

**PERFORMANCE OF GROUNDNUT (*Arachis hypogaea* L.)
VARIETIES UNDER DIFFERENT IRRIGATION
DEPTHS IN SUMMER SEASON**

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PARBHANI
FEBRUARY, 1992**

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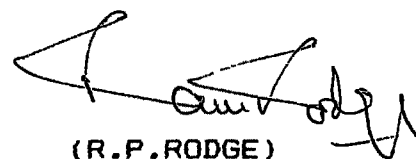
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CERTIFICATE I

This is to certify that the dissertation entitled "PERFORMANCE OF GROUNDNUT (*Arachis hypogaea* L.) VARIETIES UNDER DIFFERENT IRRIGATION DEPTHS IN SUMMER SEASON" submitted by SHAIKH MUJAHED SHAIKH ZAMIRUDDIN to The Marathwada Agricultural University, Parbhani for the award of the degree of DOCTOR OF PHILOSOPHY in Agronomy, is a record of original and bonafide research work, prosecuted by him under my supervision and guidance. The dissertation, in my opinion, is of sufficiently high standard to warrant its presentation for the award of the said degree. I also certify that the dissertation or part thereof has not been previously submitted by him for any degree, diploma or distinction to any other University/Institute. The assistance and help rendered during the course of investigation and sources of literature have been duly acknowledged.

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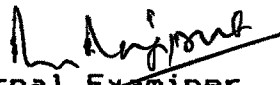
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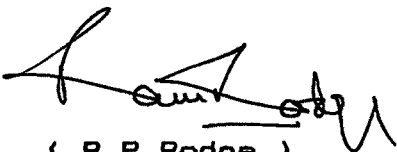

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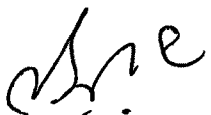

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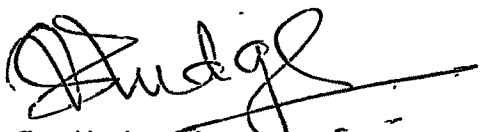

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ABBREVIATIONS

ASM	Available soil moisture
CPE	Cumulative pan evaporation
CCE	Cumulative Can evaporation
cm	Centi-metre
CU	Consumptive use
DASM	Depletion of available soil moisture
ET	Evapotranspiration
ET _o	Reference crop evapotranspiration
ET _{crop}	Crop evapotranspiration
ETR	Evapotranspiration ratio
F.C.	Field capacity
g	Gramme
ha	Hectare
IW	Irrigation water
Kc	Crop coefficient values
Kg	Kilo-gramme
m	Metre
mm	Mili-metre
NS	Non-significant
P.W.P.	Permanent wilting point
q	Quintal
Sq cm	Square centi-metre
Sq m	Square metre
t	Tonnes
WUE	Water use efficiency

INTRODUCTION

I. INTRODUCTION

Groundnut (*Arachis hypogaea* Linn.) is an important oilseed crop cultivated in India on an area of 72.40 lakh ha with a production of 59.77 lakh tonnes and accounts for 32 per cent of the world's production (Rao, 1988). However, the productivity in India is very low i.e. 759 kg/ha as compared to 3175 kg/ha of U.S.A. and world average of 1122 kg/ha. In Maharashtra groundnut is grown on an area of about 8.50 lakh ha, with average productivity of 780 kg/ha. Low productivity is mainly due to the fact that groundnut is cultivated mostly under rainfed condition (83 per cent of the total area) during monsoon season. Further, the substantial part of this area is comprised of marginal lands with the result that a certain degree of instability is inherent in the production process itself.

Groundnut is a rich source of oil (40-54%) and nutritionally very important due to presence of oleic and linoleic acids (essential fatty acids). Groundnut oil is very stable with good shelf life. Oil quality does not deteriorate even after 20 hours of deep frying. Besides being a good source of oil, it also contains 20-36% proteins and 16-24% carbohydrates. The deoiled cake is richer in protein ranging from 45-60% with no toxins. Groundnut protein

is rich in all amino acids except Lysine and Methionine which can be easily offset by blending it with sesame cake. Groundnut is a rich source of Ca, Mg and Fe besides Vitamins like B1, niacine and tocopheral (Ravindra *et al.* 1988).

Land is a limiting factor in India, because at present the area under forest is only around 15 per cent, and both needs raising their share to maintain the ecological balance. Further, it is not possible to draw land from existing food crops due to the advantages they possess. Hence, one of the ways to increase the groundnut productivity is through increasing the cropping intensity by introducing groundnut as additional crop during non-traditional seasons under irrigated conditions.

In the recent past it has been observed that with the commissioning of certain major, medium and minor irrigation projects, there is a scope for increasing the area under summer groundnut in these commands. The productivity of summer groundnut is fairly high i.e. 1483 kg/ha as compared to 888 kg/ha of monsoon crop due to assured water supply and least plant protection problems in summer. Due to this higher productivity the production of oilseeds increased from 9.37 million tonnes during 1980-81 to 13.10 million tonnes in 1986-87. This indicated that

such efforts are likely to bridge the gap between the per capita availability (12 g) against requirement (18 g), so also reduce the imports (Gopalan *et al.* 1985 and Ramanamurthy, 1984). The oilseeds production of 24 million tonnes is projected to meet the demand of 6.3 million tonnes of oil (18 g per capita) by the end of this century (NCA report-1977). This necessitates the increase in the rate of productivity of these crops.

Among the crop production factors the use of improved varieties and their optimum input requirements are the key factors. One such most important input in crop production is irrigation water. It is a scarce and expensive input and hence needs efficient use so that the available water resources can be utilized to the maximum possible advantage for crop production. Efficient water management should be an essential feature of our irrigation planning. Integrated development of water resources, efficient methods of conveyance and distribution of water on the farm, judicious methods of water application, proper soil management practices, cropping patterns for high water use efficiencies, scheduling irrigation according to development rhythm of the plant and the removal of excess water are the important aspects of comprehensive

irrigation programme. Proper irrigation scheduling has become important since available water supplies are short and costly. Higher crop yields and water use efficiencies can be obtained by proper irrigation scheduling. In irrigation scheduling timing and amount of irrigation are considered. Timing of irrigation is an important aspect since excessive crop water deficit at critical growth stages can irreversibly reduce the potential yield and quality of the crop.

Irrigation experiments conducted in India in the past were mainly based on application of fixed depth of irrigation water at fixed interval. This resulted in either over watering during the periods of low evaporative demand or under watering, during the peak crop water use period, depending upon the amount of water applied per irrigation. In either cases, a reduction in water use efficiency will result. Another approach has been to correlate the irrigation schedule with soil moisture tension or available soil moisture depletion from the root zone. Dastane and Singh (1964) suggested pan evaporation as an important criterion for scheduling irrigation to crops. Prihar *et al.* (1974) from Punjab suggested a more practical approach based on the ratio of fixed quantity of irrigation water (IW) and cumulative pan evaporation (CPE).

Earlier research conducted at Co-ordinated Project for Research on Water Management, M.A.U., Parbhani indicated that irrigation scheduling at 0.75 IW/CPE ratio with fixed quantity of 6.0 cm of irrigation water was optimum. This schedule necessitates irrigation at very short interval of 6-8 days particularly in months of April and May because of very high evaporative conditions. This schedule is therefore adaptable only under conditions where well or lift irrigations are available. In Marathwada region major irrigation source is canal system in which water is supplied at 10-12 days interval during summer. Since summer temperatures of this region are very high, such a prolonged stress period may hamper plant growth and development, particularly when lower depths of irrigation are applied. In such circumstances one of the alternatives may be to apply higher depths of water so that sufficient moisture can be stored in the soil profile which will sustain the crop till next rotation without affecting the economic yields. It is therefore, felt necessary to find out optimum depth of irrigation which may suit under these situations without much deviation in the yield.

Since area under summer groundnut has increased considerably it was felt necessary to study the potential of high yielding ICRISAT varieties

viz. ICGS-11, ICGS-21 and ICGS-44 along with traditional variety SB-XI, under different depths of irrigation in summer season. The variety ICGS-11 has been released for summer season cultivation in the states of Andhra Pradesh, Karnataka and Maharashtra where as ICGS-44 is released in Guj^arat State. Other promising variety, ICGS-21 is released for cultivation in Guj^arat and Maharashtra. Local variety SB-XI is a Spanish bunch evolved at Junagarh and released for summer cultivation in Maharashtra and is grown on vast areas since pretty long time.

An experiment entitled "Performance of groundnut (*Arachis hypogaea* L.) varieties under different irrigation depths in summer season" was conducted at the farm of Co-ordinated Project for Research on Water Management, Marathwada Agricultural University, Parbhani during summer seasons of 1989 and 1990 to study the yield potential of these varieties.

The objectives of the experiment were

1. To assess the water requirement of new groundnut varieties under summer conditions.
2. To assess the effects of irrigation depths on biometric and yield attributing characters as well as yield of groundnut varieties.

3. To compare the performance of new promising groundnut varieties (ICGS-11, ICGS-21 and ICGS-44) with standard check (SB-XI) under Marathwada conditions.
4. To study the response and water use efficiency of different groundnut genotypes in summer season.
5. To study the effect of irrigation depths on N,P and K uptake, and on protein and oil percentage in kernels of various groundnut genotypes.
6. To study the varietal response under different water regimes and irrigation frequencies as well as to find out their economic feasibility under summer conditions.

**REVIEW
OF
LITERATURE**

II. REVIEW OF LITERATURE

Work done in the past on varietal responses under irrigation and various aspects of water management of groundnut (*Arachis hypogaea* L.) is reviewed in brief in this chapter.

2.1 Effect of varieties

2.1.1 Effect of varieties on growth

Murty *et al.* (1983) observed maximum canopy at 90 days in virginia runner and at 75 days in Valencia Spanish and Verginia bunch varieties. Spanish-Valencia are sequentially branched, erect, bunch types, determinate, short season (90-110 days), having leaflets larger than Verginia types with lighter green foliage. The seeds are not dormant; pods have 2-6 seeds, kernels have a wide range of size and testa colour; they are highly susceptible to cercospora leaf spots with higher protein content and saturated fatty acids than virginia types (Rachie and Roberts, 1974).

Durugkar (1985) studied three groundnut varieties at Parbhani and reported significantly more height of UP-70-103, as compared to ICGS 11 and k.4.11. Jadhav (1987) observed more height of LG-19 over ICGS-11 and Robut-33-1. Similarly Karhale (1987) recorded significantly more height of SB-XI as compared to ICGS-11 and JL-24, at Parbhani.

Durugkar (1985) did not observe differences in branching due to different varieties. However, Karhale (1987) recorded significantly higher number of branches in variety ICGS-11 as compared to JL-24 and SB-XI. Jadhav (1987) reported higher number of branches in variety LG-19 and observed very fast rate of increase in branching upto 30 days and fast between 30-60 days.

Jadhav (1987) recorded significantly higher leaf area and dry matter in variety LG-19 as compared to ICGS-11 and Robut-33-1 whereas, Karhale (1987) recorded higher leaf area and total dry matter in variety ICGS-11 as compared to JL-24 and SB-XI at Parbhani. Deshmukh (1991) also observed higher leaf area and total dry matter of ICGS-11 and ICGS-44 as compared to SB-XI in summer season.

Durugkar (1985) observed more number of nodules and filled pods per plant in variety UF-70-103 whereas, Karhale (1987) recorded more number of nodules in variety ICGS-11 and no difference in filled and unfilled pods per plant amongst different varieties. Similarly Jadhav (1987) also observed higher number of nodules and filled pods per plant in variety ICGS-11. Shelke *et al.* (1989) at Parbhani recorded significantly higher number of filled pods in variety ICGS-11 in comparison with UF-70-103 and K-4-11. Higher

number of nodules, filled pods and two seeded pods in ICGS-11 and ICGS-44 as compared to SB-XI in summer season were recorded by Deshmukh (1991).

2.1.2 Effect of varieties on yield

Patil (1977) observed higher pod yield of 2.26 to 3.39 t/ha in variety TG-17 as compared to Punjab-1 (1.38 t/ha) and Punjab-2 (1.76 t/ha).

Desale *et al.* (1980) reported that at Digraj (Maharashtra), cv. TMV-10 out yielded (16.41 q/ha) the standard check Kopergaon-1 (9.95 q/ha) by 65 per cent in co-ordinated varietal trials, 39.7 per cent in multilocational trials and 22.81 per cent on cultivator's fields.

Bhosale and Anghale (1981) studied performance of several varieties at Dapoli and recorded pod yield of 2.67, 2.54 and 2.46 t/ha in varieties TG-1, M-13 and Shulamith respectively.

Thangavelu *et al.* (1982) studied Co-1, Pol.2 and TMV-9 varieties in summer season under irrigated condition throughout Tamilnadu and recorded higher pod yield (17.48 q/ha) of Co-1 as compared to 13.94 q/ha in TMV-9 and 13.99 q/ha in POL.2 varieties.

Jagtap and Deokar (1983) on the basis of trials conducted at Digraj in summer season observed

that the new groundnut cultivar UF-70-103 out yielded the standard cultivar SB-XI by giving average pod yield of 3.51 t/ha as compared to 2.28 t/ha of SB-XI.

Singh and Kalra (1983) conducted ^{the} experiments with PG-1, M-13 and Type-28 varieties at Meerut (U.P.) and observed highest pod yield of M-13 (26.94 q/ha) followed by Type-28 (22.28 q/ha) and PG-1 (20.36 q/ha) in kharif seasons. In post rainy season adaptive trials, ICGS-11 recorded 25 to 33 per cent higher pod yield over SB-XI (Anonymous, 1984 and Anonymous, 1985). Durugkar (1985) recorded significantly higher yield of dry pods i.e. 21.98 q/ha in variety ICGS-11 and 10.15 q/ha in variety K-4-11 at Parbhani.

At Parbhani, Dhoble *et al.* (1985) studied seven varieties viz. L-33, L.No. 95 A, L.No. 91, M-13, K-4-11, JL-24 and SB-XI and observed significantly higher pod yield of variety M-13 (17.18 q/ha). Similarly in Tarai region of U.P., Chhonkar and Kumar (1985) observed dry pod yield of 19.35 q/ha in variety M-13, which was significantly higher over varieties T-28, ICGS-11, GAUG-10 and J-11. Similarly at Navsari (Gujrat) variety M-13 gave 27.5% higher pod yield than GAUG-10 (Patel *et al.* 1986). More and Khade (1987) conducted an experiment with five varieties viz., SB-XI, FSB-7-2, Phule pragati (bunch type), TMV-10 (semi spreading) and M-13 (spreading) and observed significantly higher dry pod yield (36.2 q/ha) in variety M-13. The next higher

yield was obtained from FSB-7-2 (31.69 q/ha) which was at par with SB-XI (28.16 q/ha).

Jadhav (1987) at Parbhani observed significantly higher dry pod yield of ICGS-11 (21.14 q/ha). Similarly, Karhale (1987) recorded 20.66 q/ha yield of ICGS-11, which was significantly superior over JL-24 (18.61 q/ha) and SB-XI (18.00 q/ha). Bhosale *et al.* (1987) studied L-33, M-13, SB-XI and K-4-11 varieties in summer season on medium black soils of Parbhani and observed significantly higher dry pod yield (22.31 q/ha) of variety M-13 (spreading) which was at par with L-33 (21.55 q/ha) *but* superior to SB-XI (17.20 q/ha) and K-4-11 (14.34 q/ha).

In *Rabi* season at Dapoli (Thorat and Patil, 1987), variety SB-XI produced significantly higher pod yield (19.14 q/ha) as compared to varieties, Shulamith (17.78), Kopergaon-1 (16.82), TC-1 (15.78) and M-13 (15.40 q/ha). Similarly Joshi *et al.* (1987) recorded higher pod yield of SB-XI (38.89 q/ha) than TMV-10 (21.05 q/ha) at Rahuri in summer season under irrigated conditions. Under stress free condition cv. Co-1 recorded highest pod yield followed by TMV-7, TMV-2, TMV-9 and TMV-12 varieties (Srinivasan *et al.* 1987). Cultivars S-1 and TG-17 gave highest yields of 3.74 and 3.56 t/ha respectively compared with 2.24-2.88 t/ha in other cultivars (Chauhan *et al.* 1988). At 3 locations in

Maharashtra in joint demonstrations by ^{the}ICRISAT and State Department of Agriculture it was observed that variety ICGS-11 recorded 4.29 t/ha pod yield whereas SB-XI recorded 2.54 t/ha. The percentage increased in yield of ICGS-11 over SB-XI was 43 per cent. Similarly, at one location variety ICGS-44 recorded 19 per cent higher pod yield over local variety SB-XI (Anonymous, 1988).

At Parbhani, in *kharif* season, variety ICGS-11 produced pod yield of 20.79 q/ha which was superior to UF-70-103 (17.35) and K-4-11 (11.23 q/ha) under protective irrigations (Shelke *et al.* 1989). At Pune, Jadhav *et al.* (1990) tried three varieties and found that SB-XI and M-13 gave average pod yields of 8.95 and 8.09 q/ha respectively, which were comparable but more than FSB-7-2 (7.44 q/ha). Deshmukh (1991) recorded 46.41, 41.49, 45.15 and 28.70 q/ha dry pod yield of varieties ICGS-11, ICGS-21, ICGS-44 and SB-XI respectively in summer season.

2.1.3 Effect of varieties on quality

Vaithialingam and Rao (1973) observed higher protein content in dormant groundnut cultivar TMV-1 as compared to non-dormant cultivar TMV-2.

Patil *et al.* (1980) recorded 46.5 and 29.5 g weight of hundred seeds of varieties JL-24 and SB-XI respectively. Desale *et al.* (1980) studied 13 varieties at Digraj and observed higher shelling percentage in

varieties, TG-9 (74.9%) and TMV-10 (74.7%), whereas hundred kernel weight was higher in variety Georgia-119-20 (68.3 g) TMV-10 (64.6 g) as compared to other varieties. Similarly, at Dapoli (Bhosale and Andhale, 1981) varieties TG-14 and Kopergaon-1 recorded 72.00% and 72.20% shelling out turn, whereas, hundred kernel weight was highest in varieties TG-18 (85.30 g) and TG-1 (77.65 g)

Thangavelu *et al.* (1982) studied three varieties throughout Tamil Nadu in summer season, under irrigated condition and reported that cv CO-1 recorded highest shelling percentage (74.0%) and oil percentage (50.4%) as compared to TMV-9 and POL-2 varieties. However, hundred kernel weight was found to be maximum (32.3 g) in variety POL-2.

At Parbhani Durugkar (1985) recorded higher shelling percentage (65.13 %) and protein percentage (25.04%) in ICGS-11, whereas, 100 kernel weight was highest (35.79 g) in UF-70-103 and oil content (48.33%) in variety K-4-11. Similarly at Navsari (Gujrat), Patel *et al.* (1986) observed higher shelling percentage (65.14%) in variety GAUG-10 and hundred kernel weight (47.16 g) in variety M-13. Dhopte and Kudupley (1986) studied 17 groundnut cultivars and recorded 28.3 per cent protein and 50.8 per cent oil in SB-XI which was significantly higher than other varieties.

They also observed negative correlation of oil percentage and pod yield. At Parbhani significantly higher hundred kernel weight, shelling, oil and protein percentage was recorded in variety ICGS-11 (Karhale, 1987). Similarly Jadhav (1987) also reported higher shelling out turn and harvest index in variety ICGS-11 and higher 100 kernel weight in variety LG-19.

Thorat and Patil (1987) at Dapoli, recorded highest oil content (51.46%) in SB-XI as compared to Kopergaon-1 (48.75%), M-13 (48.34%), TC-1 (47.84%) and Shulamith (46.23%) varieties.

2.2 Effect of irrigation

2.2.1 Effect of irrigation on growth

Groundnut has specific moisture needs due to the unique feature of developing the pods underground. The flower is borne above ground and after it withers, the stalk elongates, bends down and forces the ovary underground and the seed matures below the surface. Hence both the quantity and the quality of groundnut seed is intimately related to conditions that favour the growth processes preceding and during the development of the seed. Proper functioning of these growth processes requires a favourable balance controlled by the relative rates of soil moisture uptake by the roots and the water loss by transpiration. water deficits that are a consequence of

the imbalance between water uptake and transpiration, affect groundnut growth depending on the stage of crop growth and the degree or intensity of the drought stress (Sivakumar and Sarma, 1986). The soil water deficit occurring during the pod filling phase has to be considered in the light of the indeterminate nature as well as the subterranean fruiting habit of the peanut plant. Soil water available in the top 4 to 5 cm of the profile is of critical importance for peg and pod development. Fruit initiation continues after the start of kernel growth, so the soil water deficit during the pod filling stage reduce both the initiation and development of pods (Pallas *et al.* 1979 and Boote and Hammond, 1981).

Growth of groundnut in terms of height was studied by numerous workers. It was not affected by irrigations and various moisture regimes in *kharif* seasons on loamy sand soils at Ludhiana (Cheema *et al.* 1974). Similarly, it was not affected by irrigation at 25, 50 and 75 per cent depletion of available soil moisture at different stages of growth on loamy sand soils during *Rabi* season at Chiplima in Orissa (Lenka and Misra, 1973). Shinde (1980) also observed non-significant effect of irrigations at 187, 125, 94 and 75 mm CPE on silty clay soil at Parbhani in summer season. However, on sandy clay loam soils of Tirupati irrigation scheduling at 25% depletion of

available soil moisture (DASM) resulted in significantly more height over 50% and 75% DASM in summer season (Ramesh babu *et al.* 1984 a). Similarly Sabale and Khuspe (1986) recorded significantly more plant height by irrigating the groundnut crop at 80 to 85% available soil moisture (ASM) on medium black soils of Pune in summer season.

On sandy loam soil of Hyderabad irrigation scheduled at 0.95 IW/CPE ratio produced significantly higher height over 0.65 and 0.80 IW/CPE ratio in *Rabi* season (Ravi Kumar *et al.* 1987). At Parbhani, in summer season, Thanzuala (1987) recorded significantly increased height at 1.0 IW/CPE ratio as compared to 0.50 and 0.75 IW/CPE ratios in summer season. On vertisol of Dharwad irrigation at 50% DASM and at weekly interval recorded more plant height as compared to irrigations at 50, 75 and 100 mm CCE i.e. cumulative can evaporation (Babalad and Kulkarni, 1988).

Lenka and Misra (1973) did not observe significant effect of irrigations at 25, 50 and 75 per cent depletion of available soil moisture on number of branches at Chiplima. Birajdar (1973) as well as Shelke and Khuspe (1980) reported significantly more branching due to irrigation scheduled at 50 to 100 mm CPE as compared to 120 to 125 mm CPE on calyey soils during summer seasons at Parbhani. However, Shinde (1980) on silty clay soil of Parbhani in summer

season, recorded non significant effect of various irrigation treatments on branching. On medium black soil of Pune, Sabale and Khuspe (1986) obtained significantly increased branches by application of irrigation at 80-85 per cent ASM over that of irrigation applied at 40 to 50 % ASM. Ravi Kumar *et al.* (1987) observed higher number of branches by irrigating the crop at 0.95 IW/CPE ratio on sandy loam soil of Hyderabad. Similar results were reported by Thanzuala (1987) at Parbhani by irrigating groundnut crop at 0.75 IW/CPE ratio and by Patel *et al.* (1988) with 0.80 IW/CPE ratio at Junagadh in summer seasons. However, Babalad and Kulkarni (1988) did not observe any significant effect of irrigation on branching. Jana *et al.* (1989) recorded more number of branches by applying two irrigations at flowering and pod development stage as compared to one irrigation at flowering and one irrigation at pod development stage in summer groundnut at Kalyani (West Bengal).

Pawar (1972) observed two peaks of dry matter accumulation i.e. one during active vegetative growth period and second during pod development period, in kharif season, at Akola. The dry matter accumulation per plant was favourably influenced on clayey soils in summer season at Parbhani due to scheduling of irrigations at 50 to 100 mm CPE (Birajdar, 1973 and Shelke and Khuspe, 1980). However, Shinde (1980) did not

observe significant effect of various irrigation treatments on total dry matter^t accumulation at Parbhani. Ramesh Babu *et al.* (1984 a) recorded significantly higher dry matter per plant by irrigating at 25% depletion of available soil moisture (DASM) on sandy clay loam soils of Tirupati in summer season. Similar observations were ^{also} made by Sabale and Khuspe (1986) on medium black soils of Pune by irrigating summer crop at 80 to 85% available soil moisture (ASM). On sandy loam soils of Hyderabad significantly higher dry matter was recorded by irrigating the crop at 0.95 IW/CPE ratio over 0.65 and 0.80 IW/CPE ratios (Ravi Kumar *et al.* 1987). At Dharwad, irrigation of crop at weekly interval and at 50% depletion of ASM resulted in significantly higher dry matter as compared to irrigation scheduled at 75 and 100 mm CCE (Babalad and Kulkarni, 1988).

Shinde (1980) recorded increased number of leaves per plant with 0.8 and 0.6 IW/CPE ratios as compared to 0.4 IW/CPE ratio at Parbhani. At Pune, Sabale and Khuspe (1986) recorded significantly higher number of leaves by irrigating the crop at 80 to 85 per cent ASM as compared to 45 to 50 per cent ASM. At Dharwad, Babalad and Kulkarni (1988) observed higher number of leaves with irrigation scheduled at 50 per cent depletion of ASM.

At Parbhani, significantly higher leaf area was observed by irrigating the crop at 40 mm and 80 mm CPE over 120 mm CPE (Shelke, 1979). However, Shinde (1980) did not observe any significant effect of irrigation on leaf area at Parbhani in summer season. Thanzuala (1987) at Parbhani recorded maximum leaf area at 0.75 and 1.0 IW/CPE ratios as compared to 0.5 IW/CPE ratio. At Dharwad, significantly higher leaf area was observed by irrigating at 50 per cent depletion of ASM over other treatments (Babalad and Kulkarni, 1988).

At Parbhani Shinde (1980) observed that *average* (height) was slow during initial stage, increased upto 60 days and slowed thereafter in summer season. Thanzuala (1987) recorded higher AGR (dry matter) with higher levels of irrigations i.e. 1.0 IW/CPE ratio as compared to 0.5 IW/CPE ratio.

Higher values of relative growth rate (RGR) was observed in high frequency irrigations at 40 and 80 mm CPE over that of 120 mm CPE at Parbhani in summer season (Shelke, 1979).

Net assimilation rate (NAR) was not influenced significantly due to different irrigation treatments at Parbhani in summer season (Shinde, 1980 and Thanzuala, 1987). At Dharwad, Babalad and Kulkarni (1988) recorded highest leaf area index (LAI) in high frequency irrigation

i.e. at 50 per cent depletion of ASM as compared to irrigations scheduled at critical growth stages which recorded lowest LAI.

2.2.2 Effect of irrigation on nodulation

On loamy sand soils of Chiplima (Lenka and Mishra, 1973) in *Rabi* season higher number of nodules were observed with irrigation at 25% depletion of ASM and decreased thereafter with irrigation of 50% and 75% depletion of ASM. The active nodulation in groundnut commenced at initiation of flowering, on loamy soils in *kharif* season at Akola (Pawar, 1972). In bunch varieties on sandy soils in *Kharif* seasons nodulation commenced after 30 days (Bhan, 1975 b). The number of nodules per plant were significantly more due to scheduling of irrigation at 50 to 100 mm CPE as compared to 120 to 125 mm CPE at Parbhani (Birajdar, 1973 and Shelke and Khuspe, 1980). On vertisols of Parbhani nodulation in summer groundnut increased significantly with increasing frequency. Irrigation scheduled at every 13 days increased the nodule number upto 37 nodules/plant and nodule weight to 37.20 mg/plant, as compared to 18 nodules/plant and 11.35 mg/plant weight with irrigation at 18 days interval at Parbhani in summer season (Rasve et al. 1983).

2.2.3 Effect of irrigation on Pods

Developed pods were found to increase when irrigation was scheduled at 50 to 100 mm CPE as compared to 120 to 125 mm CPE on clayey soils in summer at Parbhani (Birajdar, 1973 and Shelke and Khuspe, 1980). On sandy clay loam soils of Tirupati irrigation of summer crop at 25% and 50% depletion of ASM produced significantly higher number of pods/plant as compared to irrigation at 75% depletion of available soil moisture (Ramesh babu *et al.* 1984 a). Keeping the total quantity of irrigation water almost constant, high frequency irrigation (once in 5 days) resulted in maximum number of filled pods/plant on sandy loam soils of Tirupati (Rami Reddy *et al.* 1982). Scheduling of irrigation at 0.8 IW/CPE ratio resulted in significantly more number of pods/plant at Parbhani (Shinde and Pawar, 1984). Similar advantage of 0.8 to 1.0 IW/CPE ratio was also reported by Gajera and Patel (1984) from Junagadh. However, several workers obtained significantly higher number of pods with 1.0 to 1.2 IW/CPE ratios (Kachot *et al.* 1984, Patel *et al.* 1988 and Katre *et al.* 1988).

2.2.4 Effect of irrigation on yield

Highest yield of pods was recorded when irrigation was given at 12 days interval during sowing to pegging phase and at 6 days during pegging to pod development stage on sandy loam soil in Tamil Nadu

(Subramanian and Kotesvaran, 1976 and Narayana, 1976). But Subhash Babu *et al.* (1977) obtained highest yield on sandy loam soil in *Rabi* season at Tirupati by scheduling irrigation at 15 days interval during sowing to pegging, when ET/PET ratio was 1.0 during pegging to pod formation and once in 10 days during pod formation to maturity. Keeping the total quantity of irrigation water almost constant high frequency irrigation i.e. once in 5 days resulted in significantly higher pod yield of 32.9 q/ha as compared to 29.6 and 22.6 q/ha when irrigated at 7 days and 10 days interval on sandy loam soils of Tirupati, low in moisture retentive capacity (Rami Reddy *et al.* 1982). On vertisols of Parbhani application of 8 irrigations with 9 cm water at a time and following 11 days interval to summer crop produced maximum dry pod yield (30.20 q/ha) and showed highest water use efficiency of 11.5 kg/ha/mm. (Bharambe and Varade, 1982). Similar results were reported by Rasve *et al.* (1983) on vertisols of Parbhani. They observed highest dry pod yield of 16.52 q/ha by applying 9 irrigations at 10 days interval. Water use efficiency was also highest in this irrigation treatment.

In *kharif* seasons, on loamy sand soils of Ludhiana, Cheema *et al.* (1974) noted that the differences in pod yield due to soil moisture regimes (irrigation at 40, 80 per cent depletion of ASM and 80

per cent depletion of ASM upto pegging stage and control) were not significant. Irrigation at 25 per cent depletion of ASM was good for higher yields but when water resources were limited, irrigation could be scheduled at 50 per cent depletion of ASM during early stage (50 to 60 days after sowing) and at 25 per cent depletion of ASM thereafter, during pod formation and maturity stages i.e. 60 to 100 days after sowing (Sankara Reddy, 1975). On sandy red loam soil of Bhavanisagar during *Rabi* season, Kaliappa and Selvaraj (1976) observed that 75 per cent depletion of ASM was found to give significantly higher pod yield (40.13 q/ha) over 50 per cent depletion of ASM (38.82 q/ha) and 100 per cent depletion of ASM (28.32 q/ha). At Hyderabad (Andhra Pradesh) during *Rabi* season Rao *et al.* (1976) reported 56 per cent reduction in yield of groundnut with increase in moisture stress from 40 to 80 per cent depletion of available soil moisture. Scheduling of irrigation at 10 per cent available moisture on loamy sand soil in *kharif* season (Cheema *et al.* 1977) and 50 per cent available soil moisture in *kharif* season at Hebbal increased the yields significantly over rainfed crop (Reddy *et al.* 1978). On sandy clay loam soils of Tirupati (Andhra Pradesh) pod yield of groundnut was significantly reduced when irrigation was scheduled at 75 per cent depletion of available soil moisture as compared to 25 per cent and 50 per cent depletion of

available soil moisture in summer season (Ramesh Babu *et al.* 1984 b). On medium black soils of Pune application of irrigation at 80 to 85 per cent ASM increased the dry pod yield significantly over that of 45 to 50 per cent ASM in both the years in summer season (Sasale and Khuspe, 1986).

Sandhu *et al.* (1972) reported that on fine sandy loam soil in a low rainfall area of Ludhiana, irrigations at flowering and again at fruiting (Plus the two seasonal irrigations in the first and third month of sowing) gave 50.6 and 33.1 per cent higher yields than no irrigation and a single irrigation at flowering respectively. Birajdar (1973) at Parbhani also found flowering as a critical stage and missing of irrigation at this stage resulted in significant reduction in yield. Irrigating the crop at critical stages i.e. at flowering and fruiting is beneficial and positive results on sandy loam soils during *kharif* season were reported by Saini and Sandhu (1973). On sandy loam soils of Madurai (Tamil Nadu) during summer season, irrigation at 0.9 IW/CPE during pod formation and maturity phases recorded 21.78 q/ha yield as compared to 15.35 q/ha at 0.60 IW/CPE ratio (Subramanian *et al.* 1974). Bhan (1975 a) recorded favourable response to irrigations applied at flower initiation and pegging stages (about 35 and 55 days, respectively after sowing). Subbarao *et al.* (1974), Narayan (1976) and Subhash babu *et al.* (1977) reported that the pegging, pod formation and pod development stages in summer crop were critical

stages and irrigation given at these stages increased the pod yield considerably.

The pod yield was significantly higher (18.59 q/ha) when irrigation was scheduled at 75 mm CPE in summer season as compared to 50, 100 and 125 mm CPE at Parbhani (Birajdar, 1973). Similarly at Akola, Dahatonde (1978) recorded significantly higher pod yield (16.15 q/ha) by scheduling irrigation at 75 mm CPE in summer season. At Parbhani irrigations scheduled at 40 and 80 mm CPE to summer crop produced significantly higher dry pod yield over 120 mm CPE (Shelke, 1979). At Parbhani, Shinde and Pawar (1984) observed significantly higher dry pod yield by scheduling irrigation at 95 mm CPE and 125 mm CPE as compared to 187 mm CPE, which resulted in reduced pod yield due to stress condition. On vertisols of Dharwad, treatments receiving irrigation at 50 per cent depletion of ASM recorded significantly higher pod yield (49.76 q/ha) which was on par with irrigation at weekly interval and at 50 mm CCE (Babalad and Kulkarni, 1988). Thanzuala (1987) recorded significantly higher pod yield with 50 to 80 mm CPE as compared to 120 mm CPE, irrigation at 10 days interval and at critical stages, in summer season at Parbhani.

At Junagadh (Gujrat) irrigation scheduled at 1.0 IW/CPE ratio with 50 mm depth of IW recorded significantly higher dry pod yield of 27.6 q/ha as compared to 25.3, 19.9 and 16.7 q/ha in 0.8, 0.6 and 0.4 IW/CPE ratios respectively (Gajera, and Patel, 1984). However, Kachot *et al.* (1984) observed significantly higher pod yield upto 1.2 IW/CPE ratio as compared to 1.0 and 0.8 ratios in summer season at Junagadh. At IARI, on alluvial sandy loam soil in *kharif* season irrigation given at 0.8 IW/CPE with 60 mm depth of IW resulted in significantly higher pod yield of 19.4 q/ha as compared to 17.7 q/ha in 0.6 IW/CPE ratio (Rao and Singh, 1985). At Parbhani, in summer season, Thanzuala (1987) observed 1.0 IW/CPE ratio, most suitable for groundnut. Thorat *et al.* (1988) conducted experiments at Dapoli in three *Rabi* hot weather seasons and observed that throughout the period 1.0 IW/CPE ratio with 50 mm depth gave significantly higher mean pod yield (19.15 q/ha) as compared to 0.8 (16.46 q/ha), 0.6 (12.87 q/ha), and 0.4 (11.76 q/ha) ratios. On sandy clay loam soils of Bilaspur (Madhya Pradesh) significantly higher pod yield (32.63 q/ha) was obtained under 1.2 IW/CPE ratio with 70 mm depth of IW (Katre *et al.* 1988). At Junagadh, in summer seasons, experiments from 1981 to 1985 (Patel *et al.* 1988) revealed that irrigation scheduled at IW/CPE ratios of 0.8 and 1.0 gave 30.0 and 46.4% higher pod yield, respectively over that of 0.6

(18.3 q/ha). On lateritic soil of Kokan in *Rabi* season irrigation scheduled at 0.8 IW/CPE ratio (75 mm CPE) produced significantly more pod yield (18.79 q/ha) than the irrigation scheduled at 0.4 IW/CPE ratio (Chavan *et al.* 1988). At Parbhani, Rodge *et al.* (1990) recorded higher pod yield of SB-XI with 0.75 and 1.0 IW/CPE ratio.

2.2.5 Effect of irrigation on quality

Birajdar (1973) observed that irrigation at 75 mm CPE recorded significantly higher test weight and irrigation at 50, 75 and 100 mm CPE recorded significantly higher shelling percentage over 125 mm CPE. Shelling percentage was not affected due to various irrigation treatments on sandy loam soil in Andhra Pradesh (Narsimham *et al.* 1977). However, Cheema *et al.* (1977) observed increased test weight and shelling percentage with higher soil moisture regimes over control. Dahatonde (1978) reported that shelling percentage and test weight were significantly higher with irrigation at 75 mm CPE than that with 125 mm CPE. At Parbhani, Shelke (1979) recorded non significant effect of irrigation on test weight, but shelling percentage was significantly improved with high frequency irrigation (80 mm CPE) as compared to lower frequency (120 mm CPE). The non significant effect of irrigation on test weight was also reported by Shinde (1980).

