INTERACTIVE EFFECTS OF LATE PLANTING DATES AND TYPES OF SOIL MULCHING ON PRODUCTIVITY AND QUALITY OF LETTUCE HEAD (*Lactuca sativa* L.) CULTIVARS

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Committee Decision

This Thesis [Interactive effects of late planting dates and types of soil mulching on productivity and quality of lettuce head (*Lactuca sativa* L.) cultivars] was successfully defended and approved on May 11, 2005.

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DEDICATION

"Little drops of water … little grains of sand
Make the mighty ocean and the pleasant land"

To my dear dad,
the moral centre of our family, who continuously lifts my heart because of his great intellectual and emotional knowledge and inexhaustible hope and spiritual wholeness.

To my dear mom,
the source of endless and infinite love and sacrifice.

To my dear sister lina

To my brother Yazan

and whomever…

Encourage me…

Care about me…

Help me, and …

Lighten the way…

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LIST OF ABBREVIATIONS

Aug.	:	August
cm.	:	centimetre
ºC	:	Degree Celsius
ºF	:	Degree Fahrenheit
hr.	:	hour
Jul.	:	July
Jun.	:	June
mm.	:	millimetre
n.d.	:	No date

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INTERACTIVE EFFECTS OF LATE PLANTING DATES AND TYPES OF SOIL MULCHING ON PRODUCTIVITY AND QUALITY OF LETTUCE HEAD (*Lactuca sativa* L.) CULTIVARS

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ABSTRACT

A field study was conducted at Al-Yadoudeh, to evaluate the effect of planting date (Jun. 15, Jul. 15 and Aug. 15), lettuce type (Iceberg and Romaine), lettuce cultivar (summer and winter: "Robinson" and "Jordan" for Iceberg type and "Nader" and "Wild Romaine" for Romaine type) and type of mulch (black mulch, clear mulch and control) on the yield and quality of lettuce crop during summer of 2003.

Planting Aug. 15 reduced bolting % to variable extents according to type of mulch. For any cultivar on Aug. 15, planting over the different types of mulch, tended to give lower head fresh weight, stem weight, stem weight: fresh weight ratio, leaf surface area and leaf number when compared with those of both Jun. 15 and Jul. 15 planting dates; in contrast, leaf weight: fresh weight ratio was higher on Aug. 15.

Planting "Robinson" (summer Iceberg), "Jordan" (winter Iceberg) and "Nader" (summer Romaine) on Aug. 15 gave lower leaf weight than Jun. 15 and Jul. 15, while "Wild Romaine" (winter Romaine), planted on Aug. 15 gave higher values of leaf weight than the other planting dates.

In general Romaine lettuce type was more susceptible to bolting than the Iceberg type. Planting Romaine lettuce also resulted in higher values of fresh head weight, stem weight, stem weight: fresh weight ratio, leaf surface area and leaf number when compared with the Iceberg type. No significant differences were detected in leaf number of Iceberg type, for all mulch treatments and all planting dates. For all planting dates, Iceberg type gave significantly higher leaf weight: fresh weight ratio and leaf weight: stem weight ratio than Romaine type.

For all planting dates, "Wild Romaine" (winter Romaine) with any of the plastic mulches used gave the highest bolting %, stem weight and leaf number, when compared with the other cultivars.

In general, within the Iceberg type, "Jordan" (winter Iceberg) gave higher head fresh weight, stem weight: fresh weight ratio, leaf surface area and leaf number than "Robinson" (summer Iceberg), while "Wild Romaine" (winter Romaine) was higher in head fresh weight, stem weight: fresh weight ratio, leaf surface area and leaf number when compared with "Nader" (summer Romaine).

Within the Romaine type, and at any planting date, "Nader" (summer Romaine) resulted in higher leaf weight: fresh weight ratio and leaf weight: stem weight ratio than "Wild Romaine" (winter Romaine). Within the Iceberg type, "Robinson" (summer Iceberg) tended to give higher leaf weight: fresh weight ratio and leaf weight: stem weight ratio than "Jordan" (winter Iceberg).

Planting any cultivar on Jun. 15 and Jul. 15, in absence of mulch resulted in higher bolting % and lower head fresh weight, leaf weight, stem weight, stem weight: fresh weight ratio and leaf number. For all mulches, no significant differences were detected on Aug. 15.

It is therefore recommended to plant summer cultivars over black mulch on Aug. 15 under conditions similar to those of this experiment.

INTRODUCTION

Lettuce (*Lactuca sativa* L.), an annual crop of the family Compositae (Dehpande and Salunkhe, 1998), is one of the most widely used vegetables (Armstrong, 2002).

In Jordan, lettuce is considered one of the most important vegetable crops grown in winter. In the years 2001, 2002, and 2003 lettuce occupied 592, 700, and 960 ha of cultivated area and gave 10920, 13500, and 32700 tons, respectively (FAO., 2001, 2001 & 2003); also, a formidable portion of the local lettuce production is exported to neighbouring Arab countries thus providing a profitable market for Jordanian producers and exporters.

When cultivating lettuce, many factors are taken into consideration to provide an optimal environment for crop growth. These include the following:

- Temperature: Lettuce is a cool season crop requiring a mean air temperature of 10-20 ºC (Thompson and Kelly, 1957, Yamaguchi, 1983 and Dehpande and Salunkhe, 1998). It thrives in areas having cool summers and mild winters (Thompson and Kelly, 1957 and Dehpande and Salunkhe, 1998), since cool nights are essential for good quality lettuce (Yamaguchi, 1983 and Dehpande and Salunkhe, 1998).
- Soil: A well-drained fertile soil with a pH of 6.0 is critical for lettuce cultivation (Yamaguchi, 1983 and Dehpande and Salunkhe, 1998). In practice, however, it is preferable to adjust the pH to 6.5 (Thompson and Kelly, 1957). Lettuce is fairly salt tolerant (Yamaguchi, 1983 and Dehpande and Salunkhe, 1998).
- Irrigation: Optimally, a constant and relatively abundant supply of moisture throughout the growing period is required (University of Hawaii, n.d). It is particularly important to avoid any level of water stress during the critical period

of plant growth; i.e. at seedling establishment and during the last two weeks before harvest (Bianco, 1990), as lettuce growth can be severely impaired; too much water during this period along with high temperatures may result in loose, puffy heads in heading types of lettuce, while too dry conditions may induce premature bolting (University of Hawaii, n.d). Consequently, it is suggested to irrigate when 30% of the soil moisture had been lost from open fields. For plastic house crops, irrigation can be pursued when 20% of the soil moisture is lost (Bianco, 1990).

- Fertilization: Fertilization would depend upon the nutrient availability and the status of soil fertility with respect to essential nutrients (Dehpande and Salunkhe, 1998). Lettuce plant is a poor forager with a shallow root system (Thompson and Kelly, 1957).

There are two principal types of lettuce cultivated in Jordan, Iceberg and Romaine. Crisphead lettuce is also known as Iceberg (Relf, and McDaniel, 2000), which is a class of head lettuce (Dehpande and Salunkhe, 1998). Crisphead lettuce is the most widely available as a fresh market type (Relf, and McDaniel, 2000) because of its ease in transport and storage (Armstrong, 2002). Head lettuce forms a dense (Armstrong, 2002), tightly compact head with crisp, light green leaves (Relf, and McDaniel, 2000) making it attractive to consumers. Romaine lettuce (Cos lettuce) is a very nutritious type that deserves attention. It is relatively easy to grow (Relf, and McDaniel, 2000), forming upright cylindrical heads (Armstrong, 2002) with long (Armstrong, 2002) rather wavy attractive (Relf, and McDaniel, 2000) leaves.

However, some of the most advertised varieties of Crisphead lettuce, are not heat resistant and tend to go to seed as soon as temperature increases (Relf and McDaniel,

2000) reducing their marketability; transplanting in early spring or in fall is useful to take advantage of the cool weather.

Nevertheless, the demand on this crop is almost throughout the year. This creates a challenge for the Jordanian farmers to produce good quality (non-bolted) lettuce, for both local and export markets, during the hot period of the year where the environmental conditions (long photoperiod and high temperature) are not suitable for both growth and heading of traditional lettuce cultivars.

Bolting in leaf lettuce is often a hazard in commercial production since flowering is markedly influenced by photoperiod and temperature (Rappaport and Wittwer, 1956).

Several lettuce cultivars were reported to grow successfully in summer and spring seasons including the late bolting “Elisa” and “Vitória” (Silva *et al.*, 1999), “Deep Red” and “Prizehead” (Kahn and Magnello, 1986), "Nader" and "Robinson" (Ministry of Agriculture).

OBJECTIVE

This experiment was conducted to evaluate the productivity and the quality of two lettuce types (Iceberg and Romaine) using, heat and non-heat tolerant cultivars at three planting dates and three types of mulch under a shade net house.

LITERATURE REVIEW

Cultivars:

According to Silva *et al.* (1999) resistance to early flowering is an important attribute of lettuce cultivars adapted to tropical conditions. "Valtemp" and "Frirton" were reported as bolt tolerant cultivars (Waycott, 1995). Lettuce cultivars, however, may vary widely in the number of days needed from sowing to inflorescence formation and flowering (Silva *et al.*, 1999).

Temperature:

Optimal growing temperatures are 23 °C during the day and 7 °C at night for Iceberg (Jackson *et al.*, 1996, a) and Romaine lettuce (Jackson *et al.*, 1996, b). According to Glenn (1984) high temperatures were associated with bolting. If the crop is exposed to high temperatures late in the growing season, lettuce may bolt causing bitterness and loose fluffy heads and tipburn is also common (Jackson *et al.*, 1996, a & b). Planting Iceberg out of slot will result in non-heading, puffiness, or bolting (Jackson *et al.*, 1996, a). In general, head weight of crisp lettuce variety Saladin, increased with later transplanting to a maximum for crops transplanted on May 29 (6.2-15.4 ºC) or June 12 (7.3-17 ºC) (Wurr *et al.*, 1987); the heaviest heads were produced from plants raised at ambient temperatures and the lightest heads were from those plants raised at 20:10 ºC. Under a floating hydroponic system, maximum dry mass was produced at 24/ 24 ºC air/ root temperature (Thompson and Langhans, 1998). Exposure of the Iceberg lettuce to low temperatures in the period up to and around hearting are associated with denser head (Wurr *et al.* 1992); smaller heads were primarily associated with high

temperatures before hearting. Optimum mean temperature for head weight in iceberg lettuce was identified as 12 °C (Wurr *et al*. 1996).

Photoperiod:

According to Rappaport and Wittwer, (1956), flower induction in “Bibb” is governed by photoperiod. Vavrina (2002) showed that during springtime, long day light conditions contribute to bolting and timely establishment of transplants can reduce the incidence of this production problem in lettuce. Waycott (1995) found that “Valtemp" and "Frirton” lettuce cultivars required nearly 6 months to begin bolting when grown in the shortest day treatment (8 hr).

Temperature and Photoperiod:

According to Thompson and knott (1934) under continuously high temperature flower stalk began to appear in the plants and flower-stalk elongated under long photoperiod more rapidly. Elongation of stems was promoted and the formation of compact heads was absent in plants whose roots were exposed to high diurnal ambient temperature (He *et al.*, 1998).

Although lettuce is a temperate plant, certain cultivars can be grown normally in the tropics under high light intensity and at hot ambient temperatures, provided that rootzone temperature is maintained below 25 ºC (He *et al.*, 1998); both high solar radiation and lower rootzone temperature are important for the formation of a compact lettuce head, higher shoot and root biomass and higher photosynthetic capacity.

Waycott (1995), had also confirmed that high temperatures with photoperiods of less than 12 hr proved inadequate to induce bolting during the seedling and rosette stages of growth.

Less dense heads of the Iceberg lettuce were primarily associated with higher temperature in the period up to hearting and high level of solar radiation in periods well after hearting (Wurr *et al.*, 1992); larger heads were associated with low temperatures up and around hearting, with very high temperatures in the immediate post-hearting period and with large amplitudes of temperature change and high levels of solar radiation around hearting.

