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Experiments with Budding Avocado[1]

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INTRODUCTION

The budding of 1-year-old seedlings is the most widely used method of propagating avocado in Israel. Although excellent results have been obtained with split- and side-grafting of several weeks-old avocado seedlings (15), these methods are rather tedious and require special equipment, such as glass houses. Budding, performed mainly in autumn, usually gives a satisfactory bud take, when observed several weeks later. However, during the subsequent winter many buds die, others are shed, in spite of the fact that the "shields" carrying them remain alive. According to Oppenheimer (11) only about 50% of the budded avocado seedlings in Israel reach the "maiden" stage.

Failure in Avocado budding may be caused by: a) Failure of shield take; b) shedding of buds after budding; c) failure of buds to develop or death of buds caused by inadequate after-treatment.

Among the important factors affecting avocado shield take included in our investigation was age and vegetative condition of the rootstock. Decreases in bud take with 2 and 3 year old avocado rootstocks in the nursery, compared with younger plants, have been reported (6, 12, 15). We tried to improve bud take with aged, as well as with young rootstocks with the aid of synthetic growth substances, a method found useful for grafting, but only rarely used for budding (4, 8).

The severity of avocado bud abscission after budding depends on the bud type used, thus buds with open scales tend to abscind (12), whereas very small buds fail to develop (10). Bud take and abscission of 2 types of avocado are described in this paper; investigation of the physiological causes of bud abscission in avocado will be described elsewhere.

Results on the value of improved protection of the shield from surface desiccation after budding are presented here. Some workers are satisfied with simple raffia ties (11, 12), others prefer ties impervious to water vapour (5, 7, 10, 13).

Recommendations on the after-treatment of successful avocado buds vary from cutting back the rootstock after bud-take, leaving a 25-30 cm long stub (7, 10) to cautious breaking (2, 13) or girdling (1) of the rootstock above the bud, and cutting back only several weeks later. Results from various after-treatments of budded avocado rootstocks are presented in this paper.

MATERIAL AND METHODS

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Budding experiments were conducted at the nursery of the National and University Institute of Agriculture at Rehovot. The nursery was grown in a sandy soil, not very suitable for an avocado nursery. This fact probably accentuated differences between treatments.

The rootstocks were 1-year-old seedlings of the Duke variety, seeded directly in the nursery row (except where stated otherwise). Scion varieties were Benik and Fuerte. The standard procedure was as follows: The budwood was cut from young, but lignified branches. The buds used were plump, but with closed bud scales. The buds were inserted into the green non-suberized portion of the seedling stem. The cut was made in the form of an inverted T. The shield was 3—3.5 cm long and included a thin strip of wood. The buds were tied with raffia and covered with a thin layer of paraffin (m.p. 70°C). Time of budding was autumn. Results were recorded 4 months after budding.

Experiments in cutting back the rootstocks at the time of budding and after bud-take were conducted, as well. All wounds resulting from these treatments were covered with an asphalt emulsion.

When growth substances were used, the scion wood was cut into pieces of 25-30 cm and immersed completely in the solution for 12 or 24 hours. The solutions were prepared by dissolving the pure substance in a little ethanol and diluting this with the required amount of distilled water. Pure *β*-indole acetic acid (IAA) and índole 3 butyric acid (IBA) were used.

The number of grafts varied and are reported for each experiment. The design of the experiments was in blocks. Each block contained all treatments, performed on single trees and randomized within the block. Results were statistically analyzed according to the "test of independence" with Yates' correction for continuity (3).

RESULTS

Age of rootstocks: Bud-take of 1, 2, and 3-year-old rootstocks growing in the nursery row, and 3 year-old rootstocks grown in tins (24 X 24 cm wide and 34 cm high) were compared (Table 1). Bud-take decreased with age of the rootstock. Budding 3 year old stocks growing in tins failed entirely. These stocks had been developing very poorly at the time of budding.

