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# STUDIES ON AGROTECHNIQUES FOR AMELIORATION OF DROUGHT IN RAINFED GROUNDNUT

By

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*es*  
**CHECKED 2007**

THESIS SUBMITTED TO THE  
ANDHRA PRADESH AGRICULTURAL UNIVERSITY  
IN PARTIAL FULFILMENT OF THE REQUIREMENTS  
FOR THE AWARD OF THE DEGREE OF  
**MASTER OF SCIENCE**  
IN THE FACULTY OF AGRICULTURE

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OCTOBER, 1996

## CERTIFICATE

*Ms. T.PRATHIMA has satisfactorily prosecuted the course of research and that the thesis entitled "STUDIES ON AGROTECHNIQUES FOR AMELIORATION OF DROUGHT IN RAINFED GROUNDNUT" submitted is a 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 thereof has not been previously submitted by her for a degree of any University.*

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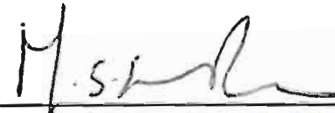
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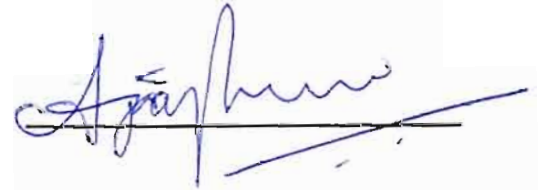
  
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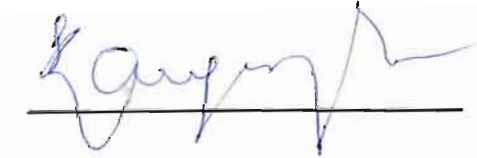
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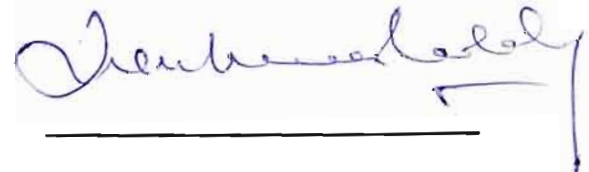
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## SYMBOLS AND ABBREVIATIONS

Centimeter	-	cm
grams	-	g
Kilograms	-	Kg
Quintals	-	Q
hactare	-	ha
per cent	-	%
Degree celcius	-	°C
Leaf area index	-	LAI
Days after sowing	-	DAS
Harvest index	-	HI
Relative water content	-	RWC
Rainfall use efficiency	-	RUE

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## DECLARATION

I, Ms. T.PRATHIMA hereby declare that the thesis entitled "STUDIES ON AGROTECHNIQUES FOR AMELIORATION OF DROUGHT IN RAINFED GROUNDNUT" submitted to Andhra Pradesh Agricultural University, Hyderabad for the degree of Master of Science in Agriculture is the result of original research work done by me. I also declare that the material contained in the thesis has not been published earlier.

T. Prathima 6.10.1996  
(MS. T. PRATHIMA)

**ABSTRACT**

<b>Author</b>	:	<b>THOTTAMBETI PRATHIMA</b>
<b>Title of the Thesis</b>	:	Studies on agrotechniques for amelioration of drought in rainfed groundnut
<b>Submitted for the award of the degree</b>	:	M.Sc., (Agriculture)
<b>Faculty</b>	:	Agriculture
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<b>University</b>	:	Andhra Pradesh Agricultural University
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A field experiment was conducted on Alfisols of Tirupati campus of Andhra Pradesh Agricultural University during kharif 1995 under rainfed conditions to study different agrotechniques for amelioration of drought in rainfed groundnut in the Southern Agroclimatic Zone of Andhra Pradesh.

The main plots consisted of rainfed, irrigated and moisture stress treatments with mulch @ 4 t ha<sup>-1</sup>, kaoline 4% spray twice, 2% urea spray twice and their combinations in sub plots in split plot design replicated thrice. The treatments were tested on TPT 1 groundnut, a drought tolerant variety evolved at Regional Agricultural Research station, Tirupati.

Plant height, leaf area index and dry matter accumulation at 30, 45, 60, 75 and 90 DAS were high in irrigated treatment. There was decrease in all these growth characters due to moisture stress. Mulch + kaoline had profound effect in conserving moisture favourably influencing all the growth characters.

The number of flowers, pegs per plant and peg to pod percentage were significantly higher where the crop was irrigated. The same trend was observed in the case of total and filled pods per plant, 100-pod weight and shelling percentage. The least was in stressed ( $M_3$ ) treatment. Mulch + kaoline had significantly higher number of flowers, pegs per plant and peg to pod percentage. Similar trend was observed for all the yield attributing characters which contributed significantly for higher pod ( $21.18 \text{ Q ha}^{-1}$ ) haulm ( $39.60 \text{ Q ha}^{-1}$ ) yields and harvest index.

Least leaf temperature, highest relative water content and soil moisture content were with irrigated treatment. Highest leaf temperature, least relative water content was with no treatment. In the mulch + kaoline treatment low leaf temperature highest relative water content and soil moisture was recorded. Rainfall use efficiency was high in the stressed treatment and in mulch + kaoline. Highest pod yield ( $22.35 \text{ Q ha}^{-1}$ ) was under irrigated and least ( $15.94 \text{ Q ha}^{-1}$ ) in stressed treatment. Stressed treatment lost  $641 \text{ Kg ha}^{-1}$  pod yield. Mulch + kaoline gave an additional yield of  $319 \text{ Kg ha}^{-1}$  over control. Highest additional returns were obtained in mulch + kaoline followed by mulching in which the net returns were the highest.

The results indicated that the loss in pod yield of rainfed groundnut due to drought in Alfisols could be offset to a considerable extent by mulching and mulch + kaoline.



## CHAPTER - I

### INTRODUCTION

The Characteristic feature of crop production in rainfed areas of Rayalaseema is of low and unstable yields which are attributed to several factors, chief of which are low and erratic rainfall occurring in a few rainy days with prolonged dryspells. This situation has resulted in unstable production, continued low and even disastrous yields in most of the dryland areas. About 73.5 per cent of the cultivated area in the country is still under rainfed farming where conservation of rain water is an important prerequisite for successful crop production. Dry spells during kharif season have very adverse and even dismal effect on the growth and development of crops. Therefore, it is essential to minimise the yield losses due to evapotranspiration and to ensure moisture supply to the crop during stress period.

Evaporation from the soil contributes to more than 50 per cent of the total evapotranspiration. Therefore if evaporation is reduced, it may be possible to raise a fairly good crop even in the years of low rainfall. Mulches reduce evaporation and control soil temperature to promote good root development and microbial action. Mulch conserves moisture and optimises crop production. The use of antitranspirants and reflectants reduce leaf temperature and increase water use efficiency which is another approach to mitigate stress effects as reported by several workers. The loss of water through transpiration and

evaporation can be reduced without any adverse effect on plant growth by using mulches and antitranspirants. On the other hand, mulching has additional advantage like controlling weeds, regulation of soil temperatures, soil microflora etc.

Recent reports from RARS, Tirupati indicated urea spray during moisture stress was reported to be effective (*Selvam et al.*,1989) . Hence application of mulches, antitranspirants and stress mitigants like urea spray would be of great help in dryland farming, where non-availability of sufficient soil moisture is a constraint in crop production. Hence by using these ameliorants either individually or in combination, considerable moisture loss can be checked which would prevent disaster and help to boost the yields in dryland farming.

Groundnut is the most important oil seed crop grown in India and is the main commercial crop of dryland farmers of Rayalaseema region of Andhra pradesh. The crop occupies 45 per cent of total area and 55 per cent of the total oil seed production. The average yields of rainfed groundnut range from 700-900  $\text{kg ha}^{-1}$  much lower compared to post rainy irrigated groundnut with an average pod yield of 1500  $\text{kg ha}^{-1}$ . More than 88 per cent of groundnut in Rayalaseema is rainfed which often results in crop failures. It is, therefore, imperative that productivity and production of this important oil seed crop on which several farmers depend for their livelihood has to be stabilised. Not much work has been done in India on the use of mulches, antitranspirants and urea sprays as an integrated technique to stabilise yields in dryland groundnut and hence the present investigation was, therefore, undertaken to findout the effects of

different agrotechniques like mulches, antitranspirants and urea spray for amelioration of drought effects on rainfed groundnut with the following objectives.

1. To study the effect of drought on certain growth parameters of rainfed groundnut, yield attributes and yield.
2. To workout the loss in yield in the drought affected crop compared to irrigated and rainfed crops.
3. To study certain treatmental effects in ameliorating the stressed groundnut crop and the extent of reduction in yield loss by these techniques.

# **REVIEW OF LITERATURE**

susceptible to drought, particularly in groundnut so

Flowering, pegging and maturation. Most are stages of a continuous cycle  
adverse affect on flower product. Lower to 50% and 10% pod num-  
ber of filled pods per plant, 100-kernel weight and 1000-pod per hectare leads  
reduction in pod yield. (Klepper, 1973)

Seshadr (1962) reported that sufficient moisture during the time of flowering  
beneficial for the formation of pods in groundnut. The variety  
was found to be not especially sensitive to drought. Pegg-  
ing and maturation were less sensitive than peak flowering stage. The water  
during the first month of sowing was found to be small compared to second

## CHAPTER - II

### REVIEW OF LITERATURE

Literature pertaining to "Studies on Agrotechniques for amelioration of drought in Rainfed groundnut" has been reviewed in this chapter.

#### 2.1 EFFECT OF MOISTURE STRESS

##### 2.1.1 *Effect of Moisture Stress at Sensitive Stages of Groundnut*

Water status invariably affects plant growth and development since about 80 per cent of plant fresh weight is contributed by water. Reduction of plant water status much below this level causes visible wilting and affects the rate of many plant functions. In a plant ontogeny several stages might be expected to be sensitive to drought, particularly in Groundnut such as early vegetative growth, Flowering, pegging and maturation. Moisture stress at sensitive stages has adverse effect on flower production, flower to peg and peg to pod ratio, number of filled pods per plant, 100-kernel weight and nutrient uptake leading to reduction in pod yield. (Klepper, 1973).

Seshadri (1962) reported that sufficient moisture at the time of flowering was beneficial for the formation of pods in groundnut. Generally, very early growth was found to be not especially sensitive to drought. Pegging and nut maturation were less sensitive than peak flowering stage. The water absorbed during the first month of sowing was found to be small compared to second month. (Su *et al.*, 1964).

Jayarami Reddy and Rao (1968) reported that the flowering period in groundnut plants was sensitive to water deficits. Joshi and Kaharia (1972) reported 51 to 80 days (Full pegging to pod development) as critical moisture period.

Mac Gillivray *et al* (1981) stated that late flowering and pod formation as critical moisture periods in groundnut. According to Balasubramanian and Yayock (1981) peg and pod development (63-91 days) stages are critical for moisture. Vanangamudi *et al* (1987) reported pod initiation, filling and maturation stages as most sensitive to moisture stress.

Stress at flowering and pegging was more injurious to crop growth, followed by stress at early pod stage, since the soil water deficit in the root zone at these physiological stages restricted not only the penetration of pegs into hard soil but also the well developed roots to absorb required nutrients from the rhizosphere. (Naveen *et al.*, 1992). In an experiment where groundnut was subjected to water stress during flowering, pegging, pod formation and pod development stages corresponding to 23-47, 33-55, 57-79 and 73-95 days after sowing, pod development stage along (or) in combination with any other stage with water stress was found most sensitive to pod yield and shelling percentage whereas pegging stage alone or in combination with any other stage with moisture stress was sensitive to haulm yield (Garara and Yadav 1992).

### 2.1.2 *Effect of Moisture Stress on Plant Height and Stem Growth*

Lin *et al* (1963) reported that the stem length of groundnut plants decreased markedly due to drought. The results of research reported by Jayarami Reddy and Rao (1968) indicated that vegetative growth and shoot growth of

groundnut were progressively reduced due to stress and entirely depended upon the availability of soil water to the plants. Lenka and Misra (1973) studied the effects of irrigation at 25, 50 and 75 per cent depletion of available soil moisture on growth and yield of groundnut. The results showed that plant height decreased with increase in stress.

Momen *et al* (1979) reported that limited soil moisture influenced Soybean field crop performance by reducing plant height. Boote and Hammond (1981) reported that during early pegging and pod formation in groundnut there was reduced vegetative growth by reducing the rate of node formation and reducing elongation between nodes. Gerri *et al* (1983) found that the shoot size at flowering had a strong effect on final yield and can be significantly reduced by drought. Due to stress in soybeans, stem elongation rates decreased significantly during the periods of moisture stress.

In groundnut, plant height decreased under all moisture stress treatments except the treatment at late pod development (76 to 88 days after sowing) by which time, the plant elongation was complete (Ramesh babu *et al.*, 1984). Results reported by Shinde and Pawar (1984) revealed that moisture stress at various irrigation water/cumulative pan evaporation (IW/CPE) levels had significant effect on plant height in groundnut. Water stress at 0.4 and 0.6 IW/CPE ratio reduced the plant height significantly as compared to 0.8 IW/CPE ratio. Gowda and Hegde (1986) reported that TMV 2 plants stressed between 30-45 days after sowing showed no significant differences in plant height.

Ike (1986) reported that a spanish peanut variety subjected to moisture stress during early flowering and pod formation stages, did not reduce plant height significantly. However there was greater reduction in the above parameters, when stress was imposed at the early flowering than at pod formation stage.

Jana *et al.*, (1989) reported that decrease of soil moisture through reduction in number of irrigations reduced plant height in groundnut. Ramana Rao (1994) reported reduction in plant height under simulated drought treatments compared to adequately irrigated and rainfed treatments.

### 2.1.3 *Effect of Water Stress on Leaf Area Index (LAI)*

Soil water deficit was known to inhibit leaf expansion and stem elongation (Allen *et al.*, 1976; Vivekanandan and Gunasena; 1976, Slatyer, 1955). There is a linear relationship between leaf area, evapotranspiration and drymatter production within certain limits (Monteith, 1977). Sammons *et al* (1978) reported that leaf area was reduced due to moisture stress in soybean plants. Scott and Batchelor (1979) reported that in soybean, leaf area and LAI values for irrigated treatments were greater than non irrigated treatments.

Moisture stress decreased the leaf area of groundnut crop. Moisture stress during flower initiation phase and commencement of flowering (22 to 32 DAS) reduced canopy area by 47 per cent but attained near normal (37.5 per cent recovery) ground cover over in next 40 days (Reddy *et al.*, 1980).

Moisture stress reduced leaf area index (Patel *et al.*, 1983). Sivakumar and Sarma (1986) reported that leaf area index (LAI) decreased due to water stress imposed in different phenophases of groundnut. The recovery of leaf area was remarkable and rapid when stress was relieved at the start of pegging.

Ravindra *et al* (1990) stated that water stress during flowering and pod development was highly detrimental to leaf area development. Soil moisture stress at flowering and pod development phase decreased leaf area compared to stress at vegetative phase (Nautiyal *et al.*, 1991). LAI was significantly higher in irrigated treatments compared to simulated drought conditions (Ramana Rao., 1994)

#### 2.1.4 *Effect of Moisture Stress on Total Drymatter*

Drymatter accumulation of peanut was reduced due to stress (Slatyer, 1955). Stansell *et al* (1976) reported decrease in drymatter production due to drought in groundnut. Scott and Batchelor (1979) reported that irrigated soybean accumulated greater amounts of drymatter than non-irrigated soybean. Reddy *et al* (1980) reported that moisture stress at flowering decreased the biomass more than at pegging (or) pod formation stages in groundnut crop.

Ramesh babu *et al* (1984) reported that moisture stress during early pod development phase (55 to 67 days after sowing) affected maximal loss (34.7 per cent) in biomass accumulation. Shinde and Pawar (1984) noted that water stress had an adverse effect on total drymatter at 0.4 IW/CPE ratio.

Nageswar Rao *et al* (1985) noted that the amount of drymatter accumulated by a crop was closely related to the water transpired. Total drymatter of groundnut was reduced more when stress was imposed from start of flowering to start of seed growth. Moisture stress at flowering reduced the total phytomass production to a greater extent compared with stress at pegging and podformation stages (Rao *et al.*, 1986). Total dry weight in groundnut plants was reduced under stress conditions over stress free conditions (Sreenivasan *et al.*, 1987).

Maximum drymatter accumulation was observed when the amount of water applied at each irrigation was equal to that lost in evapotranspiration (Reddy;1988). Moisture stress during flowering and pod development was highly detrimental to drymatter production compared with stress during vegetative phase. Growth recovery after the stress was better at the vegetative phase than at later growth phases (Ravindra *et al.*, 1990). Moisture stress at flowering and pod development phase decreased drymatter accumulation compared to stress at vegetative stage (Nautiyal *et al.*, 1991). Ramana Rao (1994) reported reduction in total drymatter production in simulated-drought treatment when compared to adequately irrigated treatment.

#### 2.1.5 *Number of Flowers*

Flower production depends on soil moisture availability. Flowering almost stopped when Soil moisture content dropped to wilting point (Scandaliaris *et al.*, 1978). However, the other view was that there was no significant difference in flower production with increase in moisture stress (Gowda and Hegde, 1986 and

Janamitti *et al.*, 1986). Contrary to the above findings there was reduction in the number of flowers due to soil moisture stress at flower initiation and fruiting stages (Illyina, 1958), Peak flowering (Chen *et al.*, 1964 and Bhatia *et al.*, 1984). Garara and Yadav (1992) reported that Number of flowers were significantly reduced due to water stress in groundnut.

#### 2.1.6 *Number of Pegs*

Moisture stress reduced number of pegs per plant (Orcutt *et al.*, 1988). Garara and Yadav (1992) reported that number of pegs were significantly reduced due to water stress.

#### 2.1.7 *Moisture Stress on Yield and Yield Attributes*

2.1.7.1 Total filled and unfilled pods per plant. Stern (1968) reported that waterstress at pod formation stage resulted in poor pod formation and increased number of pops, due to decrease in calcium and sulphur uptake under low soil moisture conditions at that stage in groundnut. Similar results were reported by Soundara Rajan *et al* (1982) and Sridhar *et al* (1985).

Berengena and Roldan (1979) found that irrigation at every 15 days reduced number of pods per plant compared with more frequent irrigations in Soybean. Reddy *et al* (1980) reported that moisture stress at flowering and pod formation stages reduced number of full pods due to suppression of flower production and inadequate pod filling. Balasubramanian and Yayock (1981) reported that moisture stress at 9 to 13 weeks after sowing, coinciding with the

period of peg and pod development lowered nitrogen uptake and increased the proportion of unfilled pods.

Boote and Hammond (1981) observed a delay in pod maturity by 10 to 11 days and reduction in pods by 51 per cent, when the groundnut crop had experienced stress for a period of 42 days during early pegging and pod formation (40 to 82 days after sowing). Total and filled pods per plant increased due to irrigations at IW/CPE ratio of 0.9 (Mathew *et al.*, 1983). Moisture stress at late pod development stage (76 to 88 days after sowing) lowered the filled pod number significantly and thereby increasing unfilled pods (Ramesh Babu *et al.*, 1984). Number of pods per plant were affected due to water stress at 0.4 and 0.6 IW/CPE ratio (Shinde and Pawar, 1984).

Ike (1986) reported that when a spanish peanut variety was subjected to moisture stress during early flowering and pod formation stages, the number of pods produced were significantly reduced. Venkateswar Rao *et al* (1986) reported that moisture stress reduced the total number of pods per square meter. In the groundnut variety J11, moisture stress at flowering, pegging and pod formation stages reduced pod number by 44.85, 20.00 and 27.87 per cent respectively over control. Waterstress during the vegetative stage had less effect on number of mature pods per plant than water stress at later developmental stages (Kulkarni *et al.*, 1988). Patel and Golakiya (1988) found that water stress at pegging to pod development reduced developed pods and consequently number of pops and undeveloped pods were affected significantly. Total number of pods as well as filled pods per plant were highest due to no soil moisture stress throughout the crop period (Reddy, 1988). Selvam *et al* (1989) reported reduced number of filled

Pods/plant due to moisture stress. Jana *et al* (1989) reported that number of pods per plant was reduced due to decrease in irrigation. Moderate (or) severe stress at pod formation stage drastically reduced the total and filled pods per plant (Reddy, 1991).

Patel and Golakiya (1991) stated that water stress during pod development stage increased the percentage of ill filled pods and finally reduced pod yield. Mature pods were significantly reduced due to water stress in groundnut (Garara and Yadav, 1992). In irrigated groundnut also stress during flowering and pegging resulted in reduced number of mature pods (Naveen *et al.*, 1992) Since the soil water deficit in the rootzone at these physiological stages restricted not only the penetration of pods into hard soil, but also well developed roots to absorb required nutrients from the rhizosphere. Number of filled pods per plant were more in adequately irrigated condition than in simulated drought and rainfed treatments. (Ramana Rao, 1994).

**2.1.7.2 100-Pod weight.** Jayarami Reddy and Rao (1968) in an experiment of imposed moisture stress on TMV-2 showed that pod weight was reduced. Boote *et al* (1976) observed only a minor change in pod weights due to moisture stress. Hundred pod weight progressively increased with increase in irrigation frequency. Application of water equal to that lost in ET significantly increased the 100-pod weight as compared to lesser depths of application on sandy loam soils of Tirupathi (Reddy *et al.*, 1981). Ramesh Babu *et al.*, 1984 reported that moisture stress at pod development stage reduced 100-pod weight significantly.

So stress treatment. Soil moisture stress from pegging

Scheduling irrigation at 0.7 IW/CPE ratio significantly improved 100 pod weight (Desai *et al.*, 1985). Gowda and Hegde (1986) reported that 100-pod weight did not reduce significantly from the normal irrigated crop. Pod weight of groundnut decreased due to water stress. (Sreenivasan *et al.* (1987). Pathak *et al.* (1988) reported that plants subjected to drought during flowering stage resulted biggest reduction (29 per cent) in 100-pod weight compared with control. 100-pod weight was lower under simulated drought and rainfed conditions compared to adequately irrigated treatment. (Ramana Rao, 1994).

2.1.7.3 Shelling percentage. Shelling percentage, in general, was less under moisture stress conditions. This was due to the fact that stress increased the number of pods and extra weight transferred to the shell for maintaining almost constant pod weight resulting in reduced shelling percentage (Stern, 1968). However, shelling percentage was more under irrigated treatments relative to that with no irrigation (Reddi 1978 and Pallas *et al.*, 1977). Reddy *et al.* (1980) observed that shelling percentage did not decrease significantly due to moisture stress in groundnut. Ramesh babu *et al.* (1984) reported that moisture stress at pod development phase decreased shelling per cent more significantly than at other stages.

Reduction in shelling percentage was 28 per cent when stress was imposed during pod development stage as compared to no soil moisture stress (Pathak *et al.*, 1988). Contrary to the above findings, Patel and Golakiya (1988) recorded higher shelling percentage due to stress during early (Seedling to Flowering) and later (Pod development to maturity) stages of the crop which were on par with no stress treatment. Soil moisture stress from pegging to pod development or

flowering to pegging resulted in more number of pods leading to reduction in shelling percentage. Jana *et al* (1989) indicated that shelling percentage was reduced due to decrease in irrigation in groundnut. Dhopte *et al* (1992) in an experiment conducted at Akola, Maharashtra reported reduction in shelling percentage due to moisture stress. Garara and Yadav (1992) reported that shelling percentage was significantly reduced due to water stress in groundnut. There was reduction in shelling percentage in drought and rainfed treatments when compared with irrigated treatment (Ramana Rao, 1994).

