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EFFECT OF ROW DIRECTIONS ON YIELD AND YIELD COMPONENTS OF SUNFLOWER (*Helianthus annuus* L.)

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SUMMARY

Effect of different row directions on yield and yield components of sunflower (*Helianthus annuus* L.) was studied in a field experiment at National Agricultural Research Center, Islamabad, Pakistan, during spring 1991 and 1992. Four row directions, *i.e.*, north-south (NS), east-west (EW), north east-south west (NESW) and north west-south east (NWSE) had very little effect on seed yield and other agronomic characters of sunflower. The differences in the mean plant height, head diameter, seed yield, 100-achene weight and fatty acid profile were statistically non-significant. Trends were similar in both years. As an average of the two years, although statistically non-significant, the highest seed yield of 3065 kg/ha was obtained from north east-south west (NESW) row direction and the lowest yield of 2624 kg/ha from east-west (EW) row direction. The most pronounced effect of row direction was noted on seed moisture content. As an average of the two years, the maximum seed moisture content at harvest (21.4%) was obtained from east-west (EW) row direction and the minimum (14.6%) from north-south (NS) row direction. NESW row direction also gave significantly lower moisture content (15.1%) than EW (21.4%) and NWSE (18.1%) row directions. Therefore, using north-south and NESW row directions would help the crop to dry more quickly before harvest and reduce post harvest costs and losses. Seed production fields that require examination of sunflower heads to detect pollen production should be planted in NS rows for efficient roguing to maintain genetic purity. For research plots, EW rows with plot labels on the east end are often preferred, because it is easier to evaluate most plots when all heads face the viewer.

Key words: ***Helianthus annuus*, sunflower, row direction, agronomic characters, moisture content, Pakistan**

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INTRODUCTION

Sunflower (*Helianthus annuus* L.) is a phototropic crop from emergence to flowering, its head and leaves facing east in the morning and west in the evening. About one day before the ray flowers open, phototropic movement ceases and the heads face east (Robinson *et al.*, 1976). Calculations from a statistical model of light interception has shown that grain sorghum in north south (NS) rows would intercept 44% and east west (EW) rows 37% of direct sunlight during August in Colorado, USA (Allen, 1974).

Robinson (1975) reported that sunflower grown in EW and NS rows did not differ in yield, oil percentage and seed size. NS row had the potential for yield advantage and may be slightly preferable over EW (Dhillon *et al.*, 1982). When sunflower is to be harvested by hand, some growers of tall cultivars preferred rows directed north-south (NS), because heads overhanging the east side of the row could be gathered more easily (Moursi *et al.*, 1980). Row direction experiments on other crops such as wheat, indicated that the direction of sowing had no effect on yield (Nordestgaard, 1984). In another study on sorghum it was noted that fresh and dry weight of forage, total protein content and solar energy conversion efficiency were increased by sowing in NS direction (Moursi *et al.*, 1980). However, the effect was not important in commercial cultivation of sunflower (Slosser *et al.*, 1986).

Seed production fields that require examination of sunflower heads to detect pollen production should be planted in NS rows for efficient roguing to maintain genetic purity. For research plots, EW rows with plot labels on the east end are often preferred, because it is easier to evaluate most plots when all heads face the viewer (Robinson *et al.*, 1974). Little scientific work has so far been done to determine the effect of row direction on the agronomic and quality characteristics in sunflower. The present study was conducted to assess the effect of row direction on sunflower yield, yield components, oil quantity and quality.

MATERIALS AND METHODS

A field experiment was conducted using NK-265 sunflower hybrid planted in four row directions *i.e.*, north-south (NS), east-west (EW), north east-south west (NESW) and north west-south east (NWSE) at National Agricultural Research Center (NARC), Islamabad, Pakistan, during spring 1991 and 1992. The experiment was laid down in a randomized complete block design having four replications, with a plot size accommodating 10 rows, each 5 meters long and spaced 75 cm apart and having 25 cm distance between the plants. The trials were sown on 15 and 25 February during 1991 and 1992, respectively. Fertilizer dose of 60 N and 60 P_2O_5 (kg/ha) was applied in the form of urea and DAP at the time of sowing, while 60 N (kg/ha) was given at the time of first irrigation, when the plants attained 35-45 cm height. The crop was thinned to one plant per hill at 2-4 leaf stage. Two hoeings

were done to eradicate weeds. Hilling was done manually after the second irrigation to prevent the crop from lodging.

