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PHYSIOLOGY, PHENOLOGY AND YIELD OF SUNFLOWER (AUTUMN) AS AFFECTED BY NPK FERTILIZER AND HYBRIDS

JEHAN BAKHT[1*], MOHAMMAD SHAFI[2], MOHAMMAD YOUSAF[3] AND HAMID ULLAH SHAH[4]

[1*]*Institute of Biotechnology and Genetic Engineering, NWFP Agricultural University, Peshawar*
[2]*Department of Agronomy, NWFP Agricultural University, Peshawar, Pakistan*
[3]*National Agricultural Research Centre Islamabad, Pakistan*
[4]*Department of Agricultural Chemistry, NWFP Agricultural University, Peshawar, Pakistan*

Abstract

The present field studies investigate the effect of NPK fertilizer on the physiology, phenology and yield response of sunflower hybrids at National Agricultural Research Centre (NARC), Islamabad, Pakistan during autumn, 2000 and 2001. The response of sunflower hybrids (SF-187 and Parsun-1) were studied using low medium and high rate of NPK (0, 50, 100,150 kg ha^{-1}) in factorial design with split plot arrangements. Days to R1 (button stage), R4 (inflorescence begins to open), R5.8 (80% anthesis) and R9 (physiological maturity) stages significantly ($P<0.05$) increased with an increase in fertilizer levels. Among the hybrids, Parsun-1 matured 4-5 days later than SF-187. Similarly, leaf area index (LAI), crop growth rate (CGR), and dry matter accumulation (DMA) also significantly ($P<0.05$) increased with an increase in fertilizer levels. Maximum LAI, CGR, DMA and seed yield was produced by fertilizer treatments of 150:100:100 kg ha^{-1} during both the seasons. Oil content also varied with different combinations of NPK fertilizers which ranged from 37 to 39% during both the seasons.

Introduction

Sunflower (*Helianthus annuus* L.) has an important place among oil seed crops in the world market and its production increased by approximately 1.8 times during the last 20 years (Pouzet, 2000). Nutrient removal by crops far exceeds than the nutrient additions through fertilizer. To this extent, the soils are becoming depleted, because much of this gap is at the expense of soil fertility (Tandon, 2004). Application of fertilizers having nutrients like nitrogen, phosphorous and potash can increase sunflower growth and yield substantially (Kho, 2000; Prasad *et al*., 2002; De Varennes *et al*., 2002; Cechin & Fumis, 2004; Sadras, 2006). Nitrogen, phosphorous and potash (NPK) ratio is an important indicator in crop production that identifies balanced or unbalanced fertilization. Intensive agriculture with fertilizer use highly skewed towards nitrogen, has deprived the soil of other essential nutrients, especially P and K. Application of nitrogenous, phosphatic and potashic fertilizer above or below the optimum level adversely affects the growth and yield. Hence, balanced fertilizer application is important for high crop yield and consequently more oil yield. Crop yield is frequently constrained by the availability of major nutrients, including nitrogen and phosphorus. While approaches for the diagnosis and management of crop nutrition often target individual nutrients, there is an increasing interest in integrated nutrient management.

*Corresponding author: E-mail: jehanbakht@yahoo.co.uk
Tel: No. +91-5842371; Fax No. +91-9216520

Fertilizer application represents an important measure to correct nutrient deficiencies and to replace elements removed in the products harvested, and has been shown to be particularly effective with respect to yield formation. However, recovery of fertilizer N is often as low as 50%, which has serious ecological consequences (Scheiner *et al*., 2002). Significant responses of seed oil yield to an increased level of NPK fertilizers have been observed by several investigators (Abu Ghazala *et al*., 2001; Ozer, 2004; Rathke *et al*., 2006). Keeping in view the role of NPK and varieties in the production of sunflower, the present study was designed to investigate the optimum nutrient needs of two sunflower hybrids; Parsun-1 and SF-187 for their optimum production.

Materials and Methods

The experiment was carried out during 2000–2001 at NARC, Islamabad. A sub plot size of 4.5 m x 5 m, with six rows, 5 m long with row-to-row distance of 75 cm and plant to plant distance of 20 cm was used for four replications. Urea was used as a source of N; single super phosphate as P and Muriate of potash as of K in the experiment. Full dose of P and K were applied at the time of planting, and half rate of N was applied at planting time and the remaining half at bud initiation stage. A factorial design with split plot arrangement was used during the course of study using 11 NPK treatments ($T_{1=}$ Control; T_2 = 00-100-100 ; T3= 50-100-100 ; T4= 100-100-100 ; T5= 150-100-100 ; T6= 100-00-100 ; T7= 100-50-100 ; T8= 100-150-100 ; T9= 100-100-00; T10= 100-100-50; T11= 100-100-150) in the main plots and two hybrids (Parsun-1 & SF-187) in sub plots. Data was recorded on days to RI (button stage), R4 (inflorescence begin to open), R5.8 (80% anthesis) and R9 stage (physiological maturity), leaf area index, crop growth, dry matter, seed yield and oil content. Climatically Islamabad falls under sub-humid to humid conditions and forms a part of Pothwar area. Climatic data is shown in Table 1. The soils are alkaline (pH, 7.0 to 8.2), non saline (EC, 0.09 –0.76 ds m^{-2}) and slightly to moderately calcareous. The physico-chemical characteristics of the experimental sites showed that 2.56 mg NO_3-N, 1.15 mg kg^{-1} P, 100.8 mg kg^{-1} K and 0.69 % organic matter ranges between 0.31 to 2.50 % Soil at the experimental sites was loamy in texture.

Table 1. Climate data of the experimental site (NARC field station) during 2000-01.

