AJES
ASIAN JOURNAL OF ENVIRONMENTAL SCIENCE
VOLUME 12 | ISSUE 1 | JUNE, 2017 | 23-30
e ISSN-0976-8947
DOI: 10.15740/HAS/AJES/12.1/23-30
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RESEARCH ARTICLE

Effect of environment on repetitive strain in grape cultivation

SAVITA KUMARI AND MANJU MEHTA

Article Chronicle :
***Received* :**
22.02.2017;
***Revised* :**
02.05.2017;
***Accepted* :**
16.05.2017

ABSTRACT : The aim of this study was to find out the effect of environment on repetitive strain in grape cultivation. The research designs comprised on field study conducted on 15 respondents were engaged on grapes cultivation activities. Physical fitness was determined by calculating the physiological parameters *i.e.* blood pressure, body temperature, pulse rate and maximum aerobic capacity (VO_2 max). Environmental parameters measured through repetitive strain exertion, ART tool and strain index. The results indicated that mean height and weight of grape workers involved in grape was 159.9 cm and 64.2 kg, respectively. Body mass index (BMI) was observed as 21.8 kg/m^2. Fat percentage was worked out to be 29.9 per cent. Hence, LBM (Lean body mass) was 44.1 kg with variation of ±19.3kg. Aerobic capacity (VO_2 max) was found to be 31.8 ml/kg.×min exhibiting that the subjects were having good health. Conclusively environmental parameters were directly affecting the health status of workers in terms VO_2 max and BMI and (ART) and strain index. On the basis of total repetitive strains score in grape cultivation was maximum in pruning (239.5), followed by harvesting with total repetitive strain load (108.4).

HOW TO CITE THIS ARTICLE : Kumari, Savita and Mehta, Manju (2017). Effect of environment on repetitive strain in grape cultivation. *Asian J. Environ. Sci.,* **12**(1): 23-30, **DOI: 10.15740/HAS/AJES/12.1/23-30.**

Key Words :
Grapes cultivation, Environmental parameters, ART, Strain index, VO_2 max

Author for correspondence :
SAVITA KUMARI
Department of Family Resource Management, C.C.S. Haryana Agricultural University, HISAR (HARYANA) INDIA
Email : jrozydhiman@gmail.com

See end of the article for **Coopted authors'**

Grape (*Vitis vinifera* L.) is an important fruit crop in India. Grapes are the third most widely cultivated fruit after citrus and banana. Major grape-growing states are Maharashtra, Karnataka, Andhra- Pradesh, Tamil Nadu and the north- western region covering Punjab, Haryana, Delhi, western, Uttar Pradesh, Rajasthan and Madhya Pradesh (Singh, 2010). In Haryana grapes are cultivated in an area of 111.00 (000 ha) with a total production of 1235.00 (Tons) and productivity of 11.10 (tons/ha) in 2010-11 (National Horticultural Board, Government of India). Grape cultivation is grown under a variety of soil and climatic conditions (Shikamany, 2001). Agricultural workers involve several strenuous activities like ploughing, spading, carrying, uprooting, planting, weeding, cutting, shafting, threshing, sweeping, etc (Banibrata and Somnath, 2011). The Assessment of Repetitive Tasks (ART) tool was designed to assess the risks tasks that require repetitive moving of the upper limbs (arms and hands). It assessing of the common risk factors in repetitive work that contribute to the development of Upper Limb Disorders (ULDs) (Donald, 2006). Meyers *et al*. (2000) reported that nursery workers were exposed to awkward postures and poor lifting conditions in several of their activities, handling of plants in 1-gallon containers, pruning of plants, weeding, plant labelling and loading/unloading trucks. Repetitive tasks was made up of a sequence of upper limb actions, of short duration, repeated over and over again and are almost always

the same (e.g. stitching a piece of cloth, manufacturing one part, packaging one item). ART for tasks that involve actions of the upper limbs, repeat every few minutes, or even more frequently and occur for at least 1–2 hours per day or shift. The tasks were typically found in assembly, production, processing, packaging, packing and sorting work, as well as work involving the regular use of hand tools. Poupart *et al*. (2013) found that the potential effects of heat exposure on occupational health and safety were both direct and indirect. Exposure to high ambient temperature caused an increase in body temperature, which translated into coetaneous vascular dilation, sweating and increased heart rate. Conclusively the perusal of the introduction in this chapter revealed the following: Adverse environmental conditions badly affect the physiological conditions of workers. Others a repetitive exertion tool was also affect by environmental conditions.