However, irrigation ratio of 0.4 and 0.8 IW/CPE had significantly reduced the shelling percentage as compared to 0.8 ratio. High frequency irrigation of once in 5 days significantly increased the 100 kernel weight at Tirupati (Rami Reddy *et al.* 1982) and irrigations at 8-10 days interval significantly increased the shelling percentage and 100- Kernel weight at Parbhani (Rasve *et al.* 1983). At Junagadh (Gujrat) significantly higher 100-kernel weight was recorded by scheduling irrigation at 1.2 IW/CPE ratio as compared to 0.8 and 0.6 IW/CPE ratio (Kachot *et al.* 1984). Gajera and Patel (1984) recorded higher test weight at 1.0 IW/CPE ratio at Gujrat. Ramesh babu *et al.* (1984 a) observed significantly higher shelling percentage and 100 kernel weight by scheduling irrigation at 25% depletion of ASM and 50% depletion of ASM as compared to 75% depletion of ASM at Tirupati. In summer season irrigation scheduled at 1.0 IW/CPE ratio resulted in significantly higher 100 kernel weight, but shelling percentage was not affected (Patel *et al.* 1988). Similar non significant effect of irrigation on shelling percentage was also reported by Katre *et al.* (1988) at Bilaspur (Madhya Pradesh).

The oil percentage in kernels was not affected due to various irrigation treatments at Parbhani on clayey soils during summer season (Birajdar, 1973, Shelke and Shinde, 1980). However, protein percentage was significantly higher in irrigation scheduled at 125 mm

CPE as compared to 75 and 50 mm CPE (Birajdar, 1973). Shinde (1980) did not observe any significant effect of irrigation on protein percentage. On vertisol of Parbhani in summer season the protein and oil content were found to be maximum (24.2% protein and 30.4% oil) when irrigation was applied at 10 days interval (Rasve *et al.* 1983). The oil content was maximum when irrigations were scheduled at 50% depletion of ASM and was closely followed by scheduling irrigations at 25% depletion of ASM (Ramesh Babu *et al.* 1984 c). At IARI, New Delhi, in *kharif* season significantly higher oil yield was recorded by irrigating at 0.8 IW/CPE ratio (Rao and Singh, 1985). Similarly, Shinde and Umrani (1986) recorded increased protein yield with increase in number of irrigations. At Hyderabad on sandy loam soil Ravi Kumar *et al.* (1987) did not observe any significant effect of irrigations viz. 0.65, 0.80 and 0.95 IW/CPE ratios, on oil content and protein content. Similarly at Parbhani, Thanzuala (1987) did not observe significant effect of irrigation on protein content, but oil content was significantly higher (50.67%) in high frequency irrigation scheduled at 1.25 IW/CPE ratio (48 mm CPE).

2.2.6 Effect of irrigation on N, P and K uptake

At Chiplima (Orissa) on sandy loam to loamy sand soil, Lenka and Sahu (1977) observed that irrigation at depletion of 25, 50 and 75 per cent of ASM had no marked effect on N, P, and K content of

groundnut kernels. At Parbhani, Shelke (1979) observed higher concentration and uptake of total phosphorus at 80 mm CPE irrigation followed by 40 and 120 mm CPE. Zalawadia and patel (1983) reported that irrigation at 75% available soil moisture increased total uptake of N and K by haulms and kernel as compared to lower irrigations of 50 to 25 % ASM, at Junagadh (Gujrat). Similarly, Ramesh babu *et al.* (1984 d) recorded increased uptake of N, P, K by irrigating the crop at 25 and 50% depletion of ASM as compared to 75% depletion of ASM. Polara *et al.* (1984) observed decreased N, P and K uptake due to stress. The N, P and K accumulation in plant were highest with irrigation at 25 or 50 per cent depletion of ASM (Babu *et al.* 1985).

2.2.7 Consumptive use of water by groundnut

Age of the crop, climate and soil moisture stress are the main factors that influence the CU of water by the crop. Many workers have found out CU of water by groundnut with different depths of irrigation and different frequencies of irrigation. The consumptive use of water by groundnut on sandy clay loam soil in *Rabi* season at Bhavanisagar was 59.1, 57.5 and 44.2 cm at 50, 75 and 100 per cent depletion of ASM. On medium black clay loam soil in the *Rabi* season at Hyderabad it was 52.1, 46.6 and 43.0 cm at 25, 50 and 75 per cent depletion of ASM respectively

(Anonymous, 1973). In the *Rabi* season at Hyderabad it was 460, 396 and 334 mm in the treatments receiving irrigation at 40, 60 and 80 per cent depletion of ASM (Rao *et al.* 1976). On loamy sand soil in *kharif* season at Ludhiana the CU was 42.1, 51.1, 54.3 and 59.5 cm at 0, 10, 30, and 50 per cent ASM in 0-30 cm soil strata (Cheema *et al.* 1977). The CU of water by groundnut on clayey soil during summer season at Parbhani was 679, 569, 556 and 535 mm at 50, 75, 100 and 125 mm CPE (Birajdar, 1973). Shelke (1979) found 1057, 712 and 624 mm in 1976 and 1018, 673 and 608 mm consumptive use of water in 1978 when irrigations were scheduled at 40, 80 and 120 mm CPE on clayey soil during summer season at Parbhani. Shinde (1980), at Parbhani recorded mean seasonal CU by summer groundnut as 843, 882 and 988 mm in 1976 and 779, 861 and 930 mm in 1977 under the IW/CPE ratios of 0.4, 0.6 and 0.8, respectively. On vertisols of Parbhani, Bharambe and Varade (1982) found 463, 520, 655, 552 and 600 mm CU by irrigating the summer crop at 5, 6, 8, 10 and 14 days interval, respectively. On clayey soils of Junagadh in summer season CU recorded by Gajera and Patel (1984) was 238, 258, 270 and 274 mm under 0.4, 0.6, 0.8 and 1.0 IW/CPE ratio, respectively.

2.2.8 Water requirement of groundnut

Water requirement of crop include consumptive use of water and other economically unavoidable water losses and that applied for special

operations such as land preparation, transplanting and leaching etc. It is expressed as depth of water in inches or mm for a given time.

Chandramohan (1970) found the total water requirement of groundnut including rainfall as 452, 483, 531, 606 and 895 mm at 0, 20, 40, 60 and 80 per cent ASM with an average total number of irrigations as 6, 8, 9, 12 and 24 respectively. The total water requirement in *Rabi* season on sandy loam soil was 67.43 cm (Subramanian *et al.* 1976) and on loamy sand soil in *Rabi* season at Chiplima, it was 828, 712 and 620 mm at 25, 50 and 75 per cent depletion of ASM (Lenka and Misra, 1973). The total water requirement on clayey soils in summer season for maximum pod yield was found to be 95.0 cm and 89.8 cm with total 12 irrigations in 1976 and 1978, respectively when irrigation was scheduled at 80 mm CPE (Shelke, 1979). Shinde (1980) observed total water requirement for higher pod yield as 975 mm and 1050 mm with 0.6 and 0.8 IW/CPE ratio, respectively in summer season at Parbhani. At Tirupati it was found to be 680 mm water applied in 17 irrigations at 5 days interval in summer season (Rami Reddy *et al.* 1982). Bharambe and Varade (1982) at Parbhani found 720 mm water applied at 11 days interval as optimum for summer crop. Similarly, Rasve *et al.* (1983) at Parbhani observed that summer groundnut require 660 mm water which is to be applied at 8

days interval. On clayey soils of Junagadh in summer season 600 to 700 mm water was needed for maximum pod yield, which is to be applied in 12 to 14 irrigations (Gajera and Patel, 1984 and Patel *et al.* 1988). In Rabi season, at Dapoli, total water requirement for higher pod yield was found to be 500 mm applied in 10 irrigations (Thorat *et al.* 1988) and 540 to 660 mm water applied in 9-11 irrigations (Chavan *et al.* 1988). At Bilaspur, in summer season, Katre *et al.* (1988) observed 88.2 cm total water requirement for maximum dry pod yield by scheduling irrigation at 1.2 IW/CPE ratio and applied in 12 irrigations.

2.2.9 Water use efficiency

Water use efficiency is defined as the yield of marketable crop produce per unit of water used in evapotranspiration. Water use efficiency is utilized for estimating efficient water management. Water use efficiency of groundnut crop in India has been worked out by many research workers. In general they observed that the water use efficiency decreased with increase in frequency of irrigation and moisture regimes and decrease in soil moisture tension and cumulative pan evaporation at which irrigation is scheduled. It is also influenced by season. Some workers have estimated moisture use efficiency of groundnut crop irrigated based on depletion of

ASM. It was 3.7 kg/ha/mm on loamy sand soil in *Rabi* season at Chiplima and 74.7 kg/ha/cm during *Rabi* season in Tamil Nadu when irrigation was scheduled at 50 per cent depletion of ASM (Lenka and Misra, 1973 and Subbarao *et al.* 1974). The water use efficiency of 0.73 q/ha/cm and 9.2 kg/ha/mm was found by Rao *et al.* (1976) and Reddy *et al.* (1978) during *Rabi* season at Hyderabad and Tirupati when irrigation was applied at 50 and 25 per cent depletion of ASM respectively. Cheema *et al.* (1977) observed 0.67 q/ha/cm as highest WUE in *kharif* season on loamy sand soil at Ludhiana when irrigation application was done at 0 per cent depletion of ASM.

Water use efficiency was also estimated by some workers on the basis of irrigation interval. At Tirupati, Rami Reddy *et al.* (1982) recorded WUE of 4.8 and 4.7 kg/ha/mm by irrigating the summer crop at 5 days and 3 days interval respectively. Bharambe and Varade (1982) observed significantly highest WUE of 11.5 kg/ha/mm when crop was irrigated at 11 days interval in summer season at Parbhani. Similarly, at Parbhani, Rasve *et al.* (1983) found 3.25 kg/ha/mm WUE by irrigating the crop at 13 days interval. Few workers have also estimated WUE on the basis of IW/CFE ratios. The water use efficiencies of 2.83 and 3.50 kg/ha/mm was reported by Shinde and Pawar (1984) in 1976 and 1977 respectively at 0.6 IW/CPE ratio. Kachot *et al.* (1984) recorded WUE of 7.5 and 7.6 kg/ha/mm

at Gujrat with 1.0 and 1.2 IW/CPE ratios respectively. Highest WUE of 4.07 kg/ha/mm with 0.9 IW/CPE ratio was reported by Katre *et al.* (1988) from Bilaspur. On laterific soils of Kokan (Thorat *et al.* 1988) WUE of 4.70 kg/ha/mm was obtained with 0.4 IW/CPE ratio.

2.2.10 Crop coefficients (Kc)

To account for the effect of the crop characteristics on crop water requirements, the crop coefficients (Kc) are presented to relate reference crop evapotranspiration (ET₀) to crop evapotranspiration (ET_{crop}). The Kc values relates to evapotranspiration of a disease free crop grown in large fields under optimum soil water and fertility conditions and achieving full production under the given growing environment. During initial stage of crop Kc values were 0.30 and increased to 0.85 during peak period of flowering in Israel (Goldberg *et al.* 1967). Doorenbos and Kassam (1979) reported Kc values of 0.4- 0.5, 0.7 - 0.8, 0.85 - 1.1, 0.7 - 0.8 and 0.55 - 0.6 during establishment, flowering, vegetative, yield formation and ripening stages, respectively.

2.2.11 Soil moisture extraction pattern

Groundnut crop utilize maximum soil moisture from upper 0 - 30 cm layer. Rao *et al.* (1976) observed 71 per cent moisture extraction from 0- 30 cm soil layer while from 30 -60 cm layer, it was 29 per cent. At Parbhani, Shinde (1980) recorded 74.64 and 67.40 per cent

soil moisture extraction from 0-30 cm layer in 1976 and 1977, respectively. Similarly Shelke and Khuspe (1980) also recorded higher moisture utilization by groundnut crop from 0-30 cm layers.

2.3 Effect of irrigation depth

On lateritic soil of Kokan, Kadam and Patil (1989) did not observe any significant effect of 4.0 and 6.0 cm irrigation depth on pod yield, shelling percentage, protein percentage and oil percentage. However, consumptive use of water by groundnut was 22 per cent greater in frequent irrigations with 4.0 cm depth of water than that of 6.0 cm depth.

**MATERIALS
AND
METHODS**

III. MATERIALS AND METHODS

Details of the materials used and the methods adopted during the course of investigations are given in this chapter under the appropriate heads.

3.1 Soils

The experiment was conducted in Plot B₂ and Plot A₃ during the summer seasons of 1989 and 1990 respectively at the farm of Co-ordinated Project for Research on Water Management, Marathwada Agricultural University, Parbhani. The topography of the soil was fairly levelled. Soil samples were taken from 0-30 cm depth from 25 random spots covering experimental area. Before laying out the experiment in both the years, a composite sample of about 1 kg from gross sample was taken and analysed for various physico-chemical properties, viz. Mechanical analysis was carried out by International Pipette Method (Piper, 1966). Available nitrogen was estimated with alkaline permagnate method (Subbiah and Asija, 1956). The soil was extracted with 0.5 M sodium bicarbonate extractant and available P was determined calorimetrically as per the method of Olsen *et al.* (1954), as described by Black (1965) and available potassium in soil by Flame photo meter using neutral normal ammonium acetate as an extractant (Jackson, 1973). The soil pH was determined by glass electrode pH meter, electrical conductivity by conductivity bridge and

organic carbon by Walkey and Black's Method (Piper, 1966). The data obtained are presented in Table 1.

Table 1. Mechanical and chemical composition of composite soil samples

Particulars	Plot B ₂	Plot A ₃
Sand (per cent)	14.00	18.00
Silt (per cent)	20.34	20.40
Clay (per cent)	53.20	58.20
Textural class	Clayey	Clayey
Organic carbon (per cent)	0.66	0.54
Available N (kg/ha)	190.00	163.00
Available P ₂ O ₅ (kg/ha)	23.00	25.00
Available K ₂ O (kg/ha)	297.00	312.00
pH	8.24	8.10
Electrical conductivity (mmhos/cm)	0.242	0.370

The soil in the experimental plots was clayey in texture, low in nitrogen, medium in available phosphorus, high in potassium and slightly alkaline in reaction.

The moisture constants of the soils i.e. field capacity (F.C.) and permanent wilting point (P.W.P.) were estimated by pressure plate apparatus and bulk density (b.d.) was estimated by core sample method. The relevant data is given in Table 2.

Table 2. Moisture constants of the soil

Particulars	Plot B ₂	Plot A ₃
Field capacity (%)	32.5	33.2
Permanent wilting point (%)	13.5	12.5
Bulk density (g/cc)	1.32	1.30

Data indicated that soil was moisture retentive. The available moisture of the soil was 19.0 and 20.7 per cent during 1989 and 1990, respectively.

3.2 Climate and weather

Parbhani is situated at 409 m altitude, 19° 16' north latitude, and 76° 47' east longitude and has tropical climate. The average annual precipitation (worked on the basis of last 30 years) of 916 mm is received in average number of 70 rainy days mostly during June to September. The precipitation is assured for *Kharif* season. The mean daily maximum temperature varies from 29 °C in December to 41 °C in May. The mean daily minimum temperature varies from 12 °C in December to 23 °C in May. The months of July, August and September are humid and winter is cool. The rest of the period is dry. Parbhani is grouped in assured rainfall zone.

The weather data recorded at Agricultural Meteorological Observatory, M.A.U., Parbhani during the period of experimentation are given in Table 3 along with normals (1950 to 1980).

The perusal of data in Table 3 indicated that average maximum temperature varied slightly between seasons. The average maximum temperature progressively increased with crop life attaining maximum values at the ripening phase. Likewise, the average weekly minimum temperature varied between seasons.

As regards to mean relative humidity (RH), there were variations between seasons. It decreased progressively with increase in crop life and again increased at maturity.

Unlike the RH, the pan evaporation progressively increased with crop life, except that there was drop in pan evaporation in the month of March in the first season and in the month of May in the second season.

The total precipitation received during the crop growth period varied between seasons, it amounted to 85.5 mm in first season and 110.5 mm in second season.

Table Ja. Mean weekly weather parameters for experimental period.

Week No.	Temperature °C						Humidity %								
	Maximum			Minimum			A.M.			P.M.			Average evaporation mm/day		
	1989	1990	Normal	1989	1990	Normal	1989	1990	Normal	1989	1990	Normal	1989	1990	Normal
1	29.8	29.3	30.20	10.7	14.4	12.5	75	88	74.8	23	40	32.1	4.3	4.4	4.4
2	29.1	30.8	30.8	12.9	10.5	13.3	70	64	71.7	34	21	31.6	4.7	5.1	4.1
3	31.1	32.4	31.6	11.7	9.3	13.1	67	69	68.8	25	21	29.9	5.4	5.8	4.0
4	31.5	31.6	31.4	14.5	9.5	13.1	72	76	65.9	31	26	30.5	5.3	6.7	4.7
5	32.5	34.0	32.4	11.8	11.3	14.0	68	67	65.1	18	22	29.3	5.6	6.0	5.2
6	34.3	33.5	33.0	12.3	14.2	14.6	50	56	58.5	15	21	26.0	6.0	6.3	6.1
7	34.3	32.7	34.2	12.4	16.0	15.2	51	55	56.4	14	24	25.3	7.6	7.2	6.6
8	31.5	30.7	35.6	9.3	11.0	16.6	46	56	54.2	10	17	25.0	7.7	6.9	7.3
9	36.6	33.3	36.6	15.2	14.2	17.6	43	47	51.9	11	18	27.7	7.8	7.5	8.0
10	35.1	34.0	37.3	17.3	17.0	18.8	56	45	49.1	26	17	24.2	9.3	8.1	7.6
11	34.2	36.4	17.4	17.4	16.8	19.9	69	38	47.1	20	12	22.3	6.7	9.3	8.6
12	36.6	36.8	30.0	20.6	18.4	20.0	53	37	47.2	20	13	23.4	7.7	9.9	8.9
13	31.1	36.4	39.5	18.1	16.9	22.0	76	39	47.1	40	11	24.6	6.0	10.3	9.1
14	38.0	38.4	40.1	16.2	18.7	22.8	42	31	44.6	19	10	21.7	11.9	11.1	10.1
15	40.1	40.0	41.6	19.7	20.0	23.3	32	36	43.5	9	11	21.2	12.2	11.6	11.3
16	40.7	41.9	41.2	23.7	22.2	23.7	37	32	44.7	15	8	22.9	12.2	13.8	10.1
17	41.1	42.5	42.0	23.3	23.9	25.8	36	31	42.3	15	11	22.5	12.6	14.0	10.9
18	39.0	40.7	42.8	24.0	26.2	25.2	46	44	43.6	23	20	23.2	11.6	12.7	12.9
19	42.3	37.1	43.3	23.0	24.0	25.8	27	63	44.9	8	36	21.9	13.0	9.3	14.1
20	44.8	37.3	42.8	28.0	26.1	24.9	39	61	49.7	11	34	25.0	18.3	10.5	13.1
21	43.5	36.9	42.3	26.1	23.0	26.1	53	83	60.1	18	42	31.1	19.2	8.0	13.5

Table 3b. Mean weekly weather parameters for experimental period.

Week	Bright sunshine hr/day			Wind velocity km/hr			Total precipitation (mm)			Number of Rainy days		
	1989	1990	Normal	1989	1990	Normal	1989	1990	Normal	1989	1990	Normal
No.	mm/day											
1	11.0	8.1	10.1	3.8	4.0	2.3	-	-	0.14	-	-	0.03
2	10.7	10.3	9.9	5.8	3.9	2.5	-	-	1.40	-	-	0.07
3	10.3	10.0	10.2	4.0	3.9	3.0	-	-	0.43	-	-	0.03
4	10.2	10.2	10.2	5.0	3.6	3.0	-	-	0.61	-	-	0.10
5	10.8	9.7	10.4	3.4	3.1	3.5	-	-	0.21	-	-	0.07
6	10.5	10.0	10.7	4.9	5.1	3.6	-	-	0.21	-	-	0.03
7	10.6	10.2	10.7	5.3	6.5	4.7	-	-	0.05	-	-	0.03
8	10.6	10.6	10.3	7.5	5.9	4.7	-	-	0.72	-	-	0.25
9	10.3	10.3	10.5	4.8	6.8	4.5	-	-	1.72	-	-	0.21
10	8.8	10.2	10.0	8.3	6.0	4.5	4.0	-	2.60	2	-	0.28
11	9.4	10.9	9.7	4.4	5.2	4.8	-	-	0.37	-	-	0.21
12	8.4	9.9	9.8	6.6	6.1	4.0	8.2	-	2.70	2	-	0.25
13	7.5	10.6	9.8	6.8	6.3	5.1	2.8	-	5.01	1	-	0.67
14	10.7	10.9	9.6	7.1	6.3	4.8	-	-	0.97	-	-	0.32
15	10.7	10.4	9.8	6.3	6.1	5.3	-	-	4.25	-	-	0.57
16	9.4	11.0	9.9	7.5	8.9	6.2	-	-	3.10	-	-	0.57
17	10.6	10.5	10.1	8.5	6.5	6.3	-	-	2.08	-	-	0.46
18	8.8	10.0	10.3	8.3	7.7	8.1	0.5	4.5	0.77	-	1	0.35
19	9.8	6.4	10.2	8.7	9.2	9.8	-	8.5	1.12	-	2	0.25
20	9.9	6.3	9.1	13.4	14.6	10.6	-	-	3.24	-	-	0.71
21	10.6	8.8	9.2	16.7	9.9	11.9	-	9.75	9.09	-	5	1.10

The bright sunshine hours varied slightly between seasons. The wind velocity showed slight variation between seasons and increased slightly with each week.

3.3 Previous cropping

The cropping programme followed in the experimental plots for the last three years is given in Table 4.

Table 4. Cropping history

Year	Season	Plot B ₂	Plot A ₃
1986-87	<i>Kharif</i>	Udid-Bajra-Cotton	Sorghum-paddy-Soybean
	<i>Rabi</i>	Wheat-Safflower-Gram	Wheat-Sunflower-Pea
	Summer	Groundnut	Fallow
1987-88	<i>Kharif</i>	Arhar	Fallow
	<i>Rabi</i>	-	Safflower
	Summer	Groundnut	-
1988-89	<i>Kharif</i>	Arhar	Fallow
	<i>Rabi</i>	-	<i>Rabi</i> jowar
	Summer	Present experiment	-
1989-90	<i>Kharif</i>	-	Arhar
	<i>Rabi</i>	-	-
	Summer	-	Present experiment

3.4 Experimental details

3.4.1 Details of treatments and experimental design

The present experiment was laid out in factorial randomized block design in three replications comprising 4 groundnut varieties and 3 depths of irrigations. The plans of lay out adopted during both the years are given in fig. 1.

3.4.1.1 Treatment details

I. Varieties

V₁ ICGS-11

V₂ ICGS-21

V₃ ICGS-44

V₄ SB-XI

II Irrigation Depths

D₁ 6.0 cm

D₂ 7.5 cm

D₃ 9.0 cm

For all the treatments, irrigation was scheduled at 0.75 IW/CPE ratio corresponding to irrigation of D₁ at 80 mm CPE, D₂ at 100 mm CPE and D₃ at 120 mm CPE.

Plot size : Gross : 6.0 x 5.4 m

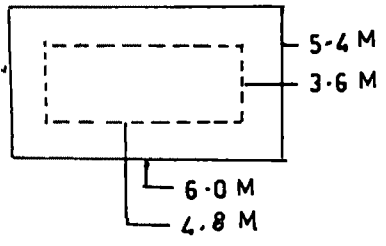
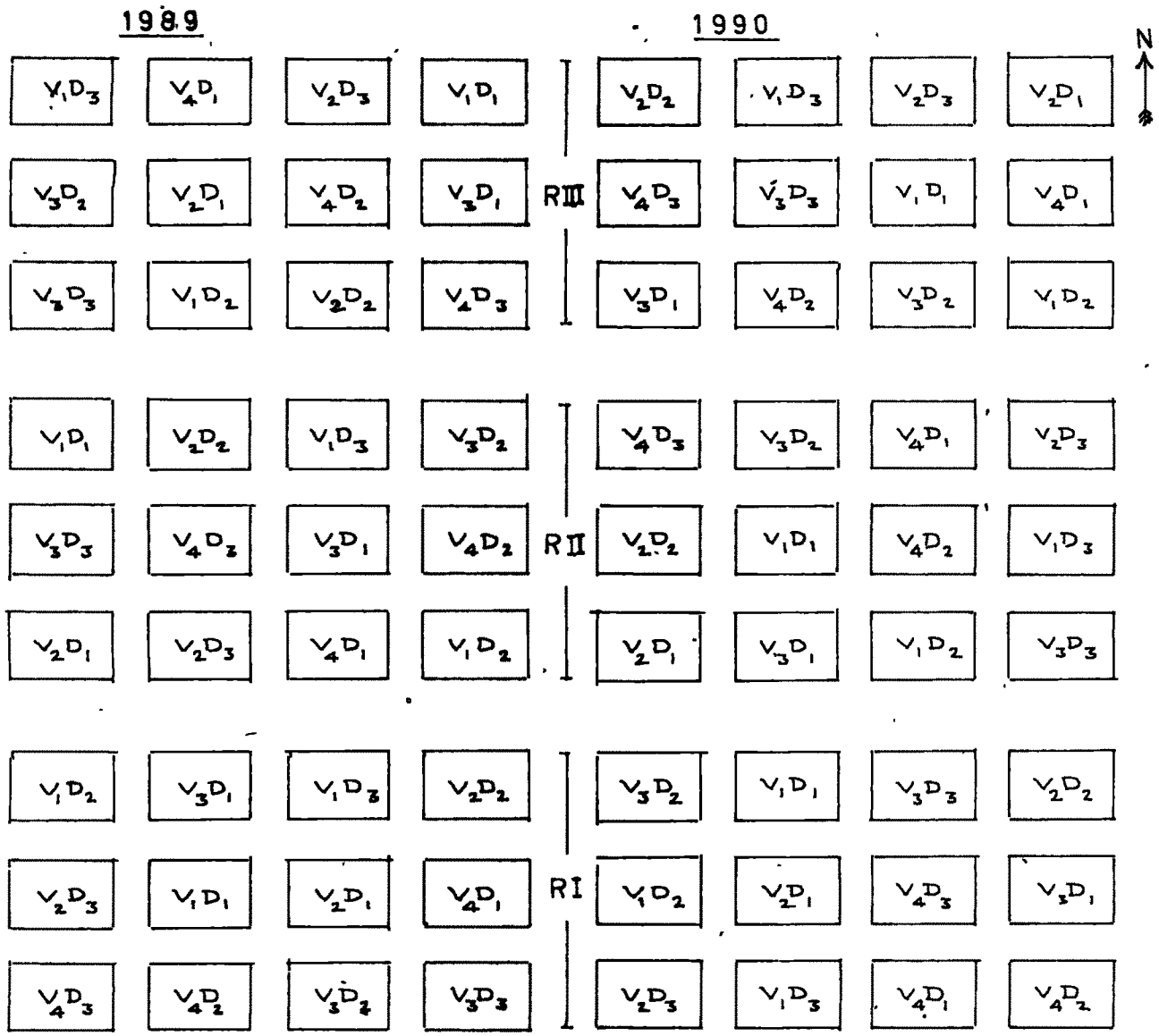
Net : 4.8 x 3.6 m

Spacing: 30 x 15 cm

Seed rate : 120 kg/ha

3.4.1.2 Varietal details

Three ICRISAT varieties i.e. ICGS-11, ICGS-21 and ICGS-44 were studied in this experiment along with local variety SB-XI as check. Characteristics of these varieties are as follows :



DESIGN: FACTORIAL RANDOMISED BLOCK DESIGN
REPLICATIONS: THREE
PLOT SIZE: GROSS: 6.0 X 5.4 M, NET: 4.8 X 3.6 M

TREATMENTS VARIETIES	IRRIGATION DEPTHS
V ₁ ICGS-11	D ₁ 6.0cm
V ₂ ICGS-21	D ₂ 7.5cm
V ₃ ICGS-44	D ₃ 9.0cm
V ₄ SB-XI	

Fig.1 PLAN OF LAY OUT

1 ICGS-11

It is also known as ICGV 87123. It is Spanish bunch variety and derive its origin from a single plant selection from variety Robut-33-1 (now known as Kadiri 3). ICGS-11 has between 6 to 9 primary branches and 2 to 3 secondary branches. It matures in 120 days in the post rainy season and has a shelling turnover of 70 per cent. It has relative tolerance of end-of-season drought and field tolerance of bud necrosis. It is photo-period insensitive. It has 25-33 per cent higher yield potential over SB-XI (Anonymous, 1989a).

2 ICGS-21

It is a cross between Robut-33-1 and NCAC 2698. It is nearly bunch, relatively less susceptible to pest and disease and bold seeded. This variety is doing well for rainy and summer season cultivation in Tamil Nadu and Maharashtra in research trials. It has 20-25 per cent higher yield potential than existing varieties (Anonymous, 1991).

3 ICGS-44

Also known as ICGV-87128; it is a selection from Robut-33-1, a Spanish bunch variety. Characters are similar to ICGS-11. It has wider adaptability. It was released for rabi/summer cultivation in Gujrat but has become popular in Tamil Nadu, Andhra Pradesh and Maharashtra. It gave 21.0, 23.0 and 24.0 per cent higher

yield over J-11, GAUG-1 and GG-2 varieties respectively (Anonymous, 1989b).

4 SB-XI

It is a spanish bunch variety, released for cultivation in Maharashtra in summer season. It was evolved at Junagarh from, a cross Ah 4213 x Ah 4354. It has average pod yield of 1300 kg/ha, shelling out-turn of about 75.0 per cent and hundred Kernel weight of 35.0 g (Anonymous, 1987).

3.4.1.3 Irrigation details

Details of irrigations are presented in Table 5.

Table 5. Irrigation details

Treatments	IW:CPE ratio	CPE (mm)	Number of irrigation applied*		Total quantity of water applied (mm)	
			1989	1990	1989	1990
D ₁ (6.0 cm)	0.75	80	15	14	900	840
D ₂ (7.5 cm)	0.75	100	13	12	945	870
D ₃ (9.0 cm)	0.75	120	11	10	930	840

* Includes two common uniform irrigations of 60 mm each, one applied as pre emergence and one after gap filling.

The cumulative pan evaporation was calculated after second common irrigation and irrigations were scheduled as per treatments.

3.4.1.4 Quantity of water applied

The quantity of water applied in different plots as per the depth of irrigation water was calculated as follows :

$$\text{Quantity of water applied (litres/plot)} = \text{Plot area (sq m)} \times \text{Depth of irrigation (mm)}$$

The net quantities of water applied at each irrigation schedules were 1944, 2430 and 2916 litres in D1 (6.0), D2 (7.5) and D3 (9.0 cm) depths, respectively.

3.5 Details of cultural operations

Details of cultural operations carried out in the experimental plots during 1989 and 1990 are presented in Table 6.

3.5.1 Preparatory tillage

The land was ploughed 30 cm deep with plough after the harvest of the previous crop. It was subsequently prepared by clod crushing with harrowings to achieve loose and friable seed bed. The stubbles of previous crop were collected and the plot was cleaned.

Table 6. Schedule of cultural operations carried out on the experimental plots during 1989 and 1990

Operation	Frequency	Dates	
		1989	1990
A. Preparatory			
1. Ploughing	1	21-12-88	27-12-89
2. Harrowing	3	26-12-88	2-1-90
		27-12-88	3-1-90
		28-12-88	4-1-90
3. Cleaning	1	2-1-89	13-1-90
B. Sowing			
1. Lay out	1	5-1-89	15-1-90
2. Fertilizer application	1	8-1-89	16-1-90
3. Preparation of main and sub-channels for irrigation	1	8-1-89	16-1-90
4. Sowing	1	17-1-89	22-1-90
C. Post sowing operations			
1. Common irrigations	2	17-1-89	22-1-90
		30-1-89	5-2-90
2. Gap filling	1	30-1-89	5-2-90
3. Hand weeding	2	13-2-89	16-2-90
		28-2-89	3-2-90
4. Hand hoeing	1	14-2-89	19-2-90
5. Spraying of Dimecron	2	11-2-89	22-2-90
		4-3-89	15-3-90
Spraying of Monocrotophos	1	18-2-89	5-3-90
6. Harvesting	1	30-5-89	28-5-90

3.5.2 Fertilizer application

The fertilizers were applied at the rate of 25 kg N and 50 kg P₂O₅/ha, at the time of sowing as a basal application. The fertilizers used were urea (46 per cent nitrogen) and single superphosphate (16 per cent phosphorus).

3.5.3 Seeds and sowing

The seed of groundnut variety SB-XI was obtained from Co-ordinated Project for Research on Water Management, M.A.U., Parbhani, whereas seed of varieties ICGS-11, ICGS-21 and ICGS-44 was obtained from the ICRISAT Centre, Patancheru, Hyderabad during first year. In second year seeds obtained from first year's experimental produce was used. The kernels were treated with Bavistin to prevent the attack of fungal diseases. Sowing was done on January 17, 1989 and January 22, 1990 during first and second year, respectively by dibbling two kernels per hill maintaining 30 cm row to row and 15 cm plant to plant distance. Immediately after dibbling the seeds, the experimental plot was irrigated to achieve the uniform germination. Emergence started 8 days after sowing. The gaps were filled in again by dibbling the two seeds to maintain required plant population per plot.

3.5.4 Intercultivation

Two hand weedings were given, first 30 days after sowing and second about 45 days after sowing. One hand hoeing was given after 30 days after sowing.

3.5.5 Preparation of main, sub-channels and guard furrows

The main and sub-channels were opened with the help of ridger before sowing of the crop. The guard furrows of 1 m size were opened from four sides of each plot to prevent lateral moisture movement from one plot to another.

3.5.6 Plant protection

Two sprayings of dimecron at the rate of 0.05 per cent concentration and one spraying of monocrotophos at the rate of 0.05 per cent concentration were taken during both the years to prevent the attack of jassids and aphids.

3.5.7 Irrigation application

Two common irrigations, one presowing and other immediately after gap filling of 60 mm depth each were applied to all the plots. Irrigation treatments were introduced 15 days after sowing. Check bed irrigation method was adopted. The irrigation water was applied by connecting the hose-pipe to main source (G.I. Pipe line) of irrigation water. The water meter was fitted to

hose pipe for measuring the water directly in the plot. Dates of irrigations applied during both the years are given in Table 7.

3.5.8 Harvesting

At maturity, border lines were harvested first and thereafter net plots were harvested separately by uprooting the plants. The pods were separated from the haulms of net plot plants. The fresh weights of pods and haulms were recorded and then the plotwise net pods and haulms were sundried separately by spreading them on threshing yard for about 8 days until constant weights were obtained. The sundried pods and haulms were weighed treatmentwise.

3.6 Biometric observations

Observations on height of main shoot and number of branches per plant were recorded periodically from five plants selected in each net plot randomly. Mean number of pods per plant, mean number of nodules per plant, weight of dry pods per plant, mean total dry matter per plant and leaf area per plant were recorded from one sample plant uprooted from each net plot.

3.6.1 Sampling technique

In order to record observations on various growth characters at different stages, five plants were selected at random from each net plot. The same plants were harvested separately for assessing individual

Table 7. Dates of irrigations applied during 1989 and 1990

Sr. No.	Irrigations of D1 (80 mm CPE)		Irrigations of D2 (100 mm CPE)		Irrigations of D3 (120 mm CPE)	
	1989	1990	1989	1990	1989	1990
1.	16-2-89	20-2-90	18-2-89	22-2-90	21-2-89	26-2-90
2.	25-2-89	3-3-90	4-3-89	9-3-90	12-3-89	13-3-90
3.	12-3-89	13-3-90	21-3-89	21-3-90	1-4-89	25-3-90
4.	23-3-89	21-3-90	7-4-89	29-3-90	12-4-89	6-4-90
5.	7-4-89	29-3-90	13-4-89	11-4-90	21-4-89	18-4-90
6.	12-4-89	6-4-90	21-4-89	18-4-90	1-5-89	25-4-90
7.	17-4-89	13-4-90	29-4-89	24-4-90	12-5-89	3-5-90
8.	24-4-89	18-4-90	9-5-89	30-4-90	18-5-89	16-5-90
9.	1-5-89	25-4-90	16-5-89	8-5-90	24-5-89	
10.	9-5-89	30-4-90	20-5-89	19-5-90		
11.	14-5-89	7-5-90	25-5-89			
12.	18-5-89	16-5-90				
13.	22-5-89					
	13 + 2 = 15	12 + 2 = 14	11 + 2 = 13	10 + 2 = 12	9 + 2 = 11	8 + 2 = 10

plant yield and recording biometric observations. The schedule of biometric observations on various characteristics and aspects recorded during the present investigation is given in Table 8.

3.6.2 Growth studies

3.6.2.1 Emergence count

The number of emerging plants from net as well as gross plots were recorded on 10th day after sowing when considerable emergence was noticed and final emergence count was recorded on 20th day after sowing.

3.6.2.2 Final plant count

The final plant stand was recorded at harvest.

The plant count expressed in per cent as :

$$\text{Per cent plant count} = \frac{\text{Actual plant count/plot}}{\text{Expected number of hills/plot}} \times 100$$

The resultant data were subjected to 'F' test.

3.6.2.3 Height of plant

The height of the main stem was measured in cm from the base of the plant i.e. ground level to the base of the last fully opened leaf (base of apex).

