ERGONOMIC CHARACTERISTICS OF NIGERIAN ASSEMBLED TRACTORS

BY

BABA ALFA

PGD /AGRIC/05/97-98

DEPARTMENT OF AGRICULTURAL ENGINEERING
FEDERAL UNIVERSITY OF TECHNOLOGY MINNA

DECEMBER , 1999.

ERGONOMIC CHARACTERISTICS OF NIGERIAN ASSEMBLED TRACTORS

BY

BABA ALFA
PGD / AGRIC / 05 /97-98

A RESEACH WORK SUBMITTED TO THE DEPARTMENT OF AGRICULTURAL ENGINEERING, SCHOOL OF ENGINEERING AND ENGINEERING TECHNOLOGY, FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA, NIGER STATE OF NIGERIA IN PARTIAL FULFILMENT OF THE AWARD OF POST GRADUATE DIPLOMA IN AGRICULTURAL ENGINEERING (FARM POWER & MACHINERY OPTION).

DECEMBER, 1999.

APPROVAL

This project work **"ERGONOMIC CHARACTERISTICS OF THE NIGERIAN ASSEMBLED TRACTORS"** by Baba Alfa meet the regulations governing the award of Post Graduate Diploma in Agricultural Engineering of the Federal University of Technology, Minna.

Dr. M.G Yisa ----------

NAME OF SUPERVISOR SIGNATURE

Dr. M.G Yisa ----------

NAME OF HEAD OF DEPT: SIGNATURE

DECLARATION

This project is my original work conducted under the supervision of Dr. M.G Yisa. To the best of my knowledge and belief the work has never been submitted whether in Federal University of Technology, Minna or any other University for the award of P.G.D.

All materials and articles used have been acknowledge accordingly in the reference.

Sign
Baba Alfa

DEDICATION

I wish to dedicate this project work to my entire family.

ACKNOWLEDGEMENT

My profound gratitude to the Almighty God and His great servant and messenger "MUHAMMED" (S.A.W) for the guide in my life and through out this course.

Special thanks go to my project supervisor Dr M.G. Yisa the Head of Department, Department of Agricultural Engineering Federal University of Technology, Minna, for his untiring assistance and support.

My sincere thanks to my sponsors Niger State Government and Ministry of Agriculture and Natural Resources, Minna. I am indeed grateful to Mall. Zubairu Z. Alhassan, Engineer Usman Jibrin, Alhaji Abdullahi Danyaya and many others in the Ministry.

I also recognise the support and encouragement of all lecturers and collegues in the University, especially Mallam Ibrahim Kuta of library department.

Finally, I must mention my other friends and my family for their encouragement.

TABLE OF CONTENTS

LIST OF TABLES

TABLES

PAGES

LIST OF FIGURES

FIGURES

ABSTRACT

The Nigerian assembled tractors are foreign manufactured. It is with this in mind that this project is aimed to appraise the tractor suitability for the Nigerian user. Some specific features of these tractors were considered for appraisal. These are access to get on the tractor, seat design, tractor steering design, tractor workspace and control. Experiments were conducted on the tractors and a sample of user population drowns from Niger State Ministry of Agriculture Tunga, Minna. Measurements of dimensions and locations of different components from seat reference point (SRP) were taken. In care of controls, emphases were on some hand and foot operated controls. While the anthropometric test on related body parts of the sample user population were conducted in line and angle measurement.

The following problems were observed; in steyr 8075, over tasking in getting on the tractor due to lack of foot step, strains caused due to steering wheel size and wheel thickness. In fiat 8066, the over tasking is cause by lack of hand support (hold) while getting on the tractor. In both tractors, pains are experience through body movements due to act of activating controls . Also both steyr 8075 and fiat 80-66 lack adequate protection against rainfall and pollution effects.

Redesign of the following were suggested for the comfort of the user. Foot step for steyr, hand support (hold) for fiat, steering wheel size and thickness for Steyr and well-ventilated workspace cabin for both fiat and Setyr.

CHAPTER ONE

INTRODUCTION

1.0 BACKGROUND

The topic "ergonomics characteristics of Nigerian assemble tractors" was conceived from the point of view of increasing usage of tractors on our farms. With advancement in the technology, Nigeria farmers are changing fast from traditional culture of farming to mechanized agriculture. Human effort to make life more tolerable dated back to centuries when attempts were made to produce simple tools and shelter to make life more comfortable. This gradual development marked the beginning of ergonomics.

Ergonomics from advanced learners dictionary is defined as a study of environment condition and efficiency of workers. It originated from two Greek words; "ERGO" meaning Work and "NOMO" meaning Law.

1.1 OBJECTIVES

To collaborate the definitions above with the tittle of this project, one can say the project's objective is to study the relationship between MAN-MACHINE (TRACTOR); and Nigeria assembled tractors to be specific. That is, to establish levels of discomfort, explore weather changes in the design of these tractors would reduce such problems associated with these discomforts, like stress and pains.

To achieve these objectives, questions like, what relationship has man with his tractor and the environment he uses it in? That is to say, has he any responsibility to the two? (Tractor and environment), and have the two any responsibility to him? Are the tractors well designed to suit the Nigerian users (operators) or he has to adopt himself to these tractors? In trying to answer these questions and many more alike; appraisals are to be done. The best appraisals for this work is the one that will evaluate the tractors in terms of suitability to the users.

1.2 JUSTIFICATION

All developed nations (the advanced countries) set standard for all equipment and general goods either locally produced or imported for the benefit of the users. Viewing this one would agree that, the justification of this project is from the fact that the level of development of agricultural mechanization in Nigeria today is so high that Nigeria should no longer be a dumping ground for all sort of tractors that do not confirm with Nigerian standards. A Nigerian standard could not be obtained without studies like this. This project is very much justified because it will lead to setting up standards for tractors coming in to Nigeria or manufactured here.

CHAPTER TWO

2.0 LITERATURE REVIEW

Various attempts had been made in recent past to appraise the ergonomic characteristics of agricultural machinery and works. Such works examined human, machinery and environmental factors. Most of these works were published in journals and bulletins, while a few number of books were written. It is the result of these works that shall form the bedrock of this project.

Clifford (1998) in a pilot study on "Ergonomics in Apple sorting" identified problems in the design of the grading table which influence on how the sorters perform the sorting task. In his work he was able to identified that ergonomic design will improve the sorting performance, if the environment and working position is designed to minimise discomfort and strain. He therefore concluded that with wide table design, sorters were performing frequent stretching movements, which were outside their sustainable working zone.

Wesley et al (1992) conclude that human factors are the most significant consideration in developing farm machinery. According to them, the fact is these machinery will often be operated by persons with minimum skill and/or minimum understanding of the system. For that they went further that farm machinery be made simple to operate and as free of hazard as possible. In their final submission, they said that mobile machines like tractors should have the following characteristics.

- Easy to hook.
- Easy to operate (start, steer, stop etc).
- Easy to mount and dismount.
- They should have special features such as comfortable seats and closed heated or cooled and well illuminated cabs.

Smith et al (1994) outlined such human characteristics by saying "Human beings act as power source and controller. The equipment they operate must be compatible with size, shape, strength and senses (e.g. vision, hearing etc) of the user population". In support of their observations they conducted a measurement of some German adults, male and female. In designing and evaluating hand tools and controls, measurement of hand size are necessary. They further concluded that the distance that hands and feet could go in a stretch to reach the control may be important in the operation of equipment.

Yandav et al (1998) in reviewing the tractor operator work- space design agreed that a successful tractor development makes technical progress profitable for farmers and tractor manufactures. They therefore came to conclusion that tractor seat and locations of various hand and foot operated controls should be designed to accommodate 90% driver population. Such design should permit ease of movement for the operator getting on and off the tractor and allow easy and uninterrupted access to all the controls.

Ernest et. al (1985) indicated that anthropometric data can have a wide range of application in the design of physical equipment and facilities and said although static anthropometric data have certain uses, it is becoming increasingly evident that functional anthropometric data have greater potential use. They therefore, concluded, that whatever type of data would be most relevant for a particular design problem; in most circumstances it is important to use data that are based on samples of subjects that are similar to the population who will ultimately use the item in question.

Rajvir et al (1998) confirmed that tractor operator's safety and comfort have received considerable attention world wide particularly with respect to vibration, noise and operator seating space. Other human factors considered by them include effect on riding, comfort, visibility, location and arrangement of controls, ease of operating control thermal, comfort, sound etc.

CHAPTER THREE

METHODOLOGY

To appraise the ergonomic characteristic of Nigerian assembled tractors, experiments were conducted on the two tractors and the twenty randomly selected user subjects. The experiments were in stages of areas mapped out for discussions. The areas under appraisal are:-

1. Accessibility: Getting on and off the tractors.
2. Seat design
3. Steering wheel and steering.
4 Work-space and controls
5. Rainfall, temperature and other environmental factors

Two tractors, one each representing the brands assembled in Nigeria were used. These are Fiat 80-66 and Steyr 8075. The choice is based on the fact that these are the most popular models.

3.1 ACCESSEBILITY

Getting on and off the tractor is the first contact of the operator with the tractor. In assessing the suitability of the mode provided for getting on the tractor, two tractors were obtained from Ministry of Agriculture and Natural Resources Tunga, Minna. Also subjects consisting of operators and mechanics were put on the experiments.

The first experiment was to determine the following dimensions of the two tractors:-

1. Tractor height
2. Steering wheel level height.
3. Footrest (floor) height.
4. Footstep height.

In conducting these tests the tractors' tyres were ganged. The tractor positioned on a level ground, and the measurements conducted.

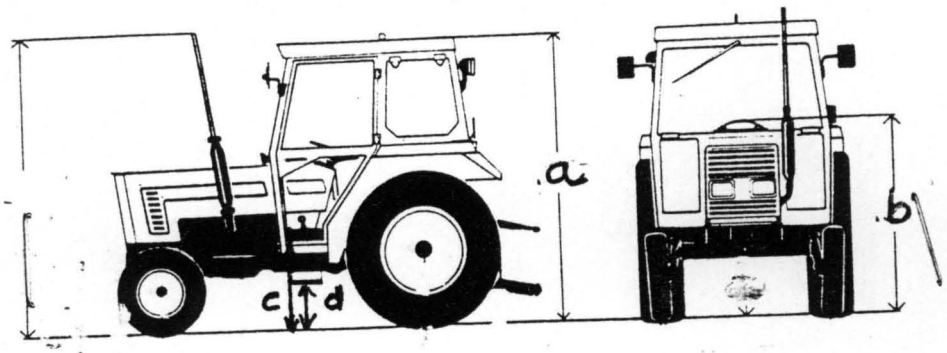


Fig 1: FIAT 80-66 dimensions: In height (a) tractor height (b) steering height (c) footrest and (d) footstep.

