RESPONSE OF YIELD AND YIELD ATTRIBUTES OF GROUNDNUT TO MOISTURE STRESS - A REVIEW

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ABSTRACT

Groundnut is an important oilseed crop in India and is commonly called as poor man's nut. India ranks first in acreage and a production of 7.21 M t. The average productivity in India is 1125 kg ha\(^{-1}\) which is less than the world’s average. The reduction in productivity and production is due to the fact mostly the crop is raised in rainfed conditions. The effect of moisture stress on yield and yield attributes plays a important role in increasing the production and productivity.

Keywords: Groundnut; Yield; Harvest index; Kernel weight; Moisture stress.

Groundnut (\textit{Arachis hypogaea} L.) is an important oilseed crop in India and is commonly called as poor man’s nut. India ranks first in acreage (6.4 m ha), which accounts for 28.44 per cent of the total world groundnut area and contributes 24.69 per cent (7.21 M t) to the world production. The average productivity of groundnut in India is 1125 kg ha\(^{-1}\), which is far below the world’s average pod yield of 1449 kg ha\(^{-1}\). The groundnut crop is mainly grown during the \textit{Kharif} season, coinciding with the South West monsoon season (June - September) under rainfed conditions. In parts of southern and western India, \textit{Rabi} groundnut is also raised under irrigated condition. The average yield in rainfed areas is lower because of erratic and variable rainfall and biotic interferences that also contribute to the yield variability.

Yield

Pod yield in groundnut is a function of many plant and environmental factors which are often interrelated. The stage at which moisture stress occurred plays a foremost role in the final yield of the crop. The final yield in the crop plant was the result of complementary functioning and relation of source and sink components (Sinha and Renu, 1975).

Irrigation given frequently maintained optimum available soil moisture in the root zone thereby contributing higher pod yield of groundnut (Bhaskara Reddy \textit{et al}., 1980; Rami Reddy \textit{et al}., 1980). Irrigation given once in five days at 40 mm cumulative pan evaporation (CPE) recorded higher filled pods per plant, 100 kernel weight and pod yield (Rami Reddy \textit{et al}., 1982).

Of eleven groundnut varieties tested during the monsoon season of 1978, under conditions in which total rainfall during the season was 517.5 mm, TMV 10 gave the highest pod yield (1503 kg ha\(^{-1}\)) and had the best water use efficiency (utilizing 6.1 kg ha\(^{-1}\) mm) (Nimbalkar \textit{et al}., 1987). Shashikumar \textit{et al}., 1988 evaluated relative drought tolerance of seventeen groundnut genotypes under six gradients of moisture stress created by using line-source irrigation techniques. JL-24 and ICG-5266 had high yield potential at all the moisture regimes but the percentage of

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reduction in their yield with increasing moisture stress was higher than in other genotypes.

Under stress conditions, the groundnut showed a reduction in dry matter and yield, the percentage reduction being highest in VG77 (65.97 per cent) and JL-24 (65 per cent) (Arjunan et al., 1988). Madhusudhana Rao et al. (1988) observed a positive correlation between number of matured pods and number of irrigations. Moisture stress during the early vegetative phase resulted in an increase in 100 seed weight (Nautiyal et al., 1991). Pre-monsoon irrigation at CPE 100 and two post-monsoon irrigations at CPE 75 gave the highest pod yield of 2.06 and 2.12 t ha⁻¹ respectively (Kachroo and Walia, 1991).

Variations in Penetrometer Soil Resistance (PSR) resulting from water stress imposed at different growth stages and relationship of PSR with pods per plant and pod yield were studied. The number of pods per plant decreased linearly with increase in PSR values (Sharma and Sivakumar, 1991).

Ndunguru et al. (1993) reported that cultivars with vigorous early growth, a relatively large biomass accumulation and capable of remobilizing stored assimilates to reproductive sinks may be better adapted to moisture stress. The optimum irrigation schedule for irrigated summer groundnut was nine for highest dry pod and haulm yield, harvest index, shelling percentage and 100 kernel weight (Geethalakshmi et al., 1994).

Lamm et al. (1994) reported that imposition of a small daily deficit of 1 mm day⁻¹ resulted in yield reductions of 7, 1 and 3 per cent for the heavy, normal and deficit irrigation management levels, respectively and irrigation savings of approximately 12, 9 and 0 per cent for the three respective irrigation management levels. The larger 2 mm day⁻¹ daily deficit reduced yields by 7, 9 and 15 per cent for the three respective irrigation levels and reduced irrigation by 19, 26 and 25 per cent.

