EFFECT OF LAND SURFACE CONFIGURATIONS ON SOIL PHYSICAL CONDITIONS AND YIELDS OF GROUNDNUT ON AN ALFISOL

BY

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C E R T I F I C A T E

Miss G. Sujatha has satisfactorily prosecuted the course of research and that the thesis entitled **"EFFECT OF LAND SURFACE CONFIGURATIONS ON SOIL PHYSICAL CONDITIONS AND YIELDS OF GROUNDNUT ON AN ALFISOL"** submitted is the result of original research work and is of sufficiently high standard to warrant its presentation to the examination. I also certify that the thesis or part there of has not been previously submitted by her for a degree of any University.

4.8.92

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C E R T I F I C A T E

This is to certify that the thesis entitled **"EFFECT OF LAND SURFACE CONFIGURATIONS ON SOIL PHYSICAL CONDITIONS AND YIELDS OF GROUNDNUT ON AN ALFISOL"** submitted in partial fulfilment of the requirements for the degree of **MASTER OF SCIENCE IN AGRICULTURE** of the **ANDHRA PRADESH AGRICULTURAL UNIVERSITY,** Hyderabad is a record of the bonafide research work carried out by **Ms. G. SUJATHA** under my guidance and supervision. The subject of the thesis has been approved by the Student's Advisory Committee.

No part of the thesis has been submitted for any other degree or diploma. The published part has been fully acknowledged. All assistance and help received during the course of the investigations have been duly acknowledged by the author of the thesis.

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DECLARATION

I, **G. SUJATHA**, hereby declare that thesis entitled **"EFFECT OF LAND SURFACE CONFIGURATIONS ON SOIL PHYSICAL CONDITIONS AND YIELDS OF GROUNDNUT ON AN ALFISOL"** submitted to Andhra Pradesh Agricultural University for the degree of Master of Science in Agriculture is the result of the original research work done by me. It is further declared that the thesis or any part thereof has not been published earlier in any manner.

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ABSTRACT

A field experiment conducted in an Alfisol at ICRISAT consisted of three land configurations namely ridges, broad bed-furrow (BBF) and flat. Two varieties of groundnut namely, ICG(FDRS)10 and ICGS 11 were tested. The results indicated that lowest bulk densities of 1.41, 1.44, 1.46 and 1.48 g cm^{-3} were observed in BBF at 30, 60, 90 and 145 DAS respectively as compared to the flat. Highest soil moisture contents of 0.766, 0.683, 0.660 and 0.543 g/g were observed in BBF at 30, 60, 90 and 145 DAS respectively as compared to the flat. The penetration resistance was found to be lower in BBF by 9.3 and 15.5 kg cm^{-2} than that in ridges and flat respectively. The total porosity of the soil in BBF was found to be higher by 4.0 and 8.3 per cent than in ridges and flat respectively. Maximum oxygen content of 21.84 per cent was observed in BBF as compared to other land configurations. Maximum pod yields of 4,219 and 3,388 kg ha^{-1} were recorded in BBF with ICG(FDRS)10 and ICGS 11 varieties respectively. The mean increases in pod yields observed in BBF were 11.9 and 20.5 per cent when compared to ridges and flat respectively. The increased pod yields observed in BBF might be due to increase in soil moisture retention, decreases in bulk density and penetration resistance.

CHAPTER I
INTRODUCTION

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INTRODUCTION

Alfisols are the third most important [redacted] order in the world covering 13.1% of the world area. Compared with Vertisols, Alfisols cover a much larger area of potentially important aerable and rainfed land. These soils are most abundant in the Semi-Arid Tropics and occupy about 33% of the land area in the SAT. Due to abberant weather and soil related constraints to production, crop yields on Alfisols have remained low and unstable.

Active rooting depth of many crops are restricted in these Alfisols either by the limiting soil depth or by the compact argillic horizon. Restricted root development on these soils prevents many crops to withstand even moderate droughts. A major consequence of lack of aggregation [redacted] is the tendency of these soils to display rapid surface sealing following rainfall and crusting with subsequent drying. This crusting can adversely affect the seedling emergence and plant establishment. It often extents deeper than the immediate soil depth, resulting in often consolidation or slumping of the soil. Although, the soil permit easy tillage when wet, it becomes very hard and difficult to plough when dry. Tillage, when the soil is too wet, may result in excessive compaction.

Alfisols generally possess inherently low water and nutrient retention characteristics because of their coarse particle make up and mineralogical composition. This is often compounded by the shallow depth of the soil zone available for water storage. Insufficient water storage combined with mechanical impedance problems in these soil limit root proliferation. These soils on one hand induce excessive runoff even early in the season and on the other, directly affect seedling emergence.

Alfisols possesses low wet strength leading to rapid consolidation or slumping up of the plow layer. Consolidation is associated with decrease in airfilled porosity. With poor water retention characteristics, rainfed cropping in Alfisols faces a constant threat of deficient soil moisture even during relatively short dry spells. Even in dependable rainfall regions, the average yields in Alfisols are found to be very low. Village level surveys of some Alfisol areas in India have revealed that the groundnut pod yields on an average were 400-600 kg ha^{-1}. (Rastogi, et. al. 1982 and Sanghi and Rao, 1982).

The nonstable structure of the soils in the flat lands enhances their tendency to develop surface seals that reduce infiltration and profile recharge even when rains are moderate. These surface seals harden into crusts during the intermittent dry periods. Such conditions prevalent in flat systems of land deter the establishment of adequate protective crop cover early in the season. As a consequence, the traditional system of farming on flat lands induces excessive runoff and thereby soil loss.

Further, the ridges formed in these Alfisols to a height of 10-15 cm by a ridge plough are easily breached either by excessive rainfall or irrigation applied. They will not withstand well even for one cropping season unless they are frequently reformed and compacted by manual labour which costs more. The ridges have greater surface area, increased porespace which cause higher amounts of water evaporation from the ridges. Sometimes seeds placed on the sides of the ridges of Alfisols may not germinate and emerge due to poor soil moisture and seed contact as most of the soil moisture present in 5 cm depth of the ridges may get evaporated quickly prior to seed germination. Inspite of the above disadvantages, it was reported that more moisture was retained and lower soil temperatures were observed below 15 cm depth of the ridges under rainfed conditions of semi-arid climate in Alfisols and thereby increased grain yields of sorghum, maize, groundnut, pigeonpea and castor in the ridges as compared to the flat system of planting (Reddy, et. al. 1985)

The on-farm trials conducted by LEGOFTEN unit of ICRISAT (1990) reported that better performance of groundnut grown on the broadbed and furrow system of planting (BBF) were observed than those grown on flat land. Some of the salient observations reported by the unit were that consistently groundnut yields on BBF were greater than on the flat land, harvesting of the groundnut pods was found to be easier on BBF than on the flat land and irrigation water requirement was found to be smaller on BBF than on the flat land for some of the crops grown. However, quantitative data available on the above techniques of land configurations used are meager.

The earlier investigations carried out on BBF technology adapted at ICRISAT are giving interesting results for the management of Alfisols for soil moisture conservation and for optimised production of sorghum and groundnut. It was observed that the BBF raised land configurations increased the infiltration rates in the planting zone, improved the root growth and proliferation and reduced the velocity of overland flow of water (ICRISAT Annual Report, 1989). In particular, land and soil management techniques that are effective in reducing runoff, erosion and improving structural stability are yet to be defined in terms of soil water retention characteristics, soil temperatures changes and oxygen content under different systems of land configurations.

Therefore, it is thought desirable to study the effect of different land surface configurations on changes developed in soil physical conditions and yields of groundnut on an Alfisol at ICRISAT with the following main objectives :

1. To study the effect of three different land configurations, namely, flat, ridges and BBF on soil bulk density, soil porosity, soil moisture retention, oxygen content, penetration

resistance and soil temperature at different stages of crop growth.

2. To study the relationship between soil moisture content, soil temperature and oxygen content in the three different land configurations.

3. To establish suitable land surface configuration that will provide better moisture environment for plant growth and results in increasing the pod yields of groundnut on an Alfisol.

CHAPTER II
REVIEW
OF
LITERATURE

C H A P T E R - II

REVIEW OF LITERATURE

The ability of soil to sustain a crop is dependant not only on the inherent availability of nutrients but also on soil air and water relations essential for efficient use of nutrients and water by plants. Hence it is a prerequisite to maintain the soil in good physical condition for optimum growth, development and yield of crops.

The effect of different surface configurations on soil physical conditions and yield of groundnut on an Alfisol would be reviewed briefly in this chapter under the following headings

Effect of surface configurations on soil physical properties
Effect of surface configurations on groundnut yields

2.1 Effect of Surface Configurations on Soil Physical Properties

An optimum soil physical environment must be maintained for high yields of groundnut. Studies on sink-source relationship in groundnut have indicated that the entire source of carbohydrates is not utilised for pod development. This may be partly due to the influence of soil physical environment at peg penetration and pod development.

Soil physical properties such as soil aeration, soil temperature and soil strength have considerable influence on the productivity of groundnut (Sankara Reddy, 1982). Looseness and friability of the surface soil facilitate peg penetration, while physical factors of soil surrounding the developing pod affect its proper development (Shanmugam, 1983).

Combined effect of reduced bulk density, improved soil moisture content and retention and aeration results in better physical growth of the crop (Krishna, 1987).

2.1.1 Soil moisture condition

A minor surface ridge has been found to be effective in conserving moisture and increasing water use efficiency compared to flat soil surface. Good performance of the ridges was reported to be due to a deeper penetration of water and suppression of evaporation losses (Willis et. al. 1963).

On the contrary, Adams (1967) reported that the major effect of bed configuration was on seed bed soil water and that rapid drying of the seed bed in ridges caused much slower germination and emergence.

Perfectly levelled seed beds provide wetting of soil more evenly and to an increasingly uniform depth resulting in the proper spread and uniform development of roots of irrigated groundnut variety TMV-2, thus ensuring additional production (Chandra Mohan, 1970).

Broad ridges have been found to prevent water from breaking across to the neighboring furrow (Howe, 1976). Ridges or beds functioned as minibunds at a slope less than the maximum slope of the land. Velocity of runoff was thus reduced and water infiltration was found to increase on Vertisols (Kampen and Krantz, 1976).

In studies to compare the performance of broadbed and furrow system with flat seed beds and ridge and furrow system, available soil moisture status was found to be 60% and 36% higher in the bed and furrow than the flat and ridge and furrow system respectively (National Agriculture Research Project, 1981). Radke (1982) observed that ridged soils dry faster starting at the peak of the ridges and continue down and that ridging provides a means of managing soil water. Ridges speed up drying process because of gravitational effects on the water and the increased solar flux.

Conflicting results on the water retention by broad beds, ridges and flat seed bed have been reported in the literature. For example research conducted at Udaipur, a centre of All India Co-ordinated Research Project on Dryland Agriculture (Anonymous, 1982-83) revealed that the gravimetric soil moisture retention was 4.2% higher in flat seed bed system than in the broadbed system. Similar results were obtained at Indore. At Varanasi, broad bed system and ridge and furrows had 1.0 and 1.3 per cent more moisture respectively than flat seed bed (Anonymous, 1982-83). At Bijapur, the soil moisture in the profile under broad bed and furrows and under ridges was 8 and 14% less than the flat system at the time of sowing. But as the crop advanced, the broad bed and furrows had 7% more moisture than the flat system (Anonymous, 1982-83). At Akola, broad bed system had higher moisture retention and depletion compared to flat seed bed system. At Rajkot, the soil moisture was higher by 2 to 6% in ridge and furrow system than the flat sowing and BBF.

The work done at Bellary (Anonymous, 1982-83) indicated that broad bed and furrow (BBF) retained the highest available soil moisture followed by ridge and furrow system and flat seed bed in that order.

In case of small rain showers, ridge-furrow system has been found to offer greater moisture availability to plants because it concentrates water in furrows (Anonymous, 1985).

Different surface configurations like ridges and broad beds were found to influence the surface water movement (Huibers, 1985). Ridges and broad beds increase the total infiltration and depression storage and thus slow down the flow velocity of surface runoff.

Venkateshwarlu (1986) indicated that the BBF results in uniform rain water recharge of the profile and increase moisture retention for extended times. It therefore appears to overcome drought effects due to dry spells during the rainy season and help in establishing a second crop in high rainfall Vertisol areas.

Hegde et. al., (1987) compared the influence of land treatments on in-situ soil water conservation and crop yields. Their results showed that there was no significant difference between the BBF and flat seed bed on the moisture status and the crop yields. Beds and furrows were used mainly as disposal systems whereas a ridge and furrow system reduced runoff losses.

Vijayalakshmi (1987) indicated that land treatments are essential for better moisture conservation because they provide miniature bunds that check water flow and provide more opportunity for water to infiltrate. This increases the stored profile water and therefore results in sustained crop production. Ridges and furrows were found to be effective for in-situ moisture conservation.

The work done by Srivastava and Jangawad (1988) on the water balance of watershed under different management, revealed that the profile moisture accretion in the flat system ranged from 44 mm to 102 mm and that in the BBF system ranged from 47 mm to 132 mm. Deep drainage in the BBF was substantially greater than in the flat system. This was due to higher infiltration in the BBF.

Studies conducted by Hulugalle and Rodriguez (1988) on the effect of ridges on soil physical properties indicated that the soil water retention in the surface 0.05 metres at water potentials of -31.6 kPa and -500 kPa were 37% and 58% greater in ridged plots than in the flat plots respectively. This increase in water retention was due to the higher clay content (13.4%) in ridges than the flat seed bed (8.4%). The clay particles dispersed by rainfall was retained on-site by the ridges whereas in the flat plots, they were transported off-site by the greater water runoff.

Patil and Bangal (1989) investigated the effect of conservation practices on runoff and soil moisture retention under rainfed condition and found that the ridges retained 3% more moisture in the soil than flat seed bed. They obtained a negative correlation between crop yield and soil loss, and found that runoff and the soil loss were reduced by ridging.

On the contrary, the work done by Stone et. al. (1989) on ridge tillage clearly showed that ridges resulted in lower gravimetric soil moisture content within the seed zone early in the season. Ridges showed 10% and 18% lower soil moisture content than the flat system at soil depths of 0-5 cm and 5-10 cm respectively. Because the surface area of ridges was greater than that of flat seed beds, more water was lost in the ridges than from the flat seed bed.

Klaij and Hoogmoed (1989) in their studies on crop response to tillage practices observed that soil moisture extraction in ridges reached its maximum at 64 days after sowing with 42 mm more soil moisture extracted than the flat seed beds. Ridging increased the extractable soil moisture even from the deeper layers.

Rajput et. al. (1989) compared BBF system and the flat system of farming in increasing and stabilzing crop production in rainfed areas. Broad bed and furrow system performed better than the flat system. These authors ascribed the good performance of the BBF to its capability to store 3% more soil moisture than the flat system.

Studies have been carried out by Gupta and Sharma (1990) to test the influence of different land configurations, namely, BBF, ridge and furrow and flat system on field water balance, drainage characteristics and soil profile recharge from rain water. The results obtained by them clearly suggest that the BBF system is the best from the point of view of drainage and in-situ conservation of rain water. A considerably high profile moisture content was maintained during rainy and post-rainy seasons and this helped in recharging the water in the root zones of crops cultivated on raised beds.

The raised bed and furrow system conserves soil moisture more efficiently than the flat system. Consequently, the adoption of in-situ water harvesting and sowing of crops on raised bed and furrow system result in better drainage conditions in Vertisols (Nimje and Bhandarkar 1990).

Studies conducted by Nilantha et. al., (1990) on the effect of tied ridges on soil water content showed that tied ridges were more efficient than flat seed beds in increasing soil water content during the growing season. Gravimetric soil water content of tied ridges was 23% greater than the flat planted plots. Tied ridges therefore improved water conservation in the short term more efficiently. This may be because the ridges reduced the velocity of surface runoff, thereby ensuring that the threshold velocity required for transportation of clay particles was not reached.

Hamlett et. al. (1990) compared the water movement in ridged plots and flat plots by applying 24 mm, 50 mm and 72 mm rain. They found that the volumetric water content profiles for the ridged plots and the flat plots were similar in shape indicating the general increase in water content with increase in rains applied using a raifnall simulator. There was little difference in total downward water movement in both treatments. For the 50 mm rain, less water was recovered from the flat plot (81% recovery) than from the ridge plot (95% recovery). But the 72 mm rain resulted in equal losses of applied water for both the ridge and the flat tilled systems (52% and 53% recovery respectively). Their results indicated that in the ridge plot receiving 50 mm, more water flowed toward the furrow zone and downward from this zone, with deeper penetration than 24 mm rain. The decreased water contents for the 50 and 72 mm rains compared with the 24 mm rain can be attributed to water drainage through the profile with time.

Grewal and Abrol (1990) found more soil water content in ridge system as against the flat surface planting system and that the soil water depletion in ridges was 134 mm more than that from the profile of flat system. Ridges lost more water due to exposure of more surface area.

Raised bed system enhances in-situ moisture conservation and deep percolation leading to marginally increased water use efficiency as compared to flat system (Sharma, 1992). Narnaware and Kayande (1992) reported that the available soil moisture content in BBF was 48% more than on the flat seed bed. Total soil moisture content in BBF at different crop stages was more than that for either the flat or the ridges and furrows system.

2.1.2 Penetration Resistance

Penetration resistance is the force with which soil resists the entry of roots, water and air. Plants have to overcome this resistance for better root penetration, growth and development. Groundnut crop is more sensitive to penetration resistance as the gonophores had to penetrate into the soil and develop as pods.

Studies were conducted by Taylor and Ratliff (1969) on root elongation and growth rates of groundnuts as a function of penetration resistance and soil water content. Their results indicated that at the lowest gravimetric soil water content of 0.038 gg^{-1}, the wet weight of peanut tops decreased significantly with increased penetrometer resistance. It was found that at the penetrometer resistance of 0.05 bars the top wet weight of groundnut was 1.38 g and at 69.1 bars the top weight decreased to 0.80 g.

Soil in raised beds and ridges stays looser than on flat bed and shows lower penetrometer measurements. This could be one of the reasons in increasing the yield of a crop such as groundnut by planting on BBF and ridges (ICRISAT, 1988).

The work done by Hulugalle and Rodriguez (1988) in determining soil physical properties of ridges clearly shows that penetrometer resistance at a soil water content of 0.05 kg kg^{-1} was greater in ridged plots (77.4 kPa) as compared to flat seed beds (56.6 kPa) in the surface 20 mm.