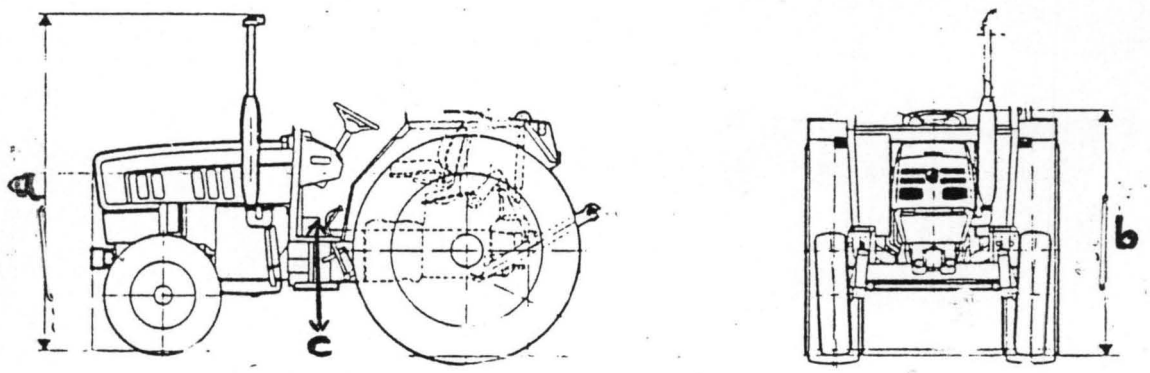


Fig. 2 Steyr 8075 Dimensions in height (a) Tractor height, (b) steering height and (c) Footrest.

The second experiment was a survey of the anthropometric data of the selected operators and their weight. The measurement conducted included:

1. Standing height
2. Full hand length
3. Popliteal height
4. Knee angle at various footstep height level.
5. Body weight.

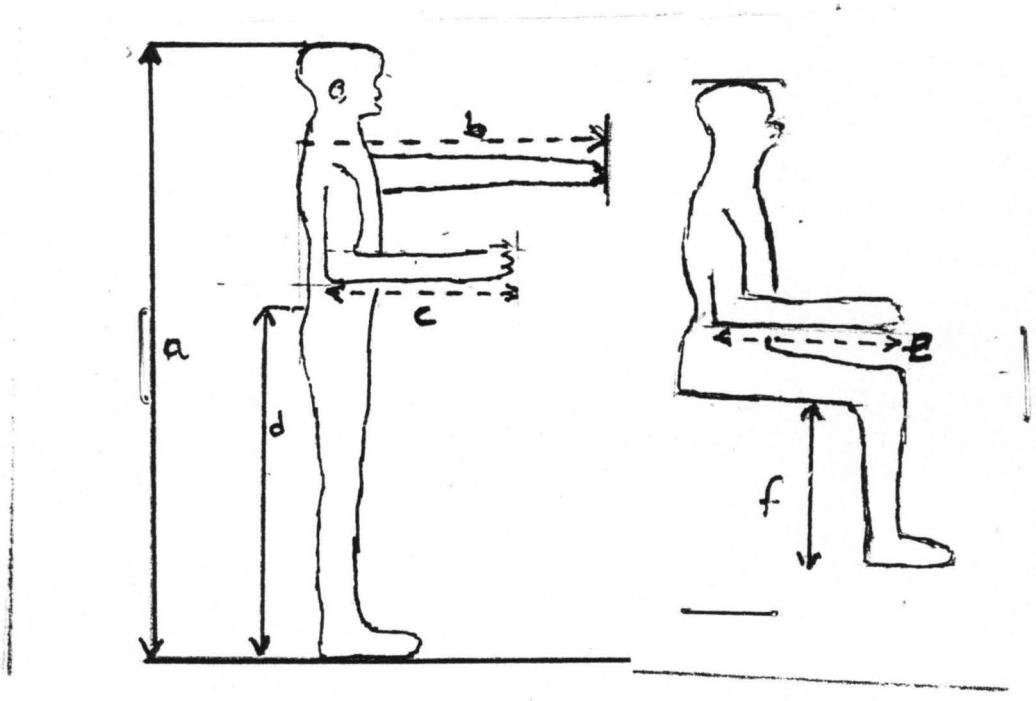


Fig 3 Indication of measured body parts standing and sitting. (a) height (b) full hand length (c) elbow-fingers (d) full leg length (e) thigh length (f) politeal height.

In determining the knee angle six pieces of 22.5 cm (9 inches) blocks were arranged in a step form of 22.5 cm, 45 cm and 67.5 cm risers from ground level. A 70 cm distance was marked out from each level of distance from each riser as a standing point for the operator.

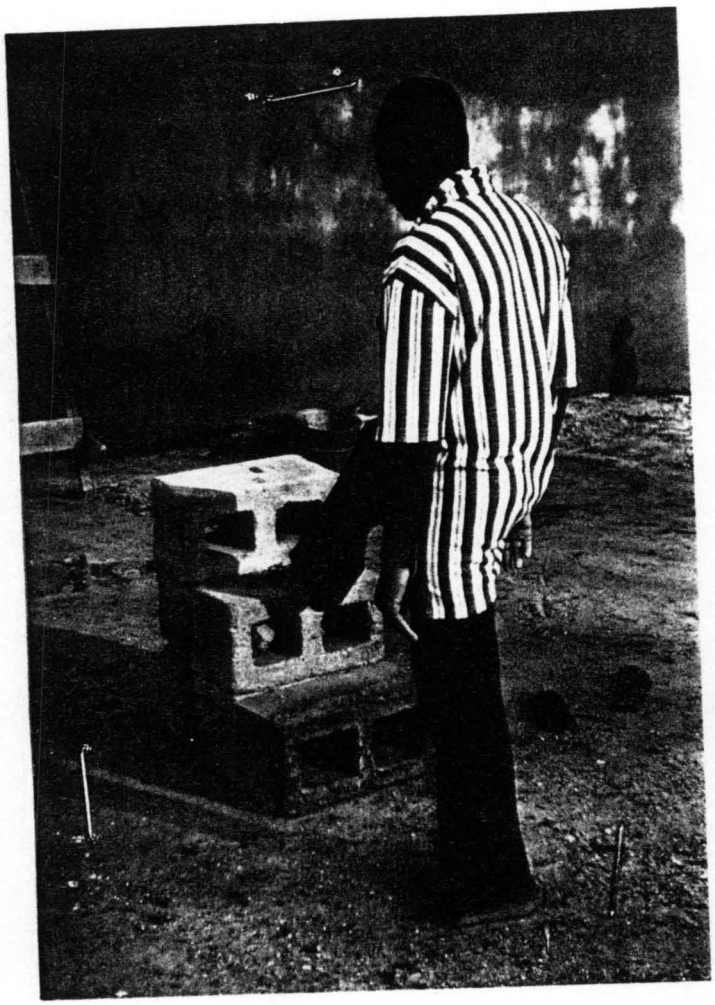


Fig 4 Subject stepping on block step rise.

The third experiment was conducted with operator attempting to getting on the tractor. The tractor was positioned and a 70 cm mark was marked away from the tractor. Each operator stood at that mark and attempted getting on the tractor. The following were closely observed.

1. Mode of getting on
2. Agony in their faces
3. Muscular reactions
4. Individual opinion on problems and comfort while undertaking the task.

3.2 SEAT DESIGN

Having got on the tractor, the sitting is the next thing to do. To determine the suitability of the seat design, a survey of the geometrical design was conducted on the following:-

1. Seat pan width
2. Seat pan depth
3. Seat back support height.

With the results of these measurement, the second test was conducted.

The second experiment was a survey of some body organs, the same twenty subjects were used and test conducted on the following:

1. Sitting height
2. Thigh length (back buttocks - knee)
3. Buttocks width.

The above were conducted in sitting position, while the popliteal height obtained in the previous experiment was used for the appraisal. The experiments were conducted with each person sitting vertically erect. The corresponding dimensions in sitting position are shown in figure below:

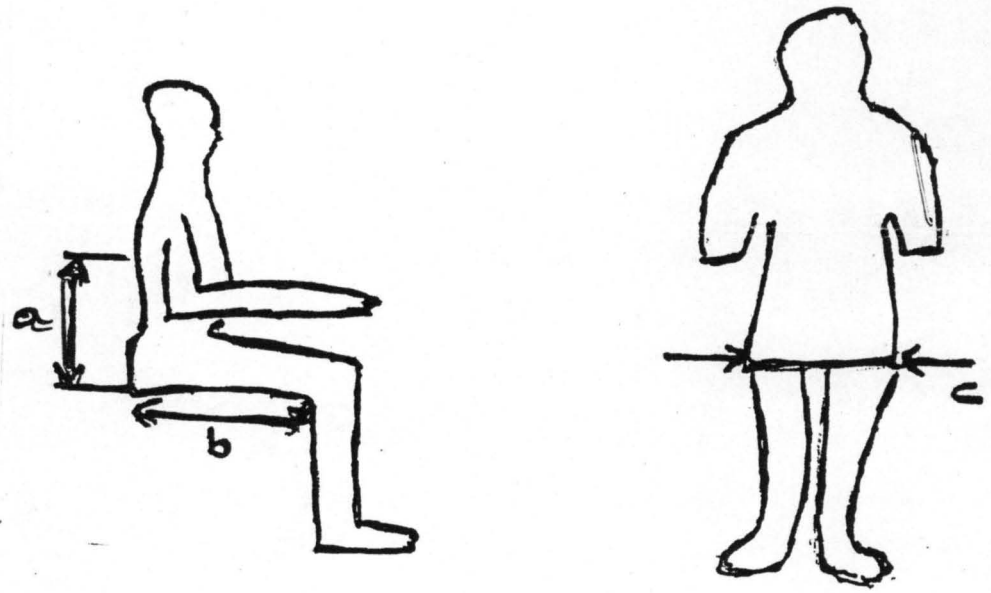


Fig: 5 Dimension in sitting position siting height (a), thigh length (b), buttock (c) width

The results were arranged in a form of a simple array of data and analysed for percentile value. The boundary value of 5^{th} and 95^{th} percentile were used in examining the fitness of the design.