Table B. Schedule of Biometric observations

Sr. No.	Particulars	Frequency	Days after sowing	Remarks
I. Initial Soil Properties				
a.	Mechanical analysis	1	Before sowing	
b.	Chemical analysis	1	Before sowing	
c.	Soil moisture constants	1	Before sowing	
II. A. Pre harvest studies				
a.	Emergence count	2	10 and 20	All plants in each plot
b.	Height of plant (cm)	7	30, 45, 60, 75 90, 105 and 120	Five plants from each net plot
c.	Number of branches/plant	7	30, 45, 60, 75 90, 105 and 120	Five plants from each net plot
d.	Dry matter/plant (g)	7	30, 45, 60, 75 90, 105 and 120	One plant from each net plot
e.	Leaf area/plant (sq cm)	7	30, 45, 60, 75 90, 105 and 120	One plant from each net plot
f.	Number of nodules/plant	7	30, 45, 60, 75 90, 105 and 120	One plant from each net plot
g.	Number of pods/plant	4	75, 90, 105 and 120	One plant for first 3 observations and 5 plants at 120 days
h.	Final plant count	1	At harvest	All plants in each plot.
B. Post harvest studies				
a.	Number of filled pods/plant	1	At harvest	Five plants from net plot

Table 8 continued

b. Number of unfilled pods/ plant	1	At harvest	Five plants from net plot
c. Number of one seeded pods/ plant	1	At harvest	Five plants from net plot
d. Number of two seeded pods/ plant	1	At harvest	Five plants from net plot
e. Weight of dry pods (g/plant)	1	At harvest	Five plants from net plot
f. Weight of dry pods (q/ha)	1	At harvest	All plants in net plot
g. Weight of dry haulms (q/ha)	1	At harvest	All plants in net plot
h. Shelling percentage	1	At harvest	From sample of net plot produce
i. Hundred kernel weight (g)	1	After shelling	From sample of net plot produce
j. Kernel yield (q/ha)	1	After shelling	From sample of net plot produce
III. Chemical studies			
a. Oil percentage	1	After shelling	From sample of net plot produce
b. Protein percentage	1	After shelling	From sample of net plot produce
c. N, P and K uptake (Kg/ha)	1	After shelling	From kernels and haulms of each net plot.
IV. Soil moisture studies	24	hours before and 48 hours after each irrigation turn as per the treatment.	
V. Statistical analysis			
a. 'F' test			
b. 't' test			
c. Simple correlation and regression			
d. Multiple regression			
e. Response analysis			
f. Economic analysis.			

3.6.2.4 Number of branches per plant

Total number of branches arising from the main shoot per plant were recorded on the selected plants periodically.

3.6.2.5 Leaf area per plant

The functional leaves of plant taken for dry matter studies were separated from stem and classified into three categories i.e. large, medium and small. Number of leaves in each category were counted and maximum length and breadth of one leaflet from each category was recorded. Leaf area per plant was calculated with the help of formula :

$$\text{Leaf area} = (L \times W \times \text{factor}) \times n$$

Where,

L = maximum length of leaf

W = maximum width of leaf at one-third length from the base of leaf

Factor = leaf area constant for the groundnut varieties

i.e. for ICGS-11-
ICGS-21 = 0.8298 (Shelke *et al.* 1988)
and ICGS-44-

SB-XI = 0.7945 (Musande *et al.* 1982)

and n = number of leaves

3.6.2.6 Number of nodules per plant

One plant from each net plot was selected randomly. plants were uprooted carefully without damaging root system of the plant. The roots were then

carefully washed to remove the sticking soil particles. All nodules on roots were counted and recorded.

3.6.2.7 Total dry matter per plant

The plants uprooted for nodulation study were preserved for recording dry matter accumulation periodically. The plants selected for biometric observations were used for dry matter studies at harvest. From uprooted plants, the roots were removed and the leaves, stem portion and pods were separated and kept for sundrying in the labelled brown paper bags and later dried in an oven at 60⁰ C until constant weights were recorded.

3.6.2.8 Number of pods per plant

The total number of pods per plant were counted on the same plants which were uprooted for nodulation study and at harvest on plants selected for biometric studies.

3.7 Growth analysis

The data on growth characters namely height, leaf area and dry matter per plant were further analysed to work out AGR, RGR, NAR and LAI. Data on these growth functions were not statistically analysed and hence inferences are based on mean values.

3.7.1 Absolute growth rate (AGR)

The rate of increase of a growth variable viz. weight of dry matter (W) and height (H) at the time (t) is called as absolute growth rate (AGR). It was measured as differential coefficient with respect to time. AGR of growth variables viz. height of main shoot and total dry matter weight were worked out by following formula (Richards, 1969).

$$\begin{aligned} \text{AGR} &= \frac{dw}{dt} = \frac{W_2 - W_1}{t_2 - t_1} \quad (\text{for total dry matter}) \\ &= \frac{H_2 - H_1}{t_2 - t_1} \quad (\text{for height}) \end{aligned}$$

Where,

dw = increase in variable

dt = time interval in days

3.7.2 Relative growth rate (RGR)

The relative rate at which a plant incorporates new material into substance is measured by relative growth rate (RGR) of dry matter accumulation and is expressed mathematically by following formula :

$$\text{RGR} = (1/w) (dw/dt)$$

Where,

w = weight of dry matter already attained by growing structure

dw = weight of newly incorporated material during the time interval

dt = time interval in days

Fisher (1921) pointed out the important corollary of the exponential function and formulated RGR based on logged values of the growth characteristics

$$\text{RGR} = \frac{(\text{Log}_e W_2 - \text{Log}_e W_1)}{(t_2 - t_1)}$$

Where,

W_1 and W_2 are the weights of dry matter in g per plant at the time T_2 and T_1 respectively.

$t_2 - t_1$ = time interval in days

RGR = increase in dry matter weight in g/g/day

3.7.3 Net assimilation rate (NAR)

The NAR represents the photosynthetic efficiency of leaves. It was calculated by using the formula given by Gregory (1917)

$$\text{NAR} = \frac{(W_2 - W_1) (\text{Log}_e A_2 - \text{Log}_e A_1)}{(t_2 - t_1) (A_2 - A_1)}$$

Where,

W_2 = dry weight of shoot per plant at the end

W_1 = dry weight of shoot per plant at the beginning

A_2 = leaf area per plant at the end

A_1 = leaf area per plant at the beginning

$(t_2 - t_1)$ = time interval in days

3.7.4 Leaf area index (LAI)

Since the crop yield is to be assessed per unit of ground area instead of per plant, the leaf area existing on unit ground area was proposed by Watson (1952). The measure is known as leaf area index and calculated by following formula :

$$\text{LAI} = \frac{\text{Leaf area per plant in sq cm}}{\text{Ground area per plant in sq cm}}$$

3.8 Post harvest studies

The plants selected for biometric observations were used for post harvest studies also. Post harvest studies included number of filled pods per plant, number of unfilled pods per plant, number of one seeded pods, number of two seeded pods, weight of dry pods per plant, shelling percentage, hundred kernel weight, kernel yield (q/ha), yield of dry pods (q/ha), yield of dry haulms (q/ha) biological yield and harvest index.

3.8.1 Number of filled pods

Filled pods on all five observation plants were counted and average was worked out.

3.8.2 Number of unfilled pods

Unfilled pods on all observation plants were counted and average was worked out.

3.8.3 Number of one seeded pods.

Pods of five observation plants having only one seed were counted and average was worked out.

3.8.4 Number of two seeded pods

Pods of five observation plants having two seeds were counted and average was worked out.

3.8.5 Total weight of pods per plant

Pods from all five observation plants were dried and weight was recorded in g and average was worked out.

3.8.6 Shelling percentage

Sample of one kg dry pods was taken from each treatment and hand shelling was done. The weight of kernel was carefully recorded. Shelling percentage was then worked out from the weight of kernels and the weight of dry pods by the formula

$$\text{Shelling percentage} = \frac{\text{weight of kernels}}{\text{Weight of pods}} \times 100$$

3.8.7 Hundred kernel weight

One hundred kernels were counted from shelled pods in each net plot and weight was recorded in g.

3.8.8 Yield of dry pods per hectare

Pods harvested from each net plot were dried and cleaned off soil and weight recorded in kg. The weight of dry pods harvested from five observation plants was added in it and per hectare yield was calculated.

3.8.9 Yield of dry haulms

The creeper after separating the pods in each plot were sundried and weight was recorded in kg.

3.8.10 Kernel yield

Kernel yield was calculated from pod yield of each net plot and shelling percentage by formula.

$$\text{Kernel yield} = \frac{\text{Weight of dry pods} \times \text{Shelling \%}}{100}$$

3.8.11 Total biological yield

Total biological yield was worked out by adding the weight of dry pods of each net plot with weight of dry haulms.

3.8.12 Harvest index

Harvest index indicated the yielding ability and efficiency of a crop to produce economic produce per unit of total biological yield. Harvest index in different treatments was worked out with the formula :

Yield of pods/plot

Harvest index = $\frac{\text{Yield of pods/plot}}{\text{Yield of total biological product of that plot (expressed in the same unit)}}$

3.9 Chemical studies

3.9.1 Plant analysis

The plant samples were collected after harvest and were sundried and oven-dried. Grinding was done with electrically operated grinder. The ground plant samples were stored in paper bags and used for analysis purpose.

3.9.1.1 Total nitrogen

Nitrogen from plant samples and kernels was determined by Micro Kjeldahl's method (A.O.A.C., 1965).

3.9.1.2 Total phosphorus

The plant and kernels sample was digested in tri acid mixture (nitric acid, sulphuric acid and perchloric acid) and phosphorus was determined calorimetrically, yellow colour method (Piper, 1966).

3.9.1.3 Total potassium

Potassium in plant and kernels was estimated by flame photometer as described by Jackson (1973).

3.9.2 Oil content in kernels

Kernels from each treatment of all three replications were analysed for oil content on Nuclear Magnetic Resonance (N.M.R.).

3.9.3 Protein content in kernels

For estimating protein content in kernels, nitrogen percentage was multiplied by factor 6.25 (A.O.A.C., 1965).

3.10 Soil moisture studies

The soil moisture content of the respective treatment was determined 24 hours before and 48 hours after irrigation from 0-30 and 30-45 cm soil layers.

3.10.1 Sampling techniques

Soil samples for moisture studies were taken with the help of screw auger. In each treatment soil sample was taken from one spot selected at random in net plot area. Then the samples were transferred immediately to aluminium soil moisture boxes and covered with polythene sheets to avoid heating and evaporation in field. Care was taken to avoid sub-sampling and contamination of the soil from different layers during insertion or withdrawal of the auger. The soil moisture boxes with samples were transported to the laboratory for weighing and drying the samples.

3.10.2 Weighing and drying of samples

The soil samples from respective depths were weighed immediately (W_1) and then transferred to a hot air oven with thermostat control. The samples were dried at a temperature of 105°C till constant weight was

obtained (W_2). The loss in soil moisture was expressed in percentage on oven dry weight basis.

$$\text{Soil moisture percentage (oven dry weight basis)} = \frac{W_1 - W_2}{W_2} \times 100$$

where,

W_1 and W_2 are fresh and dry weights of sample respectively.

3.11 Consumptive use of water

The field consumptive use of water by groundnut in mm was computed by the formula :

$$CU = \sum_{i=1} (E_0 \times 0.8) + \frac{M_{1i} - M_{2i}}{10} \times ASI \times D_i \times ER$$

Where,

CU = Consumptive use of water in mm

E_0 = actual evaporation recorded by U.S.A. class A pan evaporimeter for the period of 48 hours from scheduling of irrigation

M_{1i} = moisture percentage on oven dry weight basis at first sampling in the i th layer

M_{2i} = moisture percentage on oven dry weight basis at the second sampling in the i th layer

ASI = bulk density of i th layer (g/cc)

D_i = depth of the soil in i th layer (cm)

ER = effective rainfall (m)

3.11.1 Consumptive water use efficiency

Consumptive water use efficiency i.e. Kg of groundnut pods produced per mm of water per hectare in each treatment was worked out by the formula :

$$WUE = \frac{Y}{CU}$$

Where,

WUE = consumptive water use efficiency (Kg of pod yield per ha per mm)

Y = pod yield of groundnut in Kg per ha

CU = total seasonal consumptive use of water (mm).

3.11.2 Evapotranspiration ratio (ETR)

It refers to the amount of water consumptively used (mm) for producing unit amount of dry matter (Kg). It was calculated by formula :

$$ETR \text{ (mm/Kg/ha)} = \frac{\text{Total seasonal consumptive use (mm)}}{\text{Pod yield in Kg/ha}}$$

3.12 Potential evapotranspiration

3.12.1 Evaporation

It is the process of transformation of water from liquid to vapour phase through purely physical process in mm per day, called evaporation.

3.12.2 Evapotranspiration

It is the rate of actual water loss per unit area covered by the vegetation through the transpiration from the leaves and evaporation from the soil surface at prevailing soil moisture status.

3.12.3 Potential evapotranspiration

It is the potential rate of water loss per unit area of biologically active plant surface through transpiration and evaporation under unlimited soil moisture status.

3.12.4 Determination of potential evapotranspiration (PET)

There are different models of computing the potential evapotranspiration by considering different climatic parameters. The model of computing the potential evapotranspirations are dependent upon the choice of weather elements. In the present study the potential evapotranspiration was determined by adopting the following model proposed by Penman (1965).

3.12.5 Modified penman method

This model assumes that the potential evapotranspiration is the formation of integrated effect of the radiation (energy) and aerodynamic (wind and humidity) properties of the atmosphere. This model accounts for temperature, humidity, wind speed and bright sunshine hours in establishing the relationship in

between the water requirement of the crop and its surrounding environments (i.e. weather variables). The recommended relationship is as follows :

$$ET_0 = C (W. R_n + (1-W). f(u). (e_a - e_d))$$

Radiation Aerodynamic
term term

ET_0 = Reference crop evapotranspiration in mm/day

W = temperature related weighing factor

$(1-W)$ = weighing factor for effect of wind and humidity, dependent upon the temperature and elevation

R_n = net radiation in equivalent evaporation in mm/day

$f(u)$ = wind related function

$$f(u) = 0.27 \left(1 + \frac{U}{100} \right)$$

U = wind speed recorded at given height
(2 m above ground level)

$(e_a - e_d)$ = the difference between the saturation vapour pressure at mean air temperature and the mean actual vapour pressure of the air, both in m bar

C = adjustment factor to compensate for the effect of day and night weather conditions

To find the ET_0 , the reference crop evapotranspiration, ET crop needs to be adjusted for day and night weather conditions (not required in India).

3.12.6 Crop ^{Co}efficients (Kc) values

The Kc values of groundnut for various growth stages at Parbhani were computed by the following formula :

$$Kc = \frac{ET \text{ (crop)}}{ET_0}$$

Where,

Kc = crop coefficients at various stages

ET (crop) = evapotranspiration or consumptive use of groundnut in mm

ET_0 = reference crop evapotranspiration by modified Penman method

3.13 Statistical analysis and interpretation of data

Data obtained on various variables were analysed by 'Analysis of Variance' method (Panse and Sukhatme, 1985). The total variance (S^2) and d.f. (n-1) were partitioned into different possible sources. The variance due to replications, varieties, irrigation depths and interactions were compared with error variance for finding out 'F' values and ultimately for testing the significance at $P = 0.05$. The standard errors for the treatments based on error variance were calculated.

Wherever, the result was found to be significant, critical difference was calculated for the comparison of treatment means at 5 per cent level of significance (C.D. at $P = 0.05$).

3.13.1 Pooled analysis of yield data

The simple technique of analysis of variance may not be valid under different seasonal conditions, if the error variance in the seasons are not of the same order and interaction (treatment x seasons) is also significantly different. Hence pooled analysis of pod and haulm yield data of three years was carried out as per method described by Panse and Sukhatme (1985). During the year 1989, emergence of variety ICGS-44 was not optimum and this resulted in its lower plant density. The statistical analysis of the yield of dry pods during 1989 was done by using the technique of co-variance, as described by Chandel (1970), still the true potential of the variety was not reflected. In view of this the experiment was again continued for one more year and object was limited only to the extent of yield potential. Three years data of dry pod and haulm yield was pooled and results presented.

3.14 Correlation and regression studies

3.14.1 Simple correlation studies

Simple correlation coefficient (r) for ascertaining the nature of relations between dependent (y) and independent variables (X_i) were computed between weight of pods in g per plant (Y) and further mentioned

independent characters (X_i) for both the years of experimentation.

- 1) Height of plant at harvest (cm) = X_1
- 2) Number of branches per plant = X_2
- 3) Maximum leaf area per plant (sq. cm) at 105 days = X_3
- 4) Total dry matter at harvest in g per plant = X_4
- 5) Number of maximum root nodules per plant = X_5
- 6) Number of pods per plant at harvest = X_6
- 7) Shelling percentage = X_7
- 8) Hundred kernel weight (g) = X_8

The procedure and formulae described by Snedecor and Cochran (1968) were adopted and significance was tested.

$$r = \frac{SP \times Y}{(SSy \times SSx)^{1/2}}$$

$$t = \frac{r}{(1-r^2)^{1/2}} \times (n-2)^{1/2}$$

Where,

r = correlation coefficient

y = dependent variable (yield)

X = independent variable

n = number of observations

3.14.2 Simple regression studies

Simple regression coefficient (b) computed for measuring the magnitude of association between dependent (y) and independent (Xi) characters as per the procedure and formula described by Snedecor and Cochran (1968).

$$b = \frac{SP \cdot XY}{SS \cdot X^2}$$

The significance of 'b' was tested by applying 't' test.

$$t = \frac{b}{sb}$$

The intercepts (a) of these relationships were calculated.

$$a = \bar{y} - b_i \bar{X}_i$$

Where,

\bar{y} = mean yield of pods (g) per plant

b_i = regression coefficient of ith characters on y

\bar{X}_i = mean of ith independent character

The value of Y were calculated as :

$$Y = a + bx$$

3.14.3 Multiple regression studies

Since the yield of pods g/plant (Y) is the resultant of the effect of more than one independent variable (Xn), the relations obtained by simple regression analysis may not furnish so satisfactory information. Hence the attempt was made to disentagle and

measure the effects of X-variable on pod weight response (Y) by computing multiple regression coefficients from both the years of experimentation. The regression equation of the following type was set-up

$$Y = a + b_1X_1 + b_2X_2$$

The X- variables used for simple regression analysis were included in these studies also.

3.15 Crop response to water and its analysis

The functional relationship between the level of input and corresponding output is called production function or response function. The output was related to the variation in the level of single (irrigation) input factor keeping the other factors at constant. Thus the response surface was obtained.

The yield was taken as a function of water consumed i.e. $Y = F(W)$. The appropriate form of the response surface was ascertained by polynomial test. Hence the quadratic function was fitted to total yield of pods (t/ha) as dependent (Y) and consumptive use as independent (X) factors, by least square method. The nature of function was as follows :

$$\begin{aligned} Y &= \bar{Y} + b_1 (X - \bar{X}) + b_2 (X - \bar{X})^2 \\ &= b_0 + b_1X + b_2 X^2 \end{aligned}$$

Where,

Y = expected yield in t/ha

\bar{Y} = mean yield (t/ha)

X = quantity of water consumed by plant (in m)

\bar{X} = mean quantity of water consumed by plant in m

b_1, b_2 = empirical coefficients of production function

b_0 = intercept

3.15.1 Marginal physical product

Broadly defined, the marginal physical product of the variable input (X_1) is the addition of the total physical product (TPP) for the unit increase in the input X_1 , other things remaining the same. It may be more precisely and rigorously defined as the first partial derivative (slope) of the production function with respect to X_1 .

Thus dy/dx_1 represents the MPP of X_i

$$\text{MPP} = \frac{dy}{dx_1} = b_1 + 2b_2 X_i$$

3.15.2 Added physical product

$$Y = b_1 X + b_2 X^2$$

Y = additional product in t/ha

b_1 and b_2 = regression coefficients of production function

The additional physical product (Y) increases as levels of (X) factor (input) increases and the mean

yield per added unit of input ($Y = dy/dx$) attains an equilibrium state at particular point i.e. the point of yield potential.

The maximum level of input for exploitation of yield was defined where the marginal response is zero and on differentiation it become

$$X_{\max} = \frac{b_1}{2b_2}$$

3.15.3 Average physical product

It is computed by dividing the total added output by the total variable input. Symbolically Y/X_i or $F(X_1, X_2, X_3, X_4) / X_i$ is the average physical product of input

$$X_i = (i = 1, 2, \dots, n)$$

$$APP = \frac{Y}{X_i} = b_1 + b_2 X_i$$

3.16 Economic analysis of irrigation water

The optimum quantity of input is a function of the factor and product prices with b_1 and b_2 being constants in production function. As the price of input factor (P_x) increases, the optimum magnitude of factor (X) declines. On the other hand as the price of product (P_y) increases the optimum level of factor (X) also increases. Irrigation being a costly and major limiting factor in crop production (pod yield), the quantity of water that

gives the highest yield would not necessarily give the maximum profit. The total profit is maximum when the marginal profit is zero, the maximum profitable levels of input factor (X) coincide with the zero marginal profit point. This necessitates to work out the optimum level of water application that would give the maximum profit. The most remunerative level of water application can be determined by differentiating the response equation with respect of water consumed and reequating the resulting equation to zero.

$$\frac{dv}{dx} = b_1 P_y - 2b_2 P_y x = P_x$$

by differentiation

$$XMPR = \frac{P_x/P_y - b_1}{2b_2} = V = P_y V = b_0 P_y + b_1 P_y x - b_2 P_y x^2 - B$$

where,

dv = marginal value product

$XMPR$ = most profitable level of water

P_x = price of one unit of water i.e. 100 mm
(125, 150 and 175 Rs./100 mm)

P_y = price of one unit of yield i.e. tonne
(10000, 11000 and 12000 Rs./t) of product, b_1
and b_2

EXPERIMENTAL

FINDINGS

IV. EXPERIMENTAL FINDINGS

The summarised data on growth, yield and their attributes, statistical parameters of data and the critically interpreted results of the present investigations are presented in this chapter.

4.1 Crop stand

The plant population at emergence and at the time of harvest per net plot was counted and converted into percentage. The percentage was then subjected to statistical analysis. The data are given in Table 9 for both the years.

4.1.1 Emergence count

Mean emergence count was 76.90 and 90.73 per cent during 1989 and 1990 respectively.

Varieties

The emergence count was influenced by varieties during 1989 mainly because of low emergence of variety ICGS-44. Reason for less emergence of ICGS-44 was higher number of mouldy seeds which was confirmed in laboratory test at Seed Technology Research Unit, M.A.U. Parbhani. In view of this the dry pod yield of the year 1989 was subjected to the analysis of co-variance as per the procedure described by Chandel (1970), and accordingly dry pod yield of variety ICGS-44 was adjusted. The data in Table 9 indicated that there was no significant effect of varieties during second year of experimentation.

Table 9 . Emergence count and final plant count (per cent)
as affected by varieties and irrigation depths

Treatments	1989		1990	
	Emergence count	Final count	Emergence count	Final count
Varieties				
V ₁ ICGS-11	88.03	88.13	90.76	89.34
V ₂ ICGS-21	87.98	85.64	90.59	89.42
V ₃ ICGS-44	54.45	52.92	90.96	89.67
V ₄ SB-XI	87.98	85.47	90.62	89.28
S.E. \pm	1.09	1.05	0.71	0.59
C.D. at 5%	3.21	3.07	NS	NS
Irrigation Depths				
D ₁ 8.0 cm	79.74	77.76	90.79	89.49
D ₂ 7.5 cm	79.43	77.33	90.70	89.34
D ₃ 9.0 cm	79.65	77.56	90.70	89.46
S.E. \pm	0.95	0.91	0.61	0.51
C.D. at 5%	NS	NS	NS	NS
Interaction				
V x D (S.E. \pm)	1.90	1.82	1.23	1.02
C.D at 5%	NS	NS	NS	NS
Gen Mean	76.90	77.54	90.73	89.42

Irrigation Depths

During both the years of experimentation, emergence count was not influenced by irrigation depths.

Interaction

Interaction effects were not significant in both the years.

4.1.2 Final plant count

Mean final plant count during 1989 and 1990 was 77.54 and 89.42 per cent respectively.

Varieties

Final plant count was not influenced significantly due to different varieties during both the years, except during 1989, where in there was low final plant count ^(52.92) of variety ICGS-44 because of its low emergence as described earlier.

Irrigation Depths

Different depths of irrigation did not influence final plant count during "both" the years.

Interaction

Interaction effects were not significant in any of the years.

4.2 Biometric growth parameters

4.2.1 Plant height

Data on mean height of plant (in cm) collected at various growth stages are presented in Tables 10 and 11 for 1989 and 1990, respectively.

Table 10. Mean height (cm)/plant as affected by varieties and irrigation depths during 1989

Treatments	Period in days						
	30	45	60	75	90	105	120
Varieties							
V ₁ ICGS-11	5.46	8.36	12.24	14.97	17.43	17.85	18.21
V ₂ ICGS-21	5.37	8.17	11.84	15.49	18.08	18.38	18.68
V ₃ ICGS-44	4.07	7.46	10.72	13.71	16.30	16.88	17.29
V ₄ SB-XI	6.37	11.59	16.12	18.41	20.09	20.52	20.76
S.E. \pm	0.18	0.37	0.39	0.39	0.40	0.37	0.37
C.D. at 5%	0.54	1.08	1.16	1.13	1.18	1.09	1.09
Irrigation Depths							
D ₁ 6.0 cm	5.31	8.68	12.64	15.76	18.22	18.61	18.91
D ₂ 7.5 cm	5.42	8.98	13.03	15.81	17.95	18.93	18.78
D ₃ 9.0 cm	5.21	9.03	12.50	15.35	17.76	18.19	18.51
S.E. \pm	0.16	0.32	0.34	0.33	0.35	0.32	0.32
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS
Interaction							
V \times D. (S.E. \pm)	0.32	0.64	0.69	0.67	0.69	0.65	0.64
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS
Gen. Mean	5.32	8.89	12.73	15.64	17.98	18.41	18.73

Table 11. Mean height (cm)/plant as affected by varieties and irrigation depths during 1990

Treatments	Period in days						
	30	45	60	75	90	105	120
Varieties							
V ₁ ICGS-11	5.95	9.85	14.78	17.21	19.97	20.35	20.55
V ₂ ICGS-21	5.76	9.99	14.96	17.04	18.95	19.42	19.94
V ₃ ICGS-44	5.78	9.47	13.79	16.99	18.29	18.87	19.06
V ₄ SB-XI	5.85	10.80	16.76	20.04	23.52	24.00	24.17
S.E. \pm	0.44	0.42	0.41	0.58	0.38	0.69	0.69
C.D. at 5%	NS	NS	1.19	1.70	1.12	2.04	2.04
Irrigation Depths							
D ₁ 6.0 cm	5.76	10.00	14.97	17.31	19.93	20.46	20.64
D ₂ 7.5 cm	5.83	9.92	15.26	18.07	20.27	20.71	21.10
D ₃ 9.0 cm	5.91	10.15	14.99	18.09	20.35	20.81	21.06
S.E. \pm	0.38	0.36	0.35	0.49	0.32	0.60	0.60
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS
Interaction							
V x D. (S.E. \pm)	0.76	0.73	0.70	0.99	0.65	1.20	1.20
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS
Gen. Mean	5.83	10.03	15.07	17.82	20.18	20.91	20.93

The plant height was found to increase progressively till maturity. The increase was comparatively slow during early period ^(upto 30 days) of crop growth, rapid during 45-90 days, and slow thereafter during both the years. In general, the height was more in second season.

Varieties

The plant height was significantly affected due to different varieties at all stages of growth in first season. In the year 1990, however, differences in plant height were significant only at 60, 75, 90, 105 and harvest.

In first year variety SB-XI recorded significantly higher plant height over all other varieties at all stages of growth. Varieties ICGS-11 and ICGS-21 were statistically at par with each other throughout the growth period, being significantly superior to ICGS-44 at 30 and 75 days whereas they were at par with latter at 45 and 120 days. At 60 days ICGS-11 was significantly superior to ICGS-44 and at subsequent stages of 90 and 105 days, ICGS-21 was significantly taller than ICGS-44. In the year 1990, the differences in plant height were not significant in initial stage upto 45 days, at latter stges SB-XI recorded significantly more plant height as compared to other varieties under test. Amongst other varieties viz,

ICGS-11, ICGS-21 and ICGS-44 were at par with each other at 60, 75, 105 and 120 days. At 90 days, however, ICGS-11 recorded significantly more height *as compared to* ICGS-44, being at par with ICGS-21.

Irrigation Depths

The plant height was not significantly influenced by various depths of irrigation during both the years of experimentation.

Interaction

There was not significant effect of interaction of varieties and irrigation depths on plant height in both years throughout the growth periods.

4.2.2 Number of branches per plant

Data on mean number of branches per plant recorded at various stages in 1989 and 1990 are shown in Tables 12 and 13 respectively. Data revealed that rate of increase in mean number of branches was relatively higher upto 45 days. It was gradual thereafter upto 90 days. Then onwards, mean number of branches remained more or less constant.

Varieties

In 1989, variety SB-XI recorded significantly higher number of branches over other three varieties from 60 days onwards. In initial stage at 30 days it was at par with ICGS-11 and ICGS-21. Both these

Table 12: Mean number of branches/plant as affected by varieties and irrigation depths during 1989

Treatments	Period in days						
	30	45	60	75	90	105	120
Varieties							
V ₁ ICGS-11	2.09	5.11	5.49	7.01	7.66	7.91	8.06
V ₂ ICGS-21	2.17	4.27	5.38	6.19	7.03	7.41	7.70
V ₃ ICGS-44	1.50	2.50	4.15	5.06	6.37	6.89	7.08
V ₄ SB-XI	2.17	3.89	6.18	8.02	8.46	8.84	9.23
S.E. \pm	0.06	0.55	0.12	0.22	0.21	0.18	0.16
C.D. at 5%	0.18	1.62	0.35	0.66	0.63	0.55	0.49
Irrigation Depths							
D ₁ 6.0 cm	1.95	3.79	4.95	6.25	7.09	7.48	7.71
D ₂ 7.5 cm	1.98	3.61	6.01	7.33	7.91	8.27	8.50
D ₃ 9.0 cm	2.01	4.43	4.94	6.13	7.12	7.54	7.82
S.E. \pm	0.05	0.47	0.10	0.19	0.18	0.16	0.14
C.D. at 5%	NS	NS	0.31	0.59	0.55	0.48	0.42
Interaction							
V \times D. (S.E. \pm)	0.10	0.95	0.21	0.39	0.37	0.32	0.29
C.D. at 5%	NS	NS	0.62	NS	NS	NS	0.85
Gen. Mean	1.98	3.94	5.30	6.57	7.38	7.76	8.01

Table 13. Mean number of branches/plant as affected by varieties and irrigation depths during 1990

Treatments	Period in days						
	30	45	60	75	90	105	120
Varieties							
V ₁ ICGS-11	2.07	3.29	4.42	6.14	6.80	7.42	7.42
V ₂ ICGS-21	2.15	3.16	4.03	5.39	6.30	6.65	6.65
V ₃ ICGS-44	2.06	3.54	4.58	6.17	6.86	7.56	7.56
V ₄ SB-XI	2.13	3.47	4.80	6.71	7.35	7.65	7.65
S.E. \pm	0.05	0.13	0.11	0.12	0.18	0.17	0.17
C.D. at 5%	NS	NS	0.32	0.37	0.55	0.50	0.50
Irrigation Depths							
D ₁ 6.0 cm	2.04	3.33	4.52	6.26	6.89	7.43	7.43
D ₂ 7.5 cm	2.15	3.35	4.60	6.24	7.12	7.54	7.54
D ₃ 9.0 cm	2.08	3.42	4.25	5.80	6.48	6.98	6.98
S.E. \pm	0.04	0.11	0.09	0.10	0.16	0.14	0.14
C.D. at 5%	NS	NS	0.28	0.32	0.48	0.43	0.43
Interaction							
V x D. (S.E. \pm)	0.09	0.22	0.19	0.21	0.32	0.30	0.30
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS
Gen. Mean	2.09	3.37	4.46	6.10	6.83	7.32	7.32

varieties were at par in respect of number of branches per plant, throughout the growing period except at 75 days when ICGS-11 recorded significantly more branches when compared with ICGS-21. Variety ICGS-44 recorded significantly lower number of branches as compared to other varieties throughout the growth period, except at 105 days, when it was at par with ICGS-21.

In second year the mean differences in number of branches of different varieties were not significant upto 45 days. At 60 and 75 days SB-XI recorded significantly higher number of branches over rest of the varieties, except ICGS-44 at 60 days, when it was at par with the latter. At later stages from 90 days onwards, ICGS-11, ICGS-44 as well as SB-XI were at par with each other being significantly superior to ICGS-21.

Irrigation Depths

Mean number of branches per plant was not influenced significantly in initial stages upto 45 days due to various irrigation depths. During the first year application of 7.5 cm of irrigation depth significantly enhanced the number of branches per plant as compared to other depths which were at par with each other. In second year of experimentation lower irrigation depths of 6.0 and 7.5 cms were statistically at par with each other from 60 days to 120 days after sowing. The depth of 7.5 cm was

significantly superior to 8.0 cm at all these stages. However, 6.0 cm depth was superior to 8.0 cm at 60, 75, 105 and 120 days, being at par with it only at 90 days.

Interaction

Interaction effects of varieties and irrigation depths were non-significant at different growth stages during both the years except at 60 and 120 days during 1989. The relevant data are presented in Table 14 and 15, respectively.

Table 14. Mean number of branches per plant as influenced by interaction of varieties and irrigation depths at 60 days in 1989.

Varieties/Depths	D ₁ (6.0 cm)	D ₂ (7.5 cm)	D ₃ (9.0 cm)
V ₁ (ICGS-11)	5.33	6.53	4.60
V ₂ (ICGS-21)	5.03	6.47	4.63
V ₃ (ICGS-44)	3.80	4.23	4.43
V ₄ (SB-XI)	5.63	6.80	6.10
S.E. \pm = 0.21		C.D. at 5% = 0.62	

Data presented in Table 14 revealed that under constant depths of 6.0 and 7.5 cm varieties ICGS-11, ICGS-21 and SB-XI were at par with each other and significantly superior to ICGS-44. At higher depth of 9.0 cm, variety SB-XI recorded significantly higher

number of branches over rest of the varieties which were at par. Data would further reveal that varieties ICGS-11, ICGS-21 and SB-XI produced significantly higher number of branches with 7.5 cm irrigation depth as compared to 8.0 cm. Mean number of branches were significantly reduced in all these varieties with highest depth of irrigation (9.0 cm).

Table 15. Mean number of branches per plant as influenced by interaction of varieties and irrigation depths at 120 days in 1989.

Varieties/Depths	D ₁ (6.0 cm)	D ₂ (7.5 cm)	D ₃ (9.0 cm)
V ₁ (ICGS-11)	7.60	8.46	8.10
V ₂ (ICGS-21)	7.30	8.50	7.30
V ₃ (ICGS-44)	7.40	6.83	7.00
V ₄ (SB-XI)	8.56	10.23	8.90
S.E. \pm = 0.29		C.D. at 5 % = 0.85	

It would be evident from data in Table 15 that variety SB-XI produced significantly higher number of branches as compared to rest of the varieties with all the irrigation depths, except variety ICGS-11 with 9.0 cm depth which was at par with the former. It would be further seen that variety ICGS-44 was not significantly influenced by various irrigation depths whereas other varieties produced significantly higher number of

branches with 7.5 cm irrigation depth as compared to 6.0 cm. Further increase in depth of irrigation tended to reduce number of branches per plant, as compared to 7.5 cm depth.

4.2.3 Leaf area in sq cm per plant

Leaf area recorded in sq cm/plant at various stages in both the seasons are shown in Tables 16 and 17 and depicted in fig. 2. In general, increase in leaf area was very slow upto 45 days, fast from 45 to 90 days, marginally increased upto 105 days and decreased thereafter in both the seasons.

Varieties

Mean leaf area was significantly affected by varieties throughout the growth period except at 30 days during first season. Varieties ICGS-11 and ICGS-44 were at par and significantly superior to ICGS-21 and SB-XI. Varieties ICGS-21 and SB-XI were at par with each other from 45 days onwards upto 120 days except at 60 days when former was significantly superior to latter.

During second season, the trend was more or less similar, ICGS-11 and ICGS-44 being at par and significantly superior to other two varieties. The varieties ICGS-21 and SB-XI were at par with each other except at 75, 90 and 105 days when ICGS-21 had produced significantly more leaf area as compared to SB-XI.

Table 16. Mean leaf area in sq cm / plant as affected by varieties and irrigation depths during 1989

Treatments	Period in days						
	30	45	60	75	90	105	120
Varieties							
V ₁ ICGS-11	197	389	1063	1712	2360	2470	2343
V ₂ ICGS-21	188	324	998	1540	2052	2110	1923
V ₃ ICGS-44	208	407	1045	1665	2228	2394	2272
V ₄ SB-XI	179	341	840	1478	1954	2051	1917
S.E. \pm	7	17	31	38	39	48	43
C.D. at 5%	NS	50	92	113	115	141	126
Irrigation Depths							
D ₁ 6.0 cm	193	369	983	1619	2171	2282	2149
D ₂ 7.5 cm	192	362	1087	1704	2230	2361	2209
D ₃ 9.0 cm	192	363	888	1472	2019	2125	1982
S.E. \pm	6	14	27	33	34	41	37
C.D. at 5%	NS	NS	79	97	100	122	109
Interaction							
V x D. (S.E. \pm)	13	29	54	66	68	83	74
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS
Gen. Mean	192	365	986	1598	2144	2256	2113

Table 17. Mean leaf area in sq cm / plant as affected by varieties and irrigation depths during 1990.

