PRODUCTIVITY OF SUNFLOWER HYBRIDS IN RELATION TO PLANT DENSITY AND IRRIGATION

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INTRODUCTION

Sunflower *(Helianthus annuus* L.) is one of the important oilseed crops which has been recently introduced in India. Now, it has attained the status of major oilseed crop replacing traditional oilseed crops like groundnut and til within a short span of time. The main constraint in sunflower production is that some portion of seeds remains chaffy due to poor translocation of photosynthates from source to sink. It is more so when the crop is given wider spacing and irrigation wherein the diameter of the head increases abnormally. It is, therefore intended to study the pattern of dry matter accumulation at various growth stages of two sunflower hybrids under varying plant density and irrigation levels. Pattern of dry matter accumulation is an important factor which helps manipulate the agronomic practices in order to achieve higher productivity.

MATERIALS AND METHODS

A field experiment was conducted on deep vertisols of Agricultural Research Station, Belvatgi, Dharwad during kharif 1984. Two sunflower hybrids, namely BSH-1 and MSFH-1 were tested for their productivity under varying plant density and irrigation levels. Three plant densities of 55,555, 74,074 and 83,333 plants per hectare were maintained by manipulating inter-row and intra-row spacing of 60 cm × 30 cm, 45 cm × 30 cm and 60 cm × × 20 cm respectively .Three irrigation schedules at 0.4, 0.6 and 0.8 IW/CPE ratio were tried with 60 mm depth of irrigation water at each irrigation. Number of irrigations received during the crop growth period were 1, 2 and 3 under 0.4, 0.6 and 0.8 IW/CPE respectively. The experiment was laid out in factorial randomised block design with 18 treatment combinations and three replications. The crop was given the recommended dose of N, P and K (62.5 : 75 : 62.5 kg/ha) in the form of urea, superphosphate and muriate of potash. The biometric observations such as plant height, dry matter distribution and leaf area were recorded at floral bud initiation stage (40 DAS), seed setting stage (65 DAS), and at harvest on five randomly selected plants. Leaf area was measured by linear method (L X B X 0.6516) suggested by Prabhakar and Jagannath (1973). Further, the leaf area index was calculated by using the formula suggested by Watson (1952).

RESULTS AND DISCUSSION

The data on the yield and yield attributes of two sunflower hybrids as influenced by plant density and irrigation levels are presented in Tables 1 to 4. The results are discussed under three sub-headings.

Table 1

Yield and yield components in sunflower hybrids as influenced by plant density and irrigation levels

Treatments	Plant height (cm)	Head diameter (cm)	Seed yield/ plant (g)	1 000 seed weight (g)	Seed yield (kg/ ha)
A. **Genotypes**					
1. MSFH-1	142.90	13.81	37.96	35.74	1354
2. BSH-1	146.13	13.08	37.89	37.24	1275
S. Em. ±	2.12	0.32	0.94	0.34	14
C.D. at 5%	N.S.	N.S.	N.S.	0.98	40
B. **Plant population per ha**					
1. 55,555	143.97	13.33	36.53	35.76	1243
2. 74,074	144.88	13.45	39.39	35.72	1312
3. 83,333	144.69	13.56	37.85	37.90	1360
S. Em. ±	2.59	0.39	1.15	0.42	17
C.D. at 5%	N.S.	N.S.	N.S.	1.21	49
C. **Irrigation levels**					
1. 0.4 IW/CPE	141.01	13.15	39.48	37.12	1190
2. 0.6 — do —	138.01	12.77	33.67	35.71	1269
3. 0.8 — do —	154.51	14.42	40.62	36.65	1456
S. Em. ±	2.59	0.39	1.15	0.42	17
C.D. at 5%	7.45	1.12	3.31	1.21	49

Table 2

Total dry matter production (g/m^2) in sunflower hybrids in relation to plant density and irrigation at different growth stages

Treatments	Floral bud initiation	Seed setting	Maturity
A. **Genotypes**			
1. MSFH-1	111.33	580.60	874.94
2. BSH-1	123.36	609.15	885.26
S. Em. ±	3.47	11.63	21.76
C.D. at 5%	9.98	N.S.	N.S.
B. **Plant population per ha**			
1. 55,555	98.67	490.28	727.13
2. 74,074	122.35	607.43	878.57
3. 83,333	131.01	686.92	1034.59
S. Em. ±	4.25	14.24	26.64
C.D. at 5%	12.22	40.96	87.71
C. **Irrigation levels**			
1. 0.4 IW/CPE	105.97	579.15	887.24
2. 0.6 — do —	113.04	586.63	817.22
3. 0.8 — do —	133.03	618.84	935.83
S. Em. ±	4.25	14.24	26.64
C.D. at 5%	12.22	N.S.	N.S.