Thompson and knott, (1934) concluded that 60 °F to 70 °F were the most satisfactory temperatures for head formation, both under short and long-day conditions, while the 70 °F to 80 °F temperature under green house conditions prohibited head formation, even with short-day light period.

MATERIALS AND METHODS

This study was conducted during the summer season of 2003 under a shade-net house (60% light transmittance) in a private farm at Al-Yadoodeh, 25 km south east Amman. To investigate the effect of three planting dates (Jun. 15, Jul. 15, and Aug. 15), two lettuce types (Iceberg and Romaine), four lettuce cultivars (two summer and two winter) and three types of mulch [black, clear and a control (without mulch)] on productivity and quality of head lettuce, a split- split- split plot design with four replicates (Fig 1) was used. Planting date, lettuce type, lettuce cultivar and mulch type were assigned to main plots, sub-plots, sub-sub-plots and sub- sub- sub plots, respectively.

The soil under the shade-net house was flooded with water, allowed to dry to the field capacity then plowed and rotivated. Thereafter, ten composite soil samples were taken from the experimental area at 20 cm. depth. Samples were air dried, crushed to pass through a 2 mm. sieve. The soil was then analysed for Total nitrogen by the Kjeldahl method (Bremner, 1965), NO^{-3} and NH^{+4} by the distillation method (Keeney and Nelson, 1982), available P using a Spectrophotometer (Chapman and Pratt, 1961) and available K by the flame photometer method (Chapman and Pratt, 1961).

Rotivated soil was levelled and subdivided into raised beds 2.5 m. long and 1 m. wide. One GR drip line (inside diameter: 12.5 mm. and outside diameter: 16 mm) was used per bed, with emitters 35 cm. Apart. The discharge rate was 4 liter/ hr per emitter at one bar pressure. One week before planting, 25 Kg/ha of Ammonium Sulphate were applied. Mulch was applied as per the design and one month old seedlings (20 per treatment) were transplanted from speedling trays in two parallel rows 70 cm. apart; spacing within the row was 25 cm.

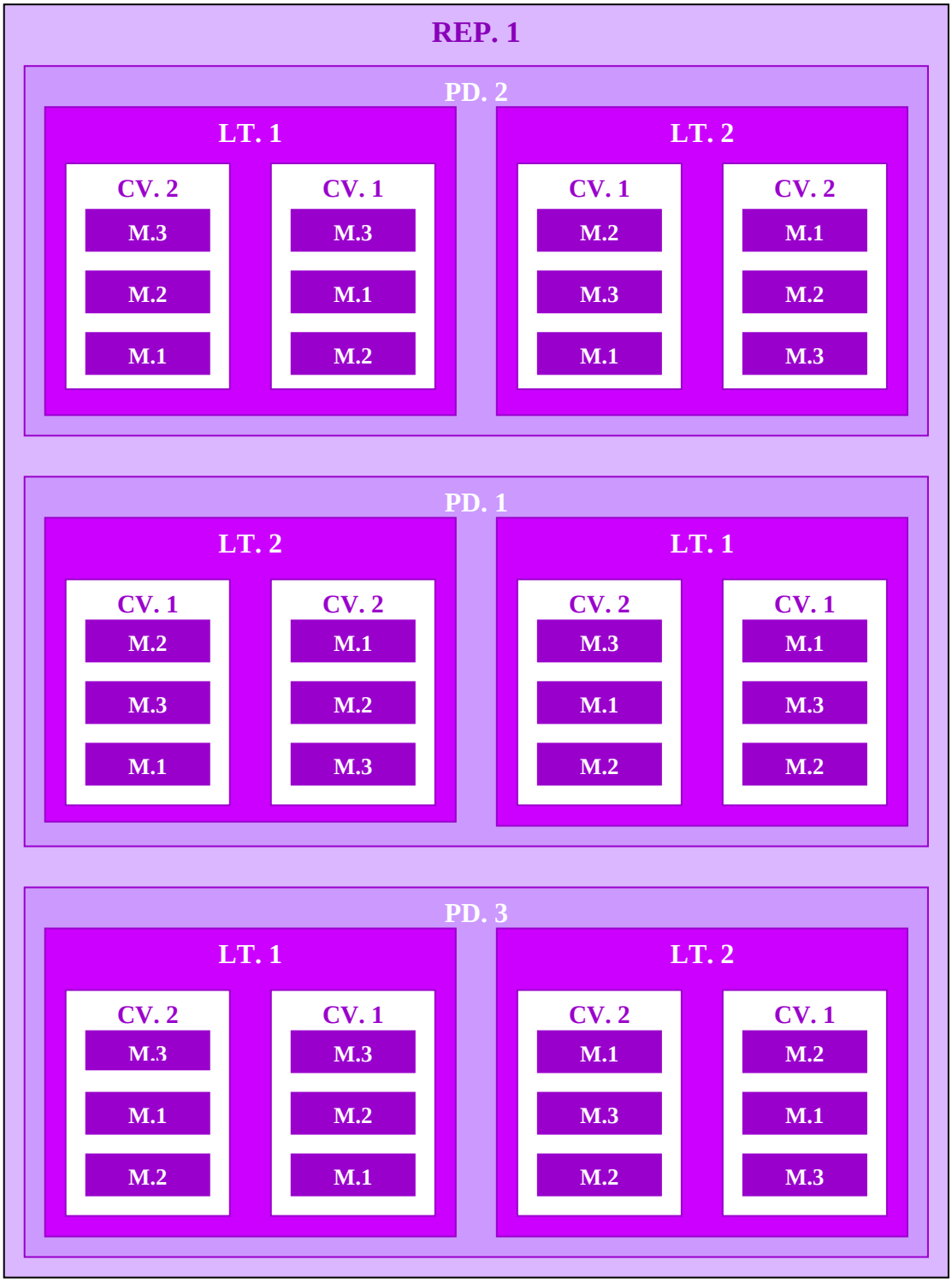

Fig. (1): The experiment layout.

- Rep.: Replicate
- PD.: Planting Date, PD.1: June 15, PD.2: July 15 and PD.3: Aug 15.
- LT.: lettuce type, LT.1: Iceberg type and LT.2: Romaine type.
- CV.: Cultivar, CV.1: summer cultivar and CV.2: winter cultivar.
- M.: Mulch type, M.1: Black mulch, M.2: Clear mulch and M.3: Control.

During the period from transplanting to two weeks before harvesting, 25 Kg of Ammonium Sulphate /ha were distributed with the irrigation water throughout the period according to its duration (4 times for Jun. 15, 3 times for Jul. 15 and 7 times for Aug. 15 planting dates). During the last two weeks before harvesting 50 Kg of Ammonium Sulphate /ha were distributed in 3 equal increments at 5 days interval. Weeds were not controlled in the plots of bare soil and the clear mulch.

The number of bolted lettuce heads for each treatment (20 plants) was counted and the bolting percentage was calculated.

Harvesting commenced at 32, 30 and 48 days, from the transplanting date for the respective planting dates (Jun. 15, Jul. 15, and Aug. 15). Afterwards, three fresh samples (plants) from each treatment were collected randomly and the roots and the outer three leaves were separated and discarded. Head fresh weight, leaf weight, stem weight and leaf number were determined. Leaf weight: total weight, stem weight: total weight and leaf weight: stem weight ratios were also calculated. Leaf area (cm^2/ head) was measured using a portable area meter (LI-3000A).

As the distribution of data on bolting was binomial rather than normal, the data on bolting % was transformed into angular or arcsine form. Then all data was analysed as for the split - split - split plot design and means were separated according to LSD at .05 level (Statistical Analysis System, 1998).

RESULTS

Bolting Percentage:

"Wild Romaine" (winter Romaine) with any of the plastic mulches used gave 100% bolting, when planted Jun. 15 or Jul. 15 (Table 1); in contrast, planting Aug. 15 reduced bolting, which varied according to the type of mulch used (9% for black mulch to 27% for the control). "Robinson" (summer Iceberg) showed no bolting, except for the control on Jun. 15, where bolting was almost negligible (2.56%).

On Aug. 15, over the different types of mulch, low and insignificant differences in bolting % were observed (0-1.67%) when "Jordan" (winter Iceberg) was used, while planting "Jordan" (winter Iceberg) on Jun.15 and Jul.15, over black mulch gave the lowest bolting % when compared to both clear mulch and the control (Table 1). In addition, Jul. 15 planting of "Jordan" (winter Iceberg) resulted in lower bolting % than Jun. 15 when both black and clear plastic mulches were used.

When "Nader" (summer Romaine) was used the control gave significantly higher bolting % than the black and clear mulches for all the planting dates (Table 1). Moreover planting "Nader" (summer Romaine) on Aug. 15 resulted in lower bolting % than the other two planting dates where bolting % was higher but similar.

In general Romaine lettuce type was more susceptible to bolting than the Iceberg type (Table 1).

Table (1): Interactive effect of "planting date x lettuce type x lettuce cultivar x mulch type" on bolting percentage.

Variables / Treatments				Bolting %	
Planting date	**Lettuce type**	**Cultivar**	**Mulch type**		
Jun 15	Iceberg	Summer (Robinson)	Black mulch	0.00	k(*)
			Clear mulch	0.00	k
			Control	2.56	jk
		Winter (Jordan)	Black mulch	3.70	jk
			Clear mulch	13.47	e-h
			Control	11.13	f-i
	Romaine	Summer (Nader)	Black mulch	18.14	d-g
			Clear mulch	24.78	de
			Control	60.47	c
		Winter (Wild Romaine)	Black mulch	100.0	a
			Clear mulch	100.0	a
			Control	100.0	a
Jul 15	Iceberg	Summer (Robinson)	Black mulch	0.00	k
			Clear mulch	0.00	k
			Control	0.00	k
		Winter (Jordan)	Black mulch	0.00	k
			Clear mulch	5.19	ij
			Control	13.47	efg
	Romaine	Summer (Nader)	Black mulch	19.82	d-g
			Clear mulch	20.81	def
			Control	76.06	b
		Winter (Wild Romaine)	Black mulch	100.0	a
			Clear mulch	100.0	a
			Control	100.0	a
Aug 15	Iceberg	Summer (Robinson)	Black mulch	0.00	k
			Clear mulch	0.00	k
			Control	0.00	k
		Winter (Jordan)	Black mulch	0.00	k
			Clear mulch	0.00	k
			Control	1.67	jk
	Romaine	Summer (Nader)	Black mulch	0.00	k
			Clear mulch	1.67	jk
			Control	6.06	hij
		Winter (Wild Romaine)	Black mulch	8.97	ghi
			Clear mulch	12.02	f-i
			Control	27.10	d

(*) Values having different letters are significantly different according to LSD Test at the 5% level.

Vegetative Growth:

Fresh weight:

Significantly highest head fresh weight was given by "Nader" (summer Romaine) on Jun. 15 when planted over the black mulch, but head fresh weights were not significantly different from those of "Nader" (summer Romaine) on Jun. 15 over clear mulch, "Wild Romaine" (winter Romaine) over black mulch on Jun. 15 and Jul. 15, "Wild Romaine" (winter Romaine) on Jul. 15, over clear mulch and "Jordan" (winter Iceberg) on Jul. 15 over black and clear mulches (Table 2). Further reduction in head fresh weight was detected when "Nader" (summer Romaine) was planted Jul. 15 over the black mulch, and "Wild Romaine" (winter Romaine) on Jul. 15, without mulch.

Planting "Robinson" (summer Iceberg) on Aug. 15 in absence of mulch gave the lowest value of head fresh weight (Table 2), but weights were not significantly different from those of "Nader" (summer Romaine) on Aug. 15 and Jul. 15 in absence of mulch, "Jordan" (winter Iceberg) on Aug. 15 over clear mulch and "Robinson" (summer Iceberg) on Jun. 15 in absence of mulch. Otherwise, values of head fresh weight varied to different extents among treatments.

