Evaluation of the role of Gibberellin and Cytokinin in Regulation of Seed Setting and Seed Filling in Sunflower plant (*Helianthus annuus* L.)

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Abstract

Sunflower yield is determined by seed (kernel) number / m^{-2} and by achene (fruit) weight. Two pot experiments were carried out during two successive seasons to investigate localized effect of GA, Kinetin or mixture of both on sink site and filling in tow cultivars of sunflower plant. The experiment was laid out in a completely randomized block design in a factorial arrangement with tow cultivars (Flame and Euroflore) and four plant growth regulators treatments ((Control , GA3 ,Kinetin and (GA3 +Kinetin)) with four replications . GA 200 ppm, Kinetin 200 ppm and (GA 200+Kinetin 200) ppm each were applied to the buds at opening stage (45 after sowing). Comparable plants in control were treated with distilled water. At maturity, heads were divided into four equal parts across the center. Each of these four parts was further divided into 1 /3 equal portions i. e. peripheral, middle and central. Data were recorded on seed weight, number of total seeds and filled seeds for each portion, then percent increase in number of seed, percent increase in number of filled seed و percentage of filled seed and mean weight of seed were calculated.

For both cultivars plant growth regulator (PGRs) applications gave higher number of total seeds, number of filled seeds and percentage of filled seed in all the three portions and improved mean of seed weight in both seasons and as a mean of seasons as compared to their respective controls. The most effective treatment was (GA 200 + Kinetin 200) ppm. Flame cultivar was superior over Euroflore in number of total seeds, number of filled seeds and percentage of filled seeds in all the three portions and in mean of seed weight in both seasons and as a mean of seasons.

Key words: Sunflower, GA, Kinetin, Seed setting, seed filling

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Introduction

Seed setting and filling problem is one of the most important constraints in sunflower production and often considered to be a major reason for low productivity. Besides poor agronomic management, there are several genetic, physiological and environmental factors causing poor seed setting and filling in sunflower. The fruit (grain) of the sunflower is formed by the pericarp (hull), which comprises between 20 and 25% of the fruit weight, and the kernel or seed (mostly embryo) where the largest proportion of lipids and dry matter is stored (Connor and Hall, 1997) A developmental model of sunflower's seed can be defined by three sequential phases (Lindstrom *et al*., 2002). The initial phase (Phase I), up to 10 days after anthesis, includes fertilization, the period of active cell division and a slow increase of the dry weight. Here, the anatomy of the embryo structures is defined and the final number of embryo cells is fixed (Lindstrom *et al*., 2002). Also during this phase the pericarp completes its development (Connor and Hall, 1997, Lindstrom *et al*., 2002). Next follows an intermediate phase (Phase II), where there is an increase of cell volume and a rapid accumulation of dry matter in the seed. In the final phase (Phase III) maximum seed weight is achieved and the fruit reaches physiological maturity. In the sunflower capitulum, there is a developmental and growth gradient, which progresse from the fruits at the periphery towards those at its center. So, the effect of any environmental stress, while the reproductive development is in progress, will not be similar for the fruits at the different positions on the capitulum. For example, Yegappan *et a*l. (1982) observed that water stress in post-anthesis reduced the weight of the central seeds and not that of the fruits at the capitulum periphery whereas Cantagallo *et al*. (2004) found that pre-anthesis shading only affected the weight of the fruits at the peripheral and mid positions on the capitulum. The developmental status reached by the pericarp before anthesis could limit the subsequent seed growth and development and, consequently diminish the final fruit weight (Egli *et a*l., 1987). Cantagallo *et al*. (2004) found in sunflower that the carpel weight at anthesis was related to the final weight of the fruit. Empty achenes consist of a pericarp (fruit wall), testa (seed coat), endosperm and a rudimentary embryo, if present at all. Incomplete seed development is frequently found in the capitulum centre. However, the physiological basis of seed set is poorly understood. The sensitive period for seed number determination lasts from floral initiation to first stages of seed filling, corresponding approximately to an interval between 30 d before and 20 d after the beginning of anthesis (Cantagallo *et al*. ,1997). This period covers a major part of the life span of the sunflower, including different simultaneous and sequential processes of ontogeny: Leaf differentiation and expansion; root and stem development; floret differentiation, sporogenesis, flowering, pollination, fertilization, early stages of embryogenesis and seed filling. Thus, not surprisingly, several factors influence seed development. Floral initiation determines the maximum number of florets and seeds that can be produced. The number of floret primordia depends on the availability of nutrients (Palmer and Steer , 1985) , water (Yegappan *et a*l. ,1982), temperature (Chimenti and Hall ,2001), radiation (Cantagallo and Hall , 2002) and day length (Palmer and Steer , 1985). Empty achenes result from disturbed growth following floral initiation. Defective fertilization due to extreme temperatures (Rawson *et a*l., 1984), self-incompatibility (Saranga *et al*., 1996) or the lack of pollination (Nur, 1978) increases the percentage of empty achenes directly. In contrast, water supply (Yegappan *et a*l., 1982), mineral nutrients (Steer *et al*., 1988), radiation (Dosio *et a*l., 2000); hormones and plant growth regulators (Vasudevan et *a*l., 1996) have multiple effects on whole plant physiology, influencing seed development indirectly. An increased source size per seed was always accompanied by a reduced percentage of empty achenes and increased dry matter per achene, whereas a lowered source–sink ratio caused the opposite result (Alkio *et al*., 2003) If these reactions are considered as a consequence of photoassimilate translocation, they support the view that seed development in sunflower is source limited (Alkio *et al*., 2003),. This is in contrast to the hypothesis that the amounts of photo-assimilates generally do not limit grain filling (Richards ,2000). Sunflower yield is determined by seed number/m^{-2} and by achene weight. Frequently, a high percentage of empty achenes in the inner portion of the capitulum, probably due to a reduced vascularization of that section of the flower head, decreases final yield. During seed filling, maximum import of photoassimilate appeared in intermediate whorls, while central whorls always exhibited the lowest import leading to poor seed filling (Alkio *et al*., 2002; Alkio *et al*., 2003).