Month/ Year	2000				2001			
	Max. temp.	Min. temp.	R.H	Rainfall	Max. temp.	Min. temp.	R.H (%)	Rainfall
	(°C)	(°C)	(%)	(mm)	(°C)	(°C)	1400 hrs	(mm)
Jan.	17.0	3.0	56.0	136	19.0	1.1	36.7	0
Feb	18.0	4.0	52.0	51	23.3	4.3	25.1	1
Mar	24.0	13.0	52.0	19.0	27.5	9.2	25.9	27.0
Apr	33.0	14.0	32.0	5.0	31.5	15.1	35.2	10.0
May	40.0	22.0	26.0	8.0	39.0	21.3	26.1	46.0
Jun	39.0	24.0	34.0	109.0	35.6	23.5	49.5	157.0
Jul	34.0	24.0	59.0	250.0	33.2	23.7	66.1	591.0
Aug	33.0	23.0	63.0	279.0	33.9	23.7	65.6	141.0
Sep.	32.0	20.0	55.0	55.0	33.6	18.8	47.3	29.0
Oct.	32.0	14.0	33.0	0.0	31.4	13.9	41.1	23.0
Nov.	26.0	8.0	33.0	0.0	26.1	7.5	33.2	4.0
Dec.	22.0	3.0	31.0	12.0	21.2	3.9	40.6	1.0

Statistical analysis: All data are presented as mean values of three replicates. Data were analyzed statistically for analysis of variance (ANOVA) following the method described by Gomez & Gomaz (1984). MSTATC computer software was used to carry out statistical analysis (Russel & Eisensmith, 1983). The significance of difference among means was compared by using Least Significant Difference (LSD) test (Steel & Torrie, 1997).

Results and Discussion

A. Crop phenology: NPK fertilization and hybrids significantly ($p \leq 0.05$) affected number of days to RI, R4, R5.8 and R9 stages. The interactive effects of year x fertilization was also significant ($p \leq 0.05$) on number of days to all stages of growth except R9 stage (Figs. 1-4). Similarly, the interactive effect of year x hybrid significantly ($p \leq 0.05$) affected number of days to R4 and R5.8 stage. The interaction of fertilizer x hybrid did significantly ($p \leq 0.05$) affect number of days to all stage of growth except RI stage. Maximum number of days to all growth stages was observed in 2001 compared with 2000. Highest number of days to RI, R4, R5.8 and R9 stage was taken by hybrid (Persun-I). Application of NPK at the ratio of 150-100-100 kg ha^{-1} took highest number of days to all stages of growth except R9 stage. Increase in number of days to different growth stages could be due to increased vegetative growth. These results agree with those reported by Mujiri & Arzani (2003), Kho (2000) Prasad *et al*., (2002) De Varennes *et al*., (2002) Cechin & Fumis, (2004) & Sadras, (2006).

B. Crop physiology: Leaf area index was significantly increased with an increase in fertilizer levels (Figs. 5 & 6). Maximum LAI was produced by fertilizer combination of 100:100:100 NPK kg ha^{-1} at 90 days after emergence in Parsun-1. In case of SF-187, maximum leaf area index was obtained from the fertilizer treatment of 150:100:100 NPK kg ha^{-1}. SF-187 responded positively to higher fertilizer levels when compared with Parsun-1 (Fig. 6). These results agree with those reported by Kho (2000), Aleman *et al*., (2002), Mujiri & Arzani (2003), Prasad *et al*., (2002) De Varennes *et al*., (2002), Cechin & Fumis, (2004), Ozer *et al*., (2004) and Sadras, (2006). Murad *et al*., (2000) concluded that increasing level of N up to 150 kg ha^{-1} increased the leaf area, but was non-significantly affected by P. Significantly ($p<0.05$) maximum crop growth rate was produced 60 days after emergence at fertilizer level of 150:100:100 NPK kg ha^{-1} in both the hybrids when compared with fertilizers treatments (Figs. 7 and 8). Parsun-1 had more crop growth rate when compared with SF-187. Difference in growth and productivity between sunflower cultivars was reported by Abu Ghazala *et al*., (2001), Bheemaiah *et al*., (2003) and Sarmah *et al*., (2000). Dry matter accumulation was significantly increased with an increase in fertilizer levels in either combination or days after emergence during both 2000 and 2001. Comparatively, SF-187 produced maximum dry matter accumulation than Parsun-I (Figs. 9 & 10). These results are also in agreement with those reported by Legha & Gajendra (2001) and Bikas & Gajendra (2002).

Seed yield (kg ha^{-1}): Year and fertilizer application had a significant ($p \leq 0.01$) effect on seed yield, while the effect of hybrids and their possible interactions with year and fertilizer was non-significant. Between years, maximum seed yield (2551 kg ha^{-1}) was obtained during 2000 compared 2001 (2293 kg ha^{-1}). Significantly ($p<0.05$) maximum seed yield was produced by SF-187 (2439 kg ha^{-1}) when compared with Parsun-1 (2405 kg ha^{-1}). In case of fertilizer application, significantly ($p<0.05$) maximum seed yield