PERFORMANCE OF GENOTYPES

The data presented in Table 1 reveal that the seed yield of the two sunflower hybrids differed significantly. Genotype MSFH-1 recorded a seed yield of 1,334 kg/ha, while BSH-1 produced 1,275 kg/ha. The yield attributing characters except seed weight of two hybrids did not differ significantly. However, the head diameter and seed yield per plant were higher in MSFH-1. Total dry matter production in the two hybrids at floral bud initiation stage was significantly different but at later growth stages it was on par. At all the growth stage, BSH-1 produced higher total dry matter than MSFH-1. The data on apportioning of total dry matter into different plant parts (Table 3) reveal some interesting facts. Genotype BSH-1 accumulated higher dry matter in stem and leaves than MSFH-1 at all the growth stages. The dry matter accumulation in reproductive parts at seed setting stage was higher in BSH-1 than MSFH-1 but at maturity the reverse was true. The above results suggest that the translocation of photosynthates from source to sink was more efficient in MSFH-1 than in BSH-1. Further, the leaf area index (LAI) was higher in MSFH-1 than BSH-1 and it was significant at seed setting stage which provides larger photosynthetic surface

Table 3

Pattern of dry matter accumulation (g/m^2) in different plant parts of sunflower hybrids as influenced by plant density and irrigation levels

Treatments	Floral bud initiation		Seed setting			Maturity		Total head weight at harvest
	Stem	Leaves	Stem	Leaves	Rep. parts.	Stem	Leaves	
A. **Genotypes**								
1. MSFH-1	38.89	71.43	310.76	161.84	107.36	332.47	146.82	395.21
2. BSH-1	47.43	75.88	318.60	153.45	136.71	345.75	151.96	387.48
S. Em. ±	1.95	2.02	5.16	5.04	6.47	11.43	5.55	11.71
C.D. at 5%	5.62	N.S.	N.S.	N.S.	18.60	N.S.	N.S.	N.S.
B. **Plant population per ha**								
1. 55,555	34.36	64.29	250.41	139.57	99.74	285.06	131.26	310.26
2. 74,074	45.64	76.63	328.43	158.34	120.60	347.33	144.44	386.38
3. 83,333	50.97	80.04	365.21	175.02	145.76	384.94	172.00	477.40
S. Em. ±	2.39	2.47	6.32	6.17	7.92	14.00	6.80	14.34
C.D. at 5%	6.88	7.11	14.84	17.74	22.78	40.26	19.56	41.24
C. **Irrigation levels**								
1. 0.4 IW/CPE	37.55	68.42	315.99	145.68	117.42	335.93	137.19	413.79
2. 0.6 — do —	41.95	71.07	319.14	149.65	116.36	308.04	142.32	366.55
3. 0.8 — do —	51.48	81.47	308.92	177.59	132.31	373.36	168.66	393.69
S. Em. ±	2.39	2.47	6.32	6.17	7.92	14.00	6.80	14.34
C.D. at 5%	6.88	7.11	N.S.	17.74	N.S.	40.26	19.56	N.S.

Table 4

Leaf area index of sunflower hybrids in relation to plant density and irrigation at different growth stages

Treatments	Floral bud initiation	Seed setting	Maturity
A. **Genotypes**			
1. MSFH-1	1.592	3.51	3.23
2. BSH-1	1.509	2.97	2.92
S. Em. ±	0.07	0.14	0.17
C.D. at 5%	N.S.	0.40	N.S.
B. **Plant population per ha**			
1. 55,555	1.204	2.92	2.74
2. 74,074	1.646	2.16	2.82
3. 83,333	1.801	3.64	3.66
S. Em. ±	0.09	0.18	0.20
C.D. at 5%	N.S.	0.52	0.57
C. **Irrigation levels**			
1. 0.4 IW/CPE	1.553	2.95	2.76
2. 0.6 — do —	1.433	2.83	2.64
3. 0.8 — do —	1.665	3.94	3.82
S. Em. ±	0.09	0.18	0.20
C.D. at 5%	0.26	0.52	0.57

area. The above factors might be responsible for higher seed yield in MSFH-1. Kushwaha and Sharma (1973) suggested that the variation in seed yield exists among the varieties of sunflower because of variation in proper filling of seeds.

