popular articles.





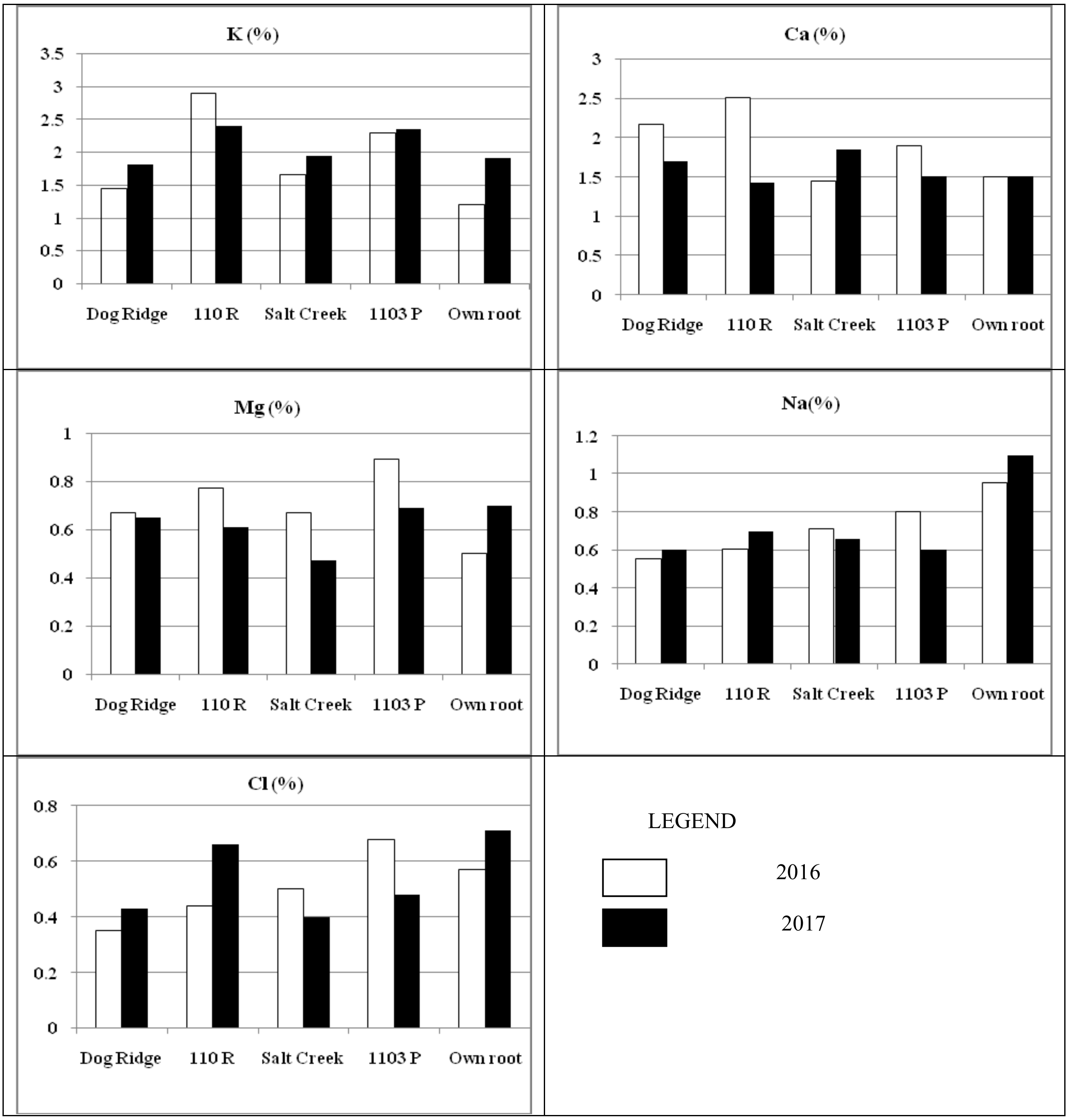


Fig.1. Year-wise petiole nutrient contents of Autumn Royal on different rootstocks

Table 1. Effect on vine growth, yield and quality parameters

Factor	Prunings weight (kg/vine)	Canes/ vine	Cane Diameter (mm)	Shoot Length (cm)	Clusters/ vine	Cluster Weight (g)	Yield/vine (kg)	Berry Diameter (mm)	TSS (^{O}B)	Acidity (g/100ml)	Brix-yield (kg/vine)
Year											
2016	0.933	38.4	7.79	51.1	15.8	391.4^{a}	5.3^{a}	15.4	18.9	0.589	0.989^{a}
2017	0.911	38.0	7.75	50.4	15.6	416.0^{b}	6.5^{b}	15.5	18.6	0.590	1.204^{b}
CD@5%	NS	NS	NS	NS	NS	7.0	0.4	NS	NS	NS	0.066
Rootstock											
Dog Ridge	1.125^{d}	39.1^{b}	7.97^{c}	61.6^{d}	19.4^{b}	452.7^{c}	8.6^{d}	17.9^{d}	19.2^{c}	0.577^{a}	1.649^{d}
110 R	0.847^{ab}	39.8^{c}	7.81^{b}	48.4^{b}	20.1^{bc}	352.6^{a}	7.0^{c}	15.1^{b}	17.8^{a}	0.610^{c}	1.241^{c}
Salt Creek	0.885^{b}	34.0^{a}	8.08^{c}	50.2^{c}	9.2^{a}	465.3^{c}	4.2^{b}	15.5^{b}	18.2^{ab}	0.595^{b}	0.762^{b}
1103 P	0.942^{c}	38.7^{b}	8.01^{c}	48.5^{bc}	22.4^{c}	339.1^{a}	6.5^{c}	16.2^{c}	18.3^{b}	0.592^{b}	1.188^{c}
Own root	0.812^{a}	39.6^{c}	6.98^{a}	45.1^{a}	7.4^{a}	408.9^{b}	3.2^{a}	12.7^{a}	20.1^{d}	0.574^{a}	0.641^{a}