Objective :

To study the effect of environment on repetitive strain in grape cultivation.

EXPERIMENTAL METHODOLOGY

A sample of 15 respondents was selected purposively from the randomly selected 2 grape orchards. Physical fitness of the workers involved in grapes cultivation activity was ascertained by measuring the four physiological parameters *i.e.* blood pressure, body temperature, pulse rate and maximum aerobic capacity (VO_2 max). The height was measured using a stadiometer. A stadiometer is a piece of medical equipment used for measuring height. The subject was asked to stand straight on the balance and the weight was recorded in kg with an accuracy of 0.1kg. (Garrow *et al.*, 1981). Blood pressure is the force of the blood pushing against the walls of the arteries. In the responses to increased demands of the muscles during exercise the systolic pressure rise more than the diastolic, producing an increase in pulse pressure. The range of normal blood pressure for an adult is 120/80 mmHg. Clinical thermometer was used to measure body temperature. Maximum aerobic capacity (VO_2 max) was on the basis of physical fitness is the term which denotes an individual ability to accomplish a given task in a given period of time aerobically with maximum utilization of oxygen possible. It is also known as maximum aerobic capacity and abbreviated as VO_2 max. The maximum aerobic capacity is considered as the best measures for the individual cardio respiratory fitness or capability of doing work Varghese *et al.* (1994).

The formula was based on the relationship between age and body weight as they have great influence on VO_2 max.

(VO_2 max) = VO_2 (1/min) = 0.023 × body weight (kg) – 0.034 × age (year) + 1.652

(VO_2 max) (Ml/kg × min) = VO_2 max (1/min/ Body weight (kg) × 10000

Environmental parameters measured were temperature, relative humidity, light, suspended particulate matter and heat stress. Repetitive strain exertion was measured through ART tool (assessment of repetitive tasks of the upper limbs) Jeremy *et al*. (2010); Strain index analysis (7-point continuum scale) Moore and Garg (1995). Based on the information derived from grapes orchards workers were presented, frequency and standard deviation. The effect of environment and repetitive strain parameters was analyzed correlation test applied to find out the association of various variables.

EXPERIMENTAL FINDINGS AND DISCUSSION

The findings of the present study as well as relevant discussion have been presented under following heads :

Physical characteristics of workers involved in grape cultivation :

Mean height and weight of grape workers involved in grape was 159.9 cm and 64.2 kg, respectively. Body mass index (BMI) was observed as 21.8 kg/m^2. Fat percentage was worked out to be 29.9 per cent. Hence, LBM (Lean body mass) was 44.1 kg with variation of ±19.3kg. Aerobic capacity (VO_2 max) was found to be 31.8 ml/kg.×min exhibiting that the subjects were having good health

Table 1: Personal profile and health status of the selected respondents (n=15)

Physical characteristics		Mean ± SD
Height (cm)		159.9± 8.8
Weight (kg)		64.2±4.7
BMI (kg/m^2)		21.8±1.1
Body composition	Fat percentage (%)	29.9±5.9
	Lean body mass (kg)	44.1±19.3
Vo_2 max(ml/kg.×min)		31.8±6.3

Strain index analysis of activities in grapes cultivation :

The various aspects under strain index analysis were intensity of exertion, duration of exertion (% of cycle), efforts per minute, hand wrist/posture, speed of work, duration of task (per day) and strain index and presented in Table 2.

Land preparation :

The activity score of intensity of exertion (6.0), duration of exertion (1.5), efforts per minute(1.0), hand wrist posture (1.5), speed of work (1.5), duration of task (per day) (1.0) resulted in strain index of 6.8 which indicate that in land preparation there was some risk/ strain.