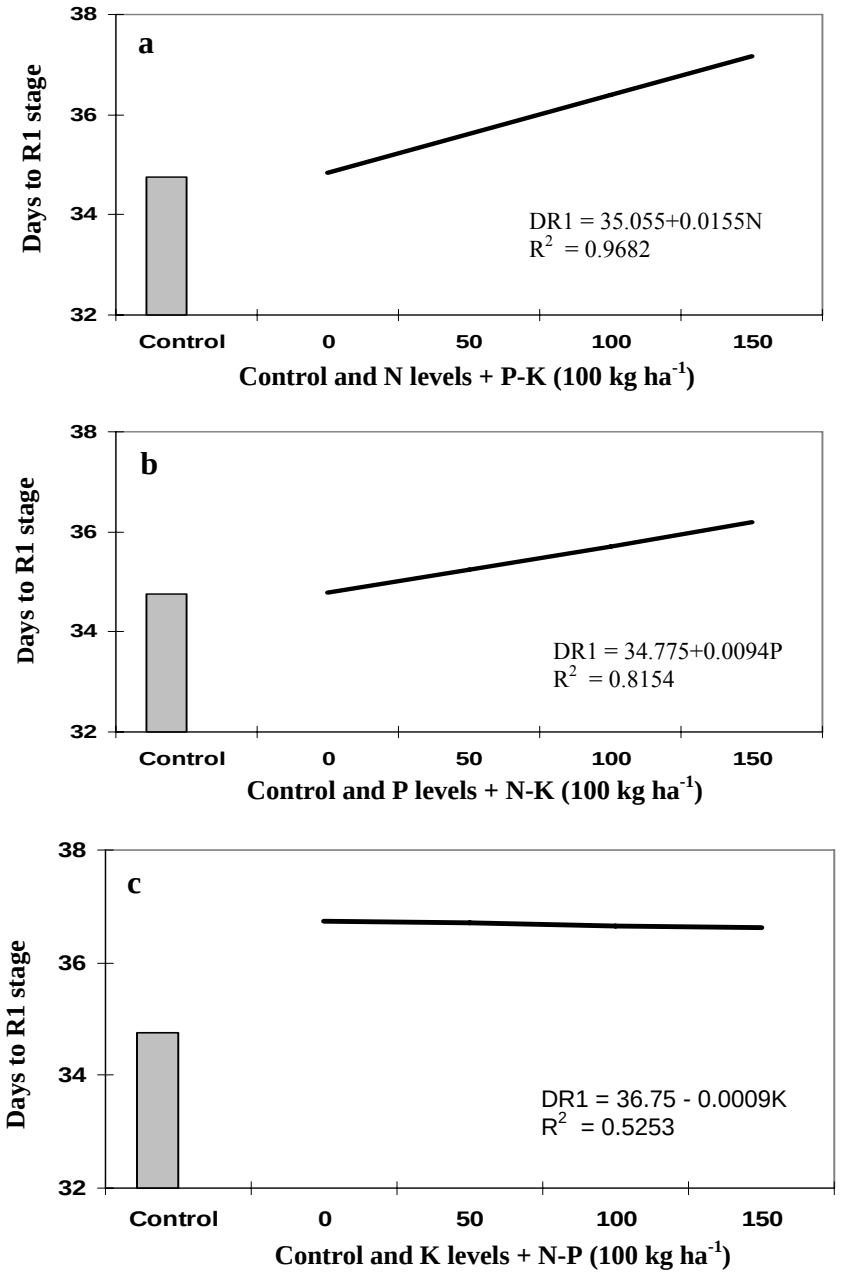

Fig. 1. Effect of NPK on days to R1 stage of sunflower hybrids during autumn 2000 and 2001 (a) N in the presence of 100 kg ha^{-1} of P and K, (b) P in the presence of 100 kg ha^{-1} of N and K, (c) K in the presence of 100 kg ha^{-1} of N and P

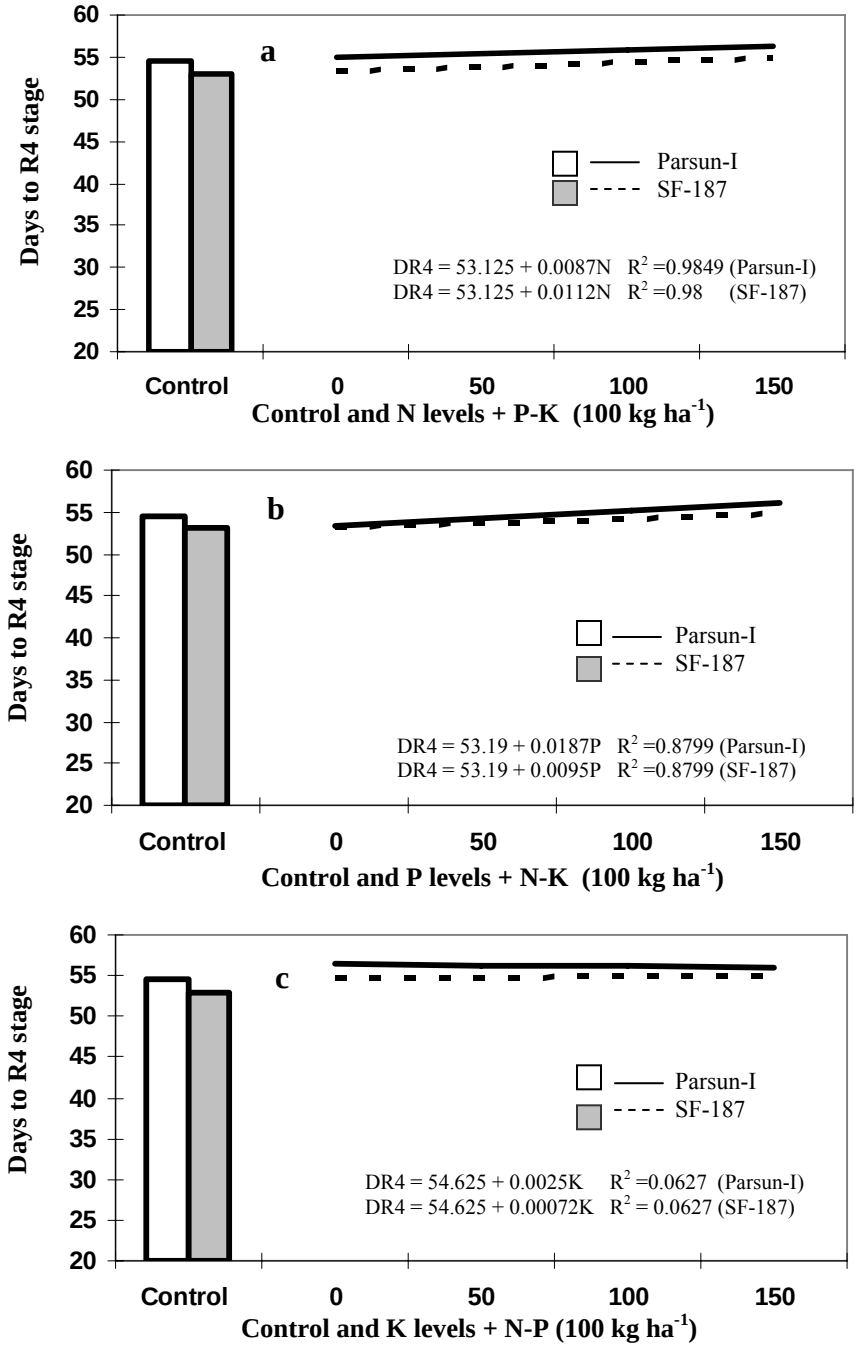

Fig. 2. Effect of NPK on days to R4 stage of sunflower hybrids during autumn 2000 and 2001 (a) N in the presence of 100 kg ha^{-1} of P and K, (b) P in the presence of 100 kg ha^{-1} of N and K, (c) K in the presence of 100 kg ha^{-1} of N and P.