2.1.7.4 Pod yield. Yield is the product of plant (genetic) and environmental interaction. The stage at which the crop is subjected to soil moisture stress plays a major role in the final yield of the crop.

Billaz and oches (1961) found that the 50 to 80 days period was most susceptible to drought causing a 46 per cent yield reduction while water stress in days 80 to 120 caused 27 per cent reduction, 10 to 31 days 21.6 per cent and 30 to 50 days 18 per cent. Jayarami Reddy and Rao (1968) in an experiment on TMV2 reported that water stress at the time of flowering (40 DAS) produced considerable reduction in yield of pods. A 35-day drought spanning from 71-105 days was more damaging than 35 -day drought at 36-70 or 106-140 days of age (Stansell and Pallas, 1979). Reddy *et al* (1980) reported that moisture stress at flowering severely reduced pod yield than moisture stress at other stages.

Balasubramaniam and Yayock (1981) reported that moisture stress at 9 to 13 weeks after sowing coinciding with the period of peg and pod development reduced the yield drastically. Reduction in pod yield was high with severe soil

moisture stress at vegetative growth, commencement of flowering, peg penetration and pod development and pod maturation stages (Venkaiah *et al.*, 1983). Work done at ICRISAT revealed that moisture stress during emergence to peg initiation had resulted in 13 to 30 per cent reduction in yield over the treatment which received continuous irrigation at 10 days interval (ICRISAT 1982 and 1983). The seed yield reduction due to moisture stress was 46 per cent and the seed filling phase was most sensitive to kernel yield (Pandey *et al.*, 1984). The pod yields were however significantly reduced (85 per cent) due to continuous moisture stress and by 25 per cent due to moisture stress from 76 to 88 days after sowing (late pod development and early pod maturation stage) (Ramesh babu *et al.*, 1984).

On sandy loam soils of Tirupathi, spanish groundnut was sensitive to soil moisture stress either althrough the crop period or from 76 to 88 DAS. Continuous stress or moisture stress from 76 to 88 days (late pod development and early pod maturation stage) reduced the pod yield by 84 and 28 per cent respectively. Vegetative, flowering, pegging and early pod development stages were not too sensitive to soil moisture stress (Babu *et al.*, 1984). Shinde and Pawar (1984) revealed that water stress at 0.4 IW/CPE ratio at all growth stages was detrimental for pod yield. Gowda and Hegde (1986) reported a reduction of 4.7 per cent in pod yield when TMV2 plants were stressed between 30-45 days after sowing. Ike (1986) reported yield reduction when peanut plants were stressed during early flowering and pod formation stages.

Venkateswara Rao *et al* (1986) reported that soil moisture stress at flowering severely reduced the pod yield by limiting the number of mature pods

per unit area. In J 11 moisture stress at flowering, pegging and pod formation stages reduced pod yield by 44.03, 18.90 and 26 per cent respectively over control. Gangamma (1987) noted that productivity decreased due to both early and midseason stress but latter being more detrimental. Srinivas and Arjunan (1987) reported that water stress imposed in the midseason of growth period especially at pod formation to maturity caused yield reduction to a greater extent, when compared to earlier drought in growth period of the bunch groundnut cultivars. Sharma and Singh (1987) reported that pod yield was highest with two irrigations, at 50 and 80 days after sowing and were lowest under rainfed conditions.

Anjaneyalu (1988) found podding stage to be more sensitive to moisture stress than early growth stage (Peak flowering). Arjunan *et al* (1988) reported that more reduction (65per cent) was observed in the variety JL 24 due to stress. Water stress during vegetative stage had less of an effect on pod yield and number of mature pods per plant than waterstress at later developmental stages (Kulkarni *et al.*, 1988). Pathak *et al* (1988) reported that highest reduction in pod yield (62.7 per cent) occurred when watering was withheld during the period of pod development. Roy *et al* (1988) noted that imposing stress at period of late flowering, Pod formation and pod filling stages reduced yields to a large extent. Yield reductions were greatest with stress imposed during the period between pegging and pod development and lowest with stress imposed from pod development to maturation. (Jana *et al.*, 1989) reported that two irrigations, one each at flowering and pod development stages recorded 38.9 per cent more pod yield than no irrigation. Highest pod yield of 2395 kg $ha^{-1}$  was recorded from

control treatment, which was 127 and 82 per cent higher than the yield recorded with treatments involving moisture stress at pod development and pegging stages respectively. Moisture stress during vegetative phase reduced pod yield by 16 per cent only, where as stress during late vegetative and flowering stages resulted in 19 and 36 per cent yield reduction in comparison to control (Parmar *et al.*, 1989). Sarma and Sivakumar (1990) reported that early moisture stress imposed from emergence to initiation of pegs caused no significant reduction in pod yield in groundnut. Ravindra *et al* (1990) reported flowering and pod development stages were highly detrimental to yield compared to stress during vegetative phase. Water stress only during early or late period of growth did not reduce yields substantially water stress at 40-80 and 30-60 DAS was most harmful in groundnut.

Soil moisture stress at flowering and pod development phase decreased pod yield in comparison with stress at vegetative phase (Nautiyal *et al.*, 1991). Patel and Golakiya (1991) observed greatest yield reduction when stress was imposed during the pod development stage. Pod yields were reduced by 49 and 37 per cent compared with control due to stress imposed at 50 and 80 DAS (Meisner and Karnok 1992). Naveen *et al* (1992) observed reduction in yields due to stress during flowering and pegging. Yields were significantly reduced due to moisture stress at flowering and pegging (Garara and Yadav, 1992). Patel and Golakiya (1993) reported that water stress from pegging to pod development stage gave the lowest pod yields. Golakiya (1993) reported that water stress from pegging to pod development stage gave the lowest pod yields. Golakiya (1993) noted that water stress at flowering, pegging, pod development and pod maturation stages reduced pod yields by 26.6, 44.7, 56.3 and 6 per cent respectively.

2.1.7.5 Haulm yield. In general, haulm yield increases with increase in available soil moisture irrespective of the growth stage. Ramesh Babu *et al* (1984) reported that moisture stress at pegging and pod formation stages reduced the haulm yield. Plants subjected to drought during pod development to harvest resulted in reduction of haulm yield to 60.5 per cent (Pathak *et al.*, 1988). Haulm yields were reduced under stress during flowering period followed by pod development period (Patel and Golakiya 1988). Higher haulm yield was obtained when irrigations were given at IW/CPE ratios of 0.8 to 1.2 (Desai *et al.*, 1985 and Patel and Golakiya, 1988). Thanzuala and Dahiphale (1988) reported that haulm yield was significantly high with irrigation scheduled at 0.75, 1.00 and 1.25 IW/CPE ratio compared to scheduling of irrigation at critical growth stages. Haulm yields were significantly reduced due to water stress in groundnut. (Garara and Yadav, 1992).

2.1.7.6 Harvest index. Water stress affected seed formation more than the total drymatter yield thus reducing the harvest index (Pandey *et al.*, 1984). Harvest index was reduced significantly due to moisture stress at pod development period. (Ramesh babu *et al.*, 1984). Venkateswara Rao *et al.*, (1986) reported that harvest index was reduced due to moisture stress in groundnut.

#### 2.1.8 *Effect of Water Stress on Leaf Temperature.*

Clark and Hiler (1973) in an experiment on southern peas (*Vigna Sinensis*.L) noted that leaf temperatures increased in stressed treatments and were dependent on radiation, wind and internal water status of the plant. A leaf temperature of 35°C drastically reduced leaf photosynthesis in groundnut (Pallas and Smith, 1974).

Leaf temperature was increased due to water stress in peanut as recorded by Bennett *et al* (1984). Canopy temperatures were influenced by time of the day and the stage at which drought stress was imposed (Sivakumar and Sarma 1986). Water stress increased leaf temperature to 34°C during pod development and harvesting (Pathak *et al.*, 1988). Samsukumar (1991) reported increase in leaf temperature by 3.0 to 5.4°C due to midseason moisture stress during post rainy season in groundnut compared to irrigated treatment.

Increased leaf temperature of 35°C markedly lowered photosynthesis during water stress from pegging to pod development stage. Leaf temperatures were higher under simulated drought and rained conditions compared to control (Ramana Rao, 1994).

#### 2.1.9 *Relative Water Content (R.W.C)*

Mungse and Bhapkar (1984) stated that RWC decreased with stress. Ravindra *et al* (1990) in a field trial stated that leaf transpiration rate and RWC were significantly reduced under stress at vegetative phase. The relative water content decreased with onset of water stress (Amaregouda, 1994). Ramana Rao (1994) reported 9 days after imposition of midseason moisture stress by using rainout shelters, that moisture stress resulted in significant decrease in RWC of simulated drought treatment compared to adequately irrigated and rainfed treatments.

## 2.2 EFFECT OF MULCHING

### 2.2.1 *Effect of Mulching on Evaporation, Moisture Conservation and Water use*

Evaporation from a cropped field leads to loss of considerable amounts of water in the soil. It is reported that from one-fourth to one-half of the water lost from a cropped field is evaporated from the soil surface. This loss can be reduced by water tight barriers (or) water retardant mulches on the soil surface. Suppressing evaporation from the soil conserves water within the root zone of the plant. The major advantage of mulches are that they conserve moisture, reduce wind and water erosion and increase crop yields especially in years of low rainfall (Viets, 1966).

Several types of materials have been used for covering soil surface. Waste materials, plastic sheets, straw, plant residues, resinous substances can be used as mulches. The research with mulches mostly concerned with crop residues and other plant waste products such as straw, stover, leaves etc., which permitted water entry into soil readily. When maintained adequately they resulted in increased soil moisture and reduced evaporation (Unger, 1975). Recent studies with different mulches at varying rates, including polythene sheets, conclusively proved the superiority of mulches in minimising the evaporation losses and increasing the water use efficiency on different crops under different agro-climatic conditions (Ghosh *et al.*, 1983; Roy and Singh 1983; Gupta 1984; Singh and Daulay, 1984; White 1984; Kim and Hong, 1986; Lee *et al.*, 1986; Subba Reddy, 1986; Kataria and Thakur, 1987; Gupta and Rao, 1989; Singh and Mongia, 1989; Sharma *et al.*, 1990).

Effects of mulch on evaporation rate was extensively studied two decades ago by Hanks and woodruff (1958) who reported that only less than half the evaporation occurred from mulched soil than that of the bare soil when the wind speed increased. Gardner (1959) pointed out the attempts to limit evaporation by a surface mulch or other treatment might be having little long range benefit over a bare soil unless the lower initial evaporation rate permitted greater downward percolation of water. Army *et al* (1961) concluded that mulches can decrease evaporation significantly from the immediate surface as long as the soil surface remains wet. This focussed the attention of workers to study how the surface evaporation can be decreased which may result in increased use of available moisture with the help of different kinds of mulches. Admas (1966) reported that the 2-inch straw mulch reduced evaporation significantly in the 0 to 6 inch soil depth during a hot rainless 10 day period.

Prihar *et al* (1968) reported that soil water was found to be more or less uniformly distributed upto the soil mulch under mulched treatment whereas under unmulched treatment soil water content increased gradually with the depth. Sathyanarayana (1971) concluded that husk, straw and polyethylene mulches were found to be more efficient in controlling surface evaporation and stored more soil moisture compared to control. He also concluded that there was no considerable effect of mulches on water requirement of dwarf wheat. Bansal *et al* (1971) reported that polyethylene mulch lowered the consumptive use in maize (39.4 cm) compared with control (43.2 cm) while consumptive use in straw mulched treatment (43.7 cm) did not differ much from control. Further it was also observed that in pearl millet, cultivation and straw mulched treatment had

highest water use efficiency (113.1 kg of grain ha<sup>-1</sup> cm<sup>-1</sup> of water used) compared to control plots (98.5 kg grain ha<sup>-1</sup> cm<sup>-1</sup> water used) under dryland conditions.

Singh (1979) recommended surface mulching as an important moisture management and conservation practice for arid and extremely arid regions and also for semiarid and subhumid regions. Organic mulches have been found to conserve more moisture in the soil thereby resulting in increased production. It has been further observed that mulching increased moisture retention from a couple of days to 10 days during the critical stage of crop growth (Umrani, 1979). It was also showed that different mulch materials like sorghum stubbles, wheat straw, pigeonpea stalks and dry grass significantly increased the grain sorghum and also fodder yield over no mulch plot. Venkatanathachary *et al* (1979) reported an increased water use efficiency due to soil mulching (67.4 kg ha<sup>-1</sup> cm<sup>-1</sup> of water used) and (60 kg ha<sup>-1</sup> cm<sup>-1</sup> of water used) due to pearl millet straw mulch over the no mulch (38.7 kg ha<sup>-1</sup> cm<sup>-1</sup> of water used). Mulching with groundnut shells recorded higher percentage of soil moisture (26.0) as compared with sawdust mulch (24.4), shallow furrowing (24.0), straw mulch (24.0), stubble mulch (23.9), and no mulch (23.4) in black soils (Subbaiah *et al.*, 1979). In Tobacco crop, highest water use efficiency of about 9.6 kg ha<sup>-1</sup> mm<sup>-1</sup> was obtained due to pearl millet straw mulch at 5.0 t ha<sup>-1</sup> (Sha *et al.*, 1980). Haranath (1980) reported that plant water content was highest with mulching. Mulching also increased the available soil moisture.

## 2.2.2 Effect of Mulches on Plant Height, Leaf Area Index (LAI) and Drymatter

Temporary depression of growth due to mulching during the early growing season of corn was observed, yet mulched corn was 64 cm taller at tasseling and produced 42 bushels per acre more grain than corn which had the straw ploughed in (Moody *et al.*, 1963). This has been due to 28 per cent higher available soil moisture in July and 17 per cent higher in August than the bare plots. In a study of sunflower with irrigation and mulching, scheduling of irrigation based on IW/Pan-E rate of 0.7 for entire season gave maximum seed yield, plant height and LAI (Patel and Singh, 1980). Haranath (1980) also reported increase in plant height of groundnut due to mulching. Purushotham Rao and Agrawal (1984) have given that plant height of barley increased due to moisture conservation practices like mulch. Similarly increase in plant height, LAI, in wheat due to mulching was reported by Sharma and Chakar (1989). Green and straw mulches significantly increased the plant height in yellow sarson. This was mainly owing to better conservation of soil moisture and greater reduction of day time soil temperature in plots receiving green and straw mulch (Moitra *et al.*, 1994).

Trivedi *et al* (1994) concluded that irrigating summer greengram with 0.7 IW/CPE ratio and mulching with sugarcane trash significantly increased the plant height and drymatter.

### 2.2.3 *Effect of Mulching on Crop Yield*

Chandramohan and Mohammed Ali (1969) studied the yield response of groundnut to organic mulches. They found that mulching was beneficial especially during the second crop season when very little (or) no rainfall was received during January to May.

The organic mulches gave increased yield and also established the profitability of mulching in irrigated groundnut. They concluded that two irrigations could be saved if the crop was mulched. Lal (1974) stated that plant growth and yields of maize were significantly higher in mulched plots than non mulched, which might be due to the availability of higher soil moisture. Efficient soil moisture utilization and higher productivity of rainfed barley by straw mulch were also observed by Agarwal and De (1976). Moisture conservation in mulched plots was more spectacular under dryland conditions which resulted in higher yields. Mulching conserved soil moisture until the flowering stage and increased yield of Rapeseed by 23 per cent (De & Giri 1978 a) and of tall wheat variety C 306 by 46.5 per cent in a season which had 58.3 mm rainfall (De & Giri 1978b) under unirrigated conditions. Results of All India Co-ordinated Research Project for Dryland Agriculture in a report stated that mulching increased the yield of pearl millet by 31 per cent, castor by 9.7 per cent and sorghum by 26 per cent over no mulched plots (Anonymous, 1978a).

At Ludhiana, Rajkot and Samba the effect of surface mulches on kharif crops was tested which revealed no beneficial effects in general. On groundnut, different mulches like pearl millet stubble, pearl millet husk, groundnut pod shells

and soil mulches increased the pod yield over control but not significantly (Anonymous, 1978 b). Umrani (1979) showed that different mulch materials like sorghum stubbles, wheat straw, pigeon pea stalks and drygrass significantly increased the yield of grain sorghum and also fodder yield over no mulch plots. Research from central arid zone research institute, Rajasthan reported that in years of high and continuous rainfall (wet years) application of surface mulches did not confer advantage either in terms of increased grain yield or conservation of moisture but during normal and subnormal years with erratic rainfall distribution, however application of pearl millet husk mulch @ 4 t ha<sup>-1</sup> resulted in significantly higher grain yield of pearl millet and better moisture use efficiency than control (Singh, 1979). Venkatanathachary *et al* (1979) reported that pearl millet mulch to 5 cm thickness gave numerically higher yield than the soil mulch and both mulches gave significantly higher yields of pearl millet grain over no mulch. Gupta (1980) reported that use of mulches in sandy soil under arid conditions have shown reduction in the evaporation and improved growth and yield of pearl millet.

Singh *et al* (1984) reported that straw mulch increased the number of pods per plant and grain yield significantly over no mulch and soil mulch. Increased pod formation in straw mulch may be attributed to efficient utilization of soil moisture throughout the crop growth. Khan (1984) stated that average yields of gram and wheat under mulch treatments were significantly higher than those of no mulch treatments. Increase in grain yield by mulching may be attributed to improved soil moisture conditions. He also stated that any mulching on the soil further increased the soil moisture content significantly. Similar results were

obtained by Jone *et al* (1969), Gupta and Gupta (1986). An increase of 49 per cent production of green gram over control with mulch @ 6 t ha<sup>-1</sup> was reported by Gupta and Gupta (1985). Sutarto *et al* (1988) reported that yield and yield attributing characters significantly increased in groundnut with 4 t ha<sup>-1</sup> of rice straw mulch. Mulching increased groundnut yields by 55 per cent (Wang and Han, 1990). Kaushik and Gautam (1991) obtained more pearl millet yield due to straw mulch compared with control. Mulching facilitated more availability of soil moisture thereby growth and yield contributing characters showed better performance and the yield of linseed was also more (Dubey *et al.*, (1993).

The marketable yield of pumpkin increased by mulching especially by groundnut shell mulch (Chhangani 1993). Singh and Surajbhan (1993) stated that irrigating the cotton crop at 120 mm pan evaporation (Requiring 6 irrigations) and covering the inter row vacant spaces with polyethylene (or) organic residue mulch like maize stover gave the highest yield. Yellamanda Reddy (1994) reported that mulching the groundnut crop with groundnut shells @ 5 t ha<sup>-1</sup> conserved more moisture and gave significantly higher yield than the control under moisture stress conditions.

Mulch had significant effect on both seed and straw yields of yellow sarson. Among the different mulches, green and straw mulches were more effective in increasing the seed and straw yields than the soil (or) no mulch treatments. Increase in the moisture content in the root zone profile due to introduction of green and straw mulches increased the crop growth resulting in higher grain yield (Moitra *et al.*, 1994). Trivedi *et al* (1994) concluded that

irrigating summer green gram with 0.7 IW/CPF ratio and mulching with sugarcane trash significantly increased the grain and stover yields.

### 2.3 EFFECT OF ANTITRANSPIRANTS

Transpiration is considered to be a necessary evil and a possible means of reducing water loss from plant canopy to suppress transpiration, has led to the search of a variety of substances that can hinder the process of transpiration. These transpiration modifying substances range from simple fine textured clays to complex chemical compounds (Davenport and Hagan 1975). A wide range of reflectant materials can be used to suppress transpiration. Serr and Foott (1963) showed that mere white wash sprays can suppress transpiration.

Antitranspirants have been widely used in horticultural crops. Hexadecanol on tomatoes (Abdalla and Flocker, 1963), polyethylene based film forming antitranspirant on vine and Bananas (Gale *et al.*, 1964), Kaolin on citrus (Abou-Khaled *et al.*, 1970), film forming antitranspirant on snapbeans (Davenport and Hagan, 1970) have been reported to be useful for higher water use efficiency and increased yields. Increase in reflectivity and decrease in temperature by the use of Kaolin resulted in the reduced energy gradient from the leaf to surrounding air (Slatyer and Bierhuizen, 1964). A major increase in leaf albedo and a consequent 25 per cent reduction in transpiration with Kaolin was reported by Abou-Khaled *et al* (1970). Kaolin spray reduced transpiration significantly over no Kaolin spray. Reduction in transpiration due to Kaolin is due to increase in the reflectivity of the incident radiation especially in the visible region (Abou-khaled *et al.*, 1970; Pati & De 1976).

Leaves when coated with kaolin reflected 8 per cent more light and 20 per cent more shortwave radiation from a soybean canopy (Doraiswamy & Rosenberg, 1974). Kaolin is a cheap material and is easily available for use as a reflectant (Patil & De, 1976).

### 2.3.1 *Effect of Kaolinite on Plant Height, Leaf Area and Drymatter.*

Agarwal and De (1976) reported that kaolin increased plant height and drymatter in Barley under dryland conditions. Kaolinite spray resulted in better plant growth due to decrease in transpiration and increasing reflection of solar radiation, and nullified the adverse effect of moisture stress on drymatter production of groundnut (Khan and Morey, 1980). Banwari Lal *et al* (1995) stated that irrigation either alone (or) coupled with Kaolin spray at 45 or 80 days stage (or) at both the stages improved plant height and drymatter per plant in lentil.

### 2.3.2 *Effect of Kaolinite on Soil Moisture*

Patil and De (1976) reported that reflective antitranspirant Kaolin in rapeseed conserved moisture in the soil by reducing transpiration loss of water by reflecting a part of solar radiation incident on leaf surface immediately after its application thus making the limited soil moisture available for better growth. Devendrasingh and Sahay (1989) reported that kaolin significantly increased root length and enabled the plant to absorb more moisture from deeper layers.

### 2.3.3 Effect of Kaolinite on Yield

Effect of kaolin is more expressive in drier periods as its effect on water conservation can lead to better plant water balance in periods of water deficit than in normal water availability situations. This was clearly seen in the case of Mung grown in kharif season. When the wet season extended until the pod filling stage, kaolin had no effect on the seed yield, but in a year when the rains had stopped much earlier than the flowering stage, kaolin applied to the foliage at pre flowering stage increased seed yield significantly (De & Giri, 1978). Kaolin sprayed at 50 days after sowing resulted in 18.8 per cent more yield of dryland grown barley (Agarwal & De, 1977) and 17 per cent more yield of dryland rapeseed (Patil & De, 1978).