Pathak et. al., (1991) studied the response of groundnut growth and yield to raised bed on Alfisol. Their results indicated that at the beginning of the season (19 DAS) the differences in penetration resistance between BBF and flat at 0-5, 5-10 and 10-15 cm soil depths were small. But near harvest the penetration resistance for all 3 depths were significantly less in the BBF than in the flat treatment, eg. at 10-15 cm depth, 91 kg cm^{-2} in flat compared to 55 kg cm^{-2} in BBF. The lower penetration resistance in BBF facilitates better penetration of gonophores and development of pods than in flat seed beds.

2.1.3 Oxygen Content

In an experiment conducted by Pathak et. al. (1991), on the response of groundnut yields to raised bed on Alfisol, the oxygen content at depths 0-5, 5-10 and 10-15 cm soil in BBF and flat treatment differed only slightly between 19.94 to 21.32%. They observed that the oxygen content mentioned in the above depths was slightly higher in BBF than in the flat treatment throughout the crop season. It was found that except for the 0-5 cm depth the oxygen content of the 5-10 and 10-15 cm depths was not significantly different.

2.1.4 Soil Temperature

A number of investigations have shown that both soil and air temperatures influence the early growth of plants. Therefore planting methods designed to raise soil temperature would enhance the probability of a successful cropping season.

Burrows (1963) characterized soil temperature distribution in a ridge and furrow microrelief and a smooth soil surface produced by different tillage systems. The results indicated no temperature gradients greater than 1°C for the air layers near the ground. Thus the treatments had no differential effect on air turbulence.

Radke et. al. (1963) found that the day time soil temperatures were warmer on the ridges than on conventional flat seed bed.

Ridges caused increase in soil temperature when compared to flat systems of planting because a larger area of soil surface is exposed on ridges for absorption of solar radiation. The improved drainage characteristics resulting from the bed configurations cause the soil to be drier and warmer (Adams, 1967).

Radke (1982) found that ridges had higher maximum temperature than a flat system. Soil water and temperature are interrelated due to changes in thermal conductivity and heat capacity with water content and also movement of water due to thermal gradients. Warming of the soil is delayed under very wet conditions because more energy is used for evaporation and less for heating the soil and air. Ridges speed up the drying process because of gravitational effects on the water and the increased solar flux.

The work done by Hulugalle and Rodriguez (1988) on the soil physical conditions of ridges had clearly shown that ridged plots had higher soil temperatures than flat plots. Soil temperatures at a depth of 30 mm in dry soil was found to be the greatest on the ridge slopes and least in the furrows of ridged plots. Furrows of the ridges were found to have low soil water contents, high clay contents and bulk densities which resulted in their having high thermal conductivities. Rate of heat and temperature increase was, therefore, lower in ridged plots.

Soil temperatures markedly influence groundnut yields. Surface soil temperatures are influenced by soil moisture content.

A decrease in soil moisture content by 3 to 4% result in 2 to 3°C rise in the soil temperature in the pod zone. It can be said that a good crop cover and maintenance of soil moisture content can appreciably reduce soil temperatures, and make it possible to maintain them around 30°C (Reddy et. al. 1989).

Stone et. al. (1989) reported that before planting, ridge tillage resulted in higher temperature within the seed zone than the flat plots. This increase was because of approximately 10% greater surface area of ridges than the flat plots. After planting, both ridges and flat plots had an insignificant effect on soil temperature.

Maliro (1989) observed that the top 10 cm soil layer in narrow ridges of 45 cm showed 2°C lower soil temperature than the broad ridges of 90 cms. This decrease in soil temperature was due to interception of more solar radiation by leaves thereby keeping the fruiting zone cool and moist for a relatively longer time. This enabled a favorable environment for pod development for a long time.

The ridge system introduces many nonuniform characteristics into the field such as variable solar radiation across the soil surface, variable water and heat transport properties caused by ridge construction (Benjamin et. al., 1990).

Grewal and Abrol (1990) reported that ridges registered 1 to

2°C higher soil temperature in the forenoon and about 5-6°C in the afternoon hours than the flat surface because the former exposed more surface area.

2.1.5 **Bulk density**

Increased bulk density is associated with a decrease in airfilled porosity. Air filled porosity in the upper 15 cm layer of BBF was found to be significantly higher than for the flat system during wet spells (ICRISAT, 1981). This confirms the effectiveness of the BBF in improving drainage in seed and root environment.

As a result of higher bulk densities in flat seed beds, the pod yields were less than in ridges due to unfavorable conditions for peg penetration and pod setting and development in the surface soil layers of flat seed beds (NARP, 1981).

Pathak et. al., (1991) conducted an experiment on response of groundnut growth to raised bed on Alfisol in which they compared the bulk density in BBF and the flat seed bed. Their results clearly showed that the bulk density of 0-15 cm soil layer was significantly lower in BBF than the flat treatment throughout the growing season. Differences in bulk density persisted between the treatments at the pegging stage. Even near the harvest, it was found that the bulk density of the 0-15 cm layer was significantly less in the BBF (1.47 Mg m^{-3}). Thus BBF has a clear advantage over flat seed bed in keeping top-soil loose with implications for gonophore penetration into the soil, pod formation and harvesting of the groundnut easy.

2.2 Effect of surface configurations on groundnut yields

Experimental results of Rotimi (1970) showed that planting on the flat result in boosting the yields of groundnuts particularly spanish varieties compared to ridges. He found that planting on the flat gave a pod yield of 4,100 kg ha^{-1}. The increase in yield was ascribed to better soil moisture conservation in flat plots.

For improving moisture conservation to tide over soil moisture stress due to prolonged dry spells, land treatments viz. broad bed and furrow, ridge and furrow were compared with the control (flat bed) at Tirupati(Anonymous,1981). A trend of increase in pod yield in broad bed and furrow method of planting over the control was obtained. It was observed that the 226 kg ha^{-1} increased pod yield on BBF over the control was due to higher moisture availability in the BBF than in the flat bed.

In another experiment conducted at Tirupati(Anonymous, 1981) sowing groundnut on the side of the ridge was compared with sowing on the flat bed. It was found that planting the seed on the side of the ridge gave higher pod yield (1,002 kg ha^{-1}) than the flat bed (638 kg ha^{-1}). The increase yields by planting on ridges is due to more number of total pods per plant (9) and filled pods per plant

(7) compared to the flat beds.

Rajah (1981) found that sowing of groundnut variety CO-1 in rainy season on flat beds which were converted to ridges at the 45th day after sowing resulted in 14.7% yield increase over the flat seed bed (1088 kg ha^{-1}). At Rajkot, it was observed that the groundnut grown on flat seed bed and later ridged gave 37 kg ha^{-1} more yield compared to flat seed bed and broad bed system respectively. The better performance was due to high soil moisture content in the ridged treatment (AICRPDA, 1982-83).

Venkateshwarlu (1986) reported that broad bed and furrows are site specific and gave a yield advantage of about 20 $\pm$ 5% over the flat on grade due to increased moisture retention for extended times.

Ali and Wallis (1986) in their studies on the effect of planting method on yield of groundnut found that flat seed bed and 4 row bed planting gave significantly higher groundnut yields (2531 and 2708 kg ha^{-1} respectively) than narrow ridges (1689 kg/ha) and that four row bed was easier to dig resulting in less left-over pod loss compared to the flat planting.

Amin et. al., (1987) reported that the BBF technology has been found to be useful for both rainfed and irrigated groundnuts. The root systems of groundnut develop better on BBF than on flat resulting in better yields. Similarly they observed (Amin et. al.

1988) that improved cultivation practices which included improved variety and BBF system of planting gave 26.6% increase in yields of groundnut over the flat with local variety.

Patil (1989) studies on evaluation of broadbeds and furrows for irrigated groundnut on medium black soils showed that the yield level of groundnut with BBF can be doubled compared to the flat system of planting. His results indicated that the total and effective number of pegs was almost doubled in BBF. A consistent trend was also evident with the dry mass of pods and dry matter per hill which resulted in increased yields on BBF (4050 kg ha^{-1}) than the flat system of planting (2190 kg ha^{-1}).

Dry pod yield of groundnut variety ICGS-11 grown on raised bed system gave 16.7% increase over the flat system at Jalgoan. Variety SBX1 also gave 18.2% increase over flat seed bed. At Junagadh, groundnut variety ICGS-44 grown on raised bed gave 23.6% increase over flat system while variety GG2 gave a 19.9% increase. At Jagtial, groundnut variety ICGS-11 gave 21.9% yield increase over flat bed (CRIDA, 1990).

Rao et. al., (1991) found that the dry mater, number of effective pods $plant^{-1}$ and shelling percentage of groundnut variety ICGS-11 were significantly higher in BBF than in flat seed bed. Broad bed and furrow contributed to 21.9% more yield than the flat seed bed (2912 kg ha^{-1}).

In yield maximization trials, it was found that raised bed and furrows resulted in overall mean yield increase in groundnut of 11% over flat seed bed (2142 kg ha^{-1}) during the post-rainy season at different locations (LEGOFTEN, 1991). This may be due to favourable soil physical environment created in raised beds facilitating easy peg penetration and pod development.

CHAPTER III
MATERIALS AND METHODS

CHAPTER III

MATERIALS AND METHODS

3.1 Experimental site and soil

The experiment was conducted during the 1991-92 postrainy season under irrigated conditions on plot RCE10, at the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) Center, Patancheru, Andhra Pradesh. The site is situated at an altitude of 545 meters above the mean sea level. Its geographical bearing is 18°N and 78°E.

3.2 Weather conditions

Patancheru is situated in the semi-arid tropical belt. The average annual rainfall is 760 mm. Meteorological data pertaining to rainfall, minimum and maximum temperature, relative humidity and hours of sunshine recorded during the period of the experiment are presented in Appendix I & Fig. 1. The mean maximum and minimum temperatures during the period of crop growth ranged from 39.1°C to 26.8°C and 23.5°C to 10.1°C respectively. The mean relative humidity at 7.14 hours and 14.16 hours during the period of crop growth ranged from 46.6% to 95.4% and 15.3% to 67.3% respectively. The mean sunshine hours varied from 1.6 to 9.7 hours.

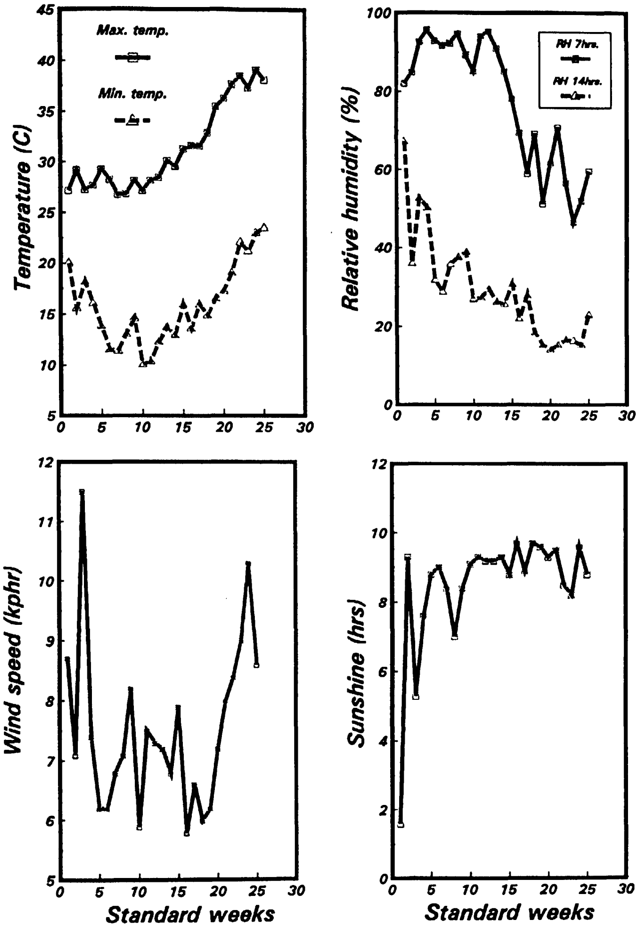

Fig. 1 Weekly mean meteorological data during crop growth period

3.3 Soil

The experiment was conducted on an Alfisol which is a reddish brown soil derived from pink granites and belong to the isohyperthermic family of Udic Rhodustalf (USDA), Soil Taxonomy, 1975). They are medium deep, well drained sandy loam to sandy clay loam at the surface, occurring on nearly flat to gently undulating uplands. The dominant clay mineral is kaolinite with varying but small proportions of 2:1 clay minerals and sesquioxides. They usually contain well defined gravel and weathered rock fragments at lower depths in the profile. They are unstable in structure, thus slaking when wet, compacting when dry and have inherently low water holding capacity.

3.4 Previous Crop History

Details of the cropping history of the experimental field during the preceding 2 years are presented in Table 1.

Table 1. Previous crop history

Year	Season	Crop
1989-90	Rainy	Pigeonpea + Groundnut
	Post rainy	Fallow
1990-91	Rainy	Pearl Millet + Pigeonpea + Groundnut
	Post rainy	Groundnut

3.5 Preparation of the field

The field was ploughed with a tractor drawn disc plough, then worked with a tractor drawn cultivator and smoothened.

3.6 Lay out of the experiment

The experiment consisted of six treatments which were laid out in a simple randomized block design and replicated four times. The field was divided into 24 plots. The treatments were allotted at random in different plots of each replication as given in Fig. 2.

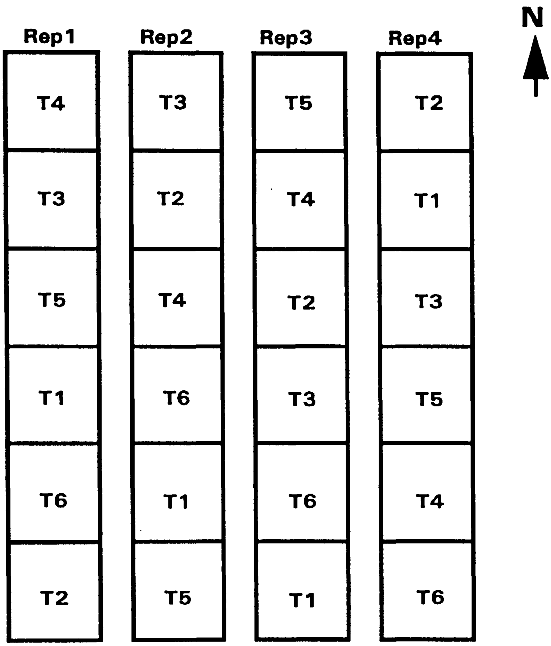

Fig.2 Lay out plan of the experiment

Treatments

T1 : Variety ICG (FDRS) 10 sown on gently sloping flat seed bed

T2 : Variety ICG (FDRS) 10 on narrow ridges of 30 cm

T3 : Variety ICG (FDRS) 10 on Broadbed and furrow (BBF)

T4 : Variety ICGS-11 sown on gently sloping flat seed bed

T5 : Variety ICGS-11 on narrow ridges of 30 cm

T6 : Variety ICGS-11 on BBF

Plot Size : 8 m x 5 m

Plant Spacing : 30 x 10 cm

Ridges of 30 cm were made manually. Broad bed and furrow of 1.5 meters width were made with bullock drawn tropiculture.

3.7 Characterization of the experimental field

Composite soil samples collected at random from the field prior to sowing of the crop from 3 depths i.e., 0-15 cm, 15-30 cm and 30-45 cm, were analysed for physical and chemical properties as described below. The results are presented in Table 2 and Figure 3.

3.7.1 Physical Properties

3.7.1.1 Particle size analysis

Mechanical composition of the soil was determined for the soil depths of 0-15 cm, 15-30 cm and 30-45 cm using Bouyoucos

Table 2 : Major properties of an Alfisol at the experimental site, ICRISAT Center

Physical properties	Depth of soil		
	(0-15 cm)	(15-30 cm)	(30-45 cm)
PARTICLE SIZE DISTRIBUTION			
1) Sand (%)	66.7	58.3	52.2
2) Silt (%)	9.8	11.3	13.8
3) Clay (%)	23.6	30.3	34.0
CHEMICAL PROPERTIES			
1) PH (1:2.5 water suspension)	7.0	7.0	6.7
2) EC (dSm^{-1}) (1:2.5 water suspension)	0.7	0.7	0.8
3) Organic carbon (%)	0.5	0.5	0.5
4) Available Nitrogen (ppm)	5.0	4.3	4.8
5) Available P (ppm)	6.0	3.2	0.5
6) Available K (ppm)	142.0	109.0	107.0
7) Exchangeable Ca (ppm)	1304.0	1978.0	2348.0
8) Exchangeable Mg (ppm)	292.0	342.0	370.2
9) Exchangeable Na (ppm)	81.0	79.4	83.6
10) Cation exchange capacity (CEC) meq/100 g	7.2	15.8	18.6

Note : $\frac{ppm}{Eq.wt}$ = meq/lt

hydrometer method (Bouyoucos, 1962) in a constant temperature room maintained at 20° ± 2° C. To 80g of soil, 100 ml of sodium hexametaphosphate solution was added, stirred and kept overnight. The following day, the soil together with the solution was stirred by a mechanical stirrer and transferred to a 1 litre jar. The volume was made upto the 1 litre mark. The jar was shaken by turning end-over-end manually for 60 seconds. The first hydrometer reading was taken at 90 seconds. Subsequent hydrometer readings were taken at 2, 3, 6, 16, 31, 61 minutes and 2, 4 and 8 hours. Thereafter, the contents were transferred to a 75 micron sieve, washed, dried in an oven and weighed. The samples were sieved through a set of sieves of size 1 mm, 500 micron, 212 micron and 100 micron and the sand, silt and clay percentages calculated.