Treatment with growth substances

In a preliminary test it was found that the immersion of the scion-wood in distilled water was very harmful to bud-take. Only the addition of a growth substance to the distilled water at the beginning of the treatment, prevented the harmful effect of pure distilled water (Table 2).

The immersion of budwood for 24 hours in a solution of 25 ppm IAA increased bud-take with all the types of rootstocks tested, but the effect was much more pronounced with older rootstocks and was highly significant ($P = 0.01$) only with 3 year-old root-stocks (Table 1). With 3 year-old rootstocks in tin containers bud-take occurred only with the IAA treatment.

Table 1.—Effect of age of stock and treatment with indole acetic acid on take of Fuerte avocado buds, set November 15. Scions immersed for 24 hours in 25 ppm IAA.

Age of stock (years)	No. of plants	Growth medium	Percentage of bud take		
			Without IAA	With IAA	Difference
1	45	nursery row	40	49	9
2	45	nursery row	33	44	11
3	35	nursery row	14+	54	40+++
3	35	containers	0++	31	31+++

+Significantly different from 1 and 2 years old stocks (without IAA treatment) at 5% level.
++Highly significantly different from 1 and 2 years old stocks (without IAA treatment) at 1% level.
+++Highly significantly difference between IAA treated and non-treated buds at 1% level.

Table 2.—Influence of immersion of scion-wood in water and solution of 100 ppm for 12 hours on the take of Benik avocado buds. Budding was done on October 10, on 2 years old stocks, 20 plants per treatment.

Medium of immersion	Bud-take (per cent)
No immersion—control	40
Distilled water—control	15
100 ppm IBA in distilled water	50+

+Significantly different from immersion in distilled water, at 5% level.

Results in Table 2 are not strictly comparable to results in Table 1, as the growth substance, the duration of immersion and other details vary in both experiments. Table 2 indicates mainly the harmful effects of the distilled water control, which can be counteracted by means of IBA.

The developmental stage of the bud

Plump buds with closed bud scales were compared with larger buds in which the scales were slightly open (Table 3). Bud abscission was significantly higher with the larger buds. Final bud-take was not significantly lower with the large type of buds, because of their somewhat (not significant) increased shield take.

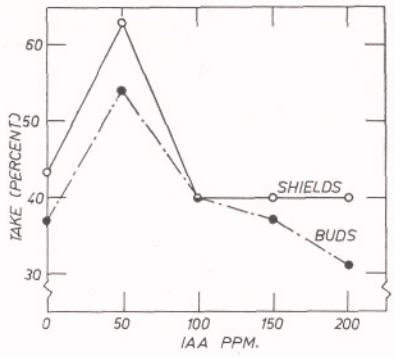

Fig. 1. Influence of concentration of IAA solutions, used for the immersion of scion-wood, on the take of buds.

With the immersion treatment for 24 hours in IAA solutions only a concentration of 50 ppm improved bud-take, as shown in Fig. 1. Higher concentrations not only produced no significant difference in take, compared with non-immersed control, but tended to be harmful mainly owing to increased bud abscission.

Prevention of bud desiccation: Two measures were tried to reduce water loss from the bud-shield;

a) Cutting back the rootstock at the time of budding in order to reduce transpiration, leaving a foliage covered stub about 20 cm long.

b) Prevention of direct evaporation loss by protecting the bud with a cover impervious to water vapor.

The advantage of cutting back of the rootstock, at the time of budding on the 10th of October may be explained by the occurrence of several hot dry days shortly after this date. No such effect was obtained when we budded at a late date (14th of November), followed by cooler weather (Table 4).

To prevent bud-shield desiccation the raffia, used normally for tying the bud-shields, was covered with molten paraffin. This treatment, when used on the 10th of October, before the hot spell, improved bud-survival significantly (Table 5).

