SEED DEVELOPMENT PROCESS IN RELATION TO PHYSICAL GROWTH AND QUALITY CHARACTER IN SUNFLOWER
Helianthus annuus L.

Rana M. A., G. M. Ali, and Shafiullah
National Agricultural Research Centre
PO. NIH, Park Road, Islamabad, PAKISTAN

SUMMARY

A field experiment was conducted to study the process seed development in sunflower (Helianthus annuus L.) during spring and autumn seasons, 1990. The seed were harvested by hand starting from 4 days after anthesis initiation (DAAI) and continued upto 40 DAAI with an interval of 2 days. First harvest was made on 13th May and 16th September during spring and autumn, respectively. With minor differences, almost a similar trend of seed growth and development was found for all the physical and quality characteristics during both the seasons although the climatic conditions were quite different in these seasons. Moisture content in the development seed reduced comparatively faster in spring than in autumn and it was 6.3 % in spring and 24.8% in autumn at 40 DAAI. 100-seed weight increased upto 30 DAAI (7.3 g) in spring and 40 DAAI (7.9 g) in autumn. Maximum oil content was 42.0 and 40.6% at 30 and 34 DAAI in spring and autumn, respectively. Seed germination was 89% at 14 DAAI in autumn and 90% at 20 DAAI in spring. Kernel seed ratio was 0.72 at 28 DAAI in both seasons which was not significantly different from their maximum values. Protein contents were 15.5% and 18.0% at 4 DAAI and 22.0% and 20.8% at 40 DAAI in spring and autumn, respectively. At 40 DAAI, oleic acid was 10.2% more in spring (39.6%) than in autumn (30.47%) while linoleic acid was 13.2% more in autumn (63.1%) than in spring (49.9%).

INTRODUCTION

The process of seed development in sunflower (Helianthus annuus L.) has been reported in literature, but the work done on this aspect did not present the influence of different environments on a wide range of characteristics related to seed development.

Robertson et al. (1978) studied moisture, oil, free fatty acids and lipids during sunflower seed development and found that the seed dry weight, oil and triglycrid contents were maximum 35 days after flowering initiation. They observed 36% seed moisture content at this stage and defined it as physiological maturity in sunflower.

Anderson (1975) reported that the dry weight of seed was maximum when the seed moisture content was about 40%. The oil and the linoleic acid contents reached their maximum at about the same time as seed dry weight.

Meada et al. (1987) found that seed oil content increased from 2.2% at 10 days after flowering initiation to 46.6% at 30 days after flowering with the highest seed viability at the latter stage.

Samui et al. (1980) studied changes in sunflower seed during maturity with an interval of three days and found that 1000-seed weight, protein and oil contents increased between 95-119 days after sowing.

Gambhir and Anand (1981) observed the highest protein and oil contents on 23 and 33 days after flowering, respectively.

Singh et al. (1988) studied oil and protein dynamics in developing sunflower seed using radioactive carbon (CO_2^{14}). They found that oil accumulation continued upto 33 days after anthesis initiation and was rapid 15 days after anthesis initiation while protein was more actively synthesized during early stages of seed development.

The objective of the present experiments was to study the seed development process in sunflower in relation to physical and quality characters influenced by two different sets of environments.

MATERIAL AND METHODS

Sunflower hybrid, "NK-212", was planted on 3rd March in spring and 4th August in autumn, 1990, at the National Agricultural Research Center, Islamabad, Pakistan. The crop was grown under irrigated conditions with recommended production practices. About 500 flowers were tagged on the day of anthesis initiation, i.e., opening of first ring of the florets. Heads were harvested by hand, starting from four days after anthesis initiation (DAAI) till 40 DAAI with two days intervals. A total of 19 harvests were made. The first harvest was made on 13th May and 16th September and the last harvest on 19th June and 22nd October in spring and autumn, respectively. Heads were covered with muslin cloth bags on 25 DAAI to protect them from bird damage. For the first eight treatments, i.e., 4, 6, 8, 10, 12, 14, 16 and 18 DAAI, 40 heads were harvested for each treatment, i.e., 10 heads from each of the four replications. For all these treatment seed was collected by hand from only outer three rings of capitulum and rest of the seeds were discarded. For the remaining of the treatments, 20 heads (5 heads x four replications) were harvested and seed from the outer 5 rings were collected.

