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CP211

SOME PHYSIOLOGICAL REASONS FOR GENOTYPE X DROUGHT INTERACTIONS IN GROUNDNUTS

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I. SUMMARY

At ICRISAT Centre, Patancheru we have investigated aspects of drought environments and interactions of genotypes with those factors which may allow adapted genotypes to be identified with less long term testing (necessary) to make a sample of years representative of the environment).

Major differences between sites and seasons are found in the duration, intensity and timing of drought relative to the physiological development of the crop. The occurence of single droughts or recurring droughts vary yields achieved ; drought in the preflowering phase decrease damage from subsequent droughts, while a short interruption of a mid season drought may greatly increase the damage.

We have found that in frequent but inadequate rainfall certain cultivars do better while others are better adapted to long periods of stress where exploitation of water at depth is more important. We have also demonstrated variations in water use efficiency which favour certain lines when water is limited.

Wilde variability has been found for the response of genotypes to the release of stress during the first half of reproductive growth. This variability can invoke substantial interactions depending on the nature of the season following the release of drought.

Yield potential may also be responsible for "interactions" since some drought resistant types have low yield potential in well watered environments but have higher yields than those with highest yield potential in the most droughted environments.

Other experiments have shown that selected genotypes

respond positively to gypsum application followed by a single drought while others do not.

II. INTRODUCTION

Largely because genotypes yield differently between sites or between seasons the plant breeders with the task of identifying genetically superior and adapted genotypes of any crop have resorted to testing their material over many sites x year combinations. This multilocational testing is expensive and very often a large portion of the variation in yield is due to environmental factors and the "genotype X environment" (GxE) interaction. These sources of variance are seldom analysed further because of inadequate descriptions of the environments, despite the fact the GxE is known to be due to biological (diseases, weeds and insects), physical (soil type, rainfall, radiation, humidity and temperature) and chemical (soil composition) environmental factors. Until the dominant sources of GxE interactions are well understood and defined it is unlikely that any serious effort at interpreting the GxE interaction will be undertaken. With improved understanding of the GxE and improved description of the environment it should be possible to be more efficient in selecting genotypes for given areas since a smaller number of site/year combinations will be needed to relate genotype responses to long term environmental situations.

Scientists at ICRISAT centre are exploring the reactions and interactions of groundnut genotypes to drougths and this paper deals with some of our findings in three projects. The interactions that are dealt with are those within material of similar maturities. The simple interaction due to variable crop maturity reacting with variable season lenght are too well documented to be of interest here.

III. TIMING, DURATION AND INTENSITY OF DROUGHT

Droughts vary in the intensity, duration and their timing relative to the phenological development of the crop. To better understand the responses and interactions of genotypes to these variations of droughts an experiment was conducted with 25 genotypes selected form 500 early maturing lines (characterized in our drought screening). These genotypes were grown in 96 irrigation treatments which varied drought stress timing and duration in 12 patterns of single or recurring water stress (Fig. 1). Within each of these patterns 8 levels of irrigation (from 0.8 to 0.05 of the potential evaporation) were applied using the line source technique.

Figure 1 : Effect of timing, intensity and duration on yield.

PATTERN		DAYS AFTER SOWING (20 ! 40 ! 60 ! 80 ! 100 ! 120 !)	DURATION IN DAYS	DROUGTH EFFECT#
P1	DWWW	********	30	-0.7
P2	WDWW	********	26	-3.0
P3	WWDW	*********	26	-4.0
P4	WWWD	*************	36	-3.9
P5	DDWW	***************	52	-2.2
P6	WWDD	***************	47	-5.7
P7	DDDD	******************************	100	-9.2
P8	DWDW	******** *********	59	-3.3
P9	WDWD	****** *******	59	-4.2
P10	D!DWW	********** ******	58	-4.3
P11	WWD!D	****** **********	58	-5.9
P11	D!D!D	********* ****** **********	85	-6.3

D = DROUGHT PHASES ****
W = WELL WATERED PHASES
! = SINGLE IRRIGATION

THE SLOPE OF REGRESSION FOR YIELD AGAINST WATER DEFICIT AS A PERCENT OF POTENTIAL EVAPORATION

These 25 genotypes provide a guide to responses of the subspecies *fastigiata* to droughts. Noteworthy responses were :

1/ For each pattern of drought yield was linearly related to the water deficit. The sensitivity of the crop to increasing intensity of a drought pattern was therefore the slope of the regression of yield on water deficit (Fig. 1).