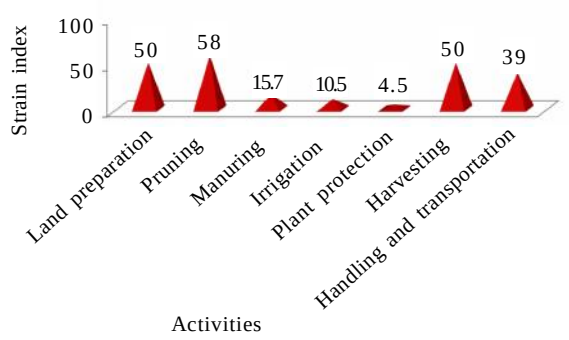

Fig. 1 : Strain index analysis of activities in grapes cultivation

Pruning :

In pruning activity score of intensity of exertion (13.0), duration of exertion (3.0), efforts per minute (2.0), hand wrist posture (2.0), speed of work (1.5), duration of task (per day) (0.8) which gave strain index of 175.5 depicting that pruning was hazardous activity.

Manuring :

For manuring the activity score of intensity of exertion (3.0), duration of exertion (1.0), efforts per minute(1.0), hand wrist posture (1.5), speed of work (1.0), duration of task (per day) (0.8) resulted in strain index of 3.4, depicting that in manuring the level of strain was uncertain.

Irrigation :

The activity score of intensity of exertion (3.0), duration of exertion (1.0), efforts per minute(1.0), hand wrist posture (1.5), speed of work (1.0), duration of task (per day) (0.8) in irrigation resulted in strain index of 3.4 depicting that strain in irrigation was uncertain.

Table 2: Strain index analysis of activities in grapes cultivation **(n=15)**

Grapes orchards activity	Intensity of exertion	Duration of exertion (% of cycle)	Efforts per minute	Hand wrist / posture	Speed of work	Duration of task (Per day)	Strain index	Interpretation	Ranking
Land preparation	6.0	1.5	1.0	1.5	1.5	1.0	6.8	Some risk	III
pruning	13.0	3.0	2.0	2.0	1.5	0.8	175.5	Hazardous	I
Manu ring	3.0	1.0	1.0	1.5	1.0	0.8	3.4	Uncertain	IV
Irrigation	3.0	1.0	1.0	1.5	1.0	0.8	3.4	Uncertain	IV
Plant protection	3.0	1.0	1.0	1.5	1.0	0.8	3.4	uncertain	IV
Harvesting	6.0	2.0	2.0	2.0	1.5	0.8	54.0	Hazardous	II
Handling and transportation	6.0	2.0	1.5	2.0	1.5	1.0	54.0	Hazardous	II

Table 3 : Relationship between the environmental parameters and strain index analysis of grape cultivation activities

Strain index	Temperature	Relative humidity	Light	CO_2	SPM	Heat stress
Land preparation	0.33**	0.34**	0.34**	-0.17*	0.29**	-0.5**
Pruning	0.53**	0.41**	0.23*	-0.41**	0.36**	0.2*
Manuring	0.24*	0.55**	0.36**	0.3**	0.28**	0.32**
Irrigation	0.24*	0.55**	0.36**	0.3**	0.28**	0.32**
Plant protection	0.24*	0.55**	0.36**	0.3**	0.28**	0.32**
Harvesting	0.14*	0.21*	-0.05^{NS}	0.31**	0.55**	-0.12*
Handling transportation	-0.38**	-0.16*	-0.05^{NS}	0.31**	0.03^{NS}	0.24*

* Low degree of correlation ** medium degree of correlation

Plant protection :

In plant protection the activity score of intensity of exertion (3.0), duration of exertion (1.0), efforts per minute(1.0), hand wrist posture (1.5), speed of work (1.0), duration of task (per day) (0.8) gave strain index of 3.4, depicting that strain in plant protection was uncertain.

Harvesting :

For harvesting the activity score of intensity of exertion (6.0), duration of exertion (2.0), efforts per minute(2.0), hand wrist posture (2.0), speed of work (1.5), duration of task (per day) (0.8) gave strain index of 54.0, which highlighted that harvesting was hazardous activity.