Moisture content (MC) of the seeds was determined at the time of each harvest by drawing a sub-sample from every treatment, dried at 70°C for 120 hours using the following formula:

$$\text{Moisture}(\%) = \frac{\text{Seed Fresh Weight - Dry wt (g)} \times 100}{\text{Seed Fresh Weight}}$$

100-seed weight (100-SW) was recorded as an average of three samples replicated four times.

To obtain kernel seed ratio (KSR), hulls were removed from 400 randomly drawn well dried seeds (four replications of 100 seeds each. Kernel seed ratios was calculated by dividing the kernel weight with the total weight of the seed.

The seed oil content (OC) at zero percent moisture was determined using a Newport Nuclear Magnetic Resonance, Model, Oxford 4000 NMR Analyzer (Granlund and Zimmermann, 1975). The fatty acid composition was measured by Gas Liquid Chromatograph (GLC), model GC-9A by using a glass column (2.1 m x 3.2 mm) packed with 3% SP 2310/2% SP 2300 coated chromosorb WAW on 100/120 mesh. The column oven was operated at 230°C. Methylating solution of four gram metallic sodium prepared in 500 ml methanol was used for preparing methyl esters of oil.

For protein content (PC), samples were digested with concentrated sulfuric acid in the presence of potassium sulphate as a catalyst at 420°C for 35 minutes. Ammonium sulphate, thus, obtained was heated with 40 % sodium hydroxide. The ammonia evolved was collected in 1.0% boric acid containing mixed indicator (bromocresol green and methyl red) and titrated against 0.1 N hydrochloric acid. Distillation and titration was done by Tecator Kjeltec Auto 1030 Analyzer. Protein was computed by multiplying nitrogen with "6.25" factor.

gradually by 10-15%. It was the highest (52.7% and 58.7%) on 22 DAAI and 16 DAAI in spring and autumn, respectively. The fluctuations in oleic acid content were considerably high during seed development. Linoleic acid exhibited a trend almost opposite to that of oleic acid (Fig. 8). It was 34.9% and 37.0% on 4 DAAI in spring and autumn, respectively, and rapidly increased to 57.2 % on 14 DAAI in spring and 65.9% on 22 DAAI in autumn.

CONCLUSION:

The two seasons, spring and autumn present two different sets of environments as could be seen from days taken to physiological maturity in each season, i.e., 104 and 76 days in spring and autumn, respectively. However, the differences in the seed growth and development in both seasons were minor and over all trend was almost similar. Seed can be harvested between 14 and 20 DAAI having 90% germination capacity. Oil content reached to its maximum between 30 and 34 DAAI when the 100-seed weight was 7.3 and 7.00 g in spring and autumn, respectively.