The 5^{th} and 95^{th} percentile value were obtained by the following calculation

5^{th} *percentile value*

5/100 x number of subjects (20) = 1 . item no: 1 in the array is the value of 5^{th} percentile (Horper, 1971).

95^{th} percentile value

95/100 x *number of subject* (20) = 19. *Item no*: 19 in the array is the value of 95^{th} percentile (Horper, 1971).

3.3 STEERING WHEEL AND STEERING:

Since it is with the steering wheel that the operator is in constant contact during operation, an experiment on its design suitability to operator was conducted.

The following tests were conducted:

1. Distance from seat reference point (SRP)
2. The steering wheel circumference.
3. The steering wheel thickness
4. The steering wheel angle to the horizontal plane.

The second experiment was operational test. The tractors were started and each person steered each for about 60 seconds. A close observation and the opinion of each person as regard the following were noted.

1. Steering speed
2. Elbow angle
3. Optimal handgrip.

In conducting the last test an adjustable spring clip was used. Each person held it at adjustment that finger touches the pan of the thumb. The optimal grip value were calculated for percentile values.

3.4 WORKSPACE AND CONTROLS

Experiments were conducted to determine the location of hand and foot operated controls of each of the two tractors. The following controls location were measured.

1. Gear level
2. Parking brake lever
3. Hydraulic control levers
4. Clutch pedal
5. Accelerator pedal
6. Brake pedal
7. Work-space width
8. Work-space length.

The second experiment was to obtain anthropometric data of the following body organs of the subjects being used.

1. Full hand length
2. Full leg length

3. Popliteal height

The third experiment was conducted with the subjects sitting on the tractor one after the other. Each attempted to activate each of the controls; both hand and foot operated. The following were observed and operators opinion taken into account:

1. Hand movement
2. Body movement during operation of hand controls.
3. Leg movement
4. Body movement during leg movement.

3.5 RAINFALL TEMPERATURE AND ENVIROMENT:

To determine the intensity of rainfall and temperature on the working operators. Rainfall and temperature statistic for selected towns in Niger State were collected from Niger State Agricultural and Development Project for the year 1992-1998

The effect of exposure to other environmental factors while working in the field were noted and subjects opinion sought.

CHAPTER FOUR

RESULT AND DISCUSSION

The result of the experiments conducted on the two tractors under appraisal are tabulated below in the same order in which the experiments were conducted. Also the results of the anthropometric measurements and related subjects of the twenty staff used are presented in the same manner. However, measurements were not repeated in cases where such measurements are required for more than one test. For the ease of statistics the anthropometric data obtained in raw form are re-arranged in form of simple array. While the raw results are provided in the appendix.

4.1 ACCESSIBILITY

Below are the results of the experiments conducted on both fiat 80-66 Steyr 8075. The parameters are those that have direct or indirect link with the act of getting on and off the tractor.

Table I: *TRACTOR DIMENSIONS (MM)*

S/No	PARAMETER	FIAT 80-66	STEYR 8075	REMARK
1.	Tractor Height (mm)	2525	2360	
2.	Steering Wheel Height (mm)	1750	1664	
3.	Footrest (floor) Height (mm)	880	680	
4.	Footstep Height (mm)	580		

Human parameters and tractor accessibility

The anthropometric data obtained from the experiment on the body members that are associated with the act of getting on and off the tractor are presented below in form of simple array.

Table 2 standing height (mm)

151	156	157	157	158	162	165	168	168	169
169	170	171	172	174	175	184	185	186	188

5^{th} percentile value is 151 cm
95^{th} percentile value is 186 cm

Table 3: FULL HAND LENGTH (CM)

70	70	75	76	76	77	77	77	78	79
80	81	81	81	82	83	85	85	85	91

5^{th} percentile value is 70cm
95^{th} percentile value is 85 cm

Table 4: POPLITEAL HEIGHT (CM)

44	46	46	47	48	49	50	50	50	51
52	52	52	53	54	54	56	57	57	58

5^{th} percentile value is 44 cm
95^{th} percentile value is 57 cm

4.1.1 KNEE ANGLE AT VARIOUS FOOT STEP HEIGHT LEVEL

The results show that the taller people are of reasonable advantage at various stages. At 22.5cm height, those around the margin of 5^{th} percentile have knee angle of 120% while those around 95^{th} percentile have angle opened to 150. At 45cm height, 5^{th} percentile have knee angle close to 70% while 95^{th} percentile have knee angle of 95%. At 67.5 cm the 5^{th} percentile have knee angle to 50% and the 95^{th} percentile have knee angle of 60%. As there is no any available recommended value of step rise in respect of automobiles reference could be made to building stairs which is recommended not to exceed 14.5cm so as to accommodate all ages(Ernest et al (1983). The general opinion of all the subjects tested was that lower steps are more comfortable and less hazardous.

4.1.2 OPERATORS ATTEMPTING TO GET ON TO TRACTOR

FIAT 80-66. The operators stepped on the foot step holding the steering wheel and rear tyre mudguard before lifting up the second leg. There was no vivid extreme suffering in their faces as they lifted the leg. The veins on the hand pulling the steering were conspecious especially of those that have thin flesh on the body. The climbing ability was fast, generally.

STEYR 8075: Those tested lifted their legs to the footrest holding the steering wheel and the hand support. While the veins on the standing legs appeared before lifting it up, most of the people pulled face as they raise up.

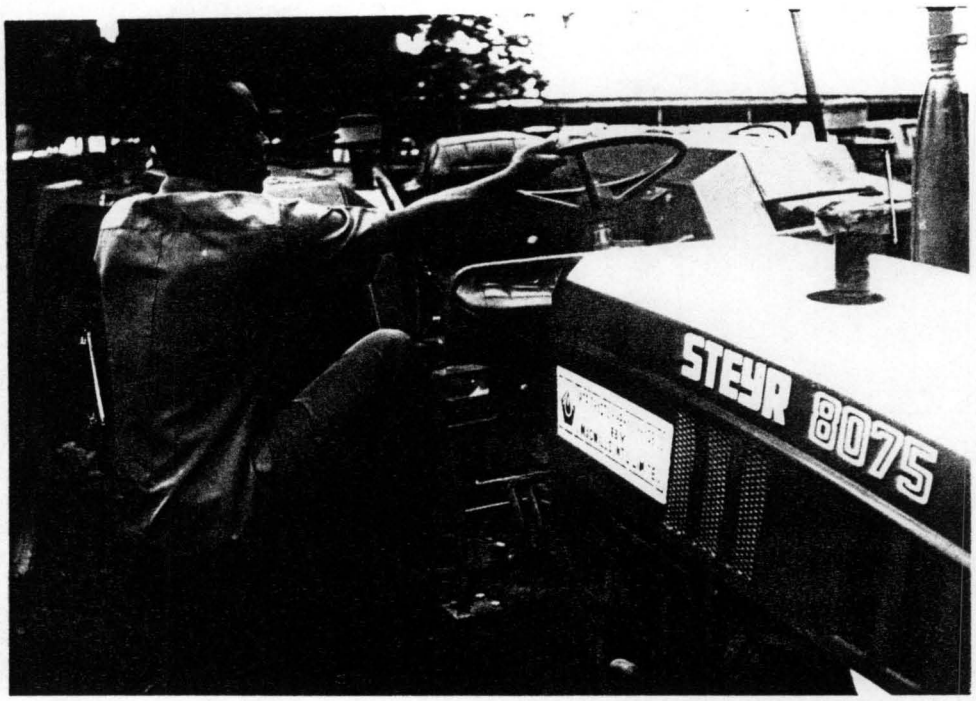


Fig. 6 Operator getting on a tractor.

TABLE 5: BODY WEIGHT (kg)

51	51	52	52	52	53	53	53	54	54
55	56	56	57	58	59	60	60	66	67

5^{th} percentile value is 51kg
95^{th} percentile value is 66kg.

Smith et al (1994) stated that the most effective means of evaluating the demands of human strength associated with task or tool is through the careful collection of subjective data, by methodically observing users performing tasks and collecting their opinion.

In view of the above, it has been observed from the result and opinions collected that the task of climbing through a media (steps) is more comfortable. The comfortable levels in this case is at height that the stepping leg knee angle range between 110^0 - 160^0
Generally, when the operator lifted his second leg from the ground level the body weight is thrown to the steering wheel and hand support he is pulling.

Looking through the two tractors one will note that for FIAT 80-66 with a foot step at 580mm from ground level, those with 95^{th} percentile value of anthropometric data have no problem while 5^{th} percentile value are quite satisfactory but the hand on the steering were over stretched, more especially in shorter hands.

STEYR 8075: With no provision for the foot step the footrest height of 684mm put those of 5^{th} percentile anthropometric data at a serious disadvantage. Even those with 95^{th} percentile value are not much comfortable. Hence re-design is necessary, the design that should accommodate 5^{th} percentile stature people conveniently.

4.2 SEAT DESIGN

The following are the data obtained from seat geometrical design experiment.

Table 6 SEAT GEOMETRY (CM)

S/NO	PARAMETER	FIAT 80-66	STEYR 8075	RAMARK
1.	Seat pan width	54	41	
2.	Seat pan depth	40	38	
3.	Seat pan support height	33	35	

For the second experiment, the anthropometric data of body organs tested are as follows presented in form of simple array for percentile determination.

Table 7 SEATPAN WIDTH (BUCT-TOCKS) (CM)

26	29	29	30	30	30	30	30	31	31
31	32	32	32	32	32	32	33	34	34

5^{th} percentile value is 26cm
95^{th} percentile value is 34cm

Table 8 SEAT PAN DEPTH (THIGH) (CM)

45	46	50	50	50	50	50	52	52	52
53	55	58	58	58	60	61	61	61	62

5^{TH} percentile value is 26cm
95^{th} percentile value is 34cm

Table 9 SEAT BACK SUPPORT (SITTING) HEIGHT:

27	27	30	30	30	31	31	31	31	32
32	32	32	32	32	32	33	33	33	33

5^{th} percentile value is 27cm
95^{th} percentile value is 33cm

Appraising the information above with the design geometry of the seat the following facts for each of the two tractors are obtained.

FIAT 80-66

SEAT WIDTH: Tractor design, 54cm. The buttock width of 5^{th} percentile subject tested has the value of 26cm while the 95^{th} percentile value is 34cm. With the information above, the tractor design accommodates well above 95^{th} percentile people.

SEAT DEPTH: Tractor design, 40cm. The thigh length of 5^{th} percentile people is 45cm while that of 95^{th} percentile people is 61cm. It can be noted that the 5^{th} percentile people have overlap of 5cm. With this, the design is satisfactory to them. For the 5cm overlap will minimise the pressure on the thigh 95^{th} percentile people have longer overlap.

