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EFFECTS OF AMMONIUM SULPHATE AND UREA ON THE SPROUTING OF WHITE YAM (DIOSCOREA ROTUNDATA POIR)

(Effet du sulfate d'ammoniaque et de l'urée sur la germination de l'igname blanche (Dioscorea rotundata Poir)

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SUMMARY

The effects of ammonium sulfate and urea on the sprouting of 6g setts called "microsetts", derived from head, middle and tail regions of the tuber are discussed. Ammonium sulfate was more effective in boosting sprouting at 3 weeks after planting (WAP), irrespective of tuber portion. The results suggest a strong coupling of sulfate and nitrogen action. The interaction of sulfate, nitrogen and ethylene-generating sources is postulated to be one of the major regulatory factors of sprouting in white yams.

RESUME

Les effets du sulfate d'ammoniaque et de l'urée sur la germination de fragments de 6 g appelés "microsetts" et issus de tête, milieu et queue du tubercule, sont discutés. Le sulfate d'ammoniaque a été le plus efficace en provoquant la germination trois semaines après plantation, indépendamment de l'origine du fragment. Les résultats suggèrent une forte association de l'action du sulfate et de l'azote. L'interaction du sulfate, de l'azote et des sources génératrices d'éhylène est admise comme l'un des facteurs majeurs de regulation de la germination des ignames blanches.

INTRODUCTION

The lack of good, inexpensive planting material is the major contributing factor to the gradual recession in yam production over the years. The edible yam is vegetatively propagated by means of small, whole tubers of size range 300 - 1000 g, called "seed yam" or pieces of tubers known as "setts" (COURSEY and BOOTH, 1977). It is from these that farmers grow the large marketable ware yams.

Farmers, traditionally, produce their own seed by undertaking double-harvesting or planting small setts (70 - 100 g) at close spacing known as the "Anambra system in Eastern Nigeria" (OKONMAH, 1980). the former technique is laborious requiring a lot of skill, whilst the latter is flexible and is within the scope of the smallholder farmer.

Research efforts aimed at evolving a better multiplication system have resulted in the minisett (OKOLI et al., 1982) and microsett techniques (ALVAREZ and HAHN, 1984). These are further improvements of the "Anambra system", involving the use of 2-5 and 2-10 g sett sizes respectively, with accompanying higher multiplication ratios of 1 : 10 and 1 : 60 respectively derivable from tuber sizes of 300-500 g.

The mini - and microsett techniques are by all standards the most practicable.

The upper-size range of the microsetts, 5-10 g, produced a mean tuber size of 163 g (AMEYAW, unpublished). The minimum seed yam size required to produce a ware yam is 200 g (Technology Transfer St., Annual Report, Dec. 1984). although only 18.0 per cent of the total numbers of tubers produced by the 5-10 g microsetts were over 200 g (AMEYAW, unpublished), the remaining 82.0 per cent had an average size of 119 g. the latter could be planted the following season to obtain mediumsized, less bulky ware yams of sizes 1000 g or more.

The potential, therefore, of the microsett technology in revitalizing yam production, cannot be overemphasized.

However, the major bottleneck in the development of the microsett technique of white yam seed yam production is the rather slow and uneven sprouting of the setts in the nursery. This situation is largely attributable to the small sett sizes involved compounded by their differential physiological age as regards the head, middle and tail regions of the tuber. The latter, according to ONWUEME (1984), is divisible into a proximal head, a distal tail and an intervening middle portion with the head dominating over the lower regions with regard to sprouting.

The need to explore possibilities of circumvening the slow sprouting constraint of the microsetts and stimulate their sprouting in the nursery as a basis for uniform field establishment became evident.

KEFELI and KADYROV (1971) reasserted the role of phytohormones in controlling growth and developmental processes along with natural inhibitors. WITTWER and BUKOVAC (1958) reported that gibberellin application promoted early and uniform sprouting of Katahdin potatoes. Furthermore, JARRET et al. (1980) working on Irish potato, reported that exogenous gibberellic acid levels of 0.3 - 1.0 ppm were optimal for shoot initiation on tuber explants.

However, most of the phytohormones are expensive and water insoluble. Their handling is therefore cumbersome for the farmer.

ADDICOT (1968) cited by CRANE (1971) reported that soluble nutrients serve as substrates for hormone biosynthesis and this was reiterated by MARSCHENER (1982) who asserted that endogenous phytohormone levels can be indirectly modulated by mineral nutrition.

Many thourea and urea derivatives are known to possess cytokinin activity (BRUCE et al., 1965, cited by THOMAS, 1979). Thioruea (SAMARAWIRA, 1983) and thiourea-chlorethanol combinations (CIBES and ADSUAR, 1966) have been reported to stimulate yam sprouting.