For any cultivar on Aug.15, planting over the different types of mulch tended to give lower head fresh weight when compared with Jun. 15 and Jul. 15 planting dates (Table 2), except for "Jordan" (winter Iceberg) over black mulch on Aug.15, "Wild Romaine" (winter Romaine) without mulch on Aug. 15 and "Robinson" (summer Iceberg) on Aug. 15 over clear mulch.

For all planting dates, "Robinson" (summer Iceberg) in absence of mulch, gave generally the lowest head fresh weight when compared to both black and clear mulches (Table 2), but when clear mulch was used highest head fresh weights were obtained except for Jun. 15.

Table (2): Interactive effect of "planting date x lettuce type x lettuce cultivar x mulch type" on fresh weight, leaf weight and stem weight of lettuce head at harvest.

Treatments / Variables				Fresh weight (g/head)	Leaf weight (g/ head)	Stem weight (g/ head)
Planting date	**Lettuce type**	**Cultivar**	**Mulch type**			
Jun 15	Iceberg	Summer (Robinson)	Black mulch	591.67 d-h(*)	527.63 a-d	64.03 k-n
			Clear mulch	475.83 j-o	423.83 f-m	52.00 l-p
			Control	431.67 l-p	395.86 k-p	35.81 op
		Winter (Jordan)	Black mulch	544.17 e-j	478.63 d-i	65.54 k-n
			Clear mulch	484.17 j-o	417.03 g-n	67.14 klm
			Control	587.20 d-h	518.01 a-e	69.19 j-m
	Romaine	Summer (Nader)	Black mulch	737.08 a	565.33 ab	171.75 ef
			Clear mulch	715.00 ab	556.92 abc	158.08 f
			Control	598.33 d-g	488.25 c-g	110.08 gh
		Winter (Wild Romaine)	Black mulch	716.25 ab	386.21 k-p	329.38 a
			Clear mulch	584.83 d-i	391.00 k-p	199.83 d
			Control	468.92 j-o	269.08 q	193.83 de
Jul 15	Iceberg	Summer (Robinson)	Black mulch	524.17 g-l	472.19 d-j	51.98 l-p
			Clear mulch	591.67 d-h	524.92 a-d	66.75 klm
			Control	499.46 h-n	445.99 e-l	53.47 l-p
		Winter (Jordan)	Black mulch	666.37 a-d	588.91 a	77.46 i-l
			Clear mulch	655.00 a-d	569.75 ab	85.25 h-k
			Control	514.17 g-m	458.40 d-k	55.77 l-p
	Romaine	Summer (Nader)	Black mulch	636.67 b-e	518.86 a-e	117.81 g
			Clear mulch	599.17 d-g	481.45 d-h	117.72 g
			Control	410.00 nop	331.14 pq	78.86 i-l
		Winter (Wild Romaine)	Black mulch	713.33 ab	412.08 h-o	301.26 b
			Clear mulch	698.08 abc	399.44 j-p	298.64 b
			Control	617.50 c-f	378.47 l-p	239.03 c
Aug 15	Iceberg	Summer (Robinson)	Black mulch	439.58 k-p	400.89 j-p	38.70 nop
			Clear mulch	529.58 f-k	477.80 d-i	51.79 l-p
			Control	368.33 p	340.28 opq	28.06 p
		Winter (Jordan)	Black mulch	546.67 e-j	495.04 b-f	51.63 l-p
			Clear mulch	425.00 m-p	381.46 l-p	43.55 m-p
			Control	493.75 I-o	446.23 e-l	47.54 m-p
	Romaine	Summer (Nader)	Black mulch	467.50 j-o	399.34 j-p	68.16 klm
			Clear mulch	475.00 j-o	404.88 I-p	70.12 j-m
			Control	403.33 op	342.51 n-q	60.83 k-o
		Winter (Wild Romaine)	Black mulch	472.25 j-o	368.92 m-p	103.33 ghi
			Clear mulch	517.50 g-m	410.08 h-o	107.42 gh
			Control	517.33 g-m	420.75 f-m	96.58 g-j

(*) Values within each column having different letters are significantly different according to LSD Test at the 5% level.

Using "Jordan" (winter Iceberg) over the black mulch resulted in higher head fresh weight than the clear mulch and the control (Table 2) except when planting in Jun. 15, where the control tended to give the highest weight.

Over the different types of mulch, low and insignificant differences in head fresh weight of "Nader" (summer Romaine) were observed on Aug. 15 (Table 2). However, planting "Nader" (summer Romaine) on Jun. 15 and Jul. 15, in absence of mulch resulted in lower head fresh weight than both the black and clear mulches, which were similar and higher.

Higher head fresh weight was observed when "Wild Romaine" (winter Romaine) was used over the black mulch compared with the clear mulch and the control for Jun. 15 and Jul. 15 planting dates; for all mulches, however, no significant differences were detected on Aug. 15 planting dates (Table 2).

In general, within Iceberg type, "Jordan" (winter Iceberg) gave higher head fresh weight than "Robinson" (summer Iceberg) (Table 2), while "Wild Romaine" (winter Romaine) recorded higher head fresh weight when compared with "Nader" (summer Romaine) of the Romaine type. Moreover, Romaine type gave higher fresh head weight than the Iceberg type.

Leaf weight:

Planting "Jordan" (winter Iceberg) on Jul. 15 over black mulch gave significantly the highest value of leaf weight, but leaf weights were not significantly different from those of "Jordan" (winter Iceberg) on Jul. 15 over clear mulch, "Nader" (summer Romaine) on Jun. 15 over black and clear mulch, "Robinson" (summer Iceberg) on Jun. 15 over black mulch, "Robinson" (summer Iceberg) on Jul. 15 over clear mulch, "Nader" (summer Romaine) on Jul. 15 over black mulch, "Jordan" (winter Iceberg) on

Jun. 15 in absence of mulch (Table 2). Further significant reduction in leaf weight was detected when "Jordan" (winter Iceberg) was planted Aug. 15 over the black mulch, and "Nader" (summer Romaine) on Jun. 15 without mulch.

Lowest leaf weight was recorded, when "Wild Romaine" (winter Romaine) was planted on Jun. 15 in absence of mulch (Table 2), these weights were not significantly different from those of "Nader" (summer Romaine) on Jul. 15 without mulch, "Robinson" (summer Iceberg) on Aug. 15 in absence of mulch and "Nader" (summer Romaine) on Aug. 15 without mulch. Otherwise, values of leaf weight varied to different extents among treatments.

Planting "Robinson" (summer Iceberg), "Jordan" (winter Iceberg) and "Nader" (summer Romaine) on Aug. 15 gave lower leaf weight than Jun. 15 and Jul. 15 (Table 2) except for "Jordan" (winter Iceberg) over black mulch and "Robinson" (summer Iceberg) over clear mulch where leaf weights were higher than Jun. 15.

Leaf weight of "Robinson" (summer Iceberg) in absence of mulch was lower than the black and clear mulches (Table 2); the clear mulch tended to give higher leaf weight except for Jun. 15 where significantly highest leaf weight was observed for "Robinson" over black mulch.

"Jordan" (winter Iceberg) when planted on Jun. 15 over black and clear mulches, gave significantly lower leaf weight than when planted Jul. 15 (Table 2); however, in absence of mulch, leaf weight was higher for Jun. 15 than Jul. 15. Moreover, planting Jordan on any planting date over the black mulch tended to give higher leaf weight than the clear mulch.

In general, planting "Nader" (summer Romaine) on Jun. 15 gave higher leaf weight than Jul. 15 (Table 2). Lower leaf weight was also observed when "Nader" (summer Romaine) was planted, on Jun. 15 and Jul. 15 in absence of mulch when

compared with the black and clear mulches, which were similar but higher. For all mulches, however, no significant differences were detected on Aug. 15.

"Wild Romaine" (winter Romaine), planted on Aug. 15 with and without mulches, gave higher values of leaf weight than the other planting dates (Table 2), except for the black mulch on Aug. 15 where leaf weight was lower. For all the mulch treatments, low and insignificant differences in leaf weight of "Wild Romaine" (winter Romaine) were observed on Jul. 15 and Aug. 15. However, planting "Wild Romaine" (winter Romaine) on Jun. 15 in absence of mulch, resulted in lower leaf weight than both the black and clear mulches which were similar and higher.

Stem weight:

Planting "Wild Romaine" (winter Romaine) on Jun. 15 over black mulch, gave significantly the highest value of stem weight (Table 2). Further significant reductions in stem weight were detected when "Wild Romaine" (winter Romaine) was planted Jul. 15 over black and clear mulches. Moreover, planting "Wild Romaine" (winter Romaine) on Jul. 15 without mulch gave stem weights significantly lower than those of the black and clear mulches.

On Jun. 15, when "Wild Romaine" (winter Romaine) was planted in absence of mulch and over clear mulch, low and insignificant differences in stem weights were observed (Table 2). Furthermore, planting "Wild Romaine" (winter Romaine) on Jun. 15 over clear mulch and the control resulted in lower stem weights when compared with the same treatments planted on Jul. 15.

Planting "Nader" (summer Romaine) over black and clear mulch on Jun. 15 gave lower stem weights than "Wild Romaine" (winter Romaine) when planted on Jun. 15 or Jul. 15 over any type of mulch (Table 2). In addition planting "Nader" (summer

Romaine) on these planting dates in absence of mulch caused further reduction in stem weight when compared with planting over both black and clear mulches. In general planting "Nader" (summer Romaine) over any type of mulch on Jul. 15 showed lower stem weights than Jun. 15 planting date.

"Wild Romaine" (winter Romaine) on Aug.15 planted over the different types of mulch, gave lower stem weights than "Nader" (summer Romaine) when planted on Jun. 15 and Jul. 15 (Table 2), but it was higher than "Nader" (summer Romaine) when both cultivars were planted on any planting date.

Lowest stem weight was observed when "Robinson" (summer Iceberg) was planted without mulch, on Aug. 15 (Table 2). Planting the same cultivar on Jun. 15 in absence of mulch tended to give higher values of stem weight than those planted on Aug. 15. Otherwise, values of stem weight varied to different extents among treatments.

Highest stem weight was observed in "Wild Romaine" (winter Romaine) for all planting dates over all mulches used (Table 2); the control, however, gave the lowest stem weight. When "Wild Romaine" (winter Romaine) was planted over black mulch on either Jun. 15 or Jul. 15 highest stem weights were obtained; in contrast black and clear mulches and the control gave similar stem weights when used on Aug.15. Furthermore, no significant differences were detected in stem weight of "Robinson" (summer Iceberg) for all mulch treatments and planting dates.

On Aug.15, lower stem weight values were observed when "Jordan" (winter Iceberg) was planted over any type of mulch compared with planting on Jun. 15 and Jul. 15 (Table 2); negligible differences, however, were shown in stem weights among the different types of mulch for Jun. 15 and Aug. 15 planting dates.

While planting "Nader" (summer Romaine) on Jun.15 gave the highest stem weight, the lowest values were observed on Aug.15 (Table 2); the control, however,

gave the lowest stem weight. Negligible differences, however, were shown in stem weights among the different types of mulch for planting dates Aug. 15. "Nader" (summer Romaine) gave the highest stem weights when planted over black and clear mulches on either Jun. 15 or Jul. 15.

In general the Romaine type recorded a higher value of stem weight when compared with the Iceberg type (Table 2).

Leaf weight: fresh weight and stem weight: fresh weight ratios:

- **Interactive effect of Planting date x Lettuce type x lettuce cultivar:**

Planting "Robinson" (summer Iceberg) on Aug. 15 gave significantly the highest and lowest values of leaf weight: fresh weight ratio and stem weight: fresh weight ratio, respectively (Table 3); both ratios, however were not significantly different from those of "Jordan" (winter Iceberg) on Aug. 15 and "Robinson" (summer Iceberg) on either Jun. 15 or Jul. 15. Further significant reduction in leaf weight: fresh weight ratio and increase in stem weight: fresh weight ratio were detected when "Jordan" (winter Iceberg) was planted Jun. 15 and Jul. 15.