In field experiments in the dry seasons on a medium black calcareous soil, groundnut cvs. GAUG-1, GG-2 and J-11 were grown with normal and excess irrigation. The pod yield was high in the normal irrigation than in the excess irrigation (Singh et al., 1995). Cessation of irrigation at the beginning of pod filling gave the highest pod yield and 100-seed weight, and similarly germination per cent and oil content was also reported (Galbiatti et al., 1995).

Pal et al. (1996) found that number of pods per plant and 100 kernel weight increased with increasing levels of irrigation. Scheduling of irrigation to groundnut crop during summer at 10 days interval recorded higher number of matured pods per plant, 100 kernel weight, shelling percentage, pod and haulm yield (Mishra, 1997). Tiwari and Dhakar (1997) observed that scheduling of irrigation with increased IW/CPE ratio from 0.4 to 1.0 improved various yield attributes viz., pods per plant and shelling percentage. Narang and Gill (1998) observed that irrigation based on 90 per cent available soil moisture from 25 cm soil depth recorded higher yield of groundnut.

Two peanut cultivars of different botanical type (Virginia and Spanish) were grown at 3 plant population densities (40000, 120000 and 240000 plants ha⁻¹) and relied solely on stored soil water for water requirements. Protracted crop water deficits occurred from flowering to maturity. The results indicate that there is scope for increasing pod yield when peanut is growing solely on stored water, by reducing plant population. The timing of water use, as distinct from the amount of water used, was the major determinant of pod yield (Wright and Bell, 2005).

**Yield attributes**

The flower production was reduced by water stress due to reduction in number of nodes from which the flowers arise (Ochos and Wormer, 1959). Adequate root zone moisture could keep pegs alive until pegging zone moisture content is sufficient to allow penetration and initiation of pod development. Once pegs are in the soil, adequate moisture and darkness are needed for pod development. Adequate pod zone moisture is critical for development of pegs.
into pods and adequate soil water in the root zone cannot compensate for lack of pod zone water for the first 30 days of peg development. After 30 days of adequate pod zone moisture, pods can continue normal growth in dry soil if roots have adequate moisture (Skelton and Shear, 1971).

The percentage of pegs that penetrated the upper 1.5 cm of pegging zone and the weight of pods that developed in the pegging zone decreased as penetrometer resistance increased due to moisture stress and soil crusting (Underwood et al., 1971). However, seed development was not affected if moisture stress occurred after pod formation stage (Ono et al., 1974). The growth of pods in the soil may be affected due to inadequate moisture in the root zone (Allen et al., 1976). Pod yield of groundnut and rainfall received during pod formation to maturity were positively correlated in a rainfed crop grown at semi-arid region of Andhra Pradesh in India (Subbaiah et al., 1974).

Groundnut pegs failed to penetrate into the soil under dry condition (Boote et al., 1976). Martin and Cox (1977) found that the only measurable decrease in pod yield resulted from drought during the period 50-80 days after flowering began, with the most severe yield decreases associated with drought during the later part of the growing period.

Boote and Hammond (1981) reported that drought during early pegging and pod formation (40-82 DAS) reduced the vegetative growth by reducing the rate of node formation and by reducing elongation between nodes resulting in 51 per cent fewer pegs. Boote et al. (1982) reported that the period of greatest sensitivity to drought stress was about six to eight weeks after planting or the pod initiation and pod filling stages.

Moisture stress affected seed formation more than total dry matter yield and hence the harvest index (HI) decreased linearly with increasing levels of moisture stress (Pandey et al., 1984). The greatest reduction in kernel yield occurred when stress was imposed during the seed-filling phase and decreased irrigation during the early phase increased the pod yield relative to the fully irrigated control by 19 per cent (Nageswara Rao et al., 1985). A significant burst in flowering on alleviation of stress is a unique feature in the pattern of flowering under moisture stress, particularly when stress is imposed just prior to reproductive development (Janamatti et al., 1986).

When stress is imposed during 30-45 days after sowing, the first flush of flowers produced up to 45 days do not form pegs during that time. However, flowers produced after re-watering compensated for this loss (Gowda and Hedge, 1986).