Handling and transportation :

The activity score of intensity of exertion (6.0), duration of exertion (2.0), efforts per minute(2.0), hand wrist posture (2.0), speed of work (1.5), duration of task (per day) (0.8) resulted in strain index of 54.0,depicting that strain in handling and transportation was hazardous activity. Wakula *et al*. (2000) conducted a study to find out the stress- strain in field and laboratory workers. Study showed that pruning grapevines and wine harvesting involved a combination of dynamic and sensorimotric work, and also a high incidence of ergonomically undesirable posture of the trunk, the upper limbs and the head irrespective of cutting tools used. Similarly Aweto *et al*. (2015) reported that the low back pain was the most common area of discomfort, followed by the shoulder and then the neck. Similarly Kittusamy *et al*. (2004) reported that 70 per cent of operators of farm equipment suffer in one or more body regions-neck, upper back, lower back, shoulders, forearm/elbow, wrist and hand, hip, knee and ankle/foot.

As per strain index of the activities of grape cultivation, pruning harvesting and handling transportation were hazardous activities but among these pruning score highest score.

Relationship between the environmental parameters and strain index analysis of grape cultivation activities :

Table 3 depicts that the during land preparation activity there was medium degree of correlation with temperature, relative humidity, suspended particulate matter and heat stress and Low degree of correlation with carbon dioxide. In pruning activity was also medium degree of correlation with temperatures, relative humidity, carbon dioxide, and suspended particulate matter and low degree of correlation with light and heat stress. During manuring and irrigation activities both medium degree of correlation with temperatures, relative humidity, carbon dioxide, suspended particulate matter, heat stress. In plant protection activity medium degree of correlation with relative humidity, light, carbon dioxide, SPM, heat stress and low degree of correlation with temperature. Further harvesting activity positive medium degree of correlation with carbon dioxide, suspended particulate matter and low degree of correlation with temp, relative humidity and heat stress and non significant with light. In handling transportation activity medium degree of correlation with temp, carbon dioxide and low degree of correlation with relative humidity and heat stress. There was non significant correlation were found in harvesting and handling transportation activity with light. Conclusively change in environmental parameters directly affecting the strain index analysis in grape cultivation activities. The finding were in line with Janowitz *et al*. (2000) who reported that vineyard workers face high stress on the hands during pruning of the grapevines under highly repetitive conditions (8 to 10 week period of intense and fast-paced work. Similarly Youakim (2006) reported that tasks such as pruning and harvesting cause repeated stressing of hands and wrists, therefore MSDs were very common during the pruning and harvesting seasons.

Assessment of repetitive tasks (ART) of the upper limb in grapes cultivation activities :

The various aspects under assessment of repetitive tasks (ART) of the upper limbs, were A1 arm movement, A2 repetition, B force, C1 head neck posture, C2 back posture, C3 arm posture, C4 wrist posture. C5 hand finger, D1 breaks, D2 work pace, D3 other factor D4 duration and task score. The Table 4 depicts The ART in various activities of grape cultivation.

Land preparation :

Assessment of repetitive tasks of upper limb score for left hand was 25 and right hand was 25, resulting in overall score of 50.The exposure score for both hands generates that further investigation was required in the task of land preparation.

Table 4: ART (tools) assessment of repetitive tasks of the upper limb) in grapes cultivation activities **(n=15)**