3.7.1.2 Moisture characteristics of the soil

Moisture contents at different pressures, namely 1/3, 1, 5, 10 and 15 bars were determined for the soil layers of 0-15 cm, 15-30 cm, 30-45 cm using a pressure plate apparatus in a constant temperature room maintained at 20°C ± 2° C. The soil samples were prewetted for 1 day on pressure plates that have pore entry pressure greater than the required equilibrating pressure. They were then transferred together with the pressure plate into the pressure plate apparatus and the pressure was raised gradually until the required predetermined pressure was reached. The apparatus was left until

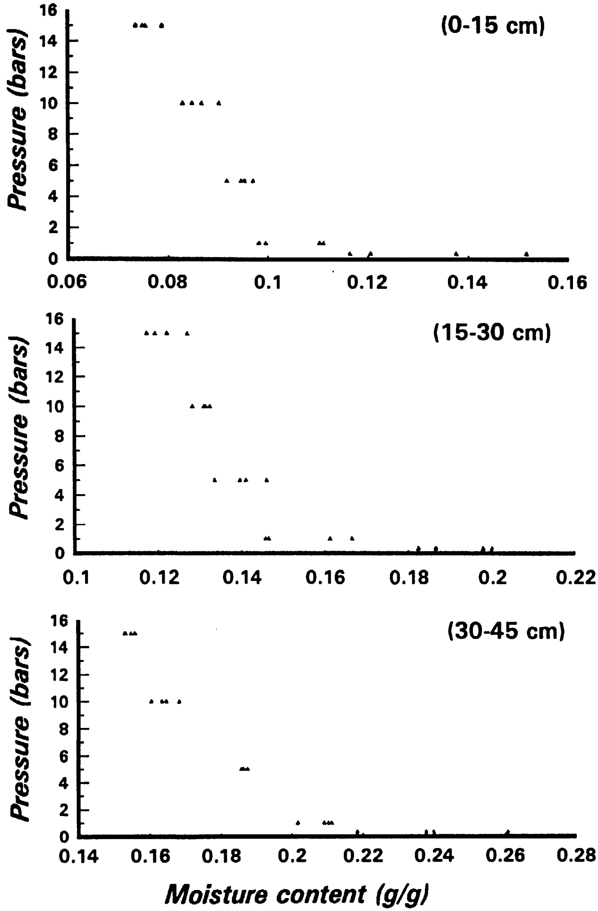

Fig.3 Moisture characteristics of the experimental soil

equilibrium between water in the soil sample and the air pressure was obtained. This was achieved in about 3 days when the outflow from the pressure membrane apparatus ceased.

3.7.2 Soil chemical analysis

Soil samples collected from 0-15, 15-30 and 30-45 cm soil depths were constituted into composite samples and used for chemical analysis.

3.7.2.1 Soil reaction (pH)

The pH of the soil was determined using 1:2.5 soil to water extract and a systronix pH meter (model 335) with glass electrodes as described by Mclean (1982). Triplicate samples of 5 g of air dry soil were weighed and 10 ml deaerated distilled water was added and shaken with a rotary shaker for 1 hour. The pH electrode was immersed in the supernatant solution and the readings were noted.

3.7.2.2 Electrical conductivity (EC)

The electrical conductivity of the soil was determined using 1:2.5 soil to water extract and an electrical conductivity meter (Elico Model EM 88) as described in the method given by Richards et al. (1954). Triplicate samples of 5 g of air dry soil were weighed and 10 ml of deaerated distilled water was added, shaken with a rotary shaker for 1 hour, filtered and the electrical conductivity of the filtrate measured by immersing the electrode of the EC meter in the filtrate and the readings noted.

3.7.2.3 Organic carbon

The organic carbon content of the soil was estimated as described by Nelson and Sommers (1982). To 10 g of air dry soil, 10 ml of 1 N $K_2 Cr_2 O_7$ solution was added and the contents were swirled gently to disperse the soil in the solution. Then 20 ml of Conc. $H_2 SO_4$ was added rapidly. After thorough shaking of the contents, the flask was allowed to stand on asbestos sheet for 30 minutes. Then 3 to 4 drops of phenanthroline indicator were added and the solution was titrated against 0.5 N Fe SO_4, until the end point of dark green colour was achieved. Organic carbon percentage was determined using the formula,

$$\text{Organic Carbon (\%)} = \frac{(\text{meq } K_2Cr_2O_7 - \text{meq Fe } SO_4)\ (0.003)\ (100)}{\text{Weight of the soil}} \times f$$

where the correction factor $f = 1.3$

3.7.2.4 Available Nitrogen

Available Nitrogen content of the soil was determined using potassium chloride as given by Keeney and Nelson (1982). To 10 g of soil samples placed in 250 ml wide mouth bottle, 100 ml of 2 M potassium chloride (KCl) was added and the contents were shaken on a mechanical shaker for 1 hour. The soil-KCl suspension was allowed to settle until the supernatant liquid was clear. Aliquots of the supernatant liquid were taken and 2-3 drops of boric acid indicator was added. The available N was determined by titrating against standard sulphuric acid until the end point was reached.

3.7.2.5 **Available Phosphorus**

Available phosphorus content of the soil was determined by the method of Olsen and Sommers (1982) using a Klett-Summerson photoelectric colorimeter. One gram of soil was placed into an extraction bottle and 7 ml. of extracting solution (0.03 N NH_4F + 0.25N Hcl) were added. The contents were shaken for 1 minute and filtered through Whatman number 42 filter paper. Five millilitres of distilled water and 2 ml. of ammonium paramolybdate solution were added to 2 ml of the filtrate and the contents were mixed thoroughly. Then 1 ml of Stannous chloride was added and the solution was mixed again. After 5 minutes, the colour was measured photometrically using 660 μm incident light. The concentration of available P was calculated as follows :

ppm of P in Soil = ppm of P in solution X 35 (1)

3.7.2.6 Available Potassium

Available potassium content of the soils was extracted with 1 N neutral ammonium acetate solution and potassium in the extractant was determined by a flame photometer as described by Knudsen et. al (1982). Samples of 10 g. of soil were placed in 50 ml. centrifuge tube, to which 25 ml of ammonium acetate (NH_4OAc) was added and the tube shaken for 10 minutes. The tube was centrifuged until the supernatant liquid was clear. The supernatant liquid was decanted into a 100 ml. volumetric flask. Three additional extractions were made in a similar manner. The combined extracts were diluted to 100 ml. with NH_4OAc, mixed thoroughly and the potassium was determined by flame photometer using 766.5 mm incident light.

3.7.2.7 Exchangeable sodium, calcium and magnesium

Exchangeable Na, Ca and Mg of the soil samples were determined as described by Thomas (1982). Samples of 10 g. soil were placed in 250 ml. flask to which 25 ml. of 1 N ammonium acetate was added. The solution was filtered through Whatman number 1 filter paper and the concentration of Na, Ca and Mg was determined by using the Atomic Absorption Spectrophotometer.

3.8 Application of Fertilizers

Fertilizers were applied at the rate of 60 kg ha^{-1} in the form of single superphosphate and 500 kg ha^{-1} of gypsum (24.2% Ca and 18.5% S). The entire quantity of single superphosphate was applied as a basal dose before sowing. Gypsum was applied 50 days after sowing in bands 5 cm away from the seed row at a depth of 5 cm.

3.9 Crop

Groundnut varieties ICGS-11 and ICG(FDRS) 10 were used in the study. ICGS-11 is a spanish selection and has dark green foliage, small to medium-sized two-seeded pods with tan-coloured seed, about 48% oil, and a 70% shelling turnover. It is tolerant to bud necrosis disease under field conditions. The growth duration is 130-135 days.

ICG (FDRS) 10 is a sequentially flowering bunch type. It has 2-seeded pods, tan-coloured medium sized seeds, 48% oil, and a shelling turnover of 68-69%. It has high resistance to rust and moderate resistance to late leaf spot. It shows less susceptibility to bud necrosis disease, peanut mottle virus, stem rot and leaf miner attack. The growth duration is 125-130 days.

3.10 Seeds and Sowing

Bold and healthy pods were selected for seeding. After shelling, the bold kernels were selected and treated with

Dithane M-45 at the rate of 3 g kg^{-1} seed to avoid seed borne diseases. The seeds were sown at a depth of 5 cm keeping a distance of 10 cm between 2 plants and 30 cm between two rows by tractor drawn vacuum planter on 4th November, 1991. Gap filling was done 10 days after sowing to maintain a uniform plant stand in all the treatments.

3.11 Intercultural and Plant Protection Operations

Immediately after sowing paraquat weedicide was applied to control weeds. Hand weeding was done twice after sowing. As a prophylactic measure, Rogor was sprayed at the rate of 2 ml L^{-1} at 60 days after sowing against sucking pests.

3.12 Irrigation

A 30 mm irrigation was applied to the field soon after the seeds were sown to achieve uniform and maximum germination of seeds. Subsequently, 10 irrigations of 24, 25, 27, 29, 28, 24, 26, 26, 24 and 29 mm respectively were given at 50% of soil moisture depletion using sprinklers.

3.13 Groundnut plant growth and yield

For preharvest observations, five plants which are representative of that plot were used for the following determinations :

3.13.1 Leaf area of plant

Leaf area per plant was measured at 50 days after sowing (DAS) from the plant samples collected using LI, 3100 leaf area meter. Leaves were separated from the plant and were placed individually on the leaf conveyor belt, and leaf area recorded in cm^2.

3.13.2 Dry matter production

Dry matter production per plant was determined at 50 DAS. The plant samples were dried in hot air oven maintained at 60°C until a constant weight was obtained.

3.13.3 Yield

In order to determine the proportion of pods remaining in soil in different treatments during harvesting, plants were pulled without wetting the soil. Later the pods left in the soil were carefully hand-picked. Pods obtained from the net plot area were sun dried until a constant weight was obtained. The pod yields were recorded plot-wise and expressed in kg ha^{-1}.

3.13.4 Haulm yield

Haulm yield obtained from the net plot area was dried to a constant weight and expressed in kg ha^{-1}.

3.14 Soil Physical Parameter

Soil samples were collected at 30 DAS, 60 DAS, pegging stage (90 DAS) and before harvesting of the crop (150 DAS), from each treatment from 0-5 cm, 5-10 cm, 10-15 cm and 15-30 cm depth. Soil moisture was determined as described in section 3.16.2. Bulk density and total porosity were determined during different stages of crop growth for the soil depth of 0-15 cm. Penetration resistance was determined for the 0-5 cm, 5-10 cm and 10-15 cm horizons. Oxygen content was determined for the same soil depths as for the penetration resistance. Similarly soil temperature was monitored for all the three soil depths i.e., 0-5 cm, 5-10 cm and 10-15 cm.

3.14.1 Bulk density

Bulk density defined in equation 2 was determined at 30 DAS, 60 DAS at the pegging stage 90 (DAS) and at the time of harvest of the crop 145 (DAS) in all the plots using a bulk density sampler described in the procedure given by Dakshinamurthy and Gupta (1967). The core sampler was driven into the soil upto a depth of 15 cm by slipping the small diameter rod of the cylindrical hammer down into the handle of the sampler, which acts as guide for the hammer. The large end of the hammer was then simply lifted and dropped to drive the barrel of the sample into the soil. The sampler was then removed from the soil and the barrel of the sampler holding the soil retaining cylinders was unscrewed from the cap. The sampler retaining cylinders were pushed out with the core extractor and was trimmed. The core sample was dried in an oven at 105°C for 24 hours and weighed. The volume of soil core was determined by measuring the diameter and height of the core.

$$\rho_b = M_s/V_t \qquad (2)$$

where, ρ_b = Bulk density (g cm^{-3})

M_s = Mass of oven dry soil (g)

V_t = Total volume of the soil (g)

3.14.2 **Total porosity**

Total porosity of 0-15 cm soil layer was determined at 30, 60, 90 and 145 DAS using the equation 3. Particle density was determined using pycnometer as per the procedure given by Blake and Hartage (1982) using the following formula.

$$\rho_p = Ms/Vs$$

where, ρ_p = Particle density (g cm^{-3})

M_s = Mass of solids (g)

V_s = Volume of solids (g)

$$f = 1 - \rho_b/\rho_p \qquad (3)$$

where, f = Total porosity

ρ_p = Particle density (g cm^{-3})

ρ_b = Bulk density (g cm^{-3})

3.14.3 Soil moisture

Soil moisture content (θ_g) defined in equation (4) and was determined on soil samples taken from 0-5 cm, 5-10 cm, 10-15 cm, and 15-30 cm depth at 30 and 35 DAS, 60 and 65 DAS, pegging stage (90 and 95 DAS) and harvesting (145 and 150 DAS). Gravimetric water content was determined, one day after irrigation and 5 days after irrigation at different stages of crop growth using equation 4. These soil samples were weighed, ovendried at 105°C for 24 hours and then reweighed to calculate the mass of water and oven dry soil and therefore the water content.

$$\theta_g = \frac{M_a - M_s}{M_s} \qquad (4)$$

M_a = Mass of air dry soil (g)

M_s = Mass of oven dry soil (g)

3.14.4 Moisture Suction

Matric suction was determined on soil samples collected at 0-5 cm, 5-10 cm and 10-15 cm using the filter paper method described by Greacen, et. al., (1987). Sampling cores were driven into the soil upto the required depth and carefully pulled out with the soil intact in them. The soil held in the cores was trimmed at the ends and then pushed out with a wooden core extractor. The soil core was divided into two halves and four Whatman number 42 filter papers were placed in between the two half halves which were carefully pressed together, restored in the core sampler and sealed with sello tape. The cores were kept for one week to allow the soil moisture to equilibrate with the filter paper. After one week, the soil and the two middle filter papers from the cores were quickly removed and weighed separately on an electronic balance. They were then dried in an oven at 105°C for 24 hours and reweighed to obtain their oven dry weights. The moisture contents of the filter paper and the soil were calculated. Using the moisture content of the filter paper, the suction was inferred from the following regression equation of Greacen et. al., (1987).

$$S = -3.095 F + 5.553 \quad (5)$$

where S = matric suction (kPa)

F = gravimetric moisture content of the filter paper

3.14.5 Penetration Resistance

Penetration resistance was determined with the proctor ring cone penetrometer of dimensions 2.8 cm diameter and 5 cm height at the soil depths of 0-5 cm, 5-10 cm and 10-15 cm at

30 and 35 DAS, 60 and 65 DAS, pegging stage (90 and 95 DAS) and before harvesting at 145 and 150 DAS in both wet and dry moisture ranges. The penetrometer was held in a vertical position on the soil and pressure was applied, controlling the rate of penetration by steadying the arms against the front of the legs and the readings were taken. The results were expressed in kg/cm^2.

3.14.6 Soil temperature

Soil temperature was determined at the 0-5 cm, 5-15 cm and 15-25 cm depths in all the treatments daily using a copper-constantin thermocouple wire and Campbell Micrologger 21X.

3.14.7 Oxygen content

Oxygen collecting tubes which allows air to enter but not water were installed at 0-5 cm, 5-10 cm and 10-15 cm depth. Oxygen contained in the tubes was siphoned using disposable syringes and the oxygen was analysed using LC700 FV2-1 oxygen analyzer.

3.15 Statistical Analysis

The experimental data were analyzed statistically by the technique of analysis of variance given by Gomez and Gomez (1984). Statistical significance was tested by F value at 0.05 level of probability. Critical differences were calculated for testing the significance. The results were further depicted by graphical representation.

CHAPTER IV
RESULTS

CHAPTER IV

RESULTS

The effect of different land configurations viz. broadbed and furrow, ridges and flat on the soil physical properties viz. bulk density, porosity, soil moisture, matric potential, penetration resistance, oxygen content and soil temperature are presented in Tables from 1 to 17 and Figures 4 to 16. The effect of different land configurations on groundnut leaf area, dry matter, pod yield and haulm yield are shown in Tables 18 to 20 and Figures 17 to 20.

4.1 Effect of surface configurations on soil physical conditions

4.1.1 Bulk density

Throughout the growing season the bulk density of 0-15 cm soil layer was significantly lower in BBF than in the ridges and the flat treatment in that order for both the groundnut varieties viz. ICG(FDRS)10 and ICGS 11 (Figure4). Differences in bulk density between the treatments persisted at 30, 60, 90 and 145 DAS. Lowest bulk densities of 1.37, 1.43, 1.45 and 1.48 g cm^{-3} were recorded in BBF while the highest densities of 1.61, 1.64, 1.65 and 1.69 g cm^{-3} were recorded in flat at 30, 60, 90 and 145 DAS respectively for groundnut variety ICG(FDRS)10. Similar results were obtained for variety ICGS-11.

Table 3 : Bulk density of the soil as influenced by different land surface configurations

Treatments	Variety	Bulk density g cm^{-3}			
		Days after sowing			
		30	60	90	145
Flat	ICG(FDRS) 10	1.61	1.64	1.65	1.69
Ridges	ICG(FDRS) 10	1.48	1.53	1.54	1.56
BBF	ICG(FDRS) 10	1.37	1.43	1.45	1.48
Flat	ICGS 11	1.64	1.66	1.67	1.74
Ridges	ICGS 11	1.53	1.56	1.60	1.62
BBF	ICGS 11	1.45	1.46	1.47	1.48
Mean		1.51	1.55	1.56	1.59
S.Ed (±)		0.0312	0.0286	0.0219	0.0298
C.D (0.05)		0.06	0.06	0.04	0.06

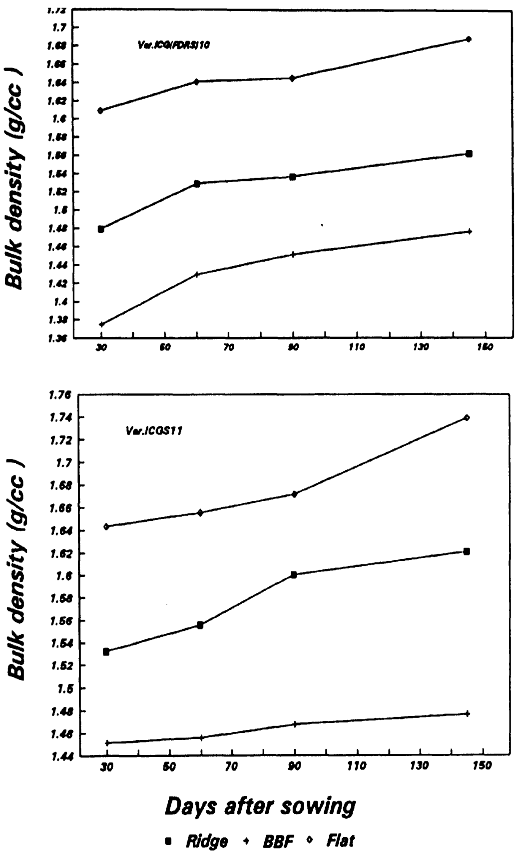

Fig.4 Bulk density of 0-15 cm layer in three land configurations on an Alfisol

Table 4 : Total porosity of the soil as influenced by different land surface configurations

Treatments	Variety	Total Porosity (%) Days after sowing			
		30	60	90	145
Flat	ICG(FDRS) 10	37	36	35	34
Ridges	ICG(FDRS) 10	42	40	40	39
BBF	ICG(FDRS) 10	46	44	43	42
Flat	ICGS 11	36	35	34	32
Ridges	ICGS 11	40	39	37	36
BBF	ICGS 11	43	43	42	42
Mean		40	39	38	37
S.Ed (±)		0.87	0.79	0.61	0.83
C.D (0.05)		1.3	0.90	1.6	1.3

4.1.2 Total porosity

The results presented in Table 4 shows that the total porosity of the soil was significantly higher in BBF compared to ridges and flat. The total porosity in BBF at 30, 60, 90, 145 DAS were higher by 9, 8, 8 and 8 percent respectively compared to flat and by 4, 4, 3 and 3 percent respectively compared to ridges with variety ICG(FDRS) 10. Similar trend in porosity was observed for the variety ICGS 11.