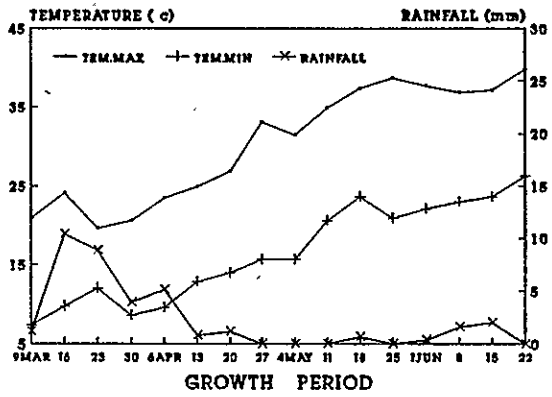

Fig. 1. WEEKLY MEAN MAXIMUM & MINIMUM TEMPERATURE AND RAINFALL DURING SPRING SEASON, 1990

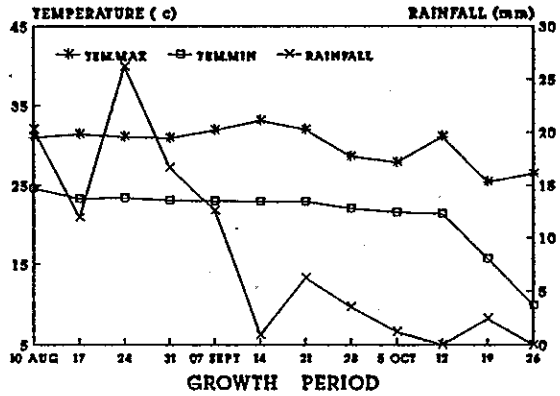

Fig. 2. WEEKLY MEAN MAXIMUM & MINIMUM TEMPERATURES AND RAINFALL DURING AUTUMN SEASON, 1990

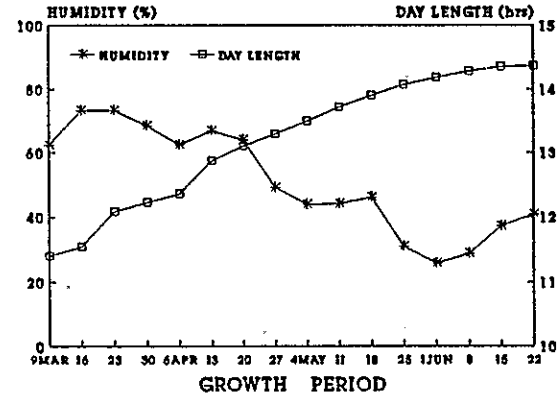

Fig. 3. WEEKLY MEAN HUMIDITY AND DAY LENGTH DURING SPRING SEASON, 1990

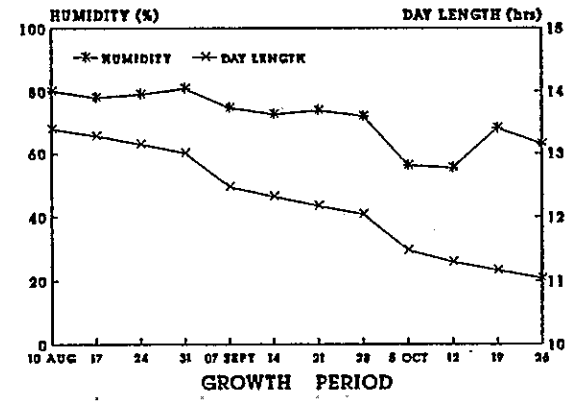

Fig. 4. WEEKLY MEAN HUMIDITY AND DAY LENGTH DURING AUTUMN SEASON, 1990

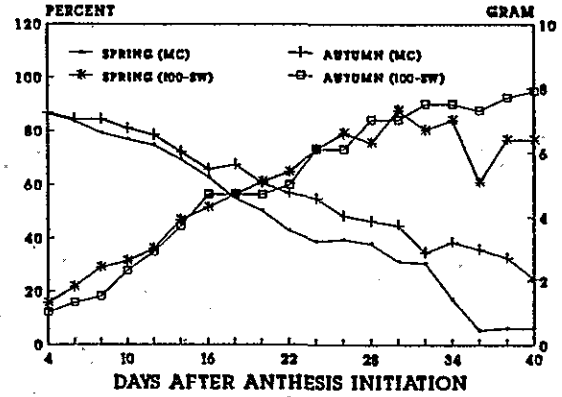