Treatments	Period in days						
	30	45	60	75	90	105	120
Varieties							
V ₁ ICGS-11	240	419	1168	1763	2430	2510	2410
V ₂ ICGS-21	212	378	893	1455	2125	2170	2053
V ₃ ICGS-44	265	430	1202	1874	2470	2543	2427
V ₄ SB-XI	189	353	903	1320	1910	1994	1908
S.E. \pm	14	27	37	30	45	38	62
C.D. at 5%	42	80	109	90	132	111	182
Irrigation Depths							
D ₁ 6.0 cm	225	392	1065	1618	2254	2320	2219
D ₂ 7.5 cm	225	399	1048	1731	2359	2432	2333
D ₃ 9.0 cm	228	392	1011	1458	2088	2160	2045
S.E. \pm	12	23	32	26	39	32	53
C.D. at 5%	NS	NS	NS	78	114	96	157
Interaction							
V x D. (S.E. \pm)	25	47	64	53	78	65	107
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS
Gen. Mean	226	394	1041	1602	2233	2304	2199

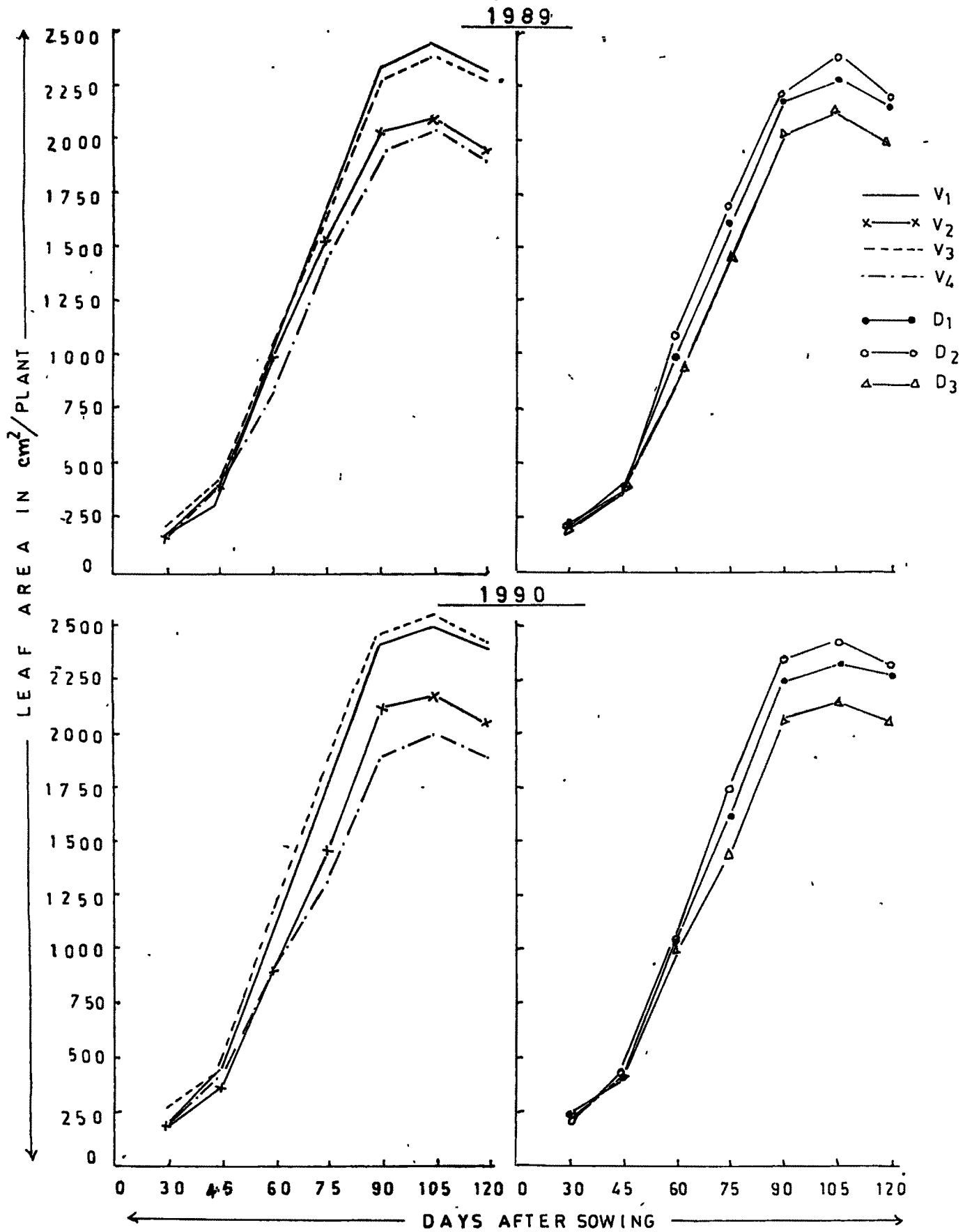


Fig.2. MEAN LEAF AREA cm² PER PLANT UNDER VARIOUS TREATMENTS

Irrigation Depths

During the year 1989, the differences in leaf area/plant were not significant upto 45 days after sowing. From 60 days onwards 6.0 and 7.5 cm irrigation depths were at par with each other and significantly better than 9.0 cm depth in producing leaf area per plant. Both these depths produced significantly higher leaf area than that of 9.0 cm depth.

The differences in leaf area could not reach to the level of significance upto 60 days in the year 1990. At 75 days, 7.5 cm depth recorded significantly more leaf area than that of 6.0 cm. Both these depths were at par with each other from 75 days onwards, producing significantly higher leaf area than that of 9.0 cm depth.

Interaction

At none of the growth stages, in both the years interaction effects were significant.

4.2.4. Number of pods per plant

Data on mean number of pods/plant at various stages for both the seasons are given in Tables 18 and 19. The mean number of pods/plant at 75 days were 13.74 and 18.53 during 1989 and 1990 respectively. At harvest mean number of pods/plant were 18.95 and 26.30 in 1989 and 1990 respectively.

Varieties

The varieties differed significantly amongst themselves in producing mean number of pods/plant from

Table 18. Number of pods/plant as affected by varieties and irrigation depths during 1989.

Treatments	Period in days			
	75	90	105	120
Varieties				
V ₁ ICGS-11	15.83	18.26	19.69	20.98
V ₂ ICGS-21	14.24	16.83	17.51	18.73
V ₃ ICGS-44	13.90	17.01	18.08	19.47
V ₄ SB-XI	11.00	13.76	15.21	16.64
S.E. ±	0.88	0.83	1.50	0.64
C.D. at 5%	2.59	2.45	NS	1.89
Irrigation Depths				
D ₁ 6.0 cm	13.95	16.56	17.76	19.17
D ₂ 7.5 cm	14.85	17.81	19.22	20.55
D ₃ 9.0 cm	12.43	15.04	15.89	17.15
S.E. ±	0.76	0.72	1.29	0.55
C.D. at 5%	NS	2.12	NS	1.63
Interaction				
V × D (S.E.±)	1.53	1.44	2.60	0.11
C.D. at 5%	NS	NS	NS	NS
Gen. Mean	13.74	16.47	17.62	18.95

Table 19. Number of pods/plant as affected by varieties and irrigation depths during 1990.

Treatments	Period in days			
	75	90	105	120
Varieties				
V ₁ ICGS-11	20.87	23.86	26.87	28.56
V ₂ ICGS-21	16.40	19.72	22.66	24.65
V ₃ ICGS-44	21.93	25.28	27.65	29.41
V ₄ SB-XI	14.92	17.97	20.41	22.60
S.E. \pm	0.95	0.59	1.13	0.47
C.D. at 5%	2.80	1.73	3.31	1.39
Irrigation Depths				
D ₁ 6.0 cm	18.81	22.05	24.44	26.58
D ₂ 7.5 cm	20.54	23.28	26.55	28.39
D ₃ 9.0 cm	16.24	19.74	22.20	23.95
S.E. \pm	0.83	0.51	0.97	0.41
C.D. at 5%	2.43	1.50	2.86	1.21
Interaction				
V \times D (S.E. \pm)	1.66	1.02	1.95	0.82
C.D. at 5%	NS	NS	NS	NS
Gen. Mean	18.53	21.70	24.39	26.30

75 days upto harvest in both the years, except, at 105 days after sowing in the 1989. During the year 1989, varieties ICGS-11 and ICGS-44 were at par with each other at 75 and 90 days and at harvest producing significantly more number of pods than that of SB-XI. Both these varieties were at par with ICGS-21 at 60, 75 and 90 days whereas, at harvest ICGS-11 was significantly superior to ICGS-21 which in turn was at par with ICGS-44. Variety ICGS-21 also produced significantly higher number of pods as compared to SB-XI throughout the season.

During the year 1990, varieties ICGS-11 and ICGS-44 were again at par with each other throughout the growth period, being significantly superior to remaining two varieties. Variety ICGS-21 produced significantly more number of pods than that of SB-XI at 90 ^{days} and at harvest, being at par with the same at other growth stages.

Irrigation Depths

The various irrigation depths did not deviated significantly at 75 and 105 days during 1989. At 90 days as well as at harvest depths of 6.0 and 7.5 cm were at par with each other. Application of 7.5 cm depth was significantly superior to 9.0 cm at both these stages, whereas, 6.0 cm was significantly superior to 9.0 cm only at harvest, being at par with it at 90 days. During the year 1990 also 7.5 and 6.0 cm depths

were at par from 75 to 105 days after sowing. At harvest 7.5 cm depth was significantly superior to 9.0 cm depth at all the stages except at 105 days, when 6.0 cm was at par with 9.0 cm.

Interaction

The interaction effects of varieties and irrigation depths were not significant at any of the growth stages during both the years of experimentation.

4.2.5 Number of nodules per plant

Data recorded on mean number of nodules/plant at various stages of crop growth during 1989 and 1990 are presented in Tables 20 and 21 respectively and depicted in fig. 3. Mean number of nodules per plant increased gradually upto 90 days from sowing in both the years when an average number of 130.09 and 133.69 nodules were recorded in 1989 and 1990 respectively. There was gradual decrease in mean number of nodules thereafter upto harvest. Mean number of nodules recorded at harvest in 1989 and 1990 were 77.19 and 81.16 respectively.

Varieties

During the year 1989, varieties ICGS-11 and ICGS-44 were at par with each other and produced significantly higher number of nodules as compared to ICGS-21 and SB-XI throughout the growing season from 45 days onwards. Amongst latter two varieties ICGS-21 was significantly superior to SB-XI at all the stages of crop growth.

Table 20. Mean number of nodules/plant as affected by varieties and irrigation depths during 1989.

Treatments	Period in days						
	30	45	60	75	90	105	120
Varieties							
V ₁ ICGS-11	16.67	31.45	58.20	108.33	147.21	110.22	65.22
V ₂ ICGS-21	15.21	26.24	45.23	92.74	125.31	99.23	78.31
V ₃ ICGS-44	15.75	30.11	56.52	111.66	142.22	108.51	80.13
V ₄ SB-XI	14.97	22.61	38.11	79.52	105.62	92.37	65.20
S.E. ±	0.58	1.16	2.22	2.18	2.24	1.44	1.70
C.D. at 5%	NS	3.40	6.51	6.39	6.57	4.22	4.99
Irrigation Depths							
D ₁ 6.0 cm	15.89	27.10	52.08	101.84	133.72	106.58	79.5
D ₂ 7.5 cm	15.46	28.51	59.21	110.92	145.09	118.66	91.9
D ₃ 9.0 cm	15.59	27.19	37.25	81.42	111.46	82.51	59.3
S.E. ±	0.49	1.00	1.92	1.89	1.95	1.25	1.4
C.D. at 5%	NS	NS	5.63	5.54	5.57	3.67	4.3
Interaction							
V × D. (S.E. ±)	1.02	2.00	3.85	3.78	3.89	2.49	2.94
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS
Gen. Mean	15.65	27.60	49.51	98.06	130.09	102.58	77.1

Table 21. Mean number of nodules/plant as affected by varieties and irrigation depths during 1990.

Treatments	Period in days						
	30	45	60	75	90	105	120
Varieties							
V ₁ ICGS-11	15.11	32.58	59.23	110.34	145.66	103.28	89.54
V ₂ ICGS-21	14.27	30.51	55.42	98.21	119.46	95.30	72.26
V ₃ ICGS-44	15.92	37.22	68.52	123.18	158.73	121.38	95.74
V ₄ SB-XI	13.45	28.24	48.73	85.73	110.81	89.16	67.11
S.E. \pm	0.61	1.11	2.39	2.89	1.48	2.26	3.48
C.D. at 5%	NS	3.26	7.01	8.48	4.34	6.63	10.21
Irrigation Depths							
D ₁ 6.0 cm	14.69	32.27	68.55	107.61	138.53	105.60	84.20
D ₂ 7.5 cm	15.02	31.95	57.91	119.36	150.80	116.13	91.19
D ₃ 9.0 cm	14.34	32.19	47.47	86.12	111.67	85.11	68.10
S.E. \pm	0.53	0.96	2.07	2.50	1.29	1.96	3.02
C.D. at 5%	NS	NS	6.07	7.33	3.78	5.75	8.86
Interaction							
V x D. (S.E. \pm)	1.13	1.91	4.15	5.00	2.57	3.91	6.04
C.D. at 5%	NS	NS	NS	NS	7.54	NS	NS
Gen. Mean	14.69	32.14	57.98	104.36	133.67	102.28	81.16

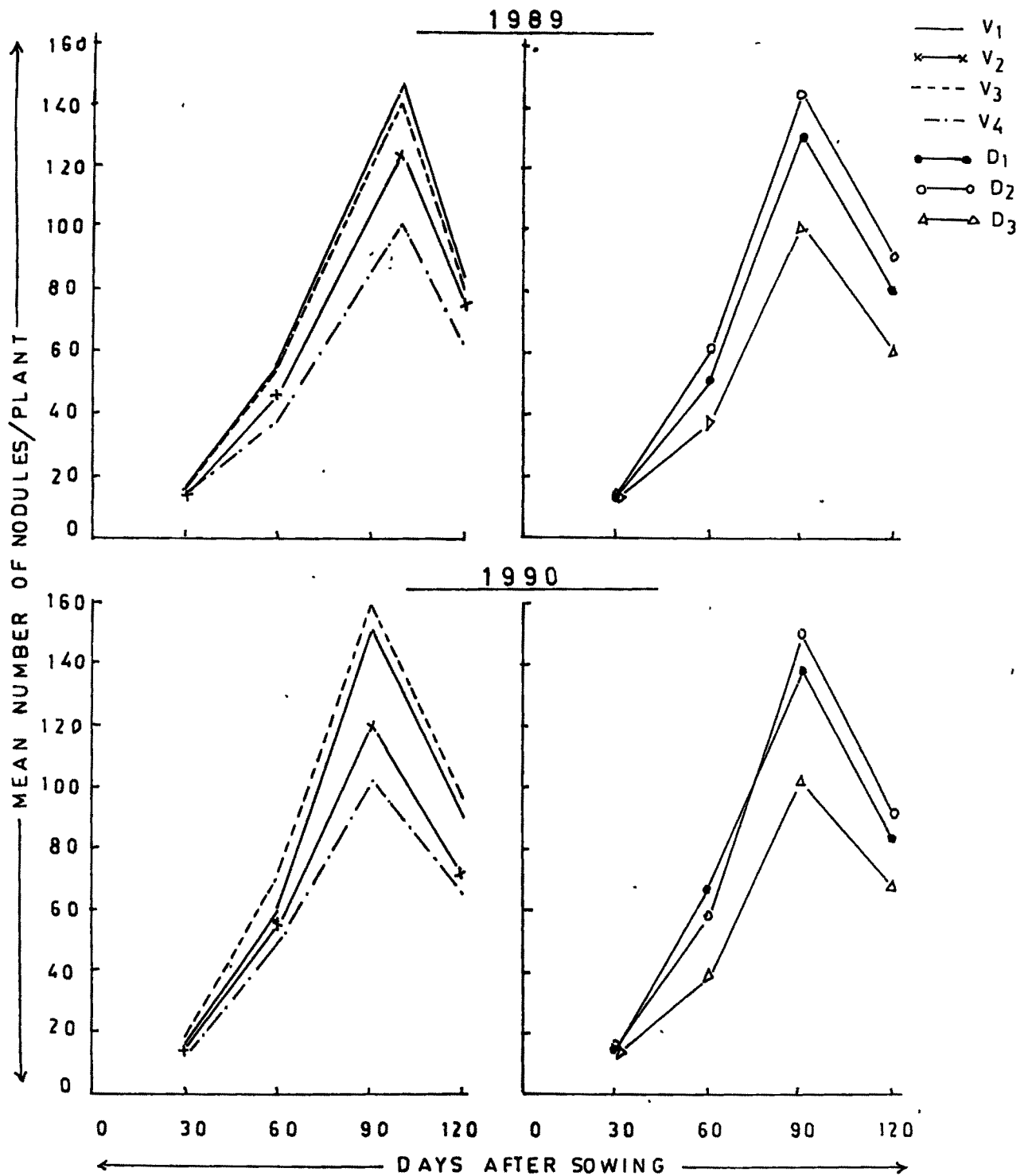


Fig.3. MEAN NUMBER OF NODULES PER PLANT UNDER VARIOUS TREATMENTS

As observed in 1989, during second year also the differences in mean number of nodules per plant reached to the level of significance from 45 days onwards. The data revealed that variety ICGS-44 produced significantly more number of nodules as compared to rest of the varieties except at 120 days when it was at par with ICGS-11. The variety ICGS-11 was at par with ICGS-21 at 60 days after sowing after which mean number of nodules recorded by former were significantly more than latter. However, variety ICGS-21 was at par with SB-XI at 45, 60, 105 and 120 days after sowing.

Irrigation Depths

The mean number of nodules per plant were significantly influenced by various irrigation depths only from 60 days onwards in both the years. In first year of investigation, irrigation depth of 7.5 cm produced significantly higher number of nodules as compared to 6.0 as well as 9.0 cm, throughout the growth period. Amongst latter two treatments, 6.0 cm depth was significantly superior to 9.0 cm.

During second year, at 60 days, lower depth of 6.0 cm produced significantly higher number of nodules per plant as compared to remaining two depths.

From 75 days onwards, the trend was more or less similar to that of earlier year, 7.5 cm producing significantly more nodules as compared to other two depths, except at 120 days, when it was at par with 6.0 cm. Both the lower depths were significantly superior to 9.0 cm throughout growing season in both the years.

Interaction

The interaction effects of varieties and irrigation depths were not significant at any of the growth stages in both the years, except, at 90 days during 1990. The relevant data are presented in Table 22.

Table 22 . Mean number of nodules/plant as influenced by interaction of varieties and irrigation depths at 90 days during 1990.

Varieties/Depths	D ₁ (6.0 cm)	D ₂ (7.5 cm)	D ₃ (8.0 cm)
V ₁ (ICGS-11)	150.11	168.34	118.28
V ₂ (ICGS-21)	120.33	136.87	101.18
V ₃ (ICGS-44)	163.23	180.67	132.34
V ₄ (SB-XI)	120.30	117.30	94.93
S.E. \pm = 2.57		C.D. at 5 % = 7.54	

The data presented in Table 22 revealed that mean number of nodules of all the varieties except SB-XI significantly increased with increase in depth of

irrigation upto 7.5 cm. As regards SB-XI the number of nodules were at par with 6.0 cm as well as 7.5 cm irrigation depth. It will be interesting to note that variety ICGS-44 recorded significantly higher number of nodules at all the irrigation depths as compared to other varieties. This was closely followed by variety ICGS-11. Varieties ICGS-21 and SB -XI were at par with 6.0 and 9.0 cm irrigation depths, former being significantly superior at 7.5 cm depth.

4.2.6 Weight of dry pods per plant

Data on weight of dry pods in g/plant are presented in Tables 23 and 24 for the year 1989 and 1990 respectively. The weight of dry pods was significantly affected due to varieties and irrigation depths throughout the growth period in both the years.

Varieties

Variety ICGS-44 recorded significantly more dry weight of pods at all stages of growth in 1989 over varieties ICGS-21 and SB-XI, however, it was at par with variety ICGS-11 at all stages except at 75 days, where, ICGS-44 recorded significantly higher pod weight over ICGS-11. Variety ICGS-21 was found to be significantly superior to SB-XI, which recorded lowest weight of dry pods at all stages of crop growth. During second year, the trend of weight of pods was

Table 23. Weight of dry pods (g/plant) as affected by varieties and irrigation depths during 1989.

Treatments	Period in days			
	75	90	105	120
Varieties				
V ₁ ICGS-11	10.23	12.54	14.84	16.86
V ₂ ICGS-21	9.10	11.32	12.91	14.63
V ₃ ICGS-44	11.31	12.73	14.58	16.24
V ₄ SB-XI	7.20	8.65	9.63	10.69
S.E. \pm	0.26	0.15	0.19	0.65
C.D. at 5%	0.76	0.44	0.56	1.91
Irrigation Depths				
D ₁ 6.0 cm	9.58	11.83	13.41	14.67
D ₂ 7.5 cm	10.72	12.07	13.57	16.27
D ₃ 9.0 cm	8.09	10.03	11.98	12.88
S.E. \pm	0.22	0.13	0.16	0.56
C.D. at 5%	0.65	0.38	0.47	1.65
Interaction				
V \times D (S.E. \pm)	0.45	0.27	0.33	1.12
C.D. at 5%	1.32	NS	0.97	NS
Gen. Mean	9.46	11.31	12.98	14.61

Table 24. Weight of dry pods (g/plant) as affected by varieties and irrigation depths during 1990.

Treatments	Period, in days			
	75	90	105	120
Varieties				
V ₁ IC68-11	11.34	13.63	16.41	20.49
V ₂ IC68-21	9.58	11.87	13.22	18.08
V ₃ IC68-44	11.72	13.93	16.84	20.68
V ₄ SB-XI	9.37	11.12	13.16	17.43
S.E. \pm	0.17	0.12	0.16	0.53
C.D. at 5%	0.49	0.35	0.47	1.58
Irrigation Depths				
D ₁ 6.0 cm	10.88	13.49	15.95	19.16
D ₂ 7.5 cm	11.56	13.94	16.11	20.78
D ₃ 9.0 cm	9.06	10.48	12.66	17.59
S.E. \pm	0.15	0.10	0.14	0.46
C.D. at 5%	0.44	0.29	0.41	1.36
Interaction				
V x D (S.E. \pm)	0.21	0.20	0.28	0.93
C.D. at 5%	0.85	NS	0.82	NS
Gen. Mean	10.50	12.64	14.91	19.17

similar to that of 1989, except that of weights of 75 days when ICGS-44 and ICGS-11 were at par.

Irrigation Depths

During the year 1989, irrigation depth of 7.5 cm was significantly superior to 6.0 cm at 75 days in recording weight of dry pods. From 90 days onwards upto 120 days both these depths were at par with each other. Both the treatments were significantly superior to higher depth of 9.0 cm except at 75 days when 6.0 cm was at par with 9.0 cm. In the second year of investigation, weights of dry pods were significantly higher due to application of 7.5 cm depth of irrigation as compared to 6.0 and 9.0 cm except at 105 days when 7.5 and 6.0 cm were at par. Application of 6.0 cm depth of irrigation was significantly superior to 9.0 cm at all the stages of crop growth.

Interaction

Interaction effects of varieties and irrigation depths were evident at 75 and 105 days in both the years. The relevant data are given in Tables 25, 26, 27 and 28.

Table 25. Weight of dry pods in g/plant as influenced by interaction of varieties and irrigation depths at 75 days in 1989.

Varieties/Depths	D ₁ (6.0 cm)	D ₂ (7.5 cm)	D ₃ (9.0 cm)
V ₁ (ICGS-11)	10.75	11.62	8.32
V ₂ (ICGS-21)	9.11	10.21	7.98
V ₃ (ICGS-44)	10.73	12.68	10.52
V ₄ (SB-XI)	7.71	8.35	5.54
S.E. ± = 0.45		C.D. at 5 % = 1.32	

Data presented in Table 25 would reveal that weights of dry pods of varieties ICGS-11, ICGS-21 and SB-XI were significantly higher with 6.0 and 7.5 cm depths of irrigation, which were at par with each other, but significantly superior to higher depth of 9.0 cm, however, in ICGS-21, 6.0 and 9.0 cm depths were also at par. Variety ICGS-44 produced significantly higher weights of dry pods with 7.5 cm depth as compared to other two depths which were at par.

Table 26. Weight of dry pods in g/plant as influenced by interaction of varieties and irrigation depths at 105 days in 1989.

Varieties/Depths	D ₁ (6.0 cm)	D ₂ (7.5 cm)	D ₃ (9.0 cm)
V ₁ (ICGS-11)	15.13	15.62	13.77
V ₂ (ICGS-21)	13.12	13.52	12.09
V ₃ (ICGS-44)	15.66	14.93	13.15
V ₄ (SB-XI)	9.74	10.21	8.94
S.E. ± = 0.33		C.D. at 5 % = 0.97	

Data would reveal that in case of all the varieties higher irrigation depth of 9.0 cm significantly reduced the weight of dry pods as compared to lower depths of 6.0 and 7.5 cm, which were at par.

Table 27. Weight of dry pods in g/plant as influenced by interaction of varieties and irrigation depths at 75 days in 1990.

Varieties/Depths	D ₁ (6.0 cm)	D ₂ (7.5 cm)	D ₃ (9.0 cm)
V ₁ (ICGS-11)	11.51	12.62	9.89
V ₂ (ICGS-21)	9.86	10.42	8.46
V ₃ (ICGS-44)	11.67	12.73	10.76
V ₄ (SB-XI)	10.51	10.47	7.13
S.E. ± = 0.29		C.D. at 5% = 0.85	

The data would reveal that varieties ICGS-11 and ICGS-44 recorded significantly higher weight of dry pods with irrigation depth of 7.5 cm as compared to 6.0 and 9.0 cm. Amongst latter two depths, 6.0 cm was significantly superior to 9.0 cm. As regards ICGS-21 and SB-XI, it was found that lower irrigation depth of 6.0 and 7.5 cm were at par and significantly superior to 9.0 cm.

Table 28: Weight of dry pods in g/plant as influenced by interaction of varieties and irrigation depths at 105 days in 1990.

Varieties/Depths	D ₁ (6.0 cm)	D ₂ (7.5 cm)	D ₃ (9.0 cm)
V ₁ (ICGS-11)	17.28	17.91	14.04
V ₂ (ICGS-21)	14.15	14.83	10.68
V ₃ (ICGS-44)	17.75	17.43	15.34
V ₄ (SB-XI)	14.63	14.27	10.58
S.E. \pm = 0.28	C.D. at 5 % = 0.82		

Data presented in Table 28 indicated that all the varieties under investigation recorded lowest weight of dry pods with 9.0 cm of irrigation depth. It was further revealed that under constant depths of 6.0 and 7.5 cms, variety ICGS-11 and ICGS-44 recorded significantly higher weight of dry pods as compared to other two varieties, being at par with each other. Varieties ICGS-21 and SB-XI were at par with each other under these two irrigation depths. Variety ICGS-44 recorded significantly higher yield of dry pods as compared to rest of the varieties with 9.0 cm irrigation depth.

4.2.7 Total dry matter (g) per plant

Data on mean total dry matter weight in g/plant at various growth stages in both the years are presented in Tables 29 and 30 and depicted in fig. 4. It is seen from the data that the total dry matter/plant was found to increase continuously with

Table 29. Mean total dry matter per plant (g) as affected by varieties and irrigation depths during 1989

Treatments	Period in days						
	30	45	60	75	90	105	120
Varieties							
V ₁ ICGS-11	2.02	4.32	9.27	20.07	25.77	28.75	29.81
V ₂ ICGS-21	1.99	4.03	8.48	17.76	21.60	24.73	25.75
V ₃ ICGS-44	2.08	4.90	10.76	21.28	26.83	29.93	32.94
V ₄ SB-XI	2.09	3.89	8.67	17.87	22.56	24.55	25.52
S.E. \pm	0.08	0.42	0.36	0.86	1.05	0.94	0.64
C.D. at 5%	NS	NS	NS	2.52	3.08	2.76	1.88
Irrigation Depths							
D ₁ 6.0 cm	2.04	4.40	9.33	19.46	24.47	27.48	28.64
D ₂ 7.5 cm	2.03	4.44	9.81	20.13	25.03	28.04	29.67
D ₃ 9.0 cm	2.08	3.98	8.76	18.14	22.11	25.45	27.21
S.E. \pm	0.07	0.37	0.52	0.75	0.91	0.81	0.56
C.D. at 5%	NS	NS	NS	NS	2.65	2.38	1.64
Interaction							
V x D. (S.E. \pm)	0.13	0.73	1.04	1.49	1.81	1.63	1.11
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS
Gen. Mean	2.05	4.28	9.29	19.24	24.05	26.99	28.51

Table 30. Mean total dry matter per plant (g) as affected by varieties and irrigation depths during 1990.

Treatments	Period in days						
	30	45	60	75	90	105	120
Varieties							
V ₁ ICGS-11	1.87	5.08	10.57	22.05	28.22	30.76	32.26
V ₂ ICGS-21	1.88	4.90	8.97	19.65	24.77	26.01	27.63
V ₃ ICGS-44	1.98	5.17	11.17	22.13	30.09	31.59	33.11
V ₄ SB-XI	1.85	4.94	8.34	18.29	23.85	25.01	25.89
S.E. \pm	0.06	0.21	0.31	0.70	0.44	0.48	0.31
C.D. at 5%	NS	NS	0.91	2.05	1.29	1.41	0.91
Irrigation Depths							
D ₁ 6.0 cm	1.88	5.04	10.15	21.76	26.94	27.48	30.41
D ₂ 7.5 cm	1.85	5.07	10.11	21.18	28.15	25.15	31.19
D ₃ 9.0 cm	1.98	4.95	9.03	18.66	25.11	26.17	27.57
S.E. \pm	0.05	0.18	0.27	0.61	0.38	0.41	0.27
C.D. at 5%	NS	NS	0.79	1.79	1.12	1.21	0.79
Interaction							
V \times D. (S.E. \pm)	0.10	0.37	0.54	1.21	0.76	0.82	0.54
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS
Gen. Mean	1.89	5.02	9.76	20.53	26.73	28.34	29.72

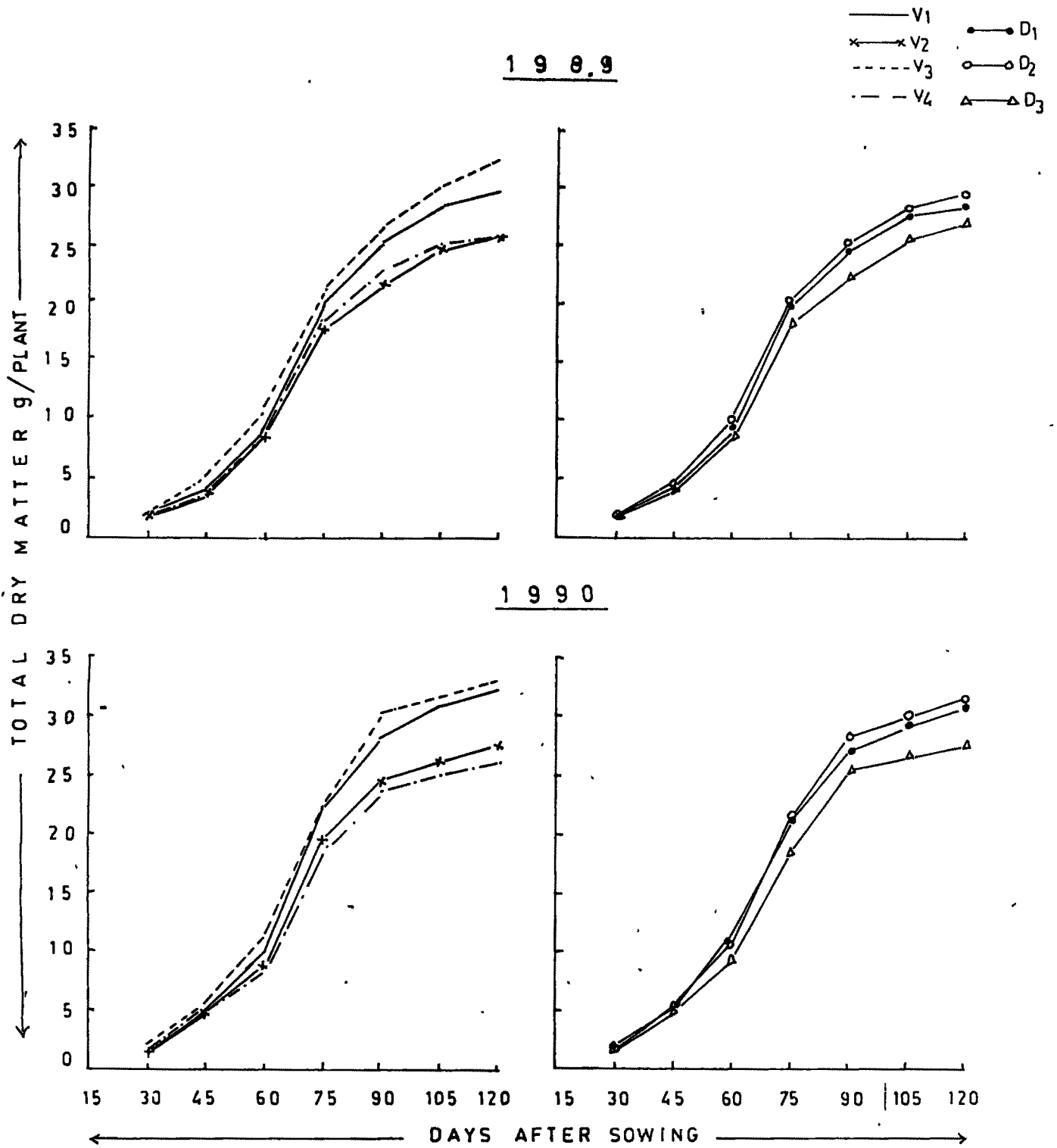


Fig.4. TOTAL DRY MATTER, g/PLANT AS INFLUENCED BY VARIETIES AND IRRIGATION DEPTHS

advancement of age of the crop. The rate of growth was slow upto 60 days, fast during 60 to 90 days and slow thereafter upto maturity in both the seasons. Mean total dry matter per plant recorded during 1989 and 1990 was 28.51 and 29.72 g, respectively, *at 120 days.*

Varieties

The dry matter accumulated by various varieties deviated significantly from 75 days onwards in 1989, when it was observed that varieties ICGS-44 and ICGS-11 produced significantly higher dry matter per plant as compared to remaining two varieties from 75 to 105 days. At 120 days, however, ICGS-44 was significantly superior to ICGS-11, ICGS-21 as well as SB-XI. Latter two varieties were at par throughout the growth period.

During 1990, pattern of dry matter accumulation was more or less similar, varieties ICGS-44 and ICGS-11 were at par with each other throughout the growth period from 60 days onwards, except at 90 days when ICGS-44 was significantly superior to ICGS-11. Both these varieties were significantly efficient in dry matter production as compared to remaining two varieties at all the stages of growth. Similarly variety ICGS-21 produced significantly higher dry matter than that of SB-XI.

Irrigation Depths

In first year of experimentation dry matter accumulation due to application of various irrigation depths did not reach to the level of significance upto 75 days after sowing. From 90 days onwards upto 120 days, lower irrigation depths of 6.0 and 7.5 cm were at par with each other. Depth of 7.5 cm was significantly superior to 9.0 cm, whereas 6.0 and 9.0 cm irrigation depths were at par at all these stages.

During second season of 1990, differences of dry matter accumulation due to different depths were not significant upto 45 days. From 60 days onwards dry matter production due to application of 6.0 and 7.5 cm irrigation depths was statistically at par throughout the growing season except at 90 days when dry matter production due to 7.5 cm irrigation depth was significantly more as compared to that of 6.0 cm. Both these treatments were significantly superior to higher irrigation depth of 9.0 cm at all the growth stages.

Interaction

The interaction effects of varieties and irrigation depths were not significant at any of the growth stages during either of the years.

4.3 Growth analysis

4.3.1 Absolute growth rate (height)

Mean values of absolute growth rate (AGR) of height in cm/day/plant obtained at various stages of

growth in both the seasons are presented in Table 31. Data were not analysed statistically. The inferences are based on the mean values. During both the years of experimentation the AGR (height) increased rapidly and reached its maximum between 46-60 days i.e. 0.255 and 0.336 cm/day/plant in 1989 and 1990 respectively. It slowed after 60 days in both the years.

Varieties

From the data it would be observed that during 1989 differences in mean value of AGR (height) of different varieties were conspicuous upto 60 days. Variety SB-XI recorded higher AGR followed by ICGS-11, ICGS-21 and ICGS-44. The trend was different at subsequent stages, varieties ICGS-21, ICGS-44 and ICGS-11 recorded higher mean values in that order as compared to SB-XI.

In second year i.e. 1990 also the pattern of mean AGR values at various stages of different varieties was more or less similar, except that AGR of SB-XI continued to be higher upto 90 days.

Irrigation Depths

The differences of mean AGR values due to different irrigation depths were marginal in both the years of experimentation.

4.3.2 Absolute growth rate (dry matter)

Mean values of AGR (dry matter) per plant in g/day/plant obtained at various stages in both the years are presented in Table 32. The data in Table 32

Table 31. Mean absolute growth rate (height) in cm/day/plant as influenced by varieties and irrigation depths.