SEAT HEIGHT (SITTING HEIGHT): The seat back support design is 35cm. The 5^{th} percentile people have the value of 27cm and the 95 percentile have 33cm. With this it can be noted that enough support is given to the operator spinal member.

4.3 **STEERING WHEEL AND STEERING**:

The following were obtained from experiments conducted on the steering wheels of the two tractors.

Table 10 STEERING LOCATION AND GEOMETRY (MM)

S/NO	PARAMETER	FIAT 80-66	STEYR	REMARK
1.	Steering wheel from SRP	820mm	830	
2.	Steering wheel circumference	1240mm	1330mm	
3.	Steering wheel thickness	93mm	70mm	
4.	Steering angle to horizontal	35^0	35^0	
5.	Seat reach adjustment	88mm	70mm	

Table 11 OPERATION TEST RESULTS:

S/NO	PARAMETER	FIAT 80-66	STEYR 8075	REMARK	
1.	Steering speed	Fast in Steering	Fast in steering	Both are powered	
2.	Elbow angle range	70^0 - 85^0	75^0 -120^0		
3.	Hand grip on wheel	More Handy	Less Handy		

The result of the anthropometric measurement of organs involved in steering; presented in a simple array.

Table 12 ELBOW - HAND MEASUREMENT (CM)

40	47	42	42	43	47	48	49	49	49
50	50	51	51	52	54	56	56	56	57

Table 13 HAND PAN WIDTH MEASUREMENT (CM)

8.0	8.0	9.0	9.0	9.0	9.5	10.0	10.0	10.0	10.0
10.0	10.0	10.0	10.7	11.0	11.0	11.0	12.0	12.0	13.0

Table14 OPTIMAL HAND GRIP MEASUREMENT (CM):

8.0	8.0	8.5	8.5	9.0	9.0	9.0	9.0	9.0	9.5
9.5	10.0	10.0	10.0	10.0	11.0	11.0	11.0	11.5	12.0

Going by the results above and the submission of Yadav et al (1998) that the position of the steering wheel with respect to the operation has determining influence on the possible steering forces, steering speed, steering energy requirement and operator comfort; and therefore recommended that the steering that should not be too far from operator is that that make about 90^0 elbow angle. The steering wheel design should be in the range of 30^0 - 45^0 to the horizontal. The appraisal can be made as follows:-

FIAT 80-66

Basing the appraisal on the submission above, Fiat 80-66 steering wheel at full back adjustment put distance from seat reference point (SRP) at 820mm. Those with 95^{th} percentile full hand reach value (850mm) have a comfortable hand enveloping. While those under 5^{th} percentile value (70mm) and seat adjusted full forward (88mm) still need to move some degree forward to catch the steering comfortably. Hence the variation in the elbow degree of 70^0 -85^0. The wheel size affect the angle too.

The thickness of the steering wheel (93mm) is satisfactory for people within boundary of 50^{th} percentile value (9.5mm), that is why those experimented on testified that the steering wheel is more handy.

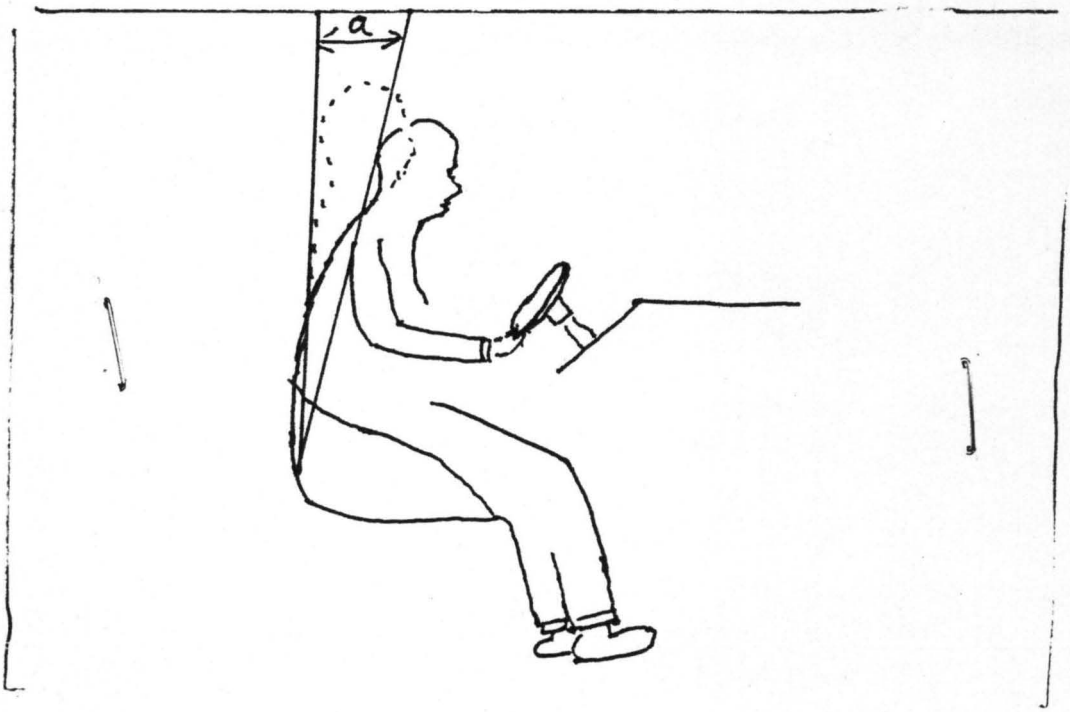


Fig. 7 Movement in body during driving. (a) degree moved.

The 35^0 of the wheel to the horizontal fall within the range of 30^0 -45^0 recommended. The operators opinion confirmed that the tilt gives them protection in case of emergency.

STEYR 8075:

The steering wheel of Steyr is 830mm from seat reference point (SRP) at full backward adjustment of the seat, 95th percentile hand reach value subjects have satisfactory hand enveloping. For those with 5th percentile value hand reach, even the forward seat adjustment of 70cm does not give good enveloping. Some degree of movement forward is necessary. This with the size (circumference) of the wheel attributed to the variation in elbow angle range of 75^0 -120^0.

The thickness of the wheel (700mm) make the wheel look small and very tiny for hand volume. This characteristic subjected some strains on fingers and hand pan.

The 35^0 tilt of the wheel is equally comfortable according to tested subjects opinion.

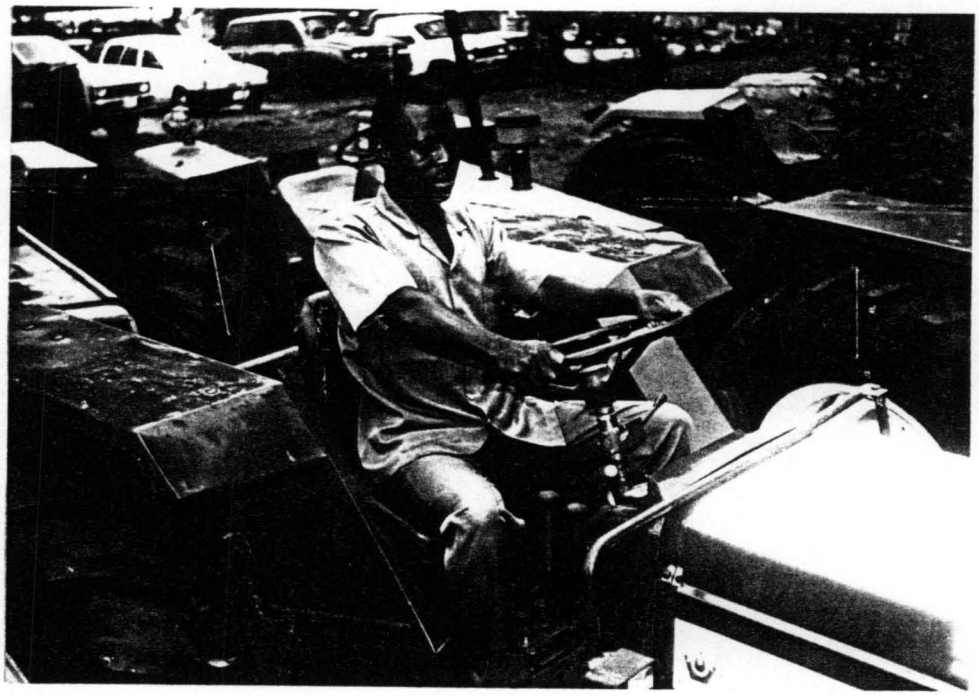


Fig. 8 An Operator on a Steyr 8075 Steering wheel.

4.4 WORKSPACE AND CONTROLS:

Below are the result of the experiment conducted

Table 15 CONTROLS LOCATION AND WORKSPACE (MM)

S/NO	PARAMETER	FIAT 80-66	STEYR8075	REMARK	
1.	Gear lever (mm)	556	530		
2.	Parking brake (mm)	653	640		
3.	Hydraulic control (mm)	200	340	Laterally	
4.	Clutch pedal (mm)	756	661		
5.	Accelerator pedal (mm)	700	740		
6.	Brake pedal (mm)	832	780		
7.	Front panel(mm)	840	900		
8.	Workspace width (mm)	840	840		
9.	Workspace length(mm)	980	990		

Table 16 FULL HAND MEASUREMENT (CM):

70	74	75	76	76	77	77	77	78	79
80	81	81	81	82	83	85	85	85	91

5^{th} percentile value is 70cm
95^{th} percentile value is 85cm

Table 17 FULL LEG MEASUREMENT (CM)

73	75	76	76	76	79	87	89	95	95
95	96	97	98	98	99	101	101	101	105

5^{th} percentile value is 73cm
95^{th} percentile value is 101cm

TABLE 18 POPLITEAL HEIGHT MEASUREMENT (CM):

44	46	46	47	48	49	50	50	50	51
52	52	52	53	54	54	56	57	57	58

For the third experimental results the operation on the two tractors after seat adjustment revealed that:-

HAND MOVEMENT: Every of the subjects stretched and moved hands towards the control he intend to activate with elbow angle less than 180^0 for forward floor controls. This indicated that the controls are within optimal reach range. The reach to the controls on the front panel opens the elbow angle wider.

BODY MOVEMENT DURING HAND CONTROL:

It was closely observed that the body (upper body) shifted forward when activating gear and parking brake levers. The movement was vivid with short subject than the taller ones. The degree of the movement range between 15^0 -25^0. Figure 9 illustrate the body actions while engaging the two levers. The hip angle range between 70^0-85^0.