Significantly lowest and highest values of leaf weight: fresh weight ratio and stem weight: fresh weight ratio, respectively, were given when "Wild Romaine" (winter Romaine) was planted on Jun. 15 and Jul. 15 (Table 3). The respective ratios increased and decreased significantly when "Wild Romaine" (winter Romaine) was planted on Aug. 15 and "Nader" (summer Romaine) on both Jun. 15 and Jul. 15.

For all planting dates, Iceberg type gave significantly higher leaf weight: fresh weight ratio than Romaine type (Table 3) but stem weight: fresh weight ratio was just the opposite.

Table (3): Interactive effect of "planting date x lettuce type x lettuce cultivar" on leaf weight: fresh weight and stem weight: fresh weight ratios of lettuce head at harvest.

Treatments / Variables			Leaf weight: fresh weight ratio	Stem weight: fresh weight ratio
Planting date	**Lettuce type**	**Cultivar**		
Jun 15	Iceberg	Summer (Robinson)	89.91 abc(*)	10.09 def
		Winter (Jordan)	87.63 cd	12.38 cd
	Romaine	Summer (Nader)	78.70 e	21.30 b
		Winter (wild Romaine)	59.83 f	40.17 a
Jul 15	Iceberg	Summer (Robinson)	89.35 abc	10.65 def
		Winter (Jordan)	88.14 bc	11.86 de
	Romaine	Summer (Nader)	80.85 e	19.15 b
		Winter (wild Romaine)	59.05 f	40.95 a
Aug 15	Iceberg	Summer (Robinson)	91.22 a	8.78 f
		Winter (Jordan)	90.23 ab	9.77 ef
	Romaine	Summer (Nader)	85.23 d	14.78 c
		Winter (wild Romaine)	79.15 e	20.85 b

(*) Values within each column having different letters are significantly different according to LSD Test at the 5% level.

Within the Romaine type, and at any planting date, "Nader" (summer Romaine) resulted in higher leaf weight: fresh weight ratio and lower stem weight: fresh weight ratio than "Wild Romaine" (winter Romaine) (Table 3). Within the Iceberg type, "Robinson" (summer Iceberg) tended to give higher leaf weight: fresh weight ratio and lower stem weight: fresh weight ratio than "Jordan" (winter Iceberg).

Planting on Aug.15 gave the highest and lowest leaf weight: fresh weight and stem weight: fresh weight ratios for the respective cultivars (Table 3); these ratios were similar on Jun.15 and Jul.15, but leaf weight: fresh weight ratios were reduced while stem weight: fresh weight ratios were enhanced.

- **Interactive effect of Planting date x Lettuce type x Mulch type:**

Significantly highest leaf weight: fresh weight ratio and lowest stem weight: fresh weight ratio were given by Iceberg type on Aug. 15 when planted in absence of mulch (Table 4). These ratios were not significantly different from those of Iceberg type on Aug. 15 in presence of the black and clear mulches, on Jun. 15 in absence of mulch and on Jul. 15 without mulch and over the black mulch. Further significant reduction in leaf weight: fresh weight ratio and increase in stem weight: fresh weight ratio were recorded when Iceberg type was planted Jun. 15 over the black and clear mulches and on Jul. 15 over the clear mulch.

Planting Romaine type on Jun. 15 over the black and clear mulches gave significantly lowest leaf weight: fresh weight ratio and highest stem weight: fresh weight ratio (Table 4). The respective ratios increased and decreased significantly on Jul. 15 in presence of the different types of mulch. Iceberg type, irrespective of mulch, showed significantly higher values of leaf weight: fresh weight ratio and lower stem weight: fresh weight ratio than Romaine type for all planting dates.

Table (4): Interactive effect of "planting date x lettuce type x mulch type" on leaf weight: fresh weight and stem weight: fresh weight ratios of lettuce head at harvest.

Treatments / Variables			Leaf weight: fresh weight ratio	Stem weight: fresh weight ratio
Planting date	**Lettuce type**	**Mulch type**		
Jun 15	Iceberg	Black mulch	88.47 bcd(*)	11.54 fg
		Clear mulch	87.63 d	12.37 f
		Control	90.20 abc	9.80 gh
	Romaine	Black mulch	65.59 i	34.42 a
		Clear mulch	67.79 hi	32.21 ab
		Control	74.43 f	25.58 d
Jul 15	Iceberg	Black mulch	89.16 a-d	10.84 fgh
		Clear mulch	87.77 cd	12.23 fg
		Control	89.31 a-d	10.69 fgh
	Romaine	Black mulch	69.70 gh	30.30 bc
		Clear mulch	68.91 gh	31.09 bc
		Control	71.23 g	28.76 c
Aug 15	Iceberg	Black mulch	90.90 ab	9.10 h
		Clear mulch	90.00 a-d	9.99 fgh
		Control	91.28 a	8.73 h
	Romaine	Black mulch	81.14 e	18.86 e
		Clear mulch	82.28 e	17.72 e
		Control	83.16 e	16.85 e

(*) Values within each column having different letters are significantly different according to LSD Test at the 5% level.

No significant differences in leaf weight: fresh weight and stem weight: fresh weight ratios were observed for planting Iceberg and Romaine types on Jul.15 and Aug.15 for all the mulch treatments (Table 4). Planting these types on Jun. 15 without mulch, however, resulted in higher leaf weight: fresh weight ratio and lower stem weight: fresh weight ratio compared with the mulched treatments which were similar.

Planting on Aug. 15 resulted in highest leaf weight: fresh weight ratio lowest stem weight: fresh weight ratio for each treatment combination of lettuce and mulch types (Table 4). In contrast, planting on Jun. 15 showed the lowest and highest values of leaf weight: fresh weight and stem weight: fresh weight ratios, respectively, for the Romaine type over all mulches, but insignificant differences were observed in leaf weight: fresh weight and stem weight: fresh weight ratios when Iceberg type was planted on any planting date.

- **Interactive effect of Lettuce type x lettuce cultivar x Mulch type:**

Planting "Robinson" (summer Iceberg) without mulch and over the black mulch resulted in significantly highest leaf weight: fresh weight ratio and lowest stem weight: fresh weight ratio (Table 5). Further reduction in leaf weight: fresh weight ratio and further increase in stem weight: fresh weight ratio were detected when planting "Robinson" (summer Iceberg) over the clear mulch and "Jordan" (winter Iceberg) without mulch and over black mulch.

Planting "Wild Romaine" (winter Romaine) over the black mulch gave significantly lowest leaf weight: fresh weight ratio and highest stem weight: fresh weight ratio (Table 5), compared with planting over the clear mulch where significantly higher leaf weight: fresh weight ratio and lower stem weight: fresh weight ratio were

Table (5): Interactive effect of "lettuce type x lettuce cultivar x mulch type" on leaf weight: fresh weight and stem weight: fresh weight ratios of lettuce head at harvest.

Treatments / Variables			Leaf weight: fresh weight ratio	Stem weight: fresh weight ratio
Lettuce type	**Cultivar**	**Mulch type**		
Iceberg	Summer (Robinson)	Black mulch	90.07 ab(*)	9.93 gh
		Clear mulch	89.24 b	10.76 g
		Control	91.17 a	8.83 h
	Winter (Jordan)	Black mulch	88.95 bc	11.05 fg
		Clear mulch	87.69 c	12.31 f
		Control	89.36 b	10.64 g
Romaine	Summer (Nader)	Black mulch	81.07 e	18.93 d
		Clear mulch	81.18 de	18.82 de
		Control	82.53 d	17.48 e
	Winter (Wild Romaine)	Black mulch	63.21 h	36.79 a
		Clear mulch	64.81 g	35.19 b
		Control	70.02 f	29.98 c

(*) Values within each column having different letters are significantly different according to LSD Test at the 5% level.

obtained. Iceberg type gave significantly higher leaf weight: fresh weight ratio and lower stem weight: fresh weight ratio when compared with Romaine type.

In general, "Jordan" (winter Iceberg) gave lower leaf weight: fresh weight ratio and higher stem weight: fresh weight ratio than "Robinson" (summer Iceberg) (Table 5). "Wild Romaine" (winter Romaine), however, recorded lower and higher values of leaf weight: fresh weight and stem weight: fresh weight ratios, respectively, when compared with "Nader" (summer Romaine).

Irrespective of lettuce type and cultivar treatments with out mulch showed higher leaf weight: fresh weight ratio and lower stem weight: fresh weight ratio than both black and clear mulches, which were similar except for "Wild Romaine" where the black mulch gave simultaneously lower leaf weight: fresh weight ratio and higher stem weight: fresh weight ratio than clear mulch (Table 5).

Leaf weight: stem weight ratio:

When "Robinson" (summer Iceberg) was planted without mulch, significantly highest leaf weight: stem weight ratio was obtained (Table 6). Further significant reductions in leaf weight: stem weight ratios were observed when "Robinson" (summer Iceberg) was planted over the black mulch and "Jordan" (winter Iceberg) without mulch and over black mulch.

Planting "Wild Romaine" (winter Romaine) over the black and clear mulches, gave significantly the lowest leaf weight: stem weight ratio, but in absence of mulch this ratio was significantly higher (Table 6).

Generally, Iceberg type recorded higher leaf weight: stem weight ratio when compared with the Romaine type (Table 6). Moreover, summer cultivars, within each type showed an increase in leaf weight: stem weight ratio than winter cultivars.

Table (6): Interactive effect of "lettuce type x lettuce cultivar x mulch type" on leaf weight: stem weight ratio of lettuce head at harvest.

Treatment / Variable			Leaf weight: stem weight
Lettuce type	**Cultivar**	**Mulch type**	
Iceberg	Summer (Robinson)	Black mulch	9.30 b(*)
		Clear mulch	8.46 c
		Control	10.79 a
	Winter (Jordan)	Black mulch	8.67 bc
		Clear mulch	7.71 d
		Control	8.71 bc
Romaine	Summer (Nader)	Black mulch	4.53 e
		Clear mulch	4.53 e
		Control	4.85 e
	Winter (Wild Romain)	Black mulch	2.14 g
		Clear mulch	2.23 g
		Control	2.92 f

(*) Values having different letters are significantly different according to LSD Test at the 5% level.

In general, planting each cultivar without mulch showed higher values of leaf weight: stem weight ratio (Table 6). Planting "Robinson" (summer Iceberg) or "Jordan" (winter Iceberg) over black mulch gave higher ratio than those of clear mulch, while in the Romaine type, especially "Wild Romaine", slight differences were observed between the black and clear mulches. In "Nader" (summer Romaine), however, these differences disappeared.

Leaf surface area:

Significantly highest value of leaf surface area was recorded on Jul. 15 when "Wild Romaine" (winter Romaine) was planted; significantly lower leaf surface area was observed when "Wild Romaine" (winter Romaine) and "Nader" (summer Romaine) were planted on Jun. 15 and when "Jordan" (winter Iceberg) was planted Jul. 15 (Table 7). When "Robinson" (summer Iceberg) was planted Aug. 15, the lowest values were obtained. Planting "Robinson" (summer Iceberg) Jun. 15 and Jul. 15 and "Nader" (summer Romaine) and "Wild Romaine" (winter Romaine) Aug. 15, resulted in almost similar leaf surface area.

Planting Romaine type on Jun. 15 gave higher values of leaf surface area than the Iceberg type (Table 7). For all planting dates, "Jordan" (winter Iceberg) gave significantly higher values of leaf surface area when compared with "Robinson" (summer Iceberg). "Wild Romaine" (winter Romaine), on the other hand, tended to give higher values of leaf surface area than "Nader" (summer Romaine).

Table (7): Interactive effect of "planting date x lettuce type x lettuce cultivar" on leaf number and leaf surface area of lettuce head at harvest.