After-treatment of budded seedlings: Various methods of inducing bud growth were tried in the spring following autumn budding (Table 6). Cutting back the rootstocks without leaving a stub above the bud resulted in the death of about half of the treated buds. Cutting back leaving a stub of 3 cm was unsatisfactory, as many buds died and only half of total number of treated buds started to grow. Breaking the rootstock about 5 cm above the bud, leaving the crown attached for a month, and subsequently cutting back without leaving any stub, gave fairly satisfactory results. A high percentage of buds started to grow, but bud-mortality was still rather high. Girdling the rootstock by removing a ring of bark, about 1 cm wide, at a height of 3 cm above the bud, and cutting back a month later, without leaving any stub, was not followed by the death of buds and resulted in a satisfactory start of growth.

Table 3.—Influence of developmental stage of Benik avocado buds on their take. Budding was done on October 11, 44 plants per treatment.

	Closed scales	Open scales
Shield take (per cent of plants budded)	50	66
Bud survival (per cent of plants budded)	45	41
Bud abscission (per cent of living shields)	9	38+

+The difference between bud abscission of the 2 bud kinds is significant at 5% level.

Table 4.—The influence of cutting back the rootstock at the time of budding. Benik avocado, 26 plants per treatment.

	Bud-take (%)	
	Budded: 10th Oct.	14th Nov.
Stock cut-back 20 cm above bud	46+	42
Control (crown of stock preserved)	27	42

+Significantly different from control at 5% level.

Table 5.—Influence of a paraffin cover over raffia ties after budding on the take of Benik avocado buds. Budded Oct. 10, 20 plants per treatment.

Bud cover	% buds alive after	
	4 weeks	16 weeks
Raffia	60	40
Raffia + paraffin	80	75+

+Significantly different from control at 5% level.

Table 6.—The effect of after treatment of avocado buds in the spring after union with the stock. Plants fall budded. Treatments applied March 15, records taken July 30, 34 trees per treatment.

Treatment of rootstock	% living buds (both dormant and grown out)	% growing buds
Cutting back without leaving stub	51	34
Cutting back, leaving stub	72+	48
Breaking	88++	65+
Girdling	100++	67+

+Different from "cutting back without stub", at 5% level.
++Different from "cutting back without stub", at 1 %level.

DISCUSSION

Success in budding depends on the formation of the union between rootstock and scion within a short time after budding; the longer the period necessary for the formation of a tissue bridge the greater the danger of desiccation of the bud-shield. Efforts to increase bud-take may be directed towards an increased callus formation at the place of union, e.g. by the use of young and vigorous rootstocks, or by the application of growth substances. Another possibility of improving bud-take is reduction of water losses of the budded plant or of tissue within the zone of graft union. Our treatments, cutting back the rootstock at budding time, and protecting the bud shield with a cover, impervious to water vapor, aimed towards such a reduction in water loss and proved beneficial.

The beneficial effect of an increased auxin supply to the bud was demonstrated by the direct supply of a growth substance to the bud stick. Even the negative effect of elution of the natural auxin from the bud-wood is strongly indicated. The harmful effect upon bud-take of soaking the bud in distilled water could be neutralized by adding índole butyric acid.

An improvement in bud-take by immersing the bud-wood in solutions of synthetic auxins has been reported for different species, both with budding and grafting methods (4, 8, 9, 14). With our avocado seedlings the concentration of the growth substance in the solution into which the bud stick was immersed produced optimal response at a much lower level than found to be beneficial with other species.

If auxin plays an important role in budding of avocado we would expect its natural supply in the scion and stock to affect the success of the operation. Thus, vigorous younger stocks in full growth, which would be expected to be richer in auxin, showed a much better take than older stocks or plants grown in containers with impeded growth. Hence the addition of auxin to the bud-wood produced a relatively greater response when used with the less vigorous stocks.

With 3 year old rootstocks in the nursery row the application of IAA restored bud-take to the level of 1 year old plants (treated also with IAA). With rootstocks of the same age growing in containers, there was no bud-take without IAA. IAA application had a marked

effect but did not restore bud-take to the level of younger plants. Applications of higher IAA concentrations than those found optimal for the other stocks did not improve bud-take further (4). Apparently with this type of plant, factors in addition to the low level of natural indolic growth substances, limited the success of the buds.

