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PROPER AGRONOMIC PRACTICES REQUIRED TO MAXIMIZE PRODUCTIVITY OF SOME MAIZE VARIETIES IN OLD AND RECLAIMED SOILS*:

VII- EFFECT OF SOIL MOISTURE STRESS ON THE PRODUCTIVITY OF SOME MAIZE HYBRIDS, UNDER NEWLY RECLAIMED SANDY SOIL CONDITIONS

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ABSTRACT

Two field experiments were performed at the Experimental Farm of Faculty of Agriculture, Zagazig University, in Khattara, Sharkia Governorate, during 2003 and 2004 growing seasons to study the effect of soil moisture stress (no stress, stress during reproductive growth, stress during vegetative growth and stress during both stages) on yield and its attributes of three maize hybrids (SC 10, SC 18 and TWC 310).

Results indicated that water stress all over maize growing season (I_4) or only at reproductive stage (I_2) significantly reduced plant height, ear length, ear diameter, number of grains/row, number of grains/ear and grain yield/fad compared with control (I_1) and water stress at vegetative growth (I_3).

The single cross 10 (SC 10) surpassed significantly the other hybrids in plant height, ear leaf area, number of grains/row, 100-grain weight and shelling %. Meantime SC 10 gave more yield than TWC 310, while SC 18 hybrid was statistically at par with the two hybrids.

The interaction effects showed that SC 10 was more sensitive for water stress during the late gross stage than the other two hybrids.

Keywords: Maize hybrids, moisture stress, clay and reclaimed sandy soils.

INTRODUCTION

Maize (*Zea mays*, L) is the third most important cereal crop in the world, after wheat and rice. It is widely used in bread making in rural areas of the country. It also forms the bases for several industries such as starch, fructose and corn oil; as well as the main component (about 70 %) of animal feed. Recently the governmental policy is to mix wheat flour (80 %) with corn flour (20 %) in bread making all over the country in order to reduce wheat imports. In Egypt the annual cultivated area with maize is about 1.5 to 2 million fad in the summer season with some recent variable declines of this area due to competition with rice.

Previous studies indicated that prolonging irrigation intervals led to decreased growth, yield and its components of maize (Grant *et al.*, 1989; El-Noemeni *et al.*, 1990; Ibrahim *et al.*, 1992; Abd El-Haleem, 1994 and El-Sheikh, 1994). Atta Allah (1996) found that maize cultivars varied in their response to irrigation intervals. Water stress caused significant reduction in

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grain yield and yield components of maize hybrids (Abd El-Mawgood *et al.*, 1999 in S_1 lines and El-Ganayni *et al.*, 2000 in 18 maize populations). Samira Hussein *et al.* (2000) determined water requirements of maize (SC10) under drip irrigation system in newly reclaimed sandy soil. The maximum yield/fad was obtained by applying 3360 m^3/fad per season. Drought conditions reduced grain yield, plant height, ear length, ear diameter and number of rows/ear in 10 single crosses and 10 three way crosses (Younis and Al-Aref, 2001). Drought adverse effect on grain yield varied depending on the stage of development at which it occured (Osman and Khalifa, 2001). Hero, Sharma and Upadhyay (1973) showed that the early vegetative growth stage (20-40 DAS) and tassling and silking (40-60 DAS) are the most critical stages where the effect of water stress is severe. Also, yield losses due to water stress could vary from one area or one season to another and could reach 50% or more (Mahgoub *et al.* 2001). Mahfouz (2003) indicated that water stress treatment (irrigation every 25 days) caused severe reduction in growth parameters, yield and yield components of ten hybrids except number of rows. Also, significant differences among hybrids were observed in growth, yield and yield components.

The present investigation was undertaken to study the response of some maize hybrids to irrigation intervals (water stress) under newly reclaimed sandy soil conditions.

MATERIALS AND METHODS

Two field experiments were carried out at the Experimental Farm of Faculty of Agriculture, Zagazig University, in Khattara Sharkia Governorate, during the two growing seasons (2003 and 2004), aiming at investigating the productivity of some maize hybrids as influenced by water stress during vegetative and reproductive growth stages in sandy soils. The studied factors were:

A-Water stress treatments:

1. I_1: Irrigation every 3 days up to100 days after sowing DAS (no stress)
2. I_2: Irrigation every 3 days up to 50 DAS and 6 days thereafter (stress during reproductive growth).
3. I_3: Irrigation every 6 days up to 50 DAS followed by irrigation every 3 days thereafter (stress during vegetative growth).
4. I_4: Irrigation every 6 days up to100 DAS (stress during both stages).