Water deficit during kernel or seed development reduce pod and seed weight. Shelling percentage is reduced by moisture stress during seed development (Janamatti et al., 1986).

The moisture retention capacity of groundnut during the crop growth period showed characteristic varietal differences. Based on dry weight, Pollachi red showed appreciable moisture retention at 40 days, at which time the peg enters the soil and a general peak of flower production has taken place. The semi spreading showed moisture retention in the early stage and the spreading at 60 days, a critical phase in pod development (Velu and Gopalakrishnan, 1988).

It is essential to identify moisture sensitive development stages to minimize damage caused stress. The pre-flowering phase is less sensitive to moisture stress than the flowering phase. Greater synchrony of pod set in moderately stressed plants during the pre-flowering phase resulted in greater proportion of mature pods at final harvest (Kulkarni et al., 1988; Rao et al., 1988).

Yield reductions are higher with stress imposed during the period between pegging and pod development and lowest with stress imposed from pod development to maturity (Patel and Golakiya, 1988). The start of flowering was not delayed by water stress (Boote and Ketring, 1990). The rate of
flower production is reduced by water stress during flowering but the total number of flowers per plant is not affected due to an increase in the duration of flowering (Gowda and Hedge, 1986; Janamatti et al., 1986; Meisner and Karnok, 1992).

Peg elongation, which is turgor dependent, is delayed due to water stress. Pegs fail to penetrate effectively into air-dry soil, especially in crusted soils. Often, within 4 days of withholding water, the soil surface becomes too dry for peg penetration (Boote and Ketring, 1990).

Pod and kernel development are progressively inhibited by water stress due to insufficient plant turgor and lack of assimilates. These stages can also be delayed by lack of soil water in the pod zone (Boote and Ketring, 1990; Stirling and Black, 1991). The number of pods per plant can be low due to increases in soil resistance caused by prolonged stress (Sharma and Sivakumar, 1991). No pods were formed when plants were in water-saturated soil (Bailey and Biosvert, 1991). Stress reduced the pod yield primarily by decreasing the duration of the pod development phase (Stirling and Black, 1991). Pod dry weight was significantly reduced by a 30 day water stress during the pod development stage (Meisner and Karnok, 1992). Suthar and Patel (1992) found that pod yield was higher with 80 per cent available soil water than with 20 per cent available water.

Flowering stage was sensitive to moisture stress and recorded 25.6 per cent less yield (Ramachandrappa and Kulkarni, 1992). Naveen et al. (1992) found that when water stress was imposed during the flowering and pegging stages, JL-24 groundnut variety produced the greatest reductions in pod yield followed by water stresses at the early and late pod stages. In JL-24 the deviation is probably due to the shorter duration of flowering. Field experiments conducted at Nagpur revealed that pod yield was the highest with irrigation at 75 mm CPE (Ghadekar et al., 1993). Allowing moderate stress at vegetative and maturity phases produced the optimum yield of 2823 kg ha\(^{-1}\) (Reddy and Reddy, 1993).

Maximum pod yield was obtained when irrigation was provided throughout the crop growth period except at pre-flowering stage (Rangaraju and Iruthayaraj, 1995).

Wright et al. (1994) and Bennett et al. (1990) reported that pod formation is affected by a dry pod zone. However, Boote et al. (1992) reported that Florunner and Robout 33-1 produced pods in air-dry soil although at a slower rate.

Patel et al. (1995) reported that water stress during pod development stage drastically reduced the pod yield. Sexton et al. (1997) reported that groundnut pod development is sensitive to surface soil (0-5 cm) conditions due to its subterranean fruiting habit. Dry pegging zone soil delayed pod and seed development. Soil water deficits in the pegging and root zone decreased pod and seed growth rates by approximately 30 per cent and decreased weight per seed from 563 to 428 mg. Peg initiation growth during water stress demonstrated an ability to suspend development during the period of soil water deficit and to re-initiate pod development after the water stress was relieved.

There was no significant difference in yield between the two irrigation treatments viz., irrigation at 7 days interval and irrigations made whenever readings of tensiometers at 20 cm soil depth were equal to or less than -30 kPa (Ahmad, 1999).