A favourable water balance in leaves could alter the ultimate yields in positive direction. Foliar coating with kaolin increased the yield of wheat by 27.7 per cent in 1973-74 (dry year) and 16.5 per cent in 1979-75 (wet year) in an experiment conducted by De and Giri (1978b) under dryland conditions. Soundara Rajan *et al* (1981) reported that kaoline 3 per cent suspension applied to foliage at 35 and 55 days after sowing during dryspells resulted in highest groundnut pod yield which was significantly superior to all other ameliorative treatments. The increase in yield was due to higher number of filled pods per plant, better filling of the kernels as reflected in higher test weight. The shelling outturn was also favourably influenced by kaolinite application. Naveen *et al* (1992) reported that kaolinite 3 per cent spray was more effective than water spray at reducing yield loss due to water stress. Spray application of kaolin helped the crop plants to minimize the evapotranspiration rate and diverting the

## 2.3.3 COMBINED EFFECT OF MULCH AND KAOLIN ON YIELD

energy to more food as compared to control leading to the increase in growth characters, yield attributes, grain and straw yields of greengram when irrigated either alone (or) coupled with kaolin spray at 45 (or) 80 days stage (or) at both the stages improved yield and yield attributes compared with no irrigation (Arya and Sharma, 1994).

### 2.3.4 *Effect of Kaolinite on Leaf Temperature and Relative Water Content (RWC)*

The increase in grain and straw yields under kaolin treatments may be attributed to an increase in leaf albedo, a consequent reduction in leaf temperature and finally a reduction in plant transpiration as the leaf temperature of kaolin-treated plants was reduced by 1 to 2.5°C when compared with control (Agarwal and De 1976). Patil and De (1978) reported 1.5°C lower temperature of Kaolin coated leaf of rapeseed than the ambient air temperature.

## 5 EFFECT OF UREA SPRAY

Reduction in transpiration by the use of kaolin had a direct bearing on leaf water balance and water use efficiency, as the relative water content of kaolin coated leaves was higher than that of normal leaves (Agarwal & De 1976; Patil and De 1978). Mungse and Bhapkar (1984) reported that Relative water content (R.W.C) decreased with stress and increased with antitranspirant sprays. Devendra singh and Sahay (1989) reported that Kaolin increased root length and enabled the plant to absorb more moisture from deeper layers and thereby maintain high relative water content. The relative water content decreased with the onset of waterstress. The extent of decrease in RWC was greater in the control than in plants treated with antitranspirants (Amaregouda *et al.*, 1994).

## **2.4 COMBINED EFFECT OF MULCH AND KAOLINE ON YIELD**

Mandal *et al* (1987) reported highest seed yield of mustard in plots receiving straw mulch followed by application of 6 per cent Kaolin at 21,42 and 63 days after sowing. Moisture conservation practices with mulch and kaolin increased consumptive use efficiency, increased root development, efficient moisture extraction. The moisture conservation practices significantly influenced growth, yield components and yield. Two groundnut cultivars were irrigated at 12 or 8 days interval (water stressed and nonstressed conditions respectively) and were either not mulched (or) mulched with 5 t wheat straw ha<sup>-1</sup> with and without 5 sprays of kaolin and pod yields under non-stressed and stressed conditions were 3.23 and 2.76 t ha<sup>-1</sup> respectively. Further yields without mulch, with mulch and mulch + kaolin sprays were 2.66, 2.99 and 3.34 t ha<sup>-1</sup> respectively. The water use efficiency was highest with mulch + kaolin spray (Joshi *et al.*, 1987).

## **2.5 EFFECT OF UREA SPRAY**

Bhaumik (1966) noted increased yields with foliar application of urea. According to work conducted at Tirupati (RARS 1984, 1986, 1987) there was an increase in yield with 2 per cent urea spray applied twice during moisture stress. This was due to more number of filled pods, 100-pod weight and shelling out turn. Selvam *et al* (1989) reported that foliar application of 2 per cent urea twice during stress improved pod yield of rainfed groundnut ranging from 20.6 to 39 per cent over no spray. Yellamanda Reddy (1994) reported that spraying of urea (2 per cent) immediately after relief of the moisture stress period gave

significantly higher pod yield than the control due to hastened recovery of plant from stress resulting in higher pod yield.

The review indicated that low and erratic rainfall with long dry spells during the crop growth period of rainfed groundnut are common in Rayalaseema areas, which causes low crop yield under rainfed conditions. Use of techniques like mulching, antitranspirants, urea spray etc. reduce moisture stress by reducing evaporation and transpiration losses and improve soil moisture by providing the basis for increased groundnut yields under dryland conditions. Recent studies in controlling evapotranspiration losses indicated greater potential for generating technology capable of increasing and stabilising agricultural production in drylands.

LOCATION OF THE EXPERIMENT

A field experiment to study the Agr...

# **MATERIALS AND METHODS**

## **WEATHER DURING THE CROP PERIOD**

The weather during the crop period in terms of rain, mean maximum and minimum temperature, relative humidity hours and the deviations from the decadal mean (Fig 1 and 2)

The weekly mean maximum temperature during the crop growth period ranged from 22.0°C to 28.0°C.

## CHAPTER - III

### MATERIALS AND METHODS

A description of the materials used and the methods followed during the course of investigation are given in this chapter.

#### 3.1 LOCATION OF THE EXPERIMENTAL SITE

A field experiment to study the Agro techniques for amelioration of drought in rainfed groundnut was conducted during kharif 1995 on the dryland block of S.V.Agricultural College Farm, Tirupati in the Southern Agroclimatic zone of Andhra Pradesh. This place is situated on 79°E longitude, 13°N latitude and at an altitude of 182.9m above mean sea level. According to Trolls (1958) climatic classification, this place falls under semi-arid Tropics (SAT).

#### 3.2 WEATHER DURING THE CROP PERIOD

The weather during the crop period in terms of rainfall, number of rainy days, mean maximum and minimum temperature, relative humidity, evaporation, sunshine hours and the deviations from the decennial means are given in Table 1 (Fig 1 and 2)

The weekly mean maximum temperature during the crop growth period (2-7-96 to 17-10-96) ranged from 30.9 to 35.7 with an average of 33.1°C. The decennial mean maximum temperature for the corresponding period ranged from 32.12 to 35.84°C with an average of 34.09°C. The weekly mean minimum temperature during crop period ranged from 23.4 to 26.9°C with an average of

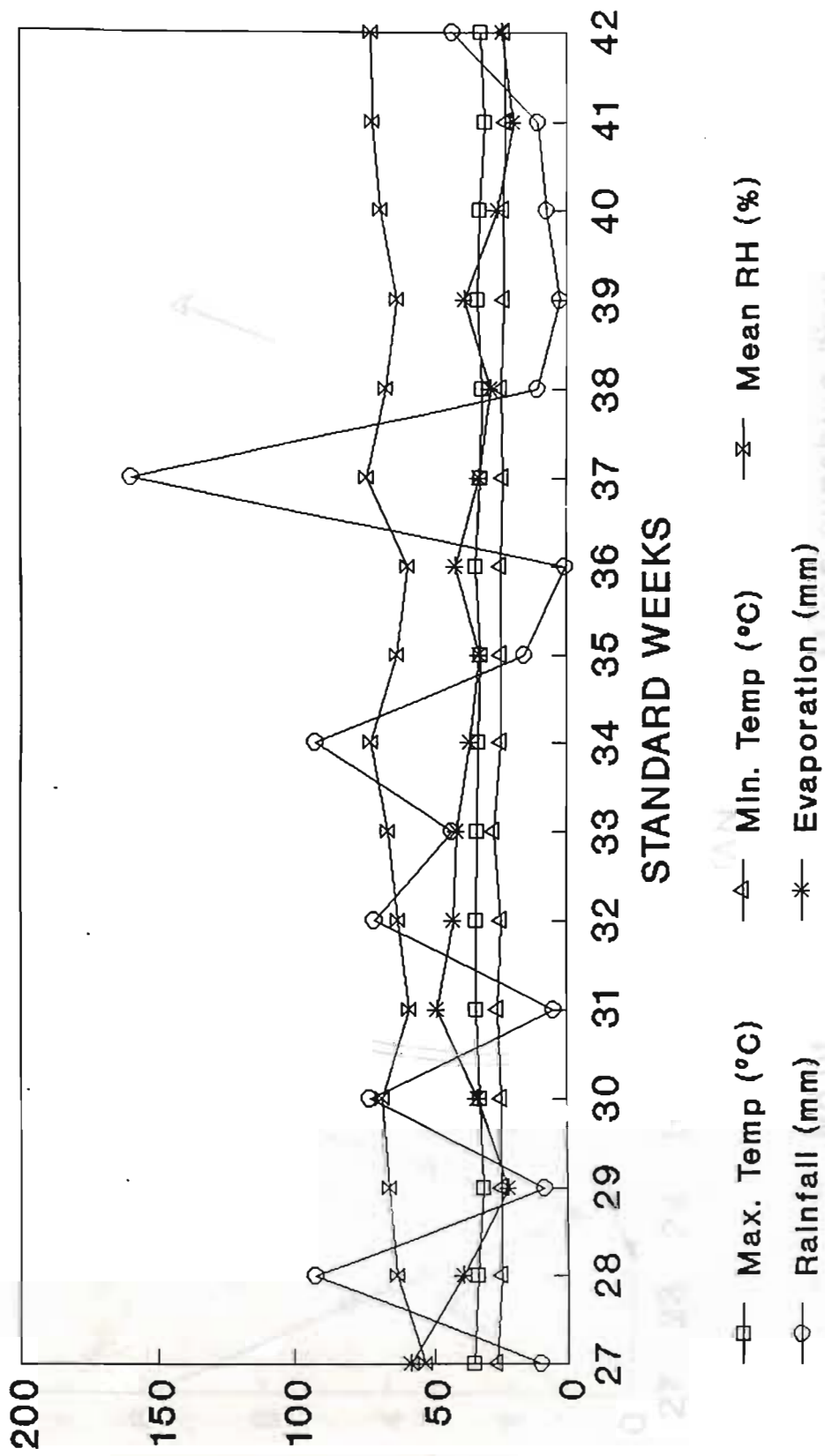
Table - 1

## WEEKLY METEOROLOGICAL DATA DURING THE CROP PERIOD (6-7-95 to 17-10-95)

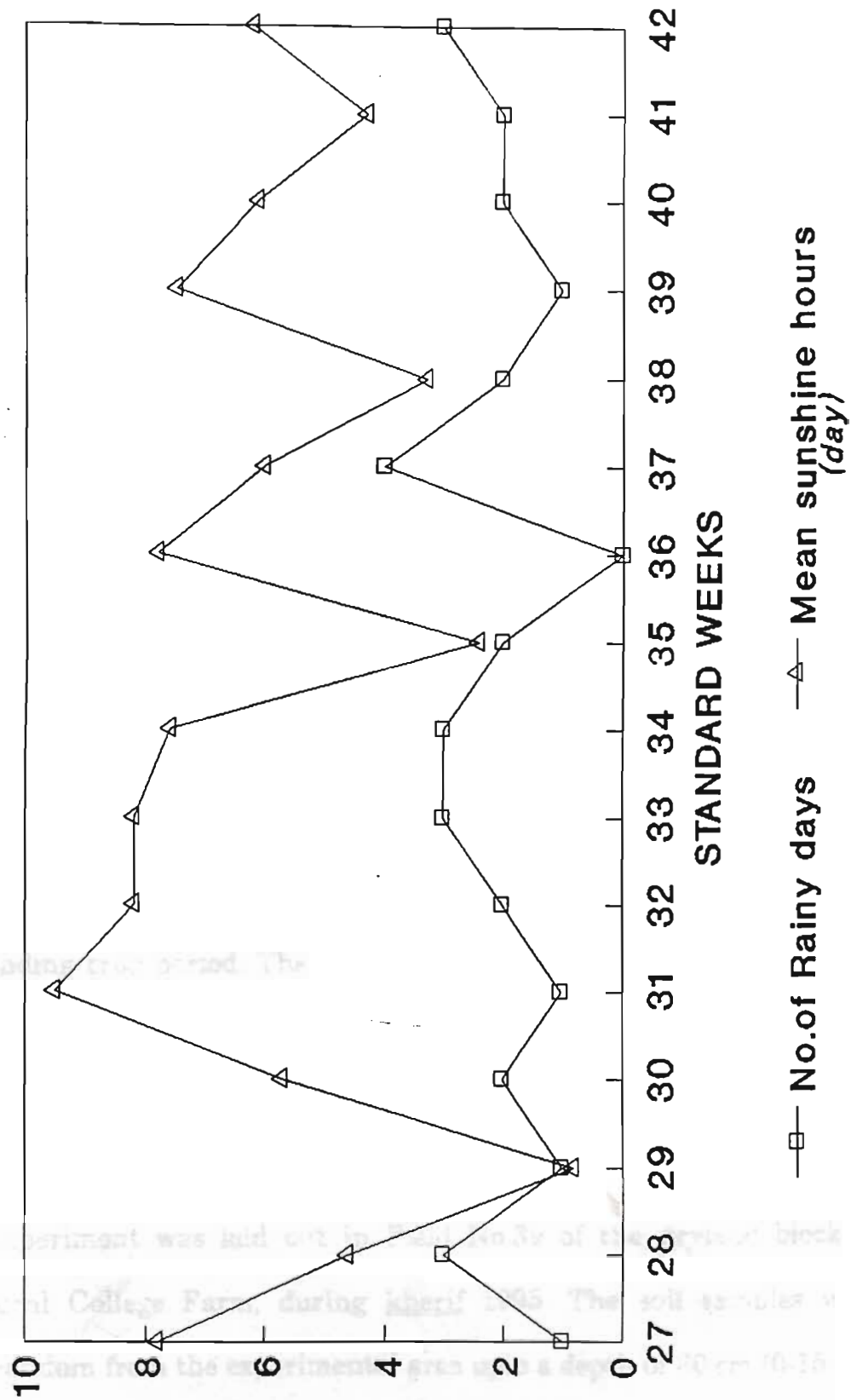
St. Week	Date & Month	Temperature (°C)		Mean Relative Humidity (%)		Rainfall (mm)		No. of rainy days		Mean sunshine hours day <sup>1</sup>		Evaporation (mm)			
		Actual	DN	Actual	DN	Actual	DN	Actual	DN	Actual	DN	Actual	DN		
27	2-8 July 95	Maximum		Minimum											
		Actual	DN	Actual	DN	Actual	DN	Actual	DN	Actual	DN	Actual	DN		
27	2-8 July 95	35.7	1.6	26.9	1.60	53.5	-1.1	10.3	24.4	1	-1.0	7.8	2.70	58.8	6.94
28	9-15 July 95	33.6	1.35	24.8	-0.80	63.5	7.9	92.1	71.0	3	1.5	4.6	-0.26	39.2	-13.16
29	16-22 July 95	31.5	1.08	24.9	-0.30	66.0	7.7	8.5	-12.5	1	-0.6	0.8	-3.30	22.4	-23.31
30	23-29 July 95	32.9	1.52	25.0	-0.20	68.5	13.5	73.1	54.0	2	0.6	5.7	1.52	33.7	-13.69
31	30-5 August 95	34.3	0.33	26.0	1.00	59.0	1.8	5.2	-33.4	1	-0.7	9.5	4.50	48.9	1.93
32	6-12 August 95	34.1	-0.53	24.7	0.20	63.0	1.9	71.1	36.7	2	0.1	8.2	3.80	42.4	-0.65
33	13-19 August 95	33.5	-0.03	27.4	2.70	66.5	7.7	43.0	29.2	3	1.3	8.2	3.70	41.1	-5.31
34	20-26 August 95	33.4	1.46	25.0	-0.50	72.5	18.5	92.0	80.9	3	1.7	7.6	1.30	36.5	-18.94
35	27-2 Sept. 95	32.2	2.18	24.9	0.20	63.5	6.8	16.0	-9.6	2	0.3	2.4	-3.90	32.7	-18.54
36	3-9 Sept. 95	34.1	0.21	24.9	0.20	59.5	3.0	0.6	-15.9	-	-1.4	7.8	1.89	41.8	-2.05
37	10-16 Sept. 95	32.4	1.88	23.8	-0.80	74.0	15.4	160.0	136.5	4	2.4	6.0	0.14	32.7	-14.11
38	17-23 Sept. 95	31.0	2.10	24.7	0.60	67.5	3.7	11.4	-12.9	2	0.3	3.3	-3.20	28.9	-8.2
39	24-30 Sept. 95	33.7	0.01	24.0	0.20	63.5	15.4	2.6	-41.2	1	-1.0	7.5	1.70	38.7	4.96
40	1-7 Octo. 95	32.9	-0.78	23.8	0.60	69.0	3.6	7.6	-34.1	2	-0.7	6.1	1.28	26.3	-2.19
41	8-14 Octo. 95	30.9	2.00	23.4	0.40	72.0	-4.4	11.0	-15.3	2	0.3	4.3	-2.11	20.6	-9.08
42	15-21 Octo. 95	32.5	0.20	23.5	1.80	72.5	-2.6	42.8	24.2	3	1.9	6.2	-0.8	24.5	0

A : Actual      DN : Deviation from decennial average

Fig.1 Weekly meteorological data during the crop growth period (06.07.95 - 17.10.95)



**Fig.2 Weekly meteorological data during the crop growth period (06.07.95 - 17.10.95)**



24.87°C. The decennial mean minimum temperature for the corresponding period ranged from 23.16 to 25.64 with an average of 24.6°C.

The weekly mean relative humidity for the crop period ranged from 48 to 69 per cent with an average of 57.25 per cent. The decennial mean relative humidity for the corresponding period ranged from 46.1 to 71.65 per cent with an average of 60.04 per cent.

The weekly mean sunshine hours during the crop period ranged from 0.8 to 9.5 per day with an average of 6 whereas the decennial average for the corresponding period ranged from 4.12 to 6.49 with an average of 5.37 per day.

A total rainfall of 619.9 mm. was received during the crop period in 30 rainy days, whereas the decennial average for the corresponding period was 424.63 mm received in 27.4 rainy days. The mean weekly evaporation for the crop period was 5.07 mm as against the decennial weekly mean of 6.11 mm for the corresponding crop period. The data revealed that there was considerably more rainfall and less evaporation during the crop period of this study.

### **3.3 SOILS**

The experiment was laid out in Field No.39 of the dryland block of S.V.Agricultural College Farm, during kharif 1995. The soil samples were collected at random from the experimental area upto a depth of 30 cm (0-15 and 15-30 cm). The composite samples were analysed for physico-chemical properties. The results are presented in the Table 2.

Table : 2

**PHYSICO-CHEMICAL CHARACTERISTICS OF THE SOIL OF  
EXPERIMENTAL FIELD**

Sl. No.	Particulars	Soil depth		Method adopted
		0-15Cm	15-30Cm	
A	MECHANICAL ANALYSIS (%)			
	Coarse Sand	51.4	47.8	
	Fine Sand	32.3	33.5	International Pipette method (Black <i>et al</i> 1965)
	Silt	2.0	2.2	
	Clay	14.3	16.5	
	Textural Class	Sandy loam	Sandy loam	
B.	CHEMICAL ANALYSIS			
	pH (1:2.5 soil water suspension)	6.9	6.8	Buckman pH meter (Jackson, 1973)
	E C (dsm) (1:2.5)	0.06	0.11	Solu-bridge method (Jackson, 1973)
	Organic carbon (%)	0.23	0.18	Walkey and Black's rapid titration method (Jackson, 1973)
	Available N (Kg N ha <sup>-1</sup> )	174.3	129.2	Alkaline permanganate method (Subbaiah and Asija, 1956)
	Available P (Kg P <sub>2</sub> O <sub>5</sub> ha <sup>-1</sup> )	21.3	10.2	Olsen's method (Olsen <i>et al</i> 1954)
	Available K (Kg K <sub>2</sub> O ha <sup>-1</sup> )	164.8	139.7	Neutral Normal NH <sub>4</sub> OAC Extraction method by flame photometry (Jackson, 1973).
C.	MOISTURE CONSTANTS	0-30 Cm		
	Soil moisture constant at field capacity (1/3 bars)	10%		Pressure Membrane apparatus
	Soil moisture constant at 15 bars (PWP)	3.5%		Pressure Membrane apparatus
	Bulk density (g.cc <sup>-1</sup> )	1.68		Core Sampling (Piper, 1950)

The results show that the soils of the experimental field were sandyloam in texture, low in available nitrogen, medium in phosphorus and potassium.

### 3.4 CROPPING HISTORY OF THE EXPERIMENTAL FIELD

The details of the crops grown in Field No.39 during preceding three seasons are given below:

Year	Kharif	Rabi
1992-93	Groundnut	Fallow
1993-94	Redgram	Fallow
1994-95	Groundnut	Fallow

### 3.5 EXPERIMENTAL DETAILS

The experiment was laid out in a split plot design replicated three times with three main plot treatments and six subplot treatments.

#### 3.5.1 Main Treatments

$M_1$  = Rainfed Treatment

$M_2$  = Irrigated treatment (An amount of 5 cm. of irrigation was given at IW/CPE ratio of 0.85 so as not to allow stress.

$M_3$  = Moisture stress treatment. (From 30 to 75 DAS the crop in this treatment was protected from rain out shelters).

*Overall view of the experimental field*



### 3.5.2 Sub Treatments

Six Agro techniques as ameliorative treatments were assigned to subplots.

$S_1$	=	Control
$S_2$	=	Water spray twice @ 750 l ha <sup>-1</sup> at 45 and 60th day after sowing (DAS).
$S_3$	=	Mulching at 30 DAS with groundnut shell @ 4 t ha <sup>-1</sup> .
$S_4$	=	4% kaolin spray twice at 45th and 60th day after sowing.
$S_5$	=	$S_3 + S_4$
$S_6$	=	$S_3 + S_4 + 2\%$ urea spray (along with kaolin)

### 3.5.3 Design and Layout

The experiment was laid out in a split plot design, replicated three times with three main treatments and six sub-treatments. The Field layout is given in Fig 3.

### 3.5.4 Plot Size

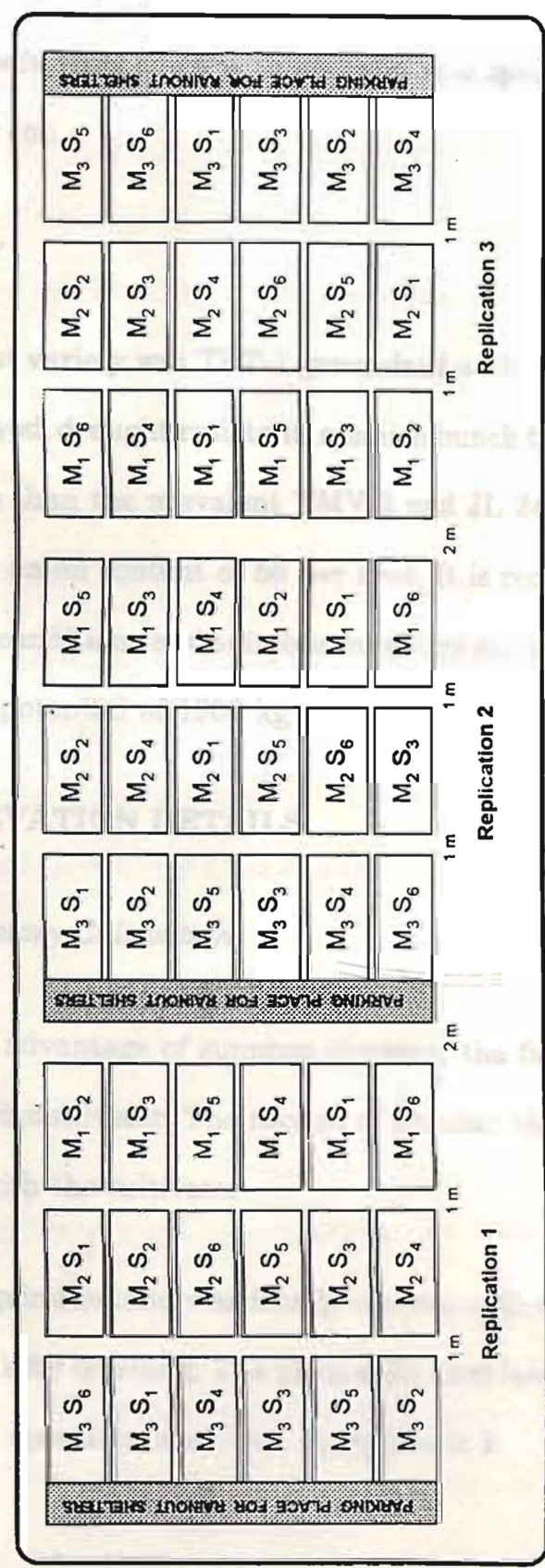
Gross	=	5x3 m
Net	=	4x1.5 m

### 3.5.5 Season

kharif, 1995.