B- Maize hybrids:

1- SC 10 2-SC 18 3- TWC 310.

A split-plot design with three replicates was used in the two seasons. Water stress treatments were arranged in the main plots while maize hybrids were randomly distributed in the sub-plots.

Main plots were surrounded by wide border (1.5 m) to avoid seepage of water among irrigated and non irrigated plots. The sub-plot area was 16.8m^2 and consisted of 6 ridges 70 cm apart and 4 m long. After complete emergence (18 DAS), the crop was thinned to one plant per hill, in 30 cm apart.

The soil of experimental fields was sandy in texture. The mechanical and chemical analyses of the soil in both seasons are presented in Table 1.

Table 1: Soil mechanical and chemical analyses of the experimental fields (for the upper 30 cm of the soil surface).

Property	2003	2004
Mechanical analysis:		
Coarse sand %	48.57	47.33
Fine sand %	36.83	35.91
Silt %	6.25	6.91
Clay %	8.35	9.85
Chemical analysis:		
pH	7.8	7.9
T.S. S. mmhos (cm^2) at 25 ^0C	0.27	0.29
Organic matter	0.084	0.093
HCO3 ppm	529.3	541.6
CL^- ppm	172.6	169.3
SO^-_4 ppm	187.1	207.2
Ca^{++} ppm		
Available soil nutrients :		
N ppm	5.28	6.48
P_2O_5 ppm	3.82	4.09
K_2O ppm	96.16	108.36

The preceding crop was wheat in the two seasons. Super phosphate (15 5 P2O5) at the rate of 100 kg/fad and potassium sulfate (48 % K_2O) at the rate of 100 kg/fad were applied before sowing. Nitrogen as ammonium sulfate (20.6 % N) at the rate of 112 kg N/fad was added in four equal doses after 12, 24, 30 and 42 days after sowing. Maize was sown on May 26th and 22nd in the first and second seasons, respectively. The other agronomic practices were followed as recommended in the region.

Recorded data:

The two outer ridges (1st and 6th) were left as borders. The second two inner ridges were used for recording growth characters and to determination yield attributes.

A) Growth characters:

After 75 days from sowing, plant height (cm), ear height (cm), leaf area/plant (dm^2) and ear leaf area (cm^2) were measured using five guarded plants from each sub-plot.

B) Grain yield and its components:

At harvest, ten guarded plants were taken from the 2nd and 5th ridges of each sub-plot, then ear length (cm),ear diameter (cm), number of grains per both row and ear, 100-grain weight (g) and shelling percentage were recorded. Plants of the central two ridges were used to determine grain yield (ardab/fad), which was then adjusted at 15.5 % moisture content.

Statistical analysis:

The obtained data of both seasons were subjected to the proper statistical analysis according to Snedecor and Cochran (1980). For comparison of means, Duncan's multiple range test was used (Duncan, 1955).In interaction Tables capital and small letters were used to compare rows and columns means, respectively.

RESULTS AND DISCUSSION

1- Water stress treatments:

Results in Table 2 clear that irrigation treatments had a significant effect of plant height, ear height, leaf area/plant (dm^2) and ear leaf area (cm^2). This was true in both seasons and their combined analysis except plant and ear heights in the 1st season where the differences did not reach the level of significance. Data of the combined analysis indicate that water stress all over the season or during the reproductive stage shortened plant height. However, the stress all over the season lowered ear height as compared with stress induced at the reproductive stage. Moreover, unstressed plants followed by those stressed during the reproductive stage recorded larger leaf area/plant compared with the other two stress treatments. Also, water stress early in vegetative growth as in I_3 or all over the season I_4 decreased ear leaf area as compared with the other two treatments.

This is to be expected since water plays an important physical role in plants and moisture deficits can have a deleterious effect on most processes. Similar trend was reported by Ibrahim *et al.* (1992) and Mahfouz (2003).