	A1 (Arm movement)		A2 (Repetition		B (Force)	C1 (Head/ Neck posture)	C2 (Back posture)	C3 (Arm posture)		C4 (Wrist posture)		C5 (Hand / finger grip)		D1 (Breaks)	D2 (Workspace)	D3 (other factor)		D4 (Duration)	(Task score)	Exposure score	Ranking
	L	R	L	R				L	R	L	R	L	R			L	R		A1+A2+B+C1−C2+C3+C4+C5+D1+D2+D3		
Land preparation	3	3	3	3	R12	1	1	2	2	1	1	0	0	0	1	1	1	×1	Left hand= 3+3+r12+1+1+2+1+0+1+1=25 Right hand= 3+3+R12+1+1−2+1+0+0+1+1= 25×1=25 Total= 50	Further investigation required (Both hands)	II
Pruning	3	3	3	3	R_{12}	2	2	2	2	1	2	0	0	0	2	1	2	×1	Left hand= 3+3+R12+2+2−2+1+0+0+2+1= 28×1=28 Right hand= 3+3+R12+2+2−2+2+0+0+2+2= 30×1=30 Total =58	Further investigation required urgently	I
Manuring	0	3	0	3	A4	0	0	0	0	0	1	0	1	2	0	0	1	×0.75	Left hand= 0+0+A4+0+0+0+0+0+2+0)= 6×0.75=4.5 Right hand= 3+3+A4+0+0+0+1+1+2+0+1= 15×0.75=11.25 Total = 15.7	Consider individual circumstance (Both hands)	IV
Irrigation	0	0	0	3	A2	0	1	0	0	0	0	0	1	2	0	0	0	×0.75	Left hand= 0+0+A2+0+1+0+0+0+2+0+0= 5×0.75=3.75 Right hand= 0+3+A2+0+1+0+0+1+2+0+0= 9×0.75=6.75 Total = 10.5	Consider individual circumstance (Both hands)	V
Plant protection	0	0	0	0	A1	0	0	0	0	0	0	0	0	2	0	0	0	×0.75	Left hand= 0+0+A1+0+0+0+0+0+2+0+0= 3×0.75=2.25 Right hand= 0+0+A1+0+0+0+0+0+2+0+0= 3×0.75=2.25 Total = 4.5	Consider individual circumstance (Both hands)	VI
Harvesting	3	3	6	6	A4	2	2	2	2	1	1	1	2	0	2	1	2	×1	Left hand= 3+6+A4+2+2+1+1+0+2+1= 24×1=24 Right hand= 3+6+A4+2+2+2+1+2+0+2+2= 26×1=26 Total = 50	Further investigation required urgently	II
Transportation	0	0	6	6	A4	1	1	2	2	1	1	0	1	2	1	1	1	×1	Left hand= 0+6+A4+1+1+2+1+0+2+1+1= 19×1=19 Right hand= 0+6+A4+1+1+2+1+1+2+1+1= 20×1=20 Total = 39	Further investigation required urgently	III

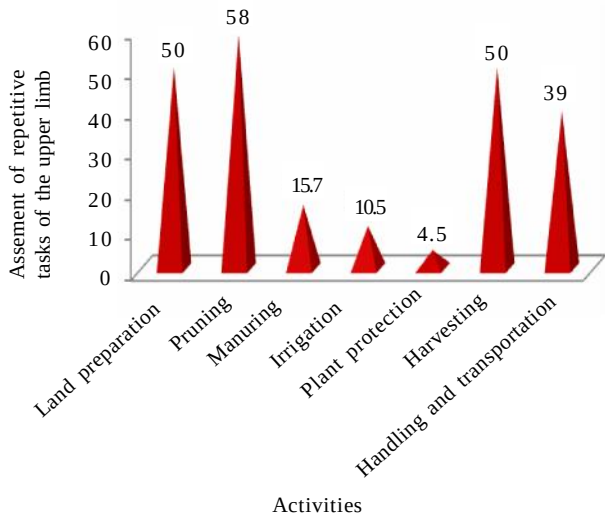

Fig. 2 : ART (tools) assessment of repetitive tasks of the upper limb) in grapes cultivation

Pruning :

For pruning the assessment of repetitive tasks score for left hand was 28 and right hand was 30, overall score was 58. The exposure score for both hands indicates that further investigation was required urgently in the pruning task.

Manuring :

During manuring assessment of repetitive tasks of upper limb ART score for left hand was 4.5 and that of right hand was 11.25, resulting in overall score of 15.7. The exposure score for both hands depicted that consideration of individual circumstance (Both hands) was required in manuring.

Irrigation :

The ART score for left hand was 3.75 and right hand was 6.75 in irrigation and overall score was 10.5. This exposure score highlighted for consideration of individual circumstance (both hands) in irrigation.

Plant protection :

In plant protection activity the ART score for left hand was 2.25, right hand was 2.25, resulting in overall score of 4.5. The exposure score generated depicted that consideration of individual circumstance (both hands) was required in the plant protection.

Harvesting :

The ART tool score in harvesting for left hand was 24 and right hand was 26 and overall score was 50, the exposure score generated indicated that further investigation was required urgently for harvesting activity.