In the light of the above, studies were initiated at the International Institute of Tropical Agriculture (IITA) to investigate the effects of mineral nutrition on the promotion of uniform sprouting of white yam microsetts.

MATERIALS AND METHODS

300-500 g tubers of the white yam variety, TDr 131, which have been in the traditional yam barn storage for 28 weeks after harvest were divided into three portions ; head, middle and tail. The heads refer to the upper 1/3 portion proximal to the corm, the distal 1/3 being the tail, whilst the intervening portion was considered as the middle.

6 g microsett sizes were derived from each of these portions and separately soaked in 5, 10, 50 and 100 ppm solutions of urea - inorganic source nitrogen and ammonium sulfate - inorganic source nitrogen and sulphur, respectively for one hour.

The microsetts were then treated with a suspension of wood ash, Aldrex "T" and Demosan (Chloroneb) at a rate of 24 g Demosan, 6 g (2 sachets) Aldrex "T" and about three-quarters, 1 litre cup full of wood ash in four litres of water. The Aldrex "T" is note very soluble in water, and thus it was first mixed with the ash, whereby the latter served as a carrier. The microsetts were soaked in this suspension for 2-3 minutes.

They were then presprouted in moist sawdust using containerized polystyrene trays in a 3 x 5 mixed factorial experiment, laid out as a completely randomized design, with three replications. There were 20 microsetts per treatment combination. The urea ammonium sulfate (NH_4SO_4) were handled separately.

The experiment was carried out in a propagation nursery (house).

At three weeks after planting (WAP) counts were made of the differentiated and undiferentiated plantlets.

The differentiated plantlets are those that formed visible shoots and are of 3 categories depending on the stage of development of the shoot : the recently formed ones which are still within the rooting medium and are whitish in appearance ; those that have emerged out of the rooting medium, and are green but leafless ; and finally, those that have emerged out of the rooting medium and have already elaborated leaves. The undifferentiated plantlets are those showing whitish, callus-like peridermal cracks. At 3 WAP in the nursery, the differentiated plantlets that are usually observed are all of the recently formed shoot types, that are still submerged within the rooting medium. Furthermore, the undifferentiated plantlets tend to predominate at this time. The counts were expressed in percentage (%).

RESULTS

Generally, percent sprouting (differentiated and undifferentiated plantlets) increased with increasing concentration for both NH_4SO_4 and Urea (Figure 1). However, NH_4SO_4 was consistently better than urea.

The response to NH_4SO_4 (figure 1) peaked at 5 ppm leading to a 10 per cent increase over the control ; this was, however, statistically insignificant. The response to Urea peaked at 10 ppm resulting in an insignificant superiority of 17.4 per cent over the control.

The tuber portion - nutrient interactions elicited easily discernible trends (Figures 2 and 3). Sprouting generally increased with increasing concentration of NH_4SO_4, with respect to only the tail-derived microsetts, resulting in 23,3 per cent greater response than the control (Figure 2). The middle-region derived microsetts marginally responded to the nutrient application at 10 ppm and then declined in response with increasing concentration.