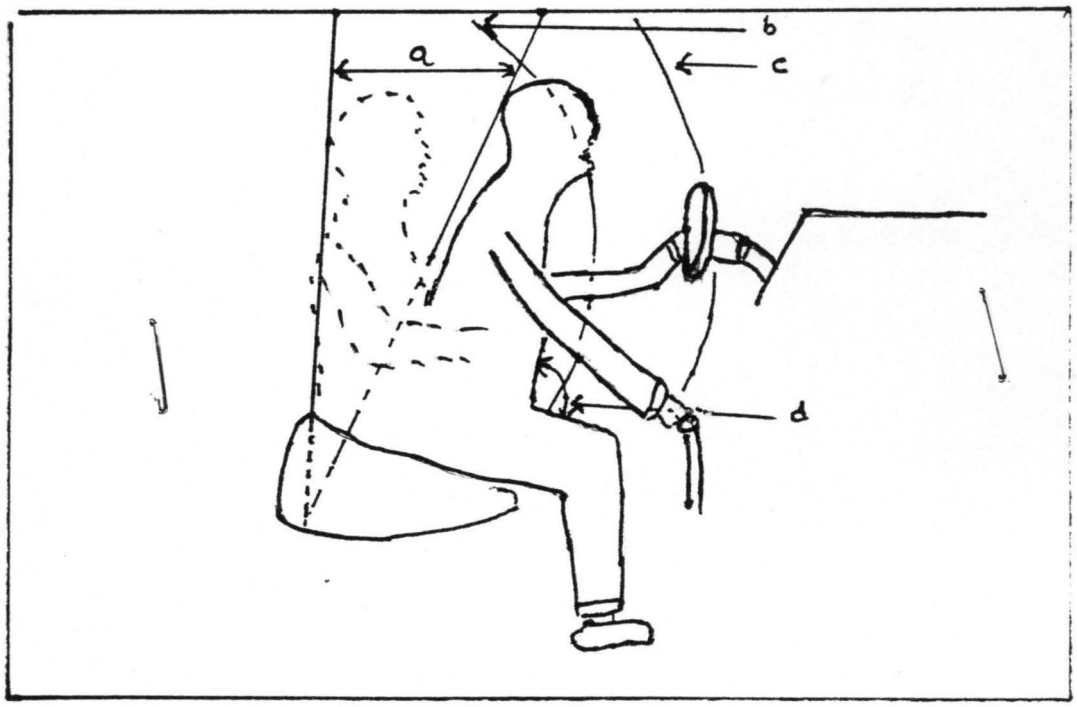


Fig. 9 Shifts and angles created while engaging gears and hand brake.
(a) body shift (b) hand reach arc at operator sitting erect (c) stretched hand reach arc to gear lever (d) hip angle.

LEG MOVEMENT IN FOOT CONTROLS: As the subject moved his foot toward a pedal, movements were noticed around the ankle and kneel region which was further transmitted to the region as testified to by the subject tested. The size of the leg determines the length of travel by foot to the pedal. While it was noted that the ankle angle was determined by the height of the pedal.

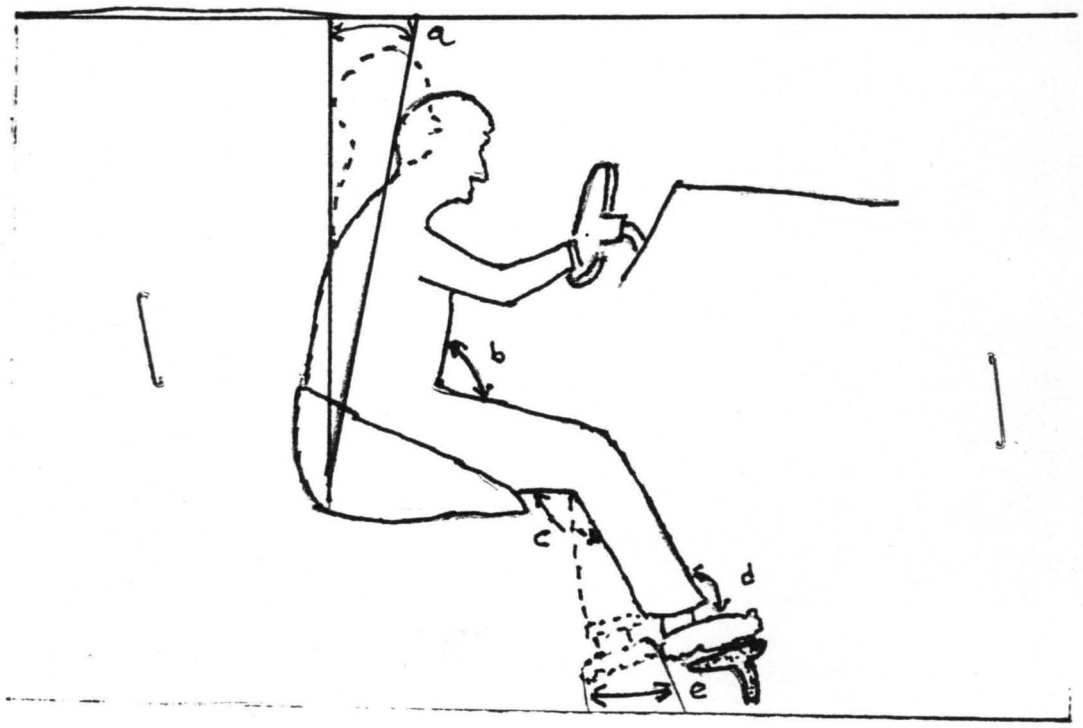


Fig. 10 Shifts and angles created while activating foot controls (a) body shift (b) hip angle (c) kneel angle (d) ankle (e) foot shift (all in degrees).

BODY MOVEMENT DURING FOOT CONTROL OPERATION:
Slight body movement were noticed from erect position (180^0) to vertical as foot moved forward to approach the pedal.

HAND CONTROL:- Both the gear and parking brake levers are located high close to seat level. This still makes the operator to bend in addition to moving forward. The gear lever at 556mm from SRP and the parking brake lever at 653mm make the activating of the two at a comfortable reach for those with 5^{th} percentile hand reach value of 70 cm and the tilting (bending) and height of the levers added to the convenience. The hydraulics control laterally located at right hand side of the operator is satisfactory to the entire population distribution at 200mm from seat reference point (SRP).

FOOT CONTROL:- The three most used foot control pedals are clutch (main) brake and throttle (accelerator). Their locations from SRP of 756mm, 832mm and 700mm respectively are comfortable for those of high percentile valve (95^{th} percentile has 1010mm value) full leg. However, the brake distance is far for those of 5^{th} percentile value at that 832mm location. Therefore the seat reach adjustment of 88mm could not even satisfactorily settle the difference but results in over tasking.

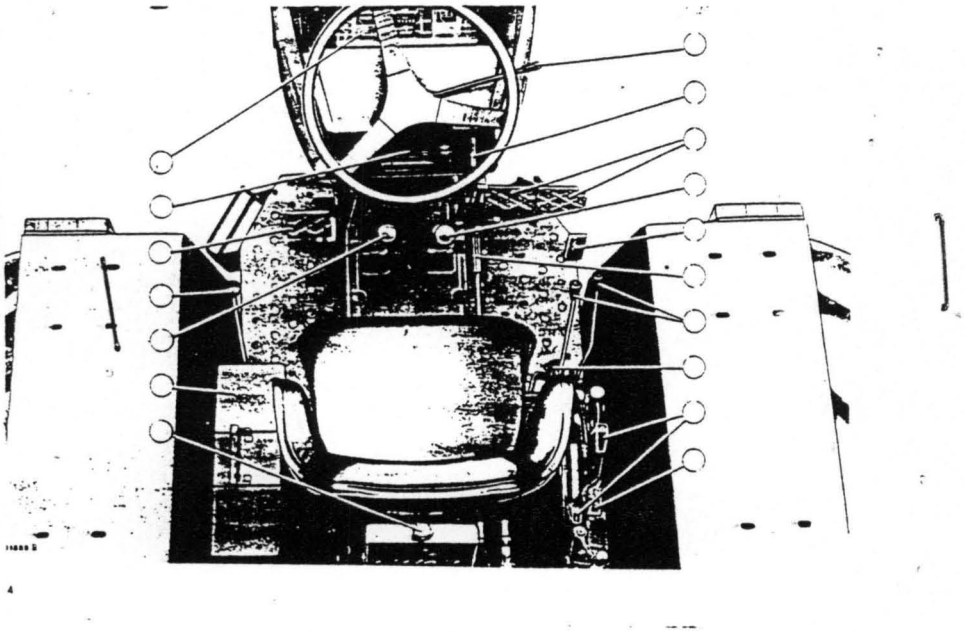


Fig. 11 Fiat 80-66 Workspace and Controls

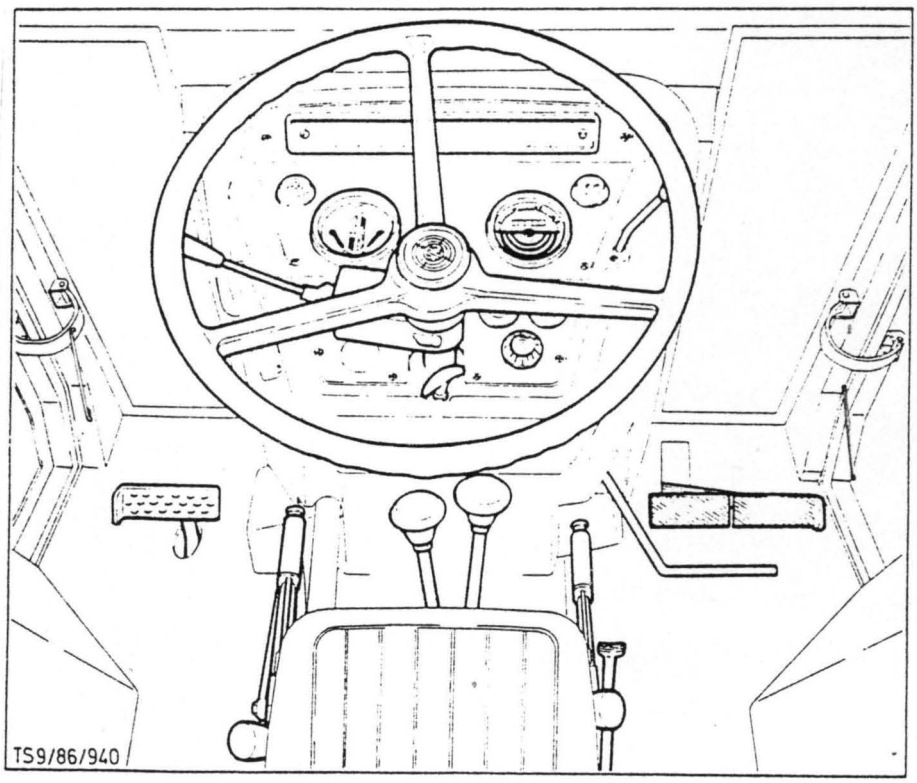


Fig. 12 Steyr 8075 Workspace and Controls.