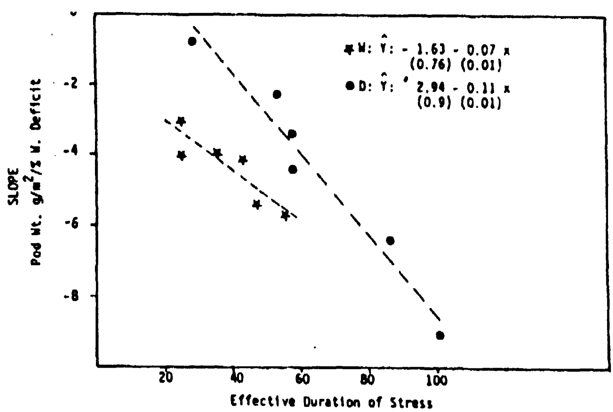
2/ As the drought occurred later in the crop's life the yield loss was greater ; compare treatments P1, 2, 3 and 4 for short drougths (± 30 days) and treatments P5 and 6 for long droughts (± 60 days). Also as the stress period became longer the sensitivity was increased.

3/ The effect of a single short term release of water stress in the middle of a long drought (compare treatments P5 and 10) had a substantial adverse effect relative to those crops where the stress was maintained for the same length of time without relief.

4/ Drought which started early and continued for 60 days (P5) was less damaging than stress which started in the middle of crop life but lasted for only half the period (P2).

The sensitivity to drought increased in a linear fashion according to the duration of stress but different relationships existed for when the crop was stressed early or not (Fig. 2). These two factors were able to account for 90 % of the sensitivity of groundnut yields to droughts patterns.

Figure 2 : The effect of pattern (first phase watered (W) or dry (D) and duration on sensitivity to drought.



Genotype x intensity of drought interactions existed and these seem to depend on rooting patterns and the way in which the intensity of drought is varied. Two causes for droughts of varied intensity are when regular but inadequate amounts of rain occur or when the soil characteristics limit water extraction to below the potential demand. In the first case genotypes with greater root lengths in the upper soil horizons would have advantage since the secure more water before soil evaporation expends it. However where soil characters such as resistance and bulk density limit root growth those with greater root lenght at depth have the advantage. We have observed both response patterns.

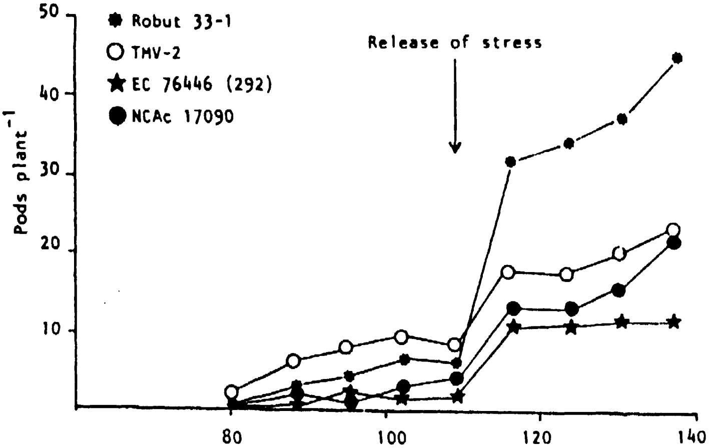
The effects of timing of drought on the yield responses has received much attention but the results reported differ. BILLAZ and OCHS (1961) reported that mid season stress was most damaging to groundnuts while PALLAS, STANSELL and KOSKE (1979) found that for Florrunner an end season stress was more damaging than a midseason stress. In our experiments we found that the average of 25 genotypes was similar for mid season and end season drought, however the individual cultivars varied in their response.