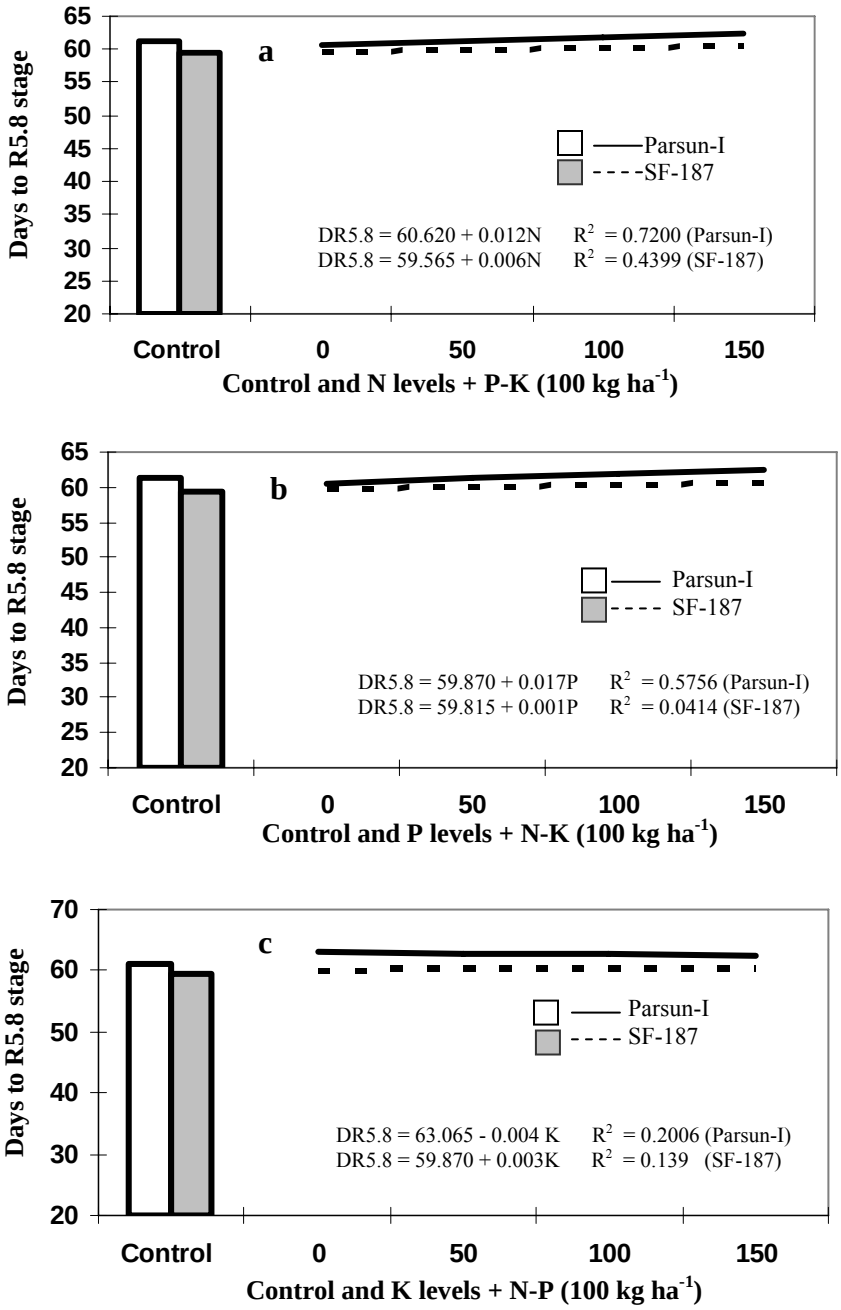

Fig. 3. Effect of NPK on days to R5.8 stage of sunflower hybrids during autumn 2000 and 2001 (a) N in the presence of 100 kg ha^{-1} of P and K, (b) P in the presence of 100 kg ha^{-1} of N and K, (c) K in the presence of 100 kg ha^{-1} of N and P.