Treatments	Period in days						
	0-30	31-45	46-60	61-75	76-90	91-105	106-120
1989							
Varieties							
V ₁ ICGS-11	0.186	0.193	0.259	0.182	0.164	0.028	0.024
V ₂ ICGS-21	0.179	0.186	0.245	0.243	0.173	0.020	0.020
V ₃ ICGS-44	0.136	0.226	0.217	0.199	0.173	0.038	0.027
V ₄ SB-XI	0.212	0.348	0.308	0.153	0.112	0.029	0.016
Irrigation Depths							
D ₁ 6.0 cm	0.177	0.225	0.264	0.208	0.164	0.026	0.020
D ₂ 7.5 cm	0.181	0.237	0.270	0.185	0.143	0.032	0.023
D ₃ 9.0 cm	0.174	0.255	0.231	0.190	0.161	0.029	0.021
Gen. Mean	0.178	0.239	0.255	0.194	0.156	0.029	0.022
1990							
Varieties							
V ₁ ICGS-11	0.198	0.260	0.329	0.162	0.184	0.025	0.013
V ₂ ICGS-21	0.192	0.282	0.331	0.139	0.127	0.031	0.035
V ₃ ICGS-44	0.193	0.246	0.288	0.213	0.087	0.039	0.013
V ₄ SB-XI	0.195	0.330	0.397	0.291	0.232	0.032	0.011
Irrigation Depths							
D ₁ 6.0 cm	0.192	0.283	0.331	0.156	0.175	0.035	0.012
D ₂ 7.5 cm	0.194	0.273	0.356	0.187	0.147	0.079	0.026
D ₃ 9.0 cm	0.197	0.283	0.323	0.207	0.151	0.031	0.017
Gen. Mean	0.194	0.241	0.336	0.183	0.157	0.048	0.018

Table 32. Mean absolute growth rate (dry matter) in g/day/plant as influenced by varieties and irrigation depths

Treatments	Period in days						
	0-30	31-45	46-60	61-75	76-90	91-105	106-120
1989							
Varieties							
V ₁ ICGS-11	0.067	0.153	0.330	0.720	0.380	0.198	0.071
V ₂ ICGS-21	0.066	0.137	0.297	0.619	0.256	0.209	0.068
V ₃ ICGS-44	0.069	0.188	0.391	0.701	0.370	0.206	0.200
V ₄ SB-XI	0.069	0.120	0.319	0.613	0.313	0.134	0.065
Irrigation Depths							
D ₁ 6.0 cm	0.068	0.157	0.329	0.675	0.334	0.201	0.077
D ₂ 7.5 cm	0.067	0.161	0.358	0.688	0.327	0.200	0.109
D ₃ 9.0 cm	0.069	0.127	0.319	0.625	0.265	0.223	0.117
Gen. Mean	0.067	0.149	0.335	0.663	0.321	0.196	0.101
1990							
Varieties							
V ₁ ICGS-11	0.062	0.214	0.366	0.765	0.411	0.169	0.100
V ₂ ICGS-21	0.063	0.201	0.271	0.712	0.341	0.083	0.108
V ₃ ICGS-44	0.066	0.213	0.400	0.731	0.531	0.100	0.101
V ₄ SB-XI	0.062	0.206	0.227	0.663	0.371	0.077	0.059
Irrigation Depths							
D ₁ 6.0 cm	0.063	0.211	0.341	0.774	0.345	0.130	0.101
D ₂ 7.5 cm	0.062	0.215	0.336	0.738	0.465	0.121	0.082
D ₃ 9.0 cm	0.063	0.204	0.272	0.642	0.430	0.071	0.092
Gen. Mean	0.063	0.209	0.316	0.715	0.413	0.107	0.092

would indicate that during first 30 days the dry matter accumulation by groundnut was meagre in both the seasons. The rate of dry matter accumulation increased from 31 days onwards and was maximum between 61 and 75 days. It marginally decreased during next 15 days while from 91 days onwards the rate of dry matter accumulation was again very less.

Varieties

It would be seen from data presented in Table 32 that during 1989, there was practically no difference in dry matter accumulation by different varieties. From 31 days onwards upto 90 days varieties ICGS-44 and ICGS-11 recorded considerably higher dry matter accumulation rate as compared to other two varieties. The differences in the rate of dry matter accumulation by these varieties i.e. ICGS-44 and ICGS-11 were marginal. Similarly varieties ICGS--21 and SB-XI deviated marginally, former showing slightly higher dry matter accumulation than latter.

Unlike the trend of 1989, during 1990 there was not much difference in the rate of dry matter accumulation by different varieties upto 45 days after sowing. However, ICGS-44 and ICGS-11 were marginally superior between 31 and 45 days. From 46 days onwards the pattern of dry matter accumulation by different varieties was broadly similar to that observed during first year.

Irrigation Depths

In both the seasons, different irrigation depths did not influence the rate of dry matter accumulation in first 30 days. From then onwards upto 105 days lower irrigation depths of 6.0 and 7.5 cm recorded higher rate of dry matter accumulation as compared to 9.0 cm. The rate of dry matter accumulation towards maturity i.e. between 106 and 120 days was very less and inconsistent.

4.3.3 Relative growth rate (dry matter)

From the data presented in Table 33 it would be seen that mean RGR was very less during first 31 and 45 days, recording 0.490 and 0.653 g/g/day during 1989 and 1990, respectively. The values of RGR continued to be substantially high and more or less stable between 46 and 60 days as well as between 61-75 days. There was drastic reduction in RGR during subsequent stages.

Varieties

In both the years of experimentation, different varieties did not showed much difference in RGR values upto 30 days. During the year 1989 varieties ICGS-44 and ICGS-11 recorded relatively higher RGR between 31 and 45 days, while during next stage between 46 and 60 days SB-XI recorded higher RGR followed by ICGS-44 and ICGS-11. It will be interesting to note that ICGS-11

Table 33. Mean relative growth rate (dry matter) in g/g/day as influenced by varieties and irrigation depths

Treatments	Period in days							
	0-30	31-45	46-60	61-75	76-90	91-105	106-120	
1989								
Varieties								
V ₁ ICGS-11	0.0234	0.0507	0.0509	0.0515	0.0167	0.0072	0.0024	
V ₂ ICGS-21	0.0229	0.0470	0.0496	0.0493	0.0130	0.0090	0.0027	
V ₃ ICGS-44	0.0244	0.0571	0.0524	0.0455	0.0155	0.0073	0.0064	
V ₄ SB-XI	0.0246	0.0414	0.0534	0.0482	0.0155	0.0056	0.0026	
Irrigation Depths								
D ₁ 6.0 cm	0.0248	0.0512	0.0501	0.0490	0.0152	0.0077	0.0028	
D ₂ 7.5 cm	0.0236	0.0522	0.0523	0.0479	0.0145	0.0076	0.0038	
D ₃ 9.0 cm	0.0243	0.0436	0.0526	0.0485	0.0132	0.0094	0.0045	
Gen. Mean	0.0240	0.0490	0.0516	0.0486	0.0148	0.0077	0.0036	
1990								
Varieties								
V ₁ ICGS-11	0.0209	0.0666	0.0488	0.0490	0.0164	0.0057	0.0031	
V ₂ ICGS-21	0.0210	0.0638	0.0403	0.0522	0.0154	0.0033	0.0040	
V ₃ ICGS-44	0.0228	0.0639	0.0514	0.0456	0.0205	0.0032	0.0031	
V ₄ SB-XI	0.0205	0.0655	0.0349	0.0524	0.0177	0.0032	0.0023	
Irrigation Depths								
D ₁ 6.0 cm	0.0210	0.0657	0.0467	0.0508	0.0142	0.0047	0.0034	
D ₂ 7.5 cm	0.0205	0.0672	0.0460	0.0493	0.0189	0.0042	0.0027	
D ₃ 9.0 cm	0.0212	0.0462	0.0401	0.0484	0.0198	0.0028	0.0035	
Gen. Mean	0.0212	0.0653	0.0440	0.0497	0.0176	0.0039	0.0032	

recorded consistently higher RGR between 31 and 75 days. The pattern of RGR values was inconsistent from 76 days onwards.. In second year of experimentation ICGS-11 and SB-XI recorded higher RGR than other two varieties. Subsequently the trend was not consistent.

Irrigation Depths

From the data it would be revealed that the differences in RGR values of 6.0 and 7.5 cm of irrigation depths were marginal and both these treatments have recorded higher RGR values upto 90 days in 1989 and upto 75 days in the year 1990. The RGR values due to different irrigation depths did not follow any specific pattern from then onwards.

4.3.4 Net assimilation rate (NAR)

Mean values of NAR computed from the data on total dry matter in g per plant and leaf area in sq cm per plant at various stages of growth are presented in Table 34 for both the years.

The rate of net assimilation was relatively higher from 31 to 75 days in both the seasons and slowed thereafter upto maturity in both the years of experimentation. Treatment effects were not consistent at various stages in both the years.

4.3.5 Leaf area index

Data on mean leaf area index (LAI) at various stages in both the years are presented in Table 35. Leaf area index was smaller upto 45 days, increased

Table 34. Net assimilation rate (NAR) as influenced by varieties and irrigation depths.

Treatments	Period in days						
	0-30	31-45	46-60	61-75	76-90	91-105	106-120
1989							
Varieties							
V ₁ ICBS-11	0.0018	0.0005	0.0005	0.0005	0.0001	0.00008	-0.00002
V ₂ ICBS-21	0.0018	0.0005	0.0004	0.0004	0.0001	0.00010	-0.00003
V ₃ ICBS-44	0.0017	0.0006	0.0005	0.0005	0.0001	0.00008	-0.00005
V ₄ SB-XI	0.0019	0.0004	0.0005	0.0005	0.0001	0.00006	-0.00003
Irrigation Depths							
D ₁ 6.0 cm	0.0018	0.0005	0.0005	0.0005	0.0001	0.00009	-0.00003
D ₂ 7.5 cm	0.0018	0.0006	0.0005	0.0005	0.0001	0.00008	-0.00004
D ₃ 9.0 cm	0.0019	0.0004	0.0005	0.0005	0.0001	0.00010	-0.00005
Gen. Mean	0.00180	0.00050	0.00048	0.00048	0.00010	0.00008	-0.00003
1990							
Varieties							
V ₁ ICBS-11	0.0014	0.0006	0.0005	0.0005	0.00019	0.00006	-0.00004
V ₂ ICBS-21	0.0015	0.0007	0.0004	0.0006	0.00019	0.00004	-0.00005
V ₃ ICBS-44	0.0014	0.0006	0.0005	0.0004	0.00024	0.00004	-0.00004
V ₄ SB-XI	0.0015	0.0007	0.0004	0.0005	0.00018	0.00004	-0.00004
Irrigation Depths							
D ₁ 6.0 cm	0.0015	0.0007	0.0005	0.0005	0.00018	0.00005	-0.00004
D ₂ 7.5 cm	0.0015	0.0007	0.0005	0.0005	0.00023	0.00005	-0.00003
D ₃ 9.0 cm	0.0015	0.0006	0.0004	0.0005	0.00024	0.00003	-0.00004
Gen. Mean	0.00150	0.00066	0.00046	0.00051	0.00021	0.00004	-0.00003

Table 35. Mean leaf area index (LAI) as influenced by varieties and irrigation depths

Treatments	Period in days						
	30	45	60	75	90	105	120
1989							
Varieties							
V ₁ ICGS-11	0.437	0.864	2.362	3.804	5.244	5.489	5.207
V ₂ ICGS-21	0.418	0.720	2.218	3.422	4.560	4.689	4.273
V ₃ ICGS-44	0.462	0.904	2.322	3.700	4.951	5.320	5.049
V ₄ SB-XI	0.398	0.758	1.867	3.284	4.342	4.558	4.260
Irrigation Depths							
D ₁ 6.0 cm	0.429	0.820	2.184	3.598	4.824	5.071	4.776
D ₂ 7.5 cm	0.427	0.804	2.416	3.787	4.956	5.247	4.909
D ₃ 9.0 cm	0.427	0.807	1.973	3.271	4.722	4.722	4.404
Gen. Mean	0.428	0.811	2.192	3.552	4.799	5.014	4.697
1990							
Varieties							
V ₁ ICGS-11	0.533	0.931	2.596	3.918	5.400	5.578	5.356
V ₂ ICGS-21	0.471	0.840	1.984	3.233	4.722	4.822	4.562
V ₃ ICGS-44	0.589	0.956	2.671	4.164	5.489	5.651	5.393
V ₄ SB-XI	0.420	0.784	2.007	2.933	4.244	4.431	4.240
Irrigation Depths							
D ₁ 6.0 cm	0.500	0.871	2.367	3.596	5.009	5.156	4.931
D ₂ 7.5 cm	0.500	0.887	2.329	3.847	5.242	5.404	5.184
D ₃ 9.0 cm	0.507	0.871	2.247	3.240	4.640	4.800	4.544
Gen. Mean	0.503	0.877	2.314	3.562	4.964	5.120	4.887

subsequently upto 105 days and slightly decreased at 120 days.

Varieties

In the year 1989, upto 30 days all the varieties recorded more or less similar LAI. From 45 days onwards upto harvest, varieties ICGS-44 and ICGS-11 recorded higher leaf area index over ICGS-21 and SB-XI. In the second year of experimentation i.e. 1990, varieties ICGS-44 and ICGS-11 appeared superior over rest of the varieties throughout the crop growth stages.

Irrigation Depths

Application of different irrigation depths also influenced LAI. Lower irrigation depths of 6.0 and 7.5 cm resulted in improved leaf area index throughout the growth period except at 30 and 45 days during both the years of experimentation.

4.4 Yield Studies

Considering the inconsistent performance of variety ICGS-44 in two seasons, as explained in earlier chapter, the experiment was continued for one more year to study the performance in respect of yield. Data collected on yield of dry pods, dry haulms, harvest index and biological yield are presented in Table 36. Data on dry pods and dry haulms are depicted in fig.s 5 and 6.

Table 36. Yield studies

Treatments	Dry pod yield (q/ha)				Dry hauls yield (q/ha)				Biological yield (q/ha)		Harvest index	
	1989	1990	1991	Pooled	1989	1990	1991	Pooled	1989	1990	1989	1990
Varieties												
V ₁ ICGS-11	32.29	34.43	24.74	30.49	52.66	60.49	47.26	53.47	84.95	94.90	0.380	0.351
V ₂ ICGS-21	27.87	31.65	23.98	27.83	45.76	52.33	48.86	48.99	73.61	83.96	0.378	0.376
V ₃ ICGS-44	19.02	35.41	26.31	26.91	35.96	57.06	49.83	47.62	54.97	92.36	0.349	0.381
V ₄ SB-XI	19.67	27.48	24.36	23.84	44.55	49.35	55.62	49.73	64.23	76.79	0.305	0.357
S. E. \pm	1.23	1.06	0.37	1.39	1.80	1.52	1.42	0.96	2.02	1.60	0.014	0.010
C.D. at 5%	3.60	3.11	1.09	4.07	5.28	4.45	4.16	2.71	5.92	4.69	0.041	NS
Irrigation Depths												
D ₁ 6.0 cm	24.95	33.44	27.05	27.99	43.05	56.73	49.67	49.82	67.99	90.10	0.366	0.361
D ₂ 7.5 cm	27.75	35.01	25.03	29.28	49.29	56.03	51.84	52.31	77.02	91.02	0.356	0.385
D ₃ 9.0 cm	21.44	28.24	22.48	24.02	41.87	51.66	49.76	47.73	63.30	79.91	0.337	0.353
S.E. \pm	1.06	0.92	0.32	1.20	1.56	1.31	1.23	0.83	1.75	1.39	0.012	0.009
C.D. at 5%	3.10	2.70	0.94	3.51	4.57	3.84	NS	2.34	5.13	4.07	NS	NS
Interaction												
V x D (S.E. \pm)	2.13	1.84	0.65	2.40	3.13	2.63	2.45	1.66	3.50	2.78	0.024	0.018
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Gen. Mean	24.71	32.23	24.85	27.19	44.73	54.80	50.40	49.92	69.43	87.00	0.353	0.366

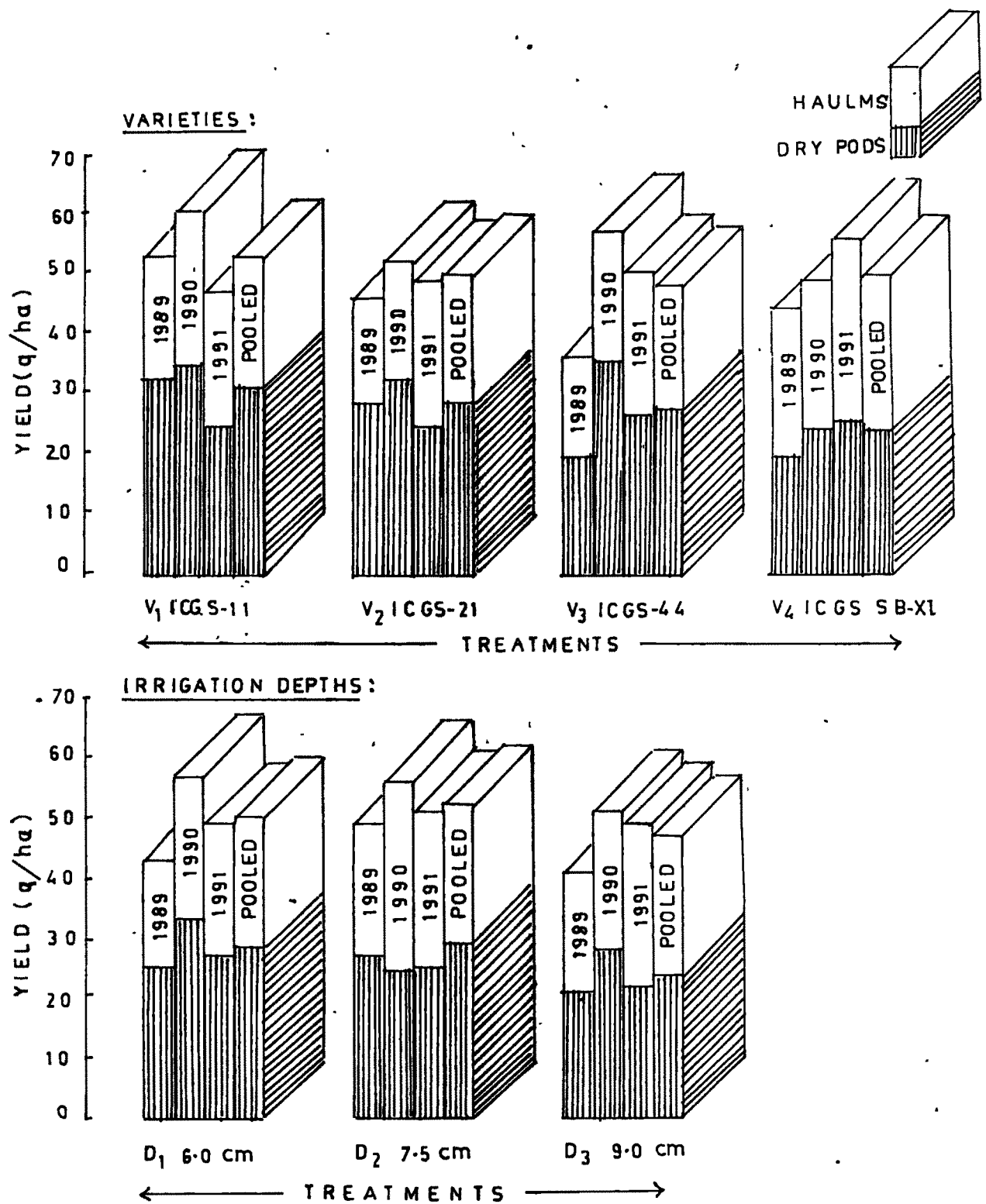


Fig.5. YIELD OF DRY PODS AND HAULMS IN q/ha AS INFLUENCED BY VARIETIES AND IRRIGATION DEPTHS

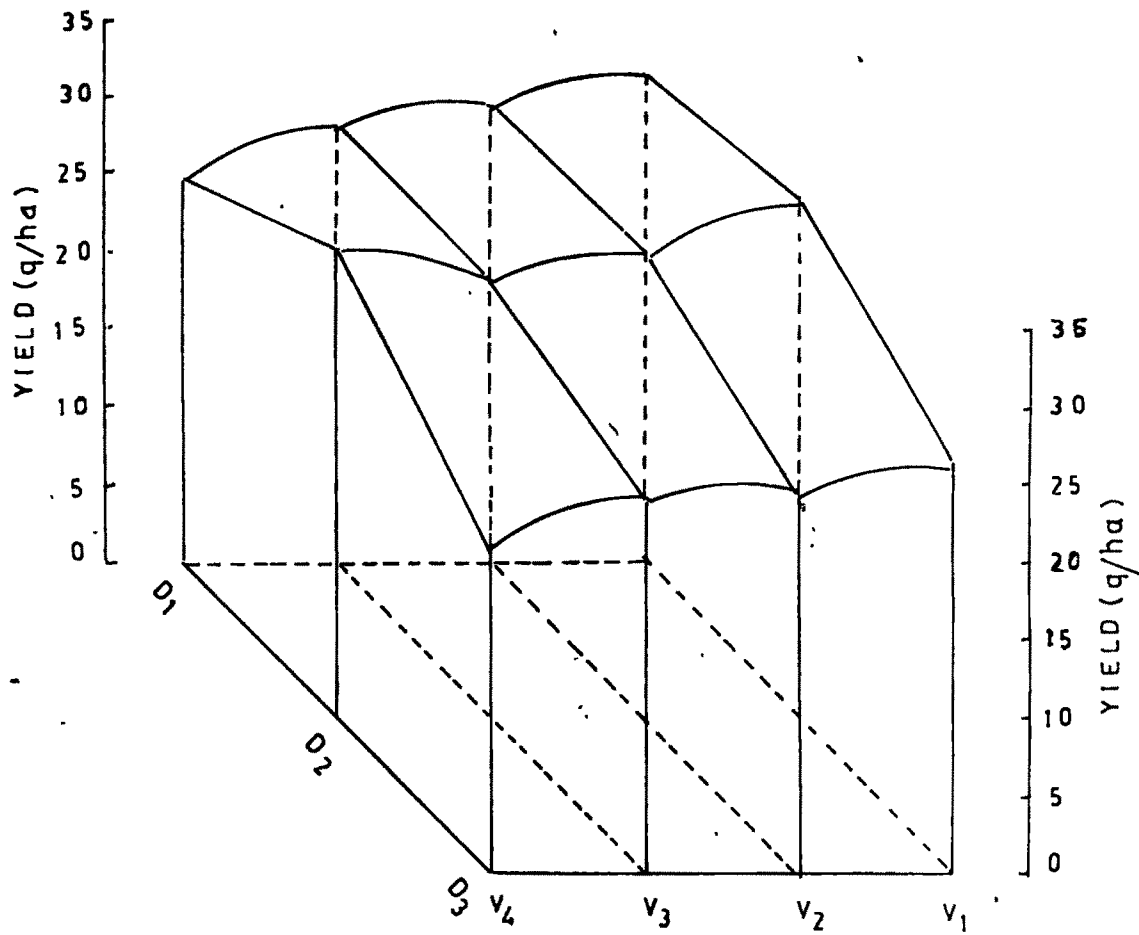


Fig.6. POOLED DRY POD YIELD AS INFLUENCED BY INTERACTION OF VARIETIES AND IRRIGATION DEPTHS

4.4.1 Yield of dry pods

The mean yield of dry pods during 1989, 1990, 1991 and pooled data was 24.71, 32.23, 24.65 and 27.19 q/ha respectively.

Varieties

Data in Table 36 revealed that dry pod yield was significantly affected by varieties in all the years of experimentation as well as in pooled. In first season variety ICGS-11 produced significantly higher pod yield over ICGS-21, ICGS-44 and SB-XI. Variety ICGS-21 occupied second position and it was significantly superior to ICGS-44 and SB-XI, which were at par with each other. In second year of experimentation variety ICGS-44 recorded significantly higher pod yield over ICGS-21 and SB-XI and it was at par with variety ICGS-11. Varieties ICGS-11 and ICGS-21 were also at par and significantly superior to variety SB-XI.

In the third year of experimentation variety ICGS-44 recorded significantly higher dry pod yield over varieties ICGS-11, ICGS-21 and SB-XI, which were at par with each other. Pooled results indicated that variety ICGS-11 proved significantly superior to SB-XI and at par with ICGS-21 and ICGS-44. Pod yield recorded by variety SB-XI was significantly lower than that of other three varieties.

Irrigation Depths

Different irrigation depths also affected dry pod yield in all the years of experimentation as well as in pooled data. Irrigation depth of 6.0 cm and 7.5 cm recorded significantly higher dry pod yield over 9.0 cm and were at par with each other in all the years as well as in pooled data except in 1991, when irrigation depth of 6.0 cm proved significantly superior over 7.5 cm and 9.0 cm irrigation depths.

Interaction

Interaction effects of varieties and irrigation depths were found to be non-significant in individual year as well as in pooled results.

4.4.2 Yield of dry haulms

Data on dry haulms yield are given in Table 36. Data revealed that haulm yield was significantly affected due to varieties during all the three seasons. It was influenced significantly due to various depths of irrigation only during first two years. The mean yield of haulms in 1989, 1990, 1991 and in pooled was 44.73, 54.80, 50.40 and 49.92 q/ha respectively.

Varieties

In the year 1989, variety ICGS-11 produced significantly higher haulm yield over ICGS-21, ICGS-44 and SB-XI. Varieties, ICGS-21 and SB-XI were at par and superior to ICGS-44. In the second year varieties ICGS-11

and ICGS-44 were at par and significantly superior to ICGS-21 and SB-XI, which were at par with each other. In the year 1991, variety SB-XI recorded significantly higher dry haulm yield over rest of the varieties i.e. ICGS-11, ICGS-21 and ICGS-44 which were at par with each other. In pooled analysis, variety ICGS-11 recorded highest dry haulms yield and was significantly superior to other varieties. However, varieties ICGS-21, ICGS-44 and SB-XI were at par with each other.

Irrigation Depths

During first year of experimentation irrigation depth of 7.5 cm produced significantly higher haulms yield over 6.0 and 9.0 cm depths, which were at par with each other. In second year, lower irrigation depths of 6.0 and 7.5 cm were at par and significantly superior to higher depth of 9.0 cm. In pooled analysis it was observed that irrigation depth of 7.5 cm produced significantly higher dry haulms yield over 6.0 and 9.0 cm depths. Irrigation depths of 6.0 and 9.0 cm were at par with each other.

Interaction

Interaction effects were not observed in any of the years as well as in pooled results.

4.4.3 Biological yield

Data given in Table 36 on biological yield revealed that it was significantly affected due to

varieties and irrigation depths in both the years of investigation. Mean total biological yield during 1989 and 1990 was 69.43 and 87.00 q/ha respectively.

Varieties

Variety ICGS-11 produced significantly higher biological yield over all other varieties in both the years. However, it was at par with ICGS-44 in the year 1990. Variety ICGS-21 occupied second position and it was superior to SB-XI in both the seasons.

Irrigation Depths

In the year 1989, irrigation depth of 7.5 cm recorded significantly higher haulm yield over 6.0 cm and 9.0 cm depths. Irrigation depth of 6.0 cm was significantly superior to 9.0 cm. In the second year of experimentation irrigation depths of 6.0 and 7.5 cm were at par and significantly superior to higher depth of 9.0 cm.

Interaction

Interaction effects of varieties and irrigation depths did not reach to the level of significance in any of the year.

4.4.4 Harvest index

Data on harvest index are presented in Table 36 for both the years. Mean harvest index was 0.353 and 0.366 during 1989 and 1990 respectively.

Varieties

Data indicated that harvest index was influenced by varieties only in first season. Varieties ICGS-11, ICGS-21 and ICGS-44 were at par with each other and recorded significantly higher harvest index over SB-XI.

Irrigation Depths

Harvest index was not influenced significantly due to different irrigation depths in both the years of experimentation.

Interaction

Interaction effects of varieties and irrigation depths were not observed in any of the years.

4.4.5 Dry pod yield (Pooled data of 1990 and 1991)

In view of low emergence of variety ICGS-44 in the year 1989, the experiment was continued during third year i.e. 1991. The data for 1990 and 1991 was separately pooled for comparing the performance of all the varieties pooled together as presented in Table 36. The mean dry pod yield of last two years i.e. 1990 and 1991 is presented in Table 36 a.

Varieties

Data presented in Table 36 a indicated that dry pod yield of all the ICRISAT varieties viz. ICGS-44, ICGS-11 and ICGS-21 was at par with each other and significantly superior to that of SB-XI. The data, thus

Table 36a . Dry pod yield (q/ha) as affected by varieties and irrigation depths during 1990, 1991 and pooled.

Treatments	1990	1991	Pooled
Varieties			
V ₁ ICGS-11	34.43	24.74	29.60
V ₂ ICGS-21	31.65	23.98	27.82
V ₃ ICGS-44	35.41	26.31	30.81
V ₄ SB-XI	27.48	24.36	25.92
S.E. ±	1.06	0.37	0.99
C.D. at 5%	3.11	1.09	3.09
Irrigation Depths			
D ₁ 6.0 cm	33.44	27.05	30.23
D ₂ 7.5 cm	35.01	25.03	30.02
D ₃ 9.0 cm	28.24	22.48	25.33
S.E. ±	0.92	0.32	0.86
C.D. at 5%	2.70	0.94	2.67
Interaction			
V x D (S.E. ±)	1.84	0.65	1.72
C.D. at 5%	NS	NS	NS
G. Mean	32.23	24.85	28.53

seperately pooled for two years is in confirmation of data presented in Table 36 i.e. three years pooled seperately.

Irrigation Depths

Different irrigation depths also affected dry pod yield. Pooled data revealed that irrigation depths of 6.0 and 7.5 cm recorded significantly higher dry pod yield over 9.0 cm irrigation depth.

Interaction

Interaction effects of varieties and irrigation depths were found to be non-significant during individual years as well as in pooled data.

4.5 Post harvest studies

Data on post harvest studies viz. number of filled and unfilled pods per plant, number of one and two seeded pods per plant, weight of dry pods per plant, hundred Kernel weight in g, shelling percentage and Kernel yield in q/ha for 1989 and 1990 are presented in Table, 37a and 37b.

4.5.1 Number of filled pods per plant

It is seen from Table 37a that mean number of filled pods per plant were 16.49 and 23.00 during 1989 and 1990, respectively.

Table 37a. Yield attributing characters as influenced by varieties and irrigation depths

Treatments	Number of filled pods /plant		Number of unfilled pods/plant		Number of one seeded pods/plant		Number of two seeded pods/plant	
	1989	1990	1989	1990	1989	1990	1989	1990
Varieties								
V ₁ ICGS-11	18.09	25.32	2.56	3.25	3.43	4.42	17.55	24.15
V ₂ ICGS-21	16.26	21.72	2.32	2.93	4.10	5.16	14.63	19.90
V ₃ ICGS-44	17.55	26.24	2.06	3.17	3.78	4.75	15.69	24.25
V ₄ SB-XI	14.08	18.74	2.84	3.86	5.60	6.87	11.04	15.73
S.E. ±	0.24	0.18	0.07	0.14	0.14	0.14	0.11	0.29
C.D. at 5%	0.70	0.53	0.21	0.41	0.41	0.41	0.32	0.85
Irrigation Depths								
D ₁ 6.0 cm	17.14	23.70	2.35	3.31	4.25	5.36	15.53	22.22
D ₂ 7.5 cm	18.25	24.47	2.47	3.24	4.14	5.33	16.10	22.98
D ₃ 9.0 cm	14.07	20.84	2.51	3.36	4.29	5.20	12.55	17.82
S.E. ±	0.21	0.16	0.06	0.15	0.13	0.12	0.09	0.23
C.D. at 5%	0.62	0.47	NS	NS	NS	NS	0.26	0.67
Interaction								
V × D (S.E.±)	0.42	0.32	0.12	0.23	0.25	0.24	0.19	0.49
C.D. at 5%	1.23	NS	NS	NS	NS	NS	0.56	NS
Gen. Mean	16.49	23.00	2.44	3.30	4.23	5.29	14.73	21.01

Table 37b. Yield attributing characters as influenced by varieties and irrigation depths

Treatments	Weight of dry pods g/plant		Hundred kernel weight(g)		Shelling percentage		Kernel yield q/ha	
	1989	1990	1989	1990	1989	1990	1989	1990
Varieties								
V ₁ ICGS-11	16.86	20.49	40.70	39.99	66.52	70.03	21.35	24.09
V ₂ ICGS-21	14.63	18.08	43.96	41.39	64.93	66.56	18.17	21.11
V ₃ ICGS-44	16.24	20.68	32.92	35.10	60.27	62.68	11.49	22.10
V ₄ SB-XI	10.69	17.43	32.21	33.90	65.23	72.47	12.78	19.88
S.E. ±	0.65	0.53	0.84	0.55	1.40	1.11	0.85	0.87
C.D at 5%	1.91	1.58	2.48	1.62	4.12	3.24	2.52	2.56
Irrigation Depths								
D ₁ 6.0 cm	14.67	19.15	37.19	37.64	65.28	68.25	16.40	22.78
D ₂ 7.5 cm	16.27	20.78	38.72	38.19	64.09	66.33	17.81	23.13
D ₃ 9.0 cm	12.88	17.59	36.43	36.95	63.33	69.22	13.64	19.48
S.E. ±	0.56	0.46	0.73	0.47	1.21	0.96	0.74	0.76
C.D. at 5%	1.65	1.36	NS	1.40	NS	NS	2.18	2.22
Interaction								
V × D (S.E.±)	1.12	0.93	1.46	0.95	2.43	1.92	1.49	1.51
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS
Gen. Mean	14.61	19.17	37.45	37.59	64.24	67.93	15.95	21.79

Varieties

Mean number of filled pods was influenced significantly by varieties in both the years. Varieties ICGS-11 and ICGS-44 produced significantly more number of filled pods per plant over ICGS-21 and SB-XI, in both the seasons. However, ICGS-11 and ICGS-44 were at par with each other whereas variety ICGS-21 was superior to variety SB-XI.

Irrigation Depths

Irrigation depth of 7.5 cm recorded significantly higher number of filled pods over 6.0 and 9.0 cm. Irrigation depth of 6.0 cm was significantly superior to 9.0 cm in both the years.

Interaction

Interaction effects of varieties and irrigation depths were found significant in 1989 only. The relevant data is given in Table 38.

Table 38 . Mean number of filled pods/plant as influenced by interaction of varieties and irrigation depths in 1989

Varieties/Depths	D ₁	D ₂	D ₃
	(6.0 cm)	(7.5 cm)	(9.0 cm)
V ₁ (ICGS-11)	20.10	19.93	14.30
V ₂ (ICGS-21)	16.68	16.17	14.38
V ₃ (ICGS-44)	17.97	18.21	15.47
V ₄ (SB-XI)	14.38	15.68	12.18
S.E. \pm = 0.42		C.D. at 5% = 1.23	

20.10
1.23

Data revealed that mean number of filled pods of ICGS-11 was not significantly influenced at 6.0 and 7.5 cm irrigation depths. In case of other varieties, it significantly increased with increase in depth of irrigation from 6.0 to 7.5 cm. In all the varieties it decreased significantly and drastically with higher depth of 9.0 cm.

4.5.2. Number of unfilled pods per plant

Mean number of unfilled pods were 2.44 and 3.30 per plant during 1989 and 1990, respectively.

Varieties

Mean number of unfilled pods were significantly affected due to varieties in both the years of experimentation. Persual of data in Table 37a revealed that variety SB-XI produced maximum number of unfilled pods which was significantly more as compared to ICGS-11, ICGS-21 and ICGS-44 during both the years.

Irrigation Depths

There was no significant effect of irrigation depths on mean number of unfilled pods.

Interaction

The interaction effects were found to be non significant.

4.5.3 Number of one seeded pods per plant

Mean number of one seeded pods/plant during 1989 and 1990 were 4.23 and 5.29, respectively.

Varieties

Mean number of one seeded pods were significantly influenced by varieties in both the seasons. Variety SB-XI produced significantly higher number of one seeded pods as compared with other varieties, amongst which ICGS-21 produced significantly higher number of one seeded pods over that of ICGS-11 and ICGS-44 which were at par with each other.

Irrigation Depths

The irrigation depths have no significant effect on number of one seeded pods.

Interaction

Interaction effects of varieties and irrigation depths were not evident.

4.5.4 Number of two seeded pods per plant

Mean number of two seeded pods/plant during 1989 and 1990 were 14.73 and 21.01, respectively.

Varieties

Mean number of two seeded pods were significantly affected due to varieties in both the seasons. During the year 1989, variety ICGS-11 produced

significantly higher number of two seeded pods and was significantly superior over varieties ICGS-44, ICGS-21 and SB-XI. However, ICGS-44, ICGS-21 and SB-XI were superior over each other in that order. In the year 1990, varieties ICGS-11 and ICGS-44 were at par and significantly superior to ICGS-21 and SB-XI. Variety ICGS-21 was superior over SB-XI.

Irrigation Depths

In the year 1989, irrigation depth of 7.5 cm produced significantly higher number of two seeded pods over 6.0 and 9.0 cm. The depth of 6.0 cm was in turn significantly superior over 9.0 cm. In the year 1990, 6.0 and 7.5 cm depths were at par and significantly superior over 9.0 cm depth.

Interaction

Interaction effects of varieties and irrigation depths were found significant during 1989 only. The relevant data is given in Table 39.

Table 39. Mean number of two seeded pods/plant as influenced by interaction of varieties and irrigation depths in 1989

Varieties/Depths	D ₁	D ₂	D ₃
	(6.0 cm)	(7.5 cm)	(9.0 cm)
V ₁ (ICGS-11)	18.53	18.93	15.19
V ₂ (ICGS-21)	15.42	16.18	12.29
V ₃ (ICGS-44)	16.74	16.97	13.36
V ₄ (SB-XI)	11.45	12.32	9.35
S.E. \pm = 0.19		C.D. at 5% = 0.56	

The data revealed that mean number of two seeded pods was not significantly influenced with 6.0 and 7.5 cm irrigation depth in respect of ICGS-11 and ICGS-44. However, in case of ICGS-21 and SB-XI it increased significantly with 7.5 cm as compared to 6.0 cm depth.

4.5.5 Weight of dry pods

Weight of dry pods was significantly influenced by varieties as well as irrigation depths. The relevant data is presented in Table 37. Mean weight of dry pods/plant was 14.91 and 19.17 g during 1989 and 1990 respectively.

Varieties

Varieties ICGS-44 and ICGS-11 were at par and significantly superior to ICGS-21 and SB-XI in both the years. Amongst latter two varieties ICGS-21 was significantly superior to SB-XI in 1989, being at par with it in the year 1990.