Treatments / Variables			Leaf number (leaf/ head)	Leaf surface area (cm^2/ head)
Planting date	**Lettuce type**	**Cultivar**		
Jun 15	Iceberg	Summer (Robinson)	35.81 fgh(*)	4095.85 fg
		Winter (Jordan)	42.16 efg	5334.57 cde
	Romaine	Summer (Nader)	77.81 c	6122.16 bcd
		Winter (Wild Romaine)	130.19 b	6660.99 b
Jul 15	Iceberg	Summer (Robinson)	30.67 gh	4510.34 efg
		Winter (Jordan)	42.81 efg	6233.93 bc
	Romaine	Summer (Nader)	52.36 de	4934.69 d-g
		Winter (Wild Romaine)	156.19 a	8587.84 a
Aug 15	Iceberg	Summer (Robinson)	26.28 h	3810.91 g
		Winter (Jordan)	34.50 fgh	5053.02 c-f
	Romaine	Summer (Nader)	44.64 ef	3904.37 fg
		Winter (Wild Romaine)	57.22 d	3974.21 fg

(*) Values within each column having different letters are significantly different according to LSD Test at the 5% level.

Leaf number:

- **Interactive effect of Planting date x Lettuce type x lettuce cultivar:**

Planting "Wild Romaine" (winter Romaine) on Jul. 15, gave significantly the highest leaf number (Table 7); further significant reduction in leaf number was observed when "Wild Romaine" (winter Romaine) was planted Jun. 15.

Significantly lowest value of leaf number was given when "Robinson" (summer Iceberg) was planted on Aug. 15 (Table 7). Moreover, leaf number was not significantly different from those of "Robinson" (summer Iceberg) on Jun. 15 and Jul. 15 and "Jordan" (winter Iceberg) for all planting dates.

When lettuce was planted Aug. 15, leaf numbers were lower compared with those of both Jun. 15 and Jul. 15 (Table 7). On this planting date, the reduction of leaf number was more for "Wild Romaine" (Winter Romaine) than "Nader" (summer Romaine). However, leaf number of Iceberg cultivars ("Robinson" and "Jordan") didn't change significantly for all planting dates.

Iceberg type gave lower leaf number when compared with Romaine type (Table 7). Moreover, "Robinson" (summer Iceberg) tended to produce lower number of leaves than "Jordan" (winter Iceberg). "Nader" (summer Romaine) gave significantly lower leaf number compared with "Wild Romaine" (Winter Romaine). In general "Robinson" (summer Iceberg) gave lowest leaf number, while values were the highest for "Wild Romaine" (Winter Romaine) for all planting dates.

- **Interactive effect of Planting date x Lettuce type x Mulch type:**

Significantly highest leaf numbers were given when Romaine type was planted on Jun.15 over the black mulch and on Jul. 15 over the black and clear mulches (Table 8). Further significant reduction in leaf number was observed on Jun. 15, when

Table (8): Interactive effect of "planting date x lettuce type x mulch type" on leaf number of lettuce head at harvest.

Variables / Treatments			Leaf number (leaf/ head)
Planting dates	**Lettuce type**	**Mulch type**	
Jun 15	Iceberg	Black mulch	42.33 def(*)
		Clear mulch	38.46 efg
		Control	36.16 fg
	Romaine	Black mulch	120.71 a
		Clear mulch	104.13 b
		Control	87.17 c
Jul 15	Iceberg	Black mulch	35.79 fg
		Clear mulch	40.29 efg
		Control	34.13 fg
	Romaine	Black mulch	109.38 ab
		Clear mulch	117.58 a
		Control	85.88 c
Aug 15	Iceberg	Black mulch	30.92 fg
		Clear mulch	30.75 fg
		Control	29.50 g
	Romaine	Black mulch	49.21 de
		Clear mulch	50.17 de
		Control	53.42 d

(*) Values having different letters are significantly different according to LSD Test at the 5% level.

Romaine type was planted over clear mulch. Moreover, planting Romaine type in absence of mulch on Jun.15 and Jul. 15 resulted in significantly lower leaf numbers than those of the black and clear mulches.

Planting Iceberg type on Aug. 15 in absence of mulch gave the lowest leaf numbers, which were not significantly different from those of Iceberg type, on Aug. 15 over black and clear mulches, on Jul. 15 with any type of mulch and on Jun. 15 in absence of mulch and over the clear mulch (Table 8). In general, the Romaine type produced higher leaf numbers than the Iceberg type for any planting date.

Planting Romaine type on Aug. 15 produced lower leaf numbers than the other planting dates, which were similar. Moreover, negligible differences in leaf number were observed among the different types of mulch for Aug. 15 (Table 8). Furthermore, no significant differences were detected in leaf number of Iceberg type for all mulch treatments and all planting dates.

- **Interactive effect of Planting date x Lettuce cultivar x Mulch type:**

Planting winter cultivars on Jun. 15 in presence of the black mulch and on Jul. 15 in presence of the black and clear mulches gave significantly the highest values of leaf number (Table 9). Further significant reduction in leaf number was observed when winter cultivars were planted Jun.15 over the clear mulch and in absence of mulch on Jun. 15 and Jul.15.

Lowest leaf numbers were observed when summer cultivars were planted on Aug 15 without mulch (Table 9); these values were insignificantly different from those of same cultivars planted on Aug. 15 over the black and clear mulches, or Jul. 15 in absence of mulch and in presence of the black mulch. The winter cultivars, however, gave similar leaf numbers when planted on Aug. 15 over black and clear mulches.

Table (9): Interactive effect of "planting date x lettuce cultivar x mulch type" on leaf number of lettuce head at harvest.

Variables / Treatments			Leaves number (leaf/ head)
Planting date	**Cultivar**	**Mulch type**	
Jun 15	Summer	Black mulch	62.75 c(*)
		Clear mulch	59.96 cd
		Control	47.71 def
	Winter	Black mulch	100.29 a
		Clear mulch	82.63 b
		Control	75.62 b
Jul 15	Summer	Black mulch	40.63 efg
		Clear mulch	46.04 ef
		Control	37.88 fg
	Winter	Black mulch	104.54 a
		Clear mulch	111.83 a
		Control	82.13 b
Aug 15	Summer	Black mulch	36.58 fg
		Clear mulch	37.08 fg
		Control	32.71 g
	Winter	Black mulch	43.54 efg
		Clear mulch	43.83 efg
		Control	50.21 de

(*) Values having different letters are significantly different according to LSD Test at the 5% level.

Summer cultivars produced higher leaf numbers when planted on Jun. than those planted in Jul. 15 or Aug. 15, which were similar.

On the other hand, winter cultivars gave significantly lower leaf numbers when planted Aug. 15 than Jun. 15 and Jul. 15 (Table 9). The winter cultivars generally produced higher leaf number than summer cultivars for the different planting dates. The differences in leaf number between summer and winter cultivars were reduced when planted Aug. 15.

For each cultivar, planting on Aug. 15 without mulch gave lower leaf number (Table 9); the winter cultivars produced higher leaf number when planted without mulch than those of black and clear mulches. Also, no significant differences in leaf number were observed for all cultivars and planting dates in presence of black and clear mulches, except for winter cultivars when planted Jun. 15 over black mulch where leaf number was higher than the clear mulch.

DISCUSSION

Bolting:

Generally, Aug. 15 planting date was the most efficient in decreasing the bolting %, especially in the winter cultivars ["Jordan" (winter Iceberg) and "wild Romaine" (winter Romaine)] (Table 1 & Appendix-A, table 1), which are considered of low tolerance ability to bolting. Several lettuce cultivars were reported to bolt earlier in summer and spring seasons including the "Bába" and "Brasil-303" (Silva *et al.*, 1999), "Black Seeded Simpson", "Ruby" and "Red Salad Bow", (Kahn and Magnello, 1986). This decrease in bolting % in comparison to Jun. 15 and Jul. 15 planting dates, which showed similar bolting (Table 1 & Appendix-A, table 1), could be due to the observed decrease in temperature (Appendix-C, tables 1 & 2 and Appendix-D, figures 1, 2 & 3) and photoperiod (Appendix-C, table 3 and Appendix-D, figure 4); this has also been documented by Vavrina (2002) who reported that long-day light conditions contribute to the bolting of lettuce. Also, variations among lettuce types (Romaine vs. Iceberg) in bolting % were observed (Table 1 & Appendix-A, table 1) and can be explained by the better ability of Iceberg type to tolerate high temperature (Appendix-C, tables 1 & 2 and Appendix-D, figures 1, 2 & 3) and long photoperiod (Appendix-C, table 3 and Appendix-D, figure 4) than the Romaine type which bolted to a greater degree (Table 1 & Appendix-A, table 1). Several authors (Silva *et al.*, 1999 and Kahn and Magnello, 1986) reported lettuce cultivars to vary in bolting tolerance in response to high temperature and long photoperiod. Winter cultivars of the present experiment ("Jordan"/ Iceberg and "Wild Romaine"/ Romaine) showed intolerance to increased temperature (Appendix-C, tables 1 & 2 and Appendix-D, figures 1, 2 & 3) and photoperiod (Appendix-C, table 3 and Appendix-D, figure 4) when planted under unseasonable

conditions (summer) and consequent increase in bolting % was observed. This is consistent with earlier findings, where exposure of lettuce plants to temperatures higher than 23/ 7 °C, Day/ Night temperature, during the last growing period may result in bolting (Jackson et al, 1996 a and b), which reduce the marketability of the crop (Waycott, 1995). In contrast, present data demonstrated the ability of summer cultivars ("Robinson"/ Iceberg and "Nader"/ Romaine) to resist bolting due to high temperature (Appendix-C, tables 1 & 2 and Appendix-D, figures 1, 2 & 3) and long photoperiod (Appendix-C, table 3 and Appendix-D, figure 4). This has also been observed by Silva et al, (1999) who worked on lettuce cultivars adapted to tropical conditions, where the average daily temperatures were 25 ºC, with a minimum of 18 ºC and a maximum of 35 ºC.

The ratio of red to far red light, the cue by plants to perceive light competition, was between 30% and 60% higher in plants with their neighbours removed (weed control) compared with controls (unweeded control) (Agrwal and Van Zandt, 2003). According to Mahoney (n.d) far-red light is known to increase stem elongation, which possibly explains the bolting responses to the different types of mulch used in this experiment (Table 1 & Appendix-A, table 1). Where the soil was left bare, the level of far-red radiation is supposed to be higher than over the other types of mulch and hence lower bolting % was observed (Table 1 & Appendix-A, table 1); the increase in the ratio of far-red to red light on the unweeded soil results from absorbance of red light by weeds during photosynthesis (Colored mulch research, n.d). By adding mulch, a great amount of far-red light is absorbed and hence the % of bolting decreased (Table 1 & Appendix-A, table 1). However, intra-mulch type variations have been noted (College of Agricultural Sciences, 2003). Black mulch absorbs most ultra-violet (UV), visible, and infrared wavelengths (IR) of incoming solar radiation and re-radiates absorbed

energy in the form of thermal radiation or long-wave infrared radiation and consequently a lower % of bolting occurred (Table 1 & Appendix-A, table 1). On the other hand clear mulch, absorbs little solar radiation but transmits 85% to 95%, depending on the thickness and degree of opacity of the polyethylene, so less light is absorbed and more far-red light is reradiated to the plant (College of Agricultural Sciences, 2003) resulting in a higher bolting % than black mulch (Table 1 & Appendix-A, table 1).

Vegetative growth:

Fresh weight, leaf weight and stem weight:

The Romaine type of lettuce is generally superior to the Iceberg type with reference to fresh weight (Table 2 & Appendix-A, table 1); as well, Jun. 15 and Jul. 15 planting dates resulted in higher fresh weight of the lettuce head. This is likely due to the higher growth contributed by increased bolting of the Romaine type. This observation was further enhanced when planting "Wild Romaine" (winter Romaine) in the summer time, where the exposure to higher temperatures (Appendix-C, tables 1 & 2 and Appendix-D, figures 1, 2 & 3) and longer photoperiod (Appendix-C, table 3 and Appendix-D, figure 4) increased the level of bolting (Table 1 & Appendix-A, table 1), where rapid stem elongation accelerates the transition into flowering (Waycott, 1995), increasing stem weight and consequently total fresh weight (R= +0.67, Appendix-C, table 5). According to Wurr *et al*. (1991) the sensitivity of lettuce to solar radiation is greatest when hearting occurs; head weight is increased by higher solar radiation in a specific period around hearting and by lower temperatures in a longer period up to and around hearting.

