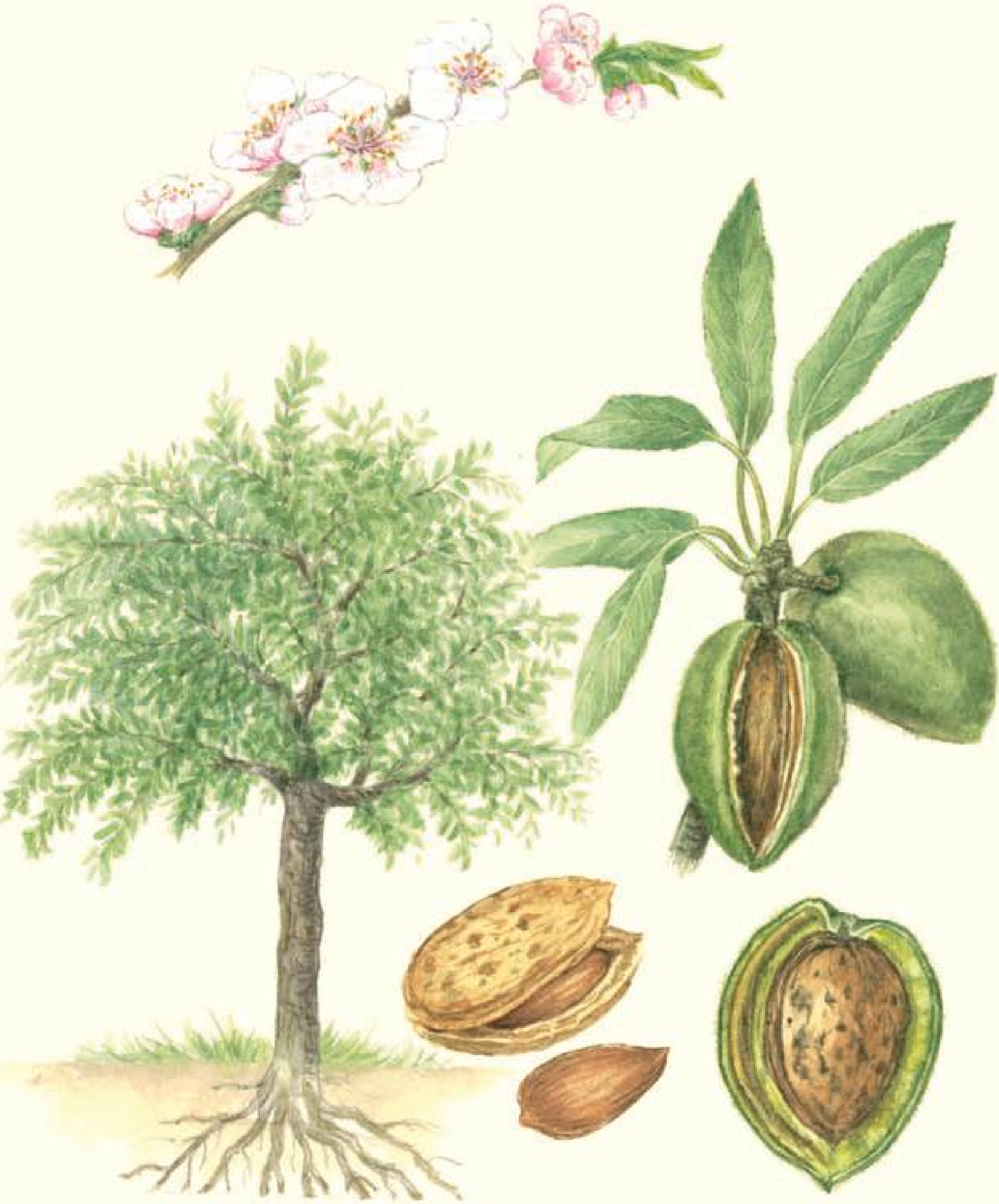

Almond

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Almond

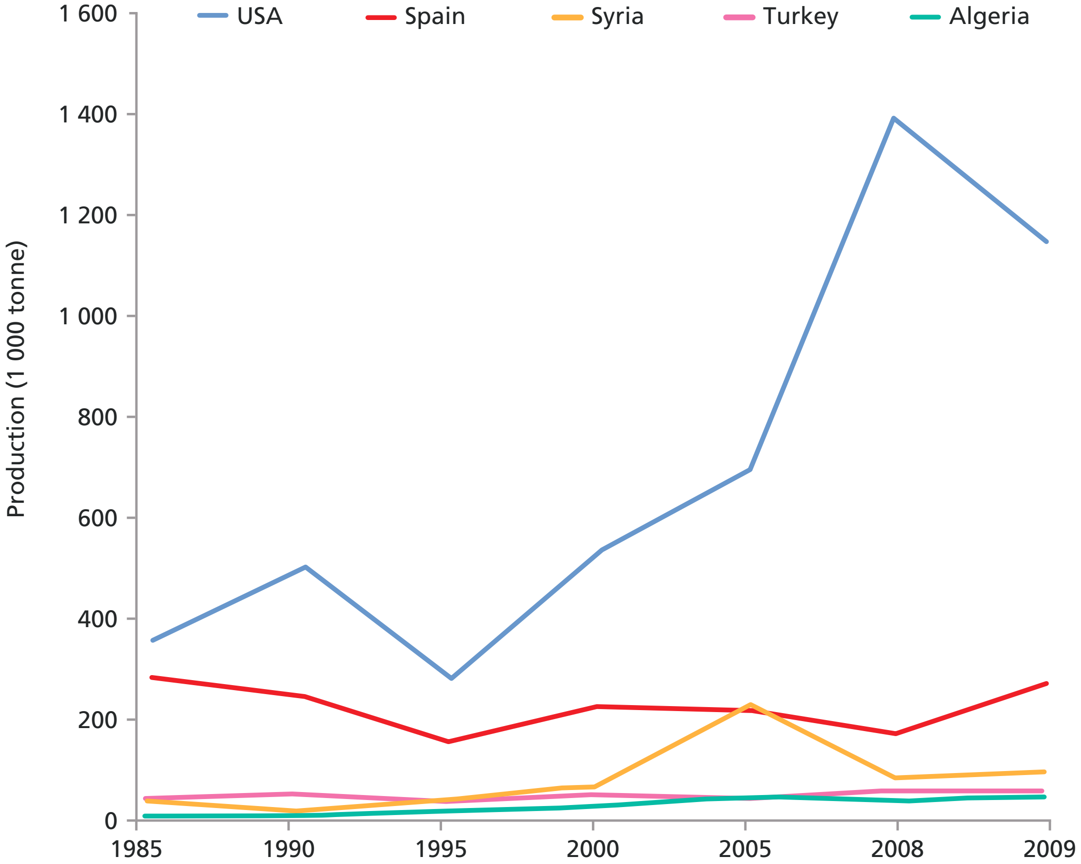
INTRODUCTION AND BACKGROUND

Almonds are grown under both rainfed and irrigated conditions; production in semi-arid zones, such as the western United States and Spain, reflects the drought tolerance of the tree. In many areas of the Mediterranean Basin, almond trees are grown on marginal soils in areas where annual rainfall does not exceed 300 mm, being important for erosion control and to prevent desertification. As a result of the limited water supply and poor soil conditions of the rainfed areas, tree densities are quite low and yields are also low and variable from year-to-year. However, they can be much higher when the water-use requirements of the trees are fully met and, in most areas of the world, this requires irrigation. New irrigated almond plantations have expanded in recent decades in many areas and are highly productive. Nevertheless, almonds are an important crop in very diverse agricultural systems, from very marginal to highly intensive. In 2009, the cultivated area worldwide amounted to 1.8 million ha with an average yield (with shell) of 1.3 tonne/ha (FAO, 2011). Figure 1 shows the recent trends in production of the major producing countries.

Modern almond cultivation presents unique challenges to irrigation in general and regulated deficit irrigation (RDI) in particular. These include dealing with multiple cultivars in each orchard, a long period between flowering and fruit maturity the need to dry the soil prior to harvest in order to mechanically shake nuts from the trees, and a relatively late reproductive bud morphogenesis period. On the other hand, since the fruit is sold dry, many of the problems associated with fresh fruit production, including physical appearance, handling and storage are absent.

The almond flower of most varieties is self-infertile; it cannot pollinate itself. Even for cultivars that are self-compatible, production is enhanced by cross-pollination. Thus, each orchard normally contains at least two different cultivars with overlapping bloom periods to help the process of cross-pollination; the transfer of pollen from the anthers of a flower from one cultivar to the stigma of a flower from another cultivar. This transfer is facilitated by the introduction of honey bees into the orchard during flowering. To maximize pollen exchange, a common arrangement is single, alternating rows of each cultivar. The fact that two or more cultivars exist in a field complicates irrigation management in that the different harvest periods usually result in harvest-related water deprivation for one cultivar, while kernel filling is occurring in the other cultivar. Further, there is some evidence that different cultivars have different stress sensitivities.