Many factors may contribute to this variability in response but from our research it seems that two factors dominate. Yield potential seems important ; those genotypes where the pod initiation process is the limiting factor to yield in good environments seem most sensitive to midseason stress. These sink limited cultivars are probably buffered against the effect of decreased crop growth in the pod filling stage by decreased stem growth in preference to decreased pod growth. However in source limited cultivars where the growth is usually completely partitioned into pod growth, end season drought seems most damaging. At present there is no direct evidence to support the above contention but the circumstantial evidence of yield potential in relation to drought responses seems to confirm this phenomena.

The other important factor which can vary the responses to droughts of different patterns is the "recovery response". Presentely we are only starting to document the phenomena and the physiology is not understood. We have observed very large differences in the way that genotypes react after the release of mid season drought. An example of this responses is provided by a growht study (in collaboration with the University of Nottingham) where four cultivars were subjected to drought starting at flowering. On release of stress the pod numbers initiated varied immensely (Fig. 3).

In a line like Robut 33-1 this reaction could be a major advantage if the crop was subsequently watered well enough to develop the fruit initiated. However the value of this response depends entirely on the quality of the

Figure 3 : Responses of 4 cultivars to the release of drought stress.



environment following the release of stress. In a trial at Anantapur in India the recovery response of Robut 33-1 failed to improve yield because of dry subsequent conditions while NC Ac 17090 which lacks the recovery response was able to fill those pods that were initiated and achieve a better yield than Robut 33-1.

IV. WATER USE EFFICIENCY

Genotypes which are able to fix more carbon per unit of transpired water during stress have been detected by both measurements of simultaneous CO_2 and H_2O exchange by the leaves and by measurements of the water use and dry matter accumulation. This effect is only likely to benefit efficient cultivars and penalize inefficient cultivars in drought conditions.

V. INTERACTIONS INDUCED BY CALCIUM IN THE SOIL

Calcium uptake by the pods is a much dependent on water in the pod zone as on the calcium status of the soil and can have a large impact on yield. We have investigated this effect further for genotype interactions with drought and calcium nutrition. We have found that gypsum applications prior to a drought may increase the yield of groundnuts but that some cultivars are not influenced by gypsum while others are very strongly influenced. The gypsum improves yield of selected lines by influenceing the numbers of pods initiated before the stress prevents further pod initiation. Although the effects are only just detectable and unimportant in the well watered control treatments these subtle differences can have a large impact in yield in the event of mid-season drought. The extent and nature of the interaction of gympsum x drought x genotype requires considerable investigation since these effects can be expected to be much greater on soils with less calcium than those at ICRISAT centre (±600 ppm available Ca).

This research into drought x genotype interactions is still continuing with considerable emphasis on investigations of the drought recovery responses and on the interactions of intensity, duration and timing of multiple droughts.

REFERENCES

(1) BILLAZ R. and OCHS R. (1961). *Stades de sensibilité de l'arachide à la sécheresse.* Oléagineux 16 : 605-611.

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RESUME

Des données sur le degré des interactions entre le génotype et la sécheresse sont présentées. Les effets de l'époque, la durée, et la sévérité de la sécheresse sur les variations des rendements totaux et en gousses des cultivars sont décrits.

Bien que les études physiologiques sur ces réponses soient insuffisantes pour obtenir une explication concluante, des expériences ont révélé que d'importantes composantes des interactions du cultivar sont liées à l'initiation reproductive et à la répartition de la croissance entre les éléments

constitutifs de végétation ou de gousses, consécutive à la récupération de la sécheresse.