HAND CONTROL: Like Fiat the hand controls that are in constant use are the gear lever, parking brake lever and those at the front panel. With gear lever at 530 mm the parking brake at 640 mm and the entire workspace forward length of 990mm, the gear and parking brake are within the reach of 5th percentile full hand reach subject (700mm) . However, even with seat reach adjustment the front panel could not be reached by those with lower percentile value conveniently.

FOOT CONTROLS:- Clutch, brake and accelerator are the most used controls, Clutch from SRP is 661mm and brake 780mm while accelerator is 740mm. The 5^{th} percentile leg length subject (70cm value) are in better convenience with clutch pedal, while those of 95^{th} percentile are satisfied with all the controls. The seat reach adjustment of 70mm makes it possible for the 5^{th} percentile value subjects to reach all the controls satisfactorily.

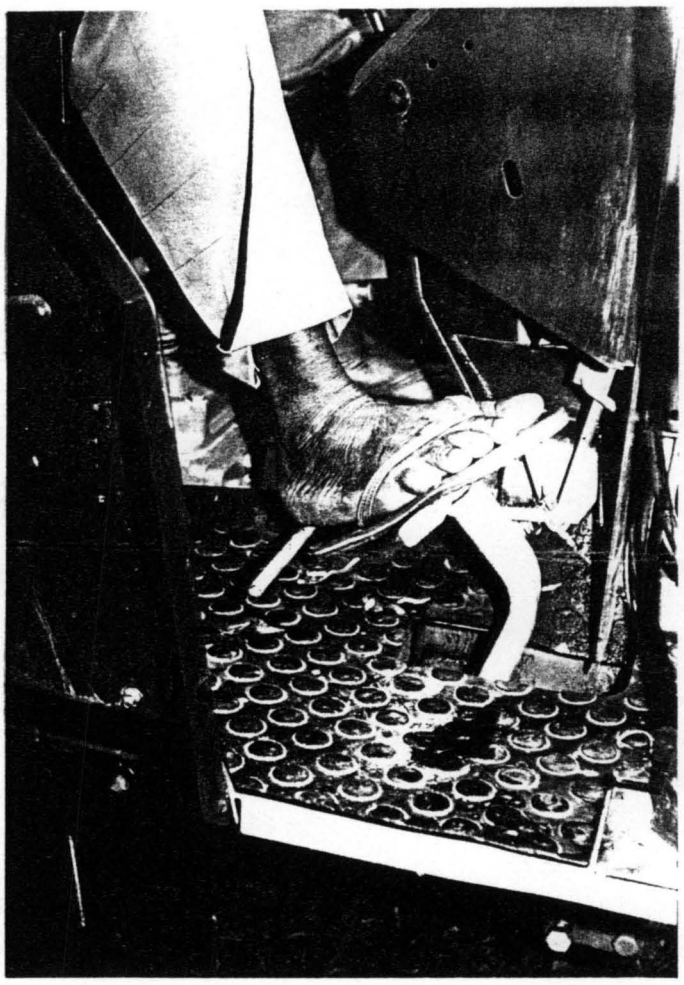


Fig. 13 An operator activating a foot control pedal.

4.5 **RAINFALLS, TEMPERATURE AND ENVIROMENT**:

The rainfall records obtained from Niger State Agricultural Development Project (NSADP), Minna show that rain falls intensively in Niger State between the months of May and October. The detail statistics are provided in the appendix, for 1992-1998

While the temperature, according to records available shows that the temperature range between 39^0C maximum and 18^0C minimum.

Exposure to other environmental problems were noted as the tractor was working in the field. Operators complained of dust and smoke.

FIAT 80-66:- Provision is available for an open canopy over the workspace. This gives protection to the operator against rainfall. However, when the rain is highly intensive, the roof does not help much. In the same vain, the thermal heat is regulated to tolerable temperature when the sun is over the head.

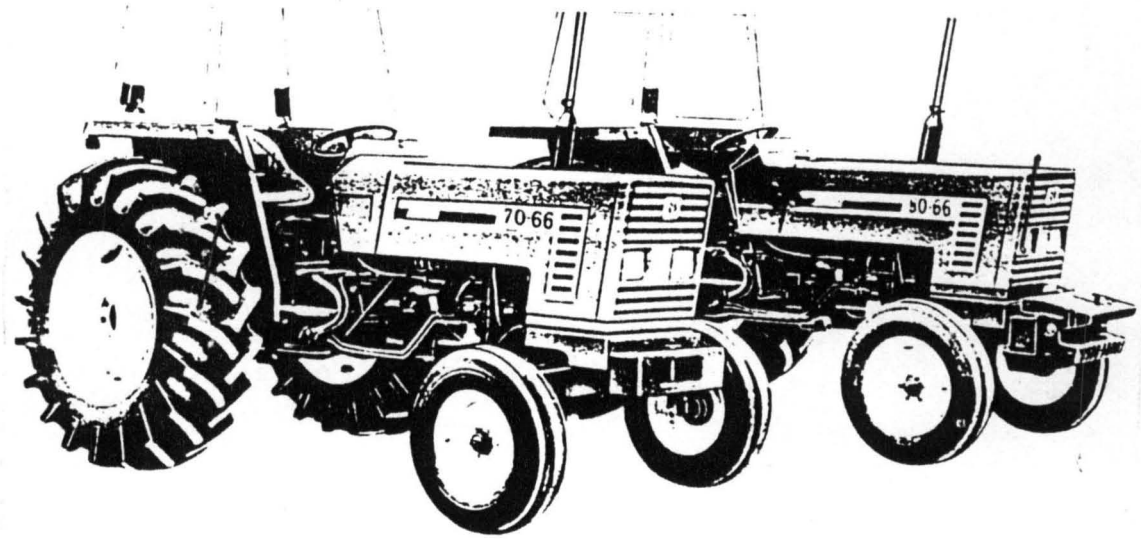


Fig .14 Models of Fiat tractor

STEYR 8075:- The Nigerian Steyr has no canopy. This exposes the operator to rainfall, direct sun shine and other environmental problems, including pollution. The dust and smoke from tractor causes ill-health on the operators just like the rain and heat.

Fig. 15 Another model of steyr tractor

CHAPTER FIVE

CONCLUSION AND RECOMMENTION

With experiments conducted and results obtained the project was able to arrive at the following conclusions and recommendations.

5.1 CONCLUSION

5.1.1 ACCESSIBILITY

FIAT 80-66: With the provision of a foot step, the task of getting on to the tractor reduces stress on the legs. However, lack of any defined hand support reduced the ease and comfort.

STEYR 8075: This tractor demand more effort and in fact greater stress on the subject using it, because of lack of footstep. There is high fatigue experienced by users.

5.1.2 SEAT DESIGN

FIAT 80-66: The results of the experiment indicated that the design of the seat is satisfactory. However, lack of adjustable back support does not give the user good spinal protection.

STEYR 8075: The design provision fit all those tested. However, like Fiat the back support with angle adjustment was noted to have capability to reduce back pain.

5.1.3 STEERING WHEEL AND STEERING

FIAT 80-66: The steering wheel is very portable and handy. These characteristic with power system of steering mechanism make the steering comfortable, minimise strains at elbow, shoulder and fingers. Those around 5^{th} percentile value require a little seat forward adjustment for better enveloping. The steering angle gives the necessary support in emergency.

STEYR 8075: The steering wheel is too large and the wheel ring is too thin. These have negative effect on body members that have connection with act of steering. The 35^0 steering angle provide good support to operators in case of any sudden forward usage.

5.1.4 WORKSPACE AND CONTROL

Fiat 80-66: From the athropometric data of the subjects tested the design of the controls both hand and foot are located at convenient distance from seat reference point (SRP). The seat reach is much more comfortable. Thereby minimising the frequent long movements and bendings.

STEYR 8075: The convenience of the controls locations are equally satisfactory for all the subjects tested. However, the control at the front panel stretched the operator more than any other control.

5.1.5 **RAINFALL, TEMPERATURE AND ENVIRONMENT**FIAT 80-66: Nigeria is a tropical country, where rain falls heavily and sunshine intensively. The provision of a mere canopy is not adequate for needed protection. It exposes the operator to dust raised by working implements and the tractor smoke wind blows toward the operator.
STEYR 8075: This tractor entirely left the operator exposed to all environmental problems. The result of this is low productivity and poor work.

5.2 RECOMMMEDATION

Having identified the problems the design of these tractors induce on the users, in terms of discomfort and pains on various body members, the following recommendations are hereby made:

5.2.1 ACCESSIBILITY

Fiat 80-66: A well defined hand support to be provided.
Steyr 8075: A footstep is necessary and a foldable one could be better.

5.2.2 SEAT DESIGN

FIAT 80-66: Adjustable back support could be provided.
STEYR 8075: Adjustable back support is recommended.

5.2.3 STEERING WHEEL AND STEERING

FIAT 80-66: The steering wheel design is satisfactory.
STEYR8075: The steering wheel circumference is too large. The size could be reduced; and the wheel ring thickness could be increased.

5.2.4 WORKSPACE AND CONTROL

FIAT 80-66: The relationship between the operator and workspace and control are satisfactory.
SEYR 8075: The front panel could be redesign to bring it closer to seat reference point.

5.2.5 RAINFALL, TEMPERATURE AND OTHER ENVIRONMENTAL FACTORS

FIAT 80-66: The canopy to be replaced by a complete ventilated cabin.
STEYR 8075: A cabin well ventilated could also be provided.

REFERENCES

Clifford Studman (1998). Ergonomics in Apple Sorting: A pilot study centre for Postharvest and Refrigeration Reseach, Massey University Palmerston North New Zealand (Received 17 Febuary 1994 accepted in revised from 16 January 1998) pp 324

Ernest J.Mc. Cormick Mark S. Sanders (1983). Human Factors in Eng Engineering And Design fifth Edition. pp 318

Fiatagri (1983). Fiat 70-66, 80-66 Operator's Manual, Fiat Trattori pp 14, 57 & 68.