4.1.3 Soil moisture

The soil moisture content observed in the soil layers of 0-5, 5-10, 10-15 and 15-30 cm are given in Tables 5 to 8 and shown in Figures 5 to 12.

The data indicated that soil moisture retention determined at 30, 35, 60, 65, 90, 95, 145 and 150 DAS had increased with the soil depth in all the treatments. Broad bed and furrow increased the soil moisture retention followed by ridges and flat for the two varieties of groundnut ICG(FDRS)10 and ICGS 11. In all the treatments depletion of soil moisture from 5-10 cm layer was found to be more followed by 0-5 cm layer. All the treatments retained more moisture in 15-30 cm layer followed by 10-15 cm layer.

Table 5 : Soil moisture content of 0-5 cm layer as influenced by land surface configurations during various stages of crop growth

Treatments	Variety	Moisture Content (gg^{-1})							
		Days after sowing							
		30	35	60	65	90	95	145	150
Flat	ICG(FDRS)10	0.141	0.078	0.121	0.047	0.120	0.046	0.099	0.042
Ridges	ICG(FDRS)10	0.155	0.089	0.150	0.055	0.147	0.056	0.120	0.053
BBF	ICG(FDRS)10	0.184	0.100	0.155	0.068	0.162	0.066	0.125	0.053
Flat	ICGS 11	0.112	0.101	0.127	0.063	0.135	0.055	0.088	0.032
Ridges	ICGS 11	0.128	0.105	0.142	0.064	0.146	0.057	0.102	0.040
BBF	ICGS 11	0.149	0.108	0.144	0.068	0.156	0.063	0.117	0.054
S.ED (±)		0.010	0.006	0.010	0.009	0.016	0.010	0.005	0.012
C.D. (0.05)		0.021	0.013	0.021	0.019	0.035	0.021	0.011	0.026

Table 6 : Soil moisture content of 5-10 cm layer as influenced by land surface configurations during various stages of crop growth

Treatments	Variety	Moisture Content (gg^{-1})							
		Days after sowing							
		30	35	60	65	90	95	145	150
Flat	ICG(FDRS)10	0.176	0.091	0.128	0.061	0.141	0.054	0.100	0.050
Ridges	ICG(FDRS)10	0.180	0.113	0.161	0.067	0.157	0.078	0.124	0.075
BBF	ICG(FDRS)10	0.195	0.131	0.172	0.078	0.167	0.085	0.125	0.084
Flat	ICGS 11	0.145	0.122	0.148	0.076	0.143	0.068	0.090	0.041
Ridges	ICGS 11	0.152	0.128	0.153	0.076	0.160	0.069	0.104	0.059
BBF	ICGS 11	0.176	0.143	0.154	0.090	0.163	0.075	0.119	0.060
S.ED (±)		0.012	0.004	0.015	0.011	0.008	0.009	0.007	0.015
C.D. (0.05)		0.025	0.009	0.033	0.023	0.018	0.020	0.015	0.031

Table 7 : Soil moisture content of 10-15 cm layer as influenced by land surface configurations during various stages of crop growth

Treatments	Variety	Moisture Content (gg^{-1})							
		Days after sowing							
		30	35	60	65	90	95	145	150
Flat	ICG(FDRS)10	0.198	0.110	0.138	0.068	0.146	0.054	0.118	0.072
Ridges	ICG(FDRS)10	0.204	0.122	0.170	0.096	0.162	0.080	0.130	0.099
BBF	ICG(FDRS)10	0.210	0.162	0.174	0.099	0.175	0.101	0.152	0.106
Flat	ICGS 11	0.168	0.131	0.155	0.079	0.153	0.070	0.094	0.057
Ridges	ICGS 11	0.185	0.134	0.162	0.083	0.165	0.075	0.116	0.077
BBF	ICGS 11	0.195	0.160	0.163	0.098	0.172	0.076	0.128	0.087
S.ED (±)		0.009	0.007	0.009	0.013	0.013	0.009	0.014	0.015
C.D. (0.05)		0.020	0.016	0.020	0.028	0.027	0.020	0.030	0.032

Table 8 : Soil moisture content of 15-30 cm layer as influenced by land surface configurations during various stages of crop growth

Treatments	Variety	Moisture Content (gg^{-1})							
		Days after sowing							
		30	35	60	65	90	95	145	150
Flat	ICG(FDRS)10	0.215	0.133	0.141	0.116	0.149	0.065	0.127	0.101
Ridges	ICG(FDRS)10	0.215	0.173	0.185	0.119	0.166	0.117	0.147	0.107
BBF	ICG(FDRS)10	0.216	0.177	0.186	0.131	0.196	0.132	0.167	0.108
Flat	ICGS 11	0.184	0.159	0.158	0.093	0.167	0.113	0.103	0.079
Ridges	ICGS 11	0.191	0.167	0.164	0.099	0.172	0.115	0.132	0.101
BBF	ICGS 11	0.207	0.170	0.173	0.112	0.175	0.118	0.154	0.106
S.ED (±)		0.009	0.006	0.011	0.013	0.013	0.010	0.013	0.014
C.D. (0.05)		0.020	0.013	0.023	0.029	0.028	0.022	0.029	0.030

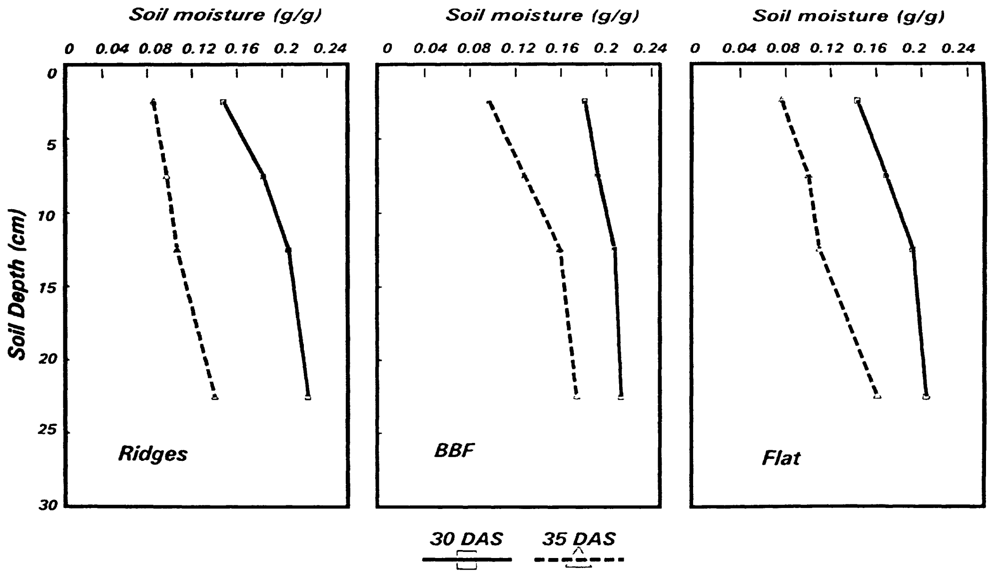

Fig.5 Moisture content as influenced by land configurations with variety ICG(FDRS)10 at 30 and 35 DAS

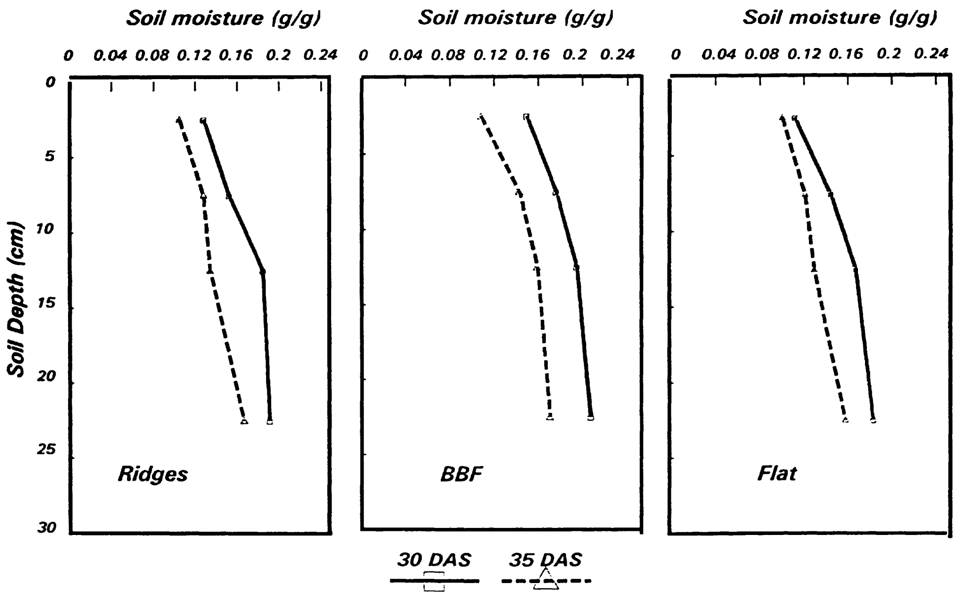

Fig. 6 Moisture content as influenced by land configurations with variety ICGS11 at 30 and 35 DAS

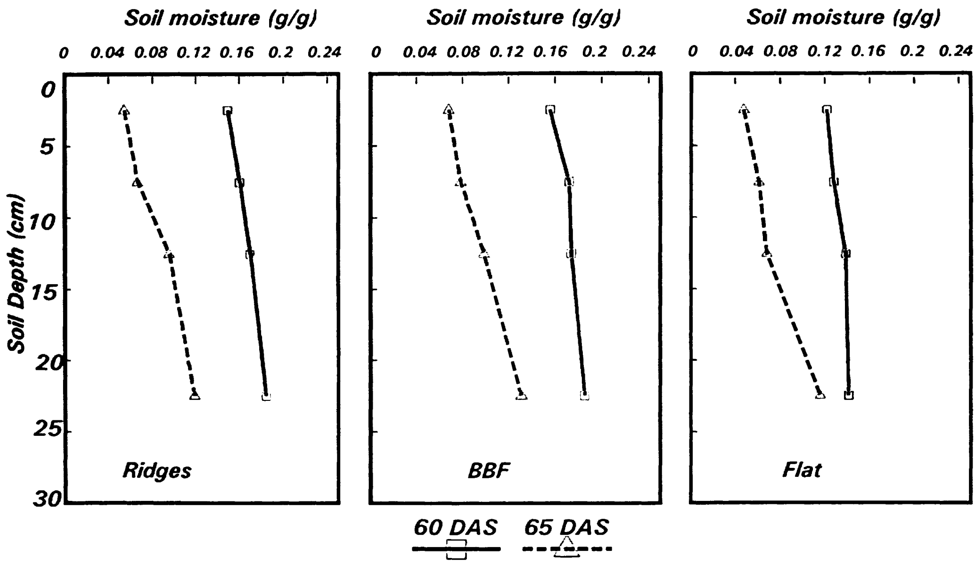

Fig. 7 Moisture content as influenced by land configurations with variety ICG(FDRS)10 at 60 & 65 DAS

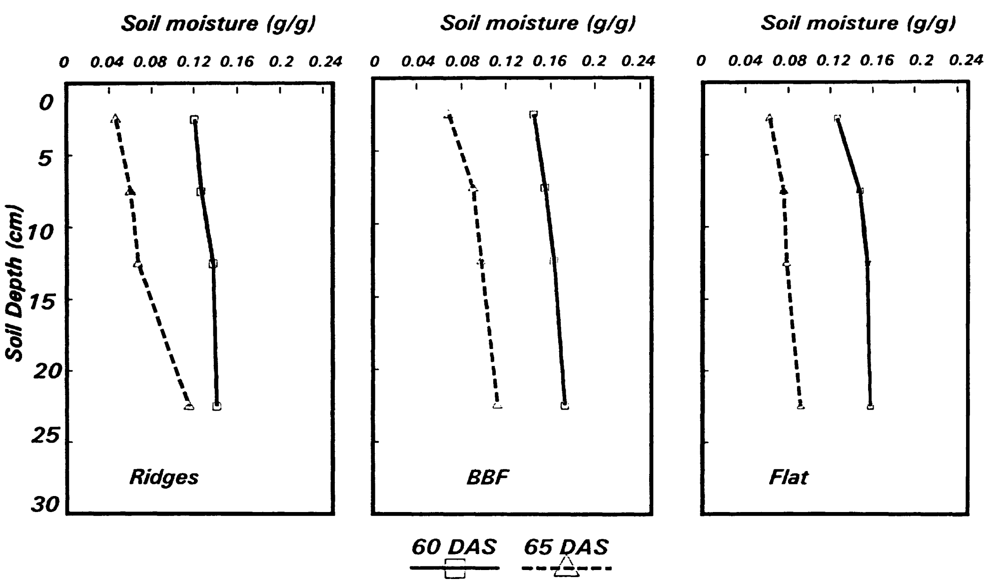

Fig.8 Moisture content as influenced by land configurations with variety ICGS 11 at 60 & 65 DAS

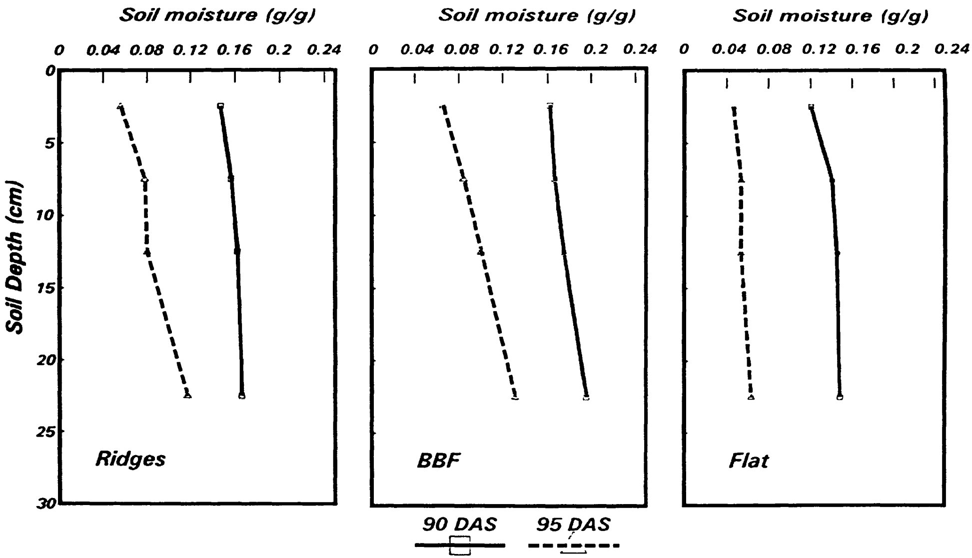

Fig.9 Moisture content as influenced by land configurations with variety ICG(FDRS)10 at 90 and 95 DAS

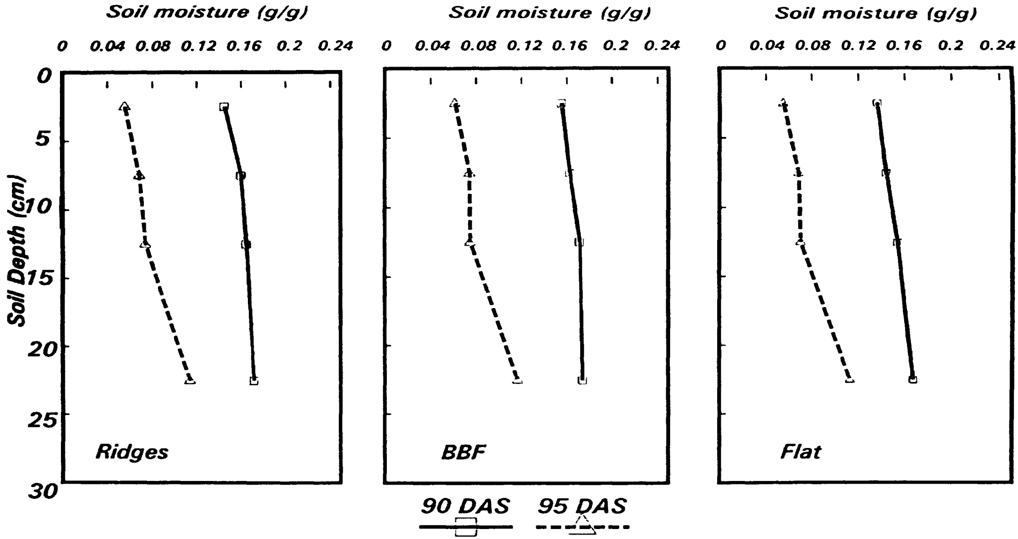

Fig. 10 Moisture content as influenced by land configurations with variety ICGS 11 at 90 and 95 DAS

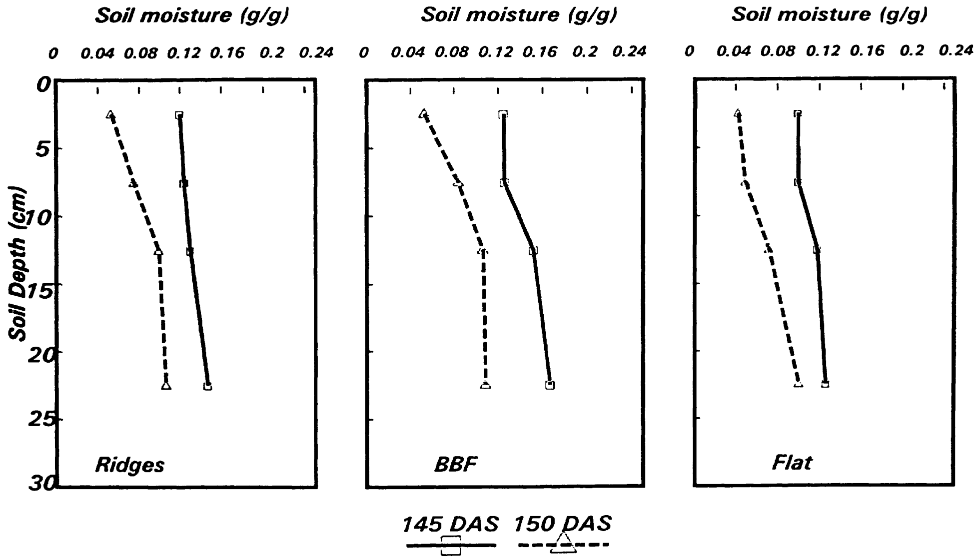

Fig. 11 Moisture content as influenced by land configurations with variety ICG(FDRS)10 at 145 & 150 DAS

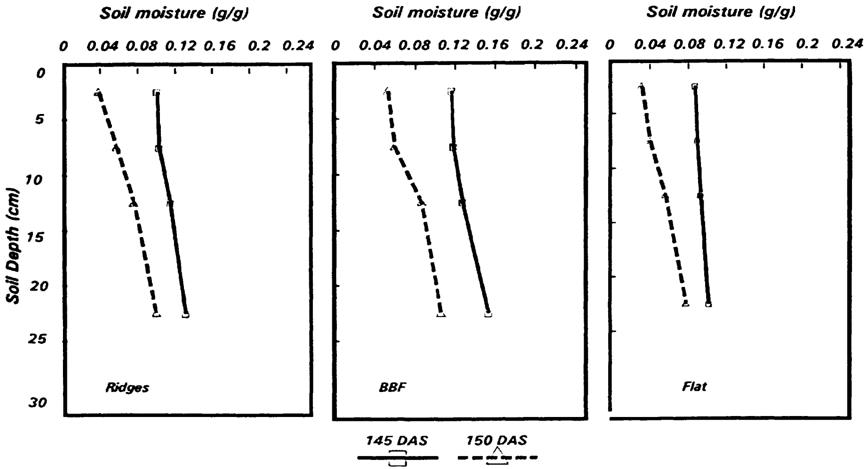

Fig. 12 Moisture content as influenced by land configurations with variety ICGS 11 at 145 & 150 DAS

4.1.4 Matric suction

The values of matric suction observed in the soil layers of 0-5, 5-10 and 10-15 cm are presented in Tables 9 to 11.