Fig. 5. MOISTURE CONTENT & 100-SW WEIGHT AT VARIOUS STAGES OF SUNFLOWER SEED DEVELOPMENT

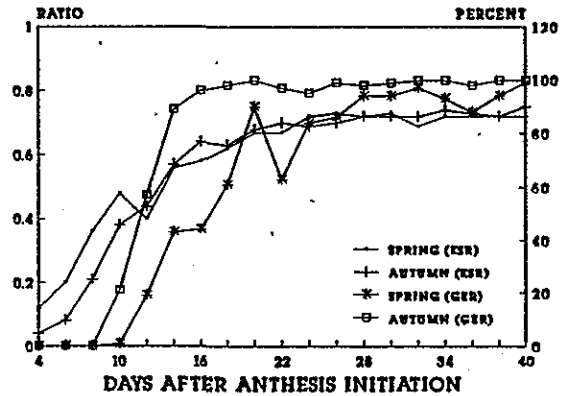

Fig. 6. KERNEL SEED RATIO & GERMINATION AT VARIOUS STAGES OF SUNFLOWER SEED DEVELOPMENT

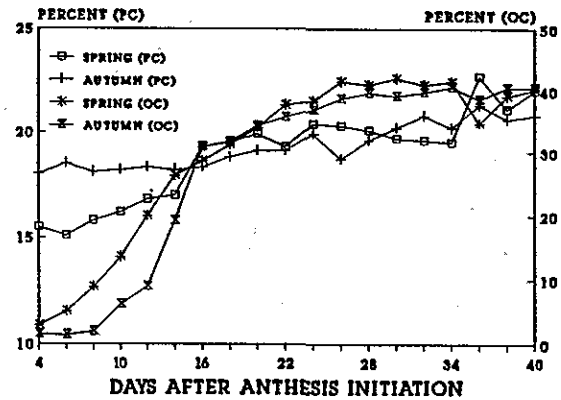

Fig. 7. OIL AND PROTEIN CONTENT AT VARIOUS STAGES OF SUNFLOWER SEED DEVELOPMENT

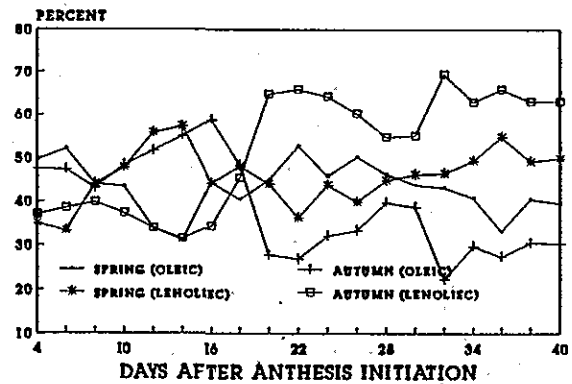

Fig. 8. PERCENT OLEIC & LINOLEIC ACID AT VARIOUS STAGES OF SUNFLOWER SEED DEVELOPMENT

Table 1. Physical and quality characteristics of sunflower seed at various stages of development process during spring and autumn, 1990