It evident from data in Table 3 that the tried water stress treatments exhibited significant effects on ear length (cm) ear diameter (cm), number of grain/row and number of grains/ear. This was the same in both seasons and their combined except in ear length in the first season differences were not significant. Data of the combined analysis showed that ears of plants exposed to water stress all over the season were shorter and thinner than those of the control plants without stress, or those exposed to early stress during the first 50 days of growth (vegetative growth). However, water stress all over the season and during the reproductive stage hand decreased the number of grains/row and consequently numbers of grains/ear as compared with the rest both treatments. These results generally reflect the role of water during the reproductive stage in promoting the make up of sink units. These results are in harmony with those obtained by Ibrahim *et al.* (1992) and El-Ganayni *et al.* (2000).

Regarding the 100-grain weight, it is evident from Table 4 that the heaviest weight was recorded by the control plants (I_1) followed by those stressed during the early 50 days of growth (I_3), but without significant differences.

Table 2: Plant height, ear height, leaf area /plant and ear leaf area of some maize hybrids as affected by the water stress treatments in the two seasons and their combined.

Main effects and interaction	Plant height (cm)			Ear height (cm)			Leaf area/plant (dm^2)			Ear leaf area (cm^2)		
	2003	2004	Comb.	2003	2004	Comb.	2003	2004	Comb.	2003	2004	Comb.
Water stress treatments (I):												
I_1 -No stress	225.8	272.0^{a}	248.9^{a}	88.9	124.1^{a}	106.5^{ab}	77.39^{a}	64.44^{a}	70.92^{a}	631.9^{a}	606.9^{ab}	619.4^{a}
I_2-Stress during reproductive growth	221 1	266.6^{a}	243.9^{b}	94.2	122.4^{a}	108.3^{a}	71.04^{b}	55 42^{b}	63.23^{b}	604.7^{b}	621.9^{a}	613.3^{a}
I_3-Stress during vegetative growth	227.5	270.0^{a}	248.8^{a}	89 2	122.3^{a}	105.8^{ab}	63.64^{c}	51.66^{c}	57.65^{c}	579.0^{c}	568.2^{c}	573.6^{b}
I_4- Stress during both stages	227.0	260.4^{b}	243.7^{b}	92.4	112.2^{b}	102.3^{b}	59.51^{d}	48.87^{d}	54.19^{c}	553.0^{d}	582.9^{bc}	568.0^{b}
F-test	N. S.	*	*	N. S.	**	*	**	**	**	**	*	**
Maize hybrids(H):												
SC 10	232.6^{a}	268 4	250.5^{a}	88.6^{b}	122.8	105.7	70.66^{a}	55.85	63.26^{a}	627.4^{a}	588.8	608.1^{a}
SC 18	226.5^{b}	266.0	246.3^{b}	91.3^{ab}	119.2	105.3	68.78^{a}	53.56	61.17^{ab}	576.1^{b}	601.5	588.8^{b}
TWC 310	216.9^{c}	267 3	242.1^{c}	93.6^{a}	118.7	106.2	64.26^{b}	55.88	60.07^{b}	572.9^{b}	594.7	583.8^{b}
F-test	**	N. S.	**	*	N S.	N. S	**	N. S.	*	*	N. S.	*
Interaction: I x H	*	N. S.	N. S.	*	N. S.	N. S.	N. S.	N. S.	N. S.	N. S.	N. S.	N. S.

Table 3: Ear length and diameter, number of grains per row and ear of some maize hybrids as affected by the water stress treatments in the two seasons and their combined.