Plant growth regulators (PGRs) have the capacity to modify every phase of plant growth spanning from seed germination to crop maturity. Since most plant growth and seed development processes are regulated by natural plant hormones, many of these processes might be manipulated either by altering the endogenous hormone level or by changing the capacity of the plant to respond to its natural hormones. It is well known that plant hormones are involved in grain filling and seed development (e.g. Yang *et al*., 2002b, and 2003b).

It was generally recognized that the role for GA, IAA, and ABA lies mainly in the seed filling, whereas CKs are most important in the early stages of seed set (Hess *et al.*, 2002). Studies conducted by Chinnamuthu *et al*. (2000) revealed that spraying Brassinolide 1 ppm (S3) at the ray floret opening stage led to the highest filled seeds percentage and was superior to other seed setting treatments. Shukla *et al*. (1987) summarized results for other researchers that gibberellins effect on translocation of photosynthates, flowering, fruit set, length and fresh weight of pistils and strength of the sink. The effects of GA3 application on flowering of sunflower and rice showed early flowering (Awan *et al*., 1999). The combined doses of GA3 + IAA and GA3 + kinetin should early flowering which was accompanied by more number of flowers in comparison to control; this clearly indicated the effect of GA3 and kinetin on the initiation of flowering. Furthermore, the threshold required for flowering may have been acquired earlier with the combination of these three hormones (Fulailin, 2004).

Evidence from soybean, maize, rice, barley, and wheat implicates CKs as promoters in establishing sink potential at early stages of reproductive development. CKs can increase sink strength by promoting cell division in the young ovaries, and this may redirect movement of assimilates into treated tissues, increase growth rates of the developing ovaries and thereby decrease the rates of abortion (Lur and Setter, 1993; Dietrich *et al.*, 1995) .Beltrano *et al*. (1994) found for both seasons and hybrids BA 150 mg/l + GA 150 mg/l applied at 40 days after emergence significantly reduced the percentage of empty achenes, increased achene weight, achene weight (× 1000) and achene number in the inner portion of the capitulum and in the middle and outer portion . And a distribution model was showing that preferential allocation of photoassimilates in the outer portion of the capitulum can be modified by PGR application, demonstrating that photoassimilate distribution is under hormonal control.

In the work presented here efforts have been made to study the effect of exogenous application of GA_3 , Kinetin and mixture of both on seed setting and seed filling in sunflower capitulum .