DAAI	MC (%)			100-SW (g)			OC (%)			Ger (%)			KSR		
	S	A	Mean	S	A	Mean	S	A	Mean	S	A	Mean	S	A	Mean
04	86.1	86.8	86.5	1.3	1.0	1.2	3.0	1.5	2.3	00	00	00	0.12	0.04	0.08
06	83.6	84.3	83.9	1.8	1.3	1.5	5.1	1.4	3.3	00	00	00	0.20	0.08	0.14
08	79.3	84.3	81.8	2.4	1.5	2.0	8.9	1.9	5.4	00	00	00	0.36	0.21	0.28
10	76.8	81.0	79.0	2.6	2.3	2.5	13.6	6.2	9.9	01	21	11	0.48	0.38	0.43
12	74.7	78.5	76.6	3.0	2.9	2.9	20.0	9.0	14.5	19	57	38	0.40	0.44	0.42
14	69.4	72.3	70.8	3.9	3.7	3.8	26.4	19.3	22.9	43	89	66	0.56	0.57	0.56
16	62.8	65.8	64.3	4.3	4.7	4.5	28.7	31.0	29.9	44	96	70	0.58	0.64	0.61
18	54.8	67.5	61.1	4.7	4.7	4.7	31.3	31.8	31.5	61	98	80	0.62	0.63	0.62
20	50.4	60.8	55.5	5.1	4.7	4.9	34.0	34.3	34.2	90	100	95	0.67	0.68	0.67
22	42.9	56.8	49.8	5.4	5.0	5.2	37.7	35.8	36.8	63	97	80	0.67	0.70	0.69
24	38.9	54.8	46.8	6.1	6.1	6.1	38.3	36.9	37.6	84	95	90	0.72	0.69	0.70
26	39.6	48.5	44.0	6.6	6.1	6.3	41.5	38.7	40.1	86	99	93	0.73	0.70	0.72
28	37.7	46.5	42.1	6.3	7.0	6.7	41.0	39.7	40.4	94	98	96	0.72	0.72	0.72
30	31.2	44.8	38.0	7.3	7.0	7.2	42.0	39.1	40.2	94	99	97	0.73	0.72	0.72
32	30.5	34.8	32.6	6.7	7.5	6.1	41.0	39.8	37.4	97	100	99	0.69	0.72	0.71
34	17.1	38.5	27.8	7.0	7.5	7.3	41.5	40.6	41.1	93	100	97	0.72	0.74	0.73
36	5.6	36.0	20.8	5.1	7.3	6.2	34.7	38.6	36.6	88	98	93	0.72	0.73	0.72
38	6.3	32.8	19.5	6.4	7.7	7.0	39.1	40.5	39.8	94	100	97	0.72	0.72	0.72
40	6.3	24.8	15.5	6.4	7.9	7.2	40.2	40.5	40.6	99	100	100	0.72	0.75	0.74
CV(%)	6.4	3.5	4.9	10.1	8.9	9.5	4.2	5.2	4.7	23.2	5.8	15.3	4.0	4.9	4.46
LSD(5%)	4.3	2.9	2.5	0.7	0.6	0.5	1.8	2.0	1.3	11.9	6.2	10.3	0.04	0.04	0.31

(Contd.)

DAAI	PC(%)			PA (%)			SA (%)			OA (%)			LA (%)		
	S	A	Mean	S	A	Mean	S	A	Mean	S	A	Mean	S	A	Mean
04	15.5	18.0	16.7	10.9	8.1	9.5	4.6	2.2	3.4	49.6	47.4	48.5	34.9	37.0	36.0
06	15.1	18.5	16.8	11.5	8.2	9.8	4.9	2.7	3.8	52.1	47.3	49.7	33.4	38.6	36.0
08	15.8	18.1	16.9	9.4	7.8	8.6	2.2	3.3	2.7	44.0	43.1	43.6	44.0	39.9	42.0
10	16.2	18.2	17.2	6.6	7.2	6.9	2.4	3.3	2.8	43.5	48.4	45.9	47.7	37.4	42.7
12	16.8	18.3	17.6	7.7	5.8	6.8	3.2	2.3	2.7	34.0	51.6	42.8	55.8	34.0	44.9
14	17.0	18.2	17.6	8.3	4.9	6.6	3.4	2.2	2.8	31.1	55.0	43.0	57.2	31.6	44.4
16	19.3	18.3	18.8	7.1	4.7	5.9	4.3	1.7	3.0	44.4	58.7	51.5	44.2	34.4	39.3
18	19.5	18.8	19.2	7.0	4.5	5.7	4.5	1.3	2.9	40.4	48.3	44.4	48.1	45.3	46.7
20	19.9	19.1	19.5	6.6	5.1	5.8	4.1	1.8	2.9	44.9	27.8	36.3	44.0	64.8	54.3
22	19.3	19.1	19.2	6.5	4.5	5.5	3.9	1.9	2.9	52.7	27.0	39.8	36.3	65.9	51.1
24	20.4	19.9	20.1	6.8	4.6	5.7	3.6	1.1	2.4	45.8	32.2	39.0	43.8	64.3	54.0
26	20.3	18.7	19.5	6.6	4.7	5.7	3.3	1.4	2.3	50.1	33.3	41.7	39.9	60.2	50.1
28	20.1	19.6	19.9	6.9	4.1	5.5	3.1	1.0	2.1	46.2	39.7	43.0	44.7	54.7	49.7
30	19.7	20.2	19.9	6.8	4.1	5.5	3.4	0.9	2.2	43.8	38.7	41.2	46.1	55.0	50.6
32	19.6	20.8	20.2	6.9	5.3	6.1	4.2	2.3	3.3	43.2	22.3	32.8	46.4	69.5	58.0
34	19.5	20.2	19.8	6.7	4.6	5.6	3.4	2.0	2.7	40.8	29.8	35.3	49.2	62.9	56.0
36	22.7	21.3	22.0	7.9	4.6	6.3	4.1	1.7	2.9	33.2	27.4	30.3	54.8	65.9	60.4
38	21.1	20.6	20.8	6.7	4.4	5.6	3.6	1.5	2.5	40.4	30.5	35.4	49.1	63.1	56.1
40	22.0	20.8	21.4	6.4	4.5	5.6	3.7	1.7	2.7	39.6	30.4	35.0	49.9	63.1	56.5
CV(%)	4.3	4.1	3.8	14.9	13.9	14.9	15.4	29.7	21.5	13.2	13.2	13.2	11.1	9.9	10.5
LSD(5%)	1.3	1.1	0.7	1.6	1.1	1.0	0.8	1.1	0.7	8.1	7.3	5.4	7.2	7.3	5.1