Days to flower initiation (DFI) was recorded when 5% of the total floral buds per plot opened their ray florets, days to flower completion (DFC) when about 90-95% of the buds per plot opened to flower. Plant height (PH) was recorded on 10 randomly selected plants in each treatment measuring from ground level to the receptacle of the head. Head diameter (HD) was also noted from the same randomly selected plants from one edge of the head to the other. Two central rows of 7.5 m length were manually harvested for recording the data on seed yield (kg/ha), oil content (OC), moisture content (MC), fatty acid profile (FAP) and 100-achene weight (100-AW). The data were analyzed using analysis of variance (Steel and Torrie, 1980) and Duncan's new multiple range test (Duncan, 1955) for separating different treatment means.

RESULTS AND DISCUSSION

The four row directions tested had little effect on agronomic characters of sunflower in both years (Table 1). The four treatment means for DFI, DFC, yield, 100-AW and FAP were not significantly different from each other. However, the PH means for 1991 and average of both years, HD means for 1991, OC means for 1991 were significantly different. Moisture content was the only character that was significantly affected by row direction in both years. Similar results were reported by Robinson *et al*. (1982). They found that sunflower grown at Minnesota in EW, NS and 16 other magnetic compass row directions did not differ in yield, oil percentage, seed size and 100-achene weight. The plant height in the four row directions during 1991 was significantly different. Taller plants (148 cm) were found in EW row direction, followed by NS direction (145 cm) during 1991, but this difference is too small to use for any practical purpose. Row direction had little but significant effect on HD during 1991. The largest head size (16.6 cm) in 1991 was obtained from NESW direction, while the other three directions had almost similar head sizes (14.9 to 15.1 cm). Similar results were obtained in a field experiment of Slosser *et al*. (1986).

In both years, yield was not significantly affected by the row direction as previously reported by Robinson (1975). However, comparatively higher yields were obtained from NESW and NWSE row directions. In 1991, 2106 and 2025 kg/ha were recorded for NS and EW directions, respectively. In 1992, comparatively higher yields of 3666 and 3620 kg/ha were obtained from SWNE and EW row directions, respectively, as compared with 3264 and 3223 kg/ha for NS and NWSE directions, respectively. The reason for consistently higher yields from NESW (3065 kg/ha) and SWNE (3019 kg/ha) row directions during both years may be due to higher interception of sunlight by upper leaves near the head, which play more affective role in photosynthesis during the reproductive phase of sunflower (Shafiullah *et al*., 1999). Row direction had significant effect on oil content in 1991. The highest oil

Table 1: Effect of row directions on yield and yield components of sunflower at NARC, during 1991-1992

Directions	DFI (days)			DFC (days)			PH (cm)			HD (cm)			Yield (kg/ha)		
	1991	1992	mean	1991	1992	mean	1991	1992	mean	1991	1992	mean	1991	1992	mean
NS	61	87	74.0	68	92	80.0	145	164	154.5	14.9	16.8	15.9	2106	3264	2685.0
EW	61	86	73.5	67	92	79.5	148	165	156.5	15.1	17.5	16.3	2025	3223	2624.0
NESW	61	86	73.5	67	91	79.0	136	163	149.5	16.6	17.5	17.1	2463	3666	3064.5
NWSE	62	86	74.0	68	92	80.0	138	163	150.5	14.9	17.5	16.2	2418	3620	3019.0
Mean	61.3	86.3	--	67.5	91.8	--	141.8	163.8	--	15.4	17.3	--	2253.0	3443.3	--
CV(%)	1.7	1.3	--	1.3	0.9	--	3.3	3.0	--	6.9	7.5	--	13.1	14.8	--
LSD 1	NS	NS		NS	NS	7.4	NS	5.0	1.7	NS	NS	NS	436		
LSD 2	NS			NS			NS			NS			617		
LSD 3	3.1			4.2			15.0			NS			751		

Table 1: Effect of row directions on yield and yield components of sunflower at NARC, during 1991-1992 (continued)