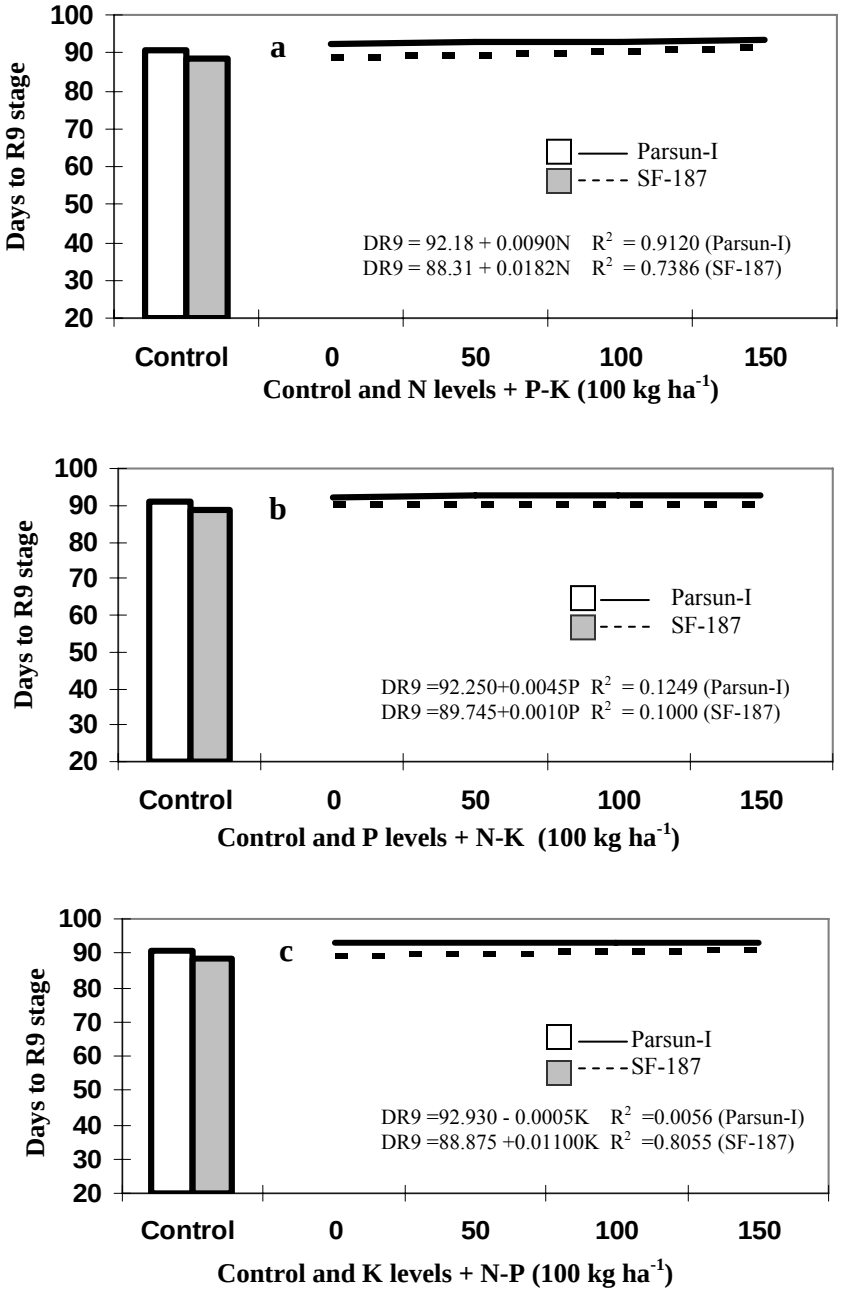

Fig. 4. Effect of NPK on days to R9 stage of sunflower hybrids during autumn 2000 and 2001 (a) N in the presence of 100 kg ha^{-1} of P and K, (b) P in the presence of 100 kg ha^{-1} of N and K, (c) K in the presence of 100 kg ha^{-1} of N and P.

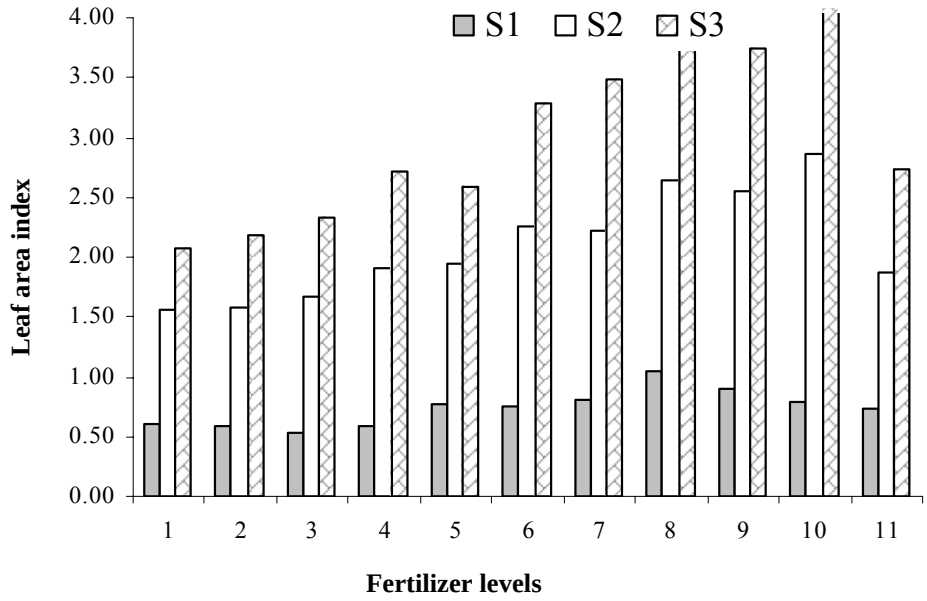

Fig. 5. Effect of NPK treatments on the leaf area index of sunflower hybrid Parsun-1 during autumn 2000-2001. (S1 = 30, S2 =60 and S3 = 90 days).

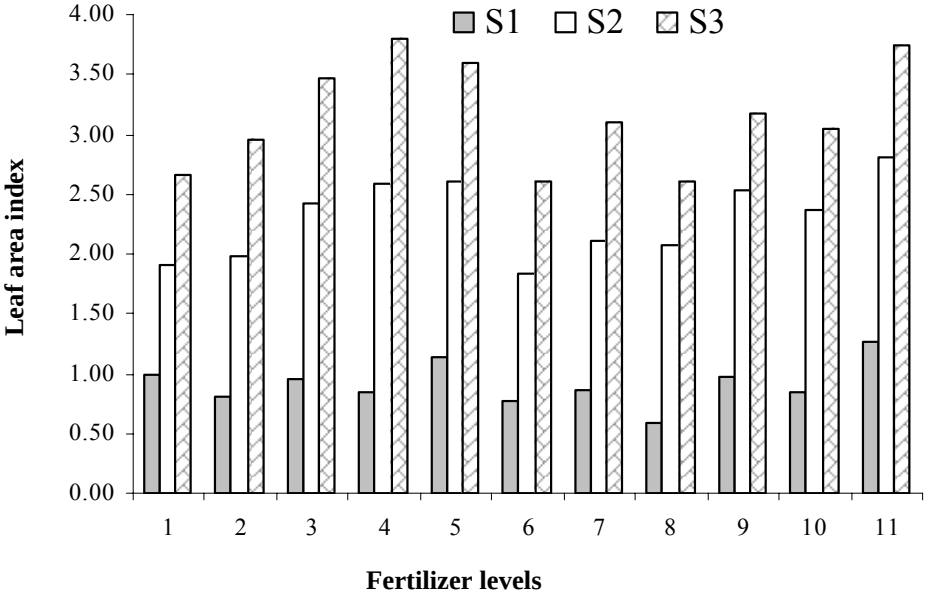

Fig. 6. Effect of NPK treatments on the leaf area index of sunflower hybrid SF-187 during autumn 2000-2001(S1 = 30, S2 =60 and S3 = 90 days).