Main effects and interaction	Ear length (cm)			Ear diameter (cm)			Number of grains/row			Number of grains/ear		
	2003	2004	Comb.	2003	2004	omb.	2003	2004	Comb.	2003	2004	Comb.
Water stress treatments(I):												
I_1 -No stress	20.64	17.22^{a}	18.93^{a}	4.16^{a}	3.47^{ab}	3.81^{a}	42.79^{a}	42.53^{a}	42.66^{a}	563.7^{a}	542.8^{a}	553.3^{a}
I_2-Stress during reproductive growth	19.33	17.24^{a}	18.28^{ab}	4.10^{a}	3.37^{ab}	3.73^{ab}	41.13^{b}	40.63^{b}	40.88^{b}	520.9^{b}	531.9^{a}	526.4^{b}
I_3 -Stress during vegetative growth	19.73	17.68^{a}	18.70^{a}	4.11^{a}	3.52^{a}	3.82^{a}	42.73^{a}	41.93^{ab}	42.33^{a}	573.6^{a}	546.9^{a}	560.2^{a}
I_4- Stress during both stages	19.56	16.31^{b}	17.93^{b}	3.89^{b}	3.21^{b}	3.55^{b}	41.11^{b}	38.48^{c}	39.80^{b}	537.8^{b}	500.5^{b}	519.2^{b}
F-test	N. S.	**	*	*	*	*	*	**	**	**	*	**
Maize hybrids(H):												
SC 10	20.53	17.03	18.78	3.97	3.38	3.67	45.47^{a}	41.25	43.36^{a}	557.8^{a}	530.9	544.4^{a}
SC 18	19.62	17.98	18.80	4.18	3.40	3.79	41.18^{b}	40.64	40.91^{b}	556.3^{a}	527.9	542.1^{a}
TWC 310	19.30	16.33	17.80	4.05	3.40	3.72	39.17^{c}	40.80	40.00^{b}	532.9^{b}	532.8	532.9^{b}
F-test	N. S.	N. S.	N. S.	N. S.	N. S.	N. S.	**	N. S.	**	**	N. S.	*
Interaction: I x H	N. S.	N. S.	N. S.	N. S.	N. S.	N. S.	N. S.	*	*	*	*	**

Table 4: 100-grain weight, shelling percentage and grain yield of some maize hybrids as affected by the water stress treatments in the two seasons and their combined.

Main effects and Interaction	100-grain weight (g)			Shelling percentage			Grain yield (ard/fad)		
	2003	2004	Comb.	2003	2004	Comb.	2003	2004	Comb.
Water stress treatments(I):									
I_1 -No stress	27.21^{a}	27.96^{a}	27.58^{a}	86.41^{a}	84.96	85.68^{a}	21.35^{a}	17.73^{a}	19.54^{a}
I_2-Stress during reproductive growth	25.54^{b}	26.36^{b}	25.95^{b}	84.56^{b}	84.32	84.44^{b}	14.43^{c}	14.03^{b}	14.23^{c}
I_3 –Stress during vegetative growth	26.17^{ab}	27.35^{a}	26.76^{ab}	83.09^{c}	85.22	84.15^{b}	16.98^{b}	17.13^{a}	17.06^{b}
I_4- Stress during both stages	24.44^{c}	24.91^{c}	24.67^{c}	83.93^{c}	84.41	84.17^{b}	17.08^{b}	12.90^{c}	14.99^{c}
F-test	**	**	**	**	N. S.	**	**	**	**
Maize hybrids(H):									
SC 10	27.25^{a}	27.61^{a}	27.43^{a}	85.82^{a}	85.44^{a}	85.63^{a}	18.98^{a}	15.92^{a}	17.45^{a}
SC 18	25.88^{b}	26.55^{b}	26.21^{b}	84.11^{b}	84.26^{b}	84.18^{b}	17.51^{b}	15.77^{a}	16.64^{ab}
TWC 310	24.40^{c}	25.77^{c}	25.08^{c}	83.57^{b}	84.48^{b}	84.02^{b}	15.89^{c}	14.66^{b}	15.27^{b}
F-test	**	**	**	**	*	**	**	**	**
Interaction:									
I x H	N. S.	**	**	*	N. S.	*	**	**	**

The lowest 100-grain weight was recorded by the whole season water stressed plaints (I_4) followed by those stressed during the late 50 days of growth I_2 Similar results were also obtained by Ibrahim *et al.* (1992) and El-Ganayni *et al.* (2000).

The results are rather expected as early water stressing did not reflect a significant adverse effect on grain filling as expressed herein in the 100-grain weight. This stress didn't, also, affect the number of grains / ear (Table 3) but however, decreased significantly the leaf area / plant (Table 2).

Shelling percentage was significantly influenced by water stress (Table 4). The control treatment recorded significantly higher shelling percentage than the other irrigation treatments. The differences did not reach the level of significance in the second season Samira Hussein *et al.* (2000) indicated that irrigation significantly affect on shelling % under sandy soil conditions.