Fig. 3 LAYOUT OF THE EXPERIMENT



- Design** : Split Plot
- Replications** : 3
- Plot size** : 5 x 3 m
- Variety** : TPT 1
- Main Plot Treatments**
- M<sub>1</sub> : Rainfed Treatment
  - M<sub>2</sub> : Irrigated Treatment
  - M<sub>3</sub> : Moisture Stress Treatment
- Sub Plot Treatments**
- S<sub>1</sub> : Control
  - S<sub>2</sub> : Water Spray
  - S<sub>3</sub> : Mulching
  - S<sub>4</sub> : 4% Kaoline Spray
  - S<sub>5</sub> : S<sub>3</sub> + S<sub>4</sub>
  - S<sub>6</sub> : S<sub>3</sub> + S<sub>4</sub> + Urea Spray

### 3.5.6 Spacing

The seeds were sown with an inter row spacing of 30 cms and intra row spacing of 10 cm.

### 3.5.7 Variety

The test variety was TPT-1 groundnut with a duration of about 100 days. It is an improved, drought resistant, spanish bunch type with erect growing habit yielding more than the prevalent TMV 2 and JL 24. Its shelling out turn is 78 per cent with an oil content of 50 per cent. It is recommended for both rainfed and irrigated conditions and suitable for entire state of Andhra Pradesh with an average yield potential of 1900 kg ha<sup>-1</sup>.

## 3.6 CULTIVATION DETAILS

### 3.6.1 Preparatory Cultivation

Taking advantage of summer showers, the field was well prepared with a tractor drawn cultivator. The receipt of another shower facilitated the field to be prepared with the cultivator.

Once again the land was finally worked with a blade harrow followed by a wooden plank for levelling. The plots were then laidout according to plan. The details of field operation are given in Appendix I.

### 3.6.2 *Seeds and Sowing*

Hand picked healthy and matured seeds of high germination (95%) were used for sowing. The seeds were pre-treated with Mancozeb (Dithane M-45) at 3 g kg<sup>-1</sup> of seed and dibbled at a spacing of 30x10 cm at a depth of about 5 cm. The furrows were covered immediately after sowing and compacted sufficiently to ensure proper germination. There was adequate plant population in all the treatments.

### 3.6.3 *Fertilizers*

A total quantity of 20 N + 40 P<sub>2</sub>O<sub>5</sub> + 50 K<sub>2</sub>O kg ha<sup>-1</sup> was applied for the crop all basally. Fertilizer dose was calculated and weighed per plot separately. Entire dose of nitrogen (urea), phosphorus (Single super phosphate) and potassium (Murate of potash) was applied in bands in the furrows made with hand hoes, 5 cm below and 5 cm away from the crop row, as basal dose at the time of sowing. Gypsum was given as top dressing at 500 kg ha<sup>-1</sup> for all treatments.

### 3.6.4 *After Cultivation*

3.6.4.1 Weeding. Hand weeding and hoeing was done twice (20 and 30 DAS) for controlling the weeds. Tall grown weeds were removed at 45 DAS.

3.6.4.2 Mulching. The mulch material was groundnut shells, applied at the rate of 4 t ha<sup>-1</sup> at 30 DAS immediately after completion of second weeding.

### 3.6.5 *Plant Protection*

As a prophylactic measure against root grub, phorate 10 G at 10 kg ha<sup>-1</sup> was incorporated into the soil at sowing along with fertilizers about 5 cm away from crop by opening furrows with a hand hoe.

Monochrotophos (Nuvacron) at 1.5 ml l<sup>-1</sup> water @ 750 l ha<sup>-1</sup> was sprayed to protect the crop from Jassids and leaf webber.

### 3.6.6 *Water, Kaolin and Urea Application*

These were done in the treatments twice at 30 and 45 DAS by using 750 l ha<sup>-1</sup> of water with a low volume sprayer.

### 3.6.7 *Harvesting*

The crop was considered mature when the vines started yellowing, and shedding of lower leaves observed. Further, when more than 75 per cent of the developed pods from 10 randomly selected plants from 100 DAS showed black streaks on the inner wall of the shell, the crop was considered ready for harvest.

In each plot, two end rows of the crop were left as border rows along the length of the plot. Further, one more row was left for sampling. In all the treatments on either side, 0.5 m along length of the plot was left to nullify border effect. A total of 5 rows were harvested in each plot. Thus the net plot was 4x1.5 m. i.e., (6 m<sup>2</sup>).

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The border rows of the plot were first harvested and removed. Then the net plot was separately harvested sub-treatment wise in each replication. The pods were hand stripped and later sundried to constant weight (to a moisture of 14%) and the pod yield was recorded in plot-wise and expressed in  $Q \text{ ha}^{-1}$ . After stripping the pods, the haulm was also thoroughly sundried to constant weight. The haulm yield was recorded plot-wise and expressed in  $Q \text{ ha}^{-1}$ .

### 3.7 OBSERVATIONS RECORDED

#### 3.7.1 *Pre Harvest Observations*

The plants were randomly selected within net plot area in each treatment from all the replications and marked for recording the non-destructive observations continuously.

3.7.1.1 Dry matter production. The dry matter production (g) at different stages of crop growth (30, 45, 60, 75, 90 DAS and at maturity) was recorded from five selected plants in the rows marked for destructive plant sampling, leaving the border rows. The root portion of the plant was separated. The entire plant sample was air dried and then oven dried to a constant weight at  $60^{\circ}\text{C}$  for 48 hours and then weights were recorded at air temperature.

3.7.1.2 Leaf area index (LAI). From the plant samples collected for dry matter, the leaf area per plant was estimated at 30, 45, 60, 75, 90 days after sowing and at maturity using LI-300 portable area meter (LI-COR Model) with transparent belt conveyor (Model LI-3050 A) utilising an electronic digital display. The area was investigated and displayed in  $\text{cm}^2$  and the separated leaves were fed into

conveyor belt assembly. Leaf area index was calculated as per the formula suggested by Watson (1952).

$$\text{LAI} = \frac{\text{Total leaf area}}{\text{Unit land area}}$$

3.7.1.3 Number of flowers. Total number of flowers were counted for ten labelled plants from first day of flowering and continued for 21 days. Then these number of flowers were averaged and expressed as number of flowers per plant.

3.7.1.4 Plant height at harvest. The height of ten labelled plants in centimeters from ground level to the tip of the main axis was recorded in each treatment, averaged and expressed in centimeters per plant.

3.7.1.5 Leaf temperature. Leaf temperatures were recorded at 60 DAS with Heat Spy Infrared Thermometer (Whal-company), a battery operated portable instrument. Readings were taken from all the treatments at 13.00 hours (IST). The readings were made on 5 plants, selected at random across the 3 replications. Measurements were made on third leaf from the top on the main axis. The measurements were recorded on the abaxial side of the leaflet.

3.7.1.6 Relative water content (RWC). Relative water content was recorded at 85 DAS, after 10 days of stress period. During the stress period 10 leaves of each treatment were collected from destructive sampling rows and relative water content (RWC) was determined by soaking the leaves for 6 hours. RWC was calculated using the formula and expressed in percentage.

$$\text{RWC} = \frac{\text{Fresh weight} - \text{Dry weight}}{\text{Turgid weight} - \text{Dry weight}}$$

### 3.7.2 *Post Harvest Observations*

3.7.2.1 Number of pegs per plant. The ten labelled plants marked for flower counts were used to count the pegs at harvest. The pegs were counted, totalled, averaged and expressed as pegs per plant. (These pegs included filled pods + unfilled pods + pegs not developed into pods).

3.7.2.2 Number of total pods per plant. Total number of pods (filled + unfilled pods) from ten labelled plants as above in each treatment was counted, totalled, averaged and expressed as number of total pods per plant.

3.7.2.3 Number of filled pods per plant. The filled pods were separated for each treatment from ten plants, counted, totalled, averaged and expressed as filled pods per plant.

3.7.2.4 Unfilled pods per plant. The unfilled pods from each treatment for the ten sample plants were counted, totalled, averaged and expressed as unfilled pods per plant.

3.7.2.5 Peg to pod percentage. The percentage of pods which developed into mature pods was worked out and expressed as peg to pod percentage as indicated below.

$$\frac{\text{Number of pods}}{\text{Number of pegs}} \times 100$$

3.7.2.6 Shelling percentage. Three separate random samples (250g) of pods were drawn, shelled and the kernels were separated and the weights were recorded, and averaged. The percentage of kernels to pods was worked out for each treatment.

$$\text{Shelling percentage} = \frac{\text{Weight of kernels from the sample}}{\text{Weight of pods sampled}} \times 100$$

3.7.2.7 100 Pod weight. After thorough drying of pods, weight (g) of three randomly selected 100-pods was recorded and expressed for each treatment.

3.7.2.8 Pod yield. Pods from net plot (including the pods of the labelled plants) were dried to constant weight. Treatment wise yield was recorded in each replication and expressed in Q ha<sup>-1</sup>.

3.7.2.9 Haulm yield. After thorough sundrying, haulm from each net plot (including that of labelled plants) were weighed and reported in Q ha<sup>-1</sup>.

3.7.2.10 Harvest index. Harvest index was computed using the following formula.

$$\text{Harvest Index} = \frac{\text{Pod yield (kg ha}^{-1}\text{)}}{\text{Total dry matter production (Pod yield + Haulm yield) (Kg ha}^{-1}\text{)}}$$

### 3.7.3 *Rainfall Use Efficiency*

Rainfall use efficiency in Kg mm<sup>-1</sup> was calculated for all the treatments. In the sheltered plots only the rain received before and after the use of shelters was taken into account.

$$\text{RUE} = \frac{\text{Pod yield Kg ha}^{-1}}{\text{Total Rainfall received during crop period (mm)}}$$

### 3.8 SOIL MOISTURE

Soil samples were taken from three root zone depths upto 60 cm, at stress periods from all the treatments in 3 replications for determining soil moisture content gravimetrically.

Soil samples from each treatment from different depths were taken in moisture cans and weighed on a physical balance ( $ws_1$ ). Samples were oven dried to a constant weight at 105°C, and dry weights ( $ws_2$ ) of the samples were taken at lab temperature. Moisture percentage (pw) on dry weight basis was calculated by using the formula given by Misra and Ahmed (1987).

$$\text{Moisture percentage (pw)} = \frac{ws_1 - ws_2}{ws_2} \times 100$$

### 3.9 ECONOMICS

Additional cost of cultivation, additional returns and net returns per rupee invested were worked out on the basis of revenue and cost functions of each treatment.

### 3.10 STATISTICAL ANALYSIS

The experimental data was subjected to statistical scrutiny following the procedure outlined by Panse and Sukhatme (1985) for split plot design. Significance was tested by 't' value at 5 per cent level of probability. Critical differences were worked out for the significant effects.

Effect of mulches. Mulch treatments were very good and their combination with stressed groundnut to mitigate losses in the yield. The weather was very good and the distribution of rainfall except for a stretch of few days and hence the yield were high. The stress treatments could be saved by rain out showers from

to growth described in this chapter. The data on growth characters and yield are given below.

# RESULTS

## PLANT POPULATION AT 15, 30 DAYS AFTER SOWING AND AT HARVEST

The data pertaining to plant population was presented in Table 1.

The plant population in the main plot treatments, mulch, stress treatments and to interaction effects were not significantly different at 15, 30 days after sowing and at harvest.

## GROWTH CHARACTERS

Plant Height (cm) at Harvest (Table 2)

Plant height at harvest was significantly influenced by different main treatments and moisture application treatments. No significant differences were observed by interaction.

## CHAPTER - IV

### RESULTS

A Field experiment was carried out on the dry lands of Tirupati campus of Andhra Pradesh Agricultural University from July - October 1995 to evaluate the effect of mulches, Kaolinite urea spray and their combination on stressed rainfed groundnut to mitigate losses in the yield. The season was very good due to good distribution of rainfall except for a stress of few days and hence the yield levels were high. The stress treatments could be saved by rain out shelters from 30-75 days after sowing. The results of observations taken at different intervals of crop growth are presented in this chapter. The data are given in tables and depicted in graphs wherever necessary.

#### 4.1 PLANT POPULATION AT 15, 30 DAYS AFTER SOWING AND AT HARVEST

The data pertaining to plant population was presented in Table:3.

The plant population in the main plot treatments, sub plot treatments and due to interaction effects were not significantly different at both 15 and 30 days after sowing and at harvest.

#### 4.2 GROWTH CHARACTERS

##### 4.2.1 *Plant Height (cm) at Harvest (Table : 4)*

Plant height at harvest was significantly influenced by different main plot treatments and moisture amelioration treatments. No significant effect was exerted by interactions.

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Table - 3

PLANT POPULATION m<sup>2</sup> OF GROUNDNUT AT 15, 30 DAS AND AT HARVEST

Treatment	Population at 15 DAS	Population at 30 DAS	Population at Harvest
M <sub>1</sub>	31.78	31.61	27.47
M <sub>2</sub>	31.83	31.00	27.73
M <sub>3</sub>	31.83	31.83	26.68
CD (P=0.05)	NS	NS	NS
S <sub>1</sub>	32.44	30.89	27.41
S <sub>2</sub>	31.89	31.67	27.66
S <sub>3</sub>	31.78	31.56	27.87
S <sub>4</sub>	31.78	31.78	27.68
S <sub>5</sub>	31.67	31.33	28.82
S <sub>6</sub>	32.11	31.67	27.76
CD (P=0.05)	NS	NS	NS
Interaction	NS	NS	NS

NS : Not significant

Table - 4

PLANT HEIGHT (CM) OF GROUNDNUT AT HARVEST AS INFLUENCED BY TREATMENTS

Treatment	M <sub>1</sub>	M <sub>2</sub>	M <sub>3</sub>	Mean
S <sub>1</sub>	50.17	50.40	46.36	48.98
S <sub>2</sub>	53.00	54.00	49.93	52.31
S <sub>3</sub>	57.02	57.40	54.46	56.29
S <sub>4</sub>	54.20	55.60	52.04	53.95
S <sub>5</sub>	57.40	58.28	55.57	57.08
S <sub>6</sub>	56.70	56.90	54.46	56.02
Mean	54.75	55.43	52.14	

CD (P=0.05)

1.217

1.356

SE

0.309

0.469

NS

1. Two main treatment means

2. Two subtreatment means

3. Interaction

In moisture stress treatment there was significant reduction in plant height whereas significantly taller plants were observed under M<sub>2</sub> (irrigated) treatment followed by M<sub>1</sub> (Rained) treatment.

Among the sub plot treatments, least plant height was with control (S<sub>1</sub>) treatment. Plant height was measured highest with mulch + kaoline (S<sub>5</sub>) treatment which was on par with S<sub>3</sub> (mulch) and S<sub>6</sub> (mulch + Kaoline + urea). All other treatments were superior to control.

#### 4.2.2 Leaf Area Index (LAI)

The leaf area index computed at 30, 45, 60, 75, 90 days after sowing and is presented in Table : 5 (Fig.4). In general, with the advancement of crop growth, the LAI increased upto 75 DAS and thereafter there was a decline towards harvest for all the treatments studied. LAI is significantly influenced by main plot, sub plot treatments and interaction effects.

Main plot treatments resulted with significant differences in leaf area index at all the days of sampling except at 30 DAS. Irrigated treatment maintained higher LAI at all sampling days compared to rainfed treatment and moisture stress treatment had the least LAI.

Sub plot treatments had a marked influence on the LAI. Among the sub plot treatments S<sub>5</sub> (Mulch + kaoline) had higher LAI compared to all other treatments. At 45 DAS also S<sub>5</sub> treatment recorded significantly higher LAI which was on a par with S<sub>6</sub> and S<sub>3</sub> followed by S<sub>4</sub> treatment. At 60 and 75 DAS highest LAI was recorded by S<sub>5</sub> which is on a par with S<sub>3</sub> and S<sub>6</sub> and least was in control

Table - 5

## LEAF AREA INDEX OF GROUNDNUT CROP AS INFLUENCED BY TREATMENTS

Treatment	Days after sowing				
	30	45	60	75	90
M <sub>1</sub>	1.03	2.59	3.21	3.52	1.36
M <sub>2</sub>	1.06	2.66	3.45	3.82	1.45
M <sub>3</sub>	1.06	2.01	2.51	2.76	1.17
SEm	0.03	0.05	0.040	0.024	0.007
CD (P=0.05)	NS	0.205	0.159	0.097	0.030
S <sub>1</sub>	1.00	2.01	2.30	2.62	1.03
S <sub>2</sub>	1.18	2.35	2.65	2.92	1.19
S <sub>3</sub>	1.00	2.57	3.43	3.67	1.47
S <sub>4</sub>	0.98	2.42	2.96	3.39	1.28
S <sub>5</sub>	1.05	2.65	3.67	3.97	1.52
S <sub>6</sub>	1.08	2.53	3.32	3.64	1.45
SEm	0.05	0.04	0.030	0.057	0.036
CD (P=0.05)	NS	0.132	0.088	0.166	0.106
Interaction	NS	NS	0.308	NS	NS

NS : Not significant

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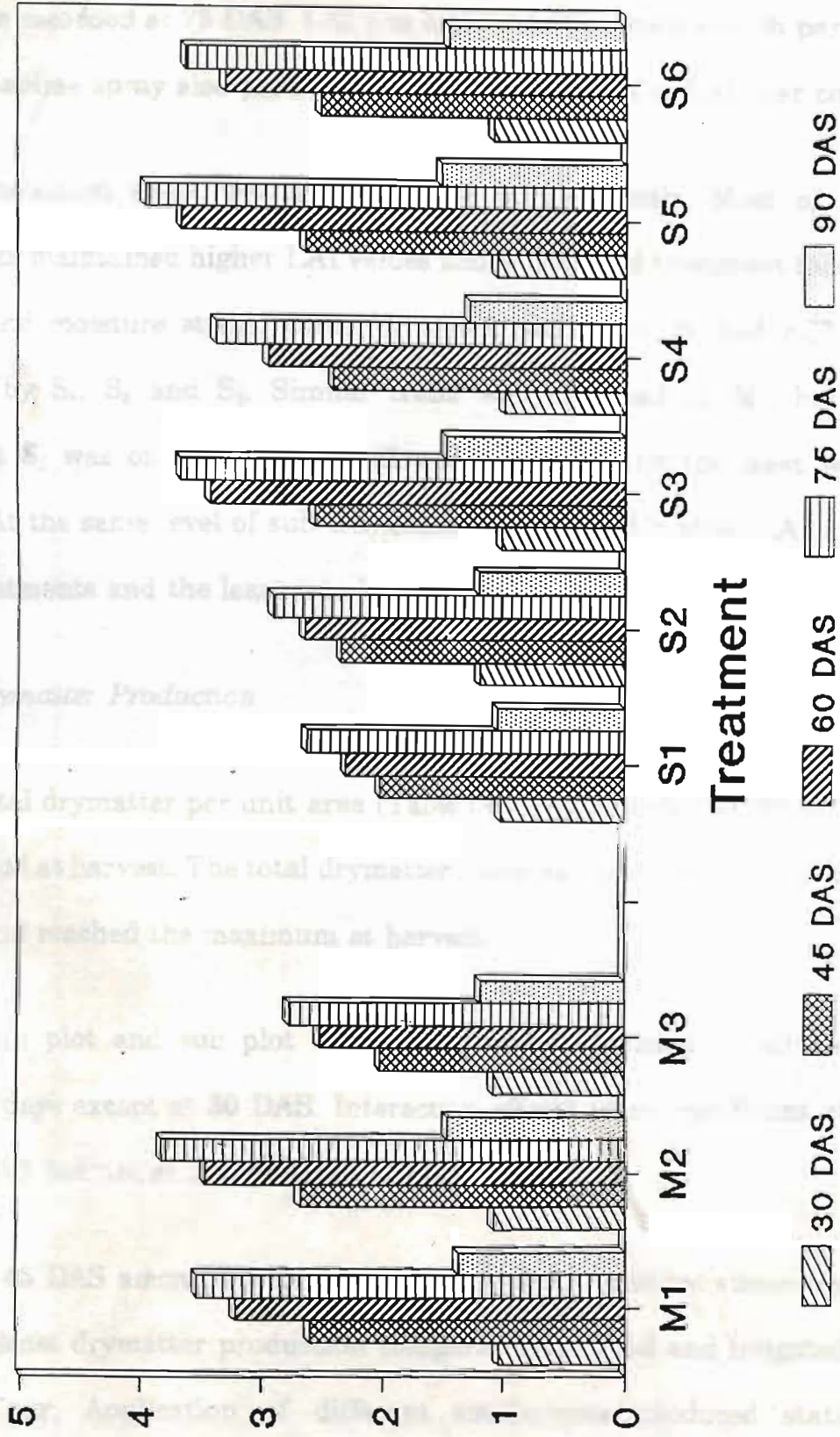
**MXS INTERACTION TABLE AT 60 DAS**

Treatment	M <sub>1</sub>	M <sub>2</sub>	M <sub>3</sub>	Mean
S <sub>1</sub>	2.40	2.85	1.64	2.30
S <sub>2</sub>	2.85	3.00	2.10	2.65
S <sub>3</sub>	3.60	3.82	2.87	3.43
S <sub>4</sub>	3.20	3.31	2.37	2.96
S <sub>5</sub>	3.80	4.10	3.10	3.67
S <sub>6</sub>	3.40	3.60	2.95	3.32
Mean	3.21	3.45	2.51	

**Significant at 5% level**

	SEM	CD
1. Two main treatment means	0.040	0.159
2. Two subtreatment means	0.030	0.088
3. Two submeans at same level of main treatment means	0.053	0.092
4. Two main treatment means at same (or) different levels of subtreatments	0.152	0.308

**Fig. 4: Leaf area index of groundnut as influenced by treatments**



and water spray treatment. At 90 DAS, the LAI values were lower compared to the values recorded at 75 DAS. LAI was highest in S<sub>5</sub> which was on par with S<sub>3</sub> and S<sub>6</sub>. Kaoline spray also produced significant increase in LAI over control.