FIGURE 1 Production trends for almonds in the principal countries (FAO, 2011).



☑ **Quality considerations**

Insect damage, shrivel, kernel colour, and broken kernels are quality criteria worldwide. Additionally, marketplace differences result in cultivar-dependent crop values.
Some markets also place a premium value on larger nuts; the United States, for example.

DESCRIPTION OF THE STAGES OF DEVELOPMENT IN RELATION TO YIELD DETERMINATION

Almond trees require very low chilling and thus, vegetative growth and flowering begin very early in the season relative to other deciduous tree species; although plant breeders aim to develop cultivars that bloom late to avoid chilling injuries. This earliness feature relates to the evolution of almonds in mild, subtropical climates with prolonged summer drought. The period from flowering to fruit maturation of almond is relatively long, depending on climate and cultivar; from late January-March to August-September in the Northern. Hemisphere, and the sensitivity of each of the physiological processes during this time to water deficits must be considered to assess the impact of stress on the yield and quality of the fruit at harvest. Not only current season impacts but those of subsequent seasons must be taken into account.

EARLY VEGETATIVE AND REPRODUCTIVE GROWTH

Flowering and initial leaf development occur almost simultaneously from late January in the Northern. Hemisphere for the earliest blooming cultivars until the end of March for the late blooming. Fertilization of the flower is followed by growth of the pollen tube into the ovary, which will evolve into the marketable kernel. The maximum potential fruit production is determined during this early period. It is established by the number of flowers produced (flower set) and the percentage of these that are successfully pollinated (fruit set). Early fruit development is largely the result of cell division. The early stages of fruit growth occur at the same time as most of the leaf expansion and shoot growth. This results in considerable competition for tree resources, principally carbohydrates. Thus, if flowering and fruit set are high, shoot growth may be lower. Since fruit are borne on spurs, this may reduce the number of new reproductive buds produced and, in turn, reduce the crop potential for the following year. In addition to its impact on fruiting positions, this carbohydrate competition can influence fruit set. If carbohydrate reserves from the previous year are low, the current year fruit set may be reduced (Esparza *et al.*, 2001). This effect may enhance alternate bearing in almonds, especially under rainfed conditions.