Water stress at pod initiation and pod development stages reduced the pod yield by 13.4 and 44.2 per cent, respectively (Patra et al., 1999). Total biomass and economic yield was higher in the treatment, with holding irrigation for 30 days starting at 20 days after sowing followed by with holding irrigation 25 days starting at 20 days after sowing. Field water use efficiency and dry matter production, including economic yield were increased by imposing a transient deficit in soil moisture during the vegetative phase (Nautiyal et al., 2001).
Water deficit during seed fill is known to accelerate the rate of seed maturation, causing yield loss due to shortened grain filling phase (Boote et al., 2003).

**Test weight of kernels**

Jayarami Reddy and Rao (1968) observed reduced kernel weight in an experiment after imposing stress on groundnut variety TMV 2. Dusek et al. (1971) reported a reduction in kernel size and weight of groundnut when stress was imposed during pod swelling. Kernel weight was higher in irrigated than in the un-irrigated control in groundnut (Cheema et al., 1977).

Pallas et al. (1977) reported that in the absence of irrigation (or) with imposed moisture stress there was a reduction in the proportion of sound mature kernels in groundnut. Khan and Datta (1982) reported that both amount of irrigation and irrigation water/ cumulative pan evaporation ratio significantly influenced 100-kernel weight in groundnut. Ramesh Babu et al. (1984) reported that 100-kernel weight was reduced significantly due to moisture stress at pod development stage in groundnut. Shinde and Pawar (1984) reported that 1000 kernel weight was not influenced by water stress in groundnut.

Gowda and Hedge (1986) reported that there was no significant decrease in 100-kernel weight of stressed groundnut crop from the normal irrigated crop. Venkateswara Rao et al. (1986) reported that moisture stress at flowering in groundnut increased the 100-kernel weight while soil moisture stress at pegging reduced 100-kernel weight as compared to control.

Sharma and Singh (1987) reported that 100-kernel weight was the highest with two irrigations at 50 and 80 days after sowing and was the lowest under rainfed conditions in groundnut. Moisture stress during flowering period caused highest reduction of 21.9 per cent in 100-kernel weight of groundnut (Pathak et al., 1988). Naunyial et al. (1991) reported that moisture stress during the early vegetative phase resulted in an increase in 100-kernel weight in groundnut. Samsukumar (1991) reported that moisture stress at flowering, pod formation and pod maturation stages in groundnut reduced the 100-kernel weight by 7.1, 11.5 and 16.2 per cent respectively compared to control. Ramana Rao (1994) stated that there was decrease in 100-kernel weight due to moisture stress in both rainfed and simulated stress treatments compared to adequately irrigated control.

**Harvest Index (HI)**

Pandey et al. (1984) reported that water stress affected seed formation more than the total dry matter yield and hence harvest index declined. Ramesh Babu et al. (1984) reported that moisture stress at pod development period in groundnut decreased harvest index significantly. Venkateswara Rao et al. (1986) reported that moisture stress reduced harvest index in groundnut. Harris et al. (1988) found that TMV 2 groundnut maintained the largest harvest index during stress, compared to other genotypes tested.

Watterott (1991) stated that harvest index and water use ratio were negatively correlated. According to Wright et al. (1991) estimates of transpiration efficiency derived from measurements of carbon isotope discrimination indicated only small variations in transpiration efficiency.

Wright et al. (1991) viewed that variation in pod yield among groundnut cultivars was largely due to difference in harvest index characteristics. Samsukumar (1991) reported that water stress at pod filling and pod maturity stages reduced harvest index of all genotypes significantly. Chavan et al. (1992) found that groundnut Cv. DVR 50 among the spreading group and Cv. ICGS 35-1 among the bunch group had a high harvest index under both natural and moisture stress conditions. Variation in pod yield among four groundnut cultivars was largely due to differences in harvest index characteristics. Results of Wright et al. (1993) revealed that water use efficiency and partitioning of dry matter to the pods was negatively correlated; this negative
association persisted up to the F4 generation in a cross of two contrasting Indonesian cultivars. Further research identified cultivars with high levels of both water use efficiency and harvest index. Ramana Rao (1994) reported significant negative correlation between HI and WUE in groundnut. In stressed plants from 40-75 DAS, Cv. ICGV 86644 showed the largest reduction (23.4 per cent) in harvest index while Cv. ICG 2738 showed the least reduction (2.5 per cent) compared to adequately irrigated plants.

From the review it has been understood that moisture stress is injurious to crop growth and reduces the yield notably. Moisture stress may be more serious to certain yield attributes and preventive measures should be adopted to increase the yield.

REFERENCES