Interaction effect was significant at 60 DAS only. Most of the sub treatments maintained higher LAI values under irrigated treatment followed by rainfed and moisture stress. Under irrigated conditions, S<sub>5</sub> had highest LAI followed by S<sub>3</sub>, S<sub>6</sub> and S<sub>4</sub>. Similar trend was observed in M<sub>1</sub>, but in M<sub>3</sub>, treatment S<sub>5</sub> was on par with S<sub>6</sub> followed by S<sub>3</sub>, S<sub>4</sub> and the least was with control. At the same level of sub treatments S<sub>5</sub> recorded highest LAI in all the main treatments and the least was in S<sub>1</sub>.

#### 4.2.3 *Drymatter Production*

Total drymatter per unit area (Table : 6) was recorded at 30, 45, 60, 75, 90 DAS and at harvest. The total drymatter increased steadily with the progress of time and reached the maximum at harvest.

Main plot and sub plot treatments were significant at all the given sampling days except at 30 DAS. Interaction effects were significant at 60, 75 and 90 DAS but not at 30, 45 DAS and at harvest.

At 45 DAS among the main plot treatments, moisture stress treatment recorded least drymatter production compared to rainfed and irrigated which were at par. Application of different ameliorants produced statistically measurable increase in drymatter production for all the growth stages over absolute control. Highest drymatter was recorded with mulch + kaoline which

Table - 6

TOTAL DRYMATTER PRODUCTION (Kg ha<sup>-1</sup>) OF GROUNDNUT AS INFLUENCED BY TREATMENTS

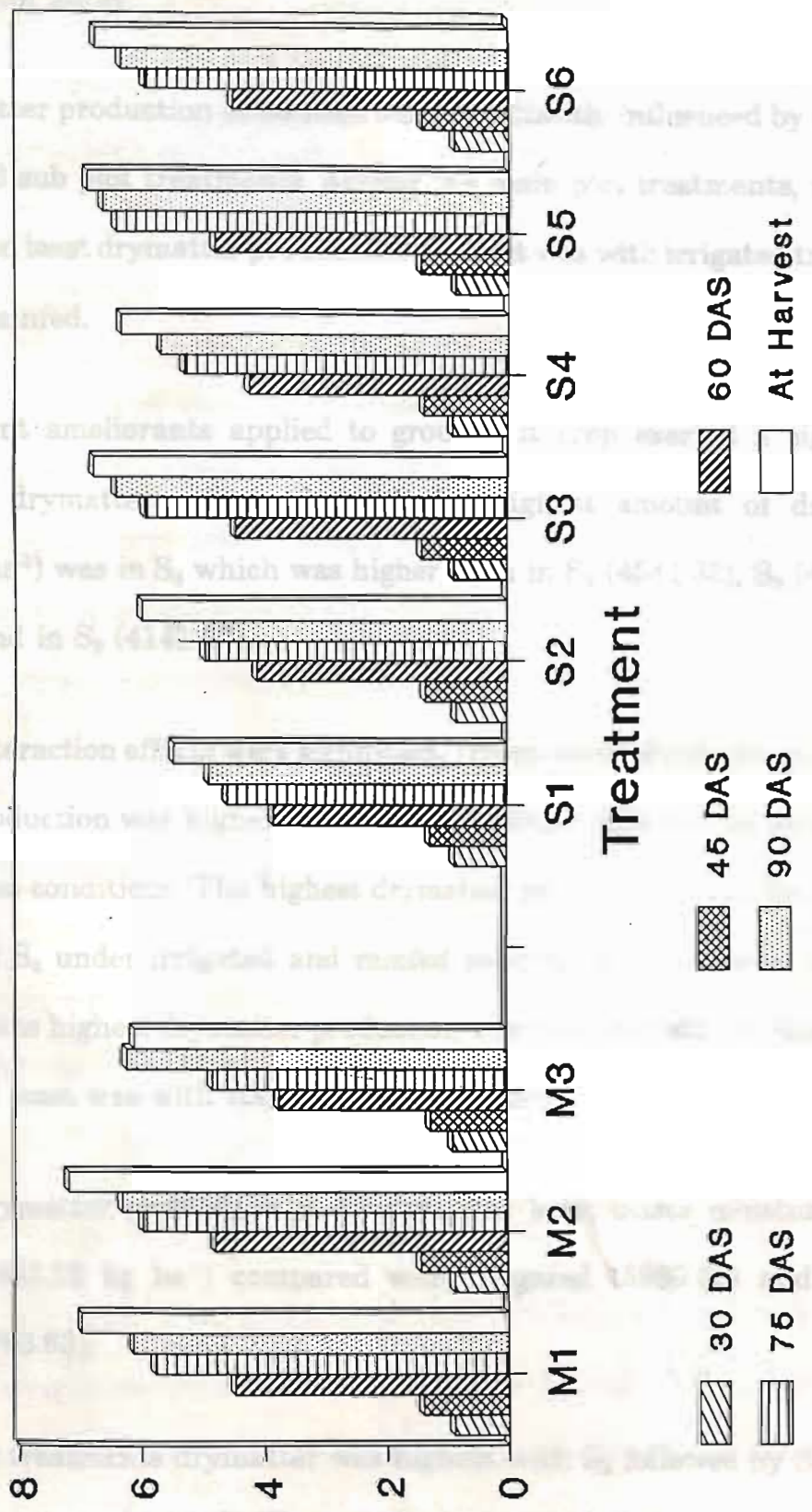
Treatment	Days after sowing						At Harvest
	30	45	60	75	90		
M <sub>1</sub>	880.41	1390.94	4474.17	5763.63	6125.73		6980.00
M <sub>2</sub>	863.98	1408.99	4791.06	5980.03	6327.00		7201.33
M <sub>3</sub>	876.13	1256.75	3770.56	4857.12	6232.86		6112.00
SEm	-	18.01	32.24	42.40	10.83		21.00
CD (P=0.05)	NS	70.717	126.551	166.437	42.525		82.433
S <sub>1</sub>	839.03	1252.45	3854.44	4606.12	4917.56		5489.33
S <sub>2</sub>	830.13	1325.49	4141.67	5001.83	5400.09		6022.67
S <sub>3</sub>	856.43	1391.05	4490.22	5946.73	6417.00		6780.84
S <sub>4</sub>	876.13	1350.63	4236.00	5293.51	5677.20		6341.33
S <sub>5</sub>	844.05	1411.70	4807.89	6408.80	6615.33		6896.80
S <sub>6</sub>	863.98	1382.04	4541.33	5944.54	6344.00		6764.44
SEm	-	13.16	39.33	59.81	26.77		40.77
CD (P=0.05)	NS	38.016	113.580	172.701	77.316		117.733
Interaction	NS	NS	Sig	Sig	Sig		NS

NS : Not significant

**MXS INTERACTION TABLE AT 60, 75, 90 DAS**

Treatment	Days after sowing		
	60	75	90
M <sub>1</sub> S <sub>1</sub>	3726.67	4731.70	5110.53
M <sub>1</sub> S <sub>2</sub>	4400.00	5288.30	5688.26
M <sub>1</sub> S <sub>3</sub>	4651.00	6243.77	6600.00
M <sub>1</sub> S <sub>4</sub>	4490.00	5581.60	5981.60
M <sub>1</sub> S <sub>5</sub>	4804.33	6625.93	6864.00
M <sub>1</sub> S <sub>6</sub>	4773.00	6110.47	6510.00
M <sub>2</sub> S <sub>1</sub>	4381.67	5081.67	5260.00
M <sub>2</sub> S <sub>2</sub>	4470.00	5477.20	5872.00
M <sub>2</sub> S <sub>3</sub>	4993.33	6372.57	6980.00
M <sub>2</sub> S <sub>4</sub>	4600.00	5934.93	6200.00
M <sub>2</sub> S <sub>5</sub>	5419.33	6850.00	7020.00
M <sub>2</sub> S <sub>6</sub>	4882.00	6163.80	6720.00
M <sub>3</sub> S <sub>1</sub>	3455.00	4005.00	4382.13
M <sub>3</sub> S <sub>2</sub>	3555.00	4240.00	4640.00
M <sub>3</sub> S <sub>3</sub>	3826.33	5223.87	5761.00
M <sub>3</sub> S <sub>4</sub>	3618.00	4364.00	4850.00
M <sub>3</sub> S <sub>5</sub>	4200.00	5750.47	5962.00
M <sub>3</sub> S <sub>6</sub>	3969.00	5559.37	5802.00
SEm			
S at M	68.13	103.59	46.37
M at S	77.27	103.81	30.74
CD			
S at M	196.727	299.127	133.915
M at S	240.096	317.797	90.7

Fig. 5: Total drymatter production ('000 kg ha-1) of groundnut as influenced by treatments



was at par with mulch alone, mulch + kaoline + urea spray followed by kaoline spray and water spray.

Drymatter production at 60 DAS was significantly influenced by different main plot and sub plot treatments. Among the main plot treatments, moisture stress recorded least drymatter production. Highest was with irrigated treatment followed by rainfed.

Different ameliorants applied to groundnut crop exerted a significant influence on drymatter compared to check. Highest amount of drymatter (4807.89 kg ha<sup>-1</sup>) was in S<sub>5</sub> which was higher than in S<sub>6</sub> (4541.33), S<sub>3</sub> (4490.22), S<sub>4</sub> (4236.0) and in S<sub>2</sub> (4141.67).

The interaction effects were significant. Irrespective of sub plot treatment, drymatter production was higher in irrigated condition followed by rainfed and moisture stress conditions. The highest drymatter produced was in the order of S<sub>5</sub>, S<sub>3</sub>, S<sub>6</sub> and S<sub>4</sub> under irrigated and rainfed conditions, whereas in moisture stress conditions highest drymatter production was recorded with S<sub>5</sub> followed by S<sub>6</sub> and S<sub>3</sub> and least was with control (No treatment).

The drymatter production at 75 days was least under moisture stress treatment (4851.12 kg ha<sup>-1</sup>) compared with irrigated (5980.03) and rainfed treatment (5763.63).

Among treatments drymatter was highest with S<sub>5</sub> followed by S<sub>3</sub> and S<sub>6</sub> which were at par and with S<sub>4</sub>. Even with water spray there is an increase of 395.71 kg ha<sup>-1</sup> of drymatter over control. Interaction effect was significant. At the

same level of main plot treatments, higher drymatter was recorded in S<sub>5</sub> followed by S<sub>3</sub> under rainfed and irrigated conditions, but in moisture stress treatment, highest drymatter was obtained in S<sub>5</sub> which was on par with S<sub>6</sub>. S<sub>5</sub> produced highest drymatter in both rainfed and irrigated conditions whereas in moisture stress condition, the highest drymatter in S<sub>5</sub> was on a par with S<sub>6</sub>. All the sub treatments were superior to control.

At 90 DAS main plot and sub plot treatments were significantly different. Interaction effect was also significant. Among main plot treatments M<sub>2</sub> recorded significantly superior drymatter content over rainfed and moisture stress treatments. Among sub plot treatments, significantly highest drymatter was obtained in all other treatments over check. The highest drymatter was in S<sub>5</sub> treatment.

Under rainfed condition, S<sub>5</sub> had highest drymatter followed by S<sub>3</sub>, S<sub>6</sub> and S<sub>4</sub> treatments. S<sub>5</sub> and S<sub>3</sub> recovered highest drymatter in irrigated condition, whereas in moisture stress treatment S<sub>5</sub> and S<sub>6</sub> had highest drymatter followed by S<sub>3</sub> and S<sub>4</sub>. All the treatments were significantly superior to control. Among the same level of sub plot treatments in all the treatments M<sub>2</sub> recorded higher drymatter over rainfed and moisture stress treatments.

At harvest, main plot treatments and ameliorative treatments had significant differences but there was no significant interaction effect. Among the main plot treatments least drymatter production was recorded in moisture stress treatment (6112.00 kg ha<sup>-1</sup>), highest was with irrigated (7201.33) followed by rainfed treatment (6980.00). Among sub treatments all the ameliorative

treatments recorded significantly superior drymatter production over check, with S<sub>5</sub> having the highest drymatter production.

### 4.3 YIELD ATTRIBUTES

#### 4.3.1 *Number of Flowers Per Plant*

The data pertaining to number of flowers per plant was presented in Table : 7 and Fig. 6

There was no significant difference in the number of flowers per plant due to main plot treatments and interaction, but, the same was significantly influenced by sub plot treatments.

Among the different amelioration treatments mulch + kaoline treatment (S<sub>5</sub>) recorded higher number of flowers (71.22) and least number of flowers were in control (54.33). In all other treatments the increase in number of flowers was significant compared to check.

#### 4.3.2 *Number of Pegs Per Plant*

The total number of pegs per plant was given in Table : 8 and Fig. 6. There was significant difference among the main plots and sub plot treatments. Interaction was also significant. The least number of pegs was recorded in M<sub>3</sub> which was significantly inferior to the pegs obtained in M<sub>1</sub> and M<sub>2</sub>.

Among the sub plot treatments the least number of pegs was in S<sub>1</sub> (check) which was on a par with S<sub>2</sub> (water spray) but was significantly inferior to other

Table - 7

**CUMULATIVE NUMBER OF FLOWERS PER PLANT OF GROUNDNUT (COUNTED UPTO 51 DAS)  
AS INFLUENCED BY TREATMENTS**

Treatment	M <sub>1</sub>	M <sub>2</sub>	M <sub>3</sub>	Mean
S <sub>1</sub>	55.00	55.67	52.33	54.33
S <sub>2</sub>	60.67	62.33	58.67	60.56
S <sub>3</sub>	67.00	68.00	63.33	66.11
S <sub>4</sub>	62.33	66.33	60.33	63.00
S <sub>5</sub>	72.00	73.67	68.00	71.22
S <sub>6</sub>	65.00	67.33	64.67	65.67
Mean	63.67	65.56	61.22	

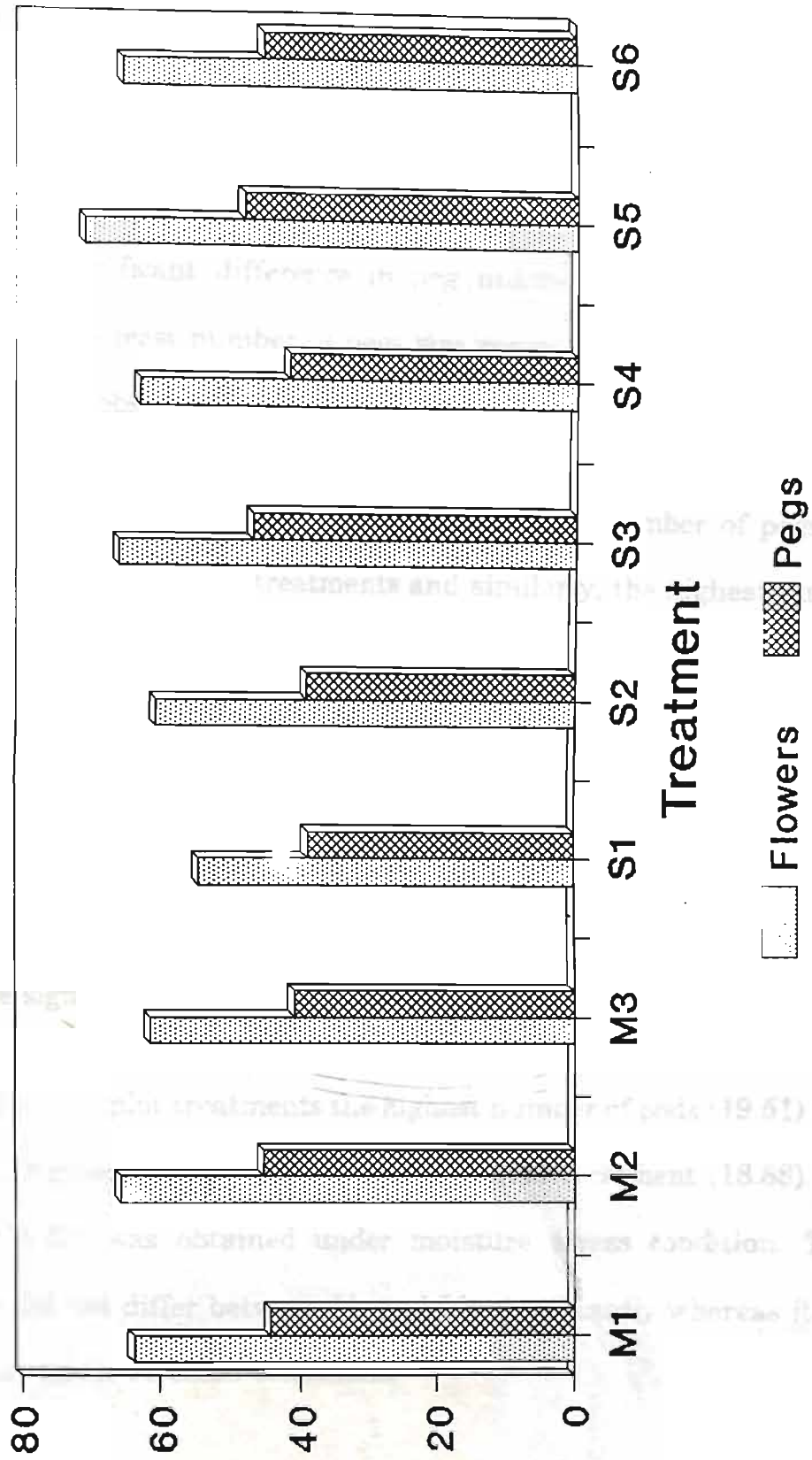
	SEm	CD
1 Two main treatment means	0.935	NS
2 Two sub treatment means	0.757	2.186
3 Interaction		NS

Table - 8  
**NUMBER OF PEGS PER PLANT OF GROUNDNUT AS INFLUENCED BY TREATMENTS**

Treatment	M <sub>1</sub>	M <sub>2</sub>	M <sub>3</sub>	Mean
S <sub>1</sub>	40.00	40.80	35.00	38.60
S <sub>2</sub>	40.07	41.00	36.00	39.02
S <sub>3</sub>	47.50	48.13	45.00	46.88
S <sub>4</sub>	44.00	44.30	37.00	41.77
S <sub>5</sub>	49.00	50.20	46.00	48.40
S <sub>6</sub>	45.00	46.20	45.40	45.53
Mean	44.26	45.11	40.73	

	SEm	CD
1 Two main treatment means	0.364	1.434
2 Two sub treatment means	0.357	1.033
3 Two sub means at same level of main treatment means	0.619	1.788
4 Two main treatment means at same (or) different levels of sub treatments	0.855	2.730

Fig. 6: Number of flowers and pegs per plant of groundnut as influenced by treatments



treatments. The number of pegs in S<sub>5</sub> (Mulch + kaoline) was significantly superior to rest of the treatments. Among the treated plots, number of pegs was lower in kaoline alone treated plot but significantly superior to those obtained in S<sub>1</sub> and S<sub>2</sub>.

There was significant difference in peg number among the sub plot treatments in M<sub>1</sub>. The least number of pegs was recorded in S<sub>1</sub> and highest in S<sub>5</sub>. Similar trend was observed under M<sub>2</sub> and M<sub>3</sub>.

At the same level of sub plot treatments the least number of pegs was recorded in M<sub>3</sub> under all the sub treatments and similarly, the highest number of pegs was recorded in M<sub>2</sub>.

#### 4.3.3 Total, Filled and Unfilled Pods Per Plant

The data on number of pods per plant were counted and presented in Table : 9 (Fig.7). From this data it is evident that the effects of main and sub treatments were significant but not the interaction.

Among the main plot treatments the highest number of pods (19.51) were counted in M<sub>2</sub> (irrigated condition) followed by rainfed treatment (18.88). The least number (16.33) was obtained under moisture stress condition. Total number of pods did not differ between M<sub>1</sub> and M<sub>2</sub> significantly whereas it was significantly least under stressed conditions.

The number of pods among the stress amelioration treatments differed significantly. The least number of pods of 15.30 was counted where no

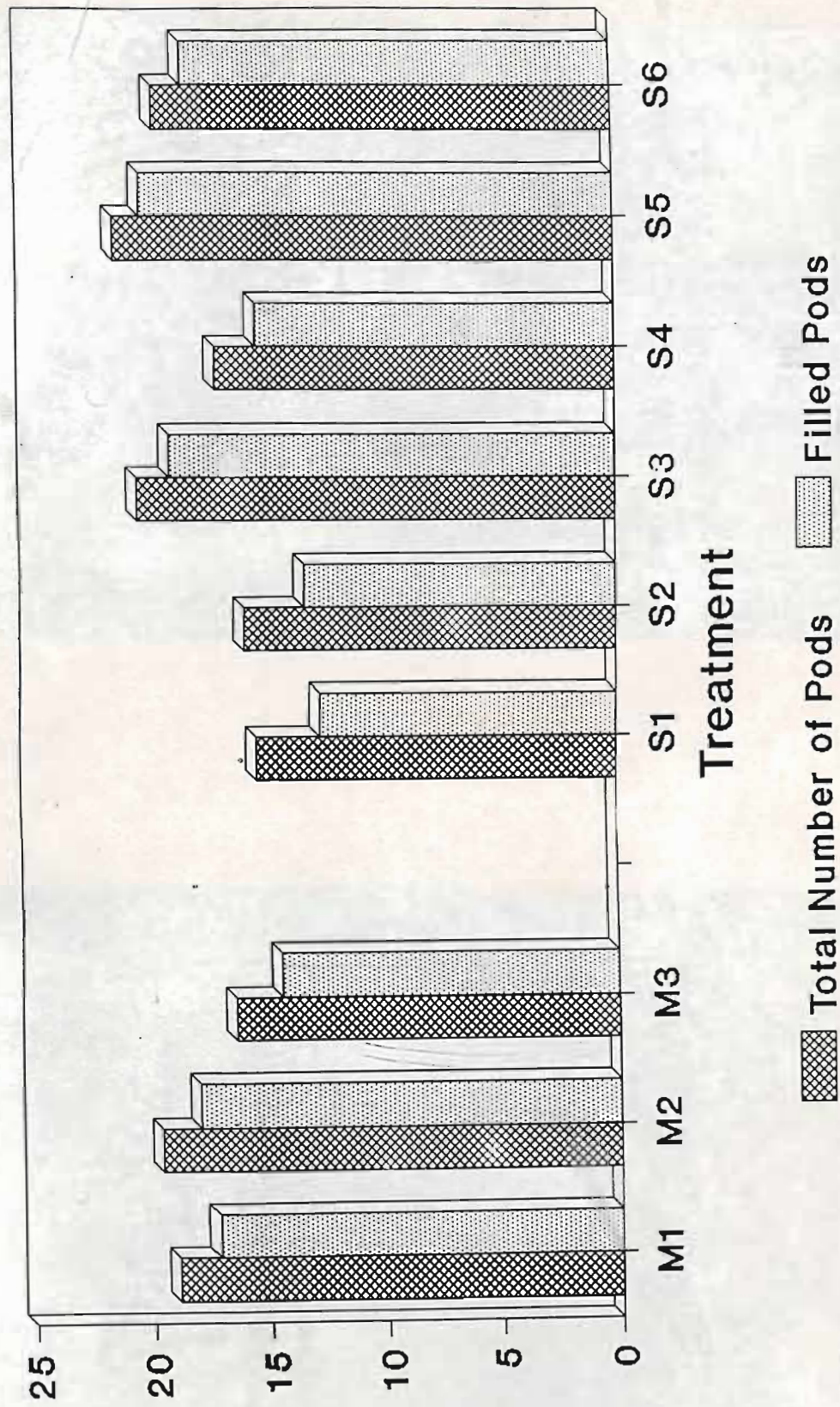
Table - 9

**TOTAL, FILLED AND UNFILLED PODS PER PLANT OF GROUNDNUT AS INFLUENCED BY TREATMENTS**

Treatment	Total number of pods	Filled pods	Unfilled pods
M <sub>1</sub>	18.88	17.15	1.73
M <sub>2</sub>	19.51	17.88	1.62
M <sub>3</sub>	16.33	14.38	1.95
SEm	0.359	0.357	0.103
CD (P=0.05)	1.413	1.405	NS
S <sub>1</sub>	15.30	12.63	2.67
S <sub>2</sub>	15.87	13.33	2.53
S <sub>3</sub>	20.36	19.00	1.36
S <sub>4</sub>	17.02	15.33	1.69
S <sub>5</sub>	21.33	20.20	1.13
S <sub>6</sub>	19.57	18.33	1.23
SEm	0.517	0.490	0.344
CD (P=0.05)	1.495	1.416	0.995
Interaction	NS	NS	NS
SEm			
S at M	0.896	0.849	0.596
M at S	0.884	0.871	0.336
Interaction	NS	NS	NS

NS : Not significant

Fig. 7: Total and filled pods per plant of groundnut as influenced by treatments





*Stress imposed control plants*



*Stress imposed mulch + kaoline treated plants*

amelioration treatment was given ( $S_1$ ) and the highest number of pods was in mulch + kaoline ( $S_5$ ) which was on a par with mulch alone. All other treatments were also significantly superior to control and water spray.