The results recorded in the above tables clearly show that the matric suction had decreased with the soil depth in all the treatments. It was observed that the values of matric suction in the BBF was significantly lower than in the ridges and flat at the depths of 0-5, 5-10 and 10-15 cm at 30, 35, 60, 65, 90, 95, 145 and 150 DAS. The matric suction of 0-5 cm soil layer at 30 DAS was 13.87, 24.90 and 43.73 kpa in BBF, ridges and flat respectively which at 35 DAS had increased to 41.77, 55.14 and 70.86 kPa in the above treatments with variety ICG(FDRS)10. Similar results were observed in the variety ICGS 11. At 5-10 cm depth, matric suction was lower than at 0-5 cm in all the treatments. The matric suction of 5-10 cm soil layer at 30 and 35 DAS was lowest in BBF (9.03 and 24.25 kPa respectively) as compared to the flat seed bed which recorded highest matric suction (24.22 and 52.57 kPa respectively) for the variety ICG(FDRS)10. Similar trend was observed in the variety ICGS 11.

4.1.5 Penetration resistance

The penetration resistance recorded from different land configurations are given in Tables 12 to 14. At the beginning of the season (30 DAS) the differences in penetration resistance

Table 9 : Effect of land surface configurations on moisture suction (kPa) of 0-5 cm layer during various stages of crop growth

Treatments	Variety	Moisture Suction (kPa)							
		Days after sowing							
		30	35	60	65	90	95	145	150
Flat	ICG(FDRS)10	43.7	70.9	106.2	200.1	35.6	98.3	69.0	140.5
Ridges	ICG(FDRS)10	24.9	55.1	80.4	143.5	24.0	83.5	52.1	126.1
BBF	ICG(FDRS)10	13.9	41.8	27.4	135.5	9.7	77.5	20.7	96.8
Flat	ICGS-11	59.1	75.5	153.4	206.5	51.7	130.6	77.8	148.8
Ridges	ICGS-11	31.0	57.8	90.0	149.6	26.6	86.1	62.4	136.0
BBF	ICGS-11	16.2	46.7	37.7	138.3	17.9	81.9	29.9	106.5
S.Ed (±)		1.8	1.5	7.2	0.8	2.7	0.4	2.4	1.3
C.D. (0.05)		3.9	3.2	15.3	1.8	5.7	1.0	5.1	2.7

Table 10 : Effect of land surface configurations on moisture suction (kPa) of 5-10 cm layer during various stages of crop growth

Treatments	Variety	Moisture Suction (kPa)							
		Days after sowing							
		30	35	60	65	90	95	145	150
Flat	ICG(FDRS)10	24.2	52.6	99.3	137.5	25.5	97.3	56.2	131.3
Ridges	ICG(FDRS)10	14.9	39.8	72.3	136.0	15.5	81.7	38.1	108.9
BBF	ICG(FDRS)10	9.0	24.2	23.1	113.0	8.2	71.9	15.0	92.4
Flat	ICGS-11	26.9	55.4	136.7	137.0	40.2	98.4	61.7	137.3
Ridges	ICGS-11	15.3	44.3	78.4	134.2	17.2	85.2	47.2	123.5
BBF	ICGS-11	12.2	31.1	32.9	123.2	12.8	80.4	24.8	95.7
S.Ed (±)		1.2	2.4	7.3	1.1	2.2	0.5	2.2	1.6
C.D. (0.05)		2.6	5.0	15.6	2.3	4.8	1.1	4.7	3.5

Table 11 : Effect of land surface configurations on moisture suction (kPa) of 10-15 cm layer during various stages of crop growth

Treatments	Variety	Moisture Suction (kpa)					
		Days after sowing					
		60	65	90	95	145	150
Flat	ICG(FDRS)10	75.6	129.1	14.4	80.8	42.1	116.7
Ridges	ICG(FDRS)10	47.8	123.7	8.4	76.2	35.3	96.6
BBF	ICG(FDRS)10	19.5	111.8	5.1	68.9	13.3	82.0
Flat	ICGS-11	96.0	128.7	15.1	80.8	57.4	126.6
Ridges	ICGS-11	56.5	126.0	11.5	79.0	37.3	111.2
BBF	ICGS-11	27.9	116.9	7.6	72.4	21.0	87.9
S.Ed (±)		2.6	1.0	0.6	0.5	1.6	2.3
C.D. (0.05)		5.5	2.1	1.4	1.1	3.4	5.0

Table 12 : Penetration resistance of 0-5 cm soil layer as influenced by land surface configurations during various stages of crop growth

Treatments	Variety	Penetration Resistance (kg cm^{-2})							
		Days after sowing							
		30	35	60	65	90	95	145	150
Flat	ICG(FDRS)10	2.3	11.7	6.4	37.9	4.9	18.0	16.9	50.6
Ridges	ICG(FDRS)10	1.8	10.5	3.8	17.3	4.0	9.5	16.2	41.4
BBF	ICG(FDRS)10	1.0	6.8	3.1	14.5	3.6	7.9	10.1	26.0
Flat	ICGS-11	2.5	12.4	7.3	38.8	5.8	18.9	17.8	51.5
Ridges	ICGS-11	2.1	11.1	4.6	18.2	4.9	10.4	17.1	42.3
BBF	ICGS-11	1.3	7.2	4.0	15.4	4.5	8.8	11.0	26.9
S.Ed (±)		0.1	0.6	0.1	0.4	0.1	0.1	0.3	0.4
C.D. (0.05)		0.2	1.3	0.2	0.7	0.2	0.2	0.7	0.9

Table 13 : Penetration resistance of 5-10 cm soil layer as influenced by land surface configurations during various stages of crop growth

Treatments	Variety	Penetration Resistance (kg cm^{-2})							
		Days after sowing							
		30	35	60	65	90	95	145	150
Flat	ICG(FDRS)10	4.0	26.5	15.2	62.3	13.2	41.3	48.3	55.1
Ridges	ICG(FDRS)10	3.5	22.8	9.1	55.1	11.8	27.3	47.5	53.0
BBF	ICG(FDRS)10	2.3	16.5	6.5	39.0	9.7	21.9	17.6	27.3
Flat	ICGS-11	4.3	27.2	16.3	63.4	14.3	42.4	49.4	56.2
Ridges	ICGS-11	4.0	23.5	10.2	56.2	12.9	28.4	48.6	54.1
BBF	ICGS-11	2.6	16.9	7.6	40.1	10.8	23.0	18.7	28.4
S.Ed (±)		0.1	0.8	0.1	0.3	0.1	0.3	0.3	0.5
C.D. (0.05)		0.2	1.7	0.2	0.7	0.2	0.8	0.7	1.2

Table 14 : Penetration resistance of 10-15 cm soil layer as influenced by land surface configurations during various stages of crop growth

Treatments	Variety	Penetration Resistance (kg cm^{-2})							
		Days after sowing							
		30	35	60	65	90	95	145	150
Flat	ICG(FDRS)10	30.5	65.7	41.9	79.6	32.8	67.1	73.1	73.4
Ridges	ICG(FDRS)10	9.3	51.9	21.7	75.2	24.9	64.9	69.4	70.5
BBF	ICG(FDRS)10	7.7	34.2	16.7	58.7	15.8	50.2	20.6	54.9
Flat	ICGS-11	31.0	66.4	43.1	80.8	34.0	68.3	74.3	74.6
Ridges	ICGS-11	9.6	52.5	22.9	76.4	26.1	66.1	70.6	71.7
BBF	ICGS-11	8.0	34.6	17.9	59.9	17.0	51.4	21.8	56.1
S.Ed (±)		0.9	1.4	0.1	0.1	0.3	0.3	0.2	0.5
C.D. (0.05)		1.9	3.0	0.2	0.2	0.7	0.7	0.4	1.1

between BBF, ridges and flat for the soil depths of 0-5 and 5-10 cm were small. But at 10-15 cm depth, BBF recorded lower penetration resistance i.e. 7.75 kg cm^{-2} as compared to the ridges (9.28 kg cm^{-2}) and the flat (30.53 kg cm^{-2}) for groundnut variety ICG(FDRS)10. Similar results were obtained for ICGS 11. Even near the harvest time (145 DAS), the penetration resistance at 0-5, 5-10 and 10-15 cm soil depth was 10.10, 17.60 and 20.60 kg cm^{-2} respectively in BBF which was significantly lower as compared to the flat which recorded 16.90, 48.35 and 73.08 kg cm^{-2} at the respective soil depths. Similar results were obtained at 35, 60, 90, 95 and 150 DAS.

4.1.6 **Oxygen content**

The values of oxygen content in the three land configurations at 30, 35, 60, 65, 90, 95, 145 and 150 DAS are presented in the Tables 15 to 17 and in Figures 13 and 14.

The differences in oxygen content between the various treatments were found to be significant only at 30 & 35 DAS and was non significant at 60, 65, 90, 95, 145 and 150 DAS. Broad bed and furrow showed significantly higher oxygen content than the ridges and the flat for the soil layers of 0-5, 5-10 cm at 30 and 35 DAS. However, for the 10-15 cm layer oxygen content was found to be not significantly different among the treatments. At 60, 65, 90 and 95 DAS the oxygen content of the 0-5, 5-10 and 10-15 cm depths was numerically higher in the BBF than in the ridges and the flat

Table 15 : Oxygen Content of 0-5 cm soil layer as influenced by land surface configurations during various stages of crop growth

Treatments	Variety	Oxygen Content (per cent)							
		Days after sowing							
		30	35	60	65	90	95	145	150
Flat	ICG(FDRS)10	20.5	21.2	21.6	21.9	21.1	21.6	21.4	21.9
Ridges	ICG(FDRS)10	20.7	21.4	21.6	21.9	21.2	21.7	21.4	21.9
BBF	ICG(FDRS)10	21.4	22.1	21.7	21.9	21.4	21.7	21.5	22.0
Flat	ICGS-11	20.5	21.2	21.2	21.8	20.7	21.6	21.4	21.5
Ridges	ICGS-11	20.5	21.2	21.5	21.9	20.9	21.6	21.5	21.6
BBF	ICGS-11	21.3	22.0	21.7	21.9	21.1	21.7	21.5	21.7
S.Ed (±)		0.2	0.2	NS	NS	NS	NS	NS	NS
C.D. (0.05)		0.5	0.5						

NS = Non Significant

Table 16 : Oxygen Content of 5-10 cm soil layer as influenced by land surface configurations during various stages of crop growth

Treatments	Variety	Oxygen Content (per cent)							
		Days after sowing							
		30	35	60	65	90	95	145	150
Flat	ICG(FDRS)10	19.9	20.6	21.3	21.8	20.9	21.6	21.3	21.7
Ridges	ICG(FDRS)10	20.3	21.0	21.5	21.9	21.0	21.6	21.4	21.8
BBF	ICG(FDRS)10	21.4	22.1	21.6	21.9	21.3	21.6	21.5	21.9
Flat	ICGS-11	19.9	20.6	21.2	21.8	20.3	21.6	21.2	21.3
Ridges	ICGS-11	20.2	21.0	21.3	21.9	20.7	21.6	21.3	21.3
BBF	ICGS-11	21.1	21.8	21.4	21.9	20.9	21.6	21.3	21.5
S.Ed (±)		0.2	0.2	NS	NS	NS	NS	NS	NS
C.D. (0.05)		0.4	0.4						

NS = Non Significant

Table 17 : Oxygen Content of 10-15 cm soil layer as influenced by land surface configurations during various stages of crop growth

Treatments	Variety	Oxygen Content (per cent)							
		Days after sowing							
		30	35	60	65	90	95	145	150
Flat	ICG(FDRS)10	18.5	18.6	20.4	21.6	19.9	21.4	20.7	21.5
Ridges	ICG(FDRS)10	19.0	19.7	21.2	21.7	20.0	21.5	20.9	21.7
BBF	ICG(FDRS)10	19.6	20.3	21.3	21.8	20.7	21.5	21.0	21.8
Flat	ICGS-11	18.5	18.6	21.0	21.7	19.8	21.3	20.6	20.9
Ridges	ICGS-11	18.9	19.6	21.1	21.8	19.9	21.4	20.6	20.9
BBF	ICGS-11	19.4	20.1	21.3	21.8	20.1	21.4	21.0	21.2
S.Ed (±)		NS	NS	NS	NS	NS	NS	NS	NS
C.D. (0.05)									

NS = Non Significant

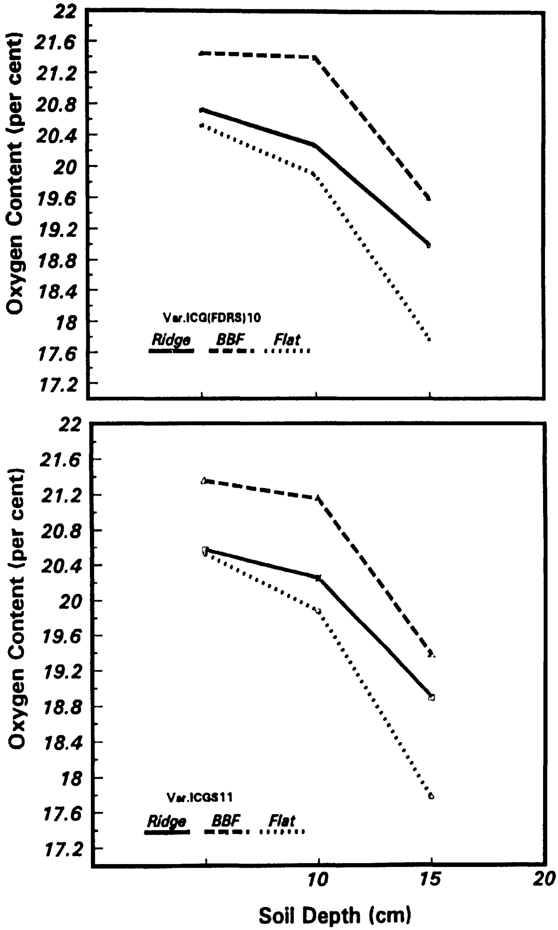

Fig.13 Oxygen content as influenced by land configurations at 30DAS

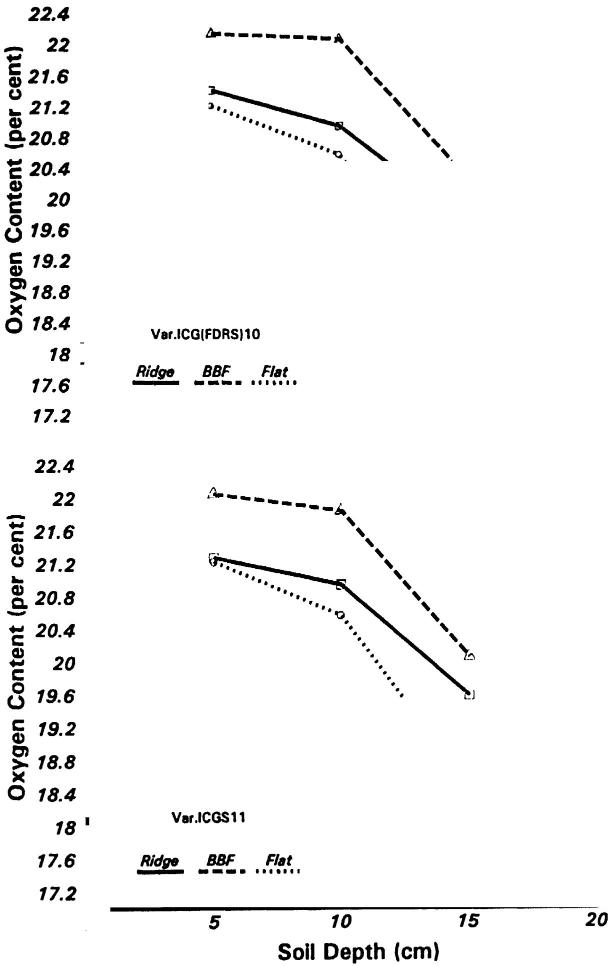

Fig.14 Oxygen content as influenced by land configurations at 35DAS

treatment in that order.