Stages of fruit growth

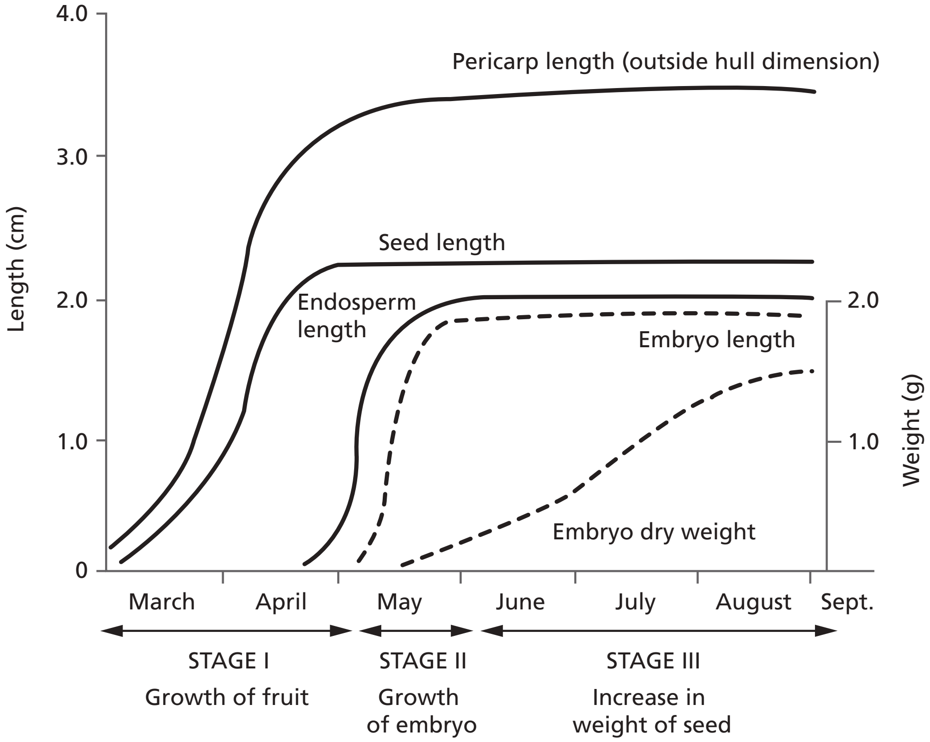
Figure 2 shows the pattern of fruit growth where three stages may be defined:

Stage I is one of rapid growth of the hull, shell, and integuments. The entire fruit remains soft and reaches its maximum size. Cell division is completed in a few weeks; the major part of growth thereafter is expansion. At this point, the kernel is a white structure filled with watery, translucent tissue. The time between fertilization of the flower to the end of fruit development is about two months. The end of Stage I is marked by the attainment of the maximum external dimensions of the hull, shell, and kernel.

Stage II is characterized by shell hardening and kernel expansion. There are two types of almond varieties: hard and soft shelled. Hard shelled, which are many of the Mediterranean varieties, have shelling percentages of 25-35 percent, while soft shelled have 70 percent. They completely harden in Stage II while the soft shelled remain soft. The growth of the embryo involves clear watery tissue becoming translucent, starting at the apical end. This white, opaque embryo rapidly expands during this period. Toward the end of Stage II, kernel dry weight begins to increase.

In Stage III, the major event is the steady dry matter accumulation in the kernel. The morphological differentiation of the hull, shell and kernel are complete. Dry matter accumulation of assimilates continues at a steady rate until maturity, as long as the vascular connections remain intact. Two events signal the approach of maturity: hull split (endocarp dehiscence) and the formation of an abscission layer at the nut-peduncle connection. Complete dehiscence requires an adequate tree-water status because the sides of the hull must be turgid to separate properly. Excessive stress may cause the hulls to adhere to the shells (hull-tights), which complicates processing. Maturity is also characterized by a sharp slowing in the rate of kernel dry matter accumulation. In some areas, commercial harvests occur prior to kernel maturation to avoid insect navel orange worm (NOW) damage.

FIGURE 2 The three stages of almond fruit development and the typical length and weight of the fruit at each stage. Adapted from the UC Almond Production Manual, 1996.



Bud development

The reproductive buds are borne on spurs and are initiated in the spring as the spurs develop. There are three subsequent stages of flower-bud development. The first is induction where the internal physiology of the growing point changes. This occurs in mid-August and the vegetative and reproductive buds are indistinguishable. Second are the morphological-anatomical changes in the internal structure, which are readily observable in September. Third is gradual growth of the reproductive parts during the autumn and winter, i.e. development of the sepals, petals, stamens and ovaries.

RESPONSES TO WATER DEFICITS

As for most crop plants, vegetative growth of almonds is very sensitive to water deficits. Avoidance of water deficits throughout the season in young trees is critical to reach full production in the shortest time period (Fereres *et al.*, 1981). In mature plantations, responses to water deficits depend on the timing of the stress.

In areas that receive substantial winter rainfall, tree processes that occur very early in the season, such as leaf out, flowering, pollination and fruit set, will be under non-limiting soil water levels. However, as the season progresses and evaporative demand increases, shoot, spur, and fruit growth will be subjected to water deficits without irrigation or in-season rainfall. Several reports state almond vegetative growth is very sensitive and directly affected by tree-water deficits.