Plants grown on mulched plots have higher growth rate and fresh weight than those grown on bare (weeded) soil (Brault, *et al*., 2002). Although bolting was lowest with black mulch (Table 1 & Appendix-A, table 1) as compared to bare soil or clear mulch treatments, fresh weight was comparatively higher. According to Hopen and Oebker (1975) mulch provides a condition of keeping higher soil temperature which increases plant growth in general. Also, bare soil allows competitive weeds to grow thriving on the expense of the lettuce plant leading to reduced head fresh weight and it's components despite that bolting is increased due to higher far-red radiation exposure (Table 1 & Appendix-A, table 1).

Generally, stem weight was greater in “Wild Romaine” (winter Romaine) than “Nader” (summer Romaine) (Table 2 & Appendix-A, table 1). This is apparently due to lower bolting in “Nader” (summer Romaine), under the prevailing high summer temperatures (Appendix-C, tables 1 & 2 and Appendix-D, figures 1, 2 & 3) and long photoperiod (Appendix-C, table 3 and Appendix-D, figure 4) and hence lower stem weight. On the other hand, winter cultivars show lower tolerance to such high temperatures, as expressed in increased bolting % (Table 1 & Appendix-A, table 1), which leads to stem elongation thus increasing stem weight (R= 0.87, Appendix-C, table 5). These results are substantiated by earlier findings (Waycott, 1995 and Kahn and Magnello, 1986). The transition to flowering is initiated by bolting (Waycott, 1995) where stem elongation is considered a key index (Kahn and Magnello, 1986). Results on fresh weight of “Nader” (summer Romaine) were inconsistent compared to those of “Wild Romaine” (winter Romaine) (Table 2 & Appendix-A, table 1), possibly due to the observed increase in leaf weight in “Nader” (summer Romaine) and in stem weight in “Wild Romaine” (winter Romaine) (Table 2 & Appendix-A, table 1). Moreover, "planting Jun. 15 x Romaine lettuce x "Wild Romaine" winter cultivar xblack mulch”

and “planting Jul. 15 x Romaine lettuce, "Wild Romaine" winter cultivar x clear mulch” showed high values of fresh weight and stem weight, but low leaf weight values (Table 2 & Appendix-A, table 1). The contribution of stem weight to fresh weight was higher (R= +0.67) than that of leaf weight (R= +0.62) mainly because of bolting. For similar reasons stem weight in the winter cultivars (Iceberg type) was higher than that of the summer cultivars but stem weight of the Iceberg cultivars was significantly lower than that in Romaine cultivars.

Mulch, particularly black, increased leaf and stem weight and consequently fresh weight (Table 2 & Appendix-A, table 1); the contribution of stem weight (R= +0.67) and leaf weight (R= +0.62) to fresh weight was considerable (Appendix- C, table 5), though bolting % was higher in plants grown on bare soil. This can be attributed to the presence of weeds on bare soil treatments competing with the lettuce plant and producing generally smaller lighter lettuce heads (Brault, *et al*., 2002).

Higher temperatures (Appendix- C, tables 1 & 2 and Appendix- D, figures 1, 2 & 3) and longer photoperiods (Appendix- C, table 3 and Appendix- D, figure 4) for Jun. 15 and Jul. 15 planting dates were associated with bolting which increased stem weight (R= 0.87) on the expense of leaf weight (R= -0.41, Appendix-C, table 5).

Leaf weight: fresh weight, stem weight: fresh weight and leaf weight: stem weight ratios:

Ratios stemming out from fresh weight and its components (Tables 3, 4, 5 & 6 & Appendix-A, table 2) showed more or less patterns similar to those of leaf weight, stem weight and fresh weight (Table 2 & Appendix-A, table 1). These ratios were affected to variable extents by the level of bolting under the prevailing conditions of this experiment. Increasing in bolting % was associated with higher stem weight: fresh

weight ratio (R= +0.92, Appendix-C, table 5), while lower leaf weight: fresh weight ratio (R= -0.92, Appendix-C, table 5) and leaf weight: stem weight ratio (R= -0.80, Appendix-C, table 5) were observed.

Leaf number and leaf surface area:

Under the prevailing conditions of high temperatures and long photoperiod and over the different types of mulch, the sensitive lettuce cultivars bolted (Table 1 & Appendix-A, table 1), the stem elongated on the expense of leaf weight and a greater number of small leaves developed on the elongated stem (Tables 7, 8 & 9 & Appendix-A, table 3) leading to a higher number of leaves (R= +0.89) and an increase in leaf surface area (R= +0.56, Appendix-A, table 5). These results are substantiated by earlier findings (Wurr and Fellows, 1984; Wurr, *et al.*, 1981 and Hicklenton and Wolynetz, 1987). Increasing air temperature lead to an increase in number of leaves (Wurr and Fellows, 1984), and a consistent relationship was established when plotted against soil temperature on an accumulated day-degree scale (Wurr, *et al.*, 1981). According to Hicklenton and Wolynetz (1987) leaf area continued to increase with day temperature up to 22.5 ºC. Leaf number and leaf surface area herein (Tables 7, 8 & 9 & Appendix-A, table 3) included the outer leaves (active in photosynthesis) and the inner leaves (inactive in photosynthesis) and the leaves on the elongated stem. Hence, it is impossible to clearly identify the role of leaf number and leaf surface area reported here in the growth and development of the lettuce plant. However the number of leaves (R= +0.98) and leaf surface area (R= +0.79) were strongly correlated with stem growth in particular. Consequently, the weight of the vegetative growth and its components are affected to variable extents and their dependence on bolting is demonstrated (R= +0.39,

+0.87, -0.41, +0.56 & +0.89 for fresh weight, stem weight, leaf weight, leaf surface area and leaf number, respectively).

CONCLUSIONS

- Aug. 15 was the optimum planting date where lowest bolting % was prominent.
- Iceberg Lettuce type was more tolerant to bolting than the Romaine type especially at high temperature and long photoperiod conditions recorded for Jun. 15 or Jul. 15.
- The number of bolted plants in "Nader" (summer Romaine) was lower than "Wild Romaine" (winter Romaine) for all planting dates and over the different mulch treatments. "Jordan" (winter Iceberg) tended to give higher bolting % than "Robinson" (summer Iceberg) when planted in absence of mulch at any planting date.
- Bolting % of all lettuce cultivars at all planting dates increased in absence of both black and clear mulches.
- Bolting increased the fresh weight, stem weight, stem weight: fresh weight ratio, leaf number and leaf surface area and decreased the leaf weight and leaf weight: fresh weight and leaf weight: stem weight ratios.

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Appendices

Appendix - A

Appendix (A) table (1): Separate effects of planting date, lettuce type, lettuce cultivar, and type of mulch on bolting percentage, fresh weight, leaf weight and stem weight of lettuce head.

Treatments	Bolting %	Fresh weight (g/head)	Leaf weight (g/ head)	Stem weight (g/ head)
Planting dates				
Jun. 15	36.19 a[1]	577.93 a	451.48 a	126.39 a
Jul. 15	36.28 a	593.80 a	465.13 a	128.67 a
Aug. 15	4.79 b	471.32 b	407.35 b	63.98 b
LSD	1.32	26.78	21.61	8.06
Lettuce types				
Iceberg	2.84 b	520.47 b	464.60 a	55.87 b
Romaine	48.66 a	574.89 a	418.04 b	156.82 a
LSD	1.07	21.87	17.65	6.58
Lettuce cultivars				
Summer cultivar	12.80 b	527.45 b	449.89 a	77.55 b
Winter cultivar	38.71 a	567.92 a	432.75 a	135.13 a
LSD	1.07	21.87	17.65	6.58
Types of mulch				
Black mulch	20.89 c	587.98 a	467.83 a	120.09 a
Clear mulch	23.16 b	552.91 b	443.05 b	109.86 b
Control	33.21 a	502.16 c	413.07 c	89.09 c
LSD	1.32	26.78	21.61	8.06

[1] Within each column means of each separate effect having different letters are significantly different according to (LSD) test at the 5% level of probability.

Appendix (A) table (2): Separate effects of planting date, lettuce type, lettuce cultivar, and type of mulch on leaf weight: fresh weight, stem weight: fresh weight and leaf weight: stem weight ratios of lettuce head.

Treatments	Leaf weight: fresh weight ratio	Stem weight: fresh weight ratio	Leaf weight: stem weight ratio
Planting dates			
Jun. 15	79.01 b[1]	20.99 a	5.60 b
Jul. 15	79.35 b	20.65 a	5.53 b
Aug. 15	86.46 a	13.54 b	7.57 a
LSD	0.70	0.702	0.326
Lettuce types			
Iceberg	89.41 a	10.59 b	8.94 a
Romaine	73.80 b	26.20 a	3.53 b
LSD	0.57	0.57	0.27
Lettuce cultivars			
Summer cultivar	85.88 a	14.13 b	7.08 a
Winter cultivar	77.34 b	22.66 a	5.40 b
LSD	0.57	0.57	0.267
Types of mulch			
Black mulch	80.83 b	19.18 a	6.16 b
Clear mulch	80.73 b	19.27 a	5.73 c
Control	83.27 a	16.73 b	6.82 a
LSD	0.70	0.70	0.33

[1] Within each column means of each separate effect having different letters are significantly different according to (LSD) test at the 5% level of probability.

Appendix (A) table (3): Separate effects of planting date, lettuce type, lettuce cultivar, and type of mulch on leaf number and leaf surface area of lettuce head.

Treatments	Leaf number (leaf/ head)	Leaf surface area (cm^2/ head)
Planting dates		
Jun. 15	71.49 a[(1)]	451.5 a
Jul. 15	70.51 a	465.1 a
Aug. 15	40.66 b	407.4 b
LSD	3.56	355.4
Lettuce types		
Iceberg	35.37 b	4839.8 b
Romaine	86.40 a	5697.4 a
LSD	2.91	290.1
Lettuce cultivars		
Summer cultivar	44.59 b	4563.1 b
Winter cultivar	77.18 a	5974.1 a
LSD	2.91	290.1
Types of mulch		
Black mulch	64.72 a	5930.9 a
Clear mulch	63.56 a	5571.6 b
Control	54.38 b	4303.2 c
LSD	3.56	355.4

(1) Within each column means of each separate effect having different letters are significantly different according to (LSD) test at the 5% level of probability.

Appendix - B

Appendix (B) table (1): Analysis of variance for the effect of planting dates, lettuce types, lettuce cultivars and types of mulch on bolting percentage, fresh weight, leaf weight and stem weight of lettuce head.

Source of Variance	d.f	Bolting %		Fresh weight		Leaf weight		Stem weight	
		Mean Square	sig	Mean Square	sig	Mean Square	sig	Mean Square	sig
PD	2	12310.65	***[1]	638830.13	**	131362.23	*	194055.46	***
LT	1	63139.40	***	319899.27	**	234146.98	**	1100578.10	***
CV	1	22561.60	***	176875.75	*	31743.45	ns	358037.62	***
MU	2	1534.03	***	268070.12	***	108284.26	***	35924.80	***
PD*LT	2	7332.97	***	115389.58	*	52516.74	ns	98017.51	***
PD*CV	2	2233.67	***	148827.53	**	120887.31	**	48168.98	***
PD*MU	4	50.31	**	91386.80	**	53433.92	**	10799.96	***
LT*CV	1	9426.12	***	13414.57	ns	331140.84	***	210890.15	***
LT*MU	2	265.75	***	9530.48	ns	928.65	ns	16307.96	***
CV*MU	2	159.89	***	137646.54	**	121634.94	***	4361.92	*
PD*LT*CV	2	651.43	***	85825.48	*	84253.35	*	39620.31	***
PD*LT*MU	4	28.87	*	17429.27	ns	7588.14	ns	6676.17	***
PD*CV*MU	4	112.83	***	21534.21	ns	13919.12	ns	2958.80	ns
LT*CV*MU	2	708.43	***	5911.63	ns	18193.52	ns	3825.57	*
PD*LT*CV*MU	4	208.51	***	77510.25	**	44414.92	*	5586.18	**

[1] ns: not significant, * $P \leq 0.05$, ** $P \leq 0.01$, *** $P \leq 0.001$, PD: planting date, LT: lettuce type, CV: cultivar, MU: mulch type.

