EFFECTS OF FERTILIZATION ON PRICKLY PEAR PRODUCTION IN ISRAEL

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Ethnobotany Introduction

The prickly pear Opuntia ficus-indica was introduced to Israel several hundred years ago, probably after having been introduced to southern Europe and northern African countries from Mexico. The plant thrives as a backyard hedge and roadside plant in the Israel's subtropical areas. It produces plenty of fruit and needs no special care or attention.

It may be found in areas with annual rainfall of 350 mm and more. In Israel, rain falls only during the winter (November-March) while the summer months are dry. The prickly pear has adapted itself so well to the region that native-born Israelies, whose parents come from abroad have been nicknamed "Sabra" or "Tzabar", which is the Hebrew name for the prickly pear fruits. Israelies have earned themselves this name because of their character, which they compare to the prickly pear-stubborn and thorny on the surface; delicate and sweet underneath! Until fairly recently (when these plants were planted commercially in orchards) the prickly pear was known from trips to the country-side, or, during the summer, from being offered for sale from ice-filled wooden boxes along city side-walks.

Commercial Production

A cultivated "low in spine" yellow cultivar named 'Ofer' which was selected by E. Slor of the Agricultural Research Organization. 'Ofer' is similar in its morphology and fruit characteristic to the common Sicilian cultivar 'Gialla'.

The first plantations were established in late 70's and early 80's in rainy areas (annual rainfall above 400 mm) in a region stretching from the south to the north of Israel. In many locations, the crop was planted on marginal soils, steep slopes, stony and sandy soils or soil with poor drainage. It was believed that the demand for water and nutrients was low, and if supplied in amounts used for other orchard crops, it will promote vegetative growth more than fruit production.

Farmers who applied water and fertilizer, irrigated the plants (60-100 mm) during progressive stages of fruit development in order to increase fruit weight. N fertilizer (10-15 kg/ha) was also applied before the beginning of the spring growth. Yields varied greatly between plantations and there were indications that soil fertility affected yield.

A very high profit was achieved in productive plantations, because the expenditures were low and consumers were ready to pay high prices for their beloved fruits. As a result, large scale plantings of prickly pear in the Negev desert, (the southern hot arid region of Israel) started in the late 80's. Since the rainfall is low (from

18 to 200 mm annually, depending on the location) all the plantations were irrigated, although much less than other orchards in this region.

As was common for other perennial crops grown by the farmers in the Negev, the plants were irrigated and fertilized around the year by a drip system. Data obtained in a plantation established from cladode cuttings on a sandy soil at Yevul (Western Negev) showed high vegetative growth and precocious yields during the first years (Table 1). Unlike plantations in rainy areas where one spring flush (summer crop) was a norm, the plants at Yevul developed two flushes of buds; a major flush in the spring and a minor one in the autumn (winter crop). The winter crop commanded high prices; 3-5 times greater than those of the summer crops, since winter fruits were scarce.

Increasing Commercial Production

In the light of the first observations we decided to investigate the effect of fertilization on vegetative and reproductive growth, believing that nutrition was a key factor in fruit production.

In an experiment conducted at Yevul plantation (Nerd et al. 1989, 1991), we found that withholding fertilizer (N-P-K) reduced significantly flower and cladode initiation in the spring (Table 2). The effect was much more significant in the second year than in the first year. An autumn flush was obtained only in fertigated plants which had 20-25 flowers/plant and 5-10 cladodes/plant.

This showed that the autumn flush was more dependent on fertilization than was the spring flush. Its small size was probably the result of summer temperatures which were unfavorable to bud initiation. In two studies, that were conducted at Yevul (Nerd et al. 1989) we found that a plastic cover applied during the winter inhibited spring flower bud initiation, suggesting that chilling was probably required for a regular flush.

In another experiment carried out in Yevul plantation, we examined the effect of interrupted fertigation after the summer harvest on autumn budding (Nerd et al. 1991). Interruptions of 1 or 2 months did not promote autumn budding and, in some cases, delayed it. As a result of Yevul studies we recommended that farmers apply N-P-K fertilizer in the late winter in order to increase flower production in the spring.

In one sandy field in the south of Israel, the effect of N fertilization was particularly dramatic. Flowers in nonfertilized rows emerged very slowly up to 30 flowers/plant while in fertilized rows (100 kg N/ha) the flush was more concentrated with the number of flowers 7 times greater. To farmers who are interested in a winter crop we recommended the application of N-P-K fertilizer after the summer harvest. Autumn flowering was obtained in most plantations and varied from year to year. In warm regions, the Arava and Jordan valley, were summer temperatures rise to 45-47°C, almost no autumn flush was obtained. This would suggest once again that temperatures play an important role in bud initiation in prickly pear, and if chilling has positive effect on flower bud formation, high temperatures would inhibit it. The limited research reported here was concerned with factors affecting bud differentiation and initiation in prickly pear. We feel that more knowledge in this field will improve our interpretation in productivity studies, since bud production is the basis for fruit production.

Effect of Nitrogen on Bud Formation

Nutrient analysis of terminal cladodes (preceding year cladodes which usually bear the spring flush) sampled at the Yevul experiment during the winter is presented in Table 3. Nitrate-N was always significantly higher in fertilized than in nonfertilized plants but not P and K. This data along with others supplied by farmers, showed the positive effect of N fertilizer on flower initiation, and led us to focus our research on the effect of N on bud formation.

