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EFFECTS OF EARLY SPRING PLANTING OF SUNFLOWER ON YIELD IN IRAQ.

S.S. RAJAN
Senior Adviser (Oilseeds), FAO of United Nations, FAO Mission, P.O. No. 163 Baghdad, Iraq.

ABSTRACT
Six fortnightly plantings of sunflower (cv. Peredovik), commencing from the first February were done in northern Iraq under rainfed and irrigated conditions, and in central Iraq under irrigation. In all the three situations the earliest planting gave the highest yield, and the last planting the lowest. The decline in yield was the most drastic in central Iraq under irrigation. Cultivation of sunflower in the north with supplementary irrigation and early February planting is recommended. Association between seed yield and other yield-determining traits was studied through correlation and path coefficient analyses. Yield was found to be differently structured under the three situations. Seed number per head, 100 seed weight and degree of empty seededness were the predominant yield determinants respectively in the north-irrigated, central-irrigated and north-rainfed situations. Based on these relationships certain crop management practices to optimize yield are suggested.

INTRODUCTION
To augment domestic supply of vegetable oils sunflower cultivation has recently been introduced in Iraq. Because of high summer temperatures and low winter rains, spring planting is considered the most feasible. This study was undertaken to find out the optimum spring planting time as an irrigated crop in central Iraq and rainfed crop in the north with and without supplementary irrigation.

MATERIALS AND METHODS
Sunflower cv. Peredovik was planted at 15 day intervals commencing from 1st February, at two locations, Baghdad (Central Iraq-irrigated, hereinafter referred to as CIR), Nineveh (North Iraq-irrigated, NIR) and also rainfed (NRF), in randomized block layouts with 4 replications. The net plot size was 13.3 m^2, the plants were spaced 0.25 m within rows which were 10 m long and 0.7 m apart. In CIR and NIR irrigation was *ad libitum.* Seed yields were estimated on plot mean basis, and single plant seed yield and other traits on the means of five randomly selected plants. The data were subjected to conventional analyses of variance, covariance leading to regression —, correlation — and path correlation coefficient estimates. The data on extent of empty seededness (ESN) were estimated as percentages and subjected to angular transformation before analysis.

RESULTS
In Table 1 are presented some climatological features of the two experimental locations that could be considered typical for their respective regions. The mean seed yields obtained at the different planting dates, under the three situations are given in Table 2. The overall mean yields recorded, viz. 1.8, 2.3 and 1.0 tonnes ha^{-1} respectively for CIR, NIR and NRF, indicate the relative potential for sunflower production in Iraq. Considering the individual planting dates, the first planting on 1st February failed in NIR and NRF due to slow and poor germination and stand, probably due to low temperatures and also to bird damage. There was a decline in seed yield with later plantings in February, March and April in all the three situations. The highest yields were obtained from the first planting in CIR and from the second NIR and NRF, and the lowest from the last planting in all of them. The steepness of this decline could be assessed by the regression equations given at the bottom of Table 2. The linear and quadratic components of the regression were all negative in sign, only the linear ones being significant. Planting on 15 April brought about 72% reduction in yield over the first planting in CIR,while in NRF it was 61%. The corresponding figure for the NIR was only 44%.

Table 1. Some climatological features of the two locations involved in Sunflower trials: Average of 30 years.

	Average of 30 years.							
	Temperature °C							
Months	Maximum		Minimum		Rainfall mm		Relative humidity %	
	A	B	A	B	A	B	A	B
January	16.0	12.8	04.3	02.5	25.4	76.8	70	82
February	18.7	15.3	05.9	03.5	24.2	64.2	61	76
March	22.7	19.0	09.6	06.3	23.7	69.6	53	71
April	28.7	25.4	14.6	10.2	22.3	50.8	45	64
May	35.8	32.9	20.0	15.0	08.1	24.7	33	48
June	41.0	39.6	23.4	19.5	0.1	0.7	23	31
July	43.4	43.4	25.3	22.9	—	0.1	23	28
August	43.3	43.0	24.6	21.8	—	—	24	30
September	39.8	38.7	21.0	16.6	0.3	—	28	37
October	33.4	31.2	16.2	11.4	03.7	09.9	37	47
November	24.6	22.4	10.3	07.0	17.2	36.1	56	67
December	17.6	15.0	05.2	03.2	22.9	67.3	70	79
					147.9	391.9		

A = Baghdad 33°14'N and 44°14'E: Elevation 34m.
B = Nineveh 36°19'N and 43°09'E: elevation 223m.

Table 2. Mean Seed Yields in Kg ha^{-1} of Sunflower planted in early spring in Iraq.