Materials and methods

Cultivars and Growth

The present study was conducted to examine the role of gibberellin and kinetin and mixture of both in regulation of seed setting and seed filling in two sunflower cultivars (Flame and Euroflore). Ten well filled seeds were sown in each plastic pot of 0. 75 *0.50 * 0.45 m size filled with soil. Finally four plants were maintained in each pot. The crop was managed according to the recommended conventional agronomical practices. The soil used was silt .Soil texture: sand (17)% clay (19.5)% and silt (63.5)% , organic matter (1.1) % were carried out in Dept. of Laboratories, Ministry of Water Resources. The electrical conductivity (Ec) (3.95) ms , pH (6.2), the other contents of the soil were as follows: N (25) % , P (1.2) % , K (72) % , Mg (0.8) ppm or Fe (0.02) ppm were conducted in the Central Laboratory ,Dept. of Biology, College of Science , Baghdad University.

Treatments and Design

The experiment was laid out in a completely randomized block design in a factorial arrangement with tow cultivars (Flame and Euroflore) and four plant growth regulators treatments ((Control (water spray) , GA_3 ,Kinetin and (GA_3 +Kinetin)) with four replications . GA3, Kinetin or (GA3 +Kinetin) were applied on the inner surface of the head on the day of its opening, at pre anthesis stage 45 day after sowing .Ten ml of 200 ppm of each treatment was used with the help of cotton on each head . Control plants were treated in the similar way with 10 ml of distilled water.

Measurements

On maturity, each harvested head was divided into four equal parts across the center. Each of these four part was further divided into 1/3 equal portions i.e. peripheral, middle and central. Data were recorded on seed weight, number of total seeds and filled seeds for each portion, then percent increase in number of seed, percent increase in number of filled seed و percentage of filled seed and mean weight of seed were calculated.

Statistical analysis

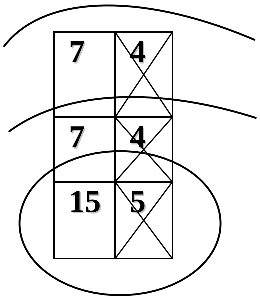
To determine the differences between treatments, the experimental results of each variable were processed by analysis of variance and differences between treatment means were evaluated with LSD test.

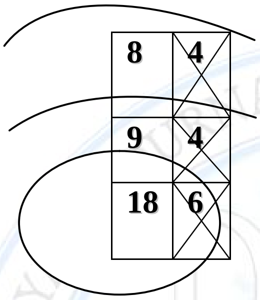
Results and Discussion

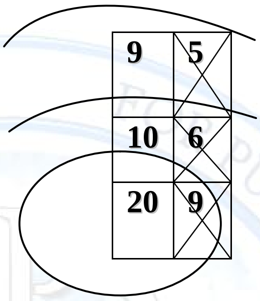
Spatially varying percentages of empty achenes and achene masses indicate an uneven seed set and filling in the sunflower capitulum, respectively. Empty achenes are found in all parts of the capitulum (figure 1) although they occur much more rarely in the periphery than in the centre. Poor vascularization has been proposed to explain the poor seed set in the central part of the capitulum (Connor and Hall , 1997). An increased source size per seed was always accompanied by a reduced percentage of empty achenes and increased dry matter per achene, whereas a lowered source–sink ratio caused the opposite result (Alkio *et al*., 2003). Data revealed different sensitivities of seed set and seed filling , percentages of empty achenes were considerably affected in the capitulum centre, but not in the periphery (figure 1) .