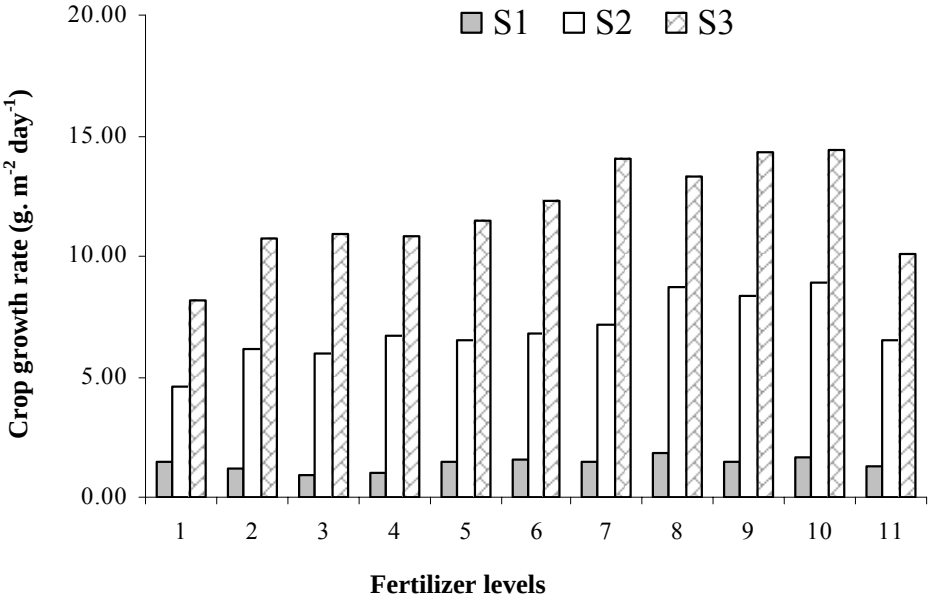

Fig. 7. Effect of NPK treatments on the crop growth rate of sunflower hybrid Parsun-1 during autumn 2000-2001. (S1 = 30, S2 =60 and S3 = 90 days)

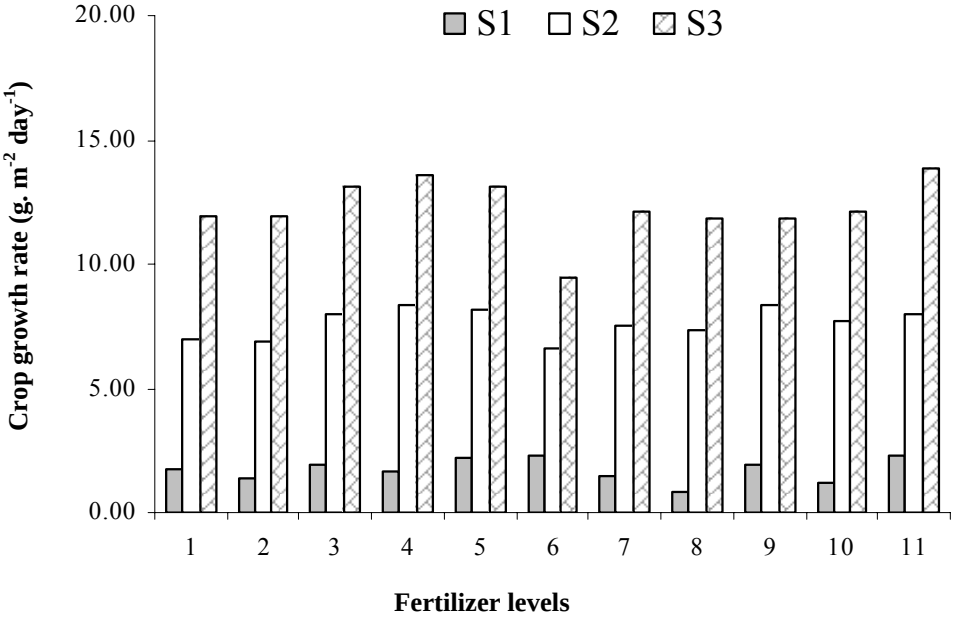

Fig. 8. Effect of NPK treatments on the crop growth rate (g. m^{-2} day^{-1}) of sunflower hybrid SF-187 during autumn 2000-2001. (S1 = 30, S2 =60 and S3 = 90 days).

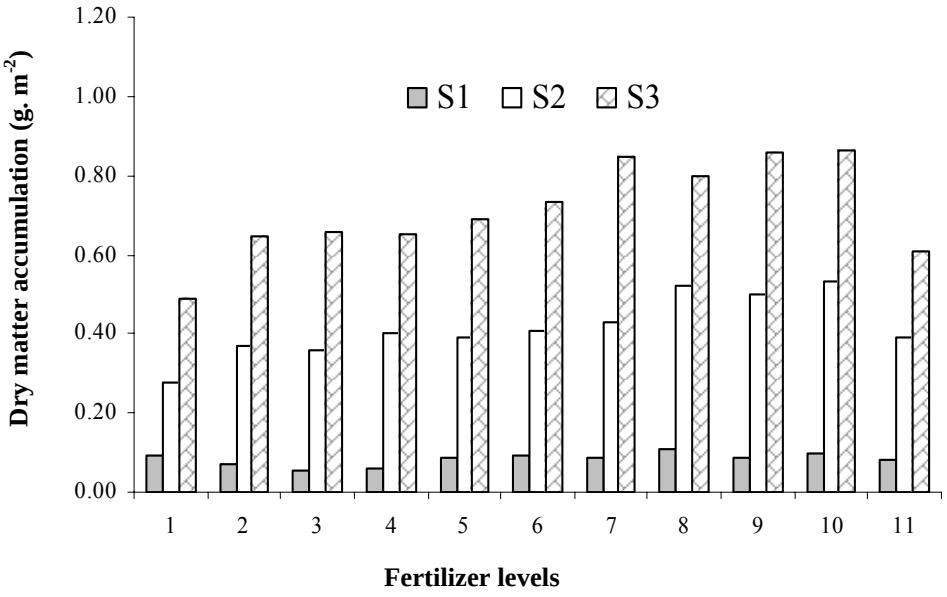

Fig. 9. Effect of NPK treatments on the dry matter accumulation (g. m^{-2}) of sunflower hybrid Parsun-1 during autumn 2000-2001. (S1 = 30, S2 =60 and S3 = 90 days).