Our studies (Nerd et al. 1993) were carried out in an eight-year-old commercial plantation planted at Nir Banim (south of Israel) at spacing of 1x4 m. The region is rainy, with an average rainfall of 650 mm and the soil has a loamy texture. The plantation was not irrigated, and fertilized sporadically. Marketed fruits (summer only) ranged between 20 to 25 ton/ha in the 6th-8th years. Fertilization treatments were 0, 30, 60 and 120 kg N/ha (N was applied as NH_4NO_3) and a combination of N-P-K, 60, 20 and 35 kg/ha respectively. The fertilizers were applied via drippers together with water (60 mm) during several weeks after the summer fruit harvest. Non fertilized and fertilized plants were irrigated equally.

The autumn flush consisted exclusively of flower buds on cladodes developed during the current year. Floral buds started emergence two weeks after the beginning of the treatments and continued for four weeks. Floral budding was markedly increased by N fertilizer (Table 4). The other nutrients, P and K, had no effect on bud initiation. The coefficient of correlation was higher between flower number and total N than with nitrate N (Table 4).

Bud initiation (both floral and vegetative) in the spring was also confined to terminal cladodes. There were 5 times more flower buds than vegetative buds in the spring. There was a minimum of 5 times more floral buds in the spring than in the fall (Table 5). Although N fertilization increased the initiation of both vegetative and floral buds, the differences between treatments were not statistically significant ($P=0.05$). In another experiment (unpublished data) carried out in the same plantation a year later, N fertilizer applied in the spring also only slightly increased flower bud initiation.

Similar to plants at Yevul the spring flush at Nir Banim was less sensitive to fertilization than the autumn flush. In contrast to Yevul, fertilization did not increase significantly the spring flush, probably because the fertility of the soil at Nir Banim is greater than at Yevul. In light of the Nir Banim study we can summarize that nitrogen fertilization induces the autumn flush of flowers in *O. ficus indica*. Values of N in cladodes tissue may serve as a criteria for fertilizer application in winter cropping. Although in our experiment P and K did not affect flower bud production, it is possible that budding was affected by the availability of these and other nutrients.

Our results support that of Mondragon and Pimienta (1987), who showed that N increases fruit productivity in prickly pear. Gathaara et al. (1989) correlated fruit production with N and P in cladodes of *O. engelmannii*. They showed that optimal N and P concentrations for fruiting were 1.16% N and 0.115% P and, with higher concentration of N, vegetative growth will be increased and fruit production decreased.

Data collected by us is not sufficiently conclusive about the relationship between fruit production and nutrients contents in cladodes of O. ficus indica. We can only indicate that in the range of 0.75% - 0.97% N in cladodes, productivity of the summer crop is high and higher concentrations of N will increase the autumn flush.

References

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Table 1. Growth and yield of young prickly pear plantation planted at Yevul (Western Negev) in Sept. 1986. Soil is sandy and annual rainfall is 160 mm. Water and fertilizer were applied every 2-3 days via drippers. Total amount of irrigation water per year was 270 mm and nutrients concentrations: 70ppm N, 30 ppm P_2O_5 and 70 ppm K_2O.

Age years	Plant height (m)	Plant width (m)	Summer crop (t/ha)	Winter crop (t/ha)	Total annual yield (t/ha)
1.5	1.2	1.5	3	1	4
2.5	1.8	1.5 - 1.7	15	3	18

Table 2. Effect of N-P-K fertilization on spring bud production at Yevul plantation (see Table 1) Modified from Nerd et al. (1989, 1991) and unpublished data.

Treatment		Buds/Plant			
Irrigation	Fertilization	1988		1989	
		Flowers	Cladodes	Flowers	Cladodes
Continuous	Continuous	266a	86a	269a	95a
Continuous	Withheld from Nov. 1987	203b	67a	81b	22b

Mean separation within columns by Duncan multiple range test, 5% level.

Table 3. Nutrient content in cladodes of fertilized and non-fertilized plants at Yevul (see Table 2) Nutrients were analyzed in terminal cladodes sampled in the winters of 1987/8 and 1988/9.

Treatment		Nitrate-N (ppm)		P (%)		K (%)	
Irrigation	Fertilization	1987/8	1988/9	1987/8	1988/9	1987/8	1988/9
Continuous	Continuous	557a	312a	0.25a	0.38a	4.18a	3.17a
Continuous	Withheld from Nov. 1987	300b	20b	0.22a	0.16b	3.02b	2.76a

Mean separation within columns by Duncan multiple range test, 5% level

Table 4. Effect of N-P-K fertilization on autumn bud production from 8 year old plantation at Nir Banim.

Fertilizer (kg/ha)			Buds/plant		Nitrogen	
N	P	K	Vegetative	Floral	Total (%)	Nitrate (ppm)
0	0	0	0	3c	0.85c	15d
3	0	0	0	14b	0.98b	123c
60	0	0	0	17b	1.04b	518b
60	25	65	0	15b	1.02b	400b
120	0	0	0	41	1.19a	746a

Mean Separation within column by Duncan's multiple range test, 5% level. Modified from Nerd et al. (1993) and unpublished data.

Table 5. Effect of N-P-K fertilization on spring bud production and cladode N in 8-year-old plantation at Nir Banim.

Fertilizer (kg/ha)			Buds/plant		Nitrogen	
N	P	K	Vegetative	Floral	Total (%)	Nitrate (ppm)
0	0	0	26ns	136ns	0.75b	8c
30	0	0	36	155	0.88a	103b
60	0	0	33	195	0.91a	253a
60	25	65	35	177	ND	ND
120	0	0	45	196	0.97a	266a

Mean Separation within column by Duncan's multiple range test, 5% level, ns Nonsignificant at the 5% or 1% levels. ND - Not determined. Modified from Nerd et al. (1993) and unpublished data.