Two different trends were obtained in the two seasons regarding grain yield /fad. In the first season, the early water stressed plants (I_3) produced the lowest yield average, whereas in the second season the lowest average was recorded by I_4 where water stress was imposed on maize plants for 100 days. In both seasons, the highest yield was recorded by the control plants but without significant difference with I_3 in the second season. However, the combined analysis ascertained the superiority of the control plants followed with significant difference by the I_2 plants where stress was practiced early in growing season. The lowest grain yield was recorded by the continuously water stressed plants (I_4) without significant difference with I_2 where plants were stressed late in the season.

It is clear from the above mentioned results that irrigation maize crop every 3 days afforded plants with adequate soil moisture content than any other irrigation treatments. Prolonging the irrigation interval to 6 days induced water stress. The question which arises here, whether the early water stress during vegetative growth was more adversely affecting the productivity of maize plants or equally effective as late water stress during the reproductive growth. These results gave an answer. If moisture stress took place late during the reproductive growth it had more adverse effect early water stress during vegetative growth stage. Moreover, when the stress was imposed during both growth stages (I_4),it produced as much grain yield as I_2 when water was imposed late during the season .Moreover, the moisture stress during the vegetative growth stage (I_3) gave yield components equal to those of the control I_1. This was observed with ear length, ear diameter and number of grains/row and ear. 100-grain weight showed similar behavior, but shared the position of I_2 indicating that the reduction in grain yield of I_3 was mainly due to trends of reductions in these components, but the differences did not reach the levels of significance. These results are in harmony with those obtained by Abd El-Mawgood *et al.* (1999), El-Ganayni *et al.* (2000), Mahgoub *et al.* (2001) and Younis and El-Aref (2001). Also, Mahfouz (2003) indicated that irrigation stress caused severe reduction in the value of growth, yield and yield components.

b) Hybrids variation:

The single cross 10 (SC 10) cultivar was significantly taller than SC 18 and both were taller than TWC 310. They did not differ in their ear height. SC 10 cultivar had greater leaf area/plant than TWC 310 or SC 18 which did not differ from each other.

The three hybrids gave similar ears in both length and diameter. SC 10 had more grain number /row than the other two hybrids and TWC 310 was inferior in number of grains/ear to the other two. SC 10 was also superior to SC18 in its 100-grain weight. But the latter had heavier 100-grain weigh than TWC 310 cultivar. SC 10 was also superior in its shelling % than the other two hybrids.

All these variations i.e. in growth and yield attributes led the SC 10 to give more yield than TWC 310, while SC 18 hybrid was significantly at par with the other two hybrids. This superiority in yield and its attributes of SC 10 may be due to its genetically make up. These results are in agreement with those obtained by Atta Alla (1996), Abd El-Mowgood *et al.* (1999), Hassan and Gaballah (1999), El-Ganayni *et al.*, (2000), Younis and El-Aref (2001) and Mahfouz (2003).

2) Effect of the interaction:

Some interactions were statistically significant, but no additional information could be added to the main effects except that interaction effect of both factors of study on grain yield (Table 5)

Table 5: **Grain yield (ard/fad) as affected by the interaction between water stress treatments and maize hybrids (combined analysis).**

Water stress treatments:	Maize hybrids		
	SC 10	S C 18	TWC 310
	A	B	C
I_1	21.91a	19.63a	17.10a
	AB	A	B
I_2	14.03d	15.00c	13.65c
	A	A	A
I_3	17.04b	17.31b	16.81b
	A	AB	B
I_4	15.83c	14.65c	14.48c

It is quite evident from Table5 that SC10 was more sensitive than the other two hybrids to water stress treatments. In this cultivar differences in grain yield / fad were significant among the four irrigation treatments. The late water stressed plants (I_2) produced the lowest grain yield followed by the continuous water stressed ones (I_4). However, the highest yield was recorded by the control plants followed by those stressed during the early 50 days of growth. In the other two hybrids I_2 or I_4 produced at par lower yield than either I_1 or I_3 where the former produced higher grain yield than the latter .

The results clearly indicate that high yielder genotypes of maize (SC10) where more adversely affected by water stress than low yielder ones. The data further indicate that the formers SC10 were more adversely affected by late water stress during grain filling to the extent that the whole season water stressed plants produced higher grain yield. This could refer to a better balance between the sources and sink in the whole season water stressed plants, than in the late water stressed ones.