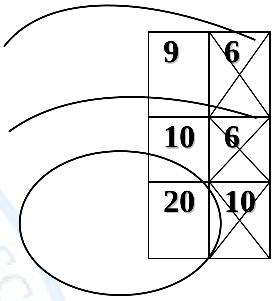
First season

Control **GA** **Kinetin** **(GA+Kinetin)**

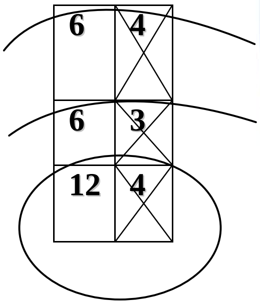


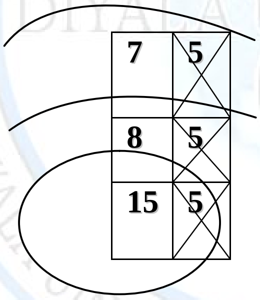


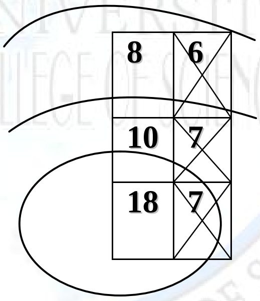


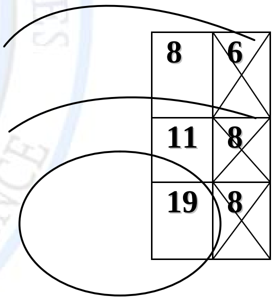


Euroflore







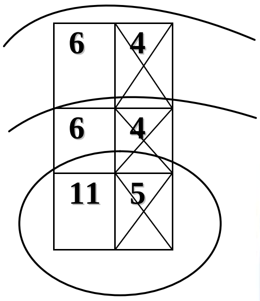


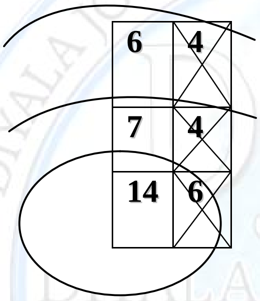
Flame

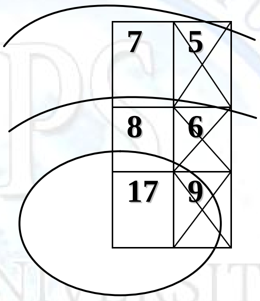
Total number of seed / square centimeter ☐

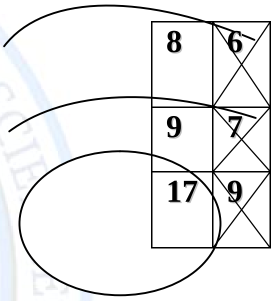
Number of filled seed / square centimeter ☒