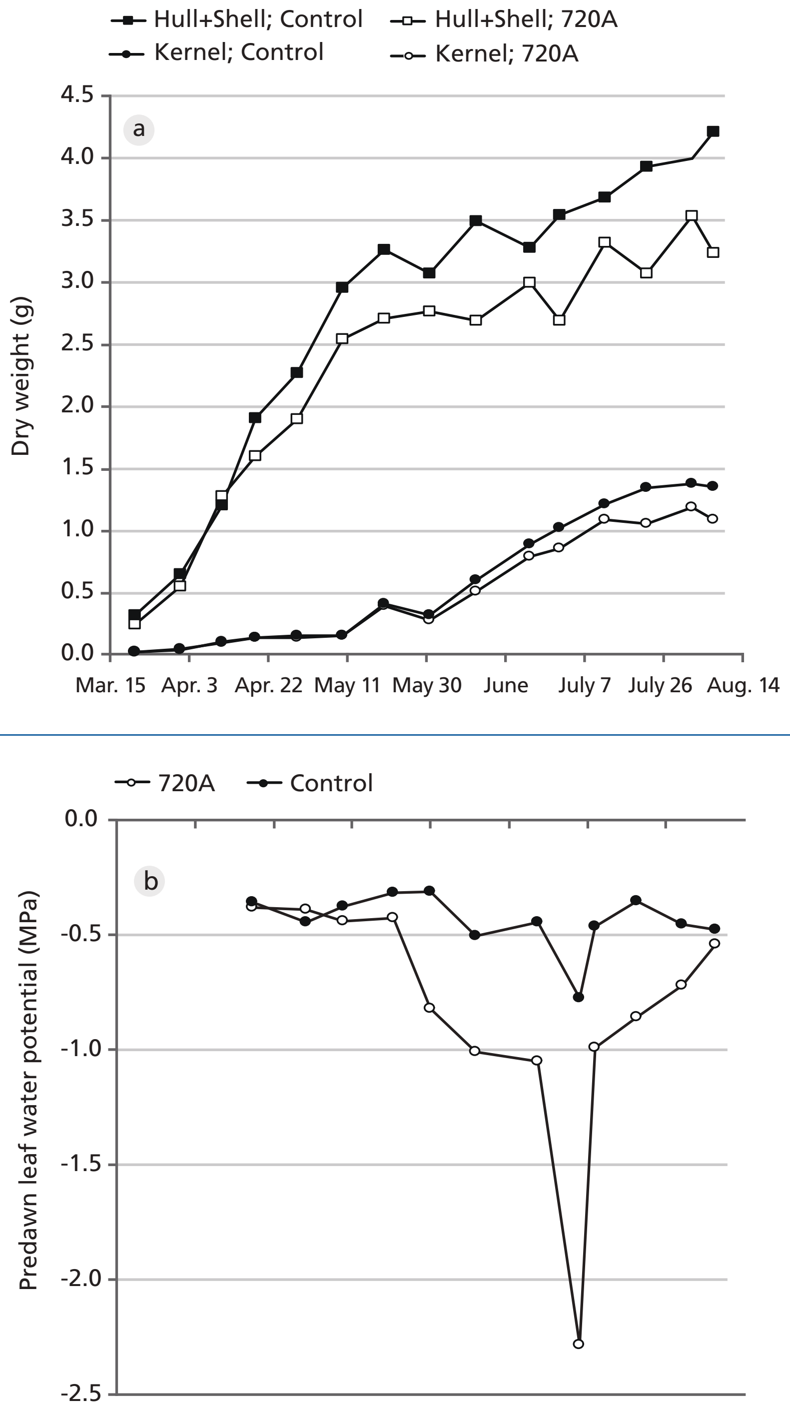
The research results on preharvest impacts of stress on kernel filling are seemingly contradictory and may reflect the importance of stress timing and cultivar differences. A study in Spain (Girona *et al*., 2005) with cv. Ferragnes, reported that kernel dry weight accumulation was not influenced during the first two seasons of an RDI regime that irrigated at 20 percent of ET_c during late June through the mid-September harvest (minimum predawn leaf water potential of -1.7 MPa in August) but was lower during the final two seasons of the study, which was attributed to the cumulative impacts of stress reducing the reserves of carbohydrates available for kernel filling and to relatively low soil water levels during those years. However, a California study (Goldhamer and Viveros, 2000) with higher evaporative demand (minimum predawn leaf water potential of -3.5 MPa) and earlier stress reported significant reductions in kernel dry matter accumulation with cv. Non Pareil in all experimental years. Dry matter accumulation in the hull and shell after three successive years of preharvest stress, diverged from the fully irrigated in late April, well before there were differences in tree stress, as shown in Figure 3. This was likely because of early season competition for carbohydrates. A study (Romero *et al.,* 2004) with cv. 'Cartagenera' that imposed an RDI regime that resulted in a minimum predawn leaf water potential of -2.5 MPa in late July found no reduction in dry kernel weight at the mid-August harvest.

A recent study with cv. Non Pareil in California showed that imposing water deficits primarily from early July through an early September harvest over a four-year period did not reduce kernel weight or nut load (Stewart *et al.*, 2011). These workers attempted to maintain midday stem-water potential between -1.4 and -1.8 MPa during this period. The objective was reduced hull rot, a disease that damages the fruit (Teviotdale *et al.*, 2001), while reducing consumptive use. Other efforts using this same philosophy have achieved positive results and this practice is now being widely adopted by California almond growers with trees afflicted by severe hull rot. However, it should be noted that detailed analysis of the fruit components (hull, shell, and kernel) suggests that the impact of preharvest stress on hull splitting may impact kernel weights. In numerous studies, California researchers found that slight reductions of kernel dry matter accumulation occurred concomitant with the onset of hull split, while at the same time, there were slight increases in the rate of dry matter accumulation in the hulls. The net result was slightly lighter kernels (generally 2-3 percent relative to full irrigation) but no difference in the dry weight of the entire nut. They hypothesized that hull split resulted in some physical disruption in assimilate transport in the pathway leading to the kernel.

It appears that there are two factors involving early season stress timing that can contribute to reduced kernel size: lower cell division and/or expansion, which is enhanced by carbohydrate competition, and the disruption in assimilate transport to the kernels because of accelerated hull split. These stress impacts may well be cultivar-dependent although comparative research studies are lacking.

Of the two primary yield components of almond, fruit load appears to be the most sensitive in terms of water stress impacts on yield. A study in Spain found that fruit loads were reduced in the final two years of a four-year RDI treatment and attributed this to the cumulative impacts of stress on the bearing surface, and thus fruiting positions, of the tree. Another study in California also reported that yield reductions associated with water deprivation in August and September (minimum midday stem-water potential of -2.5 MPa) were the result of a reduced bearing surface resulting from less shoot and spur growth. This study found that yields were reduced only after two years of stress. Other studies have found little impact of preharvest stress on fruit load.