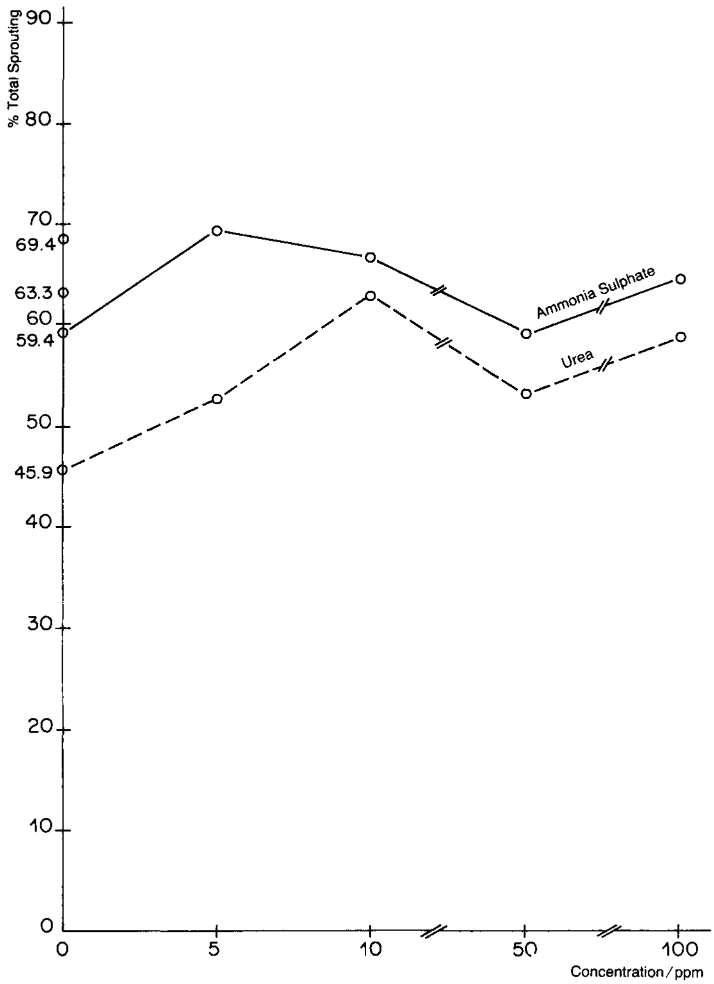

Fig.1 : Effects of nutrition on the earliness of sprouting of 28-week-old Dioscorea rotundata microsetts (3 WAP)

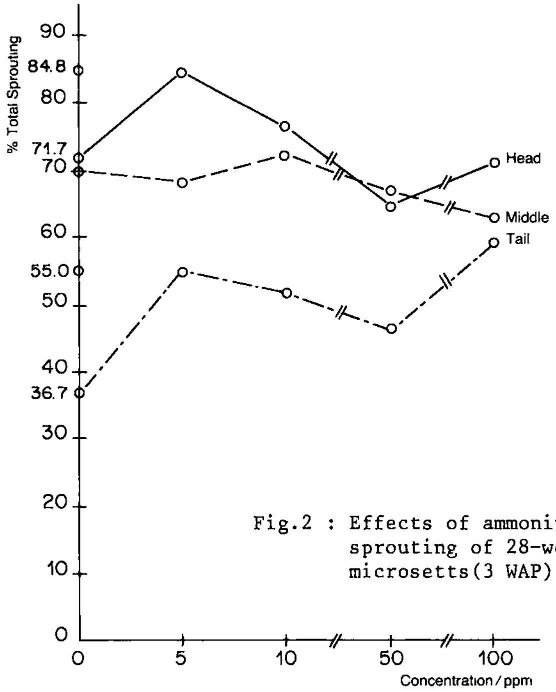

Fig.2 : Effects of ammonium sulphate on the uniformity of sprouting of 28-week-old Dioscorea rotundata microsetts (3 WAP)

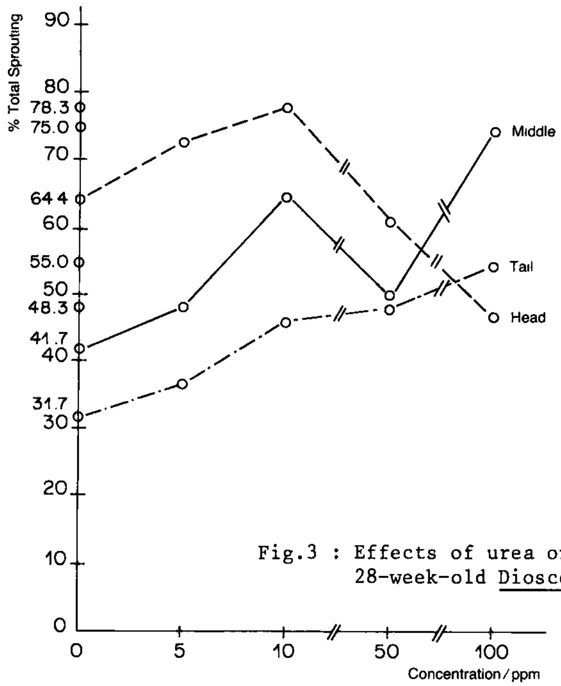

Fig.3 : Effects of urea on the uniformity of sprouting of 28-week-old Dioscorea rotundata microsetts (3 WAP)

The head-region microsetts peaked at 5 ppm resulting in a net, but insignificant response of 13.1 per cent compared to the control.

In the case of Urea, sprouting generally increased with concentration with regard to the middle - and tail-derived setts ; the former was 33.3 per cent better than the control, although this was also statistically insignificant, whilst the latter was 23.3 per cent better. The head-region setts increased with concentration up to 10 ppm, producing a net sprouting of 13.9 per cent and then declined in response thereafter.

DISCUSSION

Although, all these stated differences in response in relation to the control were not statisfically significant, they are worth considering in view of the rather immense tuber heterogeneity - differences in times of shoot emergence in the field, and hence crop duration prior to harvest, micro-climatic differences in storage and so on as well as the intra-clonal variation that is characteristic of the yams (DEGRAS,1977).