Second season

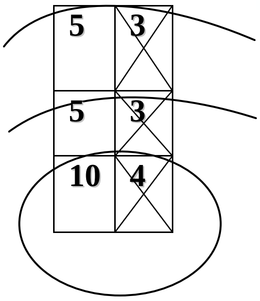


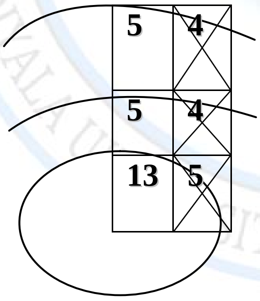


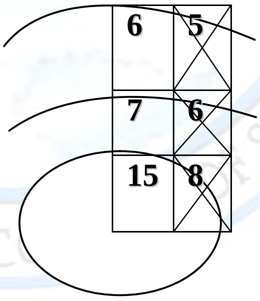


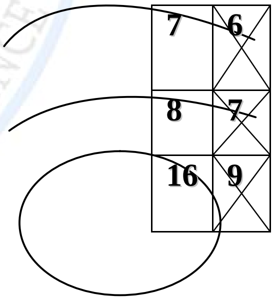


Euroflore









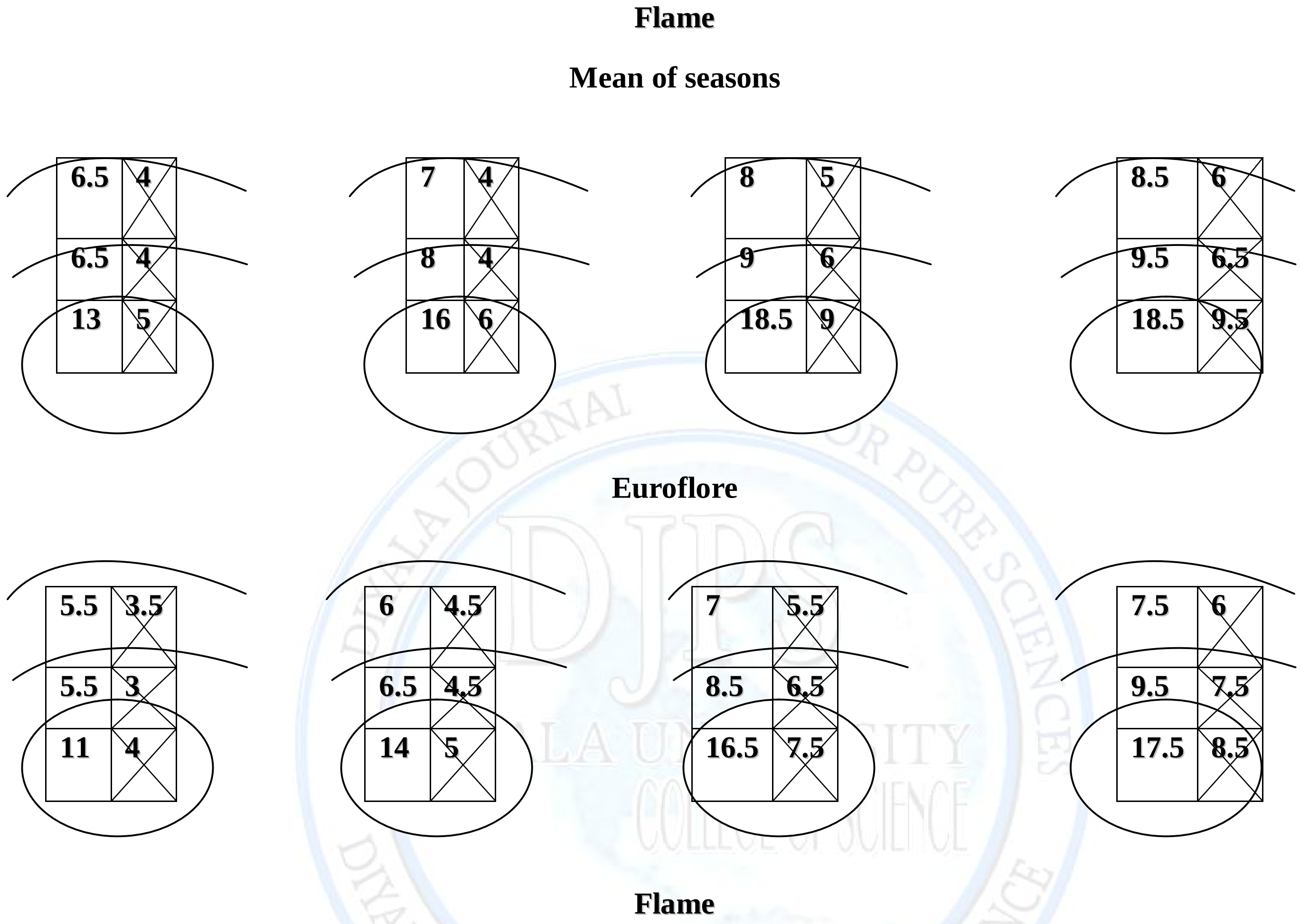


Figure 1. Effect of GA ,Kinetin and both (GA+ Kinetin) on total and filled number of seeds in central, middle and peripheral portions of head in tow cultivars of sunflower plant in tow seasons and as a mean of seasons.

Data on number of seeds per square centimeter gave increase in total number of seeds in GA3 , kinetin and (GA3 + kinetin) treated heads in both the cultivars as compared to their respective control for tow cultivars at both seasons and as mean of seasons (figure 1,table 1) . GA3 treated heads gave a slight increase in the number of filled seeds , whereas heads treated with kinetin or (GA3 + kinetin) gave high increase in the number of filled seeds as compared to control for tow cultivars at both seasons and as mean of seasons (figure 1 , table 1) . It was generally recognized that the role for GA, IAA, and ABA lies mainly in the seed filling, whereas CKs are most important in the early stages of seed set (Hess *et al.*,2002).

Data presented in table 1. showed that the cultivar Flame produced large number of seeds by GA , kinetin or (GA + kinetin) application in different portions as compared to the cultivar Euroflore in both seasons and as mean of seasons .Both cultivars produced large number of seeds in the central portion and minimum in the peripheral portion .

Table 1. Percent increase in total number of seed by plant growth regulators application over control in different portions of sunflower capitulum .

Cultivars	Treatment	Center	Middle	Periphery	Mean of treatment	Mean of cultivars
			First season			
Euroflore	GA	20.00	28.58	14.29	20.96	30.23
	Kinetin	33.33	42.56	28.56	34.82	
	GA+ Kinetin	33.33	42.86	28.56	34.92	
Flame	GA	25.00	33.33	16.67	25.00	47.28
	Kinetin	50.00	66.67	33.33	50.00	
	GA+ Kinetin	58.33	83.88	58.33	66.85	
Mean		36.67	49.65	29.96		
LSD 0.05		[	5.66	]	[8.44]	[4.44]
			Second season			
Euroflore	GA	27.27	16.67	00.00	14.65	31.82
	Kinetin	54.55	33.33	16.67	34.85	
	GA+ Kinetin	54.55	50.00	33.33	45.96	
Flame	GA	30.00	00.00	00.00	10.00	33.33
	Kinetin	50.00	40.00	20.00	36.67	
	GA+ Kinetin	60.00	60.00	40.00	53.33	
Mean		46.06	33.33	18.33		
LSD 0.05		[	7.65	]	[5.46]	[N.S]