Appendix (B) table (2): Analysis of variance for the effect of planting dates, lettuce types, lettuce cultivars and types of mulch on leaf weight: fresh weight, stem weight: fresh weight and leaf weight: stem weight: ratios, leaf surface area and leaf number of lettuce head.

Source of Variance	d.f	Leaf weight: fresh weight ratio		Stem weight: fresh weight ratio		Leaf weight: stem weight ratio		Leaf surface area		Leaf number	
		Mean Square	sig	Mean Square	sig	Mean Square	sig	Mean Square	sig	Mean Square	sig
PD	2	2546.08	***[1]	2545.66	***	192.91	***	136144948.70	**	44221.43	**
LT	1	26318.77	***	26320.33	***	3161.17	***	79432911.07	**	281260.01	***
CV	1	7873.71	***	7871.15	***	304.69	***	215031491.30	***	114696.59	***
MU	2	297.90	***	297.49	***	43.07	***	105296845.84	***	4627.03	***
PD*LT	2	1355.72	***	1355.36	***	4.18	ns	49970472.80	*	25158.06	***
PD*CV	2	684.19	***	684.94	***	3.06	ns	44539850.26	***	20658.99	***
PD*MU	4	82.20	***	82.40	***	4.78	ns	19200447.23	**	2293.58	***
LT*CV	1	5360.12	***	5356.60	***	29.66	**	9881.61	ns	60560.65	***
LT*MU	2	103.17	***	103.02	***	13.60	**	20108164.05	**	2158.18	**
CV*MU	2	53.51	*	53.80	*	2.90	ns	1033192.62	ns	371.02	ns
PD*LT*CV	2	582.91	***	582.89	***	5.42	ns	25137831.33	**	17170.75	***
PD*LT*MU	4	34.63	*	34.60	*	0.31	ns	7676850.50	ns	1243.33	*
PD*CV*MU	4	5.54	ns	5.51	ns	5.30	ns	7972086.76	ns	1236.38	*
LT*CV*MU	2	85.85	**	85.87	**	10.02	*	586733.73	ns	397.70	ns
PD*LT*CV*MU	4	7.23	ns	7.22	ns	5.55	ns	5683182.16	ns	860.46	ns

[1] ns: not significant, * $P \leq 0.05$, ** $P \leq 0.01$, *** $P \leq 0.001$, PD: planting date, LT: lettuce type, CV: cultivar, MU: mulch type.

Appendix – C

Appendix (C) table (1): Average daily minimum temperature (°C) during the growing season, Al-Yadoudeh area.

Minimum temperature °C											
Date	°C	Date	°C	Date	°C	Date	°C	Date	°C	Date	°C
Jun. 16	17.0	Jul. 5	16.0	Jul. 23	14.5	Aug. 10	16.7	Aug. 28	14.0	Sep. 15	10.5
17	13.5	6	18.0	24	15.0	11	16.0	29	14.5	16	10.0
18	15.0	7	16.5	25	14.0	12	14.9	30	13.0	17	11.5
19	13.0	8	16.0	26	15.0	13	16.0	31	14.0	18	12.5
20	13.0	9	15.0	27	14.5	14	14.0	Sep. 1	12.0	19	11.0
21	13.5	10	12.0	28	15.5	15	13.0	2	12.5	20	11.0
22	14.5	11	14.0	29	15.0	16	13.0	3	13.5	21	9.5
23	14.0	12	15.5	30	15.0	17	13.0	4	13.0	22	10.0
24	14.0	13	11.5	31	16.0	18	12.0	5	13.0	23	10.0
25	13.5	14	12.0	Aug. 1	16.5	19	12.5	6	13.5	24	11.5
26	11.0	15	14.0	2	16.0	20	12.5	7	12.0	25	11.0
27	12.0	16	14.0	3	17.5	21	12.0	8	12.5	26	9.5
28	12.0	17	12.0	4	15.0	22	12.0	9	12.5	27	9.5
29	11.5	18	13.0	5	17.0	23	14.0	10	13.0	28	11.0
30	15.0	19	12.0	6	14.5	24	12.5	11	13.5	29	11.0
Jul. 1	15.0	20	12.0	7	16.0	25	13.0	12	12.0	30	9.0
2	15.0	21	16.5	8	18.0	26	14.5	13	12.0	Oct. 1	9.5
3	15.0	22	12.5	9	18.5	27	15.0	14	11.0	Oct. 2	9.0
4	15.0										

Appendix (C) table (2): Average daily maximum temperature (°C) during the growing season, Al-Yadoudeh area.

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Maximum temperature °C											
Date	°C	Date	°C	Date	°C	Date	°C	Date	°C	Date	°C
Jun. 16	42.0	Jul. 5	45.5	Jul. 23	40.0	Aug. 10	43.0	Aug. 28	41.0	Sep. 15	38.5
17	40.0	6	46.0	24	39.0	11	42.0	29	43.0	16	38.0
18	43.0	7	42.5	25	39.0	12	42.0	30	44.0	17	39.0
19	43.0	8	39.0	26	39.0	13	42.0	31	43.0	18	38.0
20	43.0	9	39.0	27	41.0	14	42.0	Sep. 1	44.0	19	37.5
21	41.0	10	40.0	28	42.0	15	44.0	2	43.5	20	39.0
22	41.0	11	41.0	29	42.5	16	43.0	3	43.0	21	40.0
23	42.5	12	40.0	30	41.0	17	42.0	4	41.5	22	41.5
24	43.0	13	38.5	31	42.5	18	44.0	5	39.0	23	42.0
25	47.0	14	39.0	Aug. 1	45.0	19	44.0	6	38.0	24	40.5
26	43.0	15	40.0	2	44.0	20	42.5	7	38.0	25	39.0
27	43.0	16	39.0	3	42.5	21	42.0	8	40.0	26	41.0
28	43.0	17	38.0	4	43.5	22	41.0	9	41.0	27	41.5
29	42.0	18	39.5	5	44.0	23	42.0	10	40.5	28	37.0
30	37.0	19	41.5	6	42.5	24	42.0	11	42.0	29	38.0
Jul. 1	40.0	20	43.0	7	43.5	25	43.5	12	42.0	30	36.0
2	40.0	21	42.0	8	43.0	26	42.0	13	38.0	Oct. 1	37.5
3	44.5	22	40.0	9	44.0	27	40.5	14	39.0	Oct. 2	37.0
4	44.0										

Appendix (C) table (3): Average daily photoperiod (hr) during the growing season, Al- Yadoudeh area.

Photoperiod (hr)											
Date	**hr**	Date	**hr**	Date	**hr**	Date	**hr**	Date	**hr**	Date	**hr**
Jun. 16	14.43	Jul. 5	14.37	Jul. 23	14.08	Aug. 10	13.65	Aug. 28	13.12	Sep. 15	12.53
17	14.45	6	14.37	24	14.07	11	13.62	29	13.08	16	12.52
18	14.45	7	14.35	25	14.05	12	13.60	30	13.05	17	12.48
19	14.45	8	14.35	26	14.02	13	13.57	31	13.02	18	12.45
20	14.45	9	14.32	27	14.02	14	13.53	Sep. 1	13.00	19	12.42
21	14.45	10	14.32	28	13.98	15	13.52	2	12.95	20	12.38
22	14.45	11	14.30	29	13.95	16	13.48	3	12.93	21	12.35
23	14.45	12	14.28	30	13.93	17	13.45	4	12.90	22	12.32
24	14.45	13	14.27	31	13.92	18	13.42	5	12.87	23	12.28
25	14.43	14	14.27	Aug. 1	13.88	19	13.38	6	12.83	24	12.27
26	14.43	15	14.23	2	13.85	20	13.35	7	12.80	25	12.22
27	14.43	16	14.22	3	13.83	21	13.33	8	12.77	26	12.18
28	14.43	17	14.22	4	13.80	22	13.30	9	12.73	27	12.17
29	14.43	18	14.18	5	13.78	23	13.27	10	12.70	28	12.12
30	14.43	19	14.18	6	13.77	24	13.25	11	12.68	29	12.08
Jul. 1	14.40	20	14.15	7	13.73	25	13.20	12	12.63	30	12.07
2	14.40	21	14.12	8	13.70	26	13.18	13	12.60	Oct. 1	12.02
3	14.38	22	14.12	9	13.68	27	13.15	14	12.58	Oct. 2	11.98
4	14.38										

Appendix (C) table (4): Some chemical properties of the soil experimental site at Al- Yadoudeh area.

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Test \ Depth	0-30 cm
Total Nitrogen	0.023 %
NO^-_3	1.890 ppm
NH_4^+	0.450 ppm
P_2O_5	43.500 ppm
K_2O	119.000 ppm

Appendix (C) table (5): Correlation coefficients among bolting%, fresh weight, stem weight, leaf weight, leaf surface area, leaf number and leaf weight: fresh weight, stem weight: fresh weight and leaf weight: stem weight ratio.

Parameters	Bolting%	Fresh weight	Stem weight	Leaf weight	Leaf surface area	Leaf number	Leaf weight: fresh weight ratio	Stem weight: fresh weight ratio	Leaf weight: stem weight ratio
Bolting%		+0.3896	+0.8722	-0.4089	+0.5579	+0.8935	-0.9173	-0.9173	-0.7982
Fresh weight	+0.3896		+0.6719	+0.6162	+0.8486	+0.6060	-0.5058	-0.5058	-0.5360
Stem weight	+0.8722	+0.6719		-0.1694	+0.7935	+0.9844	-0.9664	-0.9664	-0.8557
Leaf weight	-0.4089	+0.6162	-0.1694		+0.2855	-0.2404	+0.3549	+0.3547	+0.1965
Leaf surface area	+0.5579	+0.8486	+0.7935	+0.2855		+0.7734	-0.6625	+0.6626	-0.5672
Leaf number	+0.8935	+0.6060	+0.9844	-0.2404	+0.7734		-0.9676	+0.9676	-0.8344
Leaf weight: fresh weight ratio	-0.9173	-0.5058	-0.9664	+0.3547	-0.6625	-0.9676		-1.0000	+0.9001
Stem weight: fresh weight ratio	+0.9173	+0.5058	+0.9664	-0.3547	+0.6626	+0.9676	-1.0000		-0.9001
Leaf weight: stem weight ratio	-0.7982	-0.5360	-0.8557	+0.1965	-0.5672	-0.8344	+0.9001	-0.9001	

Appendix - D

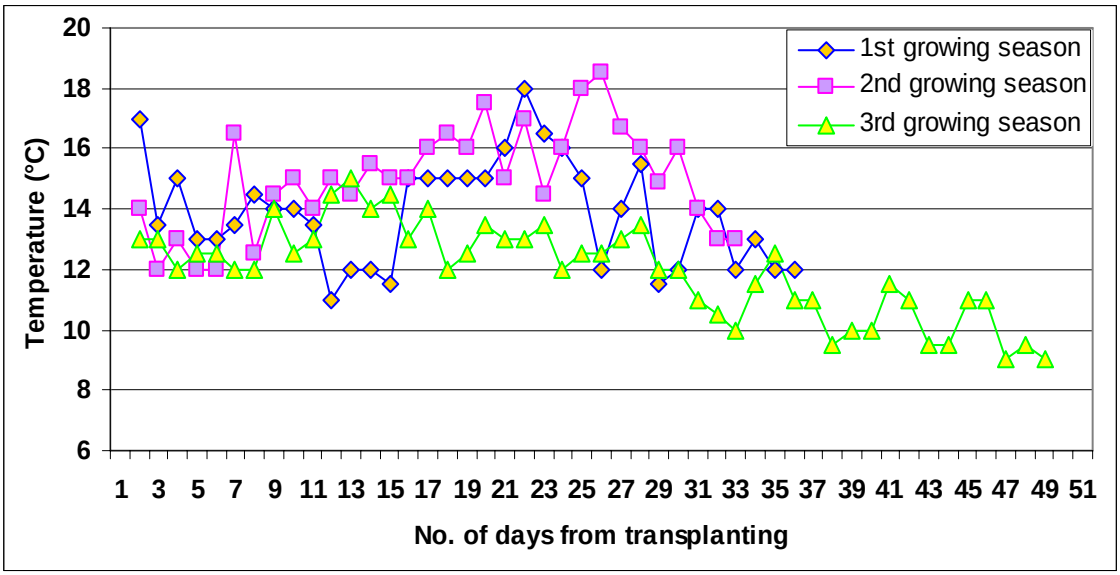

Figure (1): Minimum temperature during the growing season, Al- Yadoudeh area.