Dates of planting	Seed yield in Kg x ha^{-1}		
	Central Iraq Irrigated	North Iraq Irrigated	Rainfed
(1) 01 February	2115	—	—
(2) 15 February	2062	2715	1166
(3) 01 March	1819	2517	1083
(4) 15 March	1575	1798	666
(5) 30 March	1320	—	625
(6) 15 April	601	1521	458
(7) 30 April	—	753	—
Regression equation	Y = 1778 − 831 x − 115 x^2	= 2344 − 1835 x − 347 x^2	= 972 − 750 x − 167 x^2

The data on single plant seed yield and other traits are presented in Table 3. The highest single plant seed yields were obtained for NIR at all planting dates, as expected. But those for CIR were much lower than those for NRF for all the planting dates, although the reverse was the case for plot seed yields. The main cause for this appears to be the low number of good seeds per head in CIR. In all the three situations with later plantings there was a decrease in the number of good correlated to seed yield and only at these two situations. Diameter of the head was positively correlated to seed yield only for NRF. The number of seeds per head and weight of 100 seeds were positively correlated in CIR and NRF. This is contrary to expectations based on physiological considerations of source-sink relationships. Apparently, such a relationship is relevent only at higher productivity levels as in NIR. One could similarly explain the positive correlation between seed weight and diameter of the head, and the negative correlations between ESN on the one hand and the diameter of the head and seed weight on the other, all in the NRF.
seeds per head, but in the CIR even in the first planting the seed number was only 35% of the corresponding value for NIR and NRF. The low single plant yield in CIR is attributable to high ESN, which was uniformly high (over 44%) at all planting dates. On the other hand, in NIR and NRF, the ESN progressively increased in later plantings, although the highest figure reached was below 25%. Conversely, 100 seed weight which also showed a similar decline with later plantings, was high and the decline marginal in CIR, while in NRF not only was the value initially low but the decline in later plantings was also drastic.

Single plant seed yield was highly, positively correlated (Table 3) to the number of seeds per head in all the three situations. It was also negatively correlated to ESN only for CIR and NRF. Likewise, 100 seed weight was positively

Table 3. Correlation coefficients amongst yield determining traits for Sunflower under different production systems in Iraq.

		Single plant seed yield (x_6)	Number of seeds/head (x_1)	Diameter of head (x_2)	100 seed weight (x_3)	Plant height (x_4)	Empty seeds% (x_5)
Single	A		0.9489	0.4886	0.7996	−0.1209	−0.4516
plant	B	—	0.8981	0.7563	0.5905	−0.0709	−0.7448
yield	C		0.8539	0.8308	0.9887	0.6863	−0.9979
(x_6)							
Number of	A			0.4094	0.7867	−0.1721	−0.5424
seeds/head	B		—	0.6618	0.1789	−0.4376	−0.6316
(x_1)				0.5575	0.7686	0.8971	−0.8388
Diameter	A			—	0.0516	−0.5252	−0.3311
of head	B				0.5195	0.0426	−0.4300
(x_2)	C				0.8690	0.5919	−0.8645
100 seed	A				—	0.4629	−0.0401
weight	B					0.6907	−0.5503
(x_3)	C					0.6067	−0.9925
Plant	A					—	0.6539
height	B						−0.3164
(x_4)	C						−0.6940

'r' values of 0.811 and above are significant at P = 0.05.
A = Central Iraq irrigated; B = North Iraq irrigated; C = North Iraq rainfed.

The separation of direct and indirect effects of yield determining traits on seed yield is studied through path coefficients (Table 4). In the NIR the most significant direct effect on seed yield is through the number of seeds per head, and to a lesser extent seed weight. The most conspicuous indirect effects are those of head diameter via seed number and seed weight in the positive direction, and of ESN on yield via number of seeds and seed weight in the negative direction. Plant height does not seem to be important by itself since its positive effects on seed yield via seed weight is nullified by its negative effect via seed number. On the other hand, in the CIR the direct effects of seed number of yield is highly negative and is offset by the positive effect of seed number on yield via seed weight. The most significant direct and positive effect on yield is from seed weight, although it is considerably set off by negative effects via number of seeds and plant height. Contribution from plant height to seed yield appears to be minor since its direct negative effects on yield is nullified by positive indirect effects via other traits. ESN appears to be only of minor consequence, both directly and indirectly. Contrary to the other two cases, in the NRF seed yield is affected only by ESN, both directly and via other traits. While the direct effects of ESN on yield is high and negative, all the other traits mitigate its effect through indirect positive contributions.