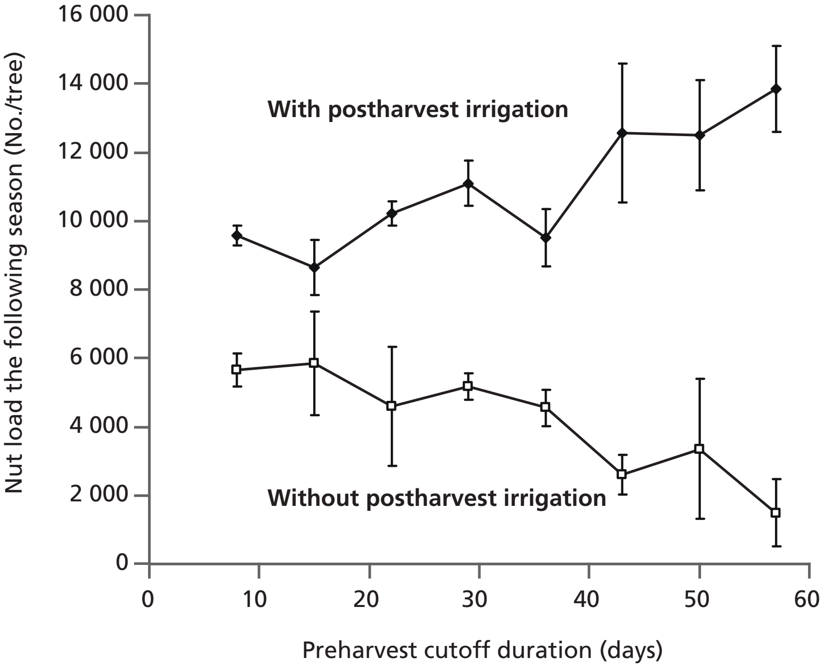
FIGURE 3 Differences in the cultivar Non Pareil trees subjected to preharvest water deficits (720A) and those fully irrigated (Control) in: **(a)** dry matter accumulation in the hulls+shells and kernels with time in the third year of the stress treatments, and **(b)** corresponding predawn leaf water potentials. Adapted from Goldhamer *et al*. (2006).



Much less work has been done on the impacts of postharvest stress on almond production, in part, because in many parts of the world, autumn rains eliminate this possibility. However, a dramatic impact of the presence or absence of postharvest irrigation on the following season's fruit load has been detected (Goldhamer and Viveros, 2000) (Figure 4). Even when the trees were near fully irrigated prior to harvest, postharvest water deprivation resulted in 40 percent reduction in fruit load the following season, relative to trees that received postharvest irrigation. It should be emphasized that this was with a mid-August harvest under high evaporative demand; predawn leaf water potential was below -4.0 MPa in mid September. For this same stress level at preharvest, there was near complete defoliation but after the reintroduction of full irrigation postharvest, there was vegetative bud break and new leaf growth, alleviation of the stress, and no reduction in fruit load the following season (Goldhamer and Viveros, 2000).

The dramatic impact of postharvest water deprivation on fruit load was attributed to stress impacts on reproductive bud development. Early work (Tufts and Morrow, 1925) showed that bud differentiation in almond occurred from late August through early September, and this has been confirmed by more recent work. The timing of bud development showed no clear pattern between cultivars or locations within California, spanning a distance of more than 500 km (Lamp *et al.*, 2001). Thus, bud development can occur both after and before harvest, depending on the cultivar and geographic location. Moreover, bud development is not related to hull split: it occurred three weeks after hull split in Non Pareil but prior to hull split in 'Butte' and 'Carmel.' Stresses that occur during flower development are likely to adversely affect flower quality to the extent that the next season's crop load, and thus yield, would be reduced.

FIGURE 4 Relationships between fruit load in the season following the imposition of different preharvest irrigation cutoff regimes for conditions with and without postharvest irrigation. Vertical lines are plus and minus one standard error. Adapted from Goldhamer and Viveros (2000).



Indicators of tree water status

To precisely schedule irrigation, it may be necessary to monitor a given soil and/or plant parameter and make decisions according to some pre-established criteria. Also, implementing an RDI regime may have to be based on estimates of tree water status, such as the stem-water potential (SWP). The SWP values of well-irrigated almond trees in mid-summer range from -0.5 to -1.0 MPa at midday, depending on the evaporative demand and the time of the year. In one study, there was a 0.2 MPa decrease in the SWP of fully irrigated trees on different days (from -0.7 to -0.9 MPa) when the air temperature increased from 25 to 40 °C. The SWP values decrease as stress increases but in almond, it seldom exceeds -4.0 MPa even under very severe stress (Castel and Fereres, 1982). The tree will shed its leaves before reaching the extreme dehydration levels that would induce lower water potential, as measured in other fruit tree species.

WATER REQUIREMENTS

Most of the almond water use estimates in the literature were developed using soil water balance approaches rather than from more accurate weighing lysimeters. The monthly crop coefficient values (K_c) for clean cultivated, weed free, high evaporative demand conditions published by several authors are shown in Table 1. Because almond ET has often been grouped with peach, apricot, and plum, weighing lysimeter K_c data for peach determined in California are also shown in Table 1 for comparison (Ayars, 2003). Early season crop K_c values for the peach used in their work are relatively low owing primarily to the slow canopy development of this cultivar. Maximum K_c values (July-August) for all the presented data range from 0.95 to 1.08. Recent data from California suggests that almond peak K_c values of an intensive, mature orchard irrigated with microsprinklers may reach as high as 1.17 (Goldhamer, unpublished), which is considerably higher than previously reported. Similar high K_c values have been recently reported in Australia (Stevens *et al.*, 2011). It should be noted that when the early ET data were developed, surface irrigation (border strip) was the primary irrigation method, whereas drip or microsprinklers were used in the more recent studies. The higher K_c values are likely due to the increase in tree densities in recent plantations, larger tree canopies (there is much less annual pruning now than previously), and higher fruit loads. Also, the more frequent wetting of the orchard floor with microirrigation and thus, higher surface evaporation may be another factor for the higher K_c values.