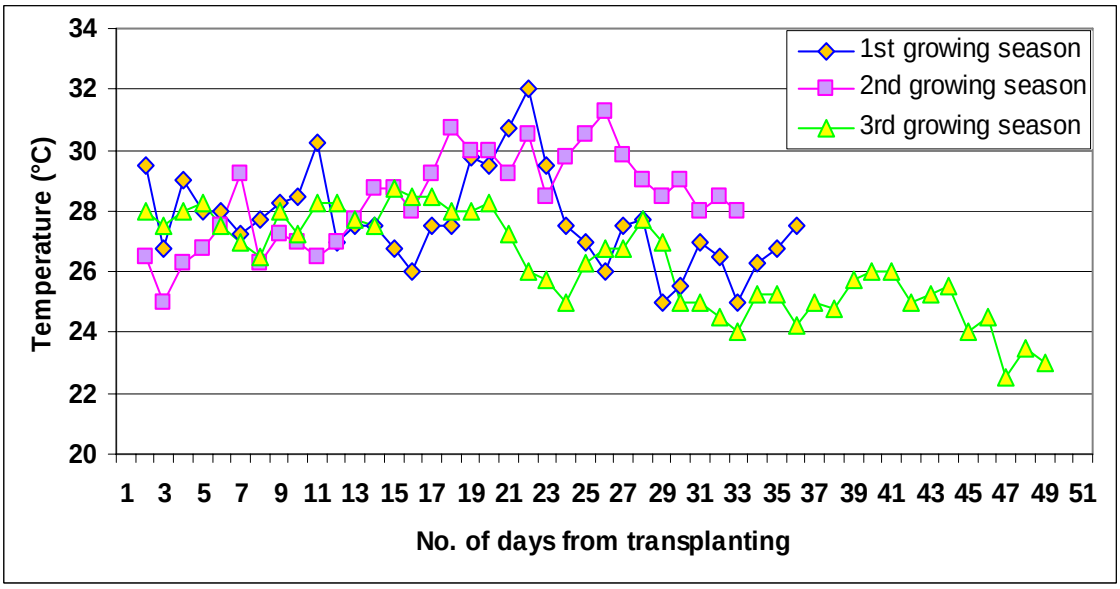

Figure (2): Average temperature during the growing season, Al- Yadoudeh area.

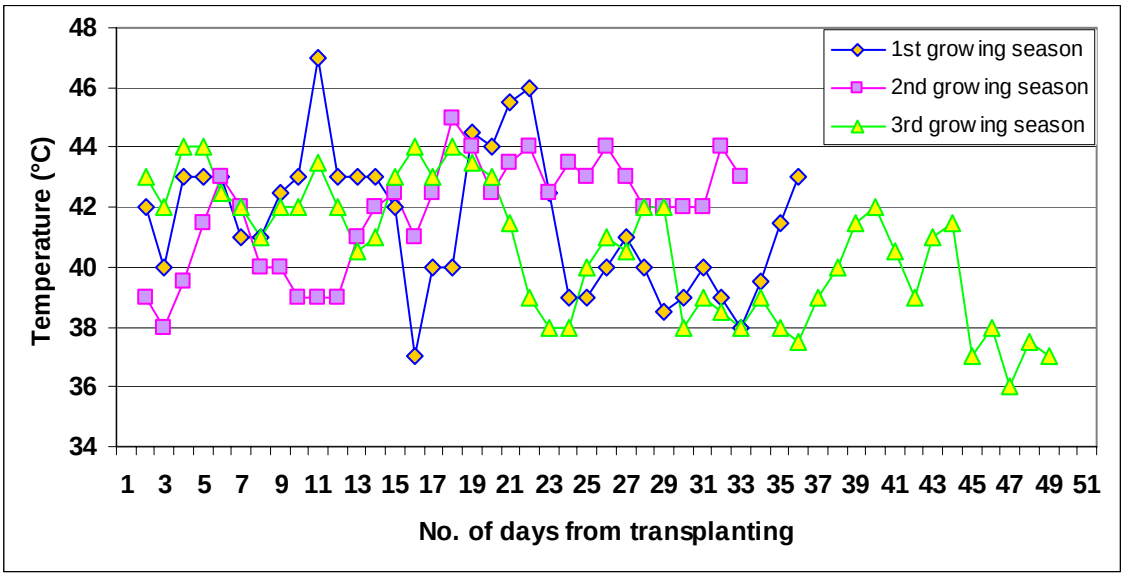

Figure (3): Maximum temperature during the growing season, Al- Yadoudeh area.

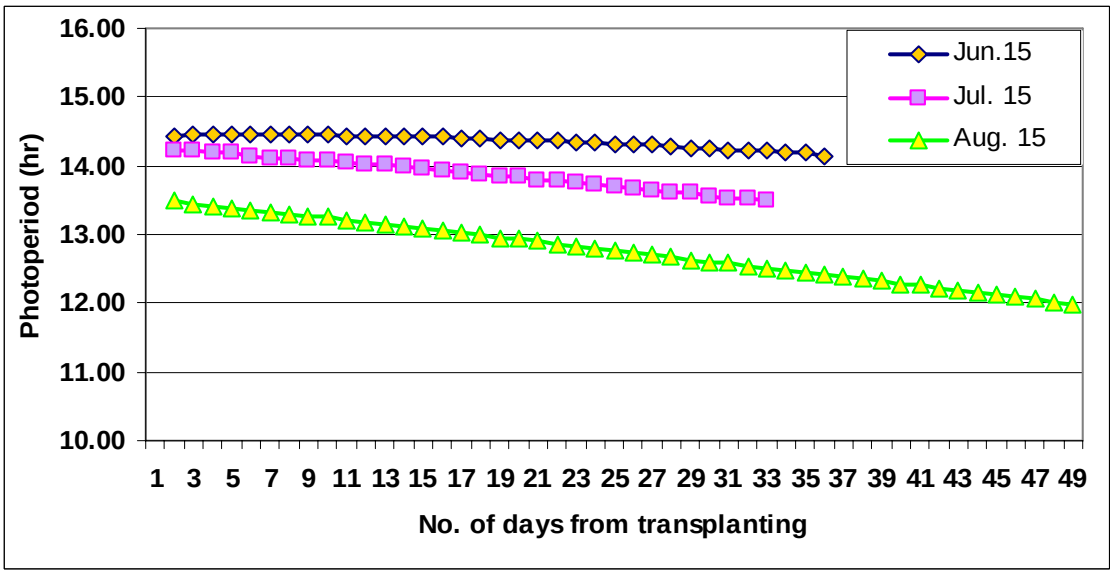

Figure (4): The photoperiod during the growing season, Al- Yadoudeh area.

دراسة تأثير مواعيد الزراعة المتأخرة ونوع الملش المستخدم على إنتاجية ونوعية رؤوس الخس

إعداد
ميس "محمد سعادة" صالح

المشرف
الدكتور عزمي أبو ريان

الملخص

أجريت تجربة حقلية في اليادودة لتقييم تأثير موعد الزراعة (15 حزيران، 15 تموز و 15 آب) ونوع الخس (آيسبرغ ورومين) وصنف الخس (صيفي وشتوي: "روبنسون" و "جوردان" للنوع آيسبرغ و"نادر" و "وايلد رومين" للنوع رومين) ونوع الملش (أسود وشفاف وبدون ملش) على إنتاج ونوعية محصول الخس خلال صيف 2003م.

قللت الزراعة في 15 آب من النسبة المئوية للإزهار المبكر وبدرجات متفاوتة حسب نوع الملش. وعند زراعة أيّ من الأصناف في 15 آب باستعمال أنواع الملش المختلفة ونقص الوزن الغض لرأس الخس ووزن الساق ونسبة وزن الساق إلى الوزن الغض ومساحة سطح الأوراق وعددها، وكان النقص غير معنوي مقارنة بموعدي الزراعة 15 حزيران و 15 تموز. في المقابل، كانت نسبة وزن الأوراق إلى الوزن الغض أعلى في 15 آب. وأدت زراعة "روبنسون" (سمر آيسبرغ) و"جوردان" (ونتر آيسبرغ) و "نادر" (سمر رومين) في 15 آب إلى وزن أوراق اقل من 15 حزيران و 15 تموز فيما أعطى "وايلد رومين" (ونتر رومين) عند زراعته في 15 آب أوراقا وزنها أعلى منها عند مواعيد الزراعة الأخرى.

وبشكل عام، كان نوع الخس رومين أكثر قابلية للإزهار المبكر من النوع آيسبرغ. وعند زراعة الخس رومين، أيضا كان وزن الرأس الغض ووزن السيقان والنسبة بين وزن السيقان إلى الوزن الغض ومساحة الأوراق وعددها أعلى منها في النوع آيسبرغ. ولم تكن هناك أية فروقات معنوية في عدد الأوراق للنوع آيسبرغ بين أنواع الملش ومواعيد الزراعة. وأعطى نوع الخس آيسبرغ عند جميع مواعيد الزراعة نسبة وزن أوراق إلى الوزن الغض ونسبة وزن أوراق إلى وزن سيقان أعلى منها في النوع رومين وبدرجة معنوية.

وعند جميع مواعيد الزراعة وبوجود أي ملش بلاستيكي أعطى "وايلد رومين" (ونتر رومين) أعلى نسبة إزهار مبكر ووزن سيقان وعدد أوراق عند المقارنة بالأصناف الأخرى.

عموما، وضمن النوع آيسبرغ، أعطى "جوردان" (ونتر آيسبرغ) أعلى وزن غض للرأس ووزن سيقان إلى الوزن الغض ومساحة أوراق وعدد أوراق من "روبنسون" (سمر آيسبرغ)، بينما كان وزن الرأس الغض ونسبة السيقان إلى الوزن الغض ومساحة الأوراق وعدد الأوراق في "وايلد رومين" (ونتر رومين) أعلى عند مقارنة ذلك ب "نادر" (سمر رومين).

وضمن النوع رومين وعند أي موعد زراعة نتج عن استعمال "نادر" زيادة في نسبة وزن الأوراق إلى الوزن الغض وفي نسبة وزن الأوراق إلى وزن السيقان عن "وايلد رومين" (ونتر رومين). أما ضمن النوع آيسبرغ فقد زادت النسب في "روبنسون" (سمر آيسبرغ) عنها في "جوردان" (ونتر آيسبرغ) زيادة طفيفة.

وعند زراعة أي صنف في 15 حزيران و 15 تموز بدون ملش زادت نسبة الإزهار المبكر ونقص الوزن الغض للرأس ووزن الأوراق ووزن السيقان ونسبة وزن السيقان إلى الوزن الغض وعدد الأوراق. ولم تحصل أية فروقات معنوية عند الزراعة في 15 آب.

وبناء على ما تقدم يوصى بزراعة أصناف الخس الصيفية باستعمال الملش الأسود في موعد الزراعة 15 آب وتحت ظروف مماثلة لظروف هذه التجربة.