Mean of seasons

Euroflore	GA	23.64	22.63	7.15	17.81	31.03
	Kinetin	43.94	37.95	22.62	34.84	
	GA+ Kinetin	43.94	46.43	30.95	40.44	
Flame	GA	27.50	16.67	8.34	17.50	38.92
	Kinetin	50.00	53.34	26.67	43.34	
	GA+ Kinetin	59.17	71.94	36.67	55.93	
Mean		41.37	41.49	22.07		
LSD 0.05		[	3.16	]	[4.37]	[3.97]

A similar trend was observed in case of filled seeds . Maximum increase in filled seeds

were obtained in the middle and central region , while they were minimum increase in the peripheral region in both seasons (table 2) . Cultivar Flame was superior over cultivar Euroflore in number of filled seeds in both seasons and as mean of seasons (table 2) . Kinetin and (GA + Kinetin) gave the highest increase in filling seed for tow cultivars at both seasons and as mean of seasons (table 2). During seed filling, maximum import of photoassimilate appeared in intermediate whorls, while central whorls always exhibited

the lowest import leading to poor seed filling (Alkio *et al*., 2002; Alkio *et al*., 2003). CKs concentrations increase after fertilization in many species when rapid cell division is occurring (Lur and Setter, 1993). Evidence from soybean, maize, rice, barley, and wheat implicates CKs as promoters in establishing sink potential at early stages of reproductive development (Lur and Setter, 1993; Dietrich et al., 1995) .

Table 2. Percent increase in number of filled seed by plant growth regulators application over control in different portions of sunflower capitulum .

Cultivars	Treatment	Center	Middle	Periphery	Mean of treatment	Mean of cultivars
			First season			
Euroflore	GA	20.00	00.00	00.00	6.67	41.11
	Kinetin	80.00	50.00	20.00	50.00	
	GA+ Kinetin	100.00	50.00	50.00	66.67	
Flame	GA	25.00	66.67	25.00	38.89	76.85
	Kinetin	75.00	133.33	50.00	86.11	
	GA+ Kinetin	100.00	166.67	50.00	105.56	
Mean		66.67	77.78	32.50		
LSD 0.05		[	10.11	]	[19.55]	[6.77]
			Second season			
Euroflore	GA	20.00	00.00	00.00	6.67	42.22
	Kinetin	80.00	50.00	25.00	51.67	
	GA+ Kinetin	80.00	75.00	50.00	68.33	
Flame	GA	25.00	33.33	33.33	30.55	79.63
	Kinetin	100.00	100.00	66.67	88.89	
	GA+ Kinetin	125.00	133.33	100.00	119.44	
Mean		71.67	65.28	45.83		
LSD 0.05		[	7.54	]	[21.11]	[5.98]
			Mean of seasons			
Euroflore	GA	20.00	00.00	00.00	6.67	41.67
	Kinetin	80.00	50.00	22.50	50.83	
	GA+ Kinetin	90.00	62.50	50.00	67.50	

Flame	GA	25.00	50.00	29.17	34.72	78.24
	Kinetin	87.50	116.67	58.34	87.50	
	GA+ Kinetin	112.50	150.00	75.00	112.50	
Mean		69.17	71.53	39.17		
LSD 0.05		[	4.54	]	[17.88]	[5.24]

Studies have shown that exogenous application of CKs-like substrates, e.g. 6-benzylaminopurine (BA), to individual racemes or to the transpiration stream could prevent pod abortion in we -watered soybeans (Nagel *et al*., 2001; Cho *et al*., 2002). CKs can increase sink strength by promoting cell division in the young ovaries, and this may redirect movement of assimilates into treated tissues, increase growth rates of the developing ovaries and thereby decrease the rates of abortion (Lur and Setter, 1993; Dietrich et al., 1995) These findings revealed that full potential of sink production in these cultivars remained unexpressed in the given conditions and plant growth regulators used in this experiment could exploit hat . It was interesting to note that in cultivar Flame , Kinetin and (GA + Kinetin) could increase the number of flower set to as high as tow times to that of untreated ones. The combined doses of GA3 + IAA and GA3 + kinetin should early flowering which was accompanied by more number of flowers in comparison to control , this clearly indicated the effect of GA3 and kinetin on the initiation of flowering (Alkio et al., 2003) .