CD@5%	0.043	0.4	0.11	1.7	2.6	17.4	0.6	0.6	0.4	0.014	0.104
Interaction	*	NS	NS	NS	NS	**	**	NS	NS	NS	**

*Sig. @ P=0.05 **Sig. @ P=0.01

Mean values superscribed with the same alphabet do not differ significantly within a column

Table 2. Interaction effect of Year x Rootstock

A. Prunings weight (kg/vine)

Year	Rootstock				
	Dog Ridge	110 R	Salt Creek	1103 P	Own root
2016	1.170^{e}	0.830^{b}	0.872^{b}	0.924^{bc}	0.870^{b}
2017	1.080^{d}	0.864^{b}	0.898^{bc}	0.960^{c}	0.754^{a}

CD @5% = 0.062

B. Yield (kg/vine)

Year	Rootstock				
	Dog Ridge	110 R	Salt Creek	1103 P	Own root
2016	7.2^{e}	7.3^{e}	3.0^{ab}	6.2^{d}	2.8^{a}
2017	10.0^{f}	6.7^{de}	5.4^{c}	6.8^{de}	3.6^{b}

CD @5% = 0.6

C. Cluster weight (g)

Year	Rootstock				
	Dog Ridge	110 R	Salt Creek	1103 P	Own root
2016	440.5^{bc}	350.8^{a}	421.1^{b}	335.0^{a}	409.8^{b}
2017	464.8^{c}	354.4^{a}	509.4^{d}	343.2^{a}	408.0^{b}

CD @5% = 34.9

D. Brix-yield (kg/vine)

Year	Rootstock				
	Dog Ridge	110 R	Salt Creek	1103 P	Own root
2016	1.397^{f}	1.292^{ef}	0.557^{a}	1.134^{d}	0.564^{a}
2017	1.900^{g}	1.189^{de}	0.968^{c}	1.243^{de}	0.718^{b}

CD @5% = 0.147

Mean values superscribed with the same alphabet do not differ significantly within a parameter

Table 3. Correlations among vine growth, yield and quality attributes

	X1	*X2*	*X3*	*X4*	*X5*	*X6*	*X7*	*X8*	*X9*	*X10*	*X11*
X1	1.000										
X2	0.050	1.000									
X3	0.362**	-0.396*	1.000								
X4	0.743**	-0.014	0.423**	1.000							
X5	0.262	-0.531**	0.070	0.434**	1.000						
X6	0.356*	0.376**	0.409**	0.263	-0.444**	1.000					
X7	0.522**	0.298*	0.425**	0.538**	-0.018	0.711**	1.000				
X8	0.653**	-0.056	0.679**	0.684**	0.165	0.541**	0.698**	1.000			
X9	-0.021	0.317*	-0.513**	0.047	0.174	-0.368*	-0.341*	-0.277	1.000		
X10	-0.111	-0.182	0.217	-0.145	-0.246	0.258	0.112	0.073	-0.583**	1.000	
X11	0.555**	0.329*	0.383**	0.585**	0.026	0.681**	0.989**	0.707**	-0.207	0.035	1.000

*Sig. @ P= 0.05 **Sig. @ P=0.01

X1= Prunings weight (kg/vine) X2= Canes/vine X3= Cane diameter (mm) X4= Shoot length (cm)
X5= Cluster weight (g) X6= Clusters/vine X7= Yield (kg/vine) X8= Berry diameter (mm)
X9= TSS (^{o}B) X10= Acidity (g/100 ml) X11= Brix-yield (kg/vine)

Table 4. Effect on petiole nutrient contents

Rootstock	N (%)	P (%)	K (%)	Ca (%)	Mg (%)	Na (%)	Cl (%)
Dog Ridge	1.100^{a}	0.210^{a}	1.625^{a}	1.935^{c}	0.660^{b}	0.575^{a}	0.390^{a}
110R	1.320^{c}	0.335^{c}	2.650^{c}	1.965^{c}	0.690^{b}	0.650^{b}	0.550^{b}
Salt Creek	1.050^{b}	0.280^{b}	1.795^{b}	1.640^{a}	0.570^{a}	0.685^{b}	0.450^{a}
1103 P	1.055^{b}	0.225^{a}	2.325^{b}	1.705^{b}	0.790^{c}	0.700^{b}	0.580^{c}
Own root	1.415^{c}	0.335^{c}	1.550^{a}	1.505^{a}	0.600^{a}	1.025^{c}	0.640^{c}
Mean	1.188	0.277	1.989	1.750	0.662	0.727	0.522
0.5 x SD	0.084	0.030	0.239	0.098	0.043	0.087	0.050

a= <normal b= normal c= >normal