PLANT DENSITY

The data presented in Table 1 reveal that the seed yield of sunflower differed significantly due to different plant densities. The yield, in general increased with increase in plant density and thus the highest seed yield of 1,360 kg/ha was obtained with 83.333 plants per hectare (60 cm × 20 cm spacing). It was on par with 74,074 plant population (1,312 kg/ha) and both were significantly superior to 55,555 plant population (1,243 kg/ha). The yield attributing characters like plant height, head diameter and seed yield per plant did not differ significantly due to various plant densities, while 1,000 seed weight was significantly higher at higher plant density. The above results suggest that it is beneficial to have higher plant population to achieve higher yields in sunflower. The results are in conformity with those of Massey (1971), Zubriski and Zimmerson (1974), Srinivas (1975), and Stanev (1981). They observed increase in yield with increase in plant population.

The total dry matter production per unit area increased significantly with increase in plant population at all the growth stages. The total dry matter produced at harvest with 55,555, 74,074 and 83,333 plant population was 727.15, 878.57 and 1,034.59 g/m^2 respectively. The per cent increase in dry matter accumulation works out to 20.8 and 42.3 over the lowest population of 55,555 plants per hectare. The pattern of dry matter accumulation in different plant parts increased significantly with increase in plant density at all the growth stages (Table 3). When per cent distribution of total dry matter is worked out, certain interesting facts are revealed. In the early growth stage, contribution towards vegetative parts increased with increase in plant density suggesting better accumulation of carbohydrate reserves at the source. While at harvest, contribution towards stem and leaves decreased considerably with concomitant increase in reproductive parts, indicating better translocation of photosynthates from source to sink particularly from leaves. Further, it is noticed that the per cent distribution of dry matter in leaves under different plant densities was more or less similar. It is also evident from the LAI data presented in Table 4 that the LAI increased significantly with increasing plant density. Significantly higher LAI of 3.64 was attained at peak growth stage with a plant density of 83,333 plants per hectare, and it was maintained throughout the crop period. These results are in conformity with those of Massey (1971) and Srinivas (1975). The above results suggest that there is no mutual shading or nonfunctional leaves in sunflower and also no shedding of leaves at higher plant densities. It is therefore, advantageous to have higher plant population for higher productivity in sunflower.

IRRIGATION

The two sunflower hybrids responded significantly to irrigation levels. The data presented in Table 1 indicate that the seed yield of sunflower increased significantly with increase in the irrigation level. Thus, the highest yield of 1,456 kg/ha was recorded with 0.8 IW/CPE ratio which received three irrigations during the crop growth period. The reduction in yield at 0.6 IW/CPE (two irrigations) and 0.4 IW/CPE (one irrigation) was to the extent of 12.8 and 18.3 per cent respectively. Similarly, the yield components such as plant height, head diameter, seed yield per plant and seed weight increased significantly with increase in irrigation frequency. Andhale and Kalbhor (1980) observed increase in seed yield with increase in the irrigation schedule.

The total matter production increased with increasing irrigation level at all the growth stages but it was significant only at floral bud

initiation stage. The distribution of total dry matter into stem and leaves increased significantly with increasing irrigation levels while it was on par in reproductive parts. Similar results were reported by Pîrjol et al. (1969) and Andhale and Kalbhor (1980). They stated that the production of dry matter in sunflower did not differ significantly due to irrigation at 0.6 and 0.3 water use factor (WUF) which received six and three irrigations respectively. Irrigation had significant influence on LAI at all the growth stages. Maximum LAI of 3.94 was recorded at seed setting stage with irrigation at 0.8 IW/CPE ratio and it was maintained till maturity. It might be responsible for higher dry matter accumulation and seed yield. Andhale and Kalbhor (1980) also reported increase in LAI with increase in irrigation level.

The interaction effect of V X I, S X I and V X S X I were statistically significant in respect of seed yield. The highest seed yield of 1,712 kg/ha was obtained in MSFH-1 hybrid with a plant population of 83.333 (60 cm × 20 cm) and irrigation at 0.8 IW/CPE ratio (three irrigations).

REFERENCES

Andhale R. K., Kalbhor P. N., 1980, *Pattern of dry matter accumulation of sunflower as influenced by irrigation schedules under various levels of nitrogen fertilization*, J. Maharastra Agric. Univ., 5, 9—14.

Kushwaha J. S., Sharma D., 1973, *Sunflower — A promising oilseed for Madhya Pradesh*, Indian Fmg., 23 (2), 7.

Massey J. H., 1971, *Effect of nitrogen rates and plant spacings on sunflower seed yield and other characters*, Agron. J., 63, 137—138.