Number of filled pods was significantly influenced by different main plot and sub plot treatments but not the interaction.

Among the main plot treatments highest number of filled pods (17.88) were observed in  $M_2$  treatment which was at par with  $M_1$  (17.15). Significantly least number of filled pods (14.38) were obtained under moisture stress treatment.

Number of filled pods differed significantly among the moisture ameliorants. The least number of filled pods were obtained where no amelioration treatment was given (12.63). Highest number of filled pods (20.20) was observed under  $S_5$  which was on a par with  $S_3$ . The increased number of filled pods (18.33) were significantly higher with  $S_6$  and  $S_4$  (15.33) compared to control (12.63) and water spray (13.33).

As already mentioned interaction effects due to main plot treatments and sub plot treatments were not significant.

Number of unfilled pods due to main plot treatment and interaction effect were not significant, whereas with sub plots, significant differences were obtained.

Among the sub plot treatments, highest number of unfilled pods per plant (2.67) were recorded under S<sub>1</sub> (check) which was on a par with S<sub>2</sub> (water spray). The number of unfilled pods were less with S<sub>5</sub>, S<sub>6</sub> and S<sub>3</sub> which were significantly reduced compared to S<sub>1</sub>. Kaoline spray (S<sub>4</sub>) also showed significant reduction in number of filled pods over control.

#### 4.3.4 *Peg to Pod Percentage (Table : 10)*

Significant differences in peg to pod percentage were observed due to main plot treatments and different amelioration treatments. The effects of interaction were not significant.

Among the main plot treatments the least peg to pod percentage was observed under moisture stress (M<sub>3</sub>). Highest peg to pod percentage was recorded with irrigation (M<sub>2</sub>) which was on a par with rainfed (M<sub>1</sub>).

All the ameliorative treatments significantly influenced the peg to pod percentage over control and water spray. Highest peg to pod percentage was with S<sub>5</sub> (Mulch + Kaoline) which was on par with S<sub>3</sub> (Mulch alone).

#### 4.3.5 *100-Pod Weight (g) and Shelling Outturn (%)*

100 pod weight and shelling percentage recorded in different ameliorative treatments at harvest are presented in table : 11. (Fig.8)

100 pod weight differed significantly due to main plot and sub plot treatments. Interaction effect was also significant. Among the main plot treatments, M<sub>2</sub> (irrigated) recorded highest 100-pod weight (68.19 g) followed by

Tabl - 10  
**PEG TO POD PERCENTAGE OF GROUNDNUT AS INFLUENCED BY TREATMENTS**

Treatment	M <sub>1</sub>	M <sub>2</sub>	M <sub>3</sub>	Mean
S <sub>1</sub>	40.00	40.77	38.00	39.59
S <sub>2</sub>	41.00	41.40	38.67	40.36
S <sub>3</sub>	44.17	44.93	40.80	43.30
S <sub>4</sub>	41.13	41.17	39.40	40.57
S <sub>5</sub>	44.80	45.77	41.27	43.94
S <sub>6</sub>	43.27	44.23	41.13	42.88
Mean	42.39	43.04	39.88	

1	Two main treatment means	SEM	CD
2	Two sub treatment means	0.566	2.225
3	Interaction	0.886	2.561
		NS	

Table - 11

100 POD WEIGHT (g) AND SHELLING OUT TURN (%) OF GROUNDNUT AS INFLUENCED BY TREATMENTS

Treatment	100 Pod weight	Shelling outturn
M <sub>1</sub>	66.21	75.90
M <sub>2</sub>	68.19	77.41
M <sub>3</sub>	64.32	71.93
SEm	0.224	0.289
CD (P=0.05)	0.883	1.139
S <sub>1</sub>	63.00	72.36
S <sub>2</sub>	64.06	72.98
S <sub>3</sub>	68.28	76.58
S <sub>4</sub>	65.61	74.19
S <sub>5</sub>	68.44	77.89
S <sub>6</sub>	68.04	76.49
SEm	0.333	0.365
CD (P=0.05)	0.962	1.056
Interaction	Sig	Sig

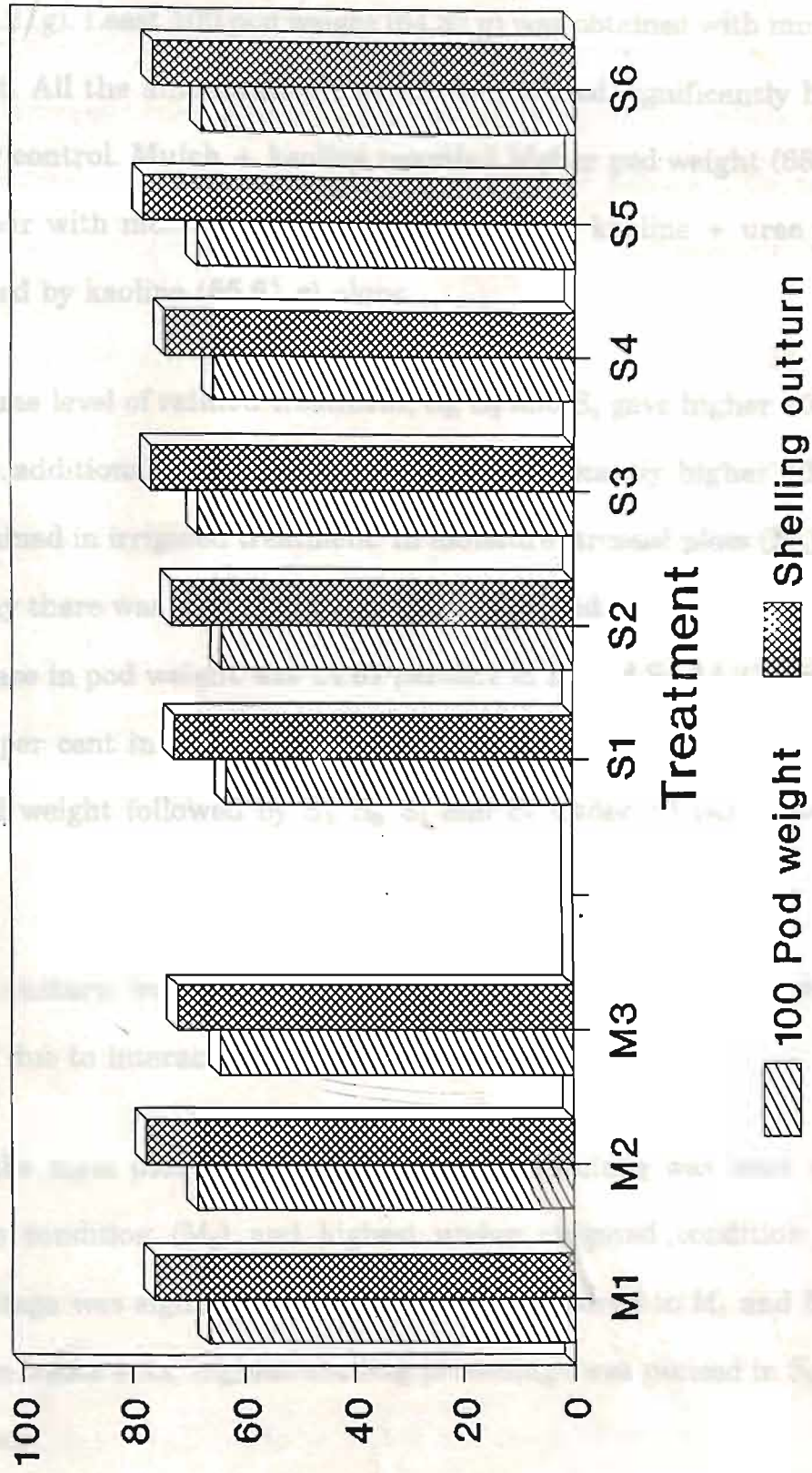
Significant at 5% level

**MXS INTERACTION TABLE**

M <sub>1</sub> S <sub>1</sub>	64.83	71.83
M <sub>1</sub> S <sub>2</sub>	65.00	72.50
M <sub>1</sub> S <sub>3</sub>	67.00	78.00
M <sub>1</sub> S <sub>4</sub>	66.33	76.00
M <sub>1</sub> S <sub>5</sub>	67.17	79.42
M <sub>1</sub> S <sub>6</sub>	66.90	77.67
M <sub>2</sub> S <sub>1</sub>	65.17	76.08
M <sub>2</sub> S <sub>2</sub>	65.83	76.17
M <sub>2</sub> S <sub>3</sub>	70.17	78.75
M <sub>2</sub> S <sub>4</sub>	67.67	75.50
M <sub>2</sub> S <sub>5</sub>	70.50	79.75
M <sub>2</sub> S <sub>6</sub>	69.83	78.20
M <sub>3</sub> S <sub>1</sub>	59.00	69.17
M <sub>3</sub> S <sub>2</sub>	61.33	70.27
M <sub>3</sub> S <sub>3</sub>	67.67	73.00
M <sub>3</sub> S <sub>4</sub>	62.83	71.07
M <sub>3</sub> S <sub>5</sub>	67.67	74.50
M <sub>3</sub> S <sub>6</sub>	67.40	73.60
SE <sub>in</sub>		
S at M	0.577	0.785
M at S	0.555	0.698
CD		
S at M	1.666	1.830
M at S	1.692	2.163

Significant at 5% level

Fig. 8: 100 Pod weight (g) and shelling out turn (%) of groundnut as influenced by treatments.



M<sub>1</sub> (rainfed) (66.21g). Least 100 pod weight (64.32 g) was obtained with moisture stress treatment. All the ameliorative treatments resulted significantly higher pod weight over control. Mulch + kaoline recorded higher pod weight (68.44 g) which was on par with mulch alone (68.28 g), mulch + kaoline + urea spray (68.04 g) followed by kaoline (65.61 g) alone.

At the same level of rainfed treatment, S<sub>5</sub>, S<sub>3</sub> and S<sub>6</sub> gave higher 100-pod weight whereas additionally in S<sub>4</sub> treatment also significantly higher 100-pod weight was obtained in irrigated treatment. In moisture stressed plots (M<sub>3</sub>) even with water spray there was significant increase in 100-pod weight over control. In M<sub>3</sub> the increase in pod weight was 14.69 percent in S<sub>5</sub> and S<sub>3</sub>, 14.23 per cent in S<sub>6</sub> and 6.09 per cent in S<sub>4</sub> over control plot. In all the treatments showed highest 100-pod weight followed by S<sub>3</sub>, S<sub>6</sub>, S<sub>4</sub> and S<sub>2</sub> under all the main plot treatments.

Shelling outturn was significantly influenced by main plot, sub plot treatments and due to interaction effects.

Among the main plot treatments, shelling percentage was least under moisture stress condition (M<sub>3</sub>) and highest under irrigated condition (M<sub>2</sub>). Shelling percentage was significantly higher in M<sub>2</sub> compared to M<sub>1</sub> and M<sub>3</sub>. In the ameliorative treatments, highest shelling percentage was noticed in S<sub>5</sub> with the least in check.

The interaction was significant between the main plot and ameliorative treatments. In the M<sub>1</sub> (rainfed), the effects of sub plots differed significantly with

highest shelling percentage in  $S_5$  which was on a par with  $S_3$  and  $S_6$  where as Kaoline alone ( $S_4$ ) was also superior to control. The same trend was repeated in  $M_2$ . In  $M_3$  the highest shelling percentage was in  $S_5$  which was on a par with  $S_6$  and  $S_3$  and the least was once again in control. Water spray or kaoline spray alone was also superior to control. At the same level of sub plots there was consistently higher shelling percentage in  $M_2$  and the least was recorded in  $M_3$ .

#### 4.3.6 Pod Yield, Haulm Yield and Harvest Index

The data on pod yield of groundnut at harvest was presented in the Table : 12 (Fig.9). It is seen from this data that the effects of main and sub treatments were significant but not the interaction. Among the three main plot treatments the highest pod yield of  $22.35 \text{ Q ha}^{-1}$  was recorded in  $M_2$  (irrigated conditions) followed by the yield of  $21.37 \text{ Q ha}^{-1}$  in  $M_1$  (rainfed treatment). The least yield ( $15.94$ ) was obtained under  $M_3$  (Moisture stress condition).

The pod yield between  $M_1$  and  $M_2$  did not differ significantly whereas it was significantly least under stressed conditions. The per cent reduction in yield under stressed conditions over rainfed was 25.41 and that of irrigated was 28.68 respectively.

The pod yield among the moisture amelioration treatments differed significantly. The least yield ( $17.99 \text{ Q ha}^{-1}$ ) was obtained where no amelioration treatment was given ( $S_1$ ) whereas even with water spray twice there was significant increase in yield ( $19.14 \text{ Q ha}^{-1}$ ) over the check. There was significant increase in yield in all the amelioration treatments over the check. Among the

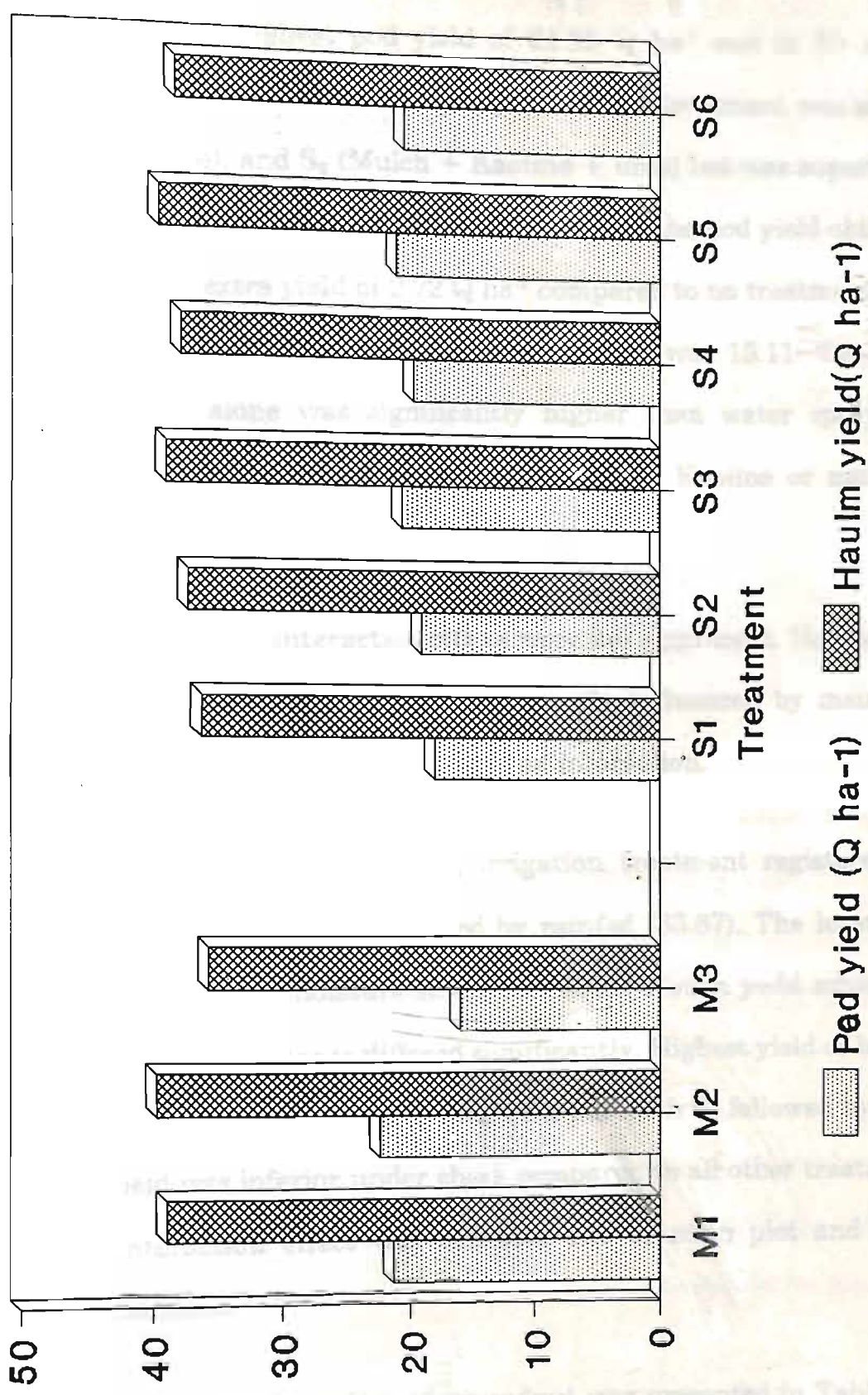
Table - 12

**POD YIELD, HAULM YIELD AND HARVEST INDEX OF GROUNDNUT  
AS INFLUENCED BY TREATMENTS**

Treatment	Pod yield (Q ha <sup>-1</sup> )	Haulm yield (Q ha <sup>-1</sup> )	Harvest index
M <sub>1</sub>	21.37	38.87	35.41
M <sub>2</sub>	22.35	39.63	36.04
M <sub>3</sub>	15.94	35.57	30.70
SEm	0.359	1.36	0.491
CD (P=0.05)	1.410	5.16	1.930
S <sub>1</sub>	17.99	36.05	33.00
S <sub>2</sub>	19.14	37.24	33.50
S <sub>3</sub>	20.71	39.01	34.49
S <sub>4</sub>	19.75	37.88	34.12
S <sub>5</sub>	21.18	39.60	34.80
S <sub>6</sub>	20.56	38.36	34.40
SEm	0.266	3.42	0.328
CD (P=0.05)	0.769	9.89	0.949
Interaction	NS	NS	NS

NS : Not significant

Fig.9 Pod yield & Haulm yield (Q ha<sup>-1</sup>) of groundnut as influenced by treatments



sub plot treatments the highest pod yield of 21.18 Q ha<sup>-1</sup> was in S<sub>5</sub> which received mulching + Kaoline spray. The pod yield in this treatment was on par with S<sub>3</sub> (Mulching alone), and S<sub>6</sub> (Mulch + Kaoline + urea) but was superior to S<sub>4</sub> (Kaoline alone). It is also observed from this data that the pod yield obtained with mulching gave an extra yield of 2.72 Q ha<sup>-1</sup> compared to no treatment. The percent increase of pod yield in mulching over control was 15.11. The yield obtained in mulching alone was significantly higher than water spray (or) Kaoline alone. However the pod yield in mulch + Kaoline or mulch + Kaoline + urea was at par.

As already stated the interaction effects were not significant. Haulm yield data is presented in table 4.3.6. It was significantly influenced by main plot treatments and sub plot treatments, but not the interaction.

Among the main plot treatments, irrigation treatment registered the highest straw yield (39.63 Q ha<sup>-1</sup>) followed by rainfed (33.87). The least yield (35.57) was obtained under moisture stress condition. Haulm yield among the moisture amelioration treatments differed significantly. Highest yield of haulms (39.60 Q ha<sup>-1</sup>) was recorded in S<sub>5</sub> which was on a par with S<sub>3</sub> followed by S<sub>6</sub>, S<sub>4</sub> and S<sub>2</sub>. Haulm yield was inferior under check compared to all other treatments. No significant interaction effect was obtained due to main plot and stress amelioration treatments.

The data on harvest index of groundnut was presented in Table : 12. Harvest index was least under moisture stress conditions. Highest harvest index

was recorded under irrigated condition which was on a par with rainfed treatment.

Among the sub treatments,  $S_5$  treatment recorded increased harvest index which was on a par with  $S_3$ ,  $S_6$  and  $S_4$  treatments. Control and water spray was inferior to all other treatments.

The differences in harvest index due to main plot and sub plot treatments and interactions were not significant.

#### 4.4 LEAF TEMPERATURES

Leaf Temperatures recorded at 60 days after sowing are presented in Table : 13.

There was significant difference among the main and sub plot treatments. Interaction was also significant. The leaf temperatures were least (29.72) under irrigated condition ( $M_2$ ) and highest (31.51) in moisture stress condition ( $M_3$ ). Leaf temperatures were significantly higher in  $M_3$  compared to  $M_2$  which was on a par with  $M_1$ .

In the sub plot treatments highest temperature was noticed in the check treatment (32.60) and the least in  $S_5$  (29.26). Leaf temperatures are significantly inferior in all other treatments compared to check. Lowest temperature recorded in  $S_5$  was on a par with  $S_6$  (29.42) only.

The interaction was significant. In the  $M_1$  (Rainfed) the effects of sub plots differed significantly with highest leaf temperature in  $S_1$ , which was on a par

Table - 13

LEAF TEMPERATURE (0°C) AT 60 DAS AS INFLUENCED BY TREATMENTS

Treatment	M <sub>1</sub>	M <sub>2</sub>	M <sub>3</sub>	Mean
S <sub>1</sub>	31.80	31.50	34.50	32.60
S <sub>2</sub>	31.53	30.17	33.00	31.57
S <sub>3</sub>	30.15	30.10	31.20	30.48
S <sub>4</sub>	30.20	29.80	30.30	30.10
S <sub>5</sub>	28.98	28.60	30.20	29.26
S <sub>6</sub>	30.31	28.13	29.83	29.42
Mean	30.49	29.72	31.51	

	SEm	CD
1 Two main treatment means	0.207	0.816
2 Two sub treatment means	0.210	0.606
3 Two sub means at same level of main treatment means	0.363	1.049
4 Two main treatment means at same (or) different levels of sub treatments	0.487	1.552

with S<sub>2</sub> and all other treatments were significantly inferior to S<sub>1</sub>. The least leaf temperature was in S<sub>5</sub> which was significantly inferior to rest of the treatments. Almost the same trend was repeated in M<sub>2</sub>, but the least leaf temperature was recorded in S<sub>6</sub>. It is also observed in M<sub>3</sub> that the highest leaf temperature was in S<sub>1</sub> followed by S<sub>2</sub>, and the least was once again in S<sub>6</sub> with the other treatments occupying positions in between. At the same level of main treatments under M<sub>1</sub> and M<sub>2</sub> leaf temperatures was highest in S<sub>1</sub> and least under S<sub>5</sub> but in S<sub>6</sub> it was least under M<sub>3</sub>. At the same level of sub plots consistently high leaf temperatures were recorded in M<sub>3</sub> and least in M<sub>2</sub> followed by M<sub>1</sub>.