WATER PRODUCTION FUNCTION

Relative yield versus relative applied water data derived from fourteen irrigation studies are presented in Figure 5. It was not possible to estimate ET_c in many of the studies and therefore, the actual production function based on consumptive use could not be drawn. These studies were done over a wide range of evaporative demands, cultivars, and soils with various deficit irrigation regimes; different timing and magnitudes of stress. The correlation coefficients of the linear regressions for these studies ranged from 0.87 to 0.98, indicating a strong functional relationship between yield and applied water. Some of these studies had similar slopes ranging from 0.7 to 0.9, whereas others had a milder slope above 0.3. The lower yield sensitivity of these studies is likely due to a combination of deep soils, relatively low crop loads, and relatively wide tree spacing. Thus, the impact of instantaneous stresses was buffered by the high potential rate of water supply to the trees. It should be noted that these studies generally had consumptive use rates that deprived the trees of up to 30-50 percent of maximum ET_c. Close inspection of

Figure 5 shows that with mild deficit irrigation that would reduce relative ET_c by only 10-15 percent, the impact on production is negligible.

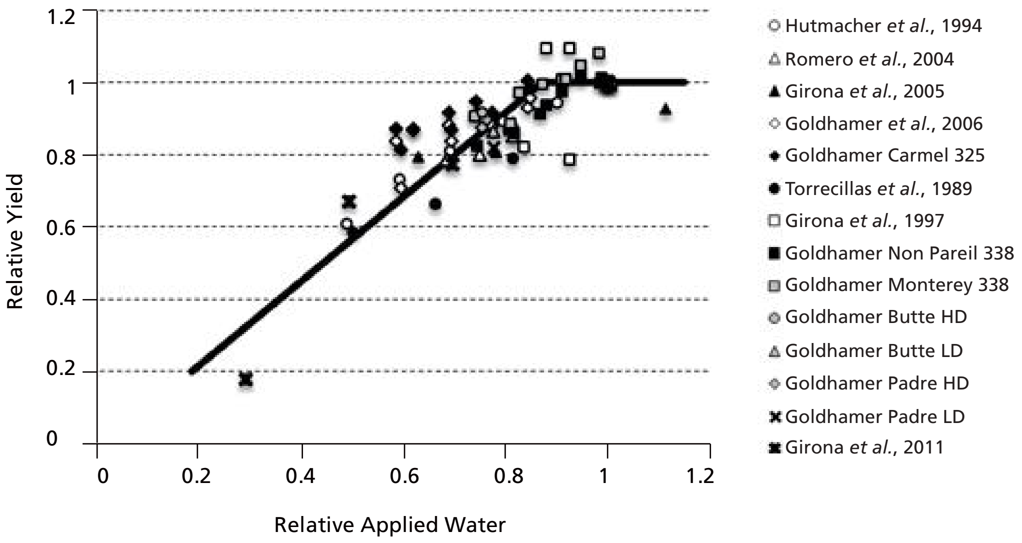
SUGGESTED RDI REGIMES

Growers with limited water supplies must make a decision on when to stress trees. Based on research results, we believe the two most stress sensitive periods are in the Spring when the

TABLE 1 Estimates of the monthly crop coefficient (K_c) values for mature deciduous trees (first column), almond (columns two-five) and peach trees (last column).

	Doorenbos and Pruitt (1977)	Fereres and Puech (1981)	Sanden (2007)	Goldhamer (unpublished)	Girona (2006)	Ayars *et al.* (2003)
March	0.50	0.60	0.59	0.20	0.40	0.28
April	0.75	0.71	0.78	0.67	0.65	0.48
May	0.90	0.84	0.92	0.95	0.80	0.68
June	0.95	0.92	1.01	1.09	0.92	0.88
July	0.95	0.96	1.08	1.15	0.96	1.06
Aug.	0.95	0.96	1.08	1.17	1.05	1.06
Sept.	0.85	0.91	1.02	1.12	0.85(*)	1.06
Oct.	0.80	0.79	0.89	0.85	0.60	0.90
Nov.	0.70		0.69		0.40	

FIGURE 5 Relationships between relative yield and relative applied water for 14 deficit irrigation studies on almond with a wide variety of cultivars, locations, soils, rainfall, stress timing patterns, and evaporative demand.