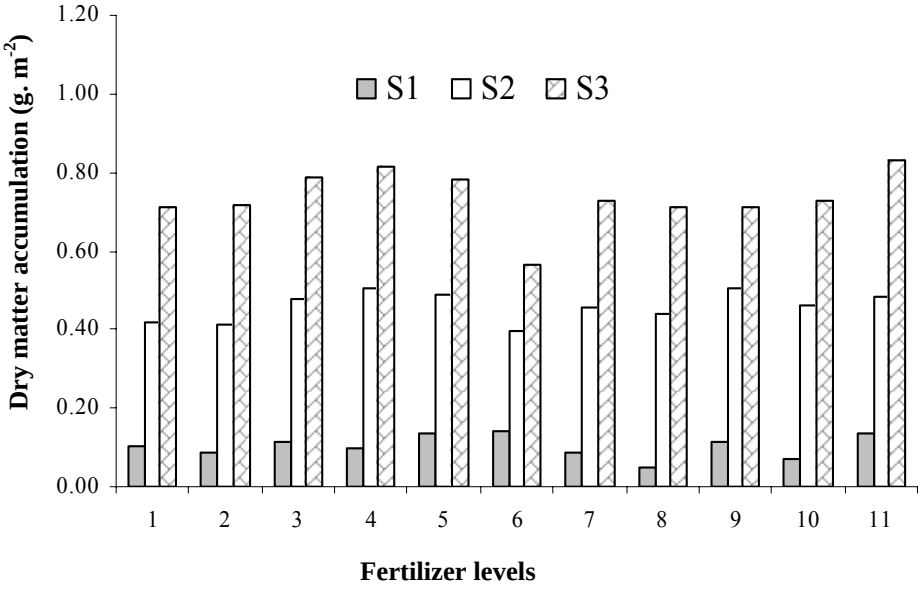

Fig. 10. Effect of NPK treatments on the dry matter accumulation (g. m^{-2}) of sunflower hybrid SF-187 during autumn 2000-2001. (S1 = 30, S2 = 60 and S3 = 90 days)

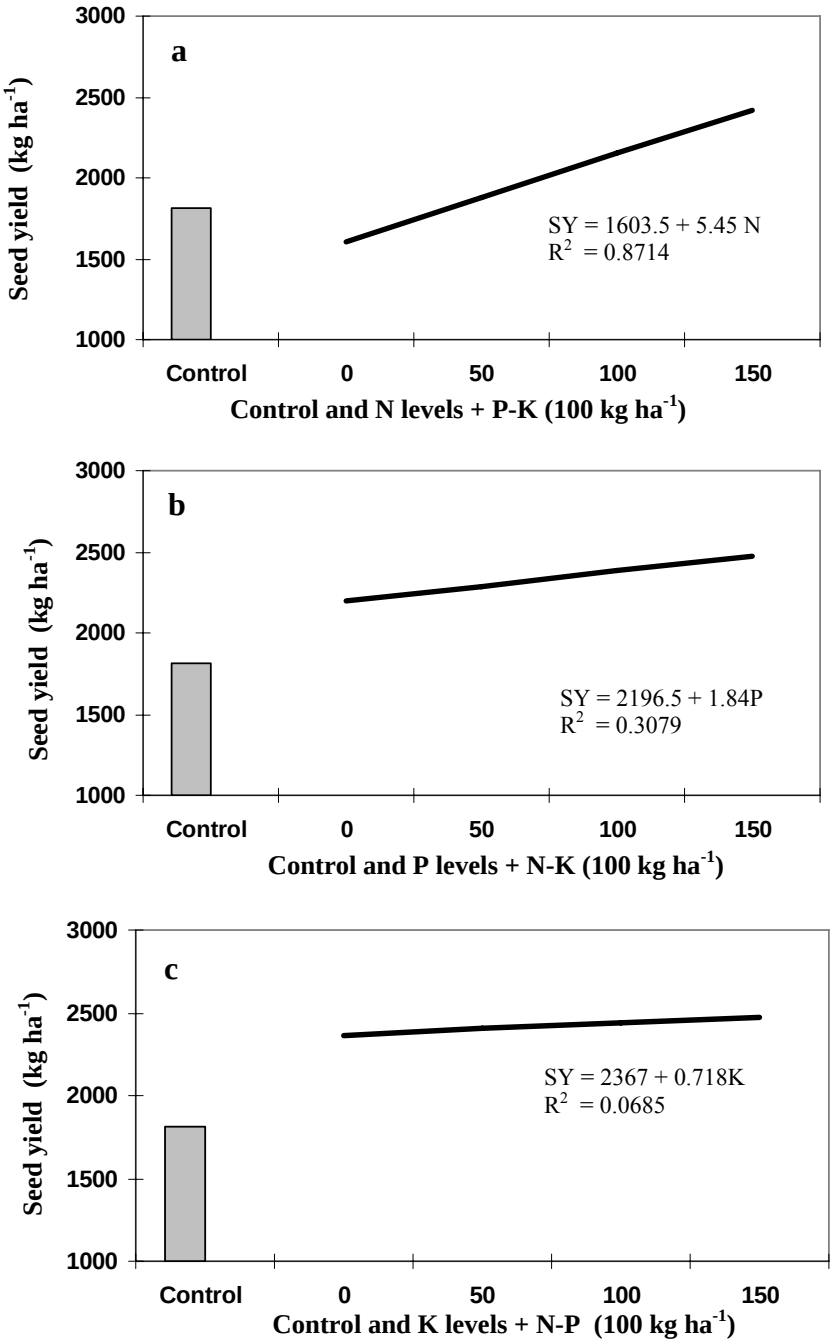

Fig. 11. Effect of NPK on seed yield of sunflower hybrids during autumn 2000 and 2001: (a) N in the presence of 100 kg ha^{-1} of P and K; (b) P in the presence of 100 kg ha^{-1} of N and K; (c) K in the presence of 100 kg ha^{-1} of N and P.