Irrigation Depths

In the year 1989, irrigation depth of 7.5 cm recorded significantly higher weight of dry pods over 6.0 and 9.0 cm depths. However, 7.5 cm and 6.0 cm depths were at par with each other in the year 1990.

Interaction

Interaction effects of varieties and irrigation depths were found non-significant in both the years.

4.5.6 Hundred kernel weight

Data on hundred kernel weight recorded during 1989 and 1990 are given in Table 37b. Mean hundred kernel weight during 1989 and 1990 was 37.45 and 37.58 g respectively.

Varieties

Different varieties recorded significant differences in hundred kernel weight in both the years. In the first year, variety ICGS-21 recorded significantly higher 100- kernel weight over all other varieties. Variety ICGS-11 was superior to ICGS-44 and SB-XI. In the year 1990, varieties ICGS-21 and ICGS-11 were at par and significantly superior to ICGS-44 and SB-XI. Variety ICGS-44 was significantly superior to SB-XI.

Irrigation Depths

Hundred kernel weight was significantly influenced due to irrigation depths in 1990 only. Irrigation depths of 8.0 and 7.5 cm were at par and significantly superior to 9.0 cm depth.

Interaction

Interaction effects were found to be non-significant in both the years.

4.5.7 Shelling percentage

Mean shelling percentage recorded during 1989 and 1990 was 64.24 and 67.93, respectively.

Varieties

Shelling percentage was significantly influenced due to varieties. In the year 1989, varieties ICGS-11, ICGS-21 and SB-XI were at par and significantly superior over ICGS-44. In 1990, varieties ICGS-11 and SB-XI were at par and significantly superior to ICGS-21 and ICGS-44.

Irrigation Depths

Effect of irrigation depths were found to be non-significant in both the years.

Interaction

Interaction effects of varieties and irrigation depths were not evident in any of the seasons.

4.5.8 Kernel yield

Data in Table 37b revealed that kernel yield (q/ha) was significantly influenced by varieties and irrigation depths. Mean kernel yield during 1989 and 1990 was 15.95 and 21.79 q/ha respectively.

Varieties

In the year 1989, variety ICGS-11 recorded significantly higher kernel yield over all other varieties. However, it was at par with ICGS-44 in 1990.

Irrigation Depths

Irrigation depths of 7.5 cm and 6.0 cm were at par and significantly superior to higher depth of 9.0 cm in both the years of experimentation.

Interaction

Interaction effects were found to be non-significant in both the years.

4.6 Chemical studies

4.6.1 Oil percentage in kernels

Data on oil percentage in kernels are given in Table 40. Mean content of oil during 1989 and 1990 was 50.82 and 50.52 per cent respectively.

Varieties

Data revealed that oil percentage in kernels was significantly influenced due to varieties in both the years. In the year 1989, varieties ICGS-21 and ICGS-44 were at par and significantly superior over ICGS-11 and SB-XI, which were at par with each other. In the year 1990, varieties ICGS-21, ICGS-44 and SB-XI were at par and significantly superior to ICGS-11.

Irrigation Depths

Application of different depths of irrigation did not influence oil percentage significantly in any of the seasons.

Interaction

Interaction effects of varieties and irrigation depths were not observed in both the years.

Table 40. Oil and protein percentage and their respective yields (q/ha) as affected by varieties and irrigation depths

Treatments	Oil percentage in kernels		Oil yield q/ha		Protein percentage in kernels		Protein yield q/ha	
	1989	1990	1989	1990	1989	1990	1989	1990
Varieties								
V ₁ ICGS-11	49.68	48.74	10.59	11.74	21.91	22.01	4.67	5.24
V ₂ ICGS-21	52.29	51.57	9.51	10.89	24.08	24.16	4.38	5.11
V ₃ ICGS-44	52.07	51.09	5.98	11.23	23.93	24.06	2.75	5.33
V ₄ SB-XI	49.29	50.69	6.29	10.06	26.25	26.39	3.35	5.24
S.E. ±	0.69	0.80	0.44	0.43	0.18	0.21	0.18	0.21
C.D. at 5%	2.03	2.10	1.31	NS	0.53	0.61	0.53	NS
Irrigation Depths								
D ₁ 6.0 cm	51.03	50.09	8.36	11.39	24.01	24.15	3.89	5.44
D ₂ 7.5 cm	50.32	49.83	8.95	11.49	24.04	24.29	4.23	5.58
D ₃ 9.0 cm	51.11	51.65	6.97	10.06	24.07	24.03	3.24	4.67
S.E. ±	0.59	0.69	0.38	0.38	0.15	0.18	0.16	0.18
C.D. at 5%	NS	NS	1.14	1.14	NS	NS	0.47	0.53
Interaction								
V × D (S.E.±)	1.19	1.39	0.77	0.76	0.31	0.36	0.32	0.36
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS
Gen. Mean	50.82	50.52	8.09	10.98	24.04	24.16	3.79	5.23

4.6.2 Oil yield (q/ha)

Mean oil yield during 1989 and 1990 was 8.09 and 10.98 q/ha respectively.

Varieties

Data on oil yield in Table 40 indicated that oil yield was significantly influenced by varieties in the year 1989 only. Variety ICGS-11 produced significantly higher oil yield over ICGS-44 and SB-XI and it was at par with ICGS-21. Varieties ICGS-44 and SB-XI were also at par with each other.

Irrigation Depths

Irrigation depths of 7.5 cm and 6.0 cm were at par and significantly superior over higher depth of 9.0 cm in oil production in both the years of experimentation.

Interaction

Interaction effects were non-significant in both the years.

4.6.3 Protein percentage in kernels

Mean protein content during 1989 and 1990 was 24.04 and 24.16 per cent respectively.

Varieties

Protein percentage in kernels was significantly influenced due to varieties. Variety SB-XI recorded significantly higher values of protein over rest of varieties in 1989 as well as in 1990. Similarly, varieties

ICGS-21 and ICGS-44 were at par and significantly superior to ICGS-11.

Irrigation Depths

Different irrigation depths did not influence protein percentage significantly in both the seasons.

Interaction

Interaction effects of varieties and irrigation depths were not observed in any of the years.

4.6.4 Protein yield (q/ha)

Mean yield of protein during 1989 and 1990 was 3.79 and 5.23 q/ha respectively.

Varieties

Protein yield was significantly influenced by varieties in 1989 only. Varieties ICGS-11 and ICGS-21 were at par and significantly superior to SB-XI and ICGS-44. However, SB-XI was significantly superior to ICGS-44.

Irrigation Depths

Application of varying depths of irrigation significantly influenced protein yield in both the years. Irrigation depths of 7.5 cm and 6.0 cm were at par and significantly superior to 9.0 cm in both the years.

Interaction

Interaction effects were not observed in both the years.

4.6.5 Uptake of N, P and K

Data on uptake of N, P and K in whole plant as well as kernel are given in Tables 41, 42 and 43 respectively for both the seasons. Pooled total uptake of N, P and K at harvest is depicted in figure 7.

4.6.5.1 Uptake of N in haulms

Data in Table 41 revealed that N uptake in haulms was significantly influenced due to varieties and irrigation depths in both the seasons. Mean uptake during 1989 and 1990 was 97.51 and 126.27 Kg N/ha respectively.

Varieties

In first year, variety ICGS-11 recorded significantly higher N uptake over ICGS-44, but it was at par with ICGS-21 and SB-XI. In second year also ICGS-11 was significantly superior to ICGS-21 and SB-XI and was at par with ICGS-44, former two being at par with each other.

Irrigation Depths

Treatment 7.5 cm recorded significantly higher N uptake in haulms over 6.0 cm and 9.0 cm treatments, in the year 1989. In second season, irrigation depths of 7.5 cm and 6.0 cm were at par with each other. Treatment 9.0 cm recorded lowest N uptake in haulms.

Interaction

Interaction effects were not evident in both the seasons.

Table 41. Uptake of nitrogen (kg/ha) in different plant parts during 1989 and 1990 at harvest as influenced by varieties and irrigation depths

Treatments	1989			1990		
	Haulms	Kernel	Total	Haulms	Kernel	Total
Varieties						
V ₁ ICGS-11	109.28	84.54	193.82	140.23	84.85	221.08
V ₂ ICGS-21	99.73	81.41	181.70	119.48	81.82	201.08
V ₃ ICGS-44	78.53	84.76	163.27	130.11	85.26	216.48
V ₄ SB-XI	102.53	83.45	185.98	115.26	83.90	199.17
S.E. \pm	3.89	3.34	5.74	3.49	3.48	4.88
C.D. at 5%	11.40	NS	16.83	10.23	NS	14.31
Irrigation Depths						
D ₁ 6.0 cm	91.91	87.18	179.08	127.44	87.75	215.86
D ₂ 7.5 cm	107.39	88.61	196.01	131.93	89.36	221.28
D ₃ 9.0 cm	93.24	74.82	168.49	119.45	74.76	191.22
S.E. \pm	3.38	2.90	4.97	3.03	3.02	4.23
C.D. at 5%	9.91	8.50	14.57	8.88	8.85	12.40
Interaction						
V \times D (S.E. \pm)	6.75	5.80	9.95	6.06	6.04	8.46
C.D. at 5%	NS	NS	NS	NS	NS	NS
Gen. Mean	97.51	83.53	181.19	126.27	83.95	209.45

4.6.5.2 Uptake of N in Kernels

Mean uptake of nitrogen in kernels was 83.53 and 83.95 kg/ha during years 1989 and 1990 respectively.

Varieties

The N uptake in kernels was not influenced significantly due to various varieties under trial during both the years of experimentation.

Irrigation Depths

Irrigation depth of 7.5 cm recorded significantly higher N uptake as compared to 9.0 cm depth. However, it was at par with 6.0 cm treatment in both the years of experimentation.

Interaction

Effect of interaction was not evident in any of the seasons.

4.6.5.3 Total uptake of N

Data in Table 41 indicated that total uptake of N was significantly influenced by varieties and irrigation depths. Mean total uptake was 181.19 and 209.45 kg N/ha during 1989 and 1990, respectively.

Varieties

During 1989 variety ICGS-11 recorded significantly higher uptake of N over ICGS-44 and it was at par with ICGS-21 and SB-XI. In second season also ICGS-11 was

significant over ICGS-21 and SB-XI and at par with ICGS-44. Varieties ICGS-21 and SB-XI were at par with each other.

Irrigation Depths

Irrigation depth of 7.5 cm was significantly superior to 9.0 cm and 8.0 cm treatments, except in second year, where 7.5 cm and 8.0 cm were at par with each other but significantly superior to 9.0 cm treatment.

Interaction

Interaction effects were found to be non-significant in both the years of experimentation.

4.6.5.4 Uptake of P in haulms

Data presented in Table 42 indicated significant effects of varieties and irrigation depths on P uptake in haulms. Mean uptake of P was 20.88 and 26.29 kg/ha in 1989 and 1990, respectively.

Varieties

In first season, variety ICGS-11 was at par with ICGS-21 and significantly superior over ICGS-44 and SB-XI. In second season ICGS-11 and ICGS-44 were at par and significantly superior to ICGS-21 and SB-XI, former being significantly superior to latter.

Irrigation Depths

Application of 7.5 cm depth of irrigation increased P uptake in haulms significantly over depths of 6.0 cm and 9.0 cm in first season. In second season, 6.0

Table 42. Uptake of Phosphorus (kg/ha) in different plant parts during 1989 and 1990 at harvest as influenced by varieties and irrigation depths

Treatments	1989			1990		
	Haulms	Kernel	Total	Haulms	Kernel	Total
Varieties						
V ₁ ICGS-11	23.94	19.94	43.88	27.56	23.09	51.86
V ₂ ICGS-21	21.63	17.11	38.75	25.81	20.54	46.35
V ₃ ICGS-44	17.19	11.60	28.79	28.20	21.52	49.72
V ₄ SB-XI	20.76	11.98	32.76	23.63	19.01	42.63
S.E. \pm	0.82	0.84	0.89	0.71	0.84	0.93
C.D. at 5%	2.40	2.46	2.61	2.08	2.46	2.72
Irrigation Depths						
D ₁ 6.0 cm	20.18	16.11	36.29	27.73	22.06	49.79
D ₂ 7.5 cm	23.14	16.81	39.95	26.61	22.45	50.02
D ₃ 9.0 cm	19.33	12.57	31.90	24.51	18.62	43.12
S.E. \pm	0.71	0.73	0.77	0.61	0.72	0.80
C.D. at 5%	2.08	2.14	2.25	1.78	2.11	2.34
Interaction						
V x D (S.E. \pm)	1.43	1.46	1.54	1.23	1.45	1.61
C.D. at 5%	NS	NS	NS	NS	NS	NS
Gen. Mean	20.88	15.16	36.04	26.29	21.04	47.64

cm and 7.5 cm were at par and significantly superior to 9.0 cm treatment.

Interaction

Effects of interaction were non-significant in both the years.

4.6.5.5 Uptake of P in Kernels

Uptake of P in kernels was significantly influenced by varieties and irrigation depths in both the years of experimentation. Mean uptake of P in Kernels in 1989 and 1990 was 15.16 and 21.04 kg/ha, respectively.

Varieties

In first season ICGS-11 recorded significantly higher uptake of P over other varieties. Variety ICGS-21 was significantly superior to ICGS-44 and SB-XI which were at par with each other. In the year 1990, varieties ICGS-11 and ICGS-44 were at par and significantly superior to ICGS-21 and SB-XI which were at par with each other.

Irrigation Depths

The uptake of P recorded by irrigation depth of 6.0 cm and 7.5 cm was more or less similar and statistically at par with each other in both the years of experimentation. Both these treatments recorded significantly higher uptake of P than that of 9.0 cm in both the years.

Interaction

Interaction effects were not significant in any of the seasons.

4.6.5.6 Total uptake of P

The mean total uptake of P during 1989 and 1990 was 36.04 and 47.64 kg/ha, respectively.

Varieties

During 1989 ICGS-11 recorded significantly higher uptake of P followed by ICGS-21, SB-XI and ICGS-44, former being significantly better than latter varieties in that order. In second season varieties ICGS-11 and ICGS-44 were at par with each other and significantly superior to ICGS-21 and SB-XI. Amongst latter two varieties ICGS-21 recorded significantly more uptake of P than SB-XI.

Irrigation Depths

In the year 1989, irrigation depth of 7.5 cm recorded significantly higher uptake of P over 6.0 cm and 9.0 cm treatments. Depth of 6.0 cm was in turn significantly superior to 9.0 cm. In second season treatments 6.0 and 7.5 cm were at par and significantly superior to 9.0 cm treatment.

Interaction

Interaction effects were non-significant in both the years.

4.6.5.7 Uptake of K in haulms

Mean uptake of K in haulms in 1989 and 1990 was 104.23 and 129.40 kg/ha, respectively.

Varieties

In first year, variety ICGS-11 recorded significantly higher uptake of K in haulms as compared to other varieties. Varieties ICGS-21 and SB-XI were at par with each other and significantly superior to ICGS-44. In second year more or less similar trend was evident except that varieties ICGS-21 and ICGS-44 were at par being significantly superior to SB-XI.

Irrigation Depths

Application of 7.5 cm depth resulted in significantly higher uptake of K over 6.0 cm and 9.0 cm treatments in first year. However treatments 6.0 cm and 9.0 cm were at par with each other. In the year 1990, treatments 6.0 cm and 7.5 cm were at par and significantly superior to 9.0 cm treatment.

Interaction

Interaction effects were not observed in both the seasons.

4.6.5.8 Uptake of K in Kernels

Mean uptake of K in kernels during 1989 and 1990 was 25.11 and 35.11 kg/ha, respectively.

Table 43. Uptake of Potassium (kg/ha) in different plant parts during 1989 and 1990 at harvest as influenced by varieties and irrigation depths

Treatments	1989			1990		
	Haulms	Kernel	Total	Haulms	Kernel	Total
Varieties						
V ₁ ICGS-11	125.08	34.63	159.71	148.36	39.79	188.15
V ₂ ICGS-21	108.41	28.32	136.74	125.54	34.15	159.69
V ₃ ICGS-44	82.81	17.91	100.10	133.14	36.13	169.27
V ₄ SB-XI	100.89	19.59	120.48	110.57	30.37	140.94
S.E. ±	4.34	1.32	4.53	4.81	1.69	4.92
C.D. at 5%	12.72	3.87	13.28	14.10	4.95	14.43
Irrigation Depths						
D ₁ 6.0 cm	100.40	26.56	126.96	133.41	37.82	171.23
D ₂ 7.5 cm	117.54	28.78	146.32	137.11	38.49	175.61
D ₃ 9.0 cm	94.48	20.01	114.50	117.69	29.02	146.71
S.E. ±	3.75	1.14	3.92	4.16	1.47	4.26
C.D. at 5%	10.99	3.34	11.49	12.20	4.31	12.49
Interaction						
V × D (S.E.±)	7.51	2.29	7.85	8.33	2.94	8.52
C.D. at 5%	NS	NS	NS	NS	NS	NS
Gen. Mean	104.23	25.11	129.25	129.40	35.11	164.51

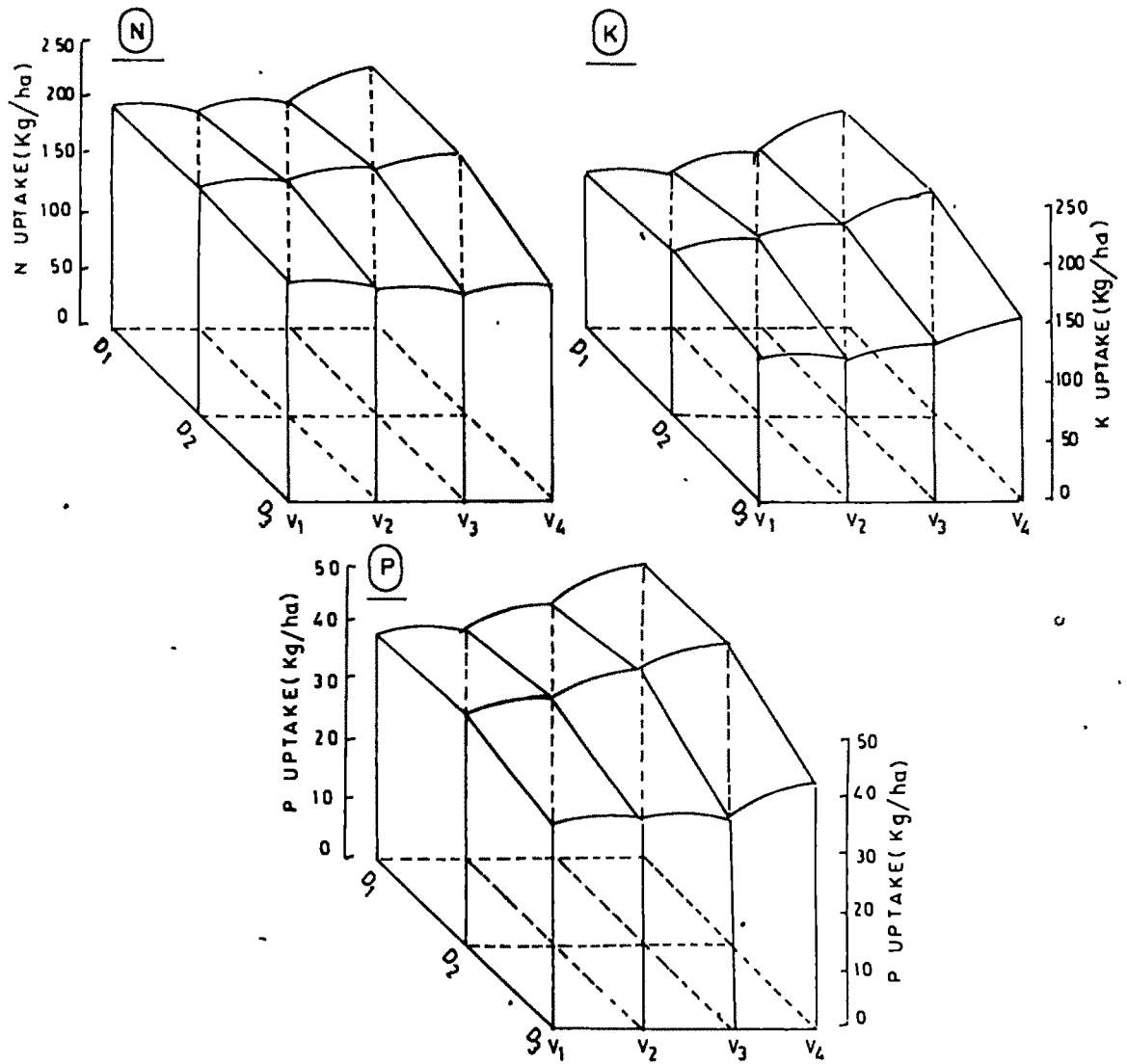


Fig 7 POOLED TOTAL UPTAKE OF N, P AND K (Kg/ha) AT HARVEST AS INFLUENCED BY INTERACTION OF VARIETIES AND IRRIGATION DEPTHS

Varieties

In the year 1989, variety ICGS-11 recorded significantly higher uptake of K over other varieties. Variety ICGS-21 was significantly superior to ICGS-44 and SB-XI, latter two being at par with each other. In the year 1990 also ICGS-11 recorded significantly higher K uptake in kernels. However, it was at par with ICGS-44 and significantly superior to ICGS-21 and SB-XI. Varieties ICGS-21 and SB-XI were at par with each other.

Irrigation Depths

Irrigation depths of 7.5 cm and 8.0 cm were at par and significantly superior to 9.0 cm depth in both the years of experimentation.

Interaction

Interaction effects were found to be non-significant in both the years.

4.6.5.9 Total uptake of K

Mean total uptake of K in 1989 and 1990 was 129.25 and 164.51 kg/ha, respectively.

Varieties

In first year variety ICGS-11 recorded significantly higher K uptake over all other varieties. Varieties ICGS-21, SB-XI and ICGS-44 were significantly superior to each other in that order. Lowest uptake was recorded by variety ICGS-44. In the year 1990 also variety ICGS-11 recorded significantly higher K uptake as compared

to other varieties. Varieties ICGS-44 and ICGS-21 were at par with each other and significantly superior over variety SB-XI.

Irrigation Depths

In first year, irrigation depth of 7.5 cm recorded significantly higher K uptake over 6.0 cm and 9.0 cm treatments. Irrigation depth of 6.0 cm was significantly superior to 9.0 cm depth. In the second year, treatments of 7.5 cm and 6.0 cm were at par with each other and significantly superior to 9.0 cm treatment.

Interaction

Interaction effects were not evident in both the years of experimentation.

4.7 Moisture studies

4.7.1 Consumptive use of water

The data on mean seasonal consumptive use of water in mm as influenced by different treatments along with reference crop evapotranspiration (by modified penman method) are presented in Table 44.

From Table 44 it is evident that mean seasonal consumptive use of water by groundnut was higher in 1990 (810.85 mm) than 1989 (736.37 mm).

Varieties

The consumptive use was significantly influenced by varieties in both the years. In first year variety ICGS-11 recorded significantly higher consumptive use followed by ICGS-21, ICGS-44 and SB-XI, former variety

Table 44. Total seasonal consumptive use along with ETo (by modified Penman method) as influenced by varieties and irrigation depths

Treatments	Consumptive use (mm)		ETo (mm) modified Penman	
	1989	1990	1989	1990
Varieties				
V ₁ ICGS-11	793.57	817.50	1055	970
V ₂ ICGS-21	766.27	809.92	1055	970
V ₃ ICGS-44	702.67	832.37	1055	970
V ₄ SB-XI	682.98	783.60	1055	970
S.E. ±	7.35	5.08	-	-
C.D. at 5%	21.56	14.90	-	-
Irrigation Depths				
D ₁ 6.0 cm	738.17	824.12	1055	970
D ₂ 7.5 cm	763.41	855.97	1055	970
D ₃ 9.0 cm	707.52	752.47	1055	970
S.E. ±	6.35	4.40	-	-
C.D. at 5%	18.65	12.90	-	-
Interaction				
V x D (S.E. ±)	12.72	8.80	-	-
C.D. at 5 %	NS	25.81	-	-
Gen. Mean	736.37	810.85	1055	970

being significantly superior to latter varieties in that order. In the year 1990, similar trend was evident except that ICGS-44 and ICGS-21 exchanged their rankings.

Irrigation Depths

The total consumptive use was significantly influenced by different irrigation depths in both the years, irrigation depth of 7.5 cm recording significantly higher consumptive use as compared to other two depths. The irrigation depth of 9.0 cm recorded significantly lower consumptive use.

Interaction

The interaction effect of varieties and irrigation depths on consumptive use was found significant only in 1990. The relevant data are presented in Table 45.

Table 45. Mean total consumptive use (mm) as influenced by interaction of varieties and irrigation depths in 1990

Varieties/Depths	D ₁	D ₂	D ₃
	(6.0 cm)	(7.5 cm)	(9.0 cm)
V ₁ (ICGS-11)	811.1	880.2	761.2
V ₂ (ICGS-21)	801.1	875.5	756.5
V ₃ (ICGS-44)	845.1	882.5	769.5
V ₄ (SB-XI)	832.5	785.6	722.7
S.E. \pm = 8.80		C.D. at 5% = 25.81	

Data revealed that varieties ICGS-11, ICGS-21 and ICGS-44 recorded significantly higher consumptive use with 7.5 cm irrigation depth than that of 6.0 and 9.0 cm,

former depth being significantly superior to latter. In respect of SB-XI consumptive use significantly decreased with increase in depth of irrigation. It would be interesting to note that under 6.0 cm depth, variety ICGS-44 and SB-XI recorded significantly higher consumptive use, being at par with each other. At higher depths, all varieties of ICGS series were at par and significantly superior to SB-XI.

4.7.2 Daily consumptive use

Data on daily consumptive use of water as influenced by different treatments during both the years of experimentation are presented in Table 46.

Table 46. Daily consumptive use of water (mm) as influenced by varieties and irrigation depths

Treatments	Daily consumptive use in mm		
	1989	1990	Mean
Varieties			
V ₁ ICGS-11	6.10	6.54	6.32
V ₂ ICGS-21	5.89	6.47	6.18
V ₃ ICGS-44	5.41	6.66	6.04
V ₄ SB-XI	5.25	6.27	5.76
Irrigation Depths			
D ₁ 6.0 cm	5.68	6.59	6.14
D ₂ 7.5 cm	5.87	6.85	6.36
D ₃ 9.0 cm	5.44	6.02	5.73
Mean	5.66	6.49	6.08

Varieties

Data presented in Table 46 revealed that the daily consumptive use was highest in ICGS-11 followed by ICGS-21, ICGS-44 and SB-XI respectively in 1989, while in 1990 ICGS-44 recorded highest consumptive use followed by ICGS-11, ICGS-21 and SB-XI, respectively.

Irrigation Depths

The depth effects revealed that the consumptive use increased due to irrigation depths of 6.0 and 7.5 cm and then declined in 9.0 cm depth in both the years of experimentation.

4.7.3 Consumptive use during various growth stages

Data on daily mean water use during different growth stages as influenced by different varieties and irrigation depths are presented in Table 47. The daily mean rate of water use of groundnut was low during establishment and early flowering as well as during subsequent stages of flowering to vegetative growth because of less vegetative cover, low moisture requirement and other climatic factors. It increased rapidly during yield formation stage. During both the years of experimentation rate of water use was maximum during yield formation stage. The rate of water use decreased slightly at ripening stage in both the years.

Table 47. The daily mean water use rate (mm/day) from 0-45 cm soil layer during different growth stages of crop as influenced by varieties and irrigation depths

Growth stage	Crop period in days	Varieties				Irrigation Depths			Mean
		V1 IC88-11	V2 IC88-21	V3 IC88-44	V4 88-11	D1 6.0cm	D2 7.5cm	D3 9.0cm	
1989									
1. Establishment/flowering	32	3.77	3.43	2.88	2.75	3.16	3.12	3.34	3.21
2. Flowering/Vegetative	35	4.81	4.76	4.38	4.29	4.91	4.67	4.21	4.58
3. Yield formation	44	7.72	7.62	7.24	7.09	7.12	7.38	7.82	7.43
4. Ripening	18	8.46	8.07	7.21	6.84	6.82	8.54	6.61	7.51
Mean		6.19	5.97	5.43	5.24	5.50	5.92	5.49	
1990									
1. Establishment/flowering	32	3.63	3.62	3.71	3.35	3.24	3.82	3.64	3.57
2. Flowering/Vegetative	30	5.25	5.15	5.60	5.31	5.51	5.14	4.34	5.33
3. Yield formation	41	8.75	8.74	8.78	8.49	8.82	9.15	8.09	8.69
4. Ripening	26	7.07	6.90	7.06	6.44	7.17	7.42	5.88	6.85
Mean		6.18	6.10	6.29	5.89	6.19	6.38	5.74	

Varieties

The varietal differences revealed that variety ICGS-11 recorded higher daily consumptive use followed by ICGS-21, ICGS-44 and SB-XI respectively, in 1988. In the year 1990, variety ICGS-44 recorded higher consumptive use followed by ICGS-11, ICGS-21 and SB-XI respectively.

Irrigation Depths

The effects of irrigation depths indicated that consumptive use under treatment of 7.5 cm depth appeared higher in both the years, and slightly declined at 9.0 cm. However, the differences in daily consumptive use due to various depths during different growth stages were marginal.

4.7.4 Crop coefficient values (Kc)

The crop coefficient values (Kc) computed from the data of ETo (mm) by modified Penman method and actual ETcrop (mm) i.e. consumptive use during various growth stages under different varieties and irrigation depths are presented in Table 48.

The perusal of data presented in Table 48 indicated that Kc values were lower at establishment to vegetative stages of crop growth, they increased gradually and thereafter they attained peak during yield formation stage and again declined during ripening stage.

Table 48. Crop coefficient values (Kc) under different varieties and irrigation depths

Growth stage	Crop period in days	Varieties				Irrigation Depths			Mean
		V1 IC88-11	V2 IC88-21	V3 IC88-44	V4 SB-11	D1 6.0cm	D2 7.5cm	D3 9.0cm	
1989									
1. Establishment/ flowering	32	0.68	0.62	0.52	0.50	0.58	0.57	0.59	0.58
2. Flowering/ Vegetative	35	0.73	0.73	0.67	0.65	0.74	0.74	0.63	0.69
3. Yield formation	44	0.88	0.88	0.83	0.74	0.86	0.85	0.85	0.84
4. Ripening	18	0.67	0.64	0.57	0.54	0.56	0.66	0.53	0.59
Mean		0.74	0.72	0.65	0.61	0.69	0.71	0.65	
1990									
1. Establishment/ flowering	32	0.73	0.66	0.67	0.61	0.61	0.69	0.66	0.66
2. Flowering/ Vegetative	30	0.81	0.79	0.86	0.82	0.83	0.82	0.82	0.82
3. Yield formation	41	1.03	1.03	1.03	0.99	1.04	1.07	0.93	1.02
4. Ripening	26	0.83	0.81	0.83	0.75	0.85	0.88	0.68	0.80
Mean		0.85	0.82	0.85	0.79	0.83	0.87	0.77	

Varieties

Amongst different varieties, ICGS-11 and ICGS-21 recorded higher Kc values than ICGS-44 and SB-XI in first year. In second year of experimentation, varieties ICGS-44, ICGS-11 and ICGS-21 recorded more or less similar Kc values, but higher than variety SB-XI. In both the years, variety SB-XI recorded lowest Kc values as compared to other varieties.

Irrigation Depths

The crop Kc values under 6.0 and 7.5 cm irrigation depths differed trivially but they were markedly higher than 8.0 cm depth in both the years of experimentation.

4.7.5 Moisture extraction pattern

Data on soil moisture extraction pattern by groundnut in different treatments from various layers are presented in Table 49 and depicted in fig. 8.

Groundnut crop utilized maximum available soil moisture from upper most layer of 0-30 cm irrespective of treatments, contributing 74.61 per cent and 69.28 per cent soil moisture in 1989 and 1990 respectively.

Varieties

Amongst different varieties studied, ICGS-11, ICGS-21 and ICGS-44 extracted higher soil moisture from the layer 0-30 cm as compared to SB-XI in both the years. However, there were no conspicuous differences in moisture

Table 49. Soil moisture extraction pattern of groundnut from different soil layers (per cent) under different varieties and irrigation depths

Treatments	Depletion of soil moisture (per cent) from different layers			
	1989		1990	
	0 - 30 cm	30 - 45 cm	0 - 30 cm	30 - 45 cm
Varieties				
V ₁ ICGS-11	74.78	25.22	69.26	30.74
V ₂ ICGS-21	75.82	24.18	70.29	29.71
V ₃ ICGS-44	74.11	25.89	69.56	30.44
V ₄ SB-XI	73.73	26.27	68.01	31.99
Irrigation Depths				
D ₁ 6.0 cm	75.43	24.57	69.63	30.37
D ₂ 7.5 cm	75.85	24.15	70.12	29.88
D ₃ 9.0 cm	72.55	27.45	68.10	31.90
Gen. Mean	74.61	25.39	69.28	30.72

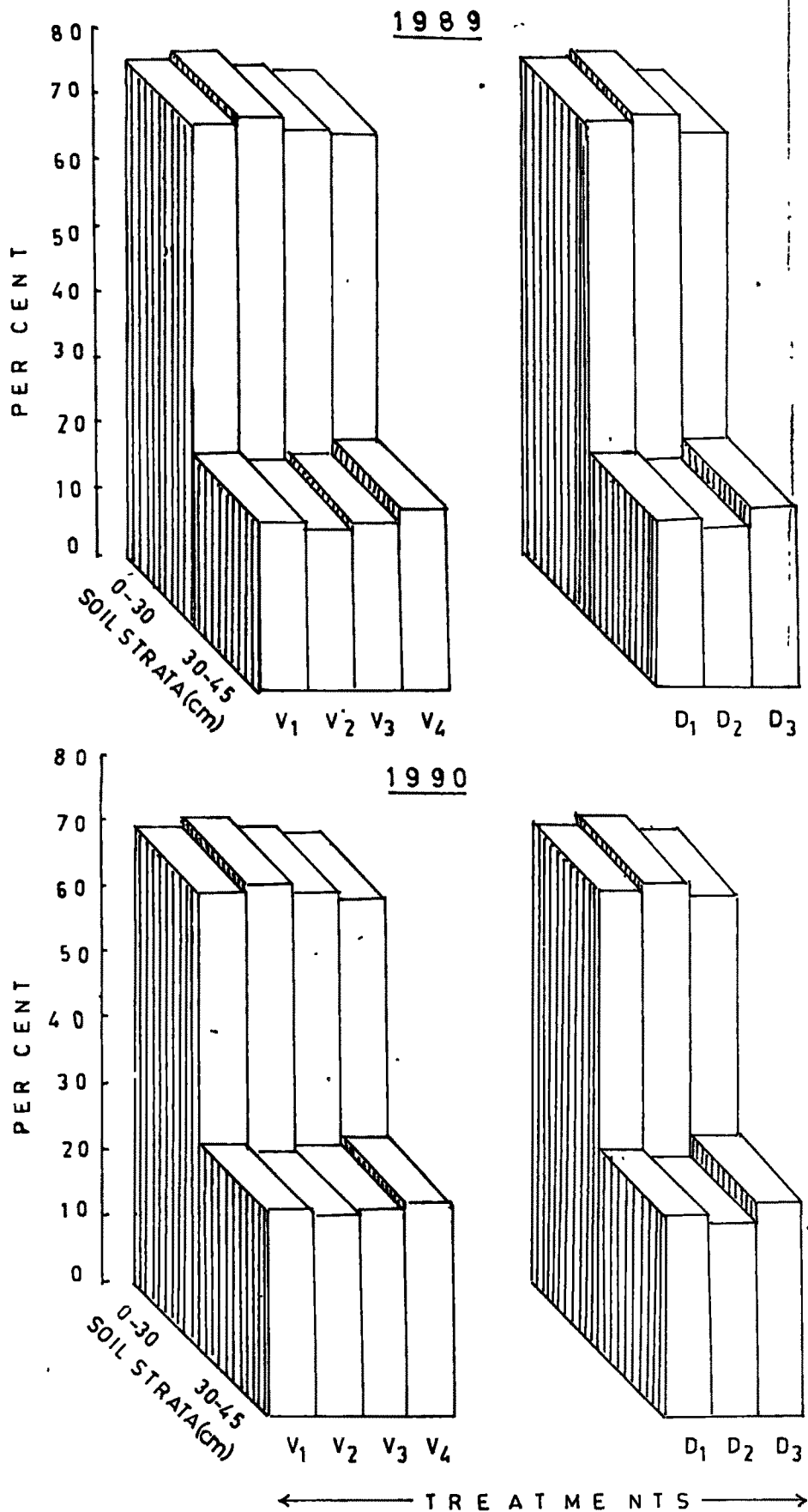


Fig. 8. SOIL MOISTURE DEPLETION (PER CENT)

extracted by different varieties from lower layer of 30-45 cm.

Irrigation Depths

In the year 1989, lower irrigation depths of 6.0 and 7.5 cm extracted more or less similar soil moisture from 0-30 and 30-45 cm layers. However, higher irrigation depth of 9.0 cm recorded higher soil moisture extraction from second layer i.e. 30-45 cm as compared to 6.0 and 7.5 cm irrigation depths. In the year 1990 also, similar pattern was observed.

4.7.6 Water use efficiency (WUE)

Data on water use efficiency presented in Table 50 indicated that mean WUE during 1989 and 1990 was 3.37 and 4.51 Kg/ha/mm, respectively.

Varieties

Water use efficiency was influenced due to varieties in both the years. In the year 1989, variety ICGS-11 recorded higher WUE (4.05 Kg/ha/mm) as compared to other varieties. It was followed by ICGS-21 (3.63), SB-XI (2.98) and ICGS-44 (2.82 kg/ha/mm). In the year 1990, varieties ICGS-44 and ICGS-11 were superior in recording higher WUE as compared to ICGS-21 and SB-XI.