Directions	100-AW (gm)			OC (%)			MC (%)			OA (%)			LA (%)		
	1991	1992	mean	1991	1992	mean	1991	1992	mean	1991	1992	mean	1991	1992	mean
NS	4.8	6.1	5.4	45.2	38.8	42.0	11.0	18.3	14.6	37.6	42.1	39.8	55.6	46.9	51.2
EW	5.4	6.0	5.7	46.5	39.1	42.8	18.8	24.0	21.4	36.3	40.5	38.4	56.7	47.8	52.3
NESW	5.5	0.9	5.7	43.7	39.6	41.6	11.0	19.3	15.1	37.0	43.3	40.1	55.5	42.0	48.7
NWSE	5.8	5.3	5.6	44.5	40.7	42.6	13.3	23.0	18.1	37.7	35.7	36.7	55.8	54.8	55.3
Mean	5.8	5.9	--	45.0	39.6	--	13.5	21.1	--	37.2	40.4	--	55.9	47.9	--
CV(%)	9.9	11.1	--	2.3	9.7	--	15.9	12.6	--	21.2	19.3	--	15.4	19.4	--
LSD 1	NS			1.7	NS	NS	3.4	4.2	2.5	NS	NS		NS	NS	
LSD 2	NS			NS			3.6			NS			NS		
LSD 3	NS			3.7			3.1			NS			NS		

LSD 1 = (0.05) for treatment means
LSD 2 = (0.05) for interaction of treatment x year
LSD 3 = (0.05) for year means

content (46.5%) was obtained from EW direction, followed by NS (45.2), which were significantly higher than the OC obtained from NESW (43.7%) direction. During 1992, the row direction did not affect oil content significantly (Robinon *et al.*, 1982). Oleic acid and LA were not affected significantly by the row directions. However, a conspicuous change was observed in OA and LA in 1992, where NWSE direction gave a comparatively lower percentage of OA (35.7) and higher percentage of LA (54.1). Moisture content of seed was affected most pronouncedly by the row direction in both years. Lower moisture contents were obtained in NS and NESW directions, when crop was harvested after physiological maturity. In 1991, the moisture content of seed was 11% in NS and NESW row directions, as compared with 18.8% in EW direction and 13.3% in NWSE direction.

A similar trend was noted in 1992 and the seed moisture contents of 18.3, 19.3, 24 and 23% were recorded in NS, NESW, EW and NWSE row directions, respectively. These results strongly indicated that interception of solar radiation was higher in NS and NESW direction (Moursi *et al.*, 1980). This finding can be utilized for commercial cultivation of sunflower in NS and NESW row directions for early drying of the crop, to reduce the period for which it occupies the field after physiological maturity. It also helps to minimize the post harvest losses and additional costs for seed drying.

CONCLUSIONS

Row directions, *i.e.*, NS, EW, NESW and NWSE, had little effect on seed yield and other agronomic characters of sunflower. As an average of the two years, although statistically non-significant, the highest seed yield of 3065 kg/ha was obtained from north east-south west (NESW) direction and the lowest yield of 2624 kg/ha from east-west (EW) row direction. The most pronounced effect of row direction was noted on the seed moisture content (MC). As an average of the two years, the maximum seed moisture content at harvest (21.4%) was obtained from east-west (EW) row direction and the minimum (14.6%) from north-south (NS) row direction. NESW row direction also gave significantly lower moisture content (15.1%) than EW (21.4%) and NWSE (18.1%) row directions. These findings can be utilized in commercial cultivation of sunflower in NS and NESW row directions for early drying of the crop, to reduce the period for which it occupies the field after physiological maturity. It also helps to minimize the post harvest losses and additional costs for seed drying. Seed production fields that require examination of sunflower heads to detect pollen production should be planted in NS rows for efficient roguing to maintain genetic purity. For research plots, EW rows with plot labels on the east end are often preferred, because it is easier to evaluate most plots when all heads face the viewer.

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EFECTO DE LA DIRECCION DE EXTENSION DE HILERA SOBRE EL RENDIMIENTO Y LOS COMPONENTES DEL RENDIMIENTO DE GIRASOL (*Helianthus annuus* L.)