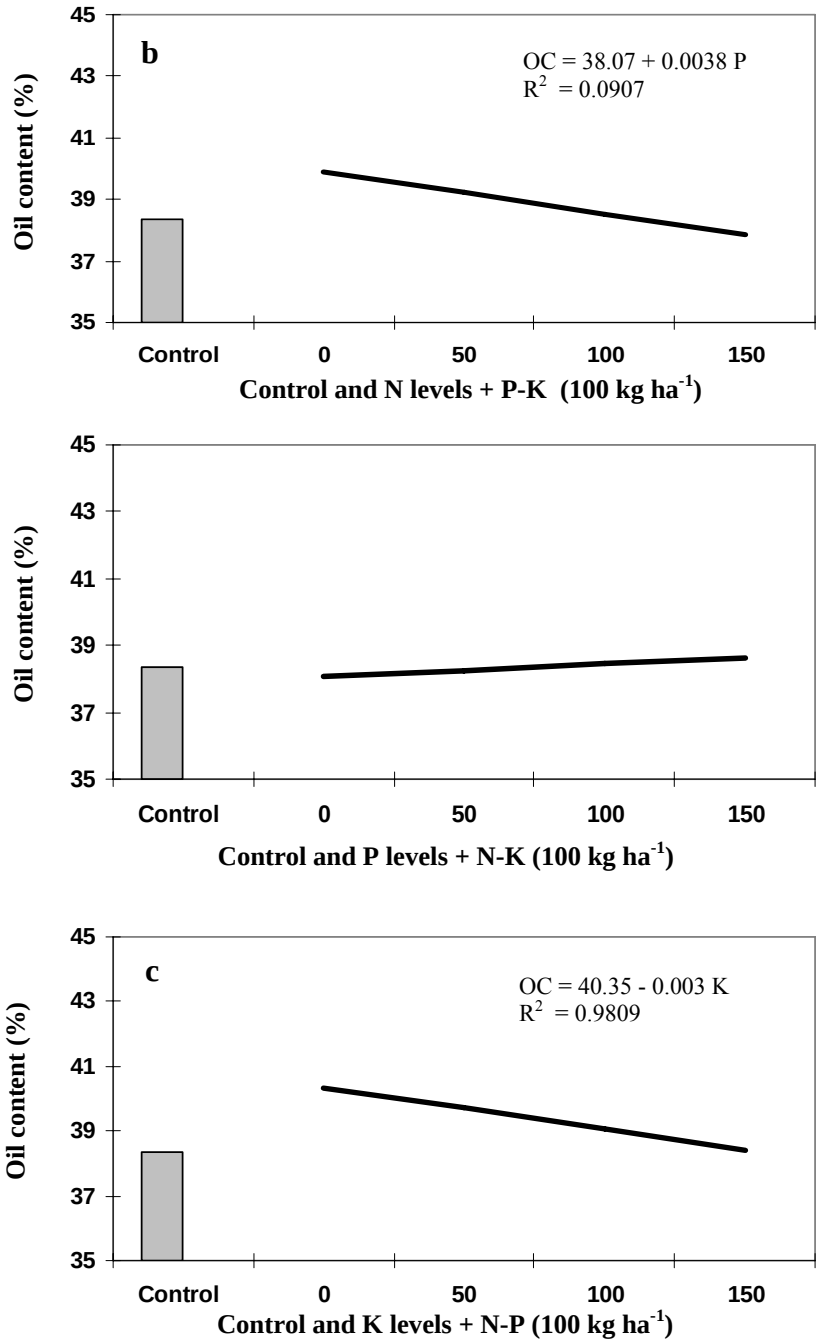

Fig. 12. Effect of NPK on oil content (%) of sunflower hybrids during autumn 2000 and 2001 (a) N in the presence of 100 kg ha^{-1} of P and K, (b) P in the presence of 100 kg ha^{-1} of N and K, (c) K in the presence of 100 kg ha^{-1} of N and P.

(2813 kg ha^{-1}) was noted for fertilizer treatment of 150:100:100 NPK kg ha^{-1} compared with other treatments. In case of year x hybrid x fertilizer interaction, maximum seed yield was recorded for Parsun-1 (3280 kg ha^{-1}) at fertilizer treatment of 150:100:100 NPK kg ha^{-1} during 2000. Seed yield increased @ 5.45, 1.84 and 0.718 kg with kg^{-1} increase in NPK (Fig. 11a, and c). These results are in conformity with those reported by Kardar *et al*., (2001), Abu Ghazala *et al*., (2001), Ayyappan *et al*., (2002), Thavaprakash *et al*., (2003), Hakoomat *et al*., (2004) and Sadras (2006).

Oil content (%): Significant ($p \leq 0.05$) effect was observed on oil content due to fertilizer and hybrids, while their interactions were not significant. Between years, maximum oil content (39.02%) was recorded for 2001 compared with plots sown during 2000 (37.92%). Among hybrids, oil content was maximum (39.65%) in Parsun-1 compared with SF-187 (37.30 %). Fertilizer treatments of 0:100:100 NPK kg ha^{-1} produced maximum oil content (39.7%). In case of year x hybrid x fertilizer interactions, maximum oil content (41.85%) was recorded for Parsun-1 at fertilizer treatments of 0:100:100 NPK kg ha^{-1} during 2001. Our results indicated that oil content decreased with an increase in the level of NP (Fig. 12a and 12b) while no effect on oil content was found due to the application of higher levels of K (Fig. 12c). Similar responses have been reported in another study by Scheiner *et al*., (2002), Syed *et al*., (2003) and Aleman *et al*., (2002).

Acknowledgments

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