The results further showed that the oxygen content generally decreased with the soil depth in all the treatments. An oxygen content of 21.65% and 21.95% were observed in BBF at 60 and 65 DAS respectively in the soil depths of 0-5 and 5-10 cm and 21.32% and 21.85% for the soil depth of 10-15 cm. Whereas 21.62, 21.50 and 21.2% were observed in ridges at 0-5, 5-10 and 10-15 cm depths respectively at 60 DAS. At 65 DAS oxygen content in ridges was 21.92, 21.90 and 21.67% at 0-5, 5-10 and 10-15 cm depths respectively. Similar results were obtained at 90, 95, 145 and 150 DAS.

4.1.7 Soil temperature

It was found that there was no significant difference in soil temperature between land configurations and the varieties. The mean soil temperature during the crop growth varied between 14° to 34°C (Figures 15 and 16). During most of the crop growth period, soil temperatures in the morning varied between 19 and 25°C at 10 cm depth. Mean soil temperatures in ridges and BBF were found to be higher by 0.5° to 2.0° C as compared to the flat at 10 cm depth. Maximum soil temperatures were observed at 25 DAS and 150 DAS. Minimum temperatures were recorded from 60 DAS to 105 DAS. It was observed that the soil temperature had decreased with increase in soil depth in all the treatments. Most of the peaks in graph were occupied by ridges followed by BBF and flat in that order at all

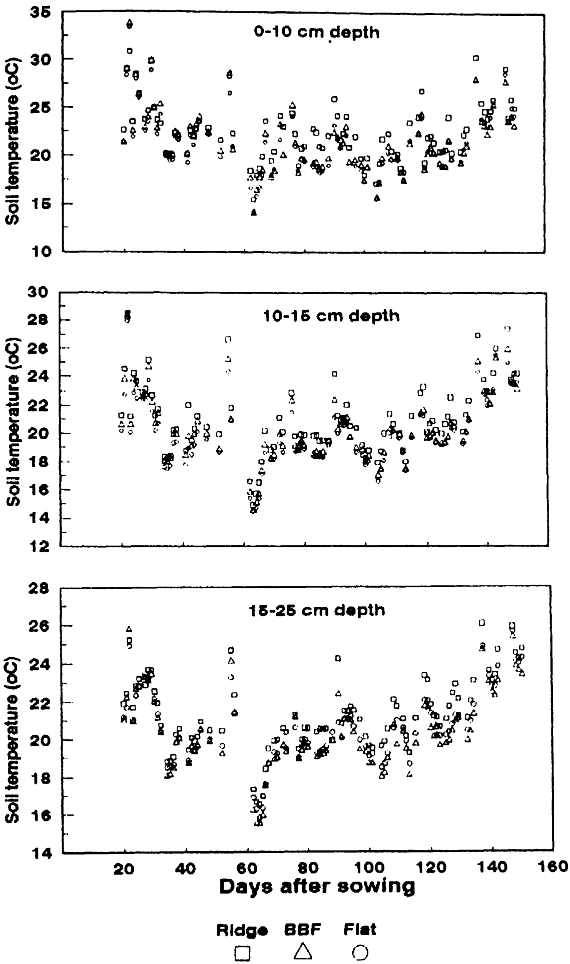

Fig.15 Effect of land configurations on soil temperature in the morning

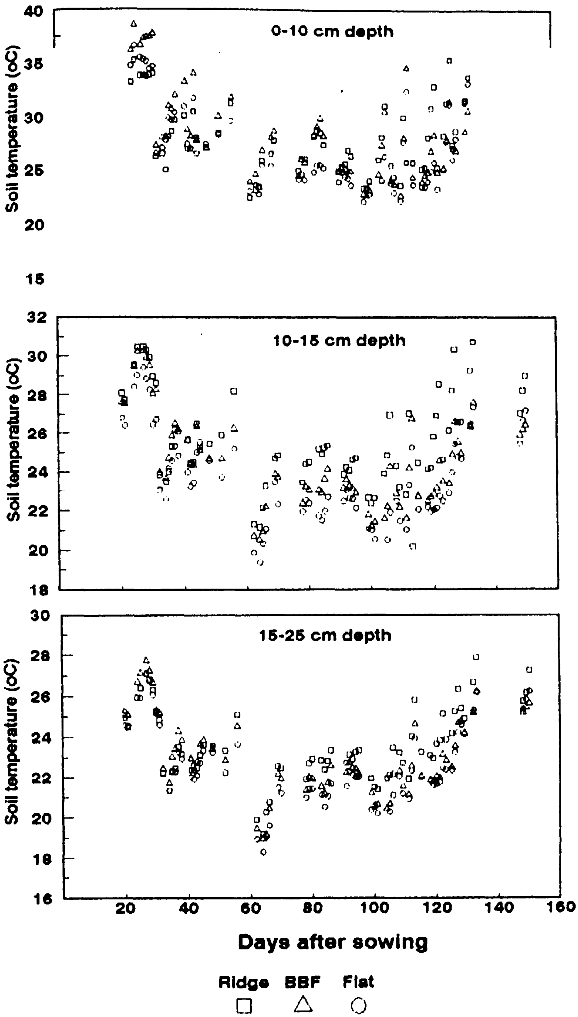

Fig.16 Effect of land configurations on soil temperature in the afternoon

the 3 depths. Soil temperature recorded in the afternoon were higher than temperature in the morning at all the soil depths. During most of the crop growth period, afternoon soil temperatures varied between 22 to 32°C, 20 to 27°C and 20 to 24°C at 10, 15 and 25 cm soil depths respectively. In the early stages of the crop growth (20 DAS), the mean soil temperatures at 10 cm soil depth were found to be 30°C and then the temperature increased to 38°C at 30 DAS which again declined to 25°C at 35 DAS. This temperature was maintained upto 120 DAS. After 120 DAS the soil temperature again increased. Similar trend was observed at soil depths of 15 and 25 cm.

4.2 Groundnut plant growth and yield

4.2.1 Leaf area

Leaf area at 50 DAS was significantly higher in BBF followed by ridges and lowest leaf area was recorded in flat for both the varieties (Table 18 and Figure 17). However, the variety ICG(FDRS)10 recorded higher leaf area as compared to the variety ICGS 11 in all the land surface configurations. Leaf area recorded were 1063, 944, 802 cm^2 $plant^{-1}$ in BBF, ridges and flat respectively for the variety ICG(FDRS)10. Leaf area recorded for the variety ICGS-11 were 805, 711 and 679 cm^2 $plant^{-1}$ in BBF, ridges and flat respectively.

Table 18 : Leaf area at 50 days after sowing in different land surface configurations

Treatments	Variety	Leaf area cm^2 $plant^{-1}$
Flat	ICG(FDRS) 10	802
Ridges	ICG(FDRS) 10	944
BBF	ICG(FDRS) 10	1063
Flat	ICGS 11	679
Ridges	ICGS 11	711
BBF	ICGS 11	805
S.Ed (±)		41
C.D (0.05)		87

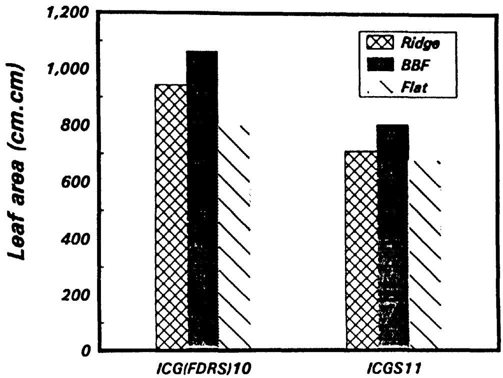

Fig. 17 Leaf area per plant as influenced by land configurations at 50DAS

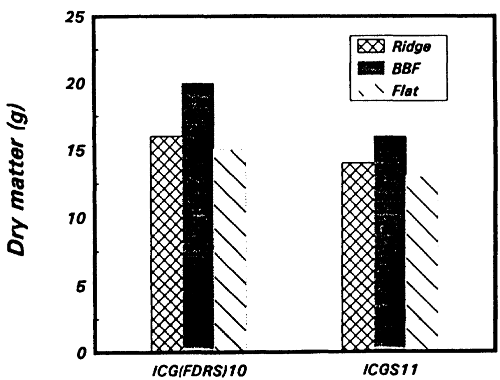

Fig. 18 Dry matter per plant as influenced by land configurations at 50DAS

4.2.2 Dry matter and Haulm yield

Values of dry matter and haulm yield are given in Table 19 and depicted graphically in Figures 18 and 19. For both the groundnut varieties dry matter production at 50 DAS was highest in BBF followed by ridges and flat. The increases in dry matter production were 25.0 and 33.3 per cent in BBF as compared to ridges and flat respectively in case of variety ICG(FDRS)10. Similar results were observed in variety ICGS-11. However, ICG(FDRS)10 produced 18.9 percent higher dry matter than the variety ICGS 11.

A similar trend was also observed in case of haulm yield. An increases of 29 and 23 per cent in haulm yield were observed in BBF when compared to the flat and ridges respectively for the variety ICG(FDRS)10. A similar trend was also observed in variety ICGS 11.

4.2.3 Pod yields

Pod yields obtained in different land configurations for two groundnut varieties ICG(FDRS)10 and ICGS 11 are shown in Table 20 and Figure 20. Significantly higher total pod yields were recorded in BBF followed by ridges and flat. This trend was observed in both the varieties ICG(FDRS)10 and ICGS 11. The pod yields of ICG(FDRS)10 recorded were 4,219, 3,706 and 3,451 kg ha^{-1} in BBF, ridges and flat respectively. In case of the variety ICGS11, the pod yields recorded were 3388, 3094 and 2863 kg ha^{-1} in BBF, ridges

Table 19 : Dry matter and haulm yield of groundnut as influenced by different land surface configurations

Treatments	Variety	Dry matter at 50 DAS (g plant^{-1})	Haulm yield (kg ha^{-1})
Flat	ICG(FDRS) 10	15	2236
Ridges	ICG(FDRS) 10	16	2345
BBF	ICG(FDRS) 10	20	2885
Flat	ICGS 11	13	2091
Ridges	ICGS 11	14	2185
BBF	ICGS 11	16	2702
S.Ed (±)		0.53	56
C.D (0.05)		1.12	120

Table 20 : Groundnut pod yield as influenced by different land surface configurations

Treatment	Pod yield (kg ha^{-1})		
	Var. ICG(FDRS)10	Var. ICGS11	Mean
Flat	3451	2863	3157
Ridges	3706	3094	3400
BBF	4219	3388	3803
S.Ed (±)	93.1	93.1	
C.D (0.05)	198.570	198.6	

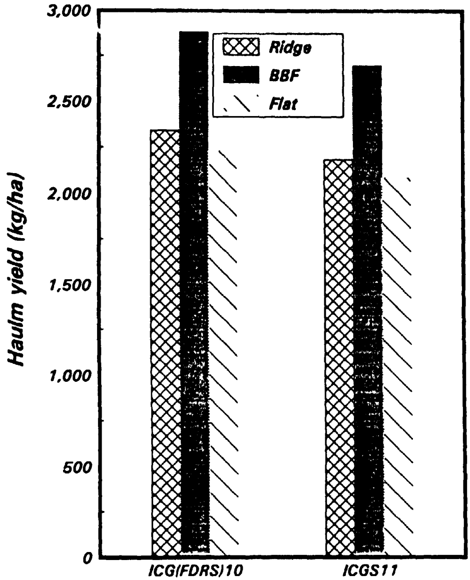

Fig. 19 Haulm yields as influenced by land configurations

and flat seed bed respectively. The groundnut variety ICG(FDRS)10 gave better pod yields than the variety ICGS 11 in all the land configurations.

The pods left over in the soil were highest in flat seed bed followed by ridges and BBF in that order. Similar trend was observed in varieties ICG(FDRS)10 and ICGS 11. The pods left over in soil in the BBF was 39.07 and 41.82 per cent lower than in the ridges and flat seed bed respectively for the variety ICG(FDRS)10. In case of variety ICGS 11, the left over pods in the soil were 32.71 and 34.47 per cent lower in BBF than in the ridges and flat seed bed respectively. This indicated that the harvesting of the pods was found to be easier in the BBF than in the ridges and flat seed bed.

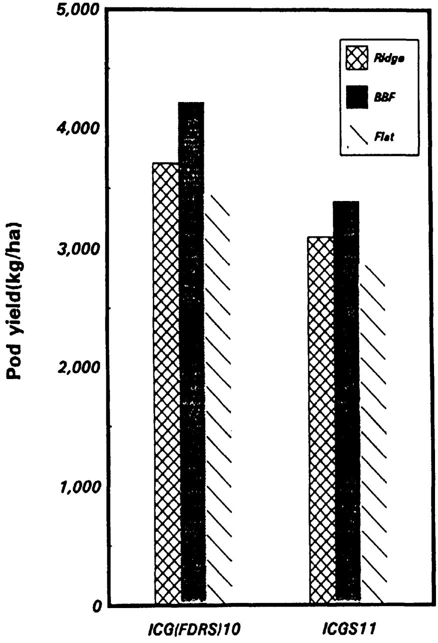

Fig.20 Groundnut pod yield as influenced by land configurations

CHAPTER V
DISCUSSION

CHAPTER V

DISCUSSION

The effect of different land surface configurations on soil physical conditions of an Alfisol were studied during the post rainy season of 1991-92 on plot RCE 10, at the ICRISAT Center, Patancheru, A.P. The productivity of groundnut was also evaluated during the experimentation. The observations made and results obtained are discussed and the conclusions drawn are presented below.

5.1 Effect of surface configurations on soil physical conditions

The effect of different surface configurations on soil physical properties namely bulk density, total porosity, moisture content, moisture suction, penetration resistance, oxygen content and soil temperature are discussed in the following paragraphs.

5.1.1 Bulk density

The results recorded in Table 3 and Figure 4 showed that the bulk density was lower in the BBF than in the ridges and flat seed bed in that order, throughout the growth period of the two groundnut varieties. All the land configurations on which variety ICG(FDRS)10 was grown resulted in lower bulk density than in the configurations on which variety ICGS 11 was grown.

Broadbed and furrow on which variety ICG(FDRS)10 grown had resulted in 0.24 and 0.11 g cm^{-3} lower bulk density than in the flat seed bed and ridges respectively at 30 DAS. It was observed that the bulk densities of soil where variety ICGS 11 was grown were found to be 1.45, 1.53 and 1.64 g cm^{-3} in BBF, ridges and flat seed bed respectively at 30 DAS.

At 60 DAS, BBF had recorded 0.21 and 0.10 g cm^{-3} lower bulk densities than in the flat and ridge treatments respectively in the variety ICG(FDRS)10 while 0.20 and 0.10 g cm^{-3} lower bulk densities in BBF were observed than in the flat and ridge treatments respectively in the variety ICGS 11.

At 90 DAS, it was observed that bulk density in BBF with variety ICG(FDRS)10 was 0.20 and 0.09 g cm^{-3} lower than in the flat and ridge treatments respectively. Similarly BBF with variety ICGS 11 showed 0.20 and 0.13 g cm^{-3} lower bulk density than in the flat and ridge treatments respectively.

Before harvest (145 DAS) it was observed that the bulk density of the soil in BBF was lower by 0.21 and 0.08 g cm^{-3} than in the flat and ridges respectively on which the variety ICG(FDRS)10 was grown. Ridges resulted in 0.10 g cm^{-3} lower bulk density than in the flat seed bed. Similarly BBF treatment in the variety ICGS 11 showed 0.26 and 0.24 g cm^{-3} lower bulk density than in the flat seed bed and ridges respectively.

The results further indicated that the bulk density increased with growth of the crop in all the treatments. The increase in bulk density at 60 DAS as compared to at 30 DAS was 0.06, 0.05 and 0.03 g cm^{-3} in BBF, ridges and flat seed bed respectively on which variety ICG(FDRS)10 was grown. The increase in bulk density were 0.01, 0.03 and 0.02 g cm^{-3} in BBF, ridges and flat seed bed respectively on which variety ICGS 11 was grown.

The increase in bulk density at 90 DAS in BBF, ridges and flat seed bed as compared to at 30 DAS with variety ICG(FDRS)10 were 0.08, 0.06 and 0.04 g cm^{-3} respectively. Similarly the increases were 0.02, 0.07 and 0.03 g cm^{-3} in BBF, ridges and flat treatments respectively on which variety ICGS 11 was grown.

The increase in bulk density at 145 DAS as compared to at 30 DAS were 0.11, 0.08 and 0.08 g cm^{-3} in BBF, ridges and flat seed bed respectively on which variety ICG(FDRS)10 was grown. It was observed that the increase was 0.03, 0.11 and 0.10 g cm^{-3} in BBF, ridges and flat seed bed respectively in the variety ICGS 11.

The increase in bulk density at 90 DAS when compared to at 30 DAS were 0.02, 0.01 and 0.01 g cm^{-3} in BBF, ridges and flat seed bed respectively on which variety ICG(FDRS)10 was grown. Similar increasing trend was observed in the land configurations on which variety ICGS 11 was grown.

It was observed that the increase in bulk density at 145 DAS when compared to at 90 DAS were 0.03, 0.02 and 0.04 g cm^{-3} in BBF, ridges and flat seed bed respectively with variety ICG(FDRS)10 while the increases were 0.01, 0.02 and 0.07 g cm^{-3} respectively for the variety ICGS 11.

There was a clear advantage of BBF over ridges and flat in keeping top soil loose with implications for gynophore penetration into the soil, pod formation and harvesting of groundnut. The lower bulk density in BBF than in ridges and flat might be ascribed to increased total porosity in BBF. The increase in bulk density in all the treatments as crop growth advanced might be attributed to the consolidation of cultivated soil layer in Alfisols with time. The cultivated soil layer had consolidated and settled down gradually with application of successive irrigations; as a result a decrease in soil total porosity and thereby increases in bulk density were observed. The reason for lower bulk densities observed in land configurations in the variety ICG(FDRS)10 than with variety ICGS 11 might be attributed to profused root growth of the variety. The leaf area in variety ICG(FDRS)10 was found to be more which might have decreased the consolidation and thereby bulk density. Similar results were observed by ICRISAT (1981), NARP (1981) and Pathak et. al. (1991).

5.1.2 **Total porosity**

Total porosity was significantly more in BBF as compared to ridges and flat (Table 4). This trend was observed in both the groundnut varieties. Total porosity of the soil was found to be more in the land configurations on which variety ICG(FDRS)10 was grown than in the variety ICGS 11. AT 30 DAS the increase in total porosity of 0-15 cm depth was 4.0 (9.52 per cent) and 9.0 (24.32 per cent) in BBF when compared to ridges and the flat seed bed respectively in the variety ICG(FDRS)10. Broad bed and furrow with the variety ICGS 11 recorded 3.0 (7.5 per cent) and 7.0 (19.5 per cent) greater total porosity than in the ridges and flat seed bed respectively at 30 DAS in the 0-15 cm soil depth.