The consistent superiority of NH_4SO_4 over Urea (Figure 1) denotes a strong synergism between sulfur and nitrogen, in the sprouting of the yams. Such an interaction has been reported by LORENZ et al. (1954) cited by BEATON (1966) for potato in which higher tuber yields were realized with ammonium sulfate than with calcium nitrate, sodium nitrate, urea and ammonium nitrate.

The differential responses of the setts to the nutrients in terms of their tuber origin may be understood in the light of their metabolic conditions, as regards carbohydrate mobilization.

According to GOODWIN and MERCER (1983) sprouting of vegetatively propagated structures involves the conversion of storage reserves into monosaccharides which are used in sucrose synthesis. The sucrose thus formed is then transferred to the meristematic regions and used int he growth processes. HAWKER et al. (1979) reported that the supply of sugars may be a factor controlling growth rate and other metabolic activities. It is therefore possible that the sulfate interacts with nitrogen to effect its physiological in this instance only in the presence of adequate carbon-skeletons provided by sucrose mobilization. This fact is illustrated by the fact that with the tail-derived setts, increasing concentrations of both NH_4SO_4 and Urea (Figures 2 and 3) resulted in the same net sprouting value of 23.3 per cent at 100 ppm. This means that there was no interaction between the nitrogen and the sulfate in NH_4SO_4 in boosting sprouting. This may probably be due to the fact that the tail-derived setts being physiologically the youngest, may not contain enough sucrose to serve as substrates for the enzymatic processes involved in shoot formation. Thus, increasing the nitrogen concentration in the tail-drived setts merely lead to increasing rates of protein synthesis, probably enzyme biosynthesis, which then would accelerate the carbohydrate mobilization processes. It appears therefore that nitrogen concentrations greater than 100 ppm may be effective on the tail-derived setts.

The middle - derived setts showed similar but better response trends to the Urea treatments than the former were physiologically older, and therefore their sucrose levels might have been higher (Figure 3). The trends elicited by the middle - derived setts in response to the ammonium sulfate treatments were less remarkable (Figure 2).

The head-derived setts under the urea treatments might have been mobilizing their reserves at a faster rate, being physiologically the oldest, and hence increasing the urea levels beyond 100 ppm might have resulted in either supra-optimal concentrations in the tissues or the accumulation of certain intermediates of nitrogen metabolism, whereby a non-competitive feedback inhibition mechanism might have set in and hence depressed sprouting (Figure 3).

The synergistic nature of sulphate and nitrogen metabolism, is illustrated with respect of the head-derived setts und NH_4SO_4 (Figure 2), whereby only 5 ppm, was enough to boost sprouting by 13.3 per cent, whilst it took a higher concentration of 10 ppm Urea to obtain a net sproutin of 13.9 per cent (Figure 3) for the same head-derived setts, assuming the same rates of carbohydrate mobilization.

Furthermore, one of the end-products of sulphate metabolism is ethylene (ADAMS and YANG, 1979) and the highest rates of ethylene biosynthesis occur in meristematic and nodal tissue in etiolated pea seedlings (ABELES, 1973).

Hence at 5 ppm NH_4SO_4 concentration (Figure 2), the sulfate radical in the latter might have probably interacted with the ammonium to effect ethylene release that might have boosted the sprouting of yams.

The time of the nutrient application must be given critical consideration. It may be more effective when applied during the dormancy period using whole tubers, when metabolic activity is suppressed than when the dormancy period is over, and they are actively mobilizing their internal storage reserves.

Despite the trends observed in Figures 2 and 3 both chemicals could not disrupt the proximal superiority in the sprouting of the setts derived from the head region over those from the distal regions. This situation may be circumvented by cutting of the distal 1/3 end of the dormant tuber, or tail, prior to the chemical treatment and handling it separately. When the dormancy is over the tails sprout on their own. Care should, however, be taken to treat the cut-surface with wood ash - fungicide mixture to forestal dry rot, and they should be also sprayed regulary to prevent infestation of the wound - periderm by insect-pest.

CONCLUSIONS

Nitrogen might be a very important element in the regulation of the inductive phase of callus development in yam sprouting, and it interacts very strongly with sulphur in this process. It is very probable that ethylene is one of the phytohormonal endproducts of this interaction that accelerate the sprouting process.

Any effort to chemical boost sprouting of white yam must take into consideration the interaction of sulfur, nitrogen and ethylene - generating sources.

The ideal stage of chemical application in this context might be the dormancy period, using whole tubers. The distal, one-third portions of the latter, should be cut and treated separately.

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