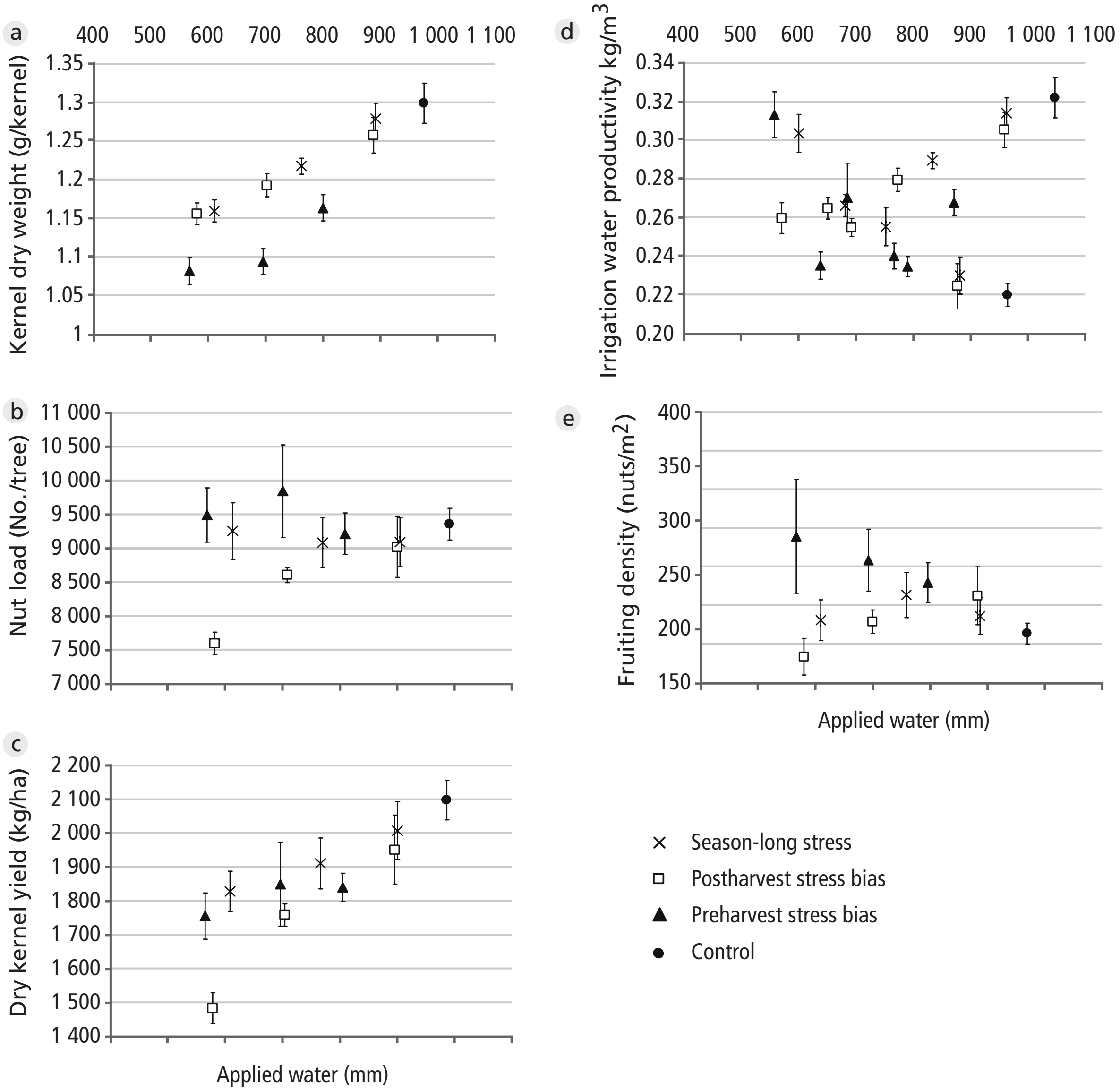
nuts are rapidly expanding and late summer/autumn when bud morphogenesis is occurring. This second stress-sensitive period is usually postharvest for early harvest cultivars but prior to harvest with later maturing cultivars. The results of an experiment (Goldhamer *et al.*, 2006) provide useful information on the relative sensitivity of pre and postharvest stress to aid RDI decision making. It was found that the greater the preharvest water deprivation, the greater was the reduction in kernel dry weight at harvest (Figure 6a). However, minimizing preharvest stress at the expense of postharvest irrigation resulted in significantly lower fruit loads in subsequent seasons (Figure 6b). Yield, the integrator of fruit weight and fruit load, was least affected by minimizing stress after harvest (Figure 6c). These regimes also resulted in the highest irrigation water productivity (Figure 6d).

Water supply constraints may be temporary, as a result of one year drought. Single season drought RDI strategies were tested (Goldhamer and Smith, 1995) where they applied less than 40 percent (400 mm) of potential seasonal ET_c with different timing regimes: irrigating at 100 percent, 75 percent, and 50 percent ET_c until the 400 mm was exhausted, which occurred in early June, mid July, and late August, respectively. They found that full irrigation early in the season limited reductions in fruit size but resulted in dramatic reductions in the following seasons' fruit load (Table 2) (Goldhamer and Smith, 1995). They attributed this to the negative impact of stress on reproductive bud differentiation. The treatment that irrigated at 50 percent ET_c, which applied water longer (through August; two weeks after harvest), did not suffer any significant decrease in fruit load the following season. When they averaged the drought year and the following two fully irrigated recovery years, they found that the 50 percent ET_c treatment had higher yields that the other two RDI regimes; those that applied their available water supply all preharvest. Nevertheless, none of the RDI regimes achieved complete production recovery even after two seasons of full irrigation following the single drought year, suggesting that impacts of reduced shoot and spur growth may have also been a factor (Goldhamer and Smith, 1995).

Suggested RDI regimes for five different levels of available water supply (300, 450, 600, 750, and 900 mm where full ET_c is 1250 mm) expressing irrigation rates as percentages of ET_c are presented in Table 3. To show how these regimes would affect applied water, we used as an example long term values of ET_o from western Fresno County, California and bimonthly crop coefficients (K_c) from Goldhamer (unpublished) for 'Non Pareil' almonds. When the water supply was relatively high, the stress is biased to the preharvest period, saving as much water as possible for the most stress sensitive period; from mid August through the end of September. With a severely restricted water supply, the concern is about tree survival and general health in addition to maximizing stress impacts on time-averaged yields. It must be emphasized that when applying very low amounts of potential seasonal water supply, surface evaporation, and thus, the number of irrigations, should be minimized. Therefore, the duration (amount of applied water) of each irrigation should be maintained as normal but the frequency of irrigation should be changed. For example, if microsprinkler irrigation is normally operated every three days, an RDI strategy that applies 25 percent ET_c would extend the frequency to every 12 days.

Since RDI reduces vegetative growth, it should not be used on young trees where the objective is to grow the canopy to full size, and thus attain maximum yields, as fast as possible. It has been confirmed (Girona *et al.*, 2005) that RDI imposed too early in the life of the orchard can reduce potential yields.

FIGURE 6 Relationships between applied water and a) kernel dry weight, b) fruit load, c) kernel yield, d) irrigation water productivity, and e) fruit density. Vertical lines are plus and minus one standard error. Data are mean values from four experimental years with Non Pareil. Adapted from Goldhamer *et al.* (2006).



Additional considerations

Water stress in almonds has been known to increase spider mite levels (Youngman and Barnes, 1986) and the navel orangeworm (Goldhamer, unpublished data). The latter becomes more of a problem when the onset of hull split is accelerated by preharvest stress and/or the nuts remain longer on the tree before shaking. Hull rot can be dramatically reduced by imposing water deficits during the first two weeks of July (Teviotdale *et al.*, 2001). Their target predawn leaf water potential value was -1.6 MPa.