#### **4.5 LEAF RELATIVE WATER CONTENT (RWC)**

The relative water content measured at 85 DAS of groundnut after 10 days of stress after removing the shelters was influenced by rainfed, irrigated and moisture stress treatments and different stress ameliorants are presented in Table : 14.

All the main plot, sub plot treatments and their interactions were significant. Among the main plot treatment, moisture stress resulted in significant decrease in RWC (71.10 per cent) compared to irrigated (81.75 per cent) and rainfed (80.62 per cent) treatments which were at par.

Lower RWC (69.50 per cent) were obtained under check (S<sub>1</sub>) compared to all other treatments. Highest RWC values were with S<sub>5</sub>, followed by S<sub>3</sub>, S<sub>6</sub>, S<sub>4</sub> and S<sub>2</sub> which were significantly superior to control.

Table - 14

**RELATIVE WATER CONTENT (%) OF GROUNDNUT AS INFLUENCED BY TREATMENTS**

Treatment	M <sub>1</sub>	M <sub>2</sub>	M <sub>3</sub>	Mean
S <sub>1</sub>	71.40	72.50	64.60	69.50
S <sub>2</sub>	76.40	77.30	66.00	73.23
S <sub>3</sub>	85.80	86.20	75.00	82.33
S <sub>4</sub>	78.60	80.00	69.00	75.87
S <sub>5</sub>	87.00	88.80	76.20	84.00
S <sub>6</sub>	84.50	85.70	75.80	82.00
Mean	80.62	81.75	71.10	

1	Two main treatment means	SEm	CD
2	Two sub treatment means	0.239	0.940
3	Two sub means at same level of main treatment means	0.271	0.784
4	Two main treatment means at same (or) different levels of sub treatments	0.470	1.357
		0.568	1.782

There was significant difference among the sub plot treatments in  $M_1$ . The least RWC was obtained in  $S_1$  and highest in  $S_5$ . Similar trend was observed under  $M_2$  and  $M_3$ .

At the same level of sub plot treatments lesser RWC was in  $M_3$ . Similarly the highest RWC was recorded in  $M_2$  under all sub plot treatments and  $M_1$  was in between.

#### 4.6 SOIL MOISTURE CONTENT (%)

The soil moisture content by weight in percentage was recorded at 45, 60, 85 days after sowing at different depths and presented in Table : 15.

In general, with increase in depth there was increase in soil moisture percentage in all the treatments. Soil moisture percentage was significantly influenced by main plot sub plot treatments and interaction.

At 45 DAS, among the main plots  $M_2$  (irrigated) recorded higher soil moisture percentage in all the three depths which was at par with  $M_1$  (rainfed).  $M_3$  (moisture stress) had significantly lower moisture percentage compared to  $M_2$  and  $M_1$ .

Among the sub plot treatments  $S_5$  recorded highest soil moisture in all the three depths and the least was with control. All other treatments had significantly higher moisture content than control.

Table - 15

**SOIL MOISTURE PERCENTAGE (w/w) UPTO 60 cm SOIL DEPTH  
AT 45, 60, 85 DAYS AFTER SOWING AS INFLUENCED BY TREATMENTS**

Treatment	45 DAS			60 DAS			85 DAS		
	0-15	15-30	30-60	0-15	15-30	30-60	0-15	15-30	30-60
M <sub>1</sub>	8.08 (2.80)	9.54 (3.03)	10.01 (3.10)	3.64 (1.84)	4.23 (2.01)	5.17 (2.27)	3.32 (1.78)	6.88 (2.55)	7.41 (2.67)
M <sub>2</sub>	8.23 (2.82)	9.82 (3.06)	10.17 (3.15)	3.88 (1.90)	4.62 (2.09)	5.64 (2.37)	3.84 (1.93)	7.43 (2.66)	8.35 (2.83)
M <sub>3</sub>	3.68 (1.85)	6.56 (2.49)	6.88 (2.56)	2.91 (1.65)	3.64 (1.89)	4.41 (2.12)	2.98 (1.67)	5.68 (2.32)	7.20 (2.63)
SEm	0.010	0.005	0.019	0.014	0.026	0.0390	0.027	0.044	0.036
CD (P=0.05)	0.031	0.015	0.060	0.043	0.080	0.120	0.082	0.136	0.111
S <sub>1</sub>	5.67 (2.27)	7.30 (2.61)	7.63 (2.70)	2.63 (1.56)	2.93 (1.75)	3.56 (1.89)	2.57 (1.59)	4.58 (2.07)	6.11 (2.43)
S <sub>2</sub>	5.85 (2.33)	7.49 (2.65)	7.85 (2.74)	2.71 (1.58)	3.56 (1.85)	4.55 (2.13)	2.84 (1.64)	5.52 (2.30)	6.62 (2.51)
S <sub>3</sub>	7.35 (2.61)	9.58 (3.04)	9.86 (3.07)	3.87 (1.91)	4.54 (2.06)	5.75 (2.39)	3.65 (1.88)	7.41 (2.65)	8.43 (2.88)
S <sub>4</sub>	6.25 (2.41)	8.12 (2.78)	8.53 (2.87)	3.25 (1.75)	3.74 (1.87)	4.69 (2.16)	3.45 (1.82)	7.10 (2.60)	7.29 (2.64)
S <sub>5</sub>	7.53 (2.67)	10.07 (3.10)	10.48 (3.16)	4.64 (2.08)	5.83 (2.38)	6.36 (2.53)	4.14 (1.99)	8.15 (2.80)	8.96 (2.95)
S <sub>6</sub>	7.94 (2.64)	9.30 (2.97)	9.77 (3.07)	3.77 (1.88)	4.37 (2.05)	5.52 (2.34)	3.63 (1.85)	7.22 (2.63)	8.51 (2.86)
SEm	0.018	0.018	0.020	0.012	0.023	0.032	0.021	0.035	0.026
CD (P=0.05)	0.052	0.051	0.057	0.034	0.064	0.091	0.061	0.098	0.072
Interaction	Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig

Transformed values in paranthesis  
NS : Not significant

Cont...

M <sub>1</sub> S <sub>1</sub>	7.18 (2.63)	8.37 (2.83)	8.87 (2.93)	2.60 (1.56)	3.00 (1.70)	3.83 (1.92)	2.63 (1.60)	4.83 (2.13)	5.76 (2.36)
M <sub>1</sub> S <sub>2</sub>	7.25 (2.66)	8.50 (2.88)	9.10 (2.96)	2.7 (1.60)	3.60 (1.83)	4.52 (2.12)	2.80 (1.65)	5.25 (2.23)	6.19 (2.43)
M <sub>1</sub> S <sub>3</sub>	8.76 (2.93)	10.53 (3.20)	10.87 (3.23)	4.20 (2.00)	4.90 (2.16)	5.49 (2.34)	3.63 (1.88)	7.76 (2.70)	8.60 (2.90)
M <sub>1</sub> S <sub>4</sub>	7.72 (2.73)	8.80 (2.93)	9.20 (3.0)	3.5 (1.83)	3.60 (1.86)	4.45 (2.15)	3.38 (1.80)	8.13 (2.80)	7.09 (2.60)
M <sub>1</sub> S <sub>5</sub>	8.90 (2.96)	10.90 (3.26)	11.40 (3.30)	4.95 (2.16)	5.90 (2.40)	6.55 (2.55)	3.90 (1.95)	8.13 (2.80)	8.80 (2.93)
M <sub>1</sub> S <sub>6</sub>	8.65 (2.90)	10.13 (3.13)	10.60 (3.20)	3.90 (1.90)	4.40 (2.10)	5.70 (2.38)	3.60 (1.81)	7.20 (2.63)	8.40 (2.83)
M <sub>2</sub> S <sub>1</sub>	7.29 (2.66)	8.59 (2.83)	8.81 (2.93)	2.77 (1.60)	3.66 (1.86)	4.41 (2.1)	3.26 (1.84)	4.98 (2.16)	7.13 (2.63)
M <sub>2</sub> S <sub>2</sub>	7.38 (2.66)	8.71 (2.90)	9.00 (2.96)	2.89 (1.63)	3.83 (1.93)	5.15 (2.26)	3.63 (1.88)	6.90 (2.60)	7.74 (2.73)
M <sub>2</sub> S <sub>3</sub>	8.90 (2.90)	10.90 (3.26)	11.20 (3.30)	4.40 (2.03)	5.24 (2.23)	6.22 (2.49)	4.07 (1.96)	8.16 (2.80)	9.05 (2.96)
M <sub>2</sub> S <sub>4</sub>	7.85 (2.76)	8.95 (2.93)	9.38 (3.00)	3.62 (1.83)	4.27 (2.00)	5.00 (2.26)	3.86 (1.95)	7.83 (2.73)	7.79 (2.70)
M <sub>2</sub> S <sub>5</sub>	9.20 (3.00)	11.40 (3.26)	11.73 (3.40)	5.52 (2.30)	6.22 (2.46)	7.14 (2.67)	4.32 (2.03)	8.68 (2.90)	9.49 (3.03)
M <sub>2</sub> S <sub>6</sub>	8.76 (2.93)	10.37 (3.16)	10.90 (3.30)	4.10 (2.00)	4.50 (2.06)	5.91 (2.48)	3.89 (1.92)	8.00 (2.80)	8.95 (2.93)
M <sub>3</sub> S <sub>1</sub>	2.46 (1.53)	4.93 (2.16)	5.20 (2.23)	2.52 (1.53)	2.9 (1.70)	3.44 (1.85)	2.81 (1.32)	3.92 (1.93)	5.44 (2.30)
M <sub>3</sub> S <sub>2</sub>	2.92 (1.66)	5.25 (2.23)	5.45 (2.30)	2.55 (1.53)	3.25 (1.80)	3.97 (1.99)	3.10 (1.40)	4.41 (2.06)	5.95 (2.36)
M <sub>3</sub> S <sub>3</sub>	4.38 (2.00)	7.30 (2.66)	7.50 (2.70)	3.03 (1.70)	3.49 (1.80)	5.08 (2.25)	3.25 (1.79)	6.30 (2.46)	8.00 (2.80)
M <sub>3</sub> S <sub>4</sub>	3.1 (1.73)	6.60 (2.50)	7.00 (2.63)	2.65 (1.60)	3.35 (1.76)	4.62 (2.14)	3.70 (1.68)	5.34 (2.29)	7.01 (2.63)
M <sub>3</sub> S <sub>5</sub>	4.48 (2.06)	7.90 (2.76)	8.30 (2.80)	3.45 (1.80)	5.38 (2.30)	5.88 (2.42)	4.20 (22.00)	7.63 (2.70)	8.60 (2.90)
M <sub>3</sub> S <sub>6</sub>	4.61 (2.10)	7.40 (2.63)	7.80 (2.73)	3.31 (1.76)	4.20 (2.00)	4.95 (2.22)	3.90 (1.80)	6.47 (2.46)	8.20 (2.83)
SE <sub>m</sub>									
S at M	0.032	0.031	0.035	0.021	0.03	0.045	0.037	0.061	0.045
M at S	0.026	0.017	0.046	0.032	0.06	0.072	0.062	0.102	0.083
CD									
S at M	0.090	0.088	0.099	0.059	0.111	0.18	0.105	0.169	0.125
M at S	0.074	0.048	0.132	0.094	0.174	0.19	0.179	0.297	0.240

Significant at 5% level

MXS INTEJ

M <sub>1</sub> S <sub>1</sub>	7.18 (2.63)	8.37 (2.83)	8.87 (2.93)	2.60 (1.56)	3.00 (1.70)	3.83 (1.92)	2.63 (1.60)	4.83 (2.13)	5.76 (2.36)
M <sub>1</sub> S <sub>2</sub>	7.25 (2.66)	8.50 (2.83)	9.10 (2.96)	2.7 (1.60)	3.60 (1.83)	4.52 (2.12)	2.80 (1.65)	5.25 (2.23)	6.19 (2.43)
M <sub>1</sub> S <sub>3</sub>	8.76 (2.93)	10.53 (3.20)	10.87 (3.23)	4.20 (2.00)	4.90 (2.16)	5.49 (2.34)	3.63 (1.88)	7.76 (2.70)	8.60 (2.90)
M <sub>1</sub> S <sub>4</sub>	7.72 (2.73)	8.80 (2.93)	9.20 (3.0)	3.5 (1.83)	3.60 (1.86)	4.45 (2.15)	3.38 (1.80)	8.13 (2.80)	7.09 (2.60)
M <sub>1</sub> S <sub>5</sub>	8.90 (2.96)	10.90 (3.26)	11.40 (3.30)	4.95 (2.16)	5.90 (2.40)	6.55 (2.55)	3.90 (1.95)	8.13 (2.80)	8.80 (2.93)
M <sub>1</sub> S <sub>6</sub>	8.65 (2.90)	10.13 (3.13)	10.60 (3.20)	3.90 (1.90)	4.40 (2.10)	5.70 (2.38)	3.60 (1.81)	7.20 (2.63)	8.40 (2.83)
M <sub>2</sub> S <sub>1</sub>	7.29 (2.66)	8.59 (2.83)	8.81 (2.93)	2.77 (1.60)	3.66 (1.86)	4.41 (2.1)	3.26 (1.84)	4.98 (2.16)	7.13 (2.63)
M <sub>2</sub> S <sub>2</sub>	7.38 (2.66)	8.71 (2.90)	9.00 (2.96)	2.89 (1.63)	3.83 (1.93)	5.15 (2.26)	3.63 (1.88)	6.90 (2.60)	7.74 (2.73)
M <sub>2</sub> S <sub>3</sub>	8.90 (2.90)	10.90 (3.26)	11.20 (3.30)	4.40 (2.03)	5.24 (2.23)	6.22 (2.49)	4.07 (1.96)	8.16 (2.80)	9.05 (2.96)
M <sub>2</sub> S <sub>4</sub>	7.85 (2.76)	8.95 (2.93)	9.38 (3.00)	3.62 (1.83)	4.27 (2.00)	5.00 (2.26)	3.86 (1.95)	7.83 (2.73)	7.79 (2.70)
M <sub>2</sub> S <sub>5</sub>	9.20 (3.00)	11.40 (3.26)	11.73 (3.40)	5.52 (2.30)	6.22 (2.46)	7.14 (2.67)	4.32 (2.03)	8.68 (2.90)	9.49 (3.03)
M <sub>2</sub> S <sub>6</sub>	8.76 (2.93)	10.37 (3.16)	10.90 (3.30)	4.10 (2.00)	4.50 (2.06)	5.91 (2.48)	3.89 (1.92)	8.00 (2.80)	8.95 (2.93)
M <sub>3</sub> S <sub>1</sub>	2.46 (1.53)	4.93 (2.16)	5.20 (2.23)	2.52 (1.53)	2.9 (1.70)	3.44 (1.85)	2.81 (1.32)	3.92 (1.93)	5.44 (2.30)
M <sub>3</sub> S <sub>2</sub>	2.92 (1.66)	5.25 (2.23)	5.45 (2.30)	2.55 (1.53)	3.25 (1.80)	3.97 (1.99)	3.10 (1.40)	4.41 (2.06)	5.95 (2.36)
M <sub>3</sub> S <sub>3</sub>	4.38 (2.00)	7.30 (2.66)	7.50 (2.70)	3.03 (1.70)	3.49 (1.80)	5.08 (2.25)	3.25 (1.79)	6.30 (2.46)	8.00 (2.80)
M <sub>3</sub> S <sub>4</sub>	3.19 (1.73)	6.60 (2.50)	7.00 (2.63)	2.65 (1.60)	3.35 (1.76)	4.62 (2.14)	3.70 (1.68)	5.34 (2.29)	7.01 (2.63)
M <sub>3</sub> S <sub>5</sub>	4.48 (2.06)	7.90 (2.76)	8.30 (2.80)	3.45 (1.80)	5.38 (2.30)	5.88 (2.42)	4.20 (22.00)	7.63 (2.70)	8.60 (2.90)
M <sub>3</sub> S <sub>6</sub>	4.61 (2.10)	7.40 (2.63)	7.80 (2.73)	3.31 (1.76)	4.20 (2.00)	4.95 (2.22)	3.90 (1.80)	6.47 (2.46)	8.20 (2.83)
SEm									
S at M	0.032	0.031	0.035	0.021	0.03	0.045	0.037	0.061	0.045
M at S	0.026	0.017	0.046	0.032	0.06	0.072	0.062	0.102	0.083
CD									
S at M	0.090	0.088	0.099	0.059	0.111	0.18	0.105	0.169	0.125
M at S	0.074	0.048	0.132	0.094	0.174	0.19	0.179	0.297	0.240

Significant at 5% level

Interaction at 0-15, 15-30 cm and 30-60 cm depths was significant. There was significant difference among the sub plot treatments in M<sub>1</sub>. The least moisture percentage was recorded in S<sub>1</sub> and highest in S<sub>5</sub>. Similar trend was observed under M<sub>2</sub>, But in M<sub>3</sub> the highest was with S<sub>5</sub> and least in control. At 15-30 cm and at 30-60 cm S<sub>5</sub> was on a par with S<sub>6</sub> which recorded highest soil moisture and least was with control. At the same level of sub plot treatments, the least moisture percentage was observed in M<sub>3</sub> under all sub plot treatments. Similarly the highest moisture percentage was recorded in M<sub>2</sub> which was on par with M<sub>1</sub>.

At 60 DAS all the main plot, sub plot treatments and interaction effects were significant. Among the main plot treatments M<sub>2</sub> recorded highest soil moisture in all the depths and the least was with M<sub>3</sub>.

Among the sub plot treatments, the least moisture content was recorded in control and the highest with S<sub>5</sub> followed by S<sub>3</sub>, S<sub>6</sub>, S<sub>4</sub> and S<sub>2</sub>. There was an increase in moisture content in S<sub>5</sub> over control. At 0-15 cm there was an increased moisture in S<sub>5</sub> (4.64%) over control (2.63%).

At the same level of main plot treatments there was significant difference among the amelioration treatments in M<sub>1</sub>. The highest moisture percentage was with S<sub>5</sub> followed by S<sub>3</sub>, S<sub>6</sub>, S<sub>4</sub> and S<sub>2</sub> and the least was under S<sub>1</sub>. Similar trend was observed under M<sub>2</sub>. But in M<sub>3</sub> (Moisture stress) mulch + kaoline (S<sub>5</sub>) was highest followed by S<sub>6</sub> (mulch + kaolin + urea spray), S<sub>3</sub>, S<sub>4</sub> and S<sub>2</sub> respectively.

At the same level of sub plot treatments, the least moisture percentage was recorded in  $M_3$  under all sub plot treatments. Similarly the highest moisture percentage was recorded in  $M_2$  under all sub plot treatments and  $M_1$  was in between.

Main plot, sub plot treatments and interaction effect at 0-15 and 15-30 and 30-60 cm depth was significant at 85 DAS. Among the main plot treatments  $M_2$  recorded highest soil moisture percentage in all the three depths and the least was with  $M_3$ . Among Sub plot treatments soil moisture percentage was highest in  $S_5$  and the least was recorded under control. There was increased moisture at 0-15 cm depth in  $S_5$  over control.

There was significant difference among the sub plot treatments in  $M_1$ . The least moisture percentage was in control and highest  $S_5$  followed by  $S_3$ ,  $S_6$ , and  $S_4$ . Similar trend was observed in  $M_2$ , but in  $M_3$  least moisture percentage in control was on a par with water spray.

At the same level of sub plots the least moisture percentage was recorded in  $M_3$ . Under all treatments. Similarly the highest moisture was recorded in  $M_2$  under all sub plot treatments.

#### **4.7 RAINFALL USE EFFICIENCY (Table : 16)**

Rainfall use efficiency was highest ( $7.01 \text{ kg mm}^{-1}$ ) in  $M_3$  (Stressed) whereas it was least ( $3.44$ ) under  $M_1$  (Rainfed). RUE ( $5.07 \text{ kg mm}^{-1}$ ) was highest in mulch + kaoline and it was least ( $4.17 \text{ kg mm}^{-1}$ ) in control. Taking a overall view the RUE was least ( $3.16 \text{ kg mm}^{-1}$ ) in  $M_1S_1$  and highest ( $7.87$ ) in  $M_3 S_5$ .

Table - 16

**RAINFALL USE EFFICIENCY AS INFLUENCED BY TREATMENTS**

Treatment	M <sub>1</sub>	M <sub>2</sub>	M <sub>3</sub>	Mean
S <sub>1</sub>	3.16	3.31	6.05	4.17
S <sub>2</sub>	3.35	3.55	6.39	4.43
S <sub>3</sub>	3.58	3.73	7.37	4.89
S <sub>4</sub>	3.36	3.62	6.97	4.65
S <sub>5</sub>	3.62	3.74	7.87	5.07
S <sub>6</sub>	3.57	3.64	7.44	4.88
Mean	3.44	3.59	7.01	

\* Data not analysed statistically.

## 4.8 ECONOMICS

The economics of the additional pod and haulm yield, the additional returns and net returns are presented in Table : 17.

The results has indicated highest additional yield and additional returns in mulch + kaoline followed by mulching. There was negative returns due to mulch + kaoline + urea spray. However the net returns was positive in all the treatments and highest in mulching treatment.

Table - 17

## ECONOMICS

Treatment	Yield (Kg ha <sup>-1</sup> )		Additional yield (Kg ha <sup>-1</sup> )	Additional returns (Rs ha <sup>-1</sup> )	Additional cost of cultivation (Rs ha <sup>-1</sup> )	Net returns (Rs ha <sup>-1</sup> )
	Pod	Haulm				
Control	1799	3605	-	-	-	-
Water spray	1914	3724	115	1469	210	1259
Mulch	2071	3901	272	3486	1260	2226
Kaoline	1975	3788	176	2249	2010	239
Mulch + Kaoline	2118	3960	319	4094	3270	824
Mulch + Kaoline + Urea spray	2056	3836	257	3257	3375	-117

Cost of Pods Rs. 10.00 per kg.

Cost of Haulm Rs. 1.00 per kg.

## CHAPTER - V DISCUSSION

Groundnut is the most important crop in drylands of Rayalaseema region of Andhra Pradesh. This crop is the main stay for the income of the farmers and the economy of this region also is largely dependent on the performance of this crop. More than 70 per cent of rainfed groundnut is grown in red sandy loam soils which even though afford a favourable physical environment for growth and soil development, limits the capacity to hold moisture adequate enough not to have stress effects on the crop. The problem is most complicated due to the uneven and erratic rainfall and long dry spells of a times dryspells ranging from 30-45 days usually coinciding with peg, pod and kernel development stages. (Ramesh Babu *et al.*, 1984; Vanangamudi *et al.*, 1987; Naveen *et al.*, 1992 and Gurara and yadav 1993). In many years, the consequences are disastrous since the farmer loses very heavily even on the investment made for the crop. There is every need to investigate ways and means to mitigate the moisture stress effects so that sustainable yields are obtained on drylands.