Handling and transportation :

The ART score for left hand was 19 and right hand 20 and overall score was 39, which depicted that further investigation was required urgently in handling and transportation activity. Fathallah *et al.* (2006) conducted a study to evaluate the effectiveness of an intervention on the incidence of musculoskeletal symptoms among workers during two grape harvest seasons. There was five-fold reduction in workers post seasons musculoskeletal symptoms scores, without significant reductions in productivity.

As per the assessment of repetitive tasks (ART), in grape cultivation pruning was risky activity and further investigation was required immediately.

Relationship between the environmental parameters and ART (tools) assessment of repetitive tasks of the upper limb) in grapes cultivation activities :

Table 5 depicts that in land preparation, pruning

Table 5: Relationship between the environmental parameters and ART (tools) assessment of repetitive tasks of the upper limb) in grapes cultivation activities

ART (TOOL)	TEMP	RH	LIGHT	CO_2	SPM	Heat stress
Land preparation	0.24*	-0.16*	0.3^{NS}	-0.4^{NS}	-0.19*	-0.3^{NS}
Pruning	0.47**	-0.02^{NS}	0.15*	0.6^{NS}	-0.15*	0.00^{NS}
Manuring	0.00^{NS}	0.5^{NS}	0.44**	0.06^{NS}	-0.19*	0.27*
Irrigation	0.11*	0.3^{NS}	-0.05^{NS}	-0.03^{NS}	-0.07^{NS}	0.46**
Plant protection	-0.35**	0.3^{NS}	0.18*	0.003^{NS}	-0.15*	0.17*
Harvesting	0.24*	-0.16*	0.3^{NS}	-0.49**	-0.19*	0.31**
Handling and transportation	0.005^{NS}	0.01^{NS}	-0.23*	-0.25*	0.15*	-0.16*

*Low degree of correlation **Medium degree of correlation

activity there was significant correlation with temperatures, relative humidity and suspended particulate matter. In manuring, irrigation, plant protection activity was also correlation with light, SPM and heat stress. In harvesting, handling transportation activity significant correlation with temperatures, relative humidity, carbon dioxide, SPM and Heat stress. There was non-significant correlation were found in land preparation activity with light, carbon dioxide, heat stress and pruning activity with relative humidity, light and heat stress. In manuring activity was found non- significant relation with temperature, relative humidity and carbon dioxide. During harvesting activity was found non- significant with light and handling transportation with temperature, relative humidity. Conclusively Environmental parameters were affecting the ART (tools) in grapes cultivation activities. Grapes orchards workers were exposed to ergonomics problems in their routine works. The ergonomics problems were unavoidable, such as awkward posture, repetitive movements. Weight handling, force in pulling and pushing activities. Montomoli *et al.* (2010) reported that the ergonomic analysis using OCRA check-lists and NIOSH method to study the spine and upper limb work-related musculoskeletal disorders in grape orchards. Each tasks analyzed showed a high risk of biomechanical overload of the upper extremities. Regarding the manual material handling in the grape-harvest and of risk changed from yellow to green.

Conclusion :

– Mean height and weight of grape workers involved in grape cultivation was 159.9 cm and 64.2 kg, respectively. Body mass index (BMI) was observed as 21.8 kg/m^2. Fat percentage was worked out to be 29.9 per cent. Hence, LBM (Lean body mass) was 44.1 kg with variation of ±19.3 kg.

– Conclusively environmental parameters were directly affecting the health status of workers in terms VO_2 max and BMI. The environmental parameters were directly affecting the assessment of repetitive tasks (ART) of the different activities in grape cultivation.

– The grapes cultivation farming includes different activities like land preparation, pruning, manuring, irrigation, plant protection and harvesting, handling transportation were workers engaged in that activities as per environmental parameters *viz.*, temperature, light, relative humidity, carbon dioxide, suspended particulate matter, heat stress directly affecting the workers they were engaged in grapes farming as per strain index analysis their intensity exertion, duration of exertion, hand wrist posture, speed of work etc.

Coopted Authors' :

MANJU MEHTA, Department of Family Resource Management, C.C.S. Haryana Agricultural University, HISAR (HARYANA) INDIA

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