The data further indicate that grain filling in SC10 was form current rather than stored assimilates to a greater extent than in either SC18 or TWC310. Below *et al.* (1981) reported that current assimilates contributed from 70 to more than 90% of grain filling in maize. They added that this contribution was, always, higher in the high yielding genotypes than in low yielder ones. Under the present study, SC10 recorded higher grain yield than the other two hybrids. Therefore, the contribution of current assimilates to grain yield might have had been higher in the former than in the latter according, prolonging the irrigation interval to 6 instead of 3 days during the last 50 days of growth, adversely affected photosynthesis and hence photosynthesis availability for grain filling. This adverse effect was more pronounced in SC10 than in SC18 or TWC 310. This could account for the more decrease of grain yield in this hybrid when water stress was imposed during the last 50 days of growth where most of grain filling was taking place.

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العمليات الزراعية المناسبة لتعظيم إنتاجية بعض أصناف الذرة الشامية فى الأراضي الجديدة والقديمة:

٧- تأثير الإجهاد الرطوبي علي إنتاجية بعض هجن الذرة الشامية تحت ظروف الأراضي الرملية المستصلحة حديثا

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أقيمت تجربتان حقليتان في المزرعة البحثية التابعة لكلية الزراعة – جامعة الزقازيق بمنطقة الخطارة التابعة لمحافظة الشرقية خلال موسمي النمو ٢٠٠٣ و ٢٠٠٤ لدراسة تأثير الإجهاد الرطوبي (بدون اجهاد رطوبي أومقارنة – اجهاد رطوبي في مرحلة التكاثر" طرد النورات و امتلاء الحبوب" – إجهاد رطوبي في مرحلة النمو الخضري ، إجهاد رطوبي في كلا المرحلتين) علي النمو و المحصول ومساهماته لثلاثة هجن من الذرة الشامية (هجين فردي ١٠ ، هجين فردي ١٨ ، هجين ثلاثي ٣١٠) و قد تم استحداث الاجهاد الرطوبي عن طريق اطالة فترة الري الي ٦ بدلا من ٣ ايام . ويمكن تلخيص أهم النتائج المتحصل عليها كما يلي:

١- أدت معاملة الإجهاد الرطوبي خلال مرحلتي النمو (I_4) أوالإجهاد الرطوبي خلال مرحلة التكاثر (I_2) إلي نقص معنوي في ارتفاع النبات ، طول الكوز ، قطر الكوز ، عدد الحبوب / سطر ، عدد الحبوب / كوز ومحصول حبوب الفدان بالمقارنة بمعاملة الري بدون إجهاد رطوبي (I_1) وكذلك بمعاملة الإجهاد الرطوبي في مرحلة النمو الخضري (I_3) .

٢- تفوق الهجين الفردي ١٠ معنويا علي الهجينين الأخرين في ارتفاع النبات ، مساحة ورقة الكوز ، عدد الحبوب / سطر ، ووزن المائة حبة ونسبة التفريط. وأعطي الهجين فردي ١٠ محصول حبوب للفدان أعلي من الهجين الثلاثي ٣١٠ بينما لم يختلف الهجين الفردي ١٨ معنويا عن الهجينين الآخرين .

٣- أشارت تأثيرات التفاعل بين معاملات الإجهاد الرطوبي وهجن الذرة الشامية إلي تفوق محصول الهجين الفردي ١٠ علي الهجينين الأخرين وتفوق الهجين الفردي ١٨ علي الهجين الثلاثي ٣١٠ تحت ظروف معاملة الكنترول (بدون حدوث إجهاد رطوبي) و ان هذا الهجين (فردي ١٠) كان اكثر حساسية للاجهاد الرطوبي خلال مرحلة التكاثر مقارنة الهجينين الآخرين .

توصي هذه الدراسة تجنب تعريض نباتات الذرة المزروعة تحت ظروف الأراضي الرملية المستصلحة حديثا للإجهاد الرطوبي خلال مرحلة التكاثر (طرد النورات حتي تمام امتلاء الحبوب) علي وجه الخصوص للهجن عالية الانتاج.

مستخلص من المشروع الممتد رقم ١٢/م/ش والممول من المجالس الإقليمية للبحوث والإرشاد دعم من الجانب الفرنسى للعام المالى ١٩٩٨/٩٧.