Irrigation Depths

The WUE tended to decrease with increasing depths of irrigation. Irrigation depths of 6.0 and 7.5 cm recorded higher WUE over 9.0 cm depth in both the years.

Table 50. Water use efficiency (WUE) and evapotranspiration ratio (ETR) as influenced by varieties and irrigation depths.

Treatments	Water use efficiency Kg/ha/mm		Evapotranspiration ratio mm/Kg/ha	
	1989	1990	1989	1990
Varieties				
V ₁ ICGS-11	4.05	4.21	0.253	0.239
V ₂ ICGS-21	3.63	3.91	0.280	0.258
V ₃ ICGS-44	2.82	4.23	0.370	0.238
V ₄ SB-XI	2.98	3.50	0.354	0.286
Irrigation Depths				
D ₁ 6.0 cm	3.43	4.06	0.313	0.252
D ₂ 7.5 cm	3.59	4.08	0.289	0.247
D ₃ 9.0 cm	3.09	3.75	0.340	0.269
Gen. Mean	3.37	4.51	0.314	0.256

4.7.7 Evapotranspiration ratio (ETR)

Data on mean evapotranspiration ratio (ETR) is presented in Table 50. The mean ETR was 0.314 and 0.256 in 1989 and 1990, respectively.

Varieties

In the year 1989, varieties ICGS-44 and SB-XI recorded higher ETR as compared to ICGS-11 and ICGS-21. In 1990, SB-XI recorded higher ETR over other varieties.

Irrigation Depths

The mean ETR for irrigation depths increased with increasing depth of irrigation, depth of 9.0 cm recording highest ETR.

4.8 Simple correlation and regression studies

Data on simple correlation coefficients among the bivariate population of weight of pods per plant (Y) as dependent and other plant characters as independent (xi) variables are presented in Table 51.

Data on correlation coefficients presented in Table 51 revealed that weight of pods in g/plant was negatively and significantly correlated with height of plant in both the years. Positive and significant correlations were observed between weight of pods in g/plant and maximum number of branches/plant, leaf area in sq cm/plant at 105 days, total dry matter in g/plant at harvest, number of root nodules/plant and number of

Table 51. Simple correlation coefficients (r) and regression coefficients (b) between weight of pods (g) per plant (y) and plant characters (X_n).

Sr. Plant characters No.	a		b		r		t	
	1989	1990	1989	1990	1989	1990	1989	1990
X ₁ Height of plant at harvest in cm	37.340	-2.425	-1.213	-0.408	-0.592	-0.384	-4.28	-2.42
X ₂ Maximum number of branches per plant	46.760	4.473	-4.011	1.599	0.377	0.453	2.37	2.96
X ₃ Maximum leaf area (sq cm)/plant at 105 days	-2.459	0.470	0.008	0.006	0.627	0.793	4.69	7.58
X ₄ Total dry matter (g)/plant at harvest	0.282	1.924	0.502	0.479	0.552	0.719	4.62	6.03
X ₅ Maximum number of root nodules/plant	1.482	8.060	0.100	0.600	0.728	0.700	6.19	5.71
X ₆ Total number of pods/plant	-0.463	3.335	0.795	0.487	0.678	0.741	5.37	6.43
X ₇ Shelling percentage	22.887	28.731	-0.128	-0.184	-0.189	0.403	-1.12	-2.56
X ₈ Hundred kernel weight (g).	13.163	12.411	0.038	0.100	0.395	0.152	3.12	0.90

Table 52. Multiple regression coefficients.

Sr. Plant characters No.	coefficients of multiple regression		't' value	
	1989	1990	1989	1990
X ₀ —	16.112	-4.3844	-	-
X ₁ Height of plant at harvest in cm	-0.4270	0.0073	1.5784	0.0496
X ₂ Maximum number of branches/plant	-0.0045	1.5268	0.0124	3.4427
X ₃ Maximum leaf area (sq cm)/plant at 105 days	0.0033	0.0050	1.8822	2.6794
X ₄ Total dry matter (g)/plant at harvest	-0.1377	-0.2478	0.7562	1.3235
X ₅ Maximum number of root nodules/plant	0.0523	0.0133	2.1761	0.6596
X ₆ Total number of pods/plant	0.2993	0.3504	1.9407	2.3864
X ₇ Shelling percentage	-0.2189	0.0933	3.0864	1.7101
X ₈ Hundred kernel weight (g)	0.1340	0.1078	2.1060	1.5745

Pods/plant in both the years of experimentation. Weight of pods/plant was found to be negatively and non-significantly correlated in 1989 with shelling percentage, but it was negatively and significantly correlated in the year 1990. Pod weight g/plant was positively and significantly correlated with hundred kernel weight, in the year 1989. However, it was positively and non-significantly correlated in 1990.

The data on simple regression revealed that the plant characters which showed significant correlations showed significant regressions between pod yield per plant and other characters. The magnitude of regression coefficients varied with the association between variables and their units.

4.9 Multiple regression studies

Multiple regression coefficients were computed between pod yield (g)/plant (Y) and plant characters viz. height of plant at harvest in cm (X_1), maximum number of branches/plant (X_2), leaf area in sq cm/plant at 105 days (X_3), total dry matter (g)/plant at harvest (X_4), maximum number of root nodules/plant (X_5), total number of pods/plant (X_6), shelling percentage (X_7) and hundred kernel weight (X_8) during both the years of experimentation.

The coefficients of multiple regression equations obtained from data of 1989 and 1990 are presented in Table 52.

The equations indicated that in 1989, maximum number of root nodules/plant, leaf area/plant, total number of pods/plant and hundred kernel weight (g) were the important characters which contributed for higher pod yields. In the year 1990 important characters affecting pod yield were leaf area/plant, total number of pods/plant, maximum number of branches/plant, hundred kernel weight and height of plant at harvest in that order.

4.10 Yield - evapotranspiration relationship

The dry pod yield (t/ha) of each variety was defined as the second degree polynomial function of evapotranspiration (ha m). These relationships were separately established for each variety. The regression parameters of these empirical relationships are presented in Table 53 along with their test statistics.

Data presented in Table 53 revealed that yield-evapotranspiration relationships were significant (F) and explained (R^2) 99.45, 98.53, 99.88 and 96.24 per cent variation between the observed and predicted yields of ICGS-11, ICGS-21, ICGS-44 and SB-XI respectively. The first (b1) and second (b2) degree coefficients were significant in ICGS-11, ICGS-21 and ICGS-44, but they were non significant in SB-XI. The algebraically positive signs of first degree (b1) coefficients and negative signs of second degree (b2) coefficients indicated that the yield-

Table 53. Regression parameters of the empirical relationship between pooled pod yield and crop evapotranspiration under different groundnut varieties.

Varieties	Regression coefficients			Test statistics					Y _{max} (t/ha)	X _{max} (m)
	b ₀	b ₁	b ₂	SEy	R ²	F	b _{1t}	b _{2t}		
V ₁ ICGS-11	-55.5053	136.9116	-79.0204	0.0435	0.9945	271.8181	8.4690	-7.9504	3.798	0.8663
V ₂ ICGS-21	-50.1519	124.2733	-71.9320	0.0637	0.9853	100.8497	5.6802	-5.3256	3.523	0.8638
V ₃ ICGS-44	-52.5124	125.79129	-70.16981	0.0283	0.9989	449.5293	9.5310	-9.1203	3.865	0.8963
V ₄ SB-XI	-26.5828	71.2177	-42.9729	0.1508	0.9624	38.3963	3.0829	-2.7972	2.924	0.8286

Table 55. Economics of yield-water relations under appraised price spectrum.

Varieties	P _x Rs/100 mm	P _y Rs/t	PR P _x /P _y	Optimum ET	Response of y (t/ha)	Cost of ET	Cost of Cultiva- tion	Total returns	Total cost	Net returns	Net return- s/ Rs. invested
V ₁ ICGS-11	125	10000	0.0125	0.8538	3.786	106	5350	37860	5456	32403	5.93
V ₂ ICGS-21	125	10000	0.0125	0.8510	3.511	106	5350	35110	5456	29654	5.43
V ₃ ICGS-44	125	10000	0.0125	0.8840	3.852	110	5350	38520	5460	33060	6.05
V ₄ SB-XI	125	10000	0.0125	0.8160	2.917	102	5350	29170	5452	23718	4.35

Note : Remaining data on optimum levels of ET of different varieties under appraised prices and cost are being presented in Appendix - I.

evapotranspiration were quadratic i.e. the dry pod yields increased at decreasing rates (fig. 9), but the responses were not bracketed by administered levels of evapotranspiration. The potential yields of 3.798, 3.523, 3.865 and 2.924 tonnes per hectare of ICGS-11, ICGS-21, ICGS-44 and SB-XI respectively were attained at 0.8663, 0.8638, 0.8963 and 0.8286 ha m of evapotranspiration. The partitioning of maximum evapotranspiration coefficients with respect to zero levels of pod yields in each variety indicated that the actual evapotranspirations for vegetative growth were 0.648, 0.643, 0.680 and 0.543 ha m in ICGS-11, ICGS-21, ICGS-44 and SB-XI respectively. Corresponding evapotranspirations for pod yield formations were 0.218, 0.221, 0.236 and 0.286 ha m respectively.

The data on marginal and physical product i.e. (Kg/ha cm) presented in fig. 10(a) revealed that variety ICGS-11 recorded highest marginal rate of increase in productivity of 420.87 kg/ha cm of water at 0.60 ha m of evapotranspiration and it decreased upto 25.77 kg/ha cm with the increase in evapotranspiration upto 0.85 ha m. The corresponding values of rates of increase were 415.86 and 65.01 kg/ha cm in variety ICGS-44 and 379.55 and 19.59 kg/ha cm in variety ICGS-21. The marginal rate of increase in variety SB-XI was lowest. It was 196.50 kg/ha cm at 0.6 ha m of water and it decreased to 24.16 kg/ha cm at 0.80 ha m of water. This showed that variety SB-XI was less responsive to evapotranspiration. The average physical

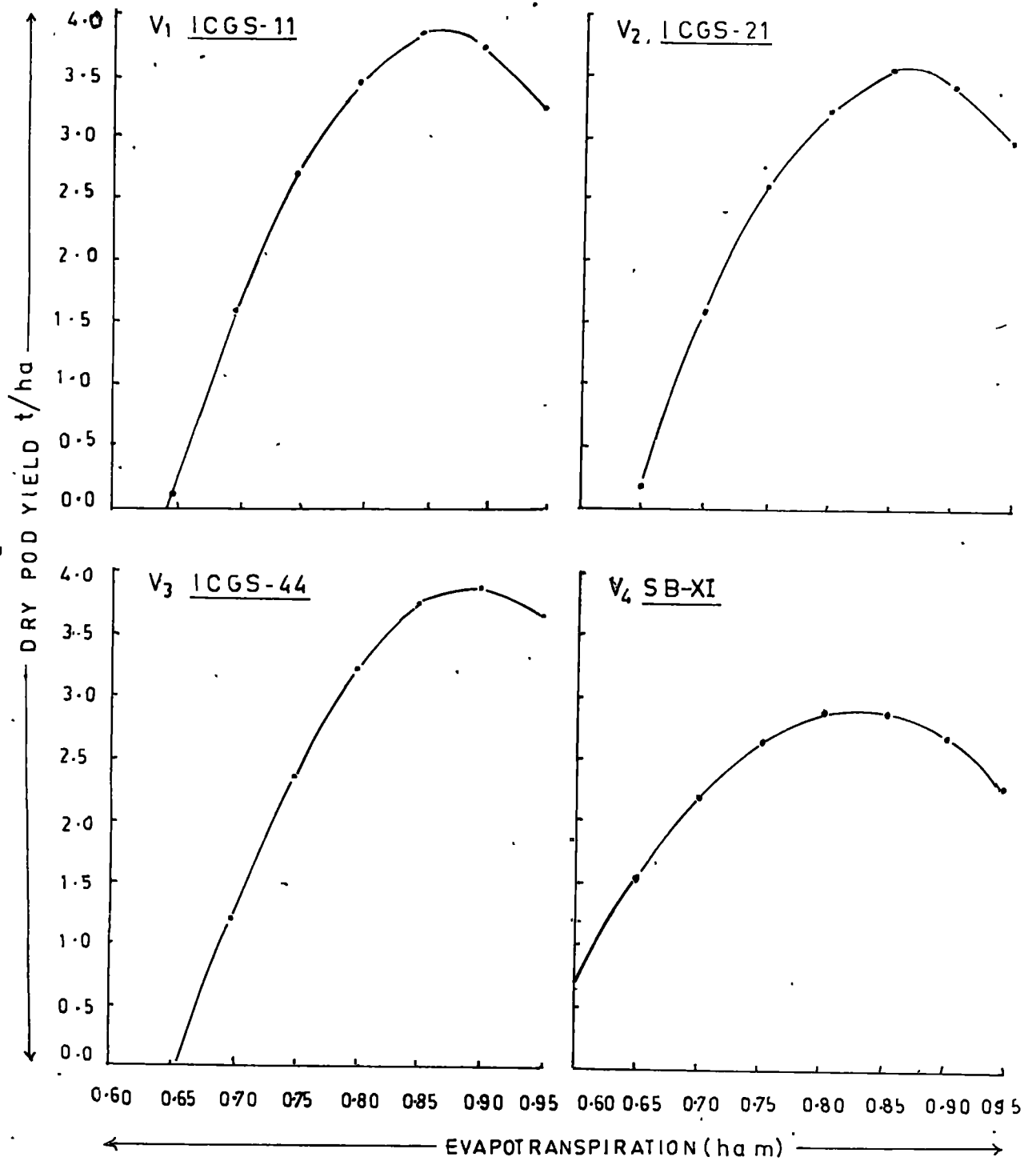
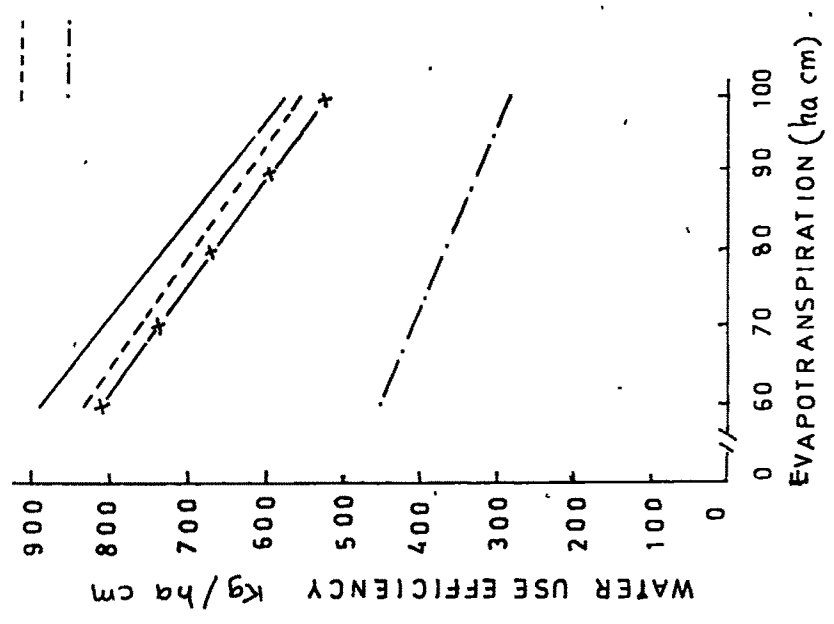
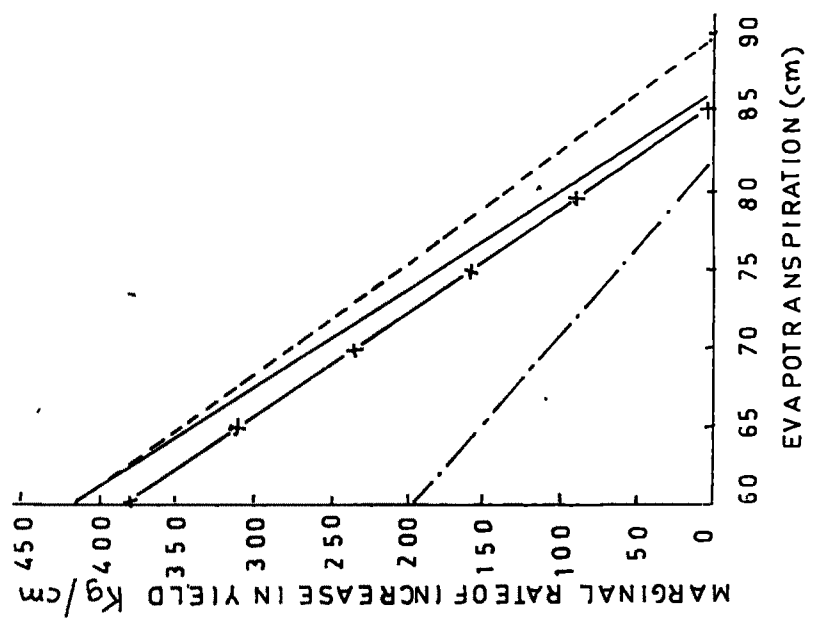


Fig 9 YIELD-EVAPOTRANSPIRATION RELATIONSHIP

V1
 V2
 V3
 V4



(b) WATER USE EFFICIENCY OF GROUNDNUT VARIETIES



(a) MARGINAL RESPONSE OF GROUNDNUT VARIETIES

Fig.10(a) MARGINAL RESPONSE OF GROUNDNUT VARIETIES

product i.e. water use efficiency at 60 to 95 cm depth of evapotranspiration presented in fig. 10(b) revealed that the water use efficiency decreased with the increase in evapotranspiration. The variety ICGS-11 recorded highest water use efficiency followed by ICGS-44 and ICGS-21. The variety SB-XI recorded lowest water use efficiency.

The programming of maximum water needs in terms of irrigation frequency of different varieties is given in crisp in Table 54 in relation to the depth of water application at 100 per cent irrigation efficiency.

Table 54. Irrigation frequency of different varieties in relation to their maximum water needs

Varieties	Maximum Evapotranspiration (cm)	Depth of irrigation (cm)		
		6.0	7.5	9.0
ICGS-11	86.63	14	12	10
ICGS-21	86.38	14	12	10
ICGS-44	89.63	15	12	10
SB-XI	82.86	14	11	9

Data presented in Table 54 revealed that varieties ICGS-11, ICGS-21, ICGS-44 and SB-XI may be grown on limited availability of canal or well irrigation.

4.11 Economic analysis of yield-water relations

In yield-water functional relations, their economic analysis is more important than its component analysis. This is because the monetary implications of

such relations can be examined in right perspective as introduction of cost and price elements of the produce in fitted functional form. So as to fulfill this objective in present case, the first derivatives of yield water relations were equated with the ratio of cost of water to value of produce and the economically viable input levels falling in rational zone were assessed along with net profit under the spectrum of appraised prices (10,000, 11,000 and 12,000 Rs. per tonne of pod yield) and cost (Rs. 125, 150, and 175 per 100 mm of water) and relevant data are presented in Table 55 and appendix -I for varieties ICGS-11, ICGS-21, ICGS-44 and SB-XI.

The perusal of data of optimum level of irrigation water presented in Table 55 and appendix-I revealed that in variety ICGS-11, economically optimum level of water ranged from 849 to 856 mm. Similarly, for variety ICGS-21 it ranged from 846 to 886 mm, for ICGS-44 from 879 to 886 mm and for variety SB-XI it ranged from 811 to 818 mm. The order of responsiveness of varieties was in the sequence of ICGS-44 followed by ICGS-11, ICGS-21 and SB-XI.

The data further showed that at constant price of produce the increasing cost of water reduced the most economical level and vice versa. Similarly, the net profit showed direct relationship with increasing price of produce and indirect relationship with increasing cost of water.

DISCUSSION

V. DISCUSSION

Results of the present investigation are discussed in brief in this chapter.

Soil and Climate

Soil of the experimental plots was low in organic carbon and nitrogen, medium in available phosphorus, high in potassium and slightly alkaline in reaction. It was clayey in texture, retentive of moisture with optimum available soil moisture range (19.0 to 20.7 per cent). The mean weekly maximum temperatures ranged from 29.1 to 44.8 °C in 1989. The corresponding figures in 1990 were 29.3 and 42.5 °C respectively. At the final stage of crop in 1989 mean maximum as well as minimum temperatures were higher as compared to 1990. Due to these higher temperatures, evaporation rate was slightly higher in final stage of crop in 1989. In initial stage of crop growth there was no much variation in evaporation rate in both the years. The mean relative humidity (RH) was slightly higher in initial and final stage in 1990 as compared to 1989. The bright sunshine hours and wind velocity were slightly higher in final stage of 1989 than 1990. Total precipitation received in 1989 and 1990 was 85.5 mm and 110.5 mm respectively. The experimental crop was sown on 17th January and 22nd January in 1989 and 1990 respectively.

Growth attributes

The height of plants was found to increase progressively till maturity. The increase was comparatively slow during early period of crop growth, rapid during 45-90 days and slow thereafter during both the years. Variety SB-XI recorded significantly more plant height at all stages of crop growth in 1989 and from 60 days onwards upto harvest in 1990 as compared to other varieties under test. Karhale (1987) and Jadhav (1987) also recorded more height of SB-XI as compared to ICGS-11 and Robut-33-1. Varieties ICGS-11, ICGS-21 and ICGS-44 did not vary much amongst themselves in respect of plant height throughout the growth period in both the seasons. The plant height thus appeared genetic character of the varieties. The variety SB-XI an erect type recorded more plant height and other three varieties grouped as semi erect were dwarfer as compared to former.

Data on mean number of branches per plant would indicate that during 1989 variety SB-XI recorded significantly more number of branches per plant. However, varieties ICGS-11 and ICGS-21 produced more or less similar number of branches, while variety ICGS-44 produced relatively lower number of branches till 105 days. In the year 1990, the pattern of branching in various varieties in general was similar to the previous year except that the number of branches of ICGS-44 was more and was comparable to SB-XI and ICGS-11. The mean number of

branches of ICGS-21 was lesser as compared to remaining varieties. The variation in the behaviour of ICGS-44 in two seasons was probably due to relatively low emergence and less initial vigour of the variety in 1989. Branching was not affected by various irrigation depths upto 45 days in both the years. In 1989, application of 7.5 cm of irrigation depth significantly enhanced the number of branches per plant as compared to 6.0 and 9.0 cm depths. In second year of experimentation, lower irrigation depths of 6.0 and 7.5 cm produced higher number of branches as compared to 9.0 cm, from 60 days onwards upto maturity. This may be due to higher frequency of irrigation in 6.0 and 7.5 cm depths which might have provided more optimum soil moisture and microclimatic conditions resulting in favourable growth and more number of branches per plant. Similar findings were reported by Shelke and Khuspe (1980) and Sabale and Khuspe (1986). However, Shinde (1980) observed non-significant effect of various frequencies of irrigation on branching.

The data on interaction effect of varieties and irrigation depths revealed that in 1989 at 60 days under constant depths of 6.0 and 7.5 cm, varieties ICGS-11, ICGS-21 and SB-XI recorded similar number of branches, but higher than ICGS-44. In all the varieties mean number of branches were significantly reduced with highest depth of irrigation of 9.0 cm. Similarly interaction effect of varieties and irrigation depths was evident at 120 days

in 1989, where in it was observed that mean number of branches of ICGS-44 was not influenced by various irrigation depths where as in other varieties number of branches per plant increased by 7.5 cm depth and significantly decreased by application of 9.0 cm depth of irrigation.

The effect of varieties on leaf area was evident at all the stages in both the years except at 30 days in 1989. During both the years, varieties ICGS-11 and ICGS-44 recorded significantly higher leaf area per plant as compared to other varieties. Varieties ICGS-21 and SB-XI produced lower leaf area per plant and were at par with each other in 1989 as well as in 1990. The relative leaf area per plant may be the genetic character of respective varieties mainly governed by number of leaves/leaflets and size of the leaflets. Varieties ICGS-11 and ICGS-44 might have produced higher number of leaves and broader leaflets as compared to other two varieties. Higher leaf area in ICGS-11 and ICGS-44 as compared to SB-XI was also observed by Deshmukh (1991). Leaf area was not influenced upto 45 and 60 days due to different irrigation depths during the year 1989 and 1990 respectively. From that stages onwards 6.0 and 7.5 cm irrigation depths recorded higher leaf area per plant than higher depth of 9.0 cm in respective years. Similar findings were reported by Thanzuala (1987) and Babalad and Kulkarni (1988).

It would be revealed from the data on mean number of pods per plant that it was significantly influenced by varieties and irrigation depths in both the years of experimentation. During 1989, varieties ICGS-11 and ICGS-44 were at par with each other producing significantly more number of pods than that of SB-XI. It would be further observed that variety ICGS-11 was significantly superior to ICGS-21, which in turn was at par with ICGS-44. During the year 1990 also varieties ICGS-11 and ICGS-44 were at par with each other and produced significantly more number of pods over remaining two varieties at harvest. Amongst other two varieties ICGS-21 was significantly superior to SB-XI. Similarly higher number of pods in variety ICGS-11 were also recorded by Jadhav (1987) and Shelke *et al.* (1989). This indicated higher potential of variety. Effect of irrigation depths on number of pods was evident at 90 days and at harvest during 1989. At both stages, irrigation depths of 6.0 and 7.5 cm were at par with each other. Application of 7.5 cm depth was significantly superior to 9.0 cm at both these stages, where as 6.0 cm depth was superior to 9.0 cm only at harvest. During the year 1990 also irrigation depths of 6.0 and 7.5 were significantly superior to 9.0 cm depth at all the stages except at 105 days, when 6.0 cm was at par with 9.0 cm. This indicated that high frequency irrigation is conducive for providing more favourable microclimate requirede for producing higher number of

Pods per plant. Rami Reddy *et al.* (1982) and Ramesh babu *et al.* (1984) also recorded higher number of pods with higher frequency of irrigation.

Data on mean number of nodules per plant indicated that the number of nodules increased upto 90 days and gradually decreased thereafter upto harvest. In the year 1989, varieties ICGS-11 and ICGS-44 were at par and produced significantly higher number of nodules as compared to ICGS-21 and SB-XI at all the stages. Variety ICGS-21 was superior to SB-XI in nodule production. During the year 1990 variety ICGS-44 produced significantly more number of nodules per plant than other varieties except at 120 days, when it was at par with ICGS-11. The results revealed that all the ICRISAT varieties were significantly superior in nodule production as compared to SB-XI. Production of nodules, thus, appeared to be a varietal character, ICRISAT varieties, particularly ICGS-11 producing relatively higher number of nodules per plant. This might have reflected in relatively more efficient fixation of atmospheric nitrogen in ICGS-11, which may result in higher productivity of the variety. More number of nodules in variety ICGS-11 were also reported by Jadhav (1987) and Shelke *et al.* (1989).

Application of different irrigation depths influenced nodule formation from 60 days onwards upto harvest in both the years. Lower depths of 6.0 and 7.5 cm produced significantly more number of nodules over higher

depth of 9.0 cm throughout the growing season in both the years. From the data it appears that most frequent irrigations might have provided more optimum conditions viz. aeration, soil temperature etc. for favourable growth of rhizobium. This probably resulted in rapid multiplication of rhizobium and more fixation of atmospheric nitrogen. Similarly, Shelke and Khuspe (1980) and Rasve *et al.* (1983) also recorded increased number of nodules with increase in frequency of irrigation.

Data on dry matter accumulation revealed that the total dry matter per plant was found to increase continuously with advancement in age of the crop. During 1989, varieties ICGS-44 and ICGS-11 produced higher dry matter per plant as compared to remaining two varieties from 75 days onwards. Varieties ICGS-21 and SB-XI were at par throughout the growth period. Pattern of dry matter accumulation during 1990 was more or less similar, except that variety ICGS-21 produced significantly higher dry matter than that of SB-XI at harvest. It would be seen from the results that varieties ICGS-11 and ICGS-44 were more efficient in dry matter production as compared to remaining two varieties viz. ICGS-21 and SB-XI. Higher dry matter accumulation by these varieties may be due to superior varietal performance as evident in more leaf area and higher number of nodules per plant. Higher leaf area per plant probably helped in accumulation of more photosynthates in the plant parts resulting in higher

production of dry matter per plant. Karhale (1987) and Deshmukh (1991) observed higher dry matter per plant in varieties ICGS-11 and ICGS-44 as compared to SB-XI.

It would be evident from the data in Tables 29 and 30 that higher frequencies of irrigation i.e. 6.0 and 7.5 cm were beneficial in production of more dry matter per plant in both the years. However, superiority of these two lower depths of irrigations over 9.0 cm was statistically significant only from 90 days onwards in first year and 60 days onwards in second year. The higher dry matter production in 6.0 and 7.5 cm depths indicated that there was optimum moisture available in these treatments. This probably also provided more conducive microclimate to the plants which were consequently benefited. Higher depth of 9.0 cm irrigation was not suitable because of probable temporary oxygen stress to the groundnut plants which are more sensitive to such type of stress. The higher depth may also result in excess application of irrigation water which might have drained out available nutrients in deeper zones of soils making nutrients as well as moisture unavailable to the plants. Lowering down the soil temperatures temporarily may probably be other reason adversely affecting the crop growth. These results are in confirmation with the results reported by Sabale and Khuspe (1986), Ravi Kumar *et al.* (1987) and Babalad and Kulkarni (1988).

Growth analysis

The analysis of plant height in terms of AGR indicated that, it was slow during initial stage, increased rapidly upto 60 days and slowed thereafter in both the years. Similar findings were recorded by Shinde (1980).

Data on AGR for dry matter revealed that rate of dry matter accumulation in varieties ICGS-11 and ICGS-44 was more as compared to ICGS-21 and SB-XI. This appeared to be varietal character. Lower irrigation depths of 6.0 and 7.5 cm recorded higher rate of dry matter accumulation as compared to 9.0 cm. This may be due to more favourable microclimatic condition received by the plants under these treatments. Similar observations were recorded by Thanzuala (1987).

Varieties ICGS-11 and ICGS-44 recorded higher values of RGR during both the years. The data thus revealed higher efficiency of these varieties in relative accumulation of dry matter as compared to other two varieties. The differences in RGR values of 6.0 and 7.5 cm depths were marginal and these treatments recorded higher RGR values as compared to 9.0 cm depth. Higher RGR values in high frequency irrigations were recorded by Shelke (1979).

Data on net assimilation rate (NAR) revealed that the NAR was relatively higher from 31 to 75 days in both the seasons and slowed thereafter upto maturity.

Treatment effects were not consistent in any of the years. These results are in confirmation with those reported by Shinde (1980).

Amongst different varieties, ICGS-44 and ICGS-11 recorded higher LAI as compared to ICGS-21 and SB-XI in both the years of experimentation. Higher LAI of these varieties provided more leaf area per unit of land. This might have proved conducive to more assimilation of photosynthates per plant by these varieties. Application of 6.0 and 7.5 cm irrigation depths improved LAI over 9.0 cm irrigation depth because of favourable soil moisture regimes. Similar results were obtained by Babslad and Kulkarni (1988).

Yield attributes

Number of filled pods were higher in varieties ICGS-11 and ICGS-44 as compared to ICGS-21 and SB-XI in 1989 as well as 1990. This may be due to relatively higher number of effective gynophores and their proper development of pods in varieties ICGS-11 and ICGS-44 as compared to other two varieties. Shelke (1989) and Deshmukh (1991) also recorded higher number of filled pods in ICGS-11 and ICGS-44. Number of filled pods per plant were higher in treatments receiving 7.5 cm irrigation depth. Rami Reddy *et al.* (1982) observed higher number of filled pods per plant with high frequency of irrigation, keeping total quantity of water almost constant. Data on interaction effect (Table 38) revealed

that number of filled pods of ICGS-11 was not influenced by 6.0 and 7.5 cm irrigation depths. In case of other varieties it increased with increase in depth of irrigation from 6.0 to 7.5 cm and decreased drastically at 9.0 cm irrigation depth. Statistically similar number of filled pods in case of ICGS-11 under higher frequency of irrigation indicated more plasticity of the variety as compared to other varieties.

Number of unfilled pods and one seeded pods were higher in variety SB-XI in both the years. This indicated that pods in variety SB-XI were not fully filled and developed, hence could not contribute to the productivity of the variety. Number of one seeded as well as unfilled pods were not influenced by irrigation depths. Shinde (1980) also observed similar results.

In the year 1988 variety ICGS-11 produced more number of two seeded pods, whereas, in 1990 varieties ICGS-11 along with ICGS-44 proved superior to ICGS-21 and SB-XI. Deshmukh (1991) also recorded higher number of two seeded pods in these varieties. In first year, irrigation depth of 7.5 cm recorded higher number of two seeded pods. However, in second year irrigation depths of 6.0 and 7.5 cm were equally effective and superior to 9.0 cm depth. Similar observations were made by Kachot *et al.* (1984) and Patel *et al.* (1988).

Weight of dry pods per plant recorded by ICGS-11 and ICGS-44 was higher as compared to ICGS-21 and SB-XI in both the years of investigation. Higher number of two seeded pods and relatively less number of unfilled pods per plant has resulted in more weight of dry pods per plant in case of varieties ICGS-11 and ICGS-44. Higher weight of dry pods per plant in ICGS-11 and ICGS-44 was recorded by Durugkar (1985) and Deshmukh (1991). Irrigation depth of 7.5 cm recorded higher dry pod weight over 6.0 and 9.0 cm depths in 1989. However, in 1990, 6.0 and 7.5 cm depths were equally effective and recorded higher dry weight of pods as compared to 9.0 cm depth, may be because of favourable moisture regimes and improved vegetative characters. The results are in confirmation with the findings of Ramesh Babu *et al.* (1984) and Sabale and Khuspe (1986).

Hundred kernel weight was significantly affected by varieties. In the year 1989, ICGS-21 recorded higher 100-kernel weight over all other varieties. However, in 1990, varieties ICGS-21 and ICGS-11 recorded similar 100-kernel weight, but superior to ICGS-44 and SB-XI. Test weight of kernels appeared to be varietal character, variety ICGS-21 being superior to rest of varieties under study. Variety SB-XI recorded lowest hundred kernel weight amongst all the varieties. Similar findings were reported by Patil (1980) and Karhale (1987). The higher 100-kernel weight of ICRISAT varieties may be one of the yield attributing characters which may

contribute to the overall productivity of these varieties. Hundred kernel weight was influenced by irrigation depths in 1990 only. Irrigation depths of 6.0 and 7.5 cm improved the hundred kernel weight over higher depth of 9.0 cm. More favourable soil moisture conditions in high frequency irrigation treatments might have proved conducive to optimum growth of the plant and resulted in proper translocation of photosynthates in the kernels. Shelke (1979) did not observe significant effect of irrigation on test weight. However, Rami Reddy *et al.* (1982) and Rasve *et al.* (1983) observed higher 100-kernel weight with high frequency irrigations.

Shelling percentage was found to be more in ICGS-11, ICGS-21 and ICGS-44 as compared to SB-XI. Similar observations were made by Karhale (1987) and Jadhav (1987). Shelling percentage was not influenced by irrigation depths in both the years of investigation. Patel *et al.* (1988) and Katre *et al.* (1988) recorded non-significant effect of irrigation on shelling percentage.

Data on kernel yield revealed that ICGS-11 recorded higher kernel yield over other varieties in 1989. However in 1990, ICGS-11 and ICGS-44 recorded similar kernel yield. The higher kernel yield in ICGS-11 and ICGS-44 may be due to higher pod yields and shelling percentage in these ICRISAT varieties. Irrigation depths of 6.0 and 7.5 cm were equally superior to 9.0 cm depth in improving kernel yield.

Yield studies

Data presented in Table 36 on yield of dry pods per ha indicated that variety ICGS-11 recorded higher yield of dry pods as compared to other varieties in first year. During second year, however, it was at par with ICGS-44 and both these varieties were significantly superior to ICGS-21 and SB-XI. The critical analysis of performance of ICGS-44 would reveal that its yield level were relatively lower as compared to its potential expressed in second year. From the detailed analysis of biometric observations it would be observed that in the year 1989, the emergence of this particular variety was not optimum and this resulted in lower plant density than optimum. Even though every effort was made to obtain the required density by gap filling, the vigour of the gap filled plants could not match with the plants emerged from the date of first planting. The statistical analysis of the yield of dry pods was done by using the technique of co-variance (Chandel, 1970), still the true potential of the variety was not reflected due to lower initial vigour of gap filled plants of ICGS-44. In view of this the experiment was again continued for one more year to confirm the differential behaviour of the variety. The object of the continuation of the experiment was limited only to the extent of yield potential.

The yield data of dry pods for year 1991 revealed that variety ICGS-44 significantly out-yielded rest of the varieties, which were at par with each other.

The pooled analysis on the basis of three years data of the yield of dry pods revealed that all the three ICRISAT varieties were at par and significantly superior to SB-XI. Variety ICGS-11 appeared superior as compared to ICGS-21 and ICGS-44 as reflected in its higher yield potential in two years out of three as well as pooled data. Higher yield of dry pods of ICRISAT varieties, particularly ICGS-11 may be attributed to more leaf area per plant, higher nodulation, better AGR (dry matter) and RGR values revealed during the growth period. Significantly higher leaf area per plant in case of ICGS-11 and ICGS-44 provided optimum conditions for efficient photosynthesis as reflected in higher dry matter accumulation per plant. It would be further revealed that ICGS-11 recorded higher number of two seeded pods as compared to other varieties. Moreover, mean number of unfilled pods was less in this variety as compared to that of SB-XI..