Harper W.M. (1971). Statistics. The M & E Handbook Series Second Edition. pp 93.

NSADP (1998) Progress Report To The PCC Meeting

Rajvir Yadav V.K. Tewari (1998). Tractor Operation Workspace Design a review Journal of Terramechanics. pp 41.

Sharma A. P.(1983). Anthropometric Survey of Indian Form Workers Agricultural Maehanization in Asia, Africa and Latin America (AMA) Vol XIV No.1 Winter 1983 pp 27-30.

Smith D. W., Simc B. G. and D.H. O Neil (1994). Testing and Evaluation of Agricultural services Bulletin 110. WHO Rome pp 67.

Steyr (1988). Steyr 8065 8075 Instructions Operating Instructions 5th Edition Steyr Austria pp 27 & 182.

Wesley E woodson, Berry Tillman Peggy & Tillman (1992). Human Factors Design Handbook pp 126 - 127.

APPENDIX

Appendix 1. Raw Anthropometric date

Appendix 2. Rainfall data 1992-1998 in Niger State

Appendix 3. Temperature data 1993-1998 in Niger State.

Appendix 4. Graph 1---- Cumulative percentile distribution of standing height

Appendix 5. Graph 2------Cumulative percentile distribution of full-hand length and popliteal height

Appendix 6. Graph 3----- Cumulative percentile distribution of full leg length, seat pan depth and seat pan width.

APPENDIX 1

RAW ANTHROPOMETRIC DATA OF TWENTY TESTED SUBJECTS

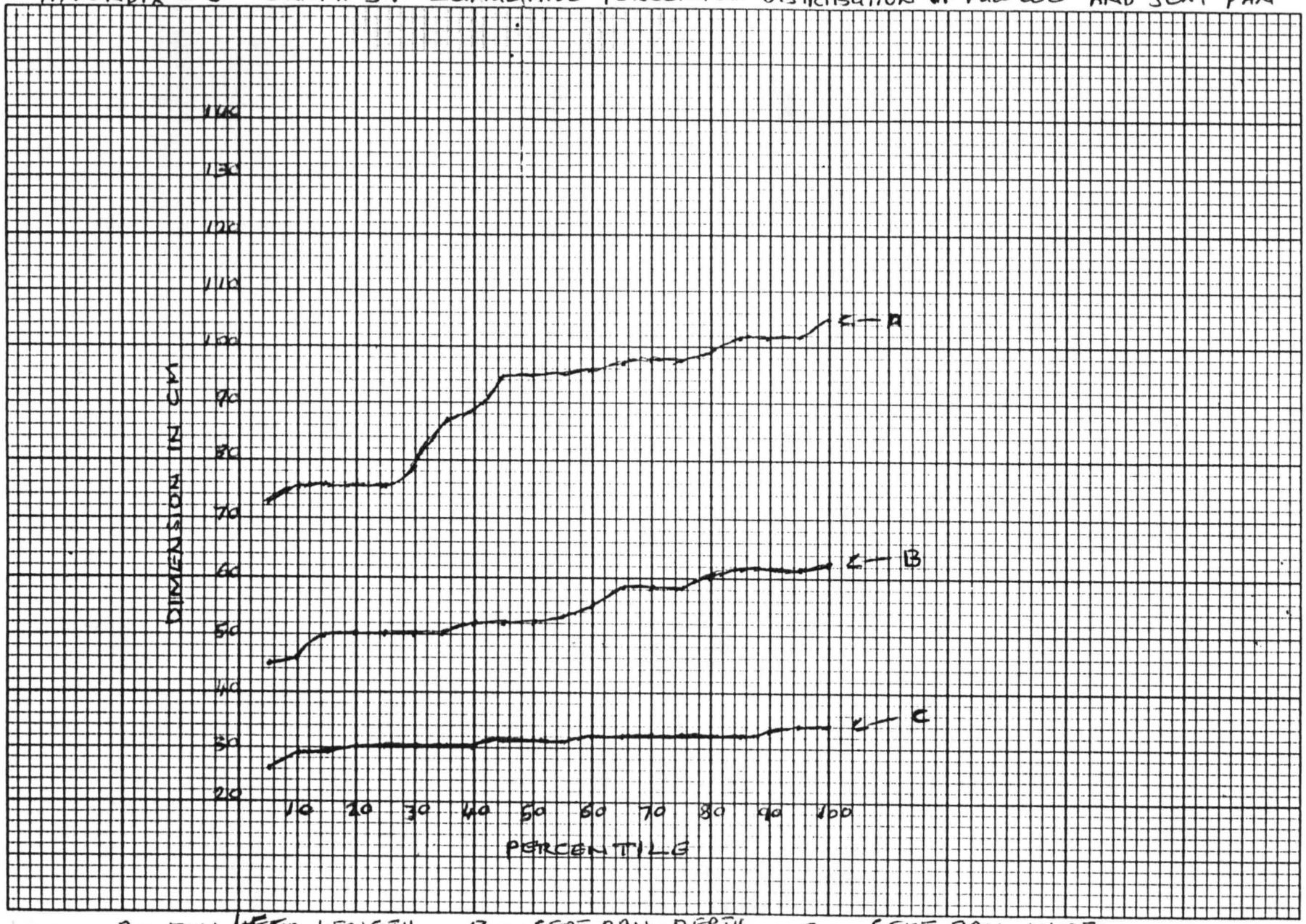
S/NO	PARAMETER (UNIT)	SUB-JECT 1	SUB-JECT 2	SUB-JECT 3	SUB-JECT 4	SUB-JECT 5	SUB-JECT 6	SUB-JECT 7	SUB-JECT 8	SUB-JECT 9	SUB-JECT 10	SUB-JECT 11	SUB-JECT 12	SUB-JECT 13	SUB-JECT 14	SUB-JECT 15	SUB-JECT 16	SUB-JECT 17	SUB-JECT 18	SUB-JECT 19	SUB-JECT 20
1.	Standing Height (cm)	157	168	171	158	169	151	170	165	185	184	169	175	172	157	174	162	168	186	156	188
2.	Full-hand Length (cm)	76	80	81	70	83	74	81	77	85	81	76	79	82	77	85	78	75	91	77	85
3.	Popliteal Height (cm)	46	50	51	50	49	44	54	48	58	53	50	54	52	47	56	52	52	57	46	57
4.	Sitting Height (cm)	30	32	33	30	31	30	32	31	33	33	31	32	31	32	32	27	27	33	32	32
5.	Thigh Length (cm)	50	53	55	58	58	50	50	46	52	45	52	52	50	61	61	50	58	62	60	61
6.	Buttock Width (cm)	32	30	31	29	32	29	30	34	32	31	30	30	30	34	32	26	31	33	32	32
7.	Elbow-Hand (cm)	42	49	50	51	49	41	50	44	57	55	47	49	51	42	51	48	47	56	41	55
8.	Hand pan Width (cm)	10	10.2	12	10	10	9	10	9	11	10	10	10	12	9	11	9	10	11	9	11
9.	Optimal Handgrip	8.5	10	10.07	9	10	8	11	10	12	11	10	11	11	10	10	9	10	12	9	13
10.	Full Leg Length (cm)	76	89	98	76	95	73	95	79	99	101	97	101	95	76	87	98	96	101	75	105
11.	Body Weight (kg)	52	51	67	54	54	53	60	52	66	53	56	53	59	56	60	55	52	58	51	57

APPENDIX - B

TEMPERATURE (C) SITUATION IN SELECTED STATIONS (JAN. 1993 – SEPT. 1998)