Prabhakar A. S., Jagannath M. K., 1973, *Leaf area estimation in crop plants*, Modern Agric., 2, 13—14.

Pîrjol Liana, Milica C. T., Vrânceanu A. V., 1969, *Sunflower drought resistance at various growth stages*, Analele I.C.C.P.T., XXXVII-C, Abstr. 55 (3), (75).

Srinivas K., 1975, *Effect of spacing and fertilizer on growth, yield and oil content of sunflower (Helianthus annuus* L.), Mysore J. Agric. Sci., 9, 350.

Stanev V., 1981, *The photosynthetic activity of sunflower in relation to the conditions of cultivation*, International Zeitschrift der Landwirtschraft, 2, 152—156 (Field Crop Abstr. 35, 183).

Watson D. J., 1952, *Physiological basis for variation in yield*, Adv. Agron., 4, 101—145.

Zubriski J. C., Zimmerson D. C., 1974, *Effect of nitrogen and phosphorous and plant density in sunflower*, Agron. J., 66, 798—800.

PRODUCTIVITÉ DES HYBRIDES DE TOURNESOL EN RELATION AVEC LA DENSITÉ DES PLANTES ET L'IRRIGATION

Résumé

Le mode d'accumulation de la matière sèche chez deux hybrides de tournesol a été étudié pendant différents stades de croissance et développement, en conditions diverses de densité et niveaux d'irrigation.

L'hybride BSH-1, comparé à l'hybride MSFH-1, a produit une quantité plus importante de matière sèche totale, dans tous les stades de végétation, particulièrement dans les tiges et les feuilles. La translocation des produits de photosynthèse de la source au sink a été, toutefois, plus efficace et l'index de la surface foliaire plus important chez l'hybride MSFH-1. Ces deux facteurs semblent être responsables de la productivité supérieure de l'hybride respectif.

Le rendement en graines et matière sèche totale par l'unité de surface ont augmenté presque proportionnellement à la densité des plantes. La taille de la plante, le diamètre du capitule et le rendement en graines par plante n'ont pas été différentes d'une façon significative, pour les trois densités. Le taux de distribution de la matière sèche dans les feuilles a été presque similaire, pour les trois densités ; en revanche, l'index de la surface foliaire a augmenté significativement en parallèle à la densité, fait qui démontre que l'ombrage des feuilles en culture n'influence pas trop la photosynthèse du tournesol.

Le nombre d'arrosages a été accompagné par une augmentation significative de la productivité, de la taille, du diamètre du capitule, de l'index foliaire et du poids des graines. L'accumulation de la matière sèche totale a été influencée positivement et significativement seulement pendant la phase de début du bouton floral. À base des résultats obtenus, des recommandations pour la pratique sont formulées.

LA PRODUCTIVIDAD DE LOS HÍBRIDOS DE GIRASOL EN RELACIÓN CON LA DENSIDAD DE LAS PLANTAS Y LA IRRIGACION

Resúmen

Se estudió el modo de acumulación de la sustancia seca en dos híbridos de girasol, en estadios distintos de crecimiento y desarrollo, en condiciones de densidades y niveles diferentes de irrigación.

El híbrido BSH-1, comparado con el híbrido MSFH-1 produjo una cantidad mayor de sustancia seca total en todos los estadios de vegetatión, sobre todo en el tallo y en las hojas. La translocació de los fotosintetizados desde la fuente hasta el sink resultó sin embargo más eficaz y el índex de la superficie foliar mayor en el híbrido MSFH-1. Parece que estos dos factores son los responsables para la productividad más elevada del híbrido respectivo.

La producción de semillas y de sustancia seca total por la unidad de superficie aumentaron casi proporcionalemente con la densidad de las plantas. La talla de la planta, el diametro del capítulo y la producción de semillas por planta no se distinguieron significativamente dentro de las tres densidades. El porcentaje de la distribución de la sustancia seca en hojas fue casi similar en las tres densidades, en cambio el índex de la superficie foliar creció significativamente a la vez con la densidad, hecho que demuestra que el sombrar de las hojas en el sembrado no influencia mucho la fotosíntesis del girasol.

El número de riegos fue acompañado por un crecimento notable de la productividad de la planta, de la talla, del diametro del capítulo, del índex de la superficie foliar y del peso de las semillas. La acumulación de sustancia total fue influída positivamente, de modo significativo sólo en la fase de incio del botón floral.

Conforme a los resultados obtenidos están formuladas recomendaciones para la producción.