RESUMEN

El efecto de direcciones de extension de hilera sobre el rendimiento y los componentes del rendimiento de girasol (*Helianthus annuus* L.) era estudiado en el experimento de campo efectuado en el Centro Nacional de investigaciones agricolas en Islamabad, Pakistan, durante la primavera de 1991 y 1992. Cuatro direcciones de extension de hileras norte-sur (NS), este-oeste (EO), nordeste-sudoeste (NESO) y noroeste-sudeste (NOSE), que eran investigadas, tenian un pequeño efecto sobre el rendimiento de semillas y otras caracteristicas agranomicas del girasol. Las diferencias entre los valores medios de alteza de la planta, diametro de cabeza, rendimiento de semillas, peso de 100 semillas y contenido de acidos grasos que estadisticamente no son significativos. Las tendencias eran semejantes en ambos años. Por termino medio para dos años, bien que no sea significativo, el mas alto rendimiento de semillas de 3065 kg/ha fue obtemido con la extension de hilera en la direccion de nordeste-sudoeste (NESO), y el mas bajo, de 2624 kg/ha, con la extension de hilera en la direccion de este-oeste (EO). El efecto de la direccion de extension de hilera era la mas notable sobre el contenido de humedad en semillas. Por termino medio para dos años, el mas alto contenido de humedad en semillas durante la cosecha (21,4%) fue obtenido con la direccion este-oeste (EO), y el mas bajo (14,6%) con la direccion norte-sur (NS). La direccion de NESO tenia tambien menos grande contenido de humedad (15,1%) que las direcciones EO (21,4%) y NOSE (18,1%). Eso significa que las direcciones de NS y NESO pueden ayudar que la humedad se reduzca mas rapidamente en el campo, lo que reduce los gastos de la cosecha y las perdidas. Los campos de semillas, donde es necesario de controlar las cabezas de girasol para verificar la eficacia en la creacion de polen y donde es necesario de eliminar las plantas atipicas, es preciso de sembrar en la direccion de norte-sur. Las parcelas experimentales tienen que ser sembradas en la direccion de este-oeste con inscripciones de las parcelas al lado oriental, pues que la evaluacion es mas facil cuando todas las cabezas estan vueltas al observador.

EFFET DU SENS DES RANGÉES SUR LE RENDEMENT ET LES COMPOSANTES DU RENDEMENT CHEZ LE TOURNESOL (*Helianthus annuus* L.)

RÉSUMÉ

L'effet de l'orientation donnée aux rangées sur le rendement et les composantes du rendement du tournesol a été étudié dans des champs expérimentaux au Centre de recherche agronomique national à Islamabad au Pakistan, au cours des printemps 1991 et 1992. Les quatre orientations données aux rangées, nord-sud (NS), est-ouest (EO) nord-est - sud-ouest (NE-SO) et nord-ouest - sud-est (NO-SE) ont eu peu d'effet sur le rendement en graines et sur d'autres caractéristiques agronomiques du tournesol. Les différences entre les moyennes de la hauteur de la plante, le diamètre de la tête, le rendement en graines, le poids de 100 graines et le contenu d'acides gras se sont montrées insignifiantes du point de vue statistique. Les tendances sont restées les mêmes au cours des deux années. En moyenne, pour les deux années, le ren-

dement en graines de 3065 kg/ha, le plus important, quoique statistiquement insignifiant, a été obtenu dans les rangées qui s'étendaient dans le sens nord-est - sud-ouest (NE-SO) et le rendement de 2624 kg/ha, le moins important, dans les rangées de sens est-ouest (EO). L'effet du sens des rangées le plus évident a été constaté dans le contenu d'humidité de la graine. En moyenne, pour les deux années, le plus grand contenu d'humidité de la graine à la récolte (21.4%) a été obtenu dans les rangées de sens est-ouest (EO), et le moins important (14.6%) dans les rangées de sens nord-sud (NS). De même, le sens NE-SO a donné un contenu d'humidité significativement inférieur (15.1%) à celui des sens EO (21.4%) et NO-SE (18.1%). Ceci signifie que les plantes des rangées orientées dans les sens NS et NE-SO pourraient sécher plus vite, ce qui réduirait les pertes et les coûts de la récolte. Les champs consacrés à la production de graines qui exigent un examen des têtes pour vérification de la production de pollen et où il faut éliminer les plantes atypiques devraient être semés en direction nord-sud. Les parcelles expérimentales, elles, devraient être semées dans le sens est-ouest, avec les indications de parcelles car l'évaluation est plus facile quand toutes les têtes sont tournées vers l'observateur.