The increases in total porosity were 4.0 (10.0 per cent), 3.0 (7.5 per cent) and 3.0 (7.69 per cent) in BBF when compared to ridges in variety ICG(FDRS)10 at 60, 90 and 145 DAS respectively. Similarly total porosity was increased by 8.0 (22.3 per cent), 8.0 (22.9 per cent) and 8.0 (23.5 per cent) in BBF at 0-15 cm soil depth when compared to flat seed bed at 60, 90 and 145 DAS respectively.

Similarly in the variety ICGS 11, total porosity in 0-15 cm soil depth was increased by 4.0 (10.3 per cent), 5.0 (13.5 per cent) and 6.0 (16.7 per cent) in BBF as compared to ridges at 60, 90 & 145 DAS respectively. An increase of 8.0 (22.9 per cent), 8.0 (23.5 per cent) and 10.0 (31.25 per cent) total porosity was observed in BBF when compared to the flat at 60, 90 and 145 DAS respectively. The increase in total porosity in the BBF might be ascribed to lower bulk density values shown in Table 4 and increased root weight.

5.1.3 Soil moisture content

The results presented in Tables 5 to 8 and Figures 5 to 12 indicated that the soil moisture content was found to be more in BBF as compared to ridges and flat seed bed at all the stages of crop growth. The increase in soil moisture content was found to be 0.028, 0.015, 0.006 and 0.001 gg^{-1} in BBF in variety ICG(FDRS)10 as compared to the ridges at 0-5, 5-10, 10-15 and 15-30 cm soil depth respectively at 30 DAS. Broad bed and furrow with variety ICGS 11 similarly showed an increase of 0.021, 0.024, 0.020 and 0.016 gg^{-1} moisture content at soil depths of 0-5, 5-10, 10-15 and 15-30 cm respectively as compared to ridges. Lowest soil moisture contents of 0.141, 0.176, 0.198 and 0.215 gg^{-1} in ICG(FDRS)10 and 0.112, 0.145, 0.168 and 0.184 gg^{-1} in ICGS 11 were observed in flat seed bed at 0-5, 5-10, 10-15 and 15-30 cm soil depth respectively. The increase in soil moisture content in BBF over flat seed bed was 0.043, 0.019, 0.012 and 0.001 gg^{-1} with variety ICG(FDRS)10 and 0.037, 0.031, 0.026 and 0.023 gg^{-1} with variety ICGS 11 at 0-5, 5-10, 10-15 and 15-30 cm soil depth respectively. At 35 DAS, a similar trend was observed in BBF which recorded the highest moisture content followed by ridges and the flat seed bed for both the groundnut varieties.

At 60 DAS, the soil moisture contents in BBF were increased by 0.006, 0.012, 0.003 and 0.001 gg^{-1} as compared to ridges and 0.034, 0.045, 0.036 and 0.044 gg^{-1} as compared to flat in the variety ICG(FDRS)10 at 0-5, 5-10, 10-15 and 15-30 cm soil depth respectively. Similar trends were observed in the variety ICGS 11. At 65 DAS the soil moisture content was decreased to 0.055, 0.068, 0.047 gg^{-1} in BBF, ridges and flat seed bed respectively in ICG(FDRS) 10 at 0-5 cm soil depth and 0.068, 0.064 and 0.066 gg^{-1} in ICGS 11. At 5-10, 10-15 and 15-30 cm soil depth, the moisture content was decreased to 0.067, 0.096 and 0.119 gg^{-1} respectively in ridges, 0.078, 0.099 and 0.131 gg^{-1} in BBF and 0.061, 0.068 and 0.116 gg^{-1} respectively in flat seed bed in ICG(FDRS)10.

At 90 DAS, the soil moisture contents in BBF were increased by 0.015 gg^{-1} (10.25 per cent), 0.010 gg^{-1} (6.24 per cent), 0.013 gg^{-1} (8.01 per cent) and 0.030 gg^{-1} (18.11 per cent) as compared to the ridges at 0-5, 5-10, 10-15 and 15-30 cm soil depth respectively. Similar increases were observed in BBF which recorded 0.0420 gg^{-1} (34.88 per cent), 0.026 gg^{-1} (18.14 per cent), 0.030 gg^{-1} (20.30 per cent) and 0.047 gg^{-1} (28.34 per cent) as compared to flat seed bed in ICG(FDRS)10 at 0-5, 5-10, 10-15 and 15-30 cm soil depths respectively. Increases in soil moisture content were observed in BBF which recorded 0.011 gg^{-1} (7.42 per cent), 0.003 gg^{-1} (1.93 per cent), 0.007 gg^{-1} (4.24 per cent) as compared to ridges and 0.021 gg^{-1} (15.32 per cent), 0.020 gg^{-1} (14.18 per cent), 0.019 gg^{-1} (12.69 per cent) and 0.008 gg^{-1} (5.04 per cent) as compared to flat seed bed at 0-5, 5-10, 10-15 and 15-30 cm depth respectively in ICGS 11. The soil moisture contents in all the treatments were decreased at 95 DAS. The differences in moisture content between 90 and 95 DAS might be ascribed partly to the water uptake by the crop plants and partly due to the evaporation losses.

The soil moisture contents at 0-5, 5-10, 10-15 and 15-30 cm depth which were 0.125, 0.125, 0.152 and 0.167 gg^{-1} respectively in BBF in ICG(FDRS)10 at 145 DAS had decreased to 0.053, 0.084, 0.106 and 0.108 gg^{-1} respectively at 150 DAS. Similar trend was observed for the other treatments. At 145 DAS, soil moisture contents were increased in BBF by 3.66, 0.80, 16.17 and 13.17 per cent as compared to ridges and by 25.35, 25.78, 28.48 and 31.57 per cent when compared to the flat seed bed in variety ICG(FDRS)10 at 0-5, 5-10, 10-15 and 15-30 cm soil depths respectively. Similarly at 150 DAS the increases in BBF were 0.56, 11.45, 6.63 and 1.69 per cent as compared to ridges and 24.53, 69.78, 46.55 and 7.12 per cent as compared to the flat seed bed in ICG(FDRS)10. Similar increased trend in BBF over ridges and flat seed bed was observed with variety ICGS-11.

These results were in good agreement with those reported by Willis et. al. (1963), Huibers (1985), Venkateshwarlu (1986), Vijayalakshmi (1987), Hulugalle and Rodriguez (1988), Patil and Bangal (1989), Rajput et. al. (1989), Nilantha et. al. (1990) and Narnaware and Kayande (1992). Good performance of the BBF and ridges might be due to deeper penetration of roots and water, increased initial water absorption rates, greater moisture availability to plants because of more water concentration in the furrows. Ridges provide miniature bunds that check water flow and provide more opportunity for water to infiltrate and increase the stored profile water. Hulugalle and Rodriguez (1968) also reported that the higher water retention in ridges as compared to flat was due to the retention of dispersed clay particles on-site in ridges whereas in flat seed beds, they were transported offsite by the greater runoff.

The results recorded in Tables 5 to 8 and Figures 5 to 12 further indicated that in all the treatments the soil moisture retention at 15-30 cm was found to be more followed by 10-15, 5-10 and 0-5 cm soil layers in that order. This might be due to the presence of more clay in the lower layers of the soil as per the results recorded in Table 2. Another reason may be that water extraction from lower layers could be low. These results are in concurrent with those reported by Mahender Reddy (1988).

5.1.4 Soil moisture suction

The results presented in Tables 9 to 11 indicated that the moisture suction was lowest in BBF than in the ridges and flat seed bed. At 30 DAS the decreases in moisture suction in BBF were 11.03 kPa (79.52 per cent) and 5.91 kPa (65.45 per cent) as compared to the ridges in ICG(FDRS)10 and 29.86 kPa and 15.19 kPa when compared to flat seed bed at 0-5 and 5-10 cm soil depth respectively. Similarly, soil moisture suction was decreased in BBF as compared to ridges and flat seed bed on which variety ICGS 11 was grown. At 35 DAS, the moisture suction was increased in all the treatments, out of which BBF recorded the lowest. At 0-5 cm, the moisture suction in BBF was 41.77 kPa which was 32.01 and 69.64 per cent lower than in the ridges and flat seed bed respectively in ICG(FDRS)10 while in ICGS 11 the moisture suction in BBF was 46.74 kPa which was 23.62 and 61.51 per cent lower than in the ridges and flat seed bed respectively. At 5-10 cm depth, the suction in BBF was lowered by 15.6 kPa and 28.32 kPa as compared to the ridges and flat seed bed (which recorded 52.57 kPa) respectively in variety ICG(FDRS)10 while in variety ICGS 11, the BBF recorded 13.16 and 24.24 kPa lower moisture suction than in ridges and flat seed bed (which recorded 55.39 kPa) respectively.

At 0-5 cm soil depth lower soil moisture suctions of 53.06 and 78.88 kPa were recorded in BBF than in ridges and flat seed respectively at 60 DAS and 8.04 and 64.62 kPa at 65 DAS in variety ICG(FDRS)10. At 5-10 cm and 10-15 cm depth, the decreases in moisture suction in BBF were 49.19 kPa and 28.27 kPa respectively as compared to ridges and 76.16 kPa and 56.05 kPa respectively as compared to the flat seed bed with variety ICG(FDRS)10 at 60 DAS. AT 65 DAS, the moisture suction was increased in all the treatments. Lowest soil moisture suction of 135.47, 112.99 and 111.78 kPa were recorded in BBF as compared to ridges which recorded 143.51, 136.03 and 123.72 kPa and flat seed bed which recorded 200.09, 137.53 and 129.08 kpa in ICG(FDRS)10 at 0-5, 5-10 and 10-15 cm depth respectively. Similarly in ICGS 11, soil moisture suctions recorded in BBF were 8.14, 8.91 and 7.76 per cent lower than in the ridges at the 3 depths respectively. But when compared to flat bed the decreases in soil moisture suctions in BBF were 49.26, 11.25 and 10.09 per cent at 0-5, 5-10 and 10-15 cm depth respectively.

At 90 DAS, the moisture suction was less in all the treatments but it was increased at 95 DAS. However, on both the days lower moisture suction was recorded in BBF than in the ridges and the flat seed bed in both the varieties. In BBF, lower soil moisture suctions of 14.28 and 25.89 kPa were observed at 0-5 cm, 7.26 and 17.23 kPa at 5-10 cm and 3.28 and 9.29 kPa at 10-15 cm than in the ridges and flat seed in ICG(FDRS)10 at 90 DAS. in ICGS 11 also, lower soil moisture suctions of 8.65, 4.45 and 3.92 kPa were observed in BBF than in ridges and 33.79, 27.43 and 7.45 kPa than in the flat seed bed at 0-5, 5-10 and 10-15 cm soil depth respectively. At 95 DAS, soil moisture suctions in BBF were found to be 6.04 and 20.86 kPa lower than in the ridges and flat seed bed in ICG(FDRS)10 at 0-5 cm depth. In BBF at 5-10 and 10-15 cm depth soil moisture suctions observed were lower by 12.01 and 10.55 per cent than in the ridges and 35.22 and 17.29 per cent lower than in the flat seed bed in variety ICG(FDRS)10. Similar decreasing trend had been observed in BBF with the variety ICGS 11. In this variety lower soil moisture suctions of 5.12, 5.93 and 8.99 per cent were observed in BBF than in ridges and 59.48, 22.26 and 11.50 per cent than in the flat seed bed at 0-5, 5-10 and 10-15 cm soil depth respectively.

A decrease of 31.38 and 48.26 kPa at 0-5 cm, 23.12 and 41.27 kPa at 5-10 cm and 21.99 and 28.77 kPa suction at 10-15 cm depth was observed in BBF when compared to ridges and flat seed bed respectively in ICG(FDRS)10 at 145 DAS. At 150 DAS moisture suction in BBF was 30.22 and 45.16 per cent lower at 0-5 cm, 17.84 and 42.07 per cent lower at 5-10 cm and 17.77 and 42.30 per cent lower at 10-15 cm than in the ridges and flat seed bed respectively. Similar decreasing trend was observed in BBF with variety ICGS 11 at 145 DAS and 150 DAS. In ICGS 11 a decrease of 32.42 and 48.26 kPa at 0-5 cm, 22.43 and 41.27 kPa at 5-10 cm and 21.99 and 28.77 kPa at 10-15 cm was observed in BBF when compared to ridges and flat seed bed respectively at 145 DAS. In BBF, observed moisture suctions were found to be lower by 30.22 and 39.70 per cent at 0-5 cm, 29.06 and 43.47 per cent at 5-10 cm and 26.50 and 44.05 per cent at 10-15 cm depth at 150 DAS than in ridges and flat seed bed respectively.

The decrease in moisture suction in BBF might be ascribed to higher soil moisture in the soil as per the results recorded in Tables from 5 to 8. The lower soil moisture suctions observed in BBF might be attributed to profused root growth. The results further indicated that in all the treatments, the moisture suction at 0-5 cm was found to be more followed by 5-10 and 10-15 cm depth. This might be due to higher concentration of clay and silt particles at the lower depths (Table 2).

5.1.5 Penetration resistance

The results recorded in Tables from 12 to 14 indicated that the penetrometer resistance had increased with soil depth upto 15 cm. The penetrometer readings were found to be lower in BBF than in ridges and flat seed bed in both the varieties. However, the land configurations on which variety ICG(FDRS)10 was grown had recorded lower penetration resistance than in the land configurations on which variety ICGS 11 was grown.

At 30 DAS, a decrease of 0.78 kg cm^{-2} (78.0 per cent) at 0-5 cm, 1.72 kg cm^{-2} (73.82 per cent) at 5-10 cm and 1.53 kg cm^{-2} (19.74 per cent) at 10-15 cm in BBF was observed in ICG(FDRS)10 when compared to ridges. The decreases of penetration resistance in BBF when compared to flat seed bed at 0-5, 5-10 and 10-15 cm soil depths were 1.28, 1.15 and 22.78 kg cm^{-2} respectively. Similar decreasing trend was observed in BBF with variety ICGS 11. The decrease was 0.8 and 1.23 kg cm^{-2} at 0.5 cm, 1.35 and 1.70 kg cm^{-2} at 5-10 cm and 1.60 and 22.98 kg cm^{-2} at 10-15 cm depth as compared to ridges and flat seed bed respectively. At 35 DAS, the penetration resistance had increased in all the treatments. Lowest penetrometer readings were recorded in BBF. A decrease of 3.75 kg cm^{-2} (55.15 per cent) and 4.88 kg cm^{-2} (71.76 per cent) at 0-5 cm, 6.30 kg cm^{-2} (38.07 per cent) and 9.96 kg cm^{-2} (60.30 per cent) at 5-10 cm and 17.68 kg cm^{-2} (51.62 per cent) and 31.5 kg cm^{-2} (91.97 per cent) at 10-15 cm depth was observed in BBF on which variety ICG(FDRS)10 was grown as compared to ridges and flat seed bed respectively. Similarly a decrease of 3.95 and 5.18 kg cm^{-2} at 0-5 cm, 6.50 and 10.27 kg cm^{-2} at 5-10 cm and 17.88 and 31.8 kg cm^{-2} at 10-15 cm depth was observed in BBF with variety ICGS 11 when compared to the ridges and flat seed bed respectively.

At 60 DAS, penetration resistances in BBF on which ICG(FDRS)10 was grown were found to be 0.63, 2.60 and 5.03 kg cm^{-2} lower than in ridges and 3.32, 8.65 and 25.2 kg cm^{-2} lower than in the flat seed bed at 0-5, 5-10 and 10-15 cm depth respectively. Similar decreases in BBF with variety ICGS 11 were observed. At 65 DAS the penetrometer readings in BBF were found to be more by 11.42, 32.45 and 42.0 kg cm^{-2} than at 60 DAS at 0-5, 5-10 and 10-15 cm depth respectively. Similarly penetrometer readings had increased in all the treatments. In BBF, lower penetrometer readings of 2.8 and 23.4 kg cm^{-2} at 0-5 cm, 16.1 and 23.3 kg cm^{-2} at 5-10 cm and 16.5 and 20.5 kg cm^{-2} at 10-15 cm depth were observed than in the ridges and flat seed bed respectively.

At 90 DAS, the penetrometer readings had decreased in BBF by 0.4 and 1.30 kg cm^{-2} at 0-5 cm, 2.10 and 3.53 kg cm^{-2} at 5-10 cm and 9.1 and 17.0 kg cm^{-2} at 10-15 cm depth when compared to ridges and flat seed bed respectively. Results recorded in Table indicated that the penetration resistance increased in all the treatments at 95 DAS. At 95 DAS, the penetration resistance had decreased in BBF by 1.6 and 10.1 kg cm^{-2} at 0-5 cm, 5.4 and 19.4 kg cm^{-2} at 5-10 cm and 14.7 and 16.9 kg cm^{-2} at 10-15 cm depth than in the ridges and flat seed bed respectively.

Penetrometer readings observed in BBF in variety ICG(FDRS)10 were 10.1 and 26.0 kg cm^{-2} at 0-5 cm, 17.6 and 27.3 kg cm^{-2} at 5-10 cm, 20.6 and 54.9 kg cm^{-2} at 10-15 cm depth at 145 and 150 DAS respectively as compared to ridges which recorded 16.20 and 41.40 kg cm^{-2} at 0-5 cm, 47.50 and 53.00 kg cm^{-2} at 5-10 cm and 69.45 and 70.50 kg cm^{-2} at 10-15 cm depth at 145 and 150 DAS respectively. Penetrometer readings in BBF were found to be 6.8, 30.75 and 52.47 kg cm^{-2} lower than in the flat seed bed at 0-5, 5-10 and 10-15 cm depth respectively at 145 DAS as compared to 24.6, 27.8 and 15.6 kg cm^{-2} at 150 DAS. A similar trend in penetrometer readings were observed in all the land configurations in variety ICGS 11.

Reason for lower penetrometer readings observed in BBF might be ascribed to the presence of loose soil layer. This might be also due to higher moisture content in all the 3 depths than in the ridges and flat seed bed. Similar results were reported by Hulugalle and Rodriguez (1988) and Pathak, et. al. (1991).

The results clearly indicated that there was an advantage by developing BBF land configuration than the ridges and flat. The lower penetration resistance observed in BBF further facilitates better penetration of roots, gonophores and development of pods.