Several investigations have been made for conservation of soil moisture and reducing the losses from the plant. The process of evapotranspiration is a necessary evil, but excessive loss of water is harmful to the crop growth and yield. These two key components soil and plant water loss play a vital role especially during dryspells as indicated by Vign (1966), Patil and De (1978) Gupta (1984) and Sharma *et al.* (1990) and therefore ways and means to check

## CHAPTER - V

### DISCUSSION

Groundnut is the most important crop in drylands of Rayalaseema region of Andhra Pradesh. This crop is the main stay for the income of the farmers and the economy of this region also is largely dependent on the performance of this crop. More than 70 per cent of rainfed groundnut is grown in red sandy loam soils which eventhough afford a favourable physical environment for growth and pod development, limits the capacity to hold moisture adequate enough not to have stress effects on the crop. The problem is most complicated due to the uneven and erratic distribution of the rainfall and many a times dryspells ranging from 30-45 days usually coinciding with peg, pod and kernel development stages. (Ramesh Babu *et al.*, 1984; Vanangamudi *et al.*, 1987; Naveen *et al.*, 1992 and Garara and yadav 1992). In many years, the consequences are disastrous since the farmer looses very heavily even on the investment made for the crop. There is every need to investigate ways and means to mitigate the moisture stress effects so that sustainable yields are obtained on drylands.

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these losses should naturally result in saving of moisture and consequent increase in yield.

In the present investigation, the experiment has been designed to study the pod yield of groundnut under no stress (irrigated), natural rainfed conditions and under imposed stress conditions (30-75 DAS) in typical Alfisols representing this region, using a drought tolerant variety of TPT-1. It was aimed to know the yield potential that could be achieved under different management treatments.

## 5.1 WEATHER

The weather conditions during the crop period as compared to decennian average showed an increase of 45.9% rainfall. Similarly there was an increase of 2.6 rainy days and 2.79% increase in mean relative humidity. However, the mean weekly evaporation and the mean weekly sunshine hours were considerably reduced. There was not much appreciable difference in the mean maximum and minimum temperature.

The seasonal conditions of kharif 1995' were good due to better distribution of rainfall, eventhough two irrigations were warranted under no stress treatments. But in the stressed treatment the rainout shelters could create the necessary stress effects. The sub plot treatments consisted of drought ameliorants like mulching with groundnut shell, reflectants like kaoline, nutrition reinforcement with urea spray and their combinations. These treatments produced necessary effect as is evident from the results on growth,

7

yield and moisture characters determined during the course of investigation which is discussed more clearly in the following paragraphs.

## 5.2 GROWTH CHARACTERS

The important growth characters those measured were plant height at harvest, LAI and drymatter production at 30, 45, 60, 75 and 90 DAS and additionally for drymatter at harvest.

The leaf area index and drymatter production was not significant at 30 days after sampling because of the fact that stress treatment was imposed after that stage and further there was well distributed rainfall during the crop period. The effects manifested clearly from 45 days onwards and continued throughout upto harvest. The leaf area index was higher in the irrigated treatment at all the stages and least under the stressed treatment. The effect of moisture stress was primarily felt on leaf expansion and growth which were the photosynthetic apparatus inturn influencing the drymatter accumulation. This was clearly seen from the result that no stress treatment was very much benefited and the difference between rainfed treatment and irrigated was not very much conspicuous because of the well distributed rainfall. The effects of moisture stress was once again manifested as noticed with the shorter plants at harvest and taller plants in no stressed treatment. The adverse effects of moisture stress on plant height, LAI and drymatter production observed in this experiment finds adequate supports from the results of several workers (Ramesh Babu *et al* (1984); Ravindra *et al* (1990); Samsukumar (1991); Nautiyal *et al* (1991); Ramana Rao (1994).

In this experiment, the drought ameliorants used in the sub plot treatments were of two types one of which was a groundnut shell, used as mulch to check evaporation from the soil and the other one was kaoline, a reflectant material, urea spray a stress mitigant and their combinations. These were compared with check where no treatment was applied and the other check was only waterspray.

The results were significant for LAI and drymatter production only from 45th day after sowing and the effects persisting upto harvest. with all the moisture management treatments at all the days of sampling as also the drought ameliorants expressing clearly and significantly. The least LAI and drymatter production was recorded under  $S_1$  (check) whereas the highest of the same parameters was obtained with mulch + kaoline. There was however increase in the above parameters with mulch alone, kaoline alone (or) due to the combination of kaoline + mulch + urea. In the case of drymatter production, mulch treatment ( $M_3$ ) was immediately following  $S_5$  in irrigated and rainfed conditions, whereas it was  $S_6$  following  $S_5$  in moisture stress condition. The favourable effect of prevention of evaporation by the use of mulch and suppressing the excessive transpiration by kaoline was well perceived individually and also additively. Eventhough, a slight stress was said to be advantageous in the early stages of the crop, preponderous evidence was available to show that during the sensitive stages of crop (30 to 75 DAS) absence of stress was helpful in realising the yield potential which is well documented (Shinde and pawar 1984; Reddy 1988; Jana *et al.*, 1989; Ramana Rao 1994).

The ameliorant effects are more impressive under stressed treatment as required under typical dryfarming environment where groundnut is grown in vast areas. The favourable effect of this ameliorants on the growth characters of crop even during stress periods as obtained in this experiment has also been reported by several researchers, (Agarwal *et al.*, 1976; Haranatan 1980; Khan and Morey 1980; Sharma and Chalkar 1989; Trivedi *et al.*, 1994).

The increased LAI in S<sub>6</sub> was due to additional urea spray (which is a method of foliar feeding) manifested in adequate nitrogen supply at the moisture stress phases of the crop resulting in better leaf expansion and hence increased LAI.

### 5.3 YIELD ATTRIBUTES

Groundnut is a leguminous plant in which the pods develop below the ground. This is a self pollinating crop and the gynophores (pegs) enter into the soil after the flowers are fertilized. These develop into pegs, hence, the pod yield of groundnut is dependent on the number of flowers produced, number of pegs formed and their entering into soil developing into pod. It is reported that moisture stress during these stages are sensitive. This observation was reiterated from the results of the experiment (Orcutt *et al.*, 1992; Reddy 1988; Patel and Golakiya 1988; Garara and Yadav 1992; and Ramana Rao 1994) in which the pegs, total pods, filed pods, 100 pod weight, shelling percentage, pod yield, haulm yield and harvest index were significantly increased in the no stressed treatment. All these parameters were significantly reduced due to moisture stress treatments as observed in M<sub>3</sub>. The absence of expression of the main plot

treatments on the number of flowers finds support from the results reported by Gowda and Hegde (1986) and Janamitti *et al* (1986) who have stated that stress in the earlier stages will not produce much influence on number of flowers. But the effect of this treatments was distinct on other parameters. The least in all these was in stressed treatment. There are number of reports to the effect that moisture stress during sensitive stages adversely effect these yield attributing characters (Ike 1986; Pathak *et al.*, 1988; Selvam *et al.*, 1989; Reddy 1991; Ramana Rao 1994).

The sub plot treatments expressed significantly on all the yield attributing characters. There was significant increase in these characters in all the treatments over check. but S<sub>5</sub>(Mulch + Kaoline) was superior to rest of the treatments for all the characters except for total, filled pods, peg to pod percentage and 100-pod weight where even mulch alone (S<sub>3</sub>) was on a par with S<sub>5</sub>. These results were a repeat performance of the growth charcaters, in that the additive effects of mulch + kaoline was more expressive because of the fact that moisture losses both from soil and plant were effectively curbed resulting in a favourable environment for more pegs and pods to develop and also increase the pod weight. Similarly, it had more favourable effect on shelling outturn. The interaction was significant for peg number, pod weight and shelling percentage. This is conceivable because a favourable soil moisture environment even under stress due to ameliorants keeps the pegs of better turgor enabling the pegs to penetrate soil and develop into pods easily. This phenomena was more clearly seen under M<sub>3</sub> (stressed) where more pegs were developed due to the favourable

soil moisture due to ameliorants. These findings were in conformity with the results reported by ICRISAT 1982 and 1983.

The increased pod weight due to better soil moisture was understandable because calcium and sulphur nutrition was more favourable under such an environment. Such favourable reports of better filling due to calcium and sulphur were available from Stern, 1968; Soundara Rajan, *et al.*, 1982 and Sridhar, *et al.*, 1985.

The better filling of pods naturally resulted in higher shelling outturn. The favourable effects of higher moisture content on increased shelling percentage was reported by Pallas *et al.*, 1977; Reddi 1978 and Ramana Rao *et al* (1994).

#### **5.4 POD, HAULM YIELD AND HARVEST INDEX**

The economic yield in groundnut is the pod yield which is the product of genetic and environmental interaction. Among the environmental factors, soil moisture is very important and a favourable soil environment improves the pod yield significantly compared to stressed plots. This was evident from the highest yield (22.35 Qha<sup>-1</sup>) obtained from irrigated condition which was closely followed by the yield (21.37 Qha<sup>-1</sup>) under rainfed conditions where the distribution of rainfall was very favourable. However the moisture stress effects reduced the pod yield by 28.68 per cent compared to irrigated treatments. The serious effect of moisture stress on reducing the pod yield was due to the cumulative effects of the stress on growth and yield attributes as already discussed. The reduction in

pod yield due to moisture stress is amply provided by the findings of several workers (Reddy *et al.*, 1980; Venkaiah *et al.*, 1983; Ravindra *et al.*, 1990; Garara and Yadav 1992; Patel 1993; and Golakiya 1993).

In the background of stress, the drought mitigating effects produced by the ameliorants has been clearly brought out from the results obtained from this study. The least yield was observed under no treatment and the highest under kaoline + mulch (S<sub>5</sub>) however, mulch alone, mulch + kaoline + urea had pod yield on a par with S<sub>5</sub>. The yield in kaoline treated plot was significantly superior to no treatment and water spray. These results have clearly shown that individual effects of mulching and kaoline application significantly mitigated the stress effects and their combined effects were superior to individual effects on pod yield. The favourable effect of these treatments on mitigating the stress effects and increasing the yield losses by 9.8%, 15% and 18% due to kaoline, mulching and mulch + kaoline respectively is of practical value in dryfarming areas.

The haulm yield has followed the trend as obtained for pod yield. The favourable effect of improved moisture relations on increasing the haulm yield has been reported by several researchers (Ramesh Babu *et al.*, 1984; Dasai *et al.*, 1985; Patel and Golakiya 1988; Trivedi *et al.*, 1994). Since harvest index is a derived parameter from pod and haulm yield, the beneficial effect of improved moisture both on pod and haulm yield expressed a direct bearing on the harvest index. This observation finds support from Ramesh Babu *et al* (1984).

## 5.5 MOISTURE INDICES

The effect of the treatments found clear expression on both soil and plant moisture indices. There was improved soil moisture content sampled from 0-15, 15-30, 30-60 cms at 45, 60 and 85 DAS. There was higher soil and plant (RWC) moisture content in the irrigated treatment and least was in moisture stress treatment. The drought ameliorant treatments also found clear expression on these characters. The soil moisture content and RWC was least in stressed treatment and highest in mulch + kaoline. These observations reveal that mulching and application of reflectant material like kaoline have effectively checked both soil and plant moisture losses. The effect of mulching in improving the soil moisture especially in stressed plots have been reported by several workers (Gupta 1980; Haranath 1980; Khan 1984; Naveen *et al.*, 1992; Yellamanda Reddy 1994). Similarly the favourable effect of kaoline in improving RWC finds support from the results reported by earlier workers (Agarwal and De 1976; Patel and De 1978; Bhapkar 1984; Amaregouda 1994).

Another parameter measured was leaf temperature during the stress period. Highest temperature was recorded in stressed treatment ( $M_3$ ) whereas least was in irrigated ( $M_2$ ). The temperature recorded under no treatment was highest with 34.50 degrees and least in  $S_6$  (29.83) and  $S_5$  (30.20). The lower temperature in  $S_5$  and  $S_6$  can be clearly explained due to the improved soil and plant moisture by the effect of ameliorants. A reduction in leaf temperature due to the improved moisture was reported by Agarwal and De, 1976; Patil and De 1978 and Samsukumar (1991).

The foregone discussion critically brings out the fact that stressed groundnut crop suffers a serious yield reduction and application of both soil and plant stress mitigants ameliorated the unfavourable effects and the yield losses were reduced considerably. These findings were of great significance to the dryland groundnut crop in Alfisols which suffer from moisture stress repeatedly. These techniques can prevent the disastrous loss in pod yield and help in sustaining the groundnut pod yield at a reasonable level in drylands.

SUMMARY

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## CHAPTER - VI

### SUMMARY

Groundnut (*Arachis hypogaea* L.) is the principal oilseed crop of Andhra Pradesh in general and Rayalaseema region in particular. Its productivity under rainfed conditions is low mainly due to low and erratic rainfall pattern with prolonged dryspells. Soil moisture gradually evaporates during dry periods and transpiration losses are heavy subjecting the standing groundnut crop to moisture stress. Such situations may compel the farmers to obtain very low yields in dryland areas. Hence, moisture conservation to minimise the adverse effects of prolonged droughts during the crop period can improve the productivity of groundnut. Several methods such as mulching, antitranspirants, urea spray etc., with varying degrees of success, have been advocated for moisture conservation. However its effectiveness in the sandy loam soils of Southern Agrolimatic Zone has to be conclusively established. Hence, it was felt necessary to test different agrotechniques for amelioration of drought in groundnut under rainfed situations.

In this experiment, three different situations of rainfed, irrigated and moisture stress treatments in main plots with water spray mulch, kaoline, urea spray and their combinations with no treatment as check were tested on TPT-1 groundnut in sub plots in split-plot design replicated thrice. The experiment was conducted at Tirupathi campus of Andhra Pradesh Agricultural University during kharif 1995.

The treatments were imposed from 30 days after sowing by rainout shelters in the main plot. Mulching was done at 30 DAS, Kaoline and urea spray were given on 45th and 60th day after sowing. Two irrigations were given during stress period in  $M_2$ . The effect of amelioration treatments on growth, yield attributes, yield, leaf temperature, relative water content, soil moisture, rainfall use efficiency and economics is briefly summarised.

Plant population was well maintained, thus no significant differences were observed due to treatments. All the growth characters were higher in irrigated treatment ( $M_2$ ) compared to moisture stressed ( $M_3$ ) only. Plant height was more in irrigated treatment and least in stressed one ( $M_3$ ). Among the sub plots  $S_5$ ,  $S_3$  and  $S_6$  recorded taller plants. Leaf area index and drymatter accumulation was higher in irrigated treatment at all the days of sampling. LAI was highest in  $S_5$  which was on a par with  $S_3$  and  $S_6$ . Interaction was significant only at 60 DAS. LAI was higher in  $M_2S_5$ . No significant differences in drymatter were observed due to main plot, sub plot treatments and interaction at 30 DAS. Besides the main and sub plot the interaction was significant at 60, 75 and 90 DAS but not at 30, 45 DAS and at harvest. Mulch along with Kaoline produced highest drymatter production at 45 and 75th day after sowing which was at par with mulch alone and mulch + kaoline + urea spray. At 60, 90 DAS and at harvest highest drymatter was in  $S_5$  followed by  $S_3$  and  $S_6$ . Among the interaction treatment dry matter was highest in  $M_2S_5$ .

Number of flowers per plant was significantly influenced by only sub plot treatments. However, main plot, sub plot treatments and interaction was significant for number of pegs per plant and for peg to pod percentage. Mulch+Kaoline had higher number of flowers and pegs compared to all other treatments. Peg to pod percentage was also higher in the same treatment which

was on par with mulch alone. Higher number of pegs and peg to pod percentage was in  $M_2S_5$ .

Total pods (19.51) and filled pods (17.88) per plant were significantly higher in irrigated treatment which were on par with rainfed treatment whereas least number of total pods (16.33) and filled pods (14.38) was with moisture stress treatment. Mulch + Kaoline had more number of total (21.33) and filled pods (20.20) which was on a par with mulch alone and least was recorded with control where no amelioration was given. Unfilled pods were significantly influenced by sub plot treatments only, highest with control and water spray. All the other treatments recorded significantly least over check. 100-pod weight and shelling outturn was significantly influenced by main, sub plot treatments and due to interaction. Highest was with irrigated and least with moisture stress treatment. Mulch + kaoline recorded highest 100-pod weight and shelling percentage but was on a par with  $S_3$  and  $S_6$  in the case of 100-pod weight. In moisture stress treatment, even with water spray and kaoline, there was significant increase in these two characters over control.

Pod yield, haulm yield and harvest index were significantly influenced by main plot and sub plot treatments but not with interaction. Pod yield was significantly high in irrigated condition and reduced significantly due to moisture stress treatment. Highest pod yield was recorded in  $S_5$  which was on a par with  $S_3$  and  $S_6$ . Haulm yield also followed similar trend. Significantly least pod and haulm yields were with control.

Leaf temperature and relative water content exerted significant differences due to main, sub treatments and interaction. Least temperature was recorded in irrigated treatment which was on a par with rainfed and highest with stressed treatment. Contrary to the above, highest RWC was with  $M_2$  and significant

reduction in RWC was observed under moisture stress. Mulch + Kaoline recorded lower leaf temperature and higher RWC values whereas lower RWC value and higher leaf temperature were with control.

Rainfall use efficiency was ( $7.01 \text{ Kg mm}^{-1}$ ) highest in  $M_3$  (stressed) whereas it was least ( $3.44$ ) under  $M_1$  (Rainfed). RUE ( $5.07 \text{ kg mm}^{-1}$ ) was highest in mulch + kaoline and it was least ( $4.17 \text{ kg mm}^{-1}$ ) in control. Taking a overall view the RUE was least ( $3.16 \text{ kg mm}^{-1}$ ) in  $M_1 S_1$  and highest ( $7.87$ ) in  $M_3 S_5$ .

Economic evaluation of drought amelioration agrotechniques indicated the profitability of all amelioration techniques which gave a positive net returns and the only treatment in which the negative returns obtained was mulch + kaoline + urea. Mulch + kaoline eventhough resulted in highest additional returns, the net return was reduced due to high cost of kaolin and mulch material. If these could be made available at cheaper rates the net returns will be more impressive.

The results of the experiment on "Studies on Agrotechniques for amelioration of drought in rainfed groundnut" indicated that 28.68 per cent yield was reduced due to stress from 30-75 DAS. Water spray is beneficial during dry spell, but the benefits due to mulching is more impressive. The profitability of groundnut production ( $319 \text{ Kg ha}^{-1}$  of additional yield and  $4094 \text{ Rs. ha}^{-1}$  additional returns) due to mulch + kaoline during dry spells was evident from this study. The farmers can adopt these agrotechniques for increasing the productivity of rainfed groundnut especially during stress period on Alfisols and to stabilise the yields.

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\* Originals not seen.

## APPENDIX - I

### ENCLOSURE OPERATIONS DURING THE CROP PERIOD

Operation	Date
	25-6-95
	1-7-95
	3-7-95
	6-7-95

# ***APPENDICES***

	19-8-95
	22-8-95
	3-9-95
	9-9-95
	29-9-95
	17-10-95
3 Stripping of post	18-10-95 to 24-10-95

## APPENDIX - I

### CALENDER OF OPERATIONS DURING THE CROP PERIOD

Operation	Date
Ploughing	25-6-95
Ploughing and levelling	1-7-95
Lay-out of the experiment	3-7-95
Sowing and Fertilizer application	6-7-95
Spraying of Fungicide	25-7-95
Weeding	25-7-95
Weeding	6-8-95
Imposing the treatments (Mulching)	6-8-95
Spraying of kaoline, urea and water spray	19-8-95
Spraying of insecticide	22-8-95
Spraying of kaoline, urea and water spray	3-9-95
Irrigation	9-9-95
Irrigation	29-9-95
Harvesting and Stripping of pods	17-10-95
Drying of pods	18-10-95 to 24-10-95

## APPENDIX - II

### AMOUNT OF RAINFALL (mm) AND EVAPORATION (mm) DURING THE CROP GROWTH PERIOD

Date	Rainfall	Evaporation
6-7-95	0.5	5.3
7-7-95	-	7.0
8-7-95	-	7.3
9-7-95	-	9.2
10-7-95	0.4	7.9
11-7-95	14.6	5.1
12-7-95	23.2	3.7
13-7-95	-	5.1
14-7-95	0.5	4.8
15-7-95	53.4	3.3
16-7-95	-	3.9
17-7-95	5.4	4.0
18-7-95	-	4.0
19-7-95	1.3	0.7
20-7-95	-	3.0
21-7-95	1.8	2.4
22-7-95	-	4.3
23-7-95	-	6.0
24-7-95	3.6	3.2
25-7-95	67.5	4.1
26-7-95	1.8	3.2
27-7-95	0.2	5.8
28-7-95	-	6.4
29-7-95	-	5.0
30-7-95	4.8	6.0
31-7-95	0.4	5.2
1-8-95	-	6.0
2-8-95	-	8.2
3-8-95	-	9.0
4-8-95	-	6.5
5-8-95	-	7.4
6-8-95	-	7.2

Date	Rainfall	Evaporation
7-8-95	57.1	9.1
8-8-95	12.0	5.0
9-8-95	-	4.0
10-8-95	-	7.0
11-8-95	2.0	4.1
12-8-95	-	6.0
13-8-95	4.0	5.6
14-8-95	8.0	4.6
15-8-95	31.0	5.4
16-8-95	-	6.0
17-8-95	-	6.2
18-8-95	-	6.4
19-8-95	-	6.9
20-8-95	-	6.0
21-8-95	-	5.7
22-8-95	65.4	5.4
23-8-95	18.6	4.8
24-8-95	-	4.9
25-8-95	-	6.3
26-8-95	8.0	3.4
27-8-95	10.4	6.9
28-8-95	-	4.9
29-8-95	5.6	3.0
30-8-95	-	2.2
31-8-95	-	3.9
1-9-95	-	5.3
2-9-95	-	6.5
3-9-95	-	6.2
4-9-95	-	5.1
5-9-95	-	4.3
6-9-95	-	6.4
7-9-95	0.6	6.7
8-9-95	-	6.7
9-9-95	-	6.4
10-9-95	-	6.0
11-9-95	5.4	5.1

Date	Rainfall	Evaporation
12-9-95	67.2	3.0
13-9-95	84.8	2.6
14-9-95	-	3.8
15-9-95	-	5.2
16-9-95	2.8	7.0
17-9-95	8.2	2.2
18-9-95	-	3.3
19-9-95	-	6.0
20-9-95	-	4.9
21-9-95	3.2	3.8
22-9-95	-	5.0
23-9-95	-	3.7
24-9-95	-	5.9
25-9-95	-	5.6
26-9-95	2.6	4.1
27-9-95	-	4.6
28-9-95	-	6.0
29-9-95	-	5.8
30-9-95	-	6.7
1-10-95	4.0	2.8
2-10-95	-	5.7
3-10-95	-	6.0
4-10-95	3.0	2.7
5-10-95	-	5.0
6-10-95	0.6	1.3
7-10-95	-	2.8
8-10-95	5.5	1.9
9-10-95	5.5	2.3
10-10-95	-	1.0
11-10-95	-	3.1
12-10-95	-	3.8
13-10-95	-	3.7
14-10-95	-	4.8
15-10-95	-	4.9
16-10-95	23.2	3.2
17-10-95	-	4.0

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