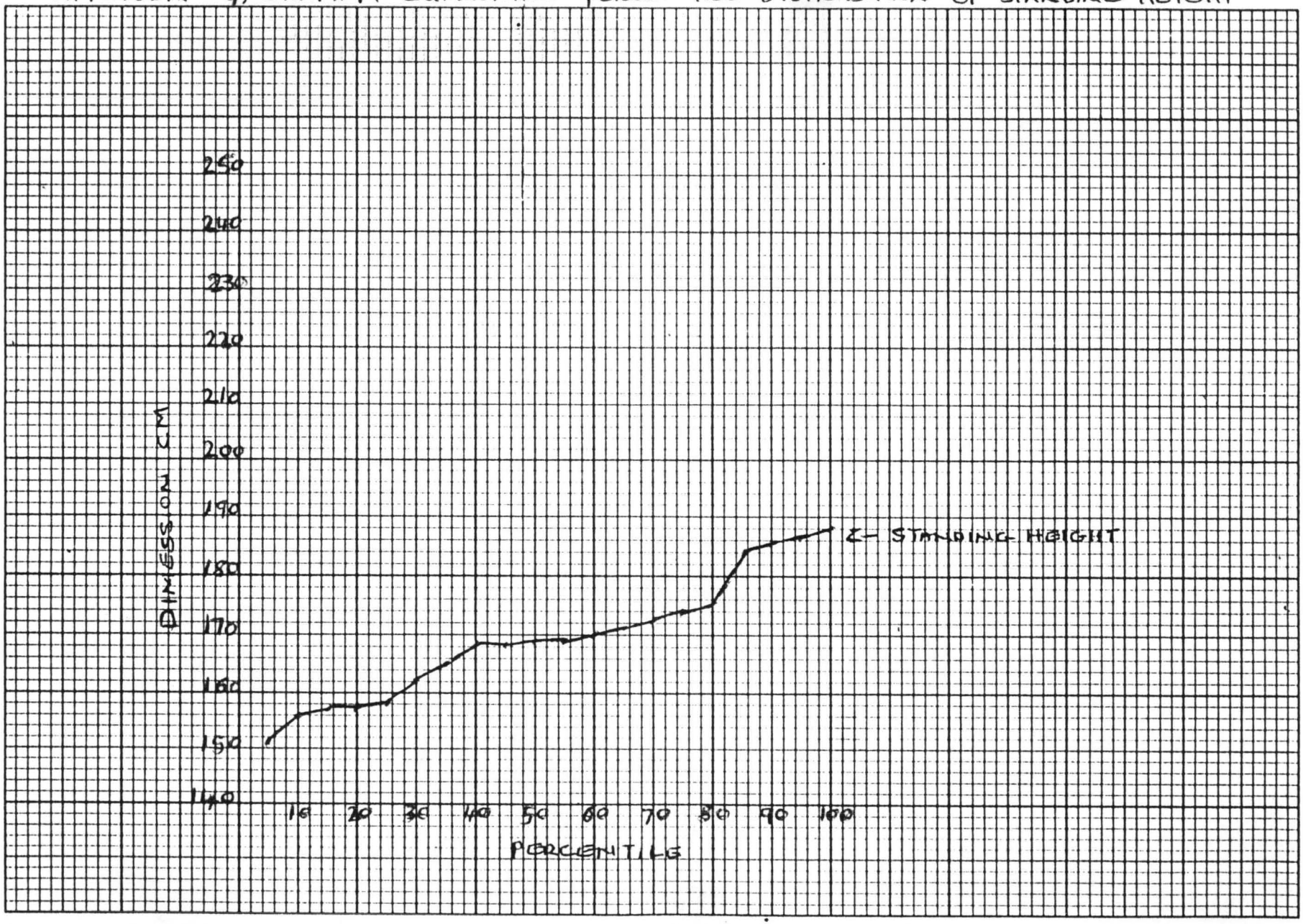
YEAR	LOCATION	ITEM	JAN	FEB	MAR.	APRIL	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
1993	MINNA	MAX.	33.5	36.8	36.6	37.6	34.9	31.3	29.7	29.4	30.7	32.5	36.3	35.3
		MIN.	19.8	22.6	24.2	25.4	23.9	22.4	21.7	21.7	21.3	21	21	20
	SHIRORO	MAX.	34	24.6	38.6	39.4	38.6	NA	21.5	30.2	27	27.8	28.1	25.5
		MIN.	20	17.2	23	23.3	23.8	NA	NA	NA	–	23.5	NA	NA
	BIDA	MAX.	34.1	37.3	38.7	37.5	34.7	31.4	32.9	30.7	28.9	32.9	35.8	35.3
		MIN.	20.2	23.5	24.7	26.3	24.5	23.1	22.8	23.6	19.8	22.6	23.2	21.4
1994	SHIRORO	UPT.	25.3	26.9	27.8	29.5	28.4	36.1	37.1	39.17	25.8	25.2	26.1	23.7
	BIDA	MAX.	33.3	36.1	39.3	36.6	33.7	32.1	30.5	30	30.5	32.3	35.4	34.2
		MIN.	21.6	23.7	26	25.9	24.5	23.1	23.1	23.1	23.2	22.9	21	19.6
	BADEGGI	MAX.	34.1	37.3	39.5	36.8	33.8	32.4	31.8	31	31.3	33	34	34
		MIN.	19.7	18.1	24	24.9	24.2	22.9	23	23	23.2	23	19	15
1995	SHIRORO	UPT.	23.8	25.4	29.3	28	31.4	27.8	26.6	26	29	29.6	30.2	22.9
	BIDA	MAX.	34.7	37.4	38.9	NA	34	32.4	31	30	31.2	NA	NA	NA
		MIN.	20.3	23.5	26.9	NA	24.9	23.9	23.2	23	23.4	23.1	21	20.9
	BADEGGI	MAX.	33.8	36.4	38.6	NA	34.6	32.2	32.1	31	32	33.4	34.7	35
		MIN.	15	17.3	24.2	NA	24.1	23	22.8	23	23	23.4	18.8	17
	MINNA	MAX.	38.4	37	NA	36	33.6	31.9	29.2	29.4	30.6	32	34.4	36
		MIN.	19.2	21.8	NA	25	23.2	22.3	22.6	21.9	21.6	22	19.9	19
1996	SHIRORO	UPT.	27.5	29.1	32	31.5	29.1	27.7	26.7	26.1	26.8	29.7	26.7	29.1
	BIDA	MAX.	F	F	F	F	F	F	F	NA	F	F	F	F
		MIN.	20.5	26.2	25.5	23.5	22	22.6	28.8	28.8	22.8	22.6	20.1	19.2
	BADEGGI	MAX.	35	38.4	39	34	35	31.2	30	31.4	31.4	33	37.3	36
		MIN.	15	23.8	25	23.1	24	22.7	22	21.4	21.4	21	21.1	17
	MINNA	MAX.	36.9	38.3	38	34.1	30.5	29.2	28.6	29.8	29.8	31.2	35	36
		MIN.	19.2	24.9	25	22.8	21.5	21.3	20.8	20.3	20.3	20.6	17.4	17.19
1997	SHIRORO	UPT.	28.4	30.0	30.7	30.5	29.2	26.9	27.0	26.9	NA	NA	NA	NA
	BIDA	MAX.	NA	NA	NA	NA	NA	NA	NA	NA	NA	32.1	35.3	35.8
		MIN.	21.8	22.2	26.0	NA	24.2	23.6	23.7	23.8	31.5	23.1	22.4	21.0
	BADEGGI	MAX.	33.3	37.0	38.0	36.0	34.0	32.0	31.9	32.0	23.1	33.0	36.0	35.0
		MIN.	17.9	20.0	23.0	24.0	23.6	22.0	23.0	23.0	32.0	23.0	21.0	17.0
	MINNA	MAX.	35.4	35.3	37	37.2	31.6	31.0	29.8	28.5	29.7	31.4	34.1	35.2
		MIN.	25	21.4	25.4	24.1	23.8	22.8	21.5	20.8	23.4	20.8	24.6	18.8
1998	SHIRORO	UPT.	NA	NA	NA	27.4	26.5	26.5	27.3	27.8	26.1	NA	NA	NA
	BIDA	MAX.	35.4	39.6	39.1	38.7	34.4	32.8	31.0	29.8	30.7	32.4	36.2	35
		MIN.	21.5	20.3	27.1	27.8	25.0	24.5	24.1	23.4	23.4	23.5	21.9	21
	BADEGGI	MAX.	35.2	40.1	39.5	38.6	34.4	33.6	31.5	30.5	31.3	32.9	35.7	34.8
		MIN.	16.9	20.5	23.3	26.7	24.9	23.8	23.5	23.6	23.4	23.6	20.4	22.3
	MINNA	MAX.	NA	NA	NA	32.4	31.7	33.3	30.9	26.1	30.9	32.9	34.6	32.4
												21.3	29.5	29.7

APPENDIX – 6 GRAPH 3: CUMULATIVE PERCENTILE DISTRIBUTION OF FULL LEG AND SEAT PAN

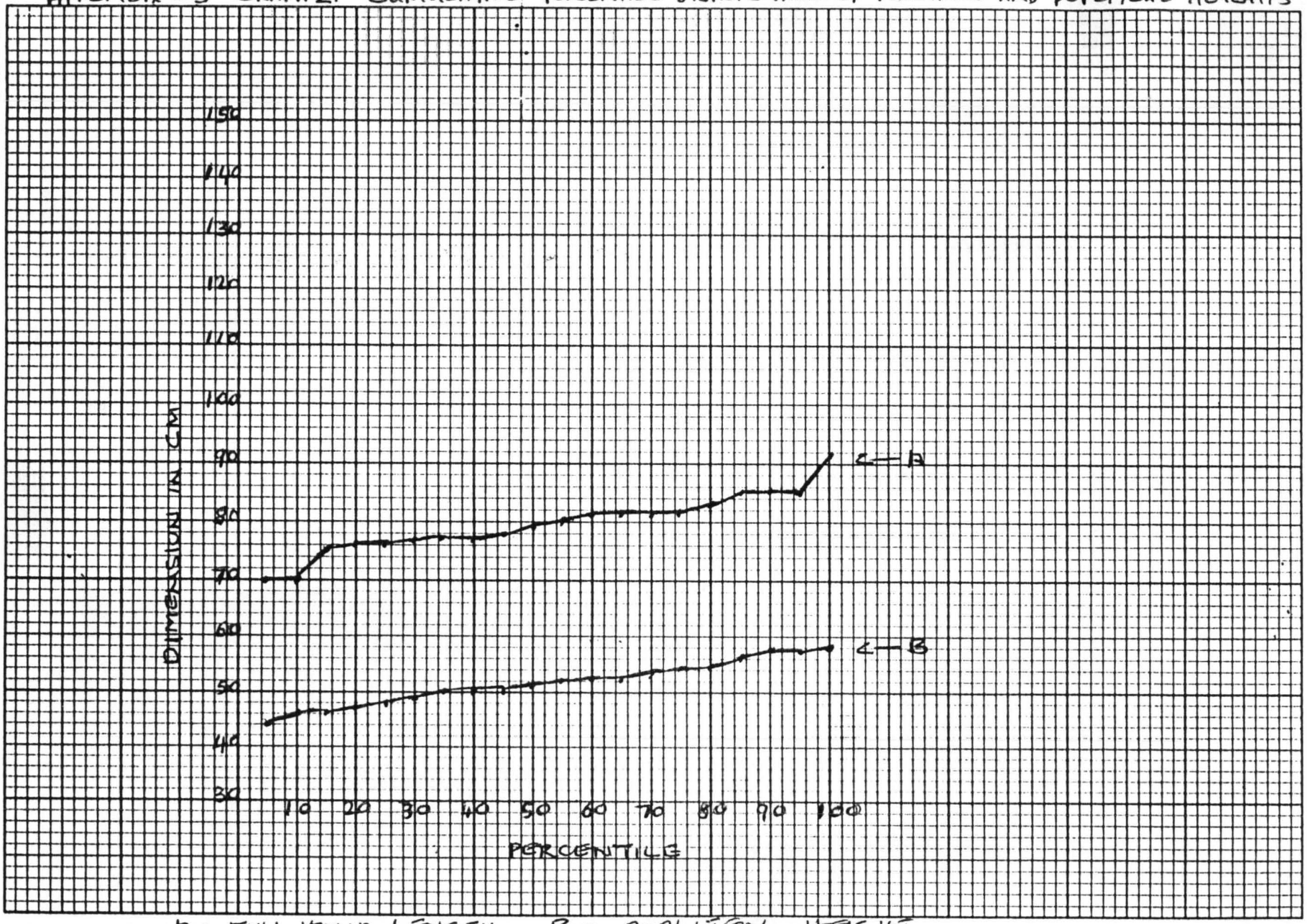


A = FULL LEG LENGTH B = SEAT PAN DEPTH C = SEAT PAN WIDTH

APPENDIX – 4, GRAPH 1 : CUMULATIVE PERCENTILE DISTRIBUTION OF STANDING HEIGHT



APPENDIX – 5 GRAPH 2: CUMULATIVE PERCENTILE DISTRIBUTION OF FULL HAND AND POPLITEAL HEIGHTS



A = FULL HAND LENGTH B = POPLITEAL HEIGHT