Data on number of filled seed revealed that the large number of seeds increased due to GA , Kinetin or (GA + Kinetin) application could not meet the requirement of their nutrition and hence percentage of empty seeds increased . In case when GA , Kinetin or (GA + Kinetin) activated large number of sinks , number of starved seeds also increased . Srivastava and Sairam (1982) and Shukla *et al*. (1987) reported low accumulation of photosynthates due to low photosynthetic activity in the leaves could responsible for the poor seed filling in sunflower . leaf senescence during seed filling period has also been correlated with the shortage of photosynthates to developing seeds in sunflower capitulum (Shukla *et al* ,1987) . The combined doses of GA3 + IAA and GA3 + kinetin should early flowering which was accompanied by more number of flowers in comparison to control, this clearly indicated the effect of GA3 and kinetin on the initiation of flowering . Furthermore, the threshold required for flowering may have been acquired earlier with the combination of these three hormones (Fulailin , 2004) . It has been found, in the present work that GA , Kinetin , or mixture of both increased the percentage of filled seeds relative to the untreated plants (table 3). Higher increments were obtained by applying Kinetin or mixture of both GA and Kinetin . Data presented in table 3 , showed that the cultivar Flame produced high percentage of filled seeds in different portions relative to Euroflore cultivar in both seasons and as mean of seasons .

Seed weight did not show any significant differences between treated plants and control plants in first season and as a mean of seasons ,whereas showed a significant differences in second season when applied (GA + Kinetin) . Similar trend was observed in case of tow cultivars in both seasons and as mean of seasons (table 4) . However , application of (GA + Kinetin) gave the highest seed weight . In present experiment local application of GA , Kinetin or (GA + Kinetin) seems to have increased large number of florets to develop into seeds but their photosynthate requirement could not be met . Data on filled seeds from control plants revealed that the photosynthate requirement even of the sinks normally available in sunflower capitulum is inadequate . GA , Kinetin or (GA + Kinetin) further increased the number of sinks to share the limited supply of nutrition . Consequently , large number of seeds remained empty . Beltrano et a1.(994) found for both seasons and hybrids BA 150 mg/l + GA 150 mg/l applied at 40 days after emergence significantly reduced the percentage of empty achenes, increased achene weight, achene weight (× 1000) and achene number in the inner portion of the capitulum and in the middle and outer portion . Other experiments support the view that seed development in sunflower is sink limited. That means that the potential of the sink to utilize photo-assimilates is less than the capacity to produce them by the source As empty achenes accumulate less than 10% of the dry matter the filled ones do, abortion seems to occur soon after fertilization. Therefore, changes in seed set reflect the sensitivity of embryo development during the cell division stage to changes in assimilate supply, whereas changes in dry mass per seed are linked with responses during the cell division or the seed maturation stage, or both (Alkio *et al*.,2003) .

Table 3. Percent filled seed in different portions of sunflower capitulum as influenced by plant growth regulators application.

Cultivars	Treatment	Center	Middle	Periphery	Mean of treatment	Mean of cultivars
			First season			
	Control	33.33	57.14	57.14	49.20	51.05
Euroflore	GA	33.33	44.44	50.00	42.59	
	Kinetin	45.00	60.00	55.56	53.52	
	GA+ Kinetin	50.00	60.00	66.67	58.89	
	Control	33.33	50.00	66.67	50.00	57.58
Flame	GA	33.33	62.50	71.43	55.75	

	Kinetin	38.89	70.00	75.00	61.30	
	GA+ Kinetin	42.11	72.73	75.00	63.28	
Mean		38.67	59.60	64.68		
LSD 0.05		[	12.68	]	[6.56]	[2.66]
			Second season			
	Control	45.45	66.67	66.67	59.60	62.55
Euroflore	GA	42.86	57.14	66.67	55.56	
	Kinetin	52.94	75.00	71.43	66.46	
	GA+ Kinetin	52.94	77.78	75.00	68.57	
	Control	40.00	60.00	60.00	53.33	66.33
Flame	GA	38.46	80.00	80.00	66.15	
	Kinetin	53.33	85.71	83.33	69.36	
	GA+ Kinetin	56.25	87.50	85.71	76.49	
Mean		47.78	73.73	73.60		
LSD 0.05		[	14.22	]	[11.29]	[2.98]
			Mean of seasons			
	Control	39.39	61.91	61.91	54.40	56.80
Euroflore	GA	38.10	50.79	58.34	49.08	
	Kinetin	48.97	67.50	63.50	59.99	
	GA+ Kinetin	51.47	68.89	70.84	63.73	
	Control	36.67	55.00	63.33	51.67	62.56
Flame	GA	35.90	71.25	75.72	60.96	
	Kinetin	46.11	77.86	79.17	67.71	
	GA+ Kinetin	49.18	80.12	80.36	69.89	
Mean		43.22	66.67	69.15		
LSD 0.05		[	12.76	]	[9.27]	[2.44]

Table 4. Mean seed weight (mg) of sunflower capitulum as influenced by plant growth regulators application.