Table 4. Path correlation analysis of yields of Sunflower under different production systems in Iraq.

		Traits involved	Central Iraq irrigated	North Iraq irrigated	North Iraq rainfed
A:		No. of seeds (x_1) and yield/plant (x_6)			
	(i)	Direct effect P 16	−2.0312	0.7269	0.1894
	(ii)	Indirect via head diameter	0.0917	−0.0132	−0.0025
	(iii)	Indirect via 100 seed weight	2.4418	0.0982	−0.0016
	(iv)	Indirect via height	0.2717	0.0626	−0.1144
	(v)	Indirect via empty seeds	0.1747	0.0236	0.7830
		Direct + indirect effects	0.9489	0.8981	0.8539
B:		Diameter of head (x_2) and yield/plant (x_6)			
	(i)	Direct effect	0.2241	−0.0200	−0.0045
	(ii)	Indirect via seeds/head	−0.8316	0.4810	0.1056
	(iii)	Indirect via 100 seed weight	0.1602	0.2852	−0.0018
	(iv)	Indirect via height	0.8292	−0.0061	−0.0755
	(v)	Indirect via empty seeds	0.1067	0.0161	0.8070
		Direct + indirect effects	0.4886	0.7563	0.8308
C:		100 seed weight (x_3) and yield/plant (x_6)			
	(i)	Direct effect	3.1039	0.5490	−0.0021
	(ii)	Indirect via seeds/head	−1.5979	0.1300	0.1456
	(iii)	Indirect via head diameter	0.0115	−0.0104	−0.0039
	(iv)	Indirect via height	−0.7308	−0.0987	−0.0773
	(v)	Indirect via empty seeds	0.0129	0.0206	0.9264
		Direct + indirect effects	0.7996	0.5905	0.9887
D:		Height (x_4) and yield/plant (x_6)			
	(i)	Direct effect	−1.5788	−0.1430	−0.1275
	(ii)	Indirect via seeds/head	0.3495	−0.3181	0.1699
	(iii)	Indirect via head diameter	−0.1177	−0.0008	−0.0026
	(iv)	Indirect via 100 seed weight	1.4368	0.3792	−0.0012
	(v)	Indirect via empty seeds	−0.2107	0.0118	0.6478
		Direct + indirect effects	−0.1209	−0.0709	0.6836
E:		Empty seeds/head (x_5) and yield/plant (x_6)			
	(i)	Direct effect	−0.3222	−0.0374	−0.9334
	(ii)	Indirect via seeds/head	1.1017	0.4591	−0.1589
	(iii)	Indirect via head diameter	−0.0742	0.0086	0.0039
	(iv)	Indirect via 100 seed weight	−0.1245	0.3021	0.0020
	(v)	Indirect via height	−0.0324	0.0452	0.0885
		Direct + indirect effects	−0.4516	−0.7448	−0.9979

DISCUSSION

From the data presented here it is clear that the northern region is very well suited for sunflower culture if supplementary irrigation is available. High levels of productivity of over 2.5 t ha^{-1} are possible. This region is preferable also on account of flexibility of planting dates. Although mid February appears to be the best planting time, planting could be up to mid March without much reduction in yields. On the other hand, in the Central region although early February plantings are possible, delayed planting affects the crop more drastically. Under rainfed cultivation earliness of spring planting date appears to be very critical, since March planting drastically reduces yield. In the Central region rainfed cultivation is not possible.

The phenomenon of empty seededness in sunflower is a complex one involving genetic, biotic, nutritional and environmental factors. In the present study we recognize two aspects. First, in all the three situations the linear increase in the ESN indicates a temperature and humidity dependent phenomenon, presumably affecting pollen growth, fertilization and seed development. Superimposed on this is the planting-date-independent ESN that was noticed in CIR. This could be due to the absence of suitable pollen foraging insects, since the seed weight did not show a linear decrease with delayed plantings. Installation of honey bee hives should solve this problem.

The character associations revealed in this study could also be used to evolve appropriate modifications in crop management practices, that will capitalize on the desirable character associations. For instance, for the NIR maintaining plant density at 57,000 plants ha^{-1} and increased fertilization with N and P can be expected to contribute to high yields. For the CIR, however, higher rates of seeding resulting in higher population densities, accompanied by higher levels of fertilization can be recommended. Drilling seeds on ridges might also ensure better plant stand and contribute to yield. Under rainfed conditions the ESN, the main yield deterrant, appears to be manifestation of an overall water stress. Here, soil moisture conservation methods, denser planting to promote deeper root system and early maturing cultivars, could be adopted for high yields.

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