5.1.6 **Oxygen content**

The results present in Tables from 15 to 17 and Figures 13 and 14 clearly shows that the oxygen content of the 0-5, 5-10 and

10-15 cm layers in BBF, ridges and flat seed bed were found to be different. However, the oxygen content decreased with the soil depth upto 15 cm in all the treatments. Throughout the season, the oxygen content of the 0-5, 5-10 and 10-15 cm depths was found to be higher in BBF than in the ridges and flat. Except at 30-35 DAS in the 0-5 and 5-10 cm depths, the oxygen content was not significantly different. Broad bed and furrow on which variety ICG(FDRS)10 grown recorded greater oxygen content than in BBF on which variety ICGS 11 grown throughout the crop growth pewriod. Similar tend was observed in the ridges and flat seed bed.

At 30 DAS, the oxygen contents of 0-5, 5-10 and 10-15 cm depths in BBF were greater by 3.49, 5.55 and 3.16 per cent respectively than in the ridges on whichy variety ICG(FDRS)10 was grown. Similarly the oxygen content in BBF was 4.51, 7.54 and 10.27 per cent greater than in the flat seed bed at 0-5, 5-10 and 10-15 cm depths respectively. The increases of oxygen contents observed at 0-5, 5-10 and 10-15 cm depths in BBF on which ICGS 11 grown were 3.77, 4.45 and 2.51 per cent as compared to the ridges and 4.02, 6.42 and 9.00 per cent as compared to flat respectively. At 35 DAS, the oxygen content in all the three depths had increased in all the treatments. The oxygen content had increased by 3.26, 3.38 and 3.41 per cent at 0-5 cm, 3.27, 3.45 and 3.52 per cent at 5-10 cm and 3.57, 3.68 and 3.94 per cent at 10-15 cm in BBF, ridges and flat in variety ICG(FDRS)10 respectively. By growing ICGS 11 in the three land configurations, a similar increasing trend in oxygen cotnent was observed. At 35 DAS of ICG(FDRS)10, the oxygen contents observed in 0-5, 5-10 and 10-15 cm soil layers of BBF treatment were 3.38, 5.36 and 3.05 per cent greater than in the ridges and 4.36, 7.28 and 9.88 per cent greater than in the flat seed bed respectively. Similarly at 35 DAS, the oxygen contents of 0-5, 5-10 and 10-15 cm depths in BBF on which ICGS 11 grown were greater by 3.64, 4.29 and 2.42 per cent than in ridges and greater by 3.89, 6.20 and 8.66 per cent than in flat seed bed respectively.

At 60 DAS of ICG(FDRS)10 greater oxygen contents of 0.12 and 0.35 per cent at 0-5 cm, 0.69 and 1.64 per cent at 5-10 cm and 0.47 and 4.28 per cent at 10-15 cm were observed in BBF than in the ridges and flat seed bed respectively. The oxygen contents observed in BBF at 0-5, 5-10 and 10-15 cm depths on which ICGS 11 grown wwew 0.58, 0.47 and 1.31 per cent greater than in the ridges and 1.8, 1.06 and 1.43 per cent greater than in the flat seed bed respectively. At 65 DAS, the oxygen contents of the three depths had increased in all the treatments. At 65 DAS the increases in oxygen content observed in BBF on which ICG(FDRS)10 grown were 0.11 and 0.23 per cent at 0-5 cm, 0.23 and 0.46 per cent at 5-10 cm and 0.81 and 1.04 per cent at 10-15 cm depths than in the ridges and flat seed bed respectively. Similar increasing trend was observed in BBF on which variety ICGS 11 was grown.

At 90 DAS of ICG(FDRS)10, oxygen contents had increased by 1.18 and 1.66 per cent at 0-5 cm, 1.55 and 1.79 per cent at 5-10 cm and 3.38 and 3.89 per cent at 10-15 cm depths in BBF as compared to ridges and flat seed bed respectively. In case of ICGS 11 similar increases of 0.83 and 1.57 per cent at 0-5 cm, 0.97 and 2.83 per cent at 5-10 cm and 1.0 and 1.51 per cent at 10-15 cm depths were observed in BBF when compared to ridges and flat seed bed respectively. The oxygen content of the 3 depths were increased in all the treatments on 95 DAS. Broad bed and furrow showed greater oxygen content than the ridges and the flat seed bed for the 2 varieties. At 95 DAS, the increases of 0.12 and 0.23 per cent at 0-5 cm and 5-10 cm and 0.12 and 0.35 per cent at 10-15 cms were observed in BBF when compared to ridges and flat seed bed respectively in the variety ICG(FDRS)10. In case of ICGS 11 the increases in oxygen contents observed in 0-5, 5-10 and 10-15 cm depths were 0.23, 0.12 and 0.24 and 0.23, 0.35 and 0.5 per cent as compared to the ridges and flat seed bed respectively.

Greater oxygen contents were observed in BBF at 0-5 cm, 5-10 cm and 10-15 cm depths at 145 and 150 DAS than in the ridges and flat seed bed for both varieties. At 145 DAS of ICG(FDRS)10 the increases in oxygen content observed in BBF were 0.47 and 0.82 per cent at 0-5 cm, 0.35 and 0.82 at 5-10 cm and 0.84 and 1.5 per cent at 10-15 cm depths when compared to ridges and flat seed bed respectively. Similar increases were observed in variety ICGS 11. At 150 DAS, the oxygen content increased in all the land configurations irrespective of the variety. However, increases in oxygen contents of 0.23 and 0.46 per cent at 0-5 cm, 0.23 and 0.81 per cent at 5-10 cm and 0.35 and 1.16 per cent at 10-15 cm depths were observed in BBF when compared to ridges and flat seed bed respectively in the variety ICG(FDRS)10. Similar increases were observed in variety ICGS 11.

The increased oxygen content observed in 0-5, 5-10 and 10-15 cm layers in the BBF over the ridges and flat seed bed could be attributed to the increased porosity and looseness of the top 15 cm soil layer. The higher oxygen contents observed at 35, 65, 95 and 150 DAS in all the land configurations than the oxygen cotnents observed at 30, 60, 90 and 145 DAS might be ascribed to the presence of lower soil moisture contents. When more moisture is present in the soil, less air is occupied on the pores. As a consequence, when less air is present in the gaseous form, less oxygen content is observed. The results further indicated that in all the treatments the oxygen content at 0-5 cm was greater than that at 5-10 cm and at 10-15 cm depth. This might be due to the presence of more soil moisture at 10-15 cm depth followed by 5-10 and 0-5 cm. Similar results were observed by Pathak, et. al. (1991).

5.1.7 **Soil temperature**

The results presented in Figures 15 and 16 indicated slightly higher soil temperature in BBF and ridges at 10, 15 and 25 cm soil depths than the flat seed bed. The increase in soil temperature observed in the ridges and BBF might be ascribed to exposure of larger area of soil surface for absorption of solar radiation. Another reason might be due to the improved drainage conditions in the bed configurations. The decrease in soil temperature with increase in soil depth upto 25 cm might be ascribed to increased soil moisture constant at lower depths. The results of the present investigation were in accordance with those reported by Radke (1963), Adams (1967), Radke (1982), Hulugalle and Rodriguez (1988), Stone, et. al. (1989) and Grewal and Abrol (1990).

5.2 Groundnut plant growth and yield

5.2.1 Leaf area

The results presented in Table 18 indicated that leaf area of ICG(FDRS)10 observed at 50 DAS was significantly higher in BBF (1063 cm^{-2} $plant^{-1}$) than in ridges (944 cm^{-2} $plant^{-1}$) and flat seed bed (802 cm^{-2} $plant^{-1}$). Similarly the leaf area of the variety ICGS 11 was found to be significantly higher in BBF (805 cm^{-2} $plant^{-1}$) than in the ridges (711 cm^{-2} $plant^{-1}$) and flat seed bed (679 cm^{-2} $plant^{-1}$). The reason for this difference in leaf area among the two varieties could be ascribed to the varietal characters. ICG(FDRS)10, being a bunch type, resulted in sturdy growth and produced broader and more number of leaves as compared to the variety ICGS 11, a spreading type, resulted in relatively less growth and narrow leaves. Increased leaf area observed in BBF as compared to the ridges and flat seed bed might be ascribed to the higher amounts of water present in different layers of the soil and increased amount of oxygen present in the soil as shown from the results recorded in Tables 5 to 8 and 17 to 20 which might ahve resulted in improving plant growth and development.

5.2.2 Dry matter and haulm yield

The results presented in Table 19 and Figures 18 and 19 indicated that dry matter and haulm yields were found to be high in BBF for both the groundnut varieties ICG(FDRS)10 and ICGS 11. In variety ICG(FDRS)10 the increases in dry matter per plant observed were 25.0, 14.29, 15.39 per cent in BBF, ridges and flat seed bed respectively as compared to the respective land configurations in ICGS 11. The higher dry matter produced in BBF might be attributed to the increased soil moisture content, higher oxygen content and lower penetration resistance of the soil which might be some of the factors responsible for improving the vegetable growth of plants.

The increases in haulm yield of variety ICG(FDRS)10 observed in BBF were 23.03 and 29.03 per cent when compared to ridges and flat seed bed respectively. In variety ICGS 11 the increases in BBF were 23.66 and 29.22 per cent when compared to the ridges and flat seed bed respectively.

The production of higher haulm yield observed in the BBF might be ascribed to the improved soil physical parameters as observed from the results recorded in Tables 3 to 20. Results observed in the present investigation are in accordance with those reported by Ali and Wallis (1986), Patil (1989) and Rao, et. al., (1991).

5.2.3 Pod Yields

The results presented in Table 20 and Figure 20 indicated that maximum pod yields of 4,219 and 3,388 kg ha^{-1} were obtained in BBF in groundnut varieties ICG(FDRS)10 and ICGS 11 respectively. In variety ICG(FDRS)10 the increases in pod yield observed in BBF were 13.84 and 22.25 per cent as compared to the ridges and flat seed bed respectively. Similarly the increases in pod yield observed in BBF on which variety ICGS-11 grown were 9.50 and 18.34 per cent as compared to the ridges and flat seed bed respectively. Mean pod yields of 3,792 and 3115 kg ha^{-1} were obtained with varieties ICG(FDRS)10 and ICGS 11 respectively and the pod yield increase was 21.73 per cent. These results clearly indicated that by adopting BBF, higher pod yields of groundnut were produced than the ridges and flat seed bed and that the bunch type of groundnut (ICG(FDRS)10) yielded better than the spreading type (ICGS 11).

The increase in pod yield observed in BBF might be attributed to lower penetration resistance, increased water retention capacity, reduced bulk density, improved aeration, better root growth and also due to the loose and friable surface soil which facilitated easy penetration of gonophores and thereby developed the pods better. These results are fairly in good agreement with those reported by NARP-T (1981), Rajah (1981), Sankara Reddy (1982), Shanmugham (1983), Venkateshwarlu (1986), Ali and Wallis (1986), Amin, et. al. (1988), Patil (1989), CRIDA (1990), Rao, et. al. (1991) and LEGOFTEN (1991).

CHAPTER VI
SUMMARY

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SUMMARY

A field experiment was conducted during the 1991-92 post-rainy season under irrigated conditions at the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru, Andhra Pradesh with a view to study the effect of land surface configurations on soil physical conditions and yield of groundnut In an Alfisol. The treatments consisted of three land configurations namely, ridges, BBF and flat with two groundnut varieties of ICG(FDRS)10 and ICGS 11. The experiment was conducted in a simple randomized block design replicated 4 times.
Penetration resistance and oxygen content were measured at 0-5, 5-10 and 10-15 cm depths at 30, 35, 60, 65, 90, 95, 145 and 150 days after sowing (DAS) during the season. Bulk density and total porosity were measured only at 0-15 cm depth at 30, 60, 90 and 145 DAS. Soil temperature was monitored at 0-10, 10-15 and 15-25 cm depths. Soil water status was measured at 0-5, 5-10, 10-15 and 15-30 cm depths at 30, 35, 60, 65, 90, 95, 145 and 150 DAS. Leaf area and dry matter per plant were determined for 5 plants selected randomly from each plot at 50 DAS.

Throughout the growing season, the bulk density of 0-15 cm soil layer was found to be significantly lower in BBF than the ridges and flat treatment for both the groundnut varieties.

Differences in bulk density between the treatments persisted at 30, 60, 90 and 145 DAS. Lowest bulk densities of 1.37, 1.43, 1.45 and 1.48 g cm^{-3} were recorded in BBF followed by 1.48, 1.53, 1.54 and 1.56 g cm^{-3} in ridges and 1.61, 1.64, 1.65 and 1.69 g cm^{-3} in flat treatment at 30, 60, 90 and 145 DAS respectively. It was observed that there was a clear advantage of BBF over ridges and flat seed bed in keeping top soil loose with implications for gonophore penetration into the soil, pod formation and harvesting of groundnut. The decrease in the bulk density in BBF when compared to ridges and flat might be ascribed to increased total porosity.

The total porosity of the soil was increased by 9, 8, 8 and 8 per cent in BBF at 30, 60, 90 and 145 DAS respectively as compared to flat while the increases in to total porosity were 4, 4, 3 and 3 per cent as compared to ridges. The increase in total porosity in the BBF might be attributed to lower bulk density values.

The soil moisture retention was increased in BBF followed by ridges and flat treatments in all the stages of crop growth. The soil moisture retention was increased in BBF by 10.3, 6.2, 8.0 and 18.1 per cent as compared to the ridges at 0-5, 5-10, 10-15 and 15-30 cm soil depths respectively. The increases in soil moisture content in BBF when compared to flat treatments were 34.9, 18.1, 20.3 and 28.3 per cent at 0-5, 5-10, 10-15 and 15-30 cm soil depths respectively. In all the treatments more soil moisture was retained in 15-30 cm depth followed by 10-15, 5-10 and 0-5 cm soil depth.

At the beginning of the season (30 DAS), the differences in penetration resistance between BBF, ridges and flat treatments for the three depths were found to be meager. But at the other stages of crop growth, lower penetration resistance was observed in BBF than in ridges and flat treatments. Even before harvest (145 DAS), the penetration resistances at 0-5, 5-10 and 10-15 cm soil depth were 10.1, 17.6 and 20.6 kg cm^{-2} respectively in BBF as compared to the flat which recorded 16.9, 48.4 and 73.1 kg cm^{-2} at the respective soil depths. The lower penetration resistances observed in BBF might be ascribed to higher moisture content in all the 3 depths.

The oxygen content of 0-5 and 5-10 cm layers was found to be significantly higher in BBF than in the ridges and flat at 30 and 35 DAS. AT 30 DAS, the oxygen content of 0-5, 5-10 and 10-15 cm soil layers in BBF was 3.5, 5.6 and 3.2 per cent greater than in ridges and 4.5, 7.5 and 10.3 per cent greater than in flat respectively. The land configurations had no significant influence on oxygen content at 60, 65, 90, 95, 145 and 150 DAS since the porosity of soil was decreased continuously.

The soil temperature had decreased with increase in soil depth upto 25 cm in all the treatments. At all the stages of crop growth, soil temperature in ridges was higher than in the BBF and flat treatments in all the depths. The mean soil temperatures in ridges and BBF were found to be higher by 0.5 to 2.0°C as compared to the flat treatment. The increased soil temperatures observed in ridges and BBF might be ascribed to the exposure of larger surface area of the soil for absorption of solar radiation.

Higher leaf area, dry matter production, haulm and pod yields were recorded in BBF than in ridges and flat treatments. Variety ICG(FDRS)10, a bunch type, gave better performance in BBF than the variety ICGS 11, a spreading type. An increase of 33.3 and 25.0 per cent in dry matter of ICG(FDRS)10 were observed in BBF as compared to the flat and ridges respectively. The variety ICG(FDRS)10 produced 18.9 per cent higher dry matter than the variety ICGS 11. A maximum increase of 22.3 percent in pod yields of ICG(FDRS)10 was observed in BBF as compared to the flat. In variety ICGS 11, a maximum increase of 18.3 per cent in pod yields were observed in BBF as compared to the flat treatment.

Based on the above results, it can be concluded that broad bed and furrow (BBF) improved the soil physical conditions as measured by penetration resistance, soil moisture content, bulk density, oxygen content and total porosity in an Alfisol. The increase in pod yields of the two varieties observed in BBF might be attributed to increased soil moisture content, lower penetration resistance and lower bulk density observed at all the growth stages of the crop. Increase in oxygen content observed at 30 and 35 DAS might also be another important contributing factor. The BBF land configuration was found to be significantly superior than that of ridges and flat in the Alfisols under agroclimatic conditions of ICRISAT.

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APPENDIX

APPENDIX I

Weekly mean meteorological data during the crop growth

Standard week no.	Rainfall mm	Evap. mm	Temperature oC Max.	Min.	R.H (per cent) 7 hrs	14 hrs	Wind speed kphr
1	1	27.4	27.2	20.0	82.1	67.3	8.7
2	0	37.5	29.2	15.6	84.9	36.1	7.1
3	2	29.9	27.3	16.2	92.7	52.7	11.5
4	0	28.9	27.7	16.1	95.7	50.3	7.4
5	0	31.0	29.3	13.9	93.0	31.9	6.2
6	0	33.1	28.3	11.6	91.9	26.7	8.2
7	0	31.8	26.6	11.4	92.4	35.7	6.8
8	0	29.1	26.9	13.1	94.7	37.6	7.1
9	0	37.1	26.2	14.6	89.6	39.8	6.2
10	0	34.6	27.2	10.1	85.3	27.0	5.9
11	0	34.2	28.2	10.4	94.3	27.4	7.5
12	0	36.6	28.5	12.3	95.4	29.4	7.3
13	0	40.2	30.1	13.7	91.1	26.3	7.2
14	0	40.9	29.6	13.0	85.3	25.7	6.8
15	0	44.0	31.3	16.0	78.3	30.7	7.9
16	0	42.7	31.6	13.6	69.7	22.0	5.8
17	0	47.2	31.6	16.0	59.1	26.0	6.6
18	0	57.5	32.9	14.9	69.3	16.6	6.0
19	0	57.0	35.5	16.8	51.3	15.3	8.2
20	0	60.0	36.3	17.3	61.7	14.1	7.2
21	0	66.0	37.7	19.1	71.0	15.3	8.0
22	0	70.0	38.5	22.1	56.6	19.8	8.4
23	0	72.5	37.3	21.2	46.8	16.3	9.0
24	0	83.4	39.1	23.0	52.0	15.3	10.3
25	0	71.5	38.1	23.5	59.9	23.0	9.9