DAAI = Days after anthesis initiation
S = Spring
A = Autumn
MC = Moisture Content
SW = Seed Weight
OC = Oil Content
GER = Germination
KSR = Kernel Seed Ratio
PC = Protein Content
PA = Palmitic Acid
SA = Stearic Acid
OA = Oleic Acid
LA = Linoleic

REFERENCES

Anderson, W. K. 1975. Maturation of sunflower. Aust. J. of Exp. Agric. and Ani. Hus. 15(77):833-838.

El-Hinnawy, S., K. R. F. Hussein, S. Eid and A. F. Tarrad. 1981. Studies of protein and amino acids composition at different stages of sunflower seeds. Research Bulletin No.1630 pp18, Fac. of Agric; Ain. Shams Univ., Cairo, Egypt. (Field Crop Absts., 37 (1): 541; 1984).

Gambhir, P. N and I. S. Anand. 1981 Oil and protein synthesis during grain development in sunflower. Indian J. Pl. Physiol; 24(1):69-73. (Field Crop Absts; 35 (4) 3432; 1982)

Grandlund, M. and D. C. Zimmerman, 1975. Effect of drying conditions on oil content of sunflower (Helianthus annus L.) seeds as determined by wide line Nuclear Magnetic Resonance (NMR) Proc. of the North Dakota Academay of Sci. 27: 128-132.

Maeda, J. A., M. R. G. Ungaros, A.A.Do. Cago and L. F. Razera. 1987. Maturation and quality of sunflower. Bragantia. 46(1):35-44. (Field Crop Abst. 42(6): 4647; 1989).

Robertson, J. A., G. W. Chapman, Jr., and R. L. Wilson, Jr., 1978. Relation of days after flowering to chemical composition and physiological maturity of sunflower seed. J. Am. Oil Chem. Soc. 55(2):266-269.

Samui, R.C., P.Bhattacharyya, K.S. Dasgupta, and S.K. Smanta. 1980. Qualitative changes in maturity of sunflower (Helianthus annuus L.) seeds. Sciences and Culture. 46(11)404-405. (Field Crop Absts. 35(2)1640; 1982).

Singh, S.P., V. Singh and P.P. Singh. 1988. Characterization of oil and protein dynamics in developing sunflower (Helianthus annuus L.) seeds. J. Oil Seeds Res. 5(1):77-79. (Field Crop Absts. 42(4):2898; 1989).