Treatments	First season			Second season			Mean of seasons		
	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean
Control	51.10	53.01	52.06	54.70	58.11	56.41	52.90	55.56	54.23
GA	52.80	54.90	53.85	55.81	59.71	57.76	54.31	57.31	55.81
Kinetin	52.00	54.01	53.01	55.31	59.21	57.26	53.66	56.61	55.14
GA + Kinetin	53.50	55.36	54.43	59.18	63.20	61.19	56.34	59.28	57.81
Means	52.35	54.32		56.28	60.06		54.30	57.19	
LSD0.05	[N.S]		[N.S]	[3.14]		[3.34]	[N.S]		[N.S]

Conclusions

The present paper clearly shows the need for screening large number of genotypes where a situation of maximum seed filling could be further , exploited using growth substances . Both seed set and seed filling in sunflower depend on the source–sink ratio. However, higher proportions of empty achenes , especially in the capitulum centre, as commonly observed in sunflower crops, result from source limitation. The growth rate of a single seed will play an important role in the determination of the total number of filled fruits produced by the plant . In our study it was revealed that the role for GAs lies mainly in the seed filling, whereas CKs are most important in seed set and increase sink strength , thereby decrease the rates of abortion .

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تقييم دور منظما النمو الجبرلين والسايتوكاينين في تنظيم عقد وامتلاء بذ ور نبات زهرة الشمس (*Helianthus annuus* L.)

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الملخص

يتحدد حاصل نبات زهرة الشمس بعدد البذور م$^{-2}$ (Kernel) ووزن الثمرة (achene) . نفذت تجربتان في اصص خلال موسمين متتاليين لدراسة تأثير الجبرلين والكاينتين ومع بعضهما (جبرلين + كاينتين) في عقد وامتلاء بذور صنفين من زهرة الشمس (يوروفلور وفلامي) . نفذت التجربة العاملية في تصميم القطاعات العشوائية الكاملة RCBD وبأربعة مكررات . اضيفت منظمات النمو بالتراكيز الاتية : الجبرلين 200 جزء من المليون والكاينتين 200 جزء من المليون و (الجبرلين 200 + الكاينتين 200) جزء من المليون الى براعم النباتات عند مرحلة التفتح (45 يوما بعد الزراعة) ، بينما اضيف الماء المقطر الى نباتات معاملة المقارنة . قسمت اقراص النباتات عند مرحلة النضج الى اربعة اقسام متساوية مرورا بمركز القرص ، ثم جزء كل قسم من الاقسام الاربعة الى ثلاثة اجزاء متساوية : المنطقة المحيطة (الخارجية) Peripheral و الوسطى Middle والمركزية Central . تم تسجيل وزن البذور وعدد الذور الكلي وعدد البذور المملوءة لكل جزء ومن ثم تم حساب نسبة الزيادة في عدد البذور الكلي ونسبة الزيادة في عدد البذور المملوءة ونسبة البذور المملوءة ومعدل وزن البذرة .

أظهرت النتائج ان اضافة منظمات النمو اعطت اعلى عدد من البذور الكلية والبذور المملوءة واعلى نسبة من البذور المملوءة في الاجزاء الثلاثة . كما ساهمت في تحسين معدل وزن البذرة لكلا الصنفين وفي كلا الموسمين مقارنة مع نباتات معاملة المقارنة . وان المعاملة الاكثر تأثيرا كانت (جبرلين 200 + كاينتين 200) جزء من المليون . تفوق الصنف فلامي على الصنف يوروفلور في عدد البذور الكلي والبذور المملوءة ونسبة البذور المملوءة في الاجزاء الثلاثة وفي متوسط وزن البذرة في كلا الموسمين ومتوسطهما .

الكلمات المفتاحية : زهرة الشمس ، الجبرلين ، الكاينتين ، عقد البذور ، ملء البذور