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TABLE 2 Irrigation management, yield, and nut quality data for a single year drought irrigation study conducted in western Fresno County, California.

Year	Treatment	Water applied through	Water allotment applied ** (mm)	Total kernel yield (lbs/acre)	Individual kernel weight (grams)	Tree nut load (No./tree)	Hull splitting		
							Full hull split	Partial hull split	Hull tight
							(- - - - - % of tree nut load - - - - -)		
Drought	Full irrigation control	Full season	1 024	1 653 a***	1.24 a	7 100 a	98.9 a	0.4 a	0.7 a
Year	100%DY ET_c*	June 19	409	1 362 b	0.97 b	8 160 a	38.2 b	48.1 b	13.7 b
	75%DY ET_c	July 11	411	1 236 b	1.10 bc	6 340 a	85.3 a	11.4 a	3.3 a
	50%DY ET_c	August 28	414	1 448 ab	1.03 bc	7 000 a	99.0 a	0.6 a	0.4 a
Recovery	Full irrigation control	Full season	843	2 730 a	1.04 a	1 2850 a	99.7 a	0.0 a	0.3 a
Year 1	100%DY ET_c*	Full season	836	911 b	1.03 a	4 770 b	99.7 a	0.1 a	0.2 a
	75%DY ET_c	Full season	836	1 493 c	0.99 ab	8250 c	99.9 a	0.0 a	0.1 a
	50%DY ET_c	Full season	846	2 010 d	0.89 b	1 1690 a d	99.6 a	0.0 a	0.4 a
Recovery	Full irrigation control	Full season	838	2 358 a	0.97 a	9 890 a	98.3 a	1.3 a	0.4 a

TABLE 2 (CONTINUED)

Year	Treatment	Water applied through	Water allotment applied ** (mm)	Total kernel yield (lbs/acre)	Individual kernel weight (grams)	Tree nut load (No./tree)	Hull splitting		
							Full hull split	Partial hull split	Hull tight
							(- - - - - % of tree nut load - - - - -)		
Year 2	100%DY ET$_c$*	Full season	838	2 327 a	1.02 a	9 200 a	98.8 a	0.7 a	0.5 ab
	75%DY ET$_c$	Full season	838	1 975 b	1.02 a	7 900 b	97.9 a	1.2 a	0.9 b
	50%DY ET$_c$	Full season	838	1 949 b	1.13 b	7 050 b	98.5 a	1.0 a	0.5 ab
Year 3	Full irrigation control		902	2 247 a	1.08 a	9 948 a	99.0 a	0.5 a	0.5 a
Mean	100%DY ET$_c$*		693	1 534 b	1.01 a	7 378 b	78.9 b	16.3 b	4.8 b
	75%DY ET$_c$		696	1 568 b	1.04 a	7 498 b	94.4 a	4.2 a	1.5 a
	50%DY ET$_c$		**699**	**1 802 c**	**1.02 a**	**8 581 b**	**99.0 a**	**0.5 a**	**0.5 a**

* Irrigation rate until allotment applied; no additional irrigation for the remainder of the season.

** Does not include 100 mm pre-season irrigation applied each year.

*** Numbers for each year followed by a different letter are significantly different at the 5% confidence level using Duncan's New Multiple Range Test.

TABLE 3 Suggested RDI strategies for different available water supply scenarios from 900 to 300 mm when potential ETc is 1250 mm.

	Potential	900 mm available case		750 mm available case		600 mm available case		450 mm available case		300 mm available case	
	ET$_c$ in	Irrigation	Applied	Irrigation	Applied	Irrigation	Applied	Irrigation	Applied	Irrigation	Applied
Date	Period	Rate	Amount	Rate	Amount	Rate	Amount	Rate	Amount	Rate	Amount
	(mm)	(% ET$_c$)	(mm)	(% ET$_c$)	(mm)	(% ET$_c$)	(mm)	(% ET$_c$)	(mm)	(% ET$_c$)	(mm)
Mar. 16-31	12	75	9	70	9	60	7	40	5	25	3
April 1-15	35	75	27	70	25	60	21	40	14	25	9
April 16-30	57	75	43	70	40	60	34	40	23	25	14
May 1-15	82	75	61	50	41	30	25	25	20	25	20
May 16-31	106	75	80	50	53	30	32	25	27	25	27
June 1-15	114	75	86	50	57	30	34	25	29	25	29
June 16-30	120	75	90	50	60	30	36	25	30	25	30
July 1-15	121	50	60	25	30	25	30	25	30	20	24
July 16-31	125	100	125	100	125	90	112	75	93	25	31

TABLE 3 (CONTINUED)

	Potential	900 mm Available Case		750 mm Available Case		600 mm Available Case		450 mm Available Case		300 mm Available Case	
	ET_c in	Irri.	Applied	Irri.	Applied	Irri.	Applied	Irri.	Applied	Irri.	Applied
Date	Period	Rate	Amount	Rate	Amount	Rate	Amount	Rate	Amount	Rate	Amount
	(mm)	(% ET_c)	(mm)	(% ET_c)	(mm)	(% ET_c)	(mm)	(% ET_c)	(mm)	(% ET_c)	(mm)
Aug. 1-15	111	100	111	100	111	90	100	60	67	25	28
Aug. 16-31	109	75	82	60	65	50	54	60	65	50	54
Sept. 1-15	90	75	67	60	54	50	45	25	22	25	22
Sept. 16-30	72	75	54	60	43	50	36	25	18	25	18
Oct. 1-15	55	25	14	60	33	50	27	25	14	0	0
Oct. 16-31	32	0	0	0	0	0	0	0	0	0	0
Total	**1242**		**909**		**746**		**595**		**458**		**298**
Irrigations	33*		24		20		16		12		8

* The grower would keep track of cumulative amounts to be applied with RDI scenarios. When they total 37 mm (the amount applied by the microsprinklers in 24 hrs in this example), he irrigates. Thus, there would be one irrigation in the first week of April with full water supply but with 300 mm available case, first irrigation would not be until the first week of May.