The critical analysis of above observations would reveal that effective fruiting was relatively more in ICGS-11. Higher weight of dry pods per plant recorded by ICGS-11 would further reveal that photosynthates assimilated during the growth of the plant were translocated more efficiently in the pods which is the economic yield of the crop. Higher yield of ICGS-11 and other ICRISAT varieties as compared to SB-XI, thus, appeared to be corollary of the superior characters as reflected in higher leaf area per plant, dry matter per

plant, AGR (dry matter), RGR, nodulation, number of two seeded pods and weight of dry pods per plant etc. Higher yield potential of ICGS-11 and ICGS-44 as compared to SB-XI was reported by Anonymous(1984), Anonymous (1985), Anonymous (1988), Shelke *et al* (1989) and Deshmukh (1991).

The data on yield of dry pods as influenced by various irrigation depths presented in Table 36 would reveal that lower irrigation depths of 6.0 and 7.5 cm recorded higher yield of dry pods as compared to higher depth of 9.0 cm in all the years of experimentation. In the year 1991, lowest irrigation depth of 6.0 cm was significantly superior to 7.5 as well as 9.0 cm irrigation depth. However, on the basis of pooled analysis of three years data 6.0 and 7.5 cm irrigation depths were at par with each other and significantly superior to 9.0 cm depth. The higher yield at lower irrigation depths i.e. high frequency irrigations can be attributed to improvement in growth characters viz. leaf area per plant, dry matter/plant and nodulation, and yield contributing characters like more number of pods/plant and higher pod weight/plant in high frequency irrigations because of favourable soil moisture conditions. Similarly higher pod yields in high frequency irrigations were also reported by Rami Reddy *et al.* (1982), Bharambe and Varsde (1982), Rasve *et al.* (1983), Gajera and Patel (1984), Thorat *et al.* (1988) and Katre *et al.* (1988).

The optimum soil moisture regime under high frequency irrigation treatments were probably conducive for better plant growth. The higher nodulation in these treatments were probably because of optimum soil moisture and temperature conditions. This might have reflected in more efficient fixation of atmospheric nitrogen in the plant which was beneficial for optimum plant growth. The higher yield of lower depths of irrigations was thus the result of beneficial influence of these treatments on growth and yield attributes. Moreover, there may be some loss of soil moisture in deep drainage besides some adverse effects on aeration and soil temperature in respect of 9.0 cm irrigation depth.

Pooled analysis of dry haulms yield revealed that variety ICGS-11 recorded higher haulms yield over ICGS-21, ICGS-44 and SB-XI. This was due to more vegetative growth of ICGS-11 probably because of higher dry matter accumulation not only in pods but also in haulms on account of its maximum efficient photosynthesis and assimilation. Application of 7.5 cm depth of irrigation improved haulms yield over 6.0 and 9.0 cm depths in pooled analysis. Data thus indicated that application of 7.5 cm irrigation depth tended to enhance the vegetative growth although the pod yield was not affected much.

Variety ICGS-11 produced higher biological yield over other varieties. It was significantly more in the year 1989 as compared to rest of the varieties, where as it was at par with ICGS-44 in year 1990. Higher biological yield in these treatments may be due to higher yield of dry pods and haulms, which ultimately resulted in higher biological productivity. Different depths of irrigations also influenced biological yield. In the year 1989, 7.5 cm irrigation depth recorded higher biological yield over other two levels. However, in 1990, irrigation depths of 6.0 and 7.5 cm were equally effective and superior to 9.0 cm depth.

Data on harvest index revealed that it was influenced by varieties only in 1989. Varieties ICGS-11, ICGS-21 and ICGS-44 were at par and recorded higher harvest index over SB-XI. Jadhav (1987) recorded higher harvest index in variety ICGS-11. Higher HI in ICRISAT varieties may be due to their higher yield potential and dry matter accumulation as well as its efficient apportionment in economical yield i.e. pods. The variety SB-XI apparently was less efficient in this aspect. Harvest index tended to decrease with application of 9.0 cm irrigation depth. However, the differences did not reach to the level of significance in both the years.

Chemical studies

Data on oil percentage (Table 40) would indicate that oil percentage was affected by varieties in both the years of experimentation. In first year varieties

ICGS-21 and ICGS-44 recorded higher oil content where as in second year, varieties ICGS-21, ICGS-44 and SB-XI were found superior to ICGS-11. It would be thus observed that variety having high yield potential tended to have less oil content. Similar negative correlations of oil content and pod yield have been reported by Dhopte and Kudupley (1986). Higher oil content of SB-XI as compared to other varieties was also reported by Thorat and Patil (1988). Oil percentage was not influenced by application of different irrigation depths in both the years. Shelke and Shinde (1980) and Ravi Kumar *et al.* (1987) also observed non-significant effect of irrigation on oil content.

Oil yield (q/ha) was influenced by varieties in the year 1989 only. Varieties ICGS-11 and ICGS-21 produced higher oil yield over ICGS-44 and SB-XI. This broadly followed the pattern of the yield of dry pods/ha. Irrigation depths of 6.0 and 7.5 cm were equally effective in producing higher oil yield as compared to 9.0 cm depth. Higher oil yield may be due to higher kernel yield under 6.0 and 7.5 cm depth. Higher oil yield with high frequency irrigations were also reported by Ramesh babu *et al.* (1984) and Ravi Kumar *et al.* (1987).

A reference to Table 40 would reveal that variety SB-XI recorded higher protein percentage in kernels as compared to other varieties during both the years of experimentation. Similarly, varieties ICGS-21 and

ICGS-44 recorded higher protein percentage over ICGS-11. Higher protein percentage in variety SB-XI as compared to other varieties was also observed by Dhopte and Kudupley (1986). Protein percentage remained unaffected due to different irrigation depths in both the years. Non-significant effects of irrigation on protein content were also reported by Ravi Kumar *et al.* (1987) and Thanzuala (1987). The protein percentage appeared to be varietal character which remained unaffected by different irrigation depths.

Protein yield (q/ha) was also influenced by varieties during 1988 only. Varieties ICGS-11 and ICGS-21 produced higher protein yield over ICGS-44 and SB-XI. Amongst different irrigation depths tried, 7.5 cm and 8.0 cm depths proved superior to 9.0 cm depth in producing higher protein yield. These differences in protein yield are due to differences in kernel yield influenced by varieties and irrigation depths. Shinde and Umrani (1986) recorded higher protein yield with increase in number of irrigations.

A reference to Table 41 would indicate that ICGS-11 and ICGS-44 recorded higher uptake of N in kernels as compared to ICGS-21 and SB-XI in both the years, however, the differences could not reach to the level of significance. In case of irrigation depths, lower depths of 6.0 and 7.5 cm resulted in increased uptake of N in kernels over higher depth of 9.0 cm. This may be because

of better crop growth under these treatments, resulting in higher uptake and higher yields. Zalawadia and Patel (1983) observed higher N uptake in kernels by irrigating at 75 per cent ASM.

The pattern of uptake of N by haulms as well as total uptake of N by whole plant was more or less similar. It was influenced by varieties in both the years. In 1989, varieties ICGS-11, ICGS-21 and SB-XI recorded higher N uptake, over ICGS-44. However, during 1990, varieties ICGS-11 and ICGS-44 were superior to ICGS-21 and SB-XI. These differences amongst varieties are due to differences in pod yields. Application of 7.5 cm depth of irrigation increased uptake of N in haulms and total uptake as compared to 6.0 and 9.0 cm depths, during 1989. In the year 1990, 6.0 and 7.5 cm depths were equally effective but superior to 9.0 cm depth. Similar findings were reported by Polara (1984) and Ravi Kumar *et al.* (1987).

Uptake of phosphorus in kernels was influenced by varieties during both the years. Variety ICGS-11 recorded higher uptake of P in kernels over all other varieties during both the years. However it was at par with ICGS-44 during 1990. Higher yield levels in ICGS-11 and ICGS-44 might have resulted in increased uptake of phosphorus. Application of 6.0 and 7.5 cm depth resulted in increased P uptake in kernels as compared to 9.0 cm depth during both the years. Babu *et al.* (1985) recorded higher P uptake with high frequency irrigations.

As in case of uptake of N, the pattern of total uptake of phosphorus by whole plant and uptake of P by haulms was similar. It was influenced by varieties as well as irrigation depths during both the years of experimentation. Variety ICGS-11 recorded higher uptake of P in haulms as well as total uptake as compared to other varieties. It was followed by ICGS-21, SB-XI and ICGS-44 in 1989, whereas in 1990 ICGS-11 was followed by ICGS-44, ICGS-21 and SB-XI. Application of 7.5 cm irrigation depth resulted in increased P uptake in 1989, however, during 1990, 6.0 and 7.5 cm proved superior to 9.0 cm depth. Shelke (1979) also observed higher phosphorus uptake in frequently irrigated treatments.

Potassium uptake in kernels was highest in ICGS-11 during both the years. It was followed by ICGS-21, SB-XI and ICGS-44 during 1989 and ICGS-44, ICGS-21 and SB-XI during 1990. During both the years of experimentation lower depths of 6.0 and 7.5 cm were equally effective in higher uptake of potassium as compared to 9.0 cm depth.

During 1989 uptake of K in haulms as well as total uptake was higher in ICGS-11, being at par with ICGS-21 and superior to other varieties. During 1990, ICGS-44 and ICGS-11 recorded higher uptake of K in haulms, as well as total K uptake as compared to rest of the varieties. Application of 7.5 cm irrigation depth recorded higher uptake of K in 1989. However, during 1990, depths

of 6.0 and 7.5 cm proved superior to 9.0 cm depth. These results are in confirmation with those reported by Polars (1984) and Babu *et al.* (1985). From foregone discussion it is revealed that moisture supply appeared to be conducive to both, chemical availability of nutrients in soil and its efficiency. The maximum utilization of the nutrients by the crop under 6.0 and 7.5 cm irrigation depths could be attributed to the better growth of the crop resulting from the optimum ecological condition created by suitable combination of aeration, temperature and supply of water.

Moisture studies

The mean seasonal consumptive use of water was 736.37 mm in 1989 and 810.85 mm in 1990. The total consumptive use in the year 1990 was relatively higher probably because of higher evaporative demands as evident from the meteorological data in Table 3, during grand growth period and pod development stage. It may also be due to better plant growth and more leaf area per plant providing more surface area for evaporation. Favourable plant growth might have also resulted in proportionality better root growth which might have enabled the plant to extract moisture from deeper soil layers.

Amongst varieties, ICGS-11 recorded higher consumptive use during first year followed by ICGS-21, ICGS-44 and SB-XI. However, in second year, variety ICGS-44 recorded highest consumptive use followed by ICGS-11, ICGS-21 and SB-XI. The improved performance of ICGS-44

during 1990 was probably due to optimum plant density and growth of the variety in second year. Total consumptive use of water was higher in 7.5 cm irrigation depth as compared to 9.0 cm irrigation depth. The higher consumptive use under 7.5 cm depth could be attributed to more number of irrigations indicating that the number and frequency rather than depth per turn increased consumptive use by the crop. Kadam and Patil (1989) recorded higher consumptive use with higher frequency of irrigation depths. Goldberg *et al.* (1971) claimed that increasing the irrigation frequency increased the availability of irrigation water through the establishment of relatively moist conditions in the root zone throughout the crop period. Several workers recorded increased consumptive use with increase in available soil moisture and irrigation frequency (Shelke, 1979, Shinde, 1980 and Gajera and Patel, 1984).

Data on interaction effect of varieties and irrigation depths revealed that varieties ICGS-11, ICGS-21 and ICGS-44 recorded higher consumptive use with 7.5 cm depth than that of 6.0 and 9.0 cm depth. In respect of SB-XI consumptive use significantly decreased with increase in depth of irrigation.

Data on daily consumptive use indicated that daily consumptive use was highest in variety ICGS-11 and it was subsequently followed by ICGS-21, ICGS-44 and SB-XI

in 1989. In 1990, however, ICGS-44 recorded highest consumptive use followed by ICGS-11, ICGS-21 and SB-XI respectively. Daily consumptive use increased due to irrigation depths of 6.0 and 7.5 cm and declined in higher depth of 9.0 cm in both the years. This might be probably due to subnormal plant growth under higher moisture regime of 9.0 cm because of unfavourable microclimatic conditions of temporary oxygen stress and lower soil temperatures.

The daily mean rate of water use of groundnut was low during establishment and early flowering as well as during subsequent stages of flowering to vegetative growth because of less vegetative cover, low moisture requirement and other climatic factors. Rate of water use increased during yield formation and pod development and decreased slightly at ripening stage may be because of low water requirements during maturity.

The crop coefficient (K_c) values followed the similar trend of daily water use, they were small in initial period i.e. establishment, flowering and vegetative stages and increased at yield formation stage and slightly decreased at ripening stage. Goldberg *et al.* (1967) and Doorenbos and Kassam (1979) also observed similar results. In first year, varieties ICGS-11 and ICGS-21 recorded higher K_c values than ICGS-44 and SB-XI. However, during second year ICRISAT varieties ICGS-11, ICGS-21 and ICGS-44 recorded more or less similar K_c values which were higher than those recorded by local

variety SB-XI. The Kc values under 6.0 and 7.5 cm irrigation depths were higher than 9.0 cm depth, probably, because of less moisture availability and prolonged stress period in higher depth.

Maximum soil moisture was utilized by the crop from upper most soil layer i.e. 0-30 cm, it was decreased in 30-45 cm layer considerably. Rao *et al.* (1976) and Shinde (1980) also recorded higher soil moisture extraction by groundnut crop from 0-30 cm soil layer. Higher water use from upper layers may be due to more evaporation in 0-15 cm layer and maximum root activity in 15-30 cm soil layer. Amongst different varieties, ICGS-11, ICGS-21 and ICGS-44 extracted higher soil moisture from 0-30 cm soil layer as compared to SB-XI in both the years. Lower irrigation depths of 6.0 and 7.5 cm extracted more or less similar soil moisture from 0-30 cm and 30-45 cm soil layers. However, higher depth of 9.0 cm recorded higher soil moisture extraction from second layer i.e. 30-45 cm. This might be due to less frequent irrigations under 9.0 cm depth, which resulted in stress condition and hence plant roots penetrating to deeper layer for moisture absorption.

During the year 1989, ICGS-11 recorded higher water use efficiency (WUE) and it was followed by ICGS-21, SB-XI and ICGS-44. However, during second year, varieties ICGS-44 and ICGS-11 were superior in recording higher WUE

over that of ICGS-21 and SB-XI. This might be due to better growth and development of ICGS-11 and ICGS-44, resulting in higher economic yields and ultimately higher WUE. Application of 6.0 and 7.5 cm depths of irrigation recorded higher WUE over 9.0 cm depth during both the years. These results are in confirmation with those reported by Rami Reddy *et al.* (1982), Bharambe and Varade (1982) and Katre *et al.* (1988).

The mean evapotranspiration ratio (ETR) was higher during 1989. In first year ICGS-44 and SB-XI recorded higher ETR as compared to ICGS-11 and ICGS-21. In second year, SB-XI recorded higher ETR over other varieties. This indicated the lower efficiency of SB-XI which required more water to produce unit weight of dry matter. Increase in irrigation depth also increased ETR, irrigation depth of 9.0 cm recording highest ETR during both the years.

Correlation and regression studies

It would be seen from simple correlation studies that the pod yield per plant was positively and significantly correlated with branches, leaf area, total dry matter, number of root nodules and number of pods per plant. It was negatively correlated with height and shelling percentage. The simple regression analysis revealed that the plant characters which showed significant correlations showed significant regressions between pod yield per plant and other characters. The

multiple regression studies would also reveal that the plant characters viz. number of branches, leaf area/plant, number of root nodules/plant, number of pods/plant and hundred kernel weight are the important yield contributing characters which increased pod yield of groundnut. Similar results were reported by Shinde (1980).

Yield - evapotranspiration relationship

The relationship between irrigation water in m and yield of groundnut pods in t/ha was found to be quadratic in nature. The dry pod yield increased with increase in irrigation water applied; but the increase in pod yield was at decreasing rate. The potential yields of 3.798, 3.523, 3.865 and 2.924 tonnes per hectare of ICGS-11, ICGS-21, ICGS-44 and SB-XI respectively were attained at 0.8663, 0.8638, 0.8963 and 0.8296 $ha\ m$ of evapotranspiration. Actual evapotranspirations for vegetative growth were 0.648, 0.643, 0.660 and 0.543 $ha\ m$ in ICGS-11, ICGS-21, ICGS-44 and SB-XI respectively. Corresponding evapotranspirations for pod yield formations were 0.218, 0.221, 0.236 and 0.286 $ha\ m$ respectively. Data on marginal and physical product i.e. water use efficiency revealed that ICGS-11 recorded highest marginal rate of increase in productivity, it was followed by variety ICGS-44, ICGS-21 and SB-XI. Similar trend was observed in water use efficiency also.

Economic analysis

Data on economic analysis of yield-water relations under the spectrum of appraised prices (10,000, 11000 and 12000 Rs. per tonne of pod yield) and cost (Rs. 125, 150, and 175 per 100 mm of water) revealed that order of responsiveness of varieties was in the sequence of ICGS-44 followed by ICGS-11, ICGS-21, and SB-XI. It was also observed that at constant price of produce the increasing cost of water reduced the most economical level and vice versa. Similarly, the net profit showed direct relationship with increasing price of produce and indirect relationship with increasing cost of water.

**SUMMARY
AND
CONCLUSION**

VI. SUMMARY AND CONCLUSION

Field experiments were conducted at the farm of Co-ordinated Project for Research on Water Management, Marathwada Agricultural University, Parbhani during summer seasons of 1989 and 1990. The experiment constituting twelve treatment combinations involving four varieties viz. ICGS-11 (V₁), ICGS-21 (V₂), ICGS-44 (V₃) and SB-XI (V₄) and three depths of irrigation viz. 6.0 cm (D₁), 7.5 cm (D₂), and 9.0 cm (D₃), was conducted in factorial randomized block design.

The experimental site was fairly uniform in topography. The soil was clayey in texture retentive of moisture, low in organic carbon and nitrogen, medium in available phosphorus and slightly alkaline in reaction. Weather conditions were more or less similar in both the seasons, except relatively higher temperatures during grand growth period of crop in 1990.

Sowing was done on January 17 and 22 during 1989 and 1990 respectively by dibbling two kernels per hill maintaining 30 x 15 cm spacing. The fertilizers were applied at the rate of 25 kg N and 50 kg, P₂O₅ /ha as basal application through urea and single superphosphate. Immediately after sowing one uniform irrigation of 60 mm depth was applied to all the plots.

Second common irrigation was applied after gap filling to establish the crop. Irrigation treatments were introduced 15 days after sowing. The inter cultivation and plant protection measures were taken as and when required during crop growth period.

Data on biometric attributes viz., plant stand, plant height, number of branches, number of nodules, number of pods, leaf area and dry matter accumulation were recorded periodically, while the data on yield attributes viz., number of filled and unfilled pods, number of one seeded and two seeded pods, weight of dry pods per plant, shelling percentage, 100-kernel weight and kernel yield were recorded after harvest. Growth analysis was carried out by working out various growth functions viz., Absolute growth rate (AGR) for height and dry matter, Relative growth rate (RGR), Net assimilation rate (NAR) and Leaf area index (LAI).

Yield of dry pods and haulms was recorded from each net plot. All data collected were subjected to statistical analysis and results were tested by adopting 'F' test at 0.05 probability level. Three years data of yield of dry pods and haulms was pooled and results presented. Data on total biological yield and harvest index was also calculated.

Soil moisture studies were started from sowing and continued upto harvest. Total consumptive use of water, water use rates during different growth stages, daily consumptive use, soil moisture depletion pattern, water use efficiency (WUE), evapotranspiration ratio (ETR) and crop coefficient values (K_c) were worked out by standard procedures. Potential evapotranspiration (PET) was worked out by modified Penman method. The K_c values were computed from the data of ET_{crop} (mm) and ET_0 by modified Penman methods for the various stages of groundnut under Parbhani conditions.

Oil and protein content in kernels as well as N, P and K uptake in kernels, haulms and total uptake in plant was found out.

Simple correlation and regression studies as well as multiple regression studies between weight of dry pods per plant and other plant characters were undertaken to assess their contribution towards pod yield.

Pod yield response to irrigation was computed by fitting quadratic equation to pooled data. The results of irrigation on pod yield response were subjected to economic analysis for ascertaining the economics of irrigation under appraised prices.

Mean height of plant was found to increase progressively till maturity. The increase was

comparatively slow during early period of crop growth, rapid during 45-90 days and slow thereafter during both the years. Amongst different varieties SB-XI recorded more plant height in both the years. Different irrigation depths did not influence plant height significantly.

The branching increased gradually upto 90 days and thereafter remained more or less constant. Variety SB-XI produced more number of branches. However, ICGS-11, ICGS-21 and ICGS-44 produced more or less similar number of branches. Lower irrigation depths of 6.0 and 7.5 cm resulted in higher number of branches as compared to 9.0 cm irrigation depth.

Varieties ICGS-11 and ICGS-44 recorded higher leaf area per plant as compared to ICGS-21 and SB-XI during both the years. Irrigation depths of 6.0 and 7.5 cm produced more leaf area over 9.0 cm depth.

Mean number of pods per plant were higher in varieties ICGS-11 and ICGS-44 as compared to other varieties. Application of lower irrigation depths of 6.0 and 7.5 cm produced more number of pods per plant than that of higher depth of 9.0 cm during both the years of experimentation.

Mean number of nodules per plant increased upto 90 days and decreased thereafter upto harvest. Varieties ICGS-11 and ICGS-44 produced more number of nodules as compared to remaining varieties. Variety ICGS-21 recorded

more nodules than SB-XI. During first year 7.5 cm depth produced higher number of nodules over 6.0 and 9.0 cm, former being superior to latter. During second year, in initial stage, 6.0 cm depth was superior, however, at later stages irrigation depth of 7.5 cm was superior to other depths.

Total dry matter per plant was found to increase continuously with advancement in age of the crop. During both the years, ICGS-11 and ICGS-44 produced more dry matter per plant over ICGS-21 and SB-XI. Variety ICGS-21 recorded higher total dry matter per plant as compared to SB-XI at harvest. High frequencies of irrigation under 6.0 and 7.5 cm were beneficial in production of more dry matter per plant during both the years.

The growth analysis in terms of AGR of height indicated that increase was slow in initial stage, rapid during active vegetative growth period and decreased thereafter. The growth functions viz. AGR and RGR of dry matter was higher in varieties ICGS-11 and ICGS-44. The differences in AGR and RGR values of 6.0 and 7.5 cm depths were marginal and they recorded higher values as compared to 9.0 cm depth. The NAR was higher upto 75 days, and slowed thereafter upto maturity. Treatments effects were not consistent in any of the year. Varieties ICGS-44 and ICGS-11 recorded higher LAI values. Application of 6.0 and 7.5 cm depth of irrigation improved LAI over 9.0 cm irrigation depth.

Varieties ICGS-11 and ICGS-44 produced more number of filled pods and two seeded pods as compared to other varieties during both the years. Irrigation depth of 7.5 cm recorded higher number of filled pods over 6.0 and 9.0 cm depths. Similarly, 7.5 cm depth produced more number of two seeded pods per plant during 1989. However during 1990, 6.0 and 7.5 cm depths were equally superior to higher depth of 9.0 cm.

Number of unfilled pods and one seeded pods were higher in SB-XI during both the years. Effect of irrigation depth was not evident in any of the season on both these characters.

Weight of dry pods per plant was higher in varieties ICGS-11 and ICGS-44 as compared to other two varieties. Application of 7.5 cm depth recorded higher weight of dry pods during first year. However, during second year, 6.0 and 7.5 cm depths were equally effective in producing higher weight of dry pods.

ICRISAT varieties ICGS-11 and ICGS-21 recorded higher hundred kernel weight. Variety SB-XI recorded lowest 100-kernel weight as compared to other varieties. Irrigation depths of 6.0 and 7.5 cm improved hundred kernel weight during 1990 as compared to 9.0 cm depth of irrigation. Kernel yield was higher in ICGS-11 and ICGS-44. Depths of 6.0 and 7.5 cm irrigation were equally effective in improving kernel yield.

Shelling percentage was higher in ICGS-11, ICGS-21 and ICGS-44 as compared to SB-XI. It was not influenced by irrigation depths in both the years of experimentation.

Variety ICGS-11 recorded higher yield of dry pods as compared to other varieties in 1989. During 1990, however, it was at par with ICGS-44 and both these varieties were superior to ICGS-21 and SB-XI. During 1991, variety ICGS-44 out-yielded rest of the varieties which were at par with each other. The pooled analysis of three years data revealed that all three ICRISAT varieties viz., ICGS-11, ICGS-21, and ICGS-44 were at par and significantly superior to SB-XI. Lower irrigation depths of 6.0 and 7.5 cm recorded higher yield of dry pods as compared to higher depth of 9.0 cm in all the years of experimentation.

Variety ICGS-11 produced higher dry haulms yield over ICGS-21, ICGS-44 and SB-XI in pooled results. Application of 7.5 cm depth of irrigation improved dry haulms yield over 6.0 and 9.0 cm depths on pooled basis.

Total biological yield was higher in ICGS-11 during 1989. However, during 1990 it was at par with ICGS-44 and superior to other varieties. Irrigation depths of 6.0 and 7.5 cm recorded higher biological yield over 9.0 cm depth. Varieties ICGS-11, ICGS-21 and ICGS-44 were at

par and recorded higher harvest index over SB-XI. Harvest index tended to decrease with 9.0 cm irrigation depth, however, differences could not reach to the level of significance.

During first year, varieties ICGS-21 and ICGS-44 recorded higher oil content, whereas in second year, varieties ICGS-21, ICGS-44 and SB-XI were found superior to ICGS-11. Oil content was not influenced by irrigation treatments. Variety SB-XI recorded higher protein percentage in kernels over other varieties. Similarly, ICGS-21 and ICGS-44 recorded higher protein percentage over ICGS-11. It remained unaffected due to different irrigation depths.

Variety ICGS-11 recorded higher total uptake of N. However, it was at par with ICGS-21 and SB-XI in 1989 and with ICGS-44 in 1990. Variety ICGS-11 also recorded higher uptake of P and K as compared to other varieties during both the years. During 1989, application of 7.5 cm irrigation depth improved total N, P and K uptake by plant over 6.0 and 9.0 cm depths. However, during 1990, irrigation depths of 6.0 and 7.5 cm were equally effective and recorded higher uptake over 9.0 cm depth.

The mean seasonal consumptive use of water by groundnut was 736 mm in 1989 and 810 mm in 1990. Variety ICGS-11 recorded higher consumptive use during first year followed by ICGS-21, ICGS-44 and SB-XI. However, in second

year, variety ICGS-44 recorded highest consumptive use followed by ICGS-11, ICGS-21 and SB-XI. Total consumptive use was higher at 7.5 cm irrigation depth as compared to 6.0 and 9.0 cm depths during both the years. Daily consumptive use was low during establishment and early flowering as well as subsequent stages of flowering to vegetative growth. Rate of water use increased during yield formation stage and decreased slightly at ripening stage. The Kc values followed the similar trend of daily water use. The varieties developed at ICRISAT recorded higher Kc values as compared to SB-XI. The Kc values were higher under 6.0 and 7.5 cm depths as compared to 9.0 cm depth.

✓ Maximum soil moisture was utilized by the crop from upper most soil layer i.e. 0-30 cm (70-75 per cent), it was decreased in 30-45 cm layer (25-30 per cent).

Variety ICGS-11 recorded higher WUE during 1989. However, during 1990 ICGS-11 and ICGS-44 recorded higher WUE over rest of the varieties. Mean evapotranspiration ratio (ETR) was higher in ICGS-44 and SB-XI during 1989, while in 1990 it was considerably higher in SB-XI. With increasing depth of irrigation upto 9.0 cm ETR also increased.

From simple correlation and regression studies and multiple regression studies it is evident that pod yield is dependent on branches, leaf area, total dry

matter, number of root nodules and number of pods per plant.

The relationship between irrigation water and yield of groundnut was found to be quadratic in nature. The dry pod yield increased with increase in irrigation water applied, but the increase in pod yield was at decreasing rate. The potential yields of 3.798, 3.523, 3.865 and 2.924 tonnes per hectare of ICGS-11, ICGS-21, ICGS-44 and SB-XI respectively were attained at 0.8663, 0.8638, 0.8963 and 0.8286 ha m of evapotranspiration.

Economic analysis of yield-water relations revealed that highest net returns were obtained from ICGS-44 followed by ICGS-11, ICGS-21 and SB-XI. It was also observed that at constant price of produce the increasing cost of water reduced the most economical level and vice versa.

CONCLUSIONS

1. Growth parameters viz. height and branches were higher in variety SB-XI, whereas leaf area, total dry matter, number of pods and number of nodules were higher in varieties ICGS-11, ICGS-21 and ICGS-44. Lower depths of 6.0 and 7.5 cm resulted in improvement in growth parameters as compared to higher depth of 9.0 cm.
2. The ICRISAT varieties ICGS-11 and ICGS-44 recorded higher yield attributing characters viz. weight of dry pods, number of filled pods, number of two seeded pods

and total number of pods and 100-kernel weight. Irrigation depths of 6.0 and 7.5 cm also improved yield attributing characters.

3. Varieties ICGS-11, ICGS-44 and ICGS-21 out-yielded the local variety SB-XI. Lower irrigation depths of 6.0 and 7.5 cm produced higher dry pod yields as compared to 9.0 cm depth.
4. Varieties ICGS-21, ICGS-44 and SB-XI recorded higher oil content, whereas protein content was highest in variety SB-XI as compared to other varieties. Oil and protein content remained unaffected by different irrigation treatments. Varieties ICGS-11 and ICGS-44 recorded higher uptake of total N, P and K in the plant. Lower irrigation depths in which irrigation frequency was higher recorded higher N, P and K uptake by plant.
5. The mean consumptive use of ICGS-11, ICGS-21, ICGS-44 and SB-XI was 805, 788, 767 and 733 mm respectively. Corresponding figures under 6.0, 7.5 and 9.0 cm irrigation depths were 781, 809 and 729 mm respectively. The daily water use rate was higher in ICRISAT varieties. The daily water use was more under 7.5 cm depth. The Kc values were lower (0.62) in initial period and increased with advancement in age. The values were 0.62, 0.75, 0.83 and 0.69 during establishment/flowering, flowering/vegetative, yield formation and ripening stages respectively.

6. The response analysis of groundnut pod yield to applied irrigation water indicated that minimum 648, 643, 660 and 543 mm of irrigation water should be applied in ICGS-11, ICGS-21, ICGS-44 and SB-XI respectively to realise yield. The maximum predicted yield levels of dry pod were 3.798, 3.523, 3.865 and 2.924 t/ha with 866, 863, 896 and 828 mm water in ICGS-11, ICGS-21, ICGS-44 and SB-XI respectively.

RECOMMENDATIONS

On the basis of the pooled analysis of three years data on the yield of dry pods it may be inferred that variety ICGS-11 alongwith ICGS-21 and ICGS-44 was superior to the existing variety SB-XI for summer cultivation. As regards irrigation depths, it was observed that lower depths of 6.0 and 7.5 cm were at par and optimum for getting significantly higher yields as compared to 9.0 cm depth. In view of this, it is recommended that variety ICGS-11 be substituted for variety SB-XI in Marathwada region and should be irrigated with the depth of either 6.0 or 7.5 cm according to the local situation during summer season.

Future line of research work

1. In view of scarcity of irrigation water and rigid rotational supply of irrigation it is necessary to test the performance of groundnut varieties at differential depths during various growth stages depending upon the relative water requirement during that period.

2. The cultivation of groundnut in broad bed furrows has shown some promise as per earlier experience. This method can be suitably modified to suit our requirements such as furrow after two lines or three lines of groundnut and scheduling irrigation in these furrows. This may save valuable irrigation water with appreciable increase in dry pod yield. Scheduling of irrigation in such irrigation layouts may lead us to some valuable findings.

3. The cultivation of groundnut on both side of ridges is also found to be promising. More research on this aspect particularly in respect of water saving is necessary.

4. Under modified method of groundnut cultivation viz. BBF and ridges and furrows method of cultivation, even lower depth of 5.0 cm may prove effective not only in saving of water but also in enhancing the productivity of groundnut.

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* Originals not seen.

APPENDICES

Appendix I
Economics of yield-water relations under appraised price spectrum.
A. For variety IC88-11

Px Rs/100 mm	Py Rs/t	PR Px/Py	Optimum ET	Response of Y (t/ha)	Cost of ET	Cost of cultiva- tion	Total returns	Total cost	Net returns	Net returns /Rs invested
125	10000	0.0125	0.853	3.786	106	5350	37860	5456	32403	5.93
125	11000	0.01136	0.854	3.786	106	5350	41646	5456	36190	6.63
125	12000	0.01046	0.856	3.789	107	5350	45468	5457	40011	7.33
150	10000	0.0150	0.851	3.780	127	5350	37800	5477	32323	5.90
150	11000	0.01363	0.853	3.784	127	5350	41624	5478	36146	6.59
150	12000	0.0125	0.854	3.786	128	5350	45232	5478	39754	7.25
175	10000	0.0175	0.849	3.774	148	5350	37740	5498	32242	5.86
175	11000	0.01590	0.850	3.777	148	5350	41547	5498	36049	6.55
175	12000	0.01458	0.852	3.782	149	5350	45384	5499	39885	7.25

B. For variety IC88-21

Px Rs/100 mm	Py Rs/t	PR Px/Py	Optimum ET	Response of Y (t/ha)	Cost of ET	Cost of cultiva- tion	Total returns	Total cost	Net returns	Net returns /Rs invested
125	10000	0.0125	0.851	3.511	106	5350	35110	5456	29654	5.43
125	11000	0.01136	0.852	3.513	106	5350	38643	5456	33187	6.08
125	12000	0.01046	0.853	3.513	106	5350	42156	5456	36700	6.72
150	10000	0.0150	0.848	3.505	127	5350	35050	5477	29573	5.39
150	11000	0.01363	0.850	3.509	127	5350	38599	5477	33122	6.04
150	12000	0.0125	0.851	3.511	127	5350	42132	5477	36655	6.69
175	10000	0.0175	0.846	3.500	148	5350	35000	5498	29502	5.36
175	11000	0.01590	0.847	3.502	148	5350	38522	5498	33024	6.00
175	12000	0.01458	0.849	3.507	148	5350	42084	5498	36586	6.65

C. For variety IC88-44

Px Rs/100 mm	Py Rs/t	PR Px/Py	Optimum ET	Response of Y (t/ha)	Cost of ET	Cost of cultiva- tion	Total returns	Total cost	Net returns	Net returns /Rs invested
125	10000	0.0125	0.884	3.852	110	5350	38520	5460	33060	6.05
125	11000	0.01136	0.885	3.854	110	5350	42394	5460	36934	6.76
125	12000	0.01046	0.886	3.856	111	5350	46272	5461	40811	7.47
150	10000	0.0150	0.881	3.847	132	5350	38470	5482	32988	6.01
150	11000	0.01363	0.883	3.851	132	5350	42361	5482	36879	6.72
150	12000	0.0125	0.884	3.852	132	5350	46224	5482	40472	7.43
175	10000	0.0175	0.879	3.842	153	5350	38420	5503	32917	5.98
175	11000	0.01590	0.880	3.844	154	5350	42284	5504	36780	6.68
175	12000	0.01458	0.882	3.849	154	5350	46188	5504	40780	7.40

D. For variety 88-XI

Px Rs/100 mm	Py Rs/t	PR Px/Py	Optimum ET	Response of Y (t/ha)	Cost of ET	Cost of cultiva- tion	Total returns	Total cost	Net returns	Net returns /Rs invested
125	10000	0.0125	0.816	2.917	102	5350	29170	5452	23718	4.35
125	11000	0.01136	0.817	2.918	102	5350	32098	5452	26646	4.88
125	12000	0.01046	0.818	2.919	102	5350	35028	5452	29576	5.42
150	10000	0.0150	0.813	2.913	122	5350	29130	5472	23658	4.32
150	11000	0.01363	0.814	2.914	122	5350	32054	5472	26582	4.85
150	12000	0.0125	0.816	2.917	122	5350	35004	5472	29532	5.39
175	10000	0.0175	0.811	2.910	142	5350	29100	5492	23608	4.29
175	11000	0.01590	0.812	2.912	142	5350	32032	5492	26540	4.83
175	12000	0.01458	0.814	2.914	142	5350	34968	5492	29476	5.36

Appendix II
Dry pod yield Kg/net plot

Treatments	1989			1990			1991		
	RI	RII	RIII	RI	RII	RIII	RI	RII	RIII
V ₁ D ₁	5.00	7.50	4.50	5.75	7.30	5.50	4.50	5.00	4.40
V ₁ D ₂	6.90	5.90	6.70	6.40	6.70	6.50	4.60	4.30	4.00
V ₁ D ₃	5.20	4.15	4.40	5.50	5.15	4.80	3.90	4.20	3.60
V ₂ D ₁	4.50	4.90	5.80	4.80	6.50	5.30	4.50	4.40	4.80
V ₂ D ₂	5.30	5.20	5.60	5.65	6.40	6.20	4.30	4.10	3.90
V ₂ D ₃	3.50	4.05	4.50	4.50	5.20	4.70	3.80	3.90	3.60
V ₃ D ₁	3.42	3.07	3.36	7.20	6.50	5.40	5.00	5.10	4.80
V ₃ D ₂	3.62	3.19	3.15	7.10	6.60	6.25	4.60	4.80	4.40
V ₃ D ₃	2.95	3.22	3.59	4.55	6.10	5.25	4.20	3.90	4.10
V ₄ D ₁	3.30	3.42	3.00	5.00	5.20	4.85	4.80	4.60	4.20
V ₄ D ₂	4.30	3.50	4.20	5.50	4.40	4.95	4.40	4.50	4.00
V ₄ D ₃	3.40	2.50	3.00	4.25	4.10	4.50	3.70	4.10	3.60