We also found a more pronounced effect of the application of growth substances with such rootstocks, compared with younger plants with mango (4).

This effect of auxin supply manifests itself not only in shield take, but is likely to be involved also in the dropping of buds. Buds that were well developed with somewhat opened bud scales, but no green tip, dropped, in our experiment, significantly more than buds with closed scales. Observations indicate that the type which is likely to drop is not in a transitional stage before bud flush, but rather a senescent type. Although in our experiment increased bud abscission with the apparently senescent bud type did not decrease total bud-take significantly, the fact of the increased abscission after take represents a potential danger. Plump buds with closed scales and without scars from shed scales, are generally used for avocado budding (7, 10). While the mechanism suggested in connection with these latter observations is only indicated, further evidence in its support will be published shortly.

The well known horticultural technique of using paraffin to protect graft wounds and sensitive shield buds from drying out, proved useful for avocadoes. Our findings indicate the value of protection of the bud-shield, which has been often recommended for avocado budding. Earlier workers used cotton strips impregnated with wax for tying the buds (5, 13). Recently plastic strips are preferred (7, 10).

To this we have added, as an additional means of reducing water stress, a severe cutting back of the stock at the time of budding. This proved effective under the particularly severe conditions of subsequent hot weather, but was apparently unnecessary under more normal climatic conditions later in the fall. Such treatment has not been recommended previously according to our knowledge. Recently a light pinching of rootstock branches at the time of budding has been advocated, to stop growth temporarily (7). This treatment is not the same as our severe cutting back of the rootstock.

The reduction in transpiration surface, at time of budding, should not be confused with the varying degrees of cutting back performed to force growth of the scion bud. It is not clear why cutting back closely to the shield bud—with proper wound protection—should have given such poor results, while in Israel it is so successful with deciduous fruit trees. Even a short stub of only 2-3 cm considerably improved results, although still quite unsatisfactory. It is possible that an even longer stub, such as 25-30 cm, as advocated by some (7, 10) but not tried by us, would produce commercially satisfactory results.

In our experiments the breaking or girdling of the rootstock showed a clear advantage, compared with cutting back in one step. Girdling was slightly better than breaking, as no buds died with this method, compared with 12% death with breaking. Girdling does not interfere with cultivation, as does breaking. Both methods have been recommended in literature (1, 2, 13).

The advantage of girdling or breaking, as compared with topping is, that they allow a partial supply of nutrients, from the leaves to the roots. Evergreen species, which do not accumulate carbohydrates in their roots to the same degree as deciduous trees towards the winter, would seem to benefit particularly from these cautious procedures.

SUMMARY

1. A comparison was made between the take of avocado buds on 1, 2, and 3 year old seedlings growing in the nursery row, and on plants growing in tin containers. Bud-take decreased with age, and growing the plants in containers reduced take even further.
2. Immersion of the budwood for 24 hours in a solution of50 ppm *β*—índole acetic acid (IAA) improved bud-take, particularly with older rootstocks. The immersion in distilled water alone reduced bud-take compared with non-immersed budwood.
3. Concentrations of 100 and 200 ppm IAA did not improve the shield-take, compared with the non-immersed control; a concentration of 200 ppm tended to increase bud abscission.
4. Large buds with partially open bud scales showed higher abscission rates after budding than smaller buds with closed scales.
5. Cutting back the rootstock at the time of budding, leaving a 20-25 cm stub covered with leaves, improved bud-take under conditions of water stress.
6. Covering the raffia, used for tying the buds, with paraffin improved bud-take under severe climatic conditions.
7. Among treatments for inducing bud break with avocadoes budded in autumn, girdling the rootstock above the bud and cutting it back a month later was most successful.
8. An explanation